IVQs in Motor Vehicle Engineering (3905)

City & Guilds

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Version 2.1

Level 1 IVQ Certificate in Motor Vehicle Systems (3905-01) (500/5966/X)

Level 2 IVQ Technician Certificate in Motor Vehicle Systems (3905-02) (500/5967/1)

Level 2 IVQ Diploma in Motor Vehicle Systems (3905-03) (500/5964/6)

Level 3 IVQ Technician Diploma in Motor Vehicle Systems (3905-04) (500/5965/8)

Level 3 IVQ Advanced Diploma in Diagnostic Techniques (3905-05/06) (500/5981/6)

Level 5 IVQ Advanced Technician Diploma in
– Diagnostic Techniques (3905-07/08) (500/5996/8)
– Motor Vehicle Engineering (3905-09/10) (500/5982/8)
– Motor Vehicle Management (3905-11/12) (500/5983/X)

Qualification handbook for centres

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Qualification handbook for centres

Version and date	Change detail	Section
2.1 October 2017	Added TQT and GLH details	Introduction to the programme

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Contents

Important notice

Following the accreditation of the IVQs in Motor Vehicle Engineering (3905) on the National Qualifications Framework of England, Wales and Northern Ireland (NQF), some changes have been made to the qualification, at the request of the Office of the Qualifications and Examinations Regulator (Ofqual), the qualifications regulator in England.

These changes took effect on 1 June 2009 and are outlined on pages 07–09.

Note: the content of the qualifications has not changed following accreditation.

Changes to the qualification titles
The qualification titles have changed as follows:

Certificate in Motor Vehicle Systems (3905-01)
changed to
Level 1 IVQ Certificate in Motor Vehicle Systems (3905-01)
Accreditation number: 500/5966/X

Technician Certificate in Motor Vehicle Systems (3905-02)
changed to
Level 2 IVQ Technician Certificate in Motor Vehicle Systems (3905-02)
Accreditation number: 500/5967/1

Diploma in Motor Vehicle Systems (3905-03)
changed to
Level 2 IVQ Diploma in Motor Vehicle Systems (3905-03)
Accreditation number: 500/5964/6

Technician Diploma in Motor Vehicle Systems (3905-04)
changed to
Level 3 IVQ Technician Diploma in Motor Vehicle Systems (3905-04)
Accreditation number: 500/5965/8

Advanced Diploma in Diagnostic Techniques – Light Vehicles (3905-05)
changed to
Level 3 IVQ Advanced Diploma in Diagnostic Techniques (Light Vehicles) (3905-05)
Accreditation number: 500/5981/6

Advanced Diploma in Diagnostic Techniques – Heavy Vehicles (3905-06)
changed to
Level 3 IVQ Advanced Diploma in Diagnostic Techniques (Heavy Vehicles) (3905-06)
Accreditation number: 500/5981/6

Advanced Technician Diploma in Diagnostic Techniques – Light Vehicles (3905-07)
changed to
Level 5 IVQ Advanced Technician Diploma in Diagnostic Techniques (Light Vehicles) (3905-07)
Accreditation number: 500/5996/8

Advanced Technician Diploma in Diagnostic Techniques – Heavy Vehicles 3905-08
changed to
Level 5 IVQ Advanced Technician Diploma in Diagnostic Techniques (Heavy Vehicles) (3905-08)
Accreditation number: 500/5996/8

Advanced Technician Diploma in Motor Vehicle Engineering – Light Vehicles 3905-09
changed to
Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Engineering (Light Vehicles) (3905-09)
Accreditation number: 500/5982/8

Advanced Technician Diploma in Motor Vehicle Engineering – Heavy Vehicles 3905-10
changed to
Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Engineering (Heavy Vehicles) (3905-10)
Accreditation number: 500/5982/8

Advanced Technician Diploma in Motor Vehicle Management – Light Vehicles 3905-11
changed to
Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Management (Light Vehicles) (3905-11)
Accreditation number: 500/5983/X

Advanced Technician Diploma in Motor Vehicle Management – Heavy Vehicles 3905-12
changed to
Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Management (Heavy Vehicles) (3905-12)
Accreditation number: 500/5983/X

Changes to the unit titles
Following the accreditation of IVQs in Motor Vehicle Engineering, each unit has been given an accreditation reference number which will appear on the Certificate of Unit Credit.

The content of the units is unchanged.

Level 1 IVQ Certificate in Motor Vehicle Systems (3905-01)
Accreditation number: 500/5966/X

K/502/2948 – Engine Systems 1
M/502/2949 – Chassis Systems 1
H/502/2950 – Vehicle Systems Practical 1

Level 2 IVQ Technician Certificate in Motor Vehicle Systems (3905-02)
Accreditation number: 500/5967/1

K/502/2948 – Engine Systems 1
M/502/2949 – Chassis Systems 1
K/502/2951 – Maths, Science and Communications
H/502/2950 – Vehicle Systems Practical 1

Level 2 IVQ Diploma in Motor Vehicle Systems (3905-03)
Accreditation number: 500/5964/6

M/502/2952 – Engine Systems 2
T/502/2953 – Chassis Systems 2
A/502/2954 – Vehicle Systems Practical 2
F/502/2955 – Engine Systems 3
J/502/2956 – Chassis Systems 3
L/502/2957 – Vehicle Systems Practical 3

Level 3 IVQ Technician Diploma in Motor Vehicle Systems (3905-04)
Accreditation number: 500/5965/8

M/502/2952 – Engine Systems 2
T/502/2953 – Chassis Systems 2
R/502/2958 – Maths, Science and Electronics 1
A/502/2954 – Vehicle Systems Practical 2
F/502/2955 – Engine Systems 3
J/502/2956 – Chassis Systems 3
Y/502/2959 – Maths, Science and Electronics 2
L/502/2957 – Vehicle Systems Practical 3

Level 3 IVQ Advanced Diploma in Diagnostic Techniques (Light Vehicles) (3905-05)
Accreditation number: 500/5981/6

Mandatory units
L/502/2960 – Vehicle Systems Practical 4

Optional units (three required)
H/502/2964 – Petrol Engines and Fuel Systems
K/502/2965 – Light Vehicle Chassis Systems
R/502/2961 – Diesel Engines and Fuel Systems
Y/502/2962 – Electrical and Electronic Systems
D/502/2963 – Service Reception in Motor Vehicle Engineering

Level 3 IVQ Advanced Diploma in Diagnostic Techniques (Heavy Vehicles) (3905-06)
Accreditation number: 500/5981/6

Mandatory units
L/502/2960 – Vehicle Systems Practical 4

Optional units (three required)
R/502/2961 – Diesel Engines and Fuel Systems
M/502/2966 – Heavy Vehicle Chassis Systems
T/502/2967 – Heavy Vehicle Transmission Systems
Y/502/2962 – Electrical and Electronic Systems
D/502/2963 – Service Reception in Motor Vehicle Engineering

Level 5 IVQ Advanced Technician Diploma in Diagnostic Techniques (Light Vehicles) (3905-07)
Accreditation number: 500/5996/8

Mandatory units
A/502/2968 – Mathematics, Science and Electronics 3
L/502/2960 – Vehicle Systems Practical 4

Optional units (three required)
H/502/2964 – Petrol Engines and Fuel Systems
K/502/2965 – Light Vehicle Chassis Systems
R/502/2961 – Diesel Engines and Fuel Systems
Y/502/2962 – Electrical and Electronic Systems
D/502/2963 – Service Reception in Motor Vehicle Engineering

Level 5 IVQ Advanced Technician Diploma in Diagnostic Techniques (Heavy Vehicles) (3905-08)
Accreditation number: 500/5996/8

Mandatory units
A/502/2968 – Mathematics, Science and Electronics 3
L/502/2960 – Vehicle Systems Practical 4

Optional units (three required)
R/502/2961 – Diesel Engines and Fuel Systems
M/502/2966 – Heavy Vehicle Chassis Systems
T/502/2967 – Heavy Vehicle Transmission Systems
Y/502/2962 – Electrical and Electronic Systems
D/502/2963 – Service Reception in Motor Vehicle Engineering

Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Engineering (Light Vehicles) (3905-09)
Accreditation number: 500/5982/8

Mandatory units
A/502/2968 – Mathematics, Science and Electronics 3
L/502/2960 – Vehicle Systems Practical 4
F/502/2969 – Engine Systems 4
T/502/2970 – Chassis Systems 4
A/502/2971 – Mathematics, Science and Electronics 4
F/502/2972 – Vehicle Systems Practical 5
J/502/2973 – Motor Vehicle Engineering Project

Optional units (three required)
H/502/2964 – Petrol Engines and Fuel Systems
K/502/2965 – Light Vehicle Chassis Systems
R/502/2961 – Diesel Engines and Fuel Systems
Y/502/2962 – Electrical and Electronic Systems
D/502/2963 – Service Reception in Motor Vehicle Engineering

Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Engineering (Heavy Vehicles) (3905-10)
Accreditation number: 500/5982/8

Mandatory units
A/502/2968 – Mathematics, Science and Electronics 3
L/502/2960 – Vehicle Systems Practical 4
F/502/2969 – Engine Systems 4
T/502/2970 – Chassis Systems 4
A/502/2971 – Mathematics, Science and Electronics 4
F/502/2972 – Vehicle Systems Practical 5
J/502/2973 – Motor Vehicle Engineering Project

Optional units (three required)
R/502/2961 – Diesel Engines and Fuel Systems
M/502/2966 – Heavy Vehicle Chassis Systems
T/502/2967 – Heavy Vehicle Transmission Systems
Y/502/2962 – Electrical and Electronic Systems
D/502/2963 – Service Reception in Motor Vehicle Engineering

Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Management (Light Vehicles) (3905-11)
Accreditation number: 500/5983/X

Mandatory units
D/502/2963 – Service Reception in Motor Vehicle Engineering
A/502/2968 – Mathematics, Science and Electronics 3
L/502/2960 – Vehicle Systems Practical 4
F/502/2972 – Vehicle Systems Practical 5
L/502/2974 – Management Skills in Motor Vehicle Engineering
R/502/2975 – Business Systems in Motor Vehicle Engineering
Y/502/2976 – Financial Systems in Motor Vehicle Engineering
J/502/2973 – Motor Vehicle Engineering Project

Optional units (three required)
H/502/2964 – Petrol Engines and Fuel Systems
K/502/2965 – Light Vehicle Chassis Systems
R/502/2961 – Diesel Engines and Fuel Systems
Y/502/2962 – Electrical and Electronic Systems

Level 5 IVQ Advanced Technician Diploma in Motor Vehicle Management (Heavy Vehicles) (3905-12)
Accreditation number: 500/5983/X

Mandatory units
D/502/2963 – Service Reception in Motor Vehicle Engineering
A/502/2968 – Mathematics, Science and Electronics 3
L/502/2960 – Vehicle Systems Practical 4
F/502/2972 – Vehicle Systems Practical 5
L/502/2974 – Management Skills in Motor Vehicle Engineering
R/502/2975 – Business Systems in Motor Vehicle Engineering
Y/502/2976 – Financial Systems in Motor Vehicle Engineering
J/502/2973 – Motor Vehicle Engineering Project

Optional units (three required)
R/502/2961 – Diesel Engines and Fuel Systems
M/502/2966 – Heavy Vehicle Chassis Systems
T/502/2967 – Heavy Vehicle Transmission Systems
Y/502/2962 – Electrical and Electronic Systems

Registration for theory examination
Registration process for the theory examination has not changed.

Result submission for practical assessment
Result submission process for the practical assessments has not changed.

Change to the grading
The grade 'Credit' has been changed to 'Merit'. All other grades are unchanged. The content of the units concerned is also unchanged.

Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUC)
Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUCs) continue to be available on completion of each assessment (theory or practical).

Final certificate will be issued on successful completion of all the required assessments.

Changes to the certificate layout
Certificates issued on completion of an accredited IVQ show the accredited title and the accreditation number for the qualification. The level in the accredited title refers to the NQF level the qualification is accredited at.

The certificate also lists all the units achieved, including the grade and the unit accreditation number.

The certificate carries the logos of the regulatory authorities in England, Wales and Northern Ireland indicating that the NQF accreditation only applies to these countries.

Levels of City & Guilds qualifications

All City & Guilds qualifications are part of an integrated progressive structure of awards arranged over eight levels, allowing people to progress from foundation to the highest level of professional competence. Senior awards, at levels 4 to 7, recognise outstanding achievement in industry, commerce and the public services. They offer a progressive vocational, rather than academic, route to professional qualifications. An indication of the different levels and their significance is given below.

NQF level#	City & Guilds qualifications/programmes	Other qualifications*
8	Fellowship (FCGI)	Doctorate
7	Membership (MCGI) Master Professional Diploma Level 5 vocational awards NVQ/SVQ Level 5	Master's Degree Postgraduate Diploma Postgraduate Certificate
6	Graduateship (GCGI) Associateship (ACGI)**	Bachelor's Degree Graduate Certificate and Diploma
5	Level 5 IVQ Advanced Technician Diploma Full Technological Diploma	Higher National Diplomas Foundation Degree Diplomas of Higher and Further Education
4	Licentiateship (LCGI) Higher Professional Diploma Level 4 vocational awards NVQ/SVQ Level 4	Certificate of Higher Education
3	Level 3 IVQ Advanced Diploma Level 3 IVQ Specialist Advanced Diploma*** Level 3 IVQ Technician Diploma Level 3 vocational awards NVQ/SVQ Level 3	A Level Scottish Higher Advanced National Certificate in Education BTEC National Certificate/Diploma
2	Level 2 IVQ Diploma Level 2 IVQ Specialist Diploma*** Level 2 IVQ Technician Certificate Level 2 vocational awards NVQ/SVQ Level 2	GCSE grades A*-C Scottish Intermediate 2/Credit S Grade BTEC First Certificate
1	Level 1 IVQ Certificate Level 1 vocational awards NVQ/SVQ Level 1	GCSE grades D-G Scottish Intermediate 1/General S Grade Scottish Access 1 and 2

\# National Qualifications Framework of England, Wales and Northern Ireland (NQF)
* Broad comparability in level
** Only graduates of the City & Guilds College, Imperial College of Science, Technology and Medicine, are awarded the Associateship (ACGI)
*** Part of a new qualification structure which is being introduced across the IVQ provision
IVQ International Vocational Qualifications
NVQ National Vocational Qualifications

IVQ in Motor Vehicle Engineering 3905

About City & Guilds

We provide assessment and certification services for schools and colleges, business and industry, trade associations and government agencies in more than 100 countries. We have over 120 years of experience in identifying training needs, developing assessment materials, carrying out assessments and training assessment staff. We award certificates to people who have shown they have mastered skills that are based on world-class standards set by industry. City & Guilds International provides a particular service to customers around the world who need high quality assessments and certification.

Introduction to this programme

We have designed the Motor Vehicle Engineering programme for those undergoing training or employed in this area of work. The programme supports international motor vehicle manufacturers' products by maintaining the high standards of quality and safety demanded by their customers and by law.

We do not say the amount of time a candidate would need to carry out the programme, but we do provide advice on guided-learning hours for each unit at each level (see below). The programme has three levels.

Certificate
The certificate (about 450 hours or 600 hours for a technician) provides a broad introduction to the theory and practical side of motor vehicle servicing for front-line workers. This prepares them to carry out a routine service operation under supervision.

Diploma
The diploma (about 600 hours or 800 hours for the technician) provides more practice involving a broader range of skills appropriate to a person who is developing skills needed to identify faults and who is able to carry out full servicing and repairs.

Advanced diploma
The advanced diploma (about 400 hours or 800 hours for a technician) takes these skills to the level appropriate for a person developing diagnostic skills in specific areas of motor vehicle engineering. We cover introduction to supervisory management in the Service Reception unit. At advanced diploma level candidates can carry out a full range of diagnostic skills on their chosen routes for light or heavy vehicles. Or, they may specialise as technicians on the engineering route. The motor vehicle management route covers Business Systems, Finance and Management Skills.

We stress that these figures are only a guideline and that we award certificates and diplomas for gaining and showing skills by whatever mode of study, and not for periods of time spent in study.

We provide certificates for all work-related skills at seven levels within our structure of awards as shown in appendix B. This programme covers levels 1, 2 and 3.

Full Technological Diploma
We will award the Full Technological Diploma (FTD) in Motor Vehicle Engineering to someone who is at least 21, who has had at least two years relevant industrial experience, and who has successfully finished the assessments for the Diploma and Advanced Diploma levels of this award. If candidates enter for this diploma, they must also send us a portfolio of evidence to support their application.

Making entries for assessments

Candidates can only be entered for the assessments in this subject if the approved examination centre agrees. Candidates must enter through an examination centre we have approved to carry out the assessments for 3905 Motor Vehicle Engineering.

There are two ways of entering candidates for assessments.

Internal candidates
Candidates can enter for examinations if they are taking or have already finished a course at a school, college or similar training institution that has directed their preparation (whether by going to a training centre, working with another institution, or by open learning methods).

External candidates
These are candidates who have not finished a programme as described above. The examination centres must receive their application for entry well before the date of the examination concerned. This allows them to act on any advice you give about assessment arrangements or any further preparation needed. External candidates must carry out practical assignments and projects if necessary, and they will need extra time and guidance to make sure that they meet all the requirements for this part of the assessment.

In this publication we use the term 'centre' to mean a school, college, place of work or other institution.

Resources

If you want to use this programme as the basis for a course, you must read this booklet and make sure you have the staff and equipment to carry out all parts of the programme. The syllabus was designed to make sure it included the latest technological advances in motor vehicle servicing, diagnostics and engineering techniques. If there are no facilities for realistic practical work, we strongly recommend that you develop links with local industry to provide opportunities for hands-on experience.

Assessments

The awards we have described in this booklet are at three levels.

Certificate
Diploma
Advanced diploma

We use a numbering system to allow entries to be made for our awards. The numbers used for this programme are as follows.

Subject number
3905

Complex numbers
01 and 02 (certificate levels)
03 and 04 (diploma levels)
05 – 12 (advanced diploma levels)

We use complex numbers to describe the level of the award.

Component numbers
001 Engine Systems 1
002 Chassis Systems 1
003 Maths, Science and Communications
004 Vehicle Systems Practical
021 Engine Systems 2
022 Chassis Systems 2
023 Maths, Science and Electronics 1
024 Vehicle Systems Practical
025 Engine Systems 3
026 Chassis Systems 3
027 Maths, Science and Electronics 2
028 Vehicle Systems Practical
041 Petrol Engines and Fuel Systems
042 Light Vehicle Chassis Systems
043 Diesel Engines and Fuel Systems
044 Heavy Vehicle Chassis Systems
045 Heavy Vehicle Transmission Systems
046 Electrical and Electronic Systems
047 Service Reception
048 Maths, Science and Electronics 3
049 Vehicle Systems Practical
061 Engine Systems 4
062 Chassis Systems 4
063 Maths, Science and Electronics 4
064 Vehicle Systems Practical
065 Management Skills
066 Business Systems
067 Financial Systems
068 Vehicle Systems Practical
069 Project

We use these numbers throughout this booklet. You must use these numbers correctly if you send forms to us.

Certificate in Motor Vehicle Systems
To carry out what is needed for the Certificate in Motor Vehicle Systems, candidates must be successful in all the following assessments.

3905-01-001 Engine Systems 1 (written multiple choice paper which lasts one and a half hours)

3905-01-002 Chassis Systems 1 (written multiple choice paper which lasts one and a half hours)

[3905-01-004] Vehicle Systems Practical
(Total of two written papers)

The practical assessment is carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

The assessments for Safety and Associated Studies are included in the assessments for Engine Systems and Chassis Systems.

Technician Certificate in Motor Vehicle Systems
To carry out what is needed for the Technician Certificate in Motor Vehicle Systems, candidates must be successful in all the following assessments.

3905-02-001 Engine Systems 1 (written multiple choice paper which lasts one and a half hours)

3905-02-002 Chassis Systems 1 (written multiple choice paper which lasts one and a half hours)

3905-02-003 Maths, Science and Communications (written multiple choice paper which lasts one and a half hours)

[3905-02-004] Vehicle Systems Practical
(Total of three written papers)

The practical assessment is carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

The assessments for Safety and Associated Studies are included in the assessments for Engine Systems and Chassis Systems.

Diploma in Motor Vehicle Systems
To carry out what is needed for the Diploma in Motor Vehicle Systems, candidates must be successful in all the following assessments.

3905-03-021 Engine Systems 2 (written multiple choice paper which lasts one and a half hours)

3905-03-022 Chassis Systems 2 (written multiple choice paper which lasts one and a half hours)

[3905-03-024] Vehicle Systems Practical

3905-03-025 Engine Systems 3 (written structured answer paper which lasts two hours)

3905-03-026 Chassis Systems 3 (written structured answer paper which lasts two hours)

[3905-03-028] Vehicle Systems Practical
(Total of four written papers)

The practical assessments are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate level, they should at least have achieved skill levels represented in the earlier programme before they prepare for the diploma award.

Technician Diploma in Motor Vehicle Systems
To carry out what is needed for the Technician Diploma in Motor Vehicle Systems, candidates must be successful in all the following assessments.

3905-04-021 Engine Systems 2 (written multiple choice paper which lasts one and a half hours)

3905-04-022 Chassis Systems 2 (written multiple choice paper which lasts one and a half hours)

3905-04-023 Maths, Science and Electronics 1 (written multiple choice paper which lasts one and a half hours)

[3905-04-024] Vehicle Systems Practical

3905-04-025 Engine Systems 3 (written structured answer paper which lasts two hours)

3905-04-026 Chassis Systems 3 (written structured answer paper which lasts two hours)

3905-04-027 Maths, Science and Electronics 2 (written structured answer paper which lasts two hours)

[3905-04-028] Vehicle Systems Practical
(Total of six written papers)

The practical assessments are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate level, they should at least have achieved skill levels represented in the earlier programme before they prepare for the diploma award.

Advanced Diploma in Diagnostic Techniques – Light Vehicles
To carry out what is needed for the Advanced Diploma in Diagnostic Techniques – Light Vehicles, candidates must be successful in any three of the following written assessments and the practical assessment.

GLH 400
TQT 560

3905-05-041 Petrol Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-05-042 Light Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-05-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-05-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

3905-05-047 Service Reception (written structured answer paper which lasts three hours)

[3904-05-049] Vehicle Systems Practical
(Total of three written papers)

The practical assessment is carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

Advanced Diploma In Diagnostic Techniques – Heavy Vehicles

To carry out what is needed for the Advanced Diploma in Diagnostic Techniques – Heavy Vehicles, candidates must be successful in any three of the following written assessments and the practical assessment.

GLH 400
TQT 560

3905-06-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-06-044 Heavy Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-06-045 Heavy Vehicle Transmission Systems (written structured answer paper which lasts three hours)

3905-06-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

3905-06-047 Service Reception (written structured answer paper which lasts three hours)

[3904-06-049] Vehicle Systems Practical
(Total of three written papers)

The practical assessment is carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

Advanced Technician Diploma in Diagnostic Techniques – Light Vehicles

To carry out what is needed for the Advanced Technician Diploma in Diagnostic Techniques – Light Vehicles, candidates must be successful in any three of the following written assessments.

GLH 560
TQT 840

3905-07-041 Petrol Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-07-042 Light Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-07-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-07-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

3905-07-047 Service Reception (written structured answer paper which lasts three hours)

And all of the following assessments.

3905-07-048 Maths, Science and Electronics 3 (written structured answer paper which lasts three hours)

[3905-07-049] Vehicle Systems Practical
(Total of four written papers)

The practical assessment is carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

Advanced Technician Diploma in Diagnostic Techniques – Heavy Vehicles

To carry out what is needed for the Advanced Technician Diploma in Diagnostic Techniques – Heavy Vehicles, candidates must be successful in any three of the following written assessments.

GLH 560
TQT 840

3905-08-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-08-044 Heavy Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-08-045 Heavy Vehicle Transmission Systems (written structured answer paper which lasts three hours)

3905-08-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

3905-08-047 Service Reception (written structured answer paper which lasts three hours)

And all of the following assessments.

3905-08-048 Maths, Science and Electronics 3 (written structured answer paper which lasts three hours)

[3905-08-049] Vehicle Systems Practical

(Total of four written papers)

The practical assessment is carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

Advanced Technician Diploma in Motor Vehicle Engineering – Light Vehicles

To carry out what is needed for the Advanced Technician Diploma in Motor Vehicle Engineering – Light Vehicles, candidates must be successful in any three of the following written assessments.

GLH 800
TQT 1200

3905-09-041 Petrol Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-09-042 Light Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-09-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-09-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

3905-09-047 Service Reception (written structured answer paper which lasts three hours)

And all of the following assessments.

3905-09-048 Maths, Science and Electronics 3 (written structured answer paper which lasts three hours)

[3905-09-049] Vehicle Systems Practical

3905-09-061 Engine Systems 4 (written structured answer paper which lasts three hours)

3905-09-062 Chassis Systems 4 (written structured answer paper which lasts three hours)

3905-09-063 Maths, Science and Electronics 4 (written structured answer paper which lasts three hours)

[3905-09-064] Vehicle Systems Practical

[3905-09-069] Project

(Total of seven written papers)

The practical assessments and the project are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

Advanced Technician Diploma in Motor Vehicle Engineering – Heavy Vehicles

To carry out what is needed for the Advanced Technician Diploma in Motor Vehicle Engineering – Heavy Vehicles, candidates must be successful in any three of the following written assessments.

GLH 800
TQT 1200

3905-10-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-10-044 Heavy Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-10-045 Heavy Vehicle Transmission Systems (written structured answer paper which lasts three hours)

3905-10-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

3905-10-047 Service Reception (written structured answer paper which lasts three hours)

And all of the following assessments.

3905-10-048 Maths, Science and Electronics 3 (written structured answer paper which lasts three hours)

[3905-10-049] Vehicle Systems Practical

3905-10-061 Engine Systems 4 (written structured answer paper which lasts three hours)

3905-10-062 Chassis Systems 4 (written structured answer paper which lasts three hours)

3905-10-063 Maths, Science and Electronics 4 (written structured answer paper which lasts three hours)

[3905-10-064] Vehicle Systems Practical

[3905-10-069] Project

(Total of seven written papers)

The practical assessments and the project are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

Advanced Technician Diploma in Motor Vehicle Management – Light Vehicles

To carry out what is needed for the Advanced Technician Diploma in Motor Vehicle Management – Light Vehicles, candidates must be successful in any two of the following written assessments.

GLH 800
TQT 1200

3905-11-041 Petrol Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-11-042 Light Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-11-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-11-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

And all of the following assessments.

3905-11-047 Service Reception (written structured answer paper which lasts three hours)

3905-11-048 Maths, Science and Electronics 3 (written structured answer paper which lasts three hours)

[3905-11-049] Vehicle Systems Practical

3905-11-065 Management Skills (written structured answer paper which lasts three hours)

3905-11-066 Business Systems (written structured answer paper which lasts three hours)

3905-11-067 Financial Systems (written structured answer paper which lasts three hours)

[3905-11-068] Vehicle Systems Practical

[3905-11-069] Project

(Total of seven written papers)

The practical assessments and the project are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

Advanced Technician Diploma in Motor Vehicle Management – Heavy Vehicles

To carry out what is needed for the Advanced Technician Diploma in Motor Vehicle Management – Heavy Vehicles, candidates must be successful in any two of the following written assessments.

GLH 800
TQT 1200

3905-12-043 Diesel Engines and Fuel Systems (written structured answer paper which lasts three hours)

3905-12-044 Heavy Vehicle Chassis Systems (written structured answer paper which lasts three hours)

3905-12-045 Heavy Vehicle Transmission Systems (written structured answer paper which lasts three hours)

3905-12-046 Electrical and Electronic Systems (written structured answer paper which lasts three hours)

And all of the following assessments.

3905-12-047 Service Reception (written structured answer paper which lasts three hours)

3905-12-048 Maths, Science and Electronics 3 (written structured answer paper which lasts three hours)

[3905-12-049] Vehicle Systems Practical

3905-12-065 Management Skills (written structured answer paper which lasts three hours)

3905-12-066 Business Systems (written structured answer paper which lasts three hours)

3905-12-067 Financial Systems (written structured answer paper which lasts three hours)

[3905-12-068] Vehicle Systems Practical

[3905-12-069] Project

(Total of seven written papers)

The practical assessments and the project are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us.

Although candidates do not need to have been successful at the certificate and diploma levels, they should at least have achieved skill levels represented in the earlier programmes before they prepare for the advanced diploma award.

We provide assessments in two ways.

a Fixed date

These are assessments which are carried out on dates and times we set. These assessments have no brackets around their numbers.

b Free date

These are assessments which are carried out at a college or other training establishment on a date or over a period which the college chooses. These assessments have brackets around their numbers.

In this programme the written assessments are fixed date; the practical assessments and the project are free date.

You must carry out assessments according to our International Directory of Examinations and Assessments. If there is any difference between information in this publication and the current directory, the Directory has the most up-to-date information.

Results and certification

Everyone who enters for our certificates, diplomas, and advanced diplomas receives a 'Notification of Candidate Results' giving details of how they performed.

If candidates successfully finish any assessment within this programme (for example, any one of the examination papers) they will receive a certificate of unit credit towards the certificate or diploma for which they are aiming. We grade course work assessments as pass or fail. We grade written assessments on the basis of fail, pass, credit or distinction. The certificate of unit credit will not mention assessments which they do not enter, which they failed or from which they were absent.

Each certificate or diploma clearly states what candidates need for full certification at the relevant level, allowing schools, colleges and employers to see whether they have met the full requirements.

If candidates successfully finish all the requirements for a full certificate or a diploma, they will automatically receive the appropriate certificate.

We will send the 'Notification of Candidate Results', certificates of unit credit, certificates, diplomas and advanced diplomas to the examination centre to be awarded to successful candidates. It is your responsibility to give the candidates the certificates. If candidates have a question about the results and certificates, they must contact you. You may then contact us if necessary.

We will also send you a results list showing how all candidates performed.

How to offer this programme

To offer this programme you must get approval from us. There are two categories of approval.

Subject approval
We give approval to offer a teaching course based on this syllabus.

Examination centre approval
We give approval to enter candidates for examinations.

To be approved by us to offer a teaching course you must send us the application form.

To enter candidates for examinations you must be approved by us as an examination centre. For this programme it is possible to act as a registered examination centre only, and accept external candidates. Approved examination centres must provide suitable facilities for taking examinations, secure places to keep the examination papers and materials, and may have an appointed visiting assessor to review practical work.

After we have received and accepted an application, we will send an approval letter confirming this. You can then send entries in at any time using the International Directory of Examinations and Assessments for guidance.

Please note that in this section we have provided an overview of centre approval procedures. Please refer to the current issue of 'Delivering International Qualifications – Centre Guide' for full details of each aspect of these procedures.

Additional information

Designing courses of study

Candidates for the various levels of award in Motor Vehicle Engineering will have come from different backgrounds and will have different employment and training experiences. We recommend the following:

- carry out an assessment of the candidates' achievements so you can see what learning they already have and decide the level of entry they will need; and
- consider what learning methods and places will best suit them.

When you assess a candidate's needs, you should design teaching programmes that consider:

- what, if any, previous education qualifications or training the candidate has, especially in the various general vocational education certificates we provide; and
- what, if any, previous practical experience the candidate has which is relevant to the aims of the programme and from which they may have learned the relevant skills and knowledge.

When you choose learning methods and places, you should consider the results of your assessments and whether the following are available.

- Open or distance learning material.
- Workplace learning that can be carried out on site or between you and a local workplace. This will allow the candidates access to specialised equipment and work experience.
- Working with other registered centres to share facilities.
- Opportunities for co-operative learning between candidates for different certificates who need to gain similar skills.

As long as the candidates meet the aims of this learning programme the structures of courses of study are up to you. So, it is possible to include extra topics that meet local needs.

You should avoid teaching theory alone. As far as possible the practical work should be closely related to work in the classroom so that candidates use their theory in a realistic work environment. You can use formal lectures in the classroom with appropriate exercises and demonstrations. Candidates should keep records of the practical work they do so they can refer to it at a later date.

We assume that you will include core skills, such as numeracy, communication, working with people, and organisation and planning throughout a teaching programme.

You may think computer literacy is an essential part of the course, but it is not a unit we test candidates on within the Motor Vehicle Engineering programme. You may design your own programme to cover this subject. We provide assessments outside the Motor Vehicle Engineering programme for Applied Information Technology.

Presentation format of units

Practical 'competences'
Each unit and module starts with a section on practical competences which shows the practical skills candidates must have.

At times we give more detail about important words in each 'competence statement'

Knowledge requirements
Immediately after the section on practical competences the unit tells you what knowledge is needed for that area. The knowledge needed is closely linked to the practical competences, so it is best to teach the two together so that the candidate appreciates the topic more.

Instructors to note

You must make sure candidates are well enough prepared before attempting any assessment. You can carry out resits for the practical assessments if you want.

A 'report' as defined in the 'practical competences' of the syllabus can be a presentation of the candidates' work. It should include one or more of the following.

Written: Lab report format.
Spoken: Audio (cassette) tape.
Graphic: Video tape, photography, drawings or sketches and computer generated graphics.

Defining the term Operating Principles within the Motor Vehicle Engineering Syllabus

At certificate level 'operating principles' means the following.

An ability to carry out basic functions such as put back fluid and gas levels, (in other words engine oil and tyre pressure).

Set line measurements (for example spark plug gaps and fourbelt tension).

Dismantle and fit parts (for example battery, wheels and alternator).

Use the above skills to carry out basic schedule servicing.

At diploma level 'operating principles' means the following.

An ability to carry out diagnostic and repair functions such as finding faults using basic techniques and putting faults right (for example, engine valve timing, worn and damaged pistons, clutch slip, worn brake disc and so on).

At advanced diploma level 'operating principles' means the following.

In the diagnostic techniques route –

An ability to carry out advanced diagnostic and repair functions such as find faults using specialised diagnostic techniques and equipment, and put them right, (for example, engine management fuel system and electronic control systems).

In the engineering route –

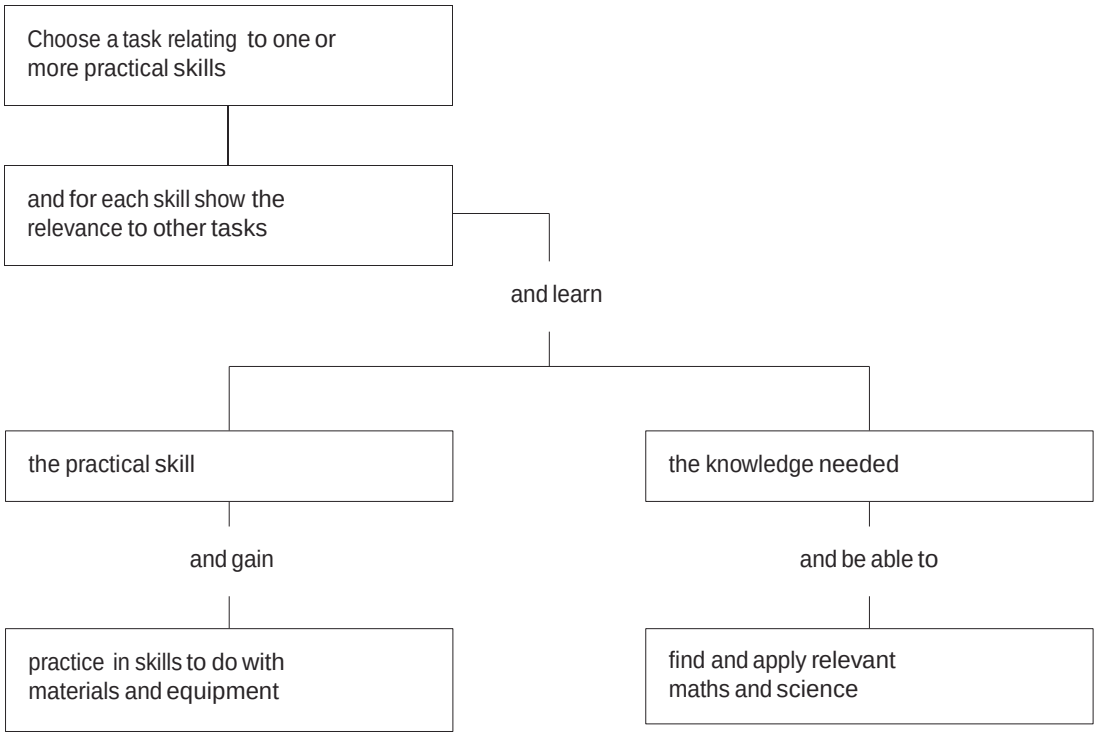
An ability to carry out advanced diagnostic and repair functions, research and analyse advanced mechtronic systems.

In the management route –

An ability to carry out advanced diagnostics and repair functions, carry out supervisory management practice, and research and analyse management systems.

The Learning Approach – guidance model

We suggest the following learning approach.



Special note to instructors and candidates

We designed the syllabus to make sure we included the latest technological advances in motor vehicle servicing and diagnostics techniques.

It is essential that you provide the vehicles, equipment and resources to allow candidates to achieve the practical skills shown.

You must make sure you include the appropriate level of safety, maths and science knowledge throughout the units.

Health and safety

You must emphasise the dangers associated with vehicle systems, fuels, and materials at all times, in particular FLUOROLASTOMEC (VETON) used in the manufacture of some brake seals, fuel pipes and possibly other rubber or plastic substitutes.

Fluorolastomec (Veton – trade name) becomes dangerous after it has been burnt. The material melts into a highly-corrosive acid, which if touched by bare skin cannot be removed – the only treatment is amputation. In this melted state, Fluorolastomec will stay dangerous for at least two years, only professional de-contamination will make it safe. So, you must take many safety precautions when working on burnt-out vehicles and their parts.

Progression routes and recognition

We consider the following programmes to be relevant preparation for this programme.

Background to Technology (3660)
Numeracy (3750)
Repair and Servicing of Motorcycles (3890)
Vehicle Body Competences (3980)
Applied Information Technology (7235)

We also consider the following Pitman Qualifications as relevant alongside this programme.

Book-keeping and Accounts
Computerised Accounts
Cost and Management Accounting
English for Speakers of Other Languages – intermediate level
English for Business Communication

A number of UK universities and other higher-education institutions will accept success at diploma or advanced diploma level of this programme for direct entry onto higher-level programmes. The decision to accept a candidate on to a degree programme, and the level of entry, is up to the institution. We provide details of organisations recognising achievement in this programme.

The following organisations approve this programme.

The Institute of The Motor Industry
Fanshaw
Brickenden
Hertfordshire
United Kingdom
SG13 8PQ.

The Institute of Road Transport Engineers
22 Greencoat Place
London
United Kingdom
SW1P 1PR.

The Society of Automotive Engineers
400 Commonwealth Drive
Warrendale
PA 15096-0001
USA.

Useful publications

We can provide a list of suggested text books covering specific areas of this programme. We may also have knowledge about other support materials. You should make sure you have the latest information. We will automatically send updated lists to centres we have approved to offer this programme.

Plain English Campaign's Crystal Mark only covers the Motor Vehicle Engineering regulations.

Syllabus
IVQ in Motor Vehicle Engineering 3905

Sections (Complex numbers)
01 Certificate in Motor Vehicle Systems
02 Technician Certificate in Motor Vehicle Systems
03 Diploma in Motor Vehicle Systems
04 Technician Diploma in Motor Vehicle Systems
05 Advanced Diploma in Diagnostic Techniques – Light Vehicles
06 Advanced Diploma in Diagnostic Techniques – Heavy Vehicles
07 Advanced Technician Diploma in Diagnostic Techniques – Light Vehicles
08 Advanced Technician Diploma in Diagnostic Techniques – Heavy Vehicles
09 Advanced Technician Diploma in Motor Vehicle Engineering – Light Vehicles
10 Advanced Technician Diploma in Motor Vehicle Engineering – Heavy Vehicles
11 Advanced Technician Diploma in Motor Vehicle Management – Light Vehicles
12 Advanced Technician Diploma in Motor Vehicle Management – Heavy Vehicles

Certificate/Technician Certificate in Motor Vehicle Systems (3905-01-001 to 3905-02-004)

Certificate in Motor Vehicle Systems

The units cover the following topic areas:

Note: The content within Modules 2d (Safety) and 2e (Associated studies) is included in the teaching of Unit 1, in addition to Unit 2.

Unit 1 – Engine Systems 1

• Petrol/Diesel Engines and Fuel Systems	Module 1a
• Ignition and Electrical Systems	Module 1b
• Cooling and Lubrication Systems	Module 1c
• Safety Module 2d	
• Associated Studies (Maths and Science)	Module 2e

Unit 2 – Chassis Systems 1

• Vehicle Systems	Module 2a
• Braking, Steering and Suspension Systems	Module 2b
• Gearbox and Transmission Systems	Module 2c
• Safety	Module 2d
• Associated Studies (Maths and Science)	Module 2e

Technician Certificate in Motor Vehicle Systems

Units 1 and 2 must be completed in full. Please note Modules 3a and 3b incorporate all topic areas covered in Associated Studies (Module 2e)

Unit 3 – Mathematics, Science and Communications

• Mathematics	Module 3a
• Science	Module 3b
• Communications	Module 3c

Unit 1 Engine Systems 1
Petrol/Diesel Engines and Fuel Systems Module (a)

Practical competences

The candidate must be able to do the following:

1.1a Collect information identifying the engines used in motor vehicles.

1.2a Inspect vehicle systems and prepare a report identifying typical petrol/diesel engine components and their functions.

1.3a Collect information identifying the operating principles of petrol/diesel engines.

1.4a Inspect vehicle systems and prepare a report identifying petrol/diesel fuel systems in standard forms and locations.

1.5a Prepare a report identifying the main petrol/diesel fuel system components and their functions.

1.6a Collect information identifying the operating principles of petrol/diesel fuel systems.

1.7a Carry out under supervision routine vehicle checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools.

1.8a Use safety, mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

1.1a Identify motor vehicle engines in a variety of forms and locations.
Types: petrol four stroke, diesel four stroke, rotary (Wankel).
Aspirated: natural, turbocharged, supercharged.
Cylinder layout: single, multi, in-line, 'V', horizontally opposed, rotary (Wankel).
Locations: front, rear, mid, transverse, longitudinal, underslung, engine mountings.

1.2a Identify main engine components and functions.
Components: cylinder heads, cylinder blocks, liners (wet/dry), manifolds, valve operating mechanisms, timing gears, camshafts, pistons, pushrods, connecting rods, crankshafts, flywheels, machined faces, securing devices, journals/bearings, seals.
Terms: top dead centre (tdc), bottom dead centre (bdc), bore, stroke, capacity, clearance volume, swept volume, compression ratio.

1.3a Identify the operating principles of petrol/diesel engines.
Convert chemical (heat) energy to mechanical energy/produce power and torque at the flywheel.
Operating cycles of engines in 1.1a above.

1.4a Identify vehicle fuel systems in standard forms and locations.
Petrol: carburettor systems, single/multi point petrol injection systems.
Diesel: in-line fuel injection pump, rotary fuel injection pump.

1.5a Identify main petrol/diesel fuel system components and their functions.
Petrol: fuel tanks, filler cap/security, venting, level sensor, mounting, lines/filters, carburettors, petrol injection units, fuel lift pumps (mechanical/electrical), control linkages/cables, air filters, fuel (octane rating, leaded, unleaded).
Diesel: fuel tanks, low pressure lines, pre-filters/sedimentors, agglomerators, in-line/rotary fuel-injection pumps, fuel lift pumps, high pressure fuel lines, fuel injectors, priming/ bleed valves (manual/automatic), diesel fuel.

1.6a Identify the operational principles of petrol/diesel fuel systems.
Store (fuel tank)/filter/pump/meter fuel for various engine requirements.

1.7a Identify routine vehicle checks and basic scheduled servicing as recommended by the manufacturer.
Oil levels, brake hydraulic fluid levels, belt tension (alternator, water pump), linear measurement (spark plugs, contact breaker), filters (oil, air), remove/refit exchange (battery, hoses, belts, alternator), radiator coolant levels/ratio.

Unit 1 Engine Systems 1
Ignition and Electrical Systems Module (b)

Practical competences

The candidate must be able to do the following:

1.1b Collect information identifying spark ignition systems.

1.2b Inspect vehicle systems and prepare a report identifying the main ignition system components and their functions.

1.3b Prepare a report identifying the basic operating principles of contact breaker and breakerless types of main ignition systems.

1.4b Inspect vehicle systems and prepare a report identifying electrical systems and components.

1.5b Prepare a report identifying operational principles and functions of electrical system components.

1.6b Carry out under supervision routine vehicle checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools.

1.7b Use safety, mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

1.1b Identify spark ignition systems.
Contact breaker, contact breakerless.

1.2b Identify the main ignition system components and functions.
Contact breaker/breakerless systems: ignition switch, ignition coil, ballast resistor/resistance cable, distributor cap, rotor arm, vacuum advance/retard unit, centrifugal advance unit, contact breaker assembly, high tension leads/connectors, suppression, spark plugs (construction, heat ranges, size).

1.3b Identify spark ignition system operational principles.
Method of initiating combustion at the correct time in the engine cycle, vary the timing of the spark in accordance with the engine speed/load.

1.4b Identify electrical systems and components.
Generation, storage, starting, motor/drive assemblies, lights, heating elements, switches/relays, conductors/terminations, circuit protection devices, driver information circuits.

1.5b Identify operational principles and functions of electrical system components.
Circuits: complete, earth/unit connections.
Generator: basic type of alternator with voltage regulator only.
Battery: lead acid, low/no maintenance.
Components: motors, drives for starter, wipers, pumps, accessories, lamp bulbs, bulb holders, housing lenses, screen heating elements, switches, relays (intermittent/continuous), time delays, direction indicator flasher, central locking, voltage stabilisers, warning lamps.
Cables: variations in size, rating, colour coding, classification systems, types of loom harness.
Terminations: ratings, common crimped, clamped, soldered, cable connectors.
Fuses: glass encased, ceramic, cartridge, fusible link, reset overloads.
Gauges/instruments: temperature, pressure, speed, fluid level.
Electronics: safety, comfort, reliability.
Sensors: pressure, temperature, fluid levels, wear, rotation, position, electronic control units.
Ignition switch: barrel/lock assembly.
Horns: high frequency, windtone, air.
In-car entertainment: suppression devices, aerials (manual, electric, screen type, single, twin).

1.6b Identify routine vehicle checks and basic scheduled servicing as recommended by the vehicle manufacturer.

1.7b The use of safety, mathematics and science is applied to the above Knowledge Requirements.

Unit 1 Engine Systems 1
Cooling and Lubrication Systems Module (c)

Practical competences

The candidate must be able to do the following:

1.1c Collect information identifying cooling/heating systems.

1.2c Inspect vehicle systems and prepare a report identifying the main cooling/heating system components and their function.

1.3c Collect information identifying the operating principles of cooling/heating systems.

1.4c Collect information identifying engine lubrication systems.

1.5c Inspect vehicle systems and prepare a report identifying the main engine lubrication system components and their function.

1.6c Collect information identifying the operating principles of engine lubrication systems.

1.7c Carry out under supervision routine vehicle service checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools.

1.8c Use safety, mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

1.1c Identify cooling/heating systems.
Air: fins, ram/forced air flow, fan, ducting.
Liquid: impeller assisted, semi-sealed, fully sealed.

1.2c Identify the main cooling/heating system components and their function.
Air cooling fans, cowlings/ducts, drive belts, shutters/control systems, radiators, heater systems, expansion tanks, thermostats, pressure caps, impellers/pumps, hoses, securing devices (hose clips, sealants), liquid coolant, anti-freeze/inhibitors, temperature warning indicators.

1.3c Identify the operational principles of cooling/heating systems.
Operating principles: correct temperature, thermal efficiency, time.
Heat transfer: conduction, convection, radiation, air flow (ram/forced), radiators, air vents, fins, deflectors, temperature control.

1.4c Identify engine lubrication systems.
Wet sump, dry sump, total loss.

1.5c Identify the main engine lubrication system components and their function.
Oil pumps, pressure relief valves, main oil filters, pump inlet filters, coolers, ventilation/breathing valves, pipes, hoses, filler/oil level indicators, securing devices (hose clips, sealants, gaskets).
Lubricant oils: viscosity, index, classification.

1.6c Identify the operational principles of engine lubrication systems.
Reduction of frictional forces, cooling effect, cleaning effect, corrosion resistance, noise reduction.

1.7c Identify routine vehicle checks and basic scheduled servicing as recommended by the vehicle manufacturer.

Test specification for written paper Engine Systems 1 (3905-01-001 and 3905-02-001)

This is a written multiple choice examination paper, lasting 1½ hours and containing 60 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
1a Petrol/Diesel Engines and Fuel Systems	30
1b Ignition and Electrical/Electronic Systems	30
1c Cooling and Lubrication Systems	30
2d Safety	5
2e Associated Studies (Mathematics and Science)	5

Unit 2 Chassis Systems 1
Vehicle Systems Module (a)

Practical competences

The candidate must be able to do the following:

2.1a Collect information identifying body types and their functional requirements.

2.2a Prepare a report identifying engine positions/drives, vehicle body components and vehicle systems.

2.3a Inspect vehicle systems to identify driver controls and information displays.

2.4a Prepare a report identifying the reasons for carrying out regular or special vehicle inspections and adjustments.

2.5a Inspect vehicle systems and prepare a report identifying the types of scheduled servicing carried out on road vehicles.

2.6a Carry out under supervision routine vehicle checks and basic scheduled servicing as recommended by the vehicle manufacturer, using general/specific tools.

2.7a Use safety, mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

2.1a Identify vehicle body types and their functional requirements.

Body types.

Construction: monocoque/unitary (one piece load bearing frame/unit), separate/composite (chassis/body).

Light vehicle: two door saloon, four door saloon, three door hatchback, five door hatchback, three door estate, five door estate, two door coupé, three door hatchback coupé and other combinations.

Commercial: rigid, articulated, pick-up/utility, flat platform, drop side platform, box van, Luton van, integral (walk-through), curtainsider, tipper (front, centre, side ram positions), tanker, temperature controlled (refrigerated).

Public Passenger Vehicles (PPV): mini bus, omnibus/coach (single deck, double deck).

Special Purpose Vehicles (SPV): ambulance, breakdown/towing, fire tender.

Functional requirements.

Accommodation: driver, passenger/s, cargo.

Cargo: rigid/free flowing (liquid, loose).

Support mountings: engine, exhaust, transmission, suspension, steering, wheels/axles, electrical units, auxiliary bodies/attachments (eg. fuel tanks), seat belts/restraints.

Access: repairability of units.

Protection: vehicle occupants, cargo, vehicle units.

Aesthetic: vehicle manufacturers' design.

Aerodynamic: body styles, design, chassis (rigid, articulated).

2.2a Identify light and heavy vehicle engine positions/drives, vehicle body components and vehicle systems.
Engine positions: forward, centre, rear, transverse, longitudinal.
Drives: front wheel, rear wheel, four wheel.
Driver position: left hand, right hand.
Commercial vehicle cab positions: forward, normal.
Chassis: cruciform (cross-members within chassis), ladder (with/without outriggers), rigid, articulated (separate tractor unit/trailer body), sub-frame (tipper/demountable body).
Sub-frames: engine, transmission, suspension.
Cabs: rigid, articulated, tilt (forward), half-cab (off road operations eg. mining/quarry work).
Load areas: platform (flat), drop side (single) platform, open box (fixed sides), box van (enclosed box).
Door closures: hinged, sliding, hatchback, open topped (cabriolet/sports convertible), curtains (commercial vehicle).
Framework: structural/non structural (light/commercial vehicle), jacking points.
Panelwork: exterior/interior (fixed/detachable), mouldings.
Glass: drop, fixed, hinged, sliding.
Interior: seats, restraints (seat belts/airbags/belt tensioners), carpets, headlinings, trim, covers, mouldings.
Engine: petrol, diesel, electrical, natural gas, hybrid (eg. diesel/electrical), power for propulsion, ancillary systems, degree of retardation.
Exhaust: removal of gases, noise reduction, layout.
Cooling: to dissipate heat from combustion process by air/liquid (water, oil).
Fuel: storage (petrol tank single/double), meter (fuel pump) supply for combustion.
Transmission: transfer mechanical energy from engine to road wheels (clutch, gearbox, final drive, drive shafts).
Suspension (minimise ride irregularities): vehicle, driver, passenger, cargo (safe carriage, security). **Steering:** driver controls, vehicle direction.
Braking: driver controls, vehicle motion, retardation (reducing vehicle speed).
Electrical: electrical energy for vehicle's starting, ignition, lighting, ancillary circuits/equipment (eg. heater, radio/in-car entertainment).

2.3a Identify driver controls and information systems.
Controls: steering wheel, accelerator, brake/clutch pedals, hand-brake lever (floor/dash mounted), gear lever; (automatic/manual) floor, dash, steering column mounted.
Lamps: head, side, tail, indicator, fog, hazard, reverse.
Screen wash/wipe: front/rear, intermittent/variable speed, windscreen washer fluid levels.
Door closures: doors, bonnet, boot, fuel filler, hatchback, tailgate, sunroof, locks, handles, tilt cab locks/releases.
Ventilation: air conditioning, heater, screen heater.
Information systems: speedometer, tachometer (revolution counter), tachograph, fuel gauge, engine radiator coolant/temperature level, brake wear/fluid level, engine oil/fuel levels, battery charging warning, bulb failure.

2.4a Identify the reasons for carrying out regular or special vehicle inspections and adjustments.
Safe vehicle condition, manufacturers' specification, legislation, reliability, efficiency, prolong vehicle unit life, corrosion resistance, locate non-routine work, sequence/job planning.

2.5a Identify the types of scheduled servicing carried out on road vehicles.
PDI (pre-delivery inspection), first service, distance based (miles/kilometres), time based (months), computer controlled (on-board vehicle computer), safety checks, warranty, safety/legislation.

2.6a Identify routine vehicle checks and basic scheduled servicing as recommended by the vehicle manufacturer.
Oil levels (engine, transmission), hydraulic fluid levels (brakes, power steering), belt tension (alternator, water pump), linear measurement (spark plugs, contact breaker), filters (oil, air), remove/refit/exchange (battery, wheels, hoses, belts, alternator), windscreen washer levels, radiator coolant levels/ratio, tyre pressure/condition (wear, tread pattern), vehicle lighting, valeting.

Unit 2 Chassis Systems 1
Braking, Steering and Suspension Systems Module (b)

Practical Competences

The candidate must be able to do the following:

2.1b Collect information identifying braking systems.

2.2b Inspect vehicle systems and prepare a report identifying the main components of braking systems and their functions.

2.3b Prepare a report identifying the operational principles of braking systems.

2.4b Prepare a report identifying the health hazards associated with braking systems.

2.5b Collect information identifying steering systems.

2.6b Inspect vehicle systems and prepare a report identifying the main components of steering systems and their functions.

2.7b Prepare a report identifying the operating principles of steering systems.

2.8b Collect information identifying suspension systems and wheels/tyres.

2.9b Inspect vehicle systems and prepare a report identifying the main components of suspension systems, wheels/tyres and their functions.

2.10b Prepare a report identifying the operational principles of suspension systems and wheels/tyres.

2.11b Carry out under supervision routine service checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools.

2.12b Use safety, mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

2.1b Identify braking systems.
Systems: drum brakes, disc brakes, parking brakes, hydraulic, pneumatic.
Functions: reduce speed (convert kinetic energy to heat energy), prevent movement when stationary.

2.2b Identify the main components of braking systems and their functions.
Master cylinder, wheel cylinders, pipes/flexible hoses, brake pedal, limiting valves, stop lamp switches, indicating circuits (wear, fluid level, pressure).
Disc brakes: callipers, brake discs, brake pads (rate of wear).
Drum brakes: brake drums, brake shoes (leading, trailing, twin leading, self-servo action, rate of wear).
Hand brake: front/rear, operating mechanisms.
Adjusters: manual, automatic.
Brake fluid: need for periodic changing, main properties, effects of air in system, effects of heat on brake fluid.

2.3b Identify the operational principles of braking systems.
Use of friction to slow/stop/hold the vehicle.
Use of levers/rods/cables/hydraulics and engine to transmit/supplement drivers' effort.
Means of compensating/equalising the braking force.
Use of split/dual systems.
Brake heat dissipation: conduction, convection, radiation, brake fade, brake fluid.

2.4b Identify the health hazards associated with braking systems.
Lining materials (asbestos dust), brake fluid, handling components.

2.5b Identify steering systems.
Systems: single track rod type (beam axle application), divided track rod type (independent front suspension – IFS).
Functions: directional control, minimum effort, provide a degree of feel, reduce shock loadings.

2.6b Identify the main components of steering systems and their functions.
Rack and pinion, steering boxes/idlers, steering joints, swivel pin assemblies, drop arm, drag link, track rods/steering arms, front hubs, bearings/seals), hub nut locking devices, lubrication, sealing devices.

2.7b Identify the operating principles of steering systems.
True rolling motion (Ackermann principle): correct wheel alignment, toe-in/toe out.
Centre point steering: camber, castor/swivel (king) pin inclination.

2.8b Identify suspension systems and wheels/tyres.
Suspension.
Systems: independent, non-independent, beam axle, live axle, strut (Macpherson strut), wishbone, trailing arm/semi trailing arm, swinging arm, torsion beam, De-Dion.
Function: driver/occupants comfort/safety, reduce strain on cargo/vehicle components.
Wheels and tyres.
Function: load carrying capacity, traction.

2.9b Identify the main components of suspension systems, wheels/tyres and their functions.
Suspension.
Components: suspension arms/links, springs (leaf, coil, torsion, rubber, gas with mechanical/hydraulic operation), suspension dampers, telescopic/lever arm types, swivel pins/Macpherson struts, swivel pins/ball joints, bushes, location rods/linkages, anti-roll bars, sub-frame assemblies, leaf spring shackles/locating devices, axles, hubs/struts acting as suspension members, chassis mounting points, bound/rebound stops.
Wheels and tyres.
Components: tubed tyres, tubeless tyres, cross-ply tyres, radial ply tyres, bias belt tyres, remould/re-tread/re-cut tyres, steel/spoke/cast alloy wheels, well base wheels, divided rim wheels, detachable flange wheels, 'run-flat' assemblies, spacesaver assemblies, wheel-nuts.

2.10b Identify the operating principles of suspension systems and wheels/tyres.
Suspension systems: independent, non-independent, minimising the effect of road surface irregularities on passengers/vehicle/load, maintaining wheel contact with the road, transmitting driving/braking torque, locating the axle, supporting the sprung weight, minimising unsprung weight, absorbing torque reaction.
Wheels and tyres: transmit drive to the road surface, withstand forces during braking/cornering, support the weight of the vehicle, absorb shock loads, provide minimum rolling resistance, minimise unsprung weight, maintain grip in wet conditions, permit removal/refitting, allow passage of air for brake cooling, appearance, run true, minimise air loss, materials for wheels, fastening device, left/right hand threads for securing wheels.
Tyre: high performance/asymmetric/low profile, tread patterns for various climatic conditions/operational requirements, relationship between tread rating/load-carrying capacity, types, sizes, speed ratings, tyre symbols, aspect ratio, materials used in the construction, wheel balancing, requirement for/use of tread-depth indicators.

2.11b Identify routine vehicle checks and basic scheduled servicing as recommended by the vehicle manufacturer.

Unit 2 Chassis Systems 1
Gearbox and Transmission Systems Module (c)

Practical competences

The candidate must be able to do the following:

2.1c Collect information identifying gearbox systems.

2.2c Inspect vehicle systems and prepare a report identifying the main gearbox components and their functions.

2.3c Prepare a report identifying the operational principles of gearboxes.

2.4c Collect information identifying clutch systems.

2.5c Inspect vehicle systems and prepare a report identifying clutch components and their functions.

2.6c Prepare a report identifying the operational principles of clutch systems.

2.7c Collect information identifying vehicle drives, drive shafts and hubs.

2.8c Inspect vehicle systems and prepare a report identifying the main components of propeller shafts, drive shafts/ hubs and their functions.

2.9c Prepare a report identifying the operational principles of propeller shafts, drive shafts and hubs.

2.10c Prepare a report identifying the reasons for carrying out regular/special inspections and adjustments of propeller shafts, drive shafts and hubs.

2.11c Collect information identifying final drive and differential systems.

2.12c Inspect vehicle systems and prepare a report identifying the components of final drive/ differential systems and their functions.

2.13c Prepare a report identifying the operational principles of final drive and differential systems.

2.14c Carry out under supervision routine service checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools.

2.15c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

2.1c Identify gearbox systems.
Types: manual/automatic/semi-automatic/constantly variable transmission.
Locations: front engine front wheel drive, front engine rear wheel drive, rear engine rear wheel drive, mid-engine rear wheel drive.

2.2c Identify the main gearbox components for four/five speed arrangements and their functions.
Gear change mechanisms: direct, indirect. **Components:** gearcases, gears, synchromesh, shafts, bearings, lubricants, securing devices (sealants, gaskets, fasteners), mechanically operated speedometer drive arrangements, reverse light switches, gearbox mountings.

2.3c Identify the operational principles of gearboxes.
Types: four speed gearbox (synchromesh), five speed gearbox (synchromesh).
Principles: torque multiplication using gears of different size, utilise engine torque characteristics effectively, provide reverse/neutral.

2.4c Identify clutch systems.
Clutch operating mechanisms: cable, hydraulic. **Clutch assembly:** single plate (coil spring), single plate (diaphragm spring), multi-plate, sliding hub (dog clutch).

2.5c Identify clutch components and their functions.
Clutch cables, self-adjusting mechanisms, master/slave cylinders, pressure plate/cover, centre plates, release bearings, first motion shaft front support bearings (spigot), release bearing carriers, fluid, fluid/hydraulic pipes.

2.6c Identify the operational principles of clutch systems.
Transmitting torque (turning moment), gradual drive take-up, neutral gear (at park), drive path (flywheel/ gearbox input).

2.7c Identify vehicle drives, drive shafts and hubs.
Front engine front wheel drive, front engine rear wheel drive, rear engine rear wheel drive.
Transmit drive from gearbox to final drive unit, accommodate angular deflection of drive, allow for change of distance between components, locate road wheels.

2.8c Identify the main components of propeller shafts, drive shafts/hubs and their functions.
Front wheel drive: hub arrangements, drive flange locations.
Rear wheel drive: semi-floating, three-quarter floating, fully floating, forces acting on shafts.

2.9c Identify the operational principles of propeller shafts, drive shafts and hubs.
Constant velocity (CV) joints.
Principles: type of friction in the joint (rolling), tubular propeller shafts, centre bearing on propeller shafts, type of friction in the bearing (rolling), associated problem of speed variation with angular displacement.
Universal joints.
Types: Hooke, Layrub, doughnut.
Principles: sliding joint on a propeller shaft, correct alignment of universal joints in series on a propeller shaft by a sliding joint, type of friction encountered in such a joint (sliding friction).

2.10c Identify the reasons for carrying out regular/special inspections and adjustments of propeller shafts, drive shafts and hubs.
Manufacturers' tolerances in maintaining propeller shafts, drive shafts and hubs.
Safety, legislation, efficiency, increase service life, prevent/arrest ingress of dirt to drive shaft boots/seals.

2.11c Identify final drive and differential systems.
Rear mounted live axle (including type of axle), rear mounted trans-axle, front wheel drive, chassis mountings.

2.12c Identify the components of final drive/differential systems and their functions.
Components: gears, bearings, casings, lubrication/ seals/gaskets, securing devices, chassis mountings.
Gear types: straight bevel, spiral bevel, hypoid spiral bevel, worm/wheel.

2.13c Identify the operational principles of final drive and differential systems.
Final drive, differential unit (torque equaliser), torque reaction on a live rear axle, driving/braking conditions, pinion location in relation to crown wheel, 'axial thrust' for spiral bevel, worm/wheel gear ratios.

2.14c Identify routine vehicle checks and basic scheduled servicing as recommended by the vehicle manufacturer.

Unit 2 Chassis Systems 1
Safety Module (d)

Safety requirements must be incorporated throughout each unit of the syllabus. It will be integrated throughout the assessments.

Practical competences

The candidate must be able to do the following:

2.1d Carry out simple first aid tasks.

2.2d Extinguish different kinds of fires using the appropriate equipment and procedures.

2.3d Carry out a simple workshop safety hazard analysis.

2.4d Wear appropriate protective clothing.

2.5d Observe all workshop safety procedures.

2.6d Recognise hazards and report to the appropriate authority.

2.7d Use safe and fully maintained equipment.

2.8d Comply with manufacturers' instructions in the operation and cleaning of equipment and machinery.

2.9d Safety store, use and dispose of dangerous substances.

Knowledge requirements

The instructor must ensure the candidate is able to:

2.1d Identify causes of accidents and accident prevention.
Human: carelessness, improper behaviour/dress, lack of training, supervision, experience, fatigue, drug-taking, alcohol excess.
Environmental: unguarded or faulty machinery/tools, inadequate ventilation, untidy/dirty/overcrowded/badly-lit workplace.
Eliminate the hazard: replace the hazard with something less dangerous, guard the hazard, personal protection, safety education/publicity.

2.2d Identify the safety procedures to prevent injury to self and colleagues.
Personal hygiene, skin protection/care: care of eyes, use of eye/face protectors, use of respirators/all personal protective equipment, dangers of hair/loose clothing getting caught in machinery/avoiding such dangers, advantages/disadvantages/use of protective clothing, use of safety guards, screens/fences.
Working with: flammable liquids/gases/harmful substances (eg. carcinogenic; cancer producing, Fluorolastomec/Veton), vehicle electrical systems, diesel/petrol fuel systems, cooling systems, wheels/tyres, running/manoeuvring vehicles especially in confined spaces, unsafe or defective vehicle, hoisting/lifting/jacking up vehicles, using axle stands, using garage machinery/equipment for drilling/grinding/providing compressed air/welding.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Effects/implications of injury: on injured party, management, immediate family, social/domestic implications, loss of income. Using hand/power tools, dispensing petrol, storing, stacking, binning, issuing or handling spare parts, disposing of waste material, disposing of hazardous/toxic/dangerous materials, use of solvent based materials reduced to minimum, gaseous emissions from solvent based materials/paint kept to minimum, high solids waste material disposed of in accordance with the regulations.
Fire prevention: combustion/extinction, cause, spread, prevention.
Fire procedures: drills, fire fighting equipment for different types of fires, protection, legislation.
Observance of safe practices: be alert, maintain personal hygiene, protect yourself/other people, emergency procedures, report all hazards, positive personal attitudes to safety.

2.3d Identify the employers' responsibilities towards the management of safety in the workplace.
Safe place of work: safe access/exit, safe plant/equipment (including safety guards, screens, fences, working notices), safe system of work, safe working methods, provision of personal protective equipment. **Safe working environment:** working temperature, fume/dust control, provision of washing, sanitation/first aid facilities.
Handling/storing/transporting goods: correct siting, storing/identification of dangerous materials, mechanical handling (aids for moving heavy goods).
Reporting of accidents: accident register, information, instruction, training/supervision of employees, safety policy (subject to regular reviews).
Employee responsibilities: maintenance of safety, health and safety of people, misuse/ interference with health and safety equipment.
Legal requirements: no person may work with any substance, operate equipment/machine unless trained and authorised to do so, environmental protection regulations/legislation, disposal of waste materials.

2.4d Identifying safety precautions when using electrical equipment.
Hazards arising from the use of electrical equipment: legislation, standards and codes of practice.
General safety rules: inspection of cables, leads/plugs, earthing, portable equipment, reduced voltage equipment, electric shock treatment, first aid, isolating the casualty, resuscitation methods.

Unit 2 Chassis Systems 1
Associated Studies Module (e)

Practical competences

The practical competences are incorporated into the modules for this unit.

Knowledge requirements

The instructor must ensure the candidate is able to:

2.1e Identify calculations involving the four arithmetic operations.
Definitions: integers, vulgar/decimal fractions.
Arithmetic operations: addition, subtraction, multiplication, division.
Applied to: positive/negative whole numbers (using rules relating to directed numbers), vulgar/decimal fractions, mixed numbers.
Precedence rules: sequence of calculations involving brackets.

2.2e Identify calculations involving fractions, ratios, percentages and proportions.
Definitions: ratio, percentage, proportion.
Convert: fraction to ratio/percentage/proportion, ratio/percentage/proportion to fraction.
Proportion: two quantities in direct proportion to each other.
Percentage: one quantity as a percentage of another.
Answers: standard form, preferred standard form.

2.3e Identify and deduce estimated solutions to arithmetic calculations.
Calculations: applied to 2.1e and 2.2e above.
Results: express as given number of significant figures/decimal places.

2.4e Identify calculations involving the use of an electronic calculator/computer.
Integers/decimal fractions: multiply, divide, square, square root, reciprocal.

2.5e Identify and deduce the Laws of Indices.
Definition: Laws of Indices, base (10), index.
Calculations: multiply powers of the same number.

2.6e Identify calculations involving circles and cylinders.
Definitions: circle, radius, diameter, circumference.
Relationship: radius/diameter/circumference of a circle.
Calculations.
Circles: radius, diameter, circumference, area.
Cylinders: surface area, volume.

2.7e Identify calculations involving the fundamental and derived SI units of measurement.
Units: length, mass, time, velocity, acceleration, force, pressure, torque, work, energy, power.
Prefixes: mega (M), kilo (k), milli (m), micro (m) , nano (n), pico (p).
Calculations: length, area, volume.

2.8e Identify calculations involving mass, force and moments.
Definition: mass, force, moment, static equilibrium.
Vector diagrams: resultant of two co-planar forces (piston loading).
Moments: forces about a point, simple beams.

2.9e Identify calculations involving distance, time, velocity and acceleration.
Definitions: displacement, distance, speed, velocity, acceleration.
Quantities: vector, scalar.
Calculations: equations of linear motion for constant linear acceleration.
Graphs: distance/time (interpreting slope as speed), velocity/time (interpreting slope as acceleration, area under graph as distance moved).

2.10e Identify calculations involving energy, work and power.
Laws: conservation of energy.
Definitions: energy, work, power.
Potential energy: energy possessed by a body by virtue of its position.
Kinetic energy: energy possessed by a body by virtue of its motion.
Calculations: work done (force/distance graphs), simple problems involving work/ energy/power/kinetic energy/potential energy.

2.11e Identify calculations involving temperature and heat.
Definitions: conduction, convection, radiation, temperature/heat (difference).
Celsius scale: fixed points (-2738C, 08C, 1008C).
Kelvin scale: absolute temperature, relationship to Celsius scale.
Change of state: application/removal of heat (solids, liquids, gasses).
Calculations: temperature change.

2.12e Identify calculations involving friction and lubrication.
Laws: friction.
Definitions: static/dynamic friction (difference).
Calculations: coefficient of friction.

2.13e Identify calculations involving machines.
Definitions: machine as a device for changing magnitude/line of action of a force, force ratio (mechanical advantage), movement ratio (velocity ratio), efficiency.
Gears: ratio of a gearbox, size of gear wheels, driver/driven, simple/compound ratios, direction of rotation. **Calculations:** simple machines (screw jacks, levers), gear ratios.

2.14e Identify calculations involving electricity.
Definitions: current (flow of electrons, amperes), conductors, insulators, resistance.
Resistance: relationship between resistance of conductor and its length/cross-sectional area/specific material resistance.
Circuits: series, parallel, circuit diagrams (resistors series/parallel).
Measurement: voltmeter, ammeter.
Current flow: complete circuit, potential difference between two points, total flow same in all parts of the circuit.
Series circuits: current flow constant at all points, sum of voltages (potential difference, pd) is equal to applied voltage (electro-motive force, emf).
Ohm's law: function of current (I)/potential difference (V)/resistance (R), $V = IR$.
Power: product of potential difference/current (direct current circuits), $P = I2R$.
Calculations: Ohm's law, formulae for equivalent resistance of resistors in series/parallel, current/voltage in series/parallel.

Test specification for written paper Chassis Systems 1 (3905-01-002 and 3905-02-002)

This is a written multiple choice examination paper, lasting 1½ hours and containing 60 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
2a Vehicle Systems	30
2b Braking, Steering and Suspension Systems	30
2c Gearbox and Transmission Systems	30
2d Safety	5
2e Associated Studies (Mathematics and Science)	5

Unit 3 Mathematics, Science and Communications
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

3.1a Perform calculations involving the four arithmetic operations.

3.2a Perform calculations involving fractions, ratios, percentages and proportions.

3.3a Give estimated solutions to arithmetic calculations.

3.4a Perform calculations involving the use of an electronic calculator.

3.5a Use the Laws of Indices.

3.6a Use algebraic operations.

3.7a Apply geometric and trigonometric operations to plane figures.

3.8a Apply geometric operations to circles and cylinders.

Knowledge requirements

The instructor must ensure the candidate is able to:

3.1a Identify calculations involving the four arithmetic operations.
Definitions: integers, vulgar/decimal fractions.
Arithmetic operations: addition, subtraction, multiplication, division.
Applied to: integers, vulgar/decimal fractions, positive/negative whole numbers (using rules relating to directed numbers), mixed numbers.
Precedence rules: sequence of calculations involving brackets.

3.2a Identify calculations involving fractions, ratios, percentages and proportions.
Definitions: ratio, percentage, proportion.
Convert: fraction to ratio/percentage/proportion, ratio/percentage/proportion to fraction.
Divide: various amounts into given ratios.
Proportion: two quantities in direct proportion to each other, two quantities in inverse proportion to each other.
Percentage: one quantity as a percentage of another.
Answers: standard form, preferred standard form.

3.3a Identify estimated solutions to arithmetic calculations.
Calculations: applied to 3.1a and 3.2a above.
Results: express as given number of significant figures/given number of decimal places.

3.4a Identify calculations involving the use of an electronic calculator.
Integers/decimal fractions: multiply, divide, square, square root, reciprocal.

3.5a Identify the Laws of Indices.
Definition: Laws of Indices, base, index. **Calculations:** multiply powers of the same number, raising power of a number to another power, dividing powers of the same number, negative indices, fractional indices, zero index.

3.6a Identify algebraic operations.
Definitions: expression, equation, identity, sum, difference, product, quotient, polynomial, linear/simultaneous equations.
Rules: deducing sum/difference/product/quotient of algebraic symbols/terms.
Laws of indices: applied to algebraic symbols.
Equations: represent quantities by symbols/translate phrases involving associated quantities into algebraic expressions, transpose simple equations.
Calculations: balance of equations whilst applying arithmetic operations, linear equations with one unknown, simultaneous equations with two unknowns.

3.7a Identify geometric and trigonometric operations to plane figures.
Definitions: Theorem of Pythagoras, sine/cosine/tangent (right angled triangles), angle (as a measure of rotation), parallelogram, polygons.
Plane figures: square, rectangle, triangle (acute-angled, right angled, obtuse-angled, equilateral, isosceles, scalene) parallelogram, polygons.
Angles: right angle, oblique (acute, obtuse), complementary, angle sum of a triangle.

Calculations.
Perimeter/area/angles/diagonals: square, rectangle, triangle, parallelogram, polygon.
Right angled triangles: Theorem of Pythagoras applied to any third side, angle/length of side (using sine/cosine/tangent).
Triangles: construct from given information (three sides, two sides/included angle, one side/two angles).

3.8a Identify geometric operations to circles and cylinders.
Definitions: radius, diameter, circumference, chord, tangent, sector, segment, arc, radian.
Relationship: radius/diameter/circumference of a circle, angle properties of a circle, angle at centre of circle to angle at circumference.
Tangent: angle between tangent and radius to tangent is a right angle.

Calculations.
Circles: radius, diameter, circumference, area.
Cylinders: surface area, volume.
Angles: degrees/minutes/seconds to radians, radians to degrees/minutes/seconds, angular rotation (multiples of radians), arcs/angles (measured in radians).

Unit 3 Mathematics, Science and Communications
Science Module (b)

Practical competences

The candidate must be able to do the following:

3.1b Perform calculations involving the fundamental and derived SI units of measurement.

3.2b Perform calculations involving mass, force and moments.

3.3b Perform calculations involving distance, time, velocity and acceleration.

3.4b Perform calculations involving energy, work and power.

3.5b Perform calculations involving temperature and heat.

3.6b Perform calculations involving friction and lubrication.

3.7b Perform calculations involving machines.

3.8b Perform calculations involving engine power.

3.9b Perform calculations involving electricity.

Knowledge requirements

The instructor must ensure the candidate is able to:

3.1b Identify calculations involving the fundamental and derived metric units of measurement.
Units: SI system, length, mass, time, velocity, acceleration, force, pressure, torque, work, energy, power.
Prefixes: mega (M), kilo (k), milli (m), micro (m) , nano (n), pico (p).
Calculations: length, area, volume.

3.2b Identify calculations involving mass, force and moments.
Definition: mass, force, moment, static equilibrium.
Relationship: mass/force/acceleration, mass/weight (gravitational pull).
Vector diagrams: resultant of two co-planar forces (piston loading).
Polygon of forces: resultant/equilibrium of three/more forces.
Moments: forces about a point, simple beams.

3.3b Identify calculations involving distance, time, velocity and acceleration.
Definitions: displacement, distance, speed, velocity, acceleration.
Quantities: vector, scalar.
Calculations: equations of linear motion for constant linear acceleration.
Graphs: distance/time (interpreting slope as speed), velocity/time (interpreting slope as acceleration, area under graph as distance moved).

3.4b Identify calculations involving energy, work and power.
Laws: conservation of energy.
Definitions: energy, work, power.
Potential energy: energy possessed by a body by virtue of its position (relationship PE = mgh).
Kinetic energy: energy possessed by a body by virtue of its motion (relationship KE = 1⁄2mv2).
Calculations: work done (force/distance graphs), simple problems involving work/ energy/power/kinetic energy/potential energy.

3.5b Identify calculations involving temperature and heat.
Definitions: conduction, convection, radiation, temperature/heat (difference), specific heat capacity, sensible/latent heat (difference), specific latent heat.
Celsius scale: fixed points (-2738C, 08C, 1008C).
Kelvin scale: absolute temperature, relationship to Celsius scale.
Change of state: application/removal of heat (solids, liquids, gases).
Calculations: mass, specific heat capacity, temperature change, specific latent heat.

3.6b Identify calculations involving friction and lubrication.
Laws: friction.
Definitions: static/dynamic friction (difference), coefficient of friction.
Calculations: coefficient of friction, linear friction, frictional torque (bearings, clutch, disc brakes).

3.7b Identify calculations involving machines.
Definitions: machine as a device for changing magnitude/line of action of a force, force ratio (mechanical advantage), movement ratio (velocity ratio), efficiency.
Gears: ratio of a gearbox, size of gear wheels, driver/driven, simple/compound ratios, direction of rotation.
Calculations: simple machines (screw jacks, levers), gear ratios.

3.8b Identify calculations involving engine power.
Definitions: angular velocity, angular/linear velocity (difference), torque/power (difference), thermal efficiency (heat engines).
Engine test (dynamometer): determine engine torque/brake power/thermal efficiency.
Calculations: angular/linear velocity, indicated power (Pi), brake power (Pb), fuel efficiency, volumetric efficiency, thermal efficiency.

3.9b Identify calculations involving electricity.
Atomic structure: protons, neutrons, electrons.
Definitions: current (flow of electrons, amperes), conductors, insulators, resistance.
Resistance: relationship between resistance of conductor and its length/cross-sectional area/specific material resistance, variation with temperature.
Measurement: voltmeter, ammeter.
Circuits: series, parallel, combined, circuit diagrams (resistors series/parallel).
Current flow: complete circuit, potential difference between two points, total flow same in all parts of the circuit.
Series circuits: current flow constant at all points, sum of voltages (potential difference, pd) is equal to applied voltage (electro-motive force, emf).
Ohm's law: function of current (I)/potential difference (V)/resistance (R), $V = IR$.
Power: product of potential difference/current (direct current circuits), $P = I2R$, dissipation in simple circuits.
Capacitors: action, charging/discharging, series/parallel, energy stored ($= 1/2CV2$).
Calculations: Ohm's law, formulae for equivalent resistance of resistors in series/parallel, current/voltage in series/parallel/combined circuits.

Unit 3 Mathematics, Science and Communications
Communications Module (c)

Practical competences

The candidate must be able to do the following:

3.1c Use language in written and oral forms to communicate needs clearly in a routine work environment.

3.2c Interpret, use and draw diagrams in a routine work environment.

3.3c Collect and select information on the use of international standards.

3.4c Collect and select technical information from different sources.

3.5c Use technical information collected in a routine workplace activity.

3.6c Use computer information technology systems in a routine work environment.

Knowledge requirements

The instructor must ensure the candidate is able to:

3.1c Identify the need for language and the common forms in use.
Documents: manufacturers' manuals, workshop instructions, technical reports, graphical (bar charts, histograms, graphs). Write: technical/commercial letters (job application, curriculum vitae/résumé), instruction sheets, bar charts, histograms, graphs, summarise (reports, instruction sheets).

3.2c Identify the use of common forms of graphical communications.
Technical drawings/specifications: purpose (shape/dimensions/characteristics/location/layout of a component), constructional features, methods of repair.
Technical information: technical drawings, line/block diagrams, operating schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, video tape, CD ROM, computer systems.

Technical drawings.
Purpose: detail/assembly/location drawings, relationship between drawing office and workshop.
Information: projection (orthographic first/third angle, isometric, oblique, exploded, free hand sketches), unit of measurement, scale, material/specification, heat/protective treatments, tolerance, tool reference, warning notes.
Conventions/abbreviations: types of line, representations of common features, abbreviations in common use.
Dimensioning: from a datum, avoidance of accumulated errors.
Draw: orthographic first/third angle, isometric, oblique, exploded, single plane sectioned views, free hand sketches.

Operations.
Operations schedule: using a simple detailed drawing, logical sequence of operation, manufacturing a component (eg. engine mounting bracket), remove/refit/assemble a component (eg. oil filter).
Identification: components from drawings/specifications/data (technical drawings, diagrams, exploded views, manufacturers' servicing/repair/parts data/data sheets/wall charts).
Data: standards/manufacturers' tables/graphs/bar charts/pie charts (select materials for a particular application, select screw thread devices for fastening components/units, select recommended twist drill size for clearance/thread forming/countersinking, obtain specific information).
Colour coding: relationship between colour coding conventions/safety, wiring (mains electricity supply/vehicle electrics), pipes/cylinders (compressed gases).

3.3c Identify the use of international standards.
Standards: British Standards (BS), International Organisation for Standardization (ISO), Deusches Institut für Normag (DIN), Federal Motor Vehicle Safety Standard (FMVSS), Society of Automotive Engineers (SAE), Système International d'Unites (SI).

3.4c Identify the use of libraries and the selection of information from different sources.
Location: library index, classification systems, document index/contents pages.
Sources: appropriate to each stage of investigation, use of trade/suppliers' catalogues.

3.5c Identify sources of technical information.
Technical descriptions: workshop equipment/processes, vehicle systems/components.
Reports: experimental data, workshop processes.

3.6c Identify computer information technology systems.
Hardware: computer, four stage model, memory, input devices, printers/plotters, visual display units/monitors, auxiliary storage systems, communications.
Software: operating systems, word processing, database, spreadsheets.
Functions: input unit, central processing unit, output stage, storage unit.
Word processor: technical/commercial letters instruction sheets, bar charts, histograms, graphs, summarise (reports, instruction sheets).

Test specification for written paper Mathematics, Science and Communications (3905-02-003)

This is a written multiple choice examination paper, lasting 1½ hours and containing 60 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
3a Mathematics	34
3b Science	33
3c Communications	33

Vehicle Systems Practical (3905-01-004 and 3905-02-004)

Assessment of the practical skills at each level of this programme is by completion of the tasks listed under practical competences. For each unit there is a competence checklist against which successful performance is recorded. It is expected that a candidate will have successfully completed each of the activities before being credited with a specific skill. Wherever possible competence should be demonstrated in the workplace or in a realistic work environment.

Candidates must demonstrate competence in all of the topics.

Centres should copy the practical assessment sheets for EACH candidate. Completed sheets for each candidate must be available for inspection by the Visiting Assessor, or submission to City & Guilds on request.

The Visiting Assessor must make a visit to the assessment centre on at least one occasion each year at a time when practical assessments are taking place. The main purpose of this visit is to ensure that the competence checklists are being completed accurately and in accordance with the regulations for assessment of this programme.

Please refer to the **Role and Duties of the Visiting Assessor** in Appendix B.

Unit 1 Engine Systems 1
Petrol/Diesel Engines and Fuel Systems Module (a)

Practical competences

The candidate must be able to do the following:

1.1a Collect information identifying the engines used in motor vehicles. ☐

1.2a Inspect vehicle systems and prepare a report identifying typical petrol/diesel engine components and their functions. ☐

1.3a Collect information identify the operating principles of petrol/diesel engines. ☐

1.4a Inspect vehicle systems and prepare a report identifying petrol/diesel fuel systems in standard forms and locations. ☐

1.5a Prepare a report identifying the main petrol/diesel fuel system components and their functions. ☐

1.6a Collect information identifying the operating principles of petrol/diesel fuel systems. ☐

1.7a Carry out under supervision routine vehicle checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools. ☐

1.8a Use safety, mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 1 Engine Systems 1
Ignition and Electrical Systems Module (b)

Practical competences

The candidate must be able to do the following:

1.1b Collect information identifying spark ignition systems. ☐

1.2b Inspect vehicle systems and prepare a report identifying the main ignition system components and their functions. ☐

1.3b Prepare a report identifying the basic operating principles of contact breaker and breakerless types of main ignition systems. ☐

1.4b Inspect vehicle systems and prepare a report identifying electrical systems and components. ☐

1.5b Prepare a report identifying operational principles and functions of electrical system components. ☐

1.6b Carry out under supervision routine vehicle checks and basic schedule servicing as recommended by the manufacturer, using general and specific tools. ☐

1.7b Use safety, mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 1 Engine Systems 1
Cooling and Lubrication Systems Module (c)

Practical competences

The candidate must be able to do the following:

1.1c Collect information identifying cooling/ heating systems. ☐

1.2c Inspect vehicle systems and prepare a report identifying the main cooling/heating system components and their functions. ☐

1.3c Collect information identify the operating principles of cooling/heating systems. ☐

1.4c Collect information identifying engine lubrication systems. ☐

1.5c Inspect vehicle systems and prepare a report identifying the main engine lubrication system components and their functions. ☐

1.6c Collect information identifying the operating principles of engine lubrication systems. ☐

1.7c Carry out under supervision routine vehicle checks and basic schedule servicing as recommended by the manufacturer, using general and specific tools. ☐

1.8c Use safety, mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 2 Chassis Systems 1
Vehicle Systems Module (a)

Practical competences

The candidate must be able to do the following:

2.1a Collect information identifying body types and their functional requirements. ☐

2.2a Prepare a report identifying engine positions/drives, vehicle body components and vehicle systems. ☐

2.3a Inspect vehicle systems to identify driver controls and information displays. ☐

2.4a Prepare a report identifying the reasons for carrying out regular or special vehicle inspections and adjustments. ☐

2.5a Inspect vehicle systems and prepare a report identifying the types of scheduled servicing carried out on road vehicles. ☐

2.6a Carry out under supervision routine vehicle checks and basic scheduled servicing as recommended by the vehicle manufacturer, using general/specific tools. ☐

2.7a Use safety, mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 2 Chassis Systems 1
Braking, Steering and Suspension Systems Module (b)

Practical competences

The candidate must be able to do the following:

2.1b Collect information identifying braking systems. ☐

2.2b Inspect vehicle systems and prepare a report identifying the main components of braking systems and their functions.

2.3b Prepare a report identifying the operational principles of braking systems. ☐

2.4b Prepare a report identifying the health hazards associated with braking systems. ☐

2.5b Collect information identifying steering systems. ☐

2.6b Inspect vehicle systems and prepare a report identifying the main components of steering systems and their functions. ☐

2.7b Prepare a report identifying the operating principles of steering systems. ☐

2.8b Collect information identifying suspension systems and wheels/tyres. ☐

2.9b Inspect vehicle systems and prepare a report identifying the main components of suspension systems, wheels/tyres and their functions. ☐

2.10b Prepare a report identifying the operational principles of suspension systems and wheels/tyres. ☐

2.11b Carry out under supervision routine vehicle checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools. ☐

2.12b Use safety, mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 2 Chassis Systems 1
Gearbox and Transmission Systems Module (c)

Practical competences

The candidate must be able to do the following:

2.1c Collect information identifying gearbox systems. ☐

2.2c Inspect vehicle systems and prepare a report identifying the main gearbox components and their functions. ☐

2.3c Prepare a report identifying the operational principles of gearboxes. ☐

2.4c Collect information identifying clutch systems. ☐

2.5c Inspect vehicle systems and prepare a report identifying clutch components and their functions ☐

2.6c Prepare a report identifying the operational principles of clutch systems. ☐

2.7c Collect information identifying vehicle drive, drive shafts and hubs. ☐

2.8c Inspect vehicle systems and prepare a report identifying the main components of propeller shafts, drive shafts/hubs and their functions. ☐

2.9c Prepare a report identifying the operational principles of propeller shafts, drive shafts and hubs. ☐

2.10c Prepare a report identifying the reasons for carrying out regular/special inspections and adjustments of propeller shafts, drive shafts and hubs. ☐

2.11c Collect information identifying final drive and differential systems. ☐

2.12c Inspect vehicle systems and prepare a report identifying the components of final drive/differential systems and their functions. ☐

2.13c Prepare a report identifying the operational principles of final drive and differential systems. ☐

2.14c Carry out under supervision routine vehicle checks and basic schedule servicing as recommended by the vehicle manufacturer, using general and specific tools. ☐

2.15c Use safety mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 2 Chassis Systems 1
Safety Module (d)

Safety requirements must be incorporated throughout each unit of the syllabus. It will be integrated throughout the assessments.

Practical competences

The candidate must be able to do the following:

2.1d	Carry out simple first aid tasks.	☐
2.2d	Extinguish different kinds of fires using the appropriate equipment and procedures.	☐
2.3d	Carry out a simple workshop safety hazard analysis.	☐
2.4d	Wear appropriate protective clothing.	☐
2.5d	Observe all workshop safety procedures.	☐
2.6d	Recognise hazards and report to the appropriate authority.	☐
2.7d	Use safe and fully maintained equipment.	☐
2.8d	Comply with manufacturers' instructions in the operation and cleaning of equipment and machinery.	☐
2.9d	Safely store, use and dispose of dangerous substances.	☐

This is to confirm that the candidate has successfully completed the above tasks:

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Candidate name (please print) _____

Instructor signature _____

Instructor name (please print) _____

Completion date _____

Unit 3 Mathematics, Science and Communications
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

3.1a Perform calculations involving the four arithmetic operations. ☐

3.2a Perform calculations involving fractions, ratios, percentages and proportions. ☐

3.3a Perform and deduce estimated solutions to arithmetic calculations ☐

3.4a Perform calculations involving the use of an electronic calculator. ☐

3.5a Use and apply the Laws of Indices. ☐

3.6a Use and apply algebraic operations. ☐

3.7a Apply geometric and trigonometric operations to plane figures. ☐

3.8a Apply geometric operations to circles and cylinders. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 3 Mathematics, Science and Communications
Science Module (b)

Practical competences

The candidate must be able to do the following:

3.1b Perform calculations involving the fundamental and derived SI units of measurement. ☐

3.2b Perform calculations involving mass, force and moments. ☐

3.3b Perform calculations involving distance, time, velocity and acceleration. ☐

3.4b Perform calculations involving energy, work and power. ☐

3.5b Perform calculations involving temperature and heat. ☐

3.6b Perform calculations involving friction and lubrication. ☐

3.7b Perform calculations involving machines. ☐

3.8b Perform calculations involving engine power. ☐

3.9b Perform calculations involving electricity. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 3 Mathematics, Science and Communications
Communications Module (c)

Practical competences

The candidate must be able to do the following:

3.1c Use language in written and oral forms to communicate needs clearly in a routine work environment. ☐

3.2c Interpret, use and draw diagrams in a routine work environment. ☐

3.3c Collect and select information on the use of international standards. ☐

3.4c Collect and select technical information from different sources. ☐

3.5c Use technical information collected in a routine workplace activity. ☐

3.6c Use computer information technology systems in a routine work environment. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Diploma/Technician Diploma in Motor Vehicle Systems (3905-02-021 to 3905-04-028)

Diploma in Motor Vehicle Systems

These units cover the following topic areas:

Unit 21 – Engine Systems 2

• Petrol/Diesel Engines and Fuel Systems	Module 21a
• Spark Ignition and Electrical/Electronic Systems	Module 21b
• Cooling Systems	Module 21c
• Associated Studies (Maths and Science)	Module 22d

Unit 22 – Chassis Systems 2

• Braking, Steering and Suspension Systems	Module 22a
• Transmission Systems	Module 22b
• Vehicle Bodywork	Module 22c
• Associated Studies (Maths and Science)	Module 22d

Unit 25 – Engine Systems 3

• Petrol/Diesel Engines and Fuel Systems	Module 25a
• Spark Ignition and Electrical/Electronic Systems	Module 25b
• Engine Auxiliary Systems	Module 25c
• Associated Studies (Maths and Science)	Module 26d

Unit 26 – Chassis Systems 3

• Braking, Steering and Suspension Systems	Module 26a
• Manual and Automatic Gearboxes	Module 26b
• Transmission Systems	Module 26c
• Associated Studies (Maths and Science)	Module 26d

Technician Diploma in Motor Vehicle Systems

Unit 21, 22, 25 and 26 must be completed in full. Please note modules 23 a, b, c and 27 a, b, c incorporate all the topic areas covered in Associated Studies Module 22d and 26d.

Unit 23 – Mathematics, Science and Electronics 1

• Mathematics	Module 23a
• Vehicle Science	Module 23b
• Vehicle Electronic Systems	Module 23c

Unit 27 – Mathematics, Science and Electronics 2

• Mathematics	Module 27a
• Vehicle Science	Module 27b
• Vehicle Electronic Systems	Module 27c

Unit 21 Engine Systems 2
Petrol/Diesel Engines and Fuel Systems Module (a)

Practical competences

The candidate must be able to do the following:

21.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of petrol/diesel engines and fuel systems.

21.2a Identify the operating principles, main constructional features and operation of main components for petrol/diesel engines and fuel systems.

21.3a Carry out routine maintenance and system adjustments on petrol/diesel engines and fuel systems.

21.4a Carry out a vehicle inspection identifying the effects of incorrect adjustments/faults on petrol/diesel engines and fuel systems.

21.5a Carry out systematic testing procedures using test equipment on petrol/diesel engines and fuel systems.

21.6a Use vehicle manufacturers' specifications in the maintenance and testing of petrol/diesel engines and fuel systems.

21.7a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

21.1a Describe safe working practices using tools, equipment and consumable materials when working on petrol/diesel engines and fuel systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures. **Electrical/electronic systems:** isolation of battery/external electrical sources during work,
electrical shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal procedures, electric welding.
Tools/equipment.
Measurement: engineers' rules, internal/external/vernier callipers, feeler gauges, internal/external micrometers, dial test indicators, vee blocks, surface plates/tables.
Spanners: open-ended, ring, combination, lock, adjustable.
Sockets: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports, stud-
removers (devices for removing broken ends), greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, cylinder gauges, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

21.2a Identify the operating principles, main constructional features and operation of main components for four stroke petrol/diesel engines and fuel systems.
Cylinder layouts: in-line, opposed, vee. **Cylinder blocks:** with/without liners(wet/dry). **Cylinder heads:** siamese ports, cross flow ports, multi valves per cylinder, single/twin cam, gaskets (materials).
Camshafts/drive methods: sprockets/chain gears, toothed (notched) belt, tensioning guides.
Valves/operating systems: valves, valve stem guides, valve springs/collets, rockers, levers, fingers, direct operating cams, hydraulic lifters, shims.
Spark plug locations: central, offset, multiple. Combustion chamber types: petrol engines, diesel engines. **Cooling:** ducts, ports, jackets, core plugs.
Drive arrangements for engine auxiliaries: water pump, fuel pump, alternator, air conditioning compressor, power steering/brakes.
Cycles of operation: four stroke petrol/diesel engines. Valve timing: lead, lag, overlap, timing diagrams, valve clearances/adjustment/adjustment methods.
Terms: top dead centre (tdc), bottom dead centre (bdc), bore, stroke, capacity, clearance volume, swept volume, compression ratio, crank throw, torque at revs/min, brake power at revs/min, specific fuel consumption (sfc), volumetric efficiency, OHV, OHC.
Engine lubrication.
Purpose: reduction of friction, cooling effect, cleaning effect, corrosion resistance, reduction of noise.
Operating principles: full flow/by-pass/single/two stage filtration, splash lubrication, forced feed, directional piston cooling, oil mist, oil ways. **Lubricant:** purpose, oil film effects, characteristics/classifications of lubricants; viscosity, viscosity index, Society of Automotive Engineers
(SAE) classification, American Petroleum Institute (API) service classification.
Exhaust/air supply systems.
Air supply: types, layout, locations, applications, air supply components, pre-cleaners, dry filters, wet (gauze) filters, oil bath filters, manifold heaters (water, electrical, hot spot), intake air temperature control systems, crankcase emission control systems, plenum chambers/manifolds.
Exhaust: manifolds, rigid/flexible pipes/joints (steel/stainless steel), single/multi branched pipe systems, silencers/expansion boxes, catalytic converter, oxygen sensor, heat shields, flexible/resilient mountings, clamping/sealing arrangements.
Purpose of exhaust/air supply systems: supply clean air for the combustion process, silence air intake noise, control (within limits) temperature/pressure of air supplied to the engine, uniform distribution, arrest flashback, conduct exhaust gases away from the vehicle, silence exhausted gas noises, utilise exhaust gas heat for induction air heating purposes.
Operating principles: intake air supply cleaning/heating, exhaust gas removal/ silencing/waste heat utilisation.
Fuel systems.
Layout: fuel systems/major components. **Carburettor systems:** single/multiple, fixed/variable Venturi, mechanical/electronic control, supply engine with atomised fuel with a suitable air/fuel ratio, cold starting (strangler valve), idling, accelerating, cruising, maximum power, control engine speed/power, change air/fuel ratio as/when required by changes in engine speed/load.
Petrol injection systems: single/multi point injectors, method of introducing fuel, chemically correct air fuel ratio for petrol, constituents of exhaust gas, environmental effect, exhaust gas products for correct/rich/weak mixtures.
Diesel injection systems: single/multi-hole injectors, in-line fuel injection pump, rotary fuel injection pump, bleed points/vents, provide an atomised fuel supply to engine, correct times, correct quantities for all engine requirements, clean supply.

21.3a Identify the routine maintenance and system adjustments necessary on petrol/diesel engines and fuel systems.
Engines: oil levels (drain/flush/refill), oil filters, seals/gaskets, air breather, filter (wet/dry), visual check for leaks, recognition of excessive engine noise, replacement of valve gear drive belt, adjustment of valve clearance, visual check for condition of engine mounts, noise, insulation.
Air supply/exhaust system: changing air filters, emptying, cleaning/refilling wet air cleaner oil baths, cleaning/re-oiling gauze air filters, setting of manual intake valve according to season, emptying/cleaning/refilling crankcase ventilation oil traps/gauzes, visual check for security/soundness of exhaust system.
Fuel systems: filter cleaning/changes, synchronise/balance carburettors, visual check for leaks, slow running/mixture setting adjustment, measurement of exhaust gas compositions as a guide to efficient combustion, fast idle mechanism adjustment, float level check, fuel pump delivery pressure, water drainage, bleeding/venting systems, flushing fuel systems, cold start/idle speed adjustments, control linkages/cables.

21.4a Identify the effects of incorrect adjustments/faults to petrol/diesel engines and fuel systems.
Engines.
Valve clearances: lack of power, uneven running, misfire, excessive fuel consumption, exhaust emissions.
Fuel systems.
Poor/non starting, lack of power, uneven running/ stalling, hesitation, popping back/backfire, running on, detonation, heavy fuel consumption, fuel leaks/odours, knocking, overheating.

21.5a Identify systematic testing procedures by aural, visual and functional methods to establish the condition of, and locate faults in petrol/diesel engines and fuel systems.
Engines.
Symptoms/rectification procedures: poor starting, non-starting, resistance to crank rotation, misfire/uneven running, cutting-out, hesitation, detonation, pinking/knocking, excessive fuel consumption, lack of power, running-on, oil/coolant leaks, oil/coolant contamination, exhaust leaks/pollutants, black/blue/white smoke, excessive oil consumption, overheating/overcooling, fuel leaks/ odours, abnormal mechanical noises.
Test equipment: cylinder compression, cylinder leakage, cylinder balance, valve clearances, oil pressure, positive crankcase ventilation (PCV) valve.
Fuel systems.
Symptoms/rectification procedures: misfire/uneven running, cutting out, hesitation, detonation, pinking, knocking, lack of power, running on, overheating, fuel leaks/odours.

21.6a Identify petrol/diesel engines and fuel systems data provided by manufacturers.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures/parts lists, electrical wiring diagrams.
Applications: shape/characteristics of a component, dimensions/location/layout of components, constructional features/methods of repair, procedures, settings/standards.
Constructional features/vehicle manufacturers' procedures for removal for further testing and inspecting.
Petrol systems: idle speed, mixture strength, fuel pump delivery pressure, air cleaner valve operation, sensor operation, test routines as specified by the manufacturer.
Diesel systems: smoke emission, induction manifold pressure, fuel pump delivery pressure, fuel aeration.

Unit 21 Engine Systems 2
Spark Ignition and Electrical/Electronic Systems Module (b)

Practical competences

The candidate must be able to do the following:

21.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle spark ignition and electrical/electronic systems.

21.2b Identify the operating principles, main constructional features and operation of main components for vehicle spark ignition and electrical/electronic systems.

21.3b Carry out routine maintenance and running adjustments necessary on vehicle spark ignition and electrical/electronic systems.

21.4b Carry out vehicle inspections identifying the effects of incorrect adjustments/faults on spark ignition and electrical/electronic systems.

21.5b Carry out systematic testing procedures using test equipment for vehicle spark ignition and electrical/electronic systems.

21.6b Use vehicle manufacturers' specifications in the maintenance and testing of vehicle spark ignition and electrical/electronic systems.

21.7b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

21.1b Describe safe working practices using tools, equipment and consumable materials when working on vehicle spark ignition and electrical/electronic systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Electrical/electronic systems: isolation of battery/external electrical sources during work, electrical shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal procedures, electric welding.
Tools/equipment.
Measurement: engineers' rules, internal/external/vernier callipers, feeler gauges, internal/external micrometers, dial test indicators, vee blocks, surface plates/tables.
Spanners: open-ended, ring, combination, lock, adjustable.
Sockets: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports, stud-removers (devices for removing broken ends), greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

21.2b Identify the operating principles, main constructional features and operation of main components for vehicle spark ignition and electrical/electronic systems.
Spark ignition systems.
Function: method of initiating combustion at the correct time in engine cycle, varying the timing of the spark in accordance with engine speed/load.
Systems: contact breaker, contact breakerless.
Contact breaker: with/without ballast resistor.
Contract breakerless: magnetic reluctor, Hall effect trigger/amplifier, trigger box.
Operating principles: contact breaker versus breakerless types, factors influencing coil output, effect of temperature/pressure/varying mixture strength on plug firing voltage, production of high voltage by mutual induction.
Main components: ignition switch, ballast resistor, resistive cable, ignition coil, distributor/cap, contact breaker assembly, rotor arm (resistive/speed limiting), high voltage flashover shield, vacuum advance and retard unit, centrifugal advance mechanism, high tension leads/connectors, radio interference suppression devices, spark plugs (heat ranges), capacitor, amplifier, magnetic reluctor, Hall effect trigger.

Electrical/electronic systems.
Electrical/electronic circuits/components/units: parallel/series/earth return circuits, generator/storage, starter systems, motor/drive assemblies, lights, screen heating elements, switches/relays, conductors/terminations, circuit protection devices, driver information circuits.
Generator: basic type of alternator with voltage regulator only.
Battery: lead acid, low/no maintenance types.
Motors/drivers: starter, wipers, pumps, accessories.
Lamps: bulbs, bulb holders, housing, lenses.
Switches/relays: intermittent/continuous/time delay relays, direction indicator flasher, hazard warning.
Cables: sizes, ratings, colour coding, loom/harness.
Terminations: ratings, common crimped, clamped, soldered, cable connectors.
Fuses: glass encased, ceramic, cartridge, fusible link, reset overloads.
Gauges/instruments: temperature, pressure, speed, fluid level, thermal/air cooled, voltage stabilisers, warning lamps.
Sensors: pressure, temperature, fluid levels, wear, rotation, position.
Ignition switch: barrel/lock assembly.
Horns: high frequency, windtone, air.
In-car entertainment: suppression devices, aerials (manual, electric, screen type, single and twin).

21.3b Identify the routine maintenance and running adjustments necessary on vehicle spark ignition and electrical/electronic systems.
Spark ignition systems.
Static/dynamic timing, contact gaps/magnetic reluctor air gaps, dwell angle, cam lubrication, advance and retard mechanism, spark plug gap/cleaning/test, resistive leads, rotor/cap insulation, high voltage flashover shield, high/low tension leads.

Electrical/electronic systems.
Visual checks: security/cleanliness of components/connections, instruments/warning lamps, lamps/electrically driven components.
Alternator: drive belt/pulley wear, belt tension adjustment, charging check using voltmeter across battery terminals.
Batteries: charging on/off vehicle using fast/slow chargers, terminals, electrolyte level, security.
Headlamps: alignment check/adjustment.

21.4b Identify the effect of incorrect adjustments/faults to vehicle spark ignition and electrical/ electronic systems.
Plug gaps: poor/non starting, lack of power, hesitation, uneven running, misfire, exhaust emissions.
Ignition setting: poor/non starting, lack of power, hesitation, exhaust emission, running on.
Alternator drive belt: overheating, low charging rate.

21.5b Identify systematic testing procedures by aural, visual and functional methods to establish the condition and locate faults in vehicle spark ignition and electrical/electronic systems.
Spark ignition systems.
Poor/non-starting, resistance to crank rotation, misfire/uneven running, cutting out, hesitation, detonation/pinking, knocking, lack of power, running on, exhaust pollutants, radio interference.

Electrical/electronic systems.
Test equipment.
Battery: stabilised open circuit voltage, state of charge (hydrometer test), condition (high rate discharge test).
Alternator: drive belt tension, charging circuit wiring continuity, voltage maximum/ regulated/drop in insulated/return circuits.
Starter: electrical resistance (voltage drop test).
Lighting: unwanted resistance (voltage drop test), lamp operation, beam alignment.
Vehicle auxiliary systems: washers/wiper circuits (voltage drop test), horn circuit (voltage drop test/current consumption), screen heater elements/circuits, instrumentation, driver information circuits.

Visual/functional methods.
Battery: under/overcharging, corrosion of terminals, casing cracks/leaks.
Alternator: noisy operation, operation of warning system (meter/warning light), incorrect output.
Lighting: non/intermittent operation, low lighting intensity, headlight beam misalignment.
Starting: low engine cranking speed, unusual noise during operation, non-operation of starting system, incorrect pinion engagement/disengagement.
Instrumentation/driver information circuitry: non/intermittent/slow operation, incorrect readings, driver information symbols.
Horns: non/continuous operation, poor tone quality.
Wipers/washers: non/intermittent/slow operation, unusual noise, incorrect parking/swept area, blade lift, screen smearing, arm/blade judder, faulty spray pattern.
Measurement: low tension/high tension circuits, ignition timing, cable resistance, coil/supply voltages, pick-up coil resistance, current coil consumption, terminal voltages.

21.6b Identify vehicle spark ignition and electrical/electronic system data provided by manufacturers.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.
Applications: shape/characteristics of a component, dimensions/location/ layout of components, constructional features/methods of repair, procedures, settings/standards.
Constructional features/vehicle manufacturers' procedures for removal for further testing and inspecting.

Unit 21 Engine Systems 2
Cooling Systems Module (c)

Practical competences

The candidate must be able to do the following:

21.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of cooling systems.

21.2c Identify the operating principles, main constructional features and operation of main components for vehicle cooling systems.

21.3c Carry out routine maintenance and running adjustments necessary on vehicle cooling systems.

21.4c Carry out vehicle inspections identifying the effects of incorrect adjustments/faults on vehicle cooling systems.

21.5c Carry out systematic testing procedures using test equipment for vehicle cooling systems.

21.6c Use vehicle manufacturers' specifications in the maintenance and testing of vehicle cooling systems.

21.7c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

21.1c Describe safe working practices using tools, equipment and consumable materials when working on vehicle cooling systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures. **Electrical/electronic systems:** isolation of battery/external electrical sources during work,
electrical shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal procedures, electric welding.

Tools/equipment.
Measurement: engineers' rules, internal/external/vernier callipers, feeler gauges, internal/external micrometers, dial test indicators, vee blocks, surface plates/tables.
Spanners: open-ended, ring, combination, lock, adjustable.
Sockets: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports, stud-
removers (devices for removing broken ends), greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

21.2c Identify the operating principles, main constructional features and operation of main components for vehicle cooling systems.
Systems: air cooled, liquid cooled.
Operating principles: cooling, radiator flow (vertically down, cross, single/double pass), pressurised systems, fans (intermittent operation/noise/power absorbtion) corrosion inhibitors/antifreeze (types, properties), operating environment.

Main components/layout/purpose.
Air cooling: fan, drive belt, cowling.
Liquid cooling: radiator/heater matrix (cellular corrugated, elongated tube with fins), expansion tank, hoses, thermostat (wax, bellows), pressure cap/valves, impeller/pump, fans, fan/drive systems (hydraulic/electrical/viscous coupling), thermostatic controls for fan/shutters.

21.3c Identify the routine maintenance and running adjustments necessary on vehicle cooling systems.
Purpose: thermal efficiency, reduce risk of component failure, antifreeze/cleaning/inhibitor.
Check: coolant level, antifreeze/inhibitors, hoses/clips, seals/gaskets, pressure caps, drain/ flush system, cowling fan/engine, thermostatically controlled components, fan belt drive, bleed heater system, adjust heater control.
Test: flow, pressure, temperature.

21.4c Identify the effect of incorrect adjustments/faults to vehicle cooling systems.
Faults: antifreeze solutions, anti-corrosion inhibitors, contamination, thermostats, core plugs, impellers (water pumps), pressure caps, radiators, temperature controlled fans, viscous coupling, electrically controlled fans.

21.5c Identify systematic testing procedures by aural, visual and functional methods to establish the condition and locate faults in vehicle cooling systems.
Testing procedure: antifreeze specific gravity, thermostat/cooling system operation, radiator caps, radiators, expansion tank, hoses, gaskets/seals, impellers, belts/pulleys/tensioners.

21.6c Identify vehicle cooling system data provided by manufacturers.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.
Applications: shape/characteristics of a component, dimensions/location/layout of components, constructional features/methods of repair, procedures, settings/standards.
Constructional features/vehicle manufacturers' procedures for removal for further testing and inspecting.

Test specification for written paper Engine Systems 2 (3905-03-021 and 3905-04-021)

This is a written multiple choice examination paper, lasting 1½ hours and containing 60 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
21a Petrol/Diesel Engines and Fuel Systems	30
21b Spark Ignition and Electrical/Electronic Systems	30
21c Cooling Systems	30
22d Associated Studies (Maths and Science)	10

Unit 22 Chassis Systems 2
Braking, Steering and Suspension Systems Module (a)

Practical competences

The candidate must be able to do the following:

22.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle braking, steering and suspension systems.

22.2a Identify the operating principles, main constructional features and operation of main components for vehicle braking, steering and suspension systems.

22.3a Carry out routine maintenance and running adjustments necessary on vehicle braking, steering and suspension systems.

22.4a Carry out vehicle inspections identifying the effects of incorrect adjustments/faults on vehicle braking, steering and suspension systems.

22.5a Carry out systematic testing procedures using test equipment for vehicle braking, steering and suspension systems.

22.6a Use vehicle manufacturers' specifications in the maintenance and testing of vehicle braking, steering and suspension systems.

22.7a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

22.1a Describe safe working practices using tools, equipment and consumable materials when working on vehicle braking, steering and suspension systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures. **Electrical/electronic systems:** isolation of battery/external electrical sources during work,
electrical shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal procedures, electric welding.

Tools/equipment.
Measurement: engineers' rules, internal/external/vernier callipers, feeler gauges, internal/external micrometers, dial test indicators vee blocks, surface plates/tables.
Spanners: open-ended, ring, combination, lock, adjustable.
Sockets: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports,
stud-removers (devices for removing broken ends), greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, brake efficiency test equipment (portable), brake bleeding devices, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

22.2a Identify the operating principles, main constructional features and operation of main components for vehicle braking, steering and suspension systems.
Braking systems.
Types: disc brakes, drum brakes.
Purpose: reduce vehicle speed, stop vehicle. **Operating principles:** use of friction to slow/stop/hold vehicle, use of levers/rods/ cables/hydraulics to transmit driver's effort, use of levers/hydraulics/engine manifold depression to supplement driver's effort, means of compensating/equalising braking force, use of split systems.
Factors affecting stopping distance: weight transference when braking, brake fade, vehicle stability when braking, road conditions/surfaces, loads carried.
Layout: basic braking systems/major components, parking brake.
Components: master cylinder (single/tandem), wheel cylinder, callipers (single/tandem), pipes/flexible hoses, brake shoes (leading/ trailing), brake pads, brake discs, brake drum, handbrake operating mechanism, pedal, limiting valves, adjusters, brake fluid, stop lamp actuator switch, wear/level/pressure indicating circuits.

Steering systems (non-assisted).
Types: single track rod, divided track rod.
Purpose: provide a means of changing direction of vehicle motion with minimum driver effort, provide a degree of feel without transmitting shock loading to the driver.
Operating principles: Ackerman principle for 'true' rolling motion, over/under steer, camber angle/swivel (king) pin inclination for centre point steering, castor angle to provide directional stability/self-centring action, need for correct wheel alignment using toe-in/toe-out.
Layout: non-assisted steering systems/major components.
Components: steering wheel/column, rack and pinion steering gearboxes, steering idlers, steering joints, swivel (pin) assemblies, MacPherson struts, front hubs, bearings/seals, drop arms, drag links, track arms, track rods.

Front/rear suspension systems.
Types: independent, non-independent. **Purpose:** effect of road surface irregularities on passengers/vehicle/load, maintaining wheel contact with the road, transmitting driving/braking torque, locating the axle where appropriate, supporting the sprung weight, minimising unsprung weight, absorbing torque reaction. **Layout:** suspension systems/major components. Components: beam axle, live axle, strut/McPherson strut, wishbone, trailing arm/semi trailing arm, swinging arm, torsion beam, De-Dion, suspension arms/links, springs (leaf, coil, torsion, rubber), suspension dampers (telescopic/lever arm), swivel pins/McPherson struts, swivel pins/ball joints, bushes, location rods/linkages, anti- roll bars, sub-frame assemblies, leaf spring shackles/locating devices, axles/hubs/struts acting as suspension members/chassis mounting points, bound/rebound stops.

Tyres/wheels.
Tyres: tubed, tubeless, cross-ply, radial ply, bias belt, remould, re-tread, re-cut.
Wheels: steel/spoke/cast alloy, well base, divided rim, detachable flange, 'run-flat', space saver assemblies.
Purpose: transmit drive to the road surface, withstand forces during braking/cornering, support the weight of the vehicle, absorb shock, provide minimum rolling resistance, minimise unsprung weight, maintain grip in wet conditions, permit removal/refitting, allow passage of air for brake cooling, appearance, run true (precise angle and direction), minimise air loss.
Operating principles: tread patterns for various climatic conditions/operational requirements, high performance asymmetric/low profile, relationship between tread rating and load-carrying capacity, tyre types, tyre sizes, speed ratings, tyre symbols, aspect ratio, materials used in the construction of tyres/wheels, wheel balancing, requirement for/use of tread-depth indicators, left/right hand threads for securing wheels (reasons for their use), reasons for selecting the materials.

22.3a Identify the routine maintenance and running adjustments on vehicle braking, steering and suspension systems.
Braking systems.
Fluid level/leaks/replacement, check wear in friction material/faces, measurement/ adjustment of pedal/ lever travel, adjustment of brakes, elimination of air from the system.

Steering (non assisted).
Check: components for wear/security, front to rear axle alignment, tyres for signs of steering misalignment, wheel alignment.
Lubrication requirements, adjustment of wheel alignment.

Suspension systems.
Check: components for wear/security/defects, suspension damper operation, alignment/geometry, leaks.
Lubrication requirements.

Wheels and tyres.
Check tyre pressure/adjustment, measurement of tread wear, assessment of tyre condition, replacement of valves/cores, tightening wheel nut/bolt to specified setting, removal of inclusions from tyre treads, assessment of wheel condition, permissible repairs to tyres/inner tubes, balancing wheels/tyres using static/dynamic methods.

22.4a Identify the effect of incorrect adjustments/faults on vehicle braking, steering and suspension systems.
Braking systems.
Adjustments: excessive pedal/brake/lever travel, reduced braking efficiency, unbalanced braking.
Faults: air in system, defective linings/pads (including oil contamination), leaking wheel/master cylinders, seized wheel cylinders, moisture contamination in fluid.

Steering (non-assisted).
Faults: abnormal/uneven tyre wear, heavy steering, pulling to one side, inadequate self centring, wandering, misalignment of the steering wheel, excessive free play, vibration, noise.

Suspension systems.
Faults: wear, incorrect alignment.

Wheels and tyres.
Faults: incorrect tyre pressure, incorrect trim height, abnormal wear.

22.5a Identify systematic testing procedures by aural, visual and functional methods to establish the condition and locate faults in vehicle braking, steering and suspension systems.
Braking systems.
Test equipment: hand instruments (measuring devices), portable/roller type brake testers.

Steering systems.
Test equipment: wheel alignment, toe out on turns, castor, camber, swivel (king) pin inclination, wheel base, front/rear axle alignment, wheel nut torque.

Suspension systems, wheels and tyres.
Test equipment: pressure gauges, dial test indicators, engineers rule, wheel balance equipment.

22.6a Identify vehicle braking, steering and suspension system data provided by manufacturers.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams, tyre pressures.
Applications: shape/characteristics of a component, dimensions/location/layout of components, constructional features/methods of repair, procedures, settings/standards.
Constructional features/vehicle manufacturers' procedures for removal for further testing and inspecting.

Unit 22 Chassis Systems 2
Transmission Systems Module (b)

Practical competences

The candidate must be able to do the following:

22.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle clutch, gearbox, propeller/drive shafts and final drive/ differential units.

22.2b Identify the operating principles, main constructional features and operation of main components for vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.

22.3b Carry out routine maintenance and running adjustments necessary on vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.

22.4b Carry out vehicle inspections identifying the effects of incorrect adjustments/faults on vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.

22.5b Carry out systematic testing procedures using test equipment for vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.

22.6b Use vehicle manufacturers' specifications in the maintenance and testing of vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.

22.7b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

22.1b Describe safe working practices using tools, equipment and consumable materials when working on vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures. **Electrical/electronic systems:** isolation of battery/external electrical sources during work,
electrical shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal procedures, electric welding.

Tools/equipment.
Measurement: engineers' rules, internal/external/ vernier callipers, feeler gauges, internal/external micrometers, dial test indicators, vee blocks, surface plates/tables.
Spanners: open-ended, ring, combination, lock, adjustable.
Sockets: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports, stud-
removers (devices for removing broken ends), greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, hydraulic system bleeding equipment, preload gauges, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

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22.2b Identify the operating principles, main constructional features and operation of main components for vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.
Clutch.
Types: operating mechanisms, assemblies. **Components:** cables, self-adjusting mechanisms, master cylinders, slave cylinders, pressure plate/cover, centre plate, release bearings, cone (within gearbox), fluid clutch, first motion shaft front support bearing (spigot), release bearing, hydraulic pipes.

Gearbox.
Types of gears: primary shaft, layshaft, main shaft, reverse idler shaft, power flow for each ratio.
Layout: shafts, bearings, seals.
Synchromesh devices, bearings, seals, gaskets, selector rails/forks, rail retention/interlock devices.
Gear change mechanisms: direct/indirect mechanical operated, internal selector mechanisms.
Speedometer drive arrangements, reverse light switches, gearbox mountings.

Propeller and drive shafts.
Purpose: transmit drive, accommodate angular deflection of drive/propeller shafts, allow changes in distance between components, locate road wheel/brake assembly.
Operating principles: reason why constant velocity joints are used, reason for using tubular propeller shafts, action of universal joint/flexible joint in relation to speed variation with different working angles, reason for using a split joint, reason why correct alignment of universal/slip joints connected in series is essential, need for propeller shaft balancing.
Layout: front wheel drive (independent), front engine rear wheel drive (live axle/independent), rear engine rear wheel drive (independent), vehicle drives, drive shafts, hub arrangements.
Components: propeller drive shafts (including Hotchkiss open-type drive), centre bearings, torque tube/housings/casings, telescopic joints, universal joints (Hooke's, flexible, constant velocity).
Driven hubs: front wheels, rear wheels, semi floating, three-quarter floating, fully floating.

Final drive and differential units.
Purpose: provide final gear reduction/torque multiplication, allow driven wheels to rotate at different speeds whilst transmitting equal torque, change direction of drive (where appropriate), support load (where appropriate).
Operating principles: relative merits of gears mounted, live/dead axles.
Layout: rear mounted live axle, rear mounted trans-axle, front wheel drive, chassis mounted.
Components: straight bevel, spiral bevel, hypoid bevel, worm and wheel, bevel-type differential, sun/planet gears, casings, breathers, mountings, bearings, seals, lubrication.

22.3b Identify the routine maintenance and running adjustments necessary on vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.
Clutch.
Fluid: levels (check/topping up), changing, bleeding system.
Operating mechanisms: adjusting, correct operation.

Manual gearboxes.
Lubricants: selection, changing, replenishing, check level, lubrication of gear change linkage.
Mountings: security, condition.
Remote gear change linkages: security, wear.

Propeller and drive shafts.
Lubrication: sliding/universal joints.
Visual check: gaiters/seals.
Check for serviceable condition: universal joints, drive shaft bolts, sliding couplings, centre bearings, check, adjustment/greasing of hub bearings, wheel securing provision.

Final drive and differential unit.
Lubricants: check levels, changing.
Check: oil seals, security of components.

22.4b Identify the effect of incorrect adjustments/faults to vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units.
Clutch.
Faults: slip, drag, judder, snatch, contamination, clearance.

Gearbox.
Faults: lack of drive, noisy operation, difficulty engaging/disengaging gears, jumping out of gears, oil leakage, vibration, excessive movement of gear lever, speedometer inoperative.

Propeller and drive shafts.
Faults: damaged gaiter/seals, worn universal joints/constant velocity joints, incorrect alignment of universal joints, incorrect clearances on wheel bearing/propeller shaft centre bearing, vibration/noise.

Final drive and differential units.
Faults: noise in operation, vibration, loss of drive, excessive free play, oil leaks.

22.5b Identify systematic testing procedures by aural, visual and functional methods to establish the condition and locate faults in clutch, gearbox, propeller/drive shafts and final drive/differential units.
Clutch.
Test equipment: clutch service arbor, press and table, pedal height, release lever free play, flywheel run-out.
Testing procedures: slip, judder, drag, snatch, squeak, rattle, lack of drive, vibration.

Gearbox and linkages.
Test equipment: rolling road, dial test indicators, preload gauges.
Faults: as listed in 22.4b above.

Propeller and drive shafts.
Test equipment: vee blocks, dial test indicator, straight edge.
Faults: as listed in 22.4b above.

Final drive and differential units.
Test equipment: dial test indicator, pre-load gauge.
Faults: as listed in 22.4b above.

22.6b Identify vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units data provided by manufacturers.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists.
Performance of systems/components.
Applications: shape/characteristics of a component, dimensions/location/ layout of components, constructional features/methods of repair, procedures, settings/standards.
Constructional features/vehicle manufacturers' procedures for removal for further testing and inspecting.

Unit 22 Chassis Systems 2
Vehicle Bodywork Module (c)

Practical competences

The candidate must be able to do the following:

22.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle bodywork and constructional alignment.

22.2c Identify the operating principles, main constructional features and operation of main components for vehicle bodywork.

22.3c Carry out routine maintenance and running adjustments necessary on vehicle bodywork.

22.4c Carry out vehicle inspections identifying misalignment of vehicle body components.

22.5c Prepare a report identifying alignment test procedures using test equipment for vehicle bodywork.

22.6c Prepare a report identifying vehicle manufacturers' specifications in the maintenance and testing of vehicle bodywork and constructional alignment.

22.7c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

22.1c Describe safe working practices using tools, equipment and consumable materials when working on vehicle bodywork and constructional alignment.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures. **Electrical/electronic systems:** isolation of battery/external electrical sources during work,
electrical shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal procedures, electric welding.

Tools/equipment.
Measurement: engineers' rules, internal/external/vernier callipers, feeler gauges, internal/external micrometers, dial test indicators, vee blocks, surface plates/tables.
Spanners: open-ended, ring, combination, lock, adjustable.
Sockets: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding, bumping blade.
Dollies: toe, button, commer.
Spoons: pry, drip moulding.
Miscellaneous: power tools, levers, supports, stud-removers (devices for removing broken ends), greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, hinge pin remover, hinge setting wrench, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

22.2c Identify the operating principles, main constructional features and operation of main components for vehicle bodies.
Components: doors, hatches, lids (boot/bonnet), roof openings, windows (fixed/ drop/sliding), seats, seat belts/anchorage points, dashboard, interior fittings.
Method of fixture: fastening (bolt/rivet/weld), accuracy of closure/fit, security, elimination of noise/draughts/water ingress.

22.3c Identify routine maintenance and running adjustments necessary on vehicle bodies:
Lubricating/adjusting: handles, hinges, locks, strikers.
Valeting (external/internal): washing, waxing, removal of corrosive residues, cleaning/ vacuuming (soft/hard trim, leather).
Repair of minor paint finish.

22.4c Identify correct settings of vehicle body components.
Door closures: doors, hatches/lids, handles, hinges, locks, strikers, window/roof opening/closing mechanisms, seat belt anchorage points.

22.5c Identify alignment testing procedures using test equipment for vehicle bodywork.
Test equipment: body measuring devices (manual/laser beam/computer), bracket/bracket-less jigs.
Methods of alignment: principles of repair, bracket/bracket-less jigs, hydraulic repair equipment.

22.6c Identify vehicle manufacturers' specifications in the maintenance and testing of vehicle bodywork and constructional alignment.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.
Applications: shape/characteristics of a component, dimensions/location/layout of components, constructional features/methods of repair, procedures, settings/standards.
Constructional features/vehicle manufacturers' procedures for removal for further testing and inspecting.

Unit 22 Chassis Systems 2
Associated Studies Module (d)

Practical competences

The practical competences are incorporated into the modules for this unit.

Knowledge requirements

The instructor must ensure the candidate is able to:

22.1d Identify mensuration operations.
Definitions: cube, cuboid, prism, cone, pyramid, sphere, hemisphere, composite figure/solids, frustum/frusta, segment/sector of a circle.

Calculations.
Surface area: cube, cuboid, prism, cone, pyramid, sphere.
Volume: cube, cuboid, prism, cone, pyramid, sphere.

22.2d Identify geometric operations.
Definitions: Theorem of Pythagoras.
Plane figures: square, rectangle, triangle (acute angled, right angled, obtuse angled, equilateral, isosceles) parallelogram, polygons.

Calculations.
Perimeter/area/diagonals: square, rectangle, triangle.
Right angled triangles: Theorem of Pythagoras applied to any third side.

22.3d Identify the types and properties of materials used in motor vehicle engineering.
Definitions: strength, elasticity, plasticity, ductility, malleability, brittleness, toughness, hardness.

Materials
Metals: ferrous/non-ferrous (differences), cast iron, steel, steel alloys, aluminium (alloys), brass, bronze.
Steels: low/medium/high carbon, ability to be hardened/tempered, mechanical properties after hardening/tempering, case hardening, alloys, alloying elements (nickel, chromium, tungsten, manganese).
Non-ferrous metals: brass/bronze (composition), use/applications (aluminium alloys), copper, brass, bronze, zinc).
Corrosion: main forms, causes, methods of surface protection, effects of acid salt solution/paraffin/petrol/brake fluid/grease on protective surfaces.
Non metals: thermosetting/thermo plastics (differences), glass/carbon fibre reinforced plastics, acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC), ceramics.

22.4d Identify the terms used and calculations associated with gas laws and engine power.
Laws: Boyle's law, Charles's law, general gas law.
Definitions: absolute pressure, gauge pressure, indicated mean effective pressure, brake mean effective pressure, indicated power, mechanical efficiency (engine).
Tests: Morse test (estimate indicated power).
Calculations: Boyle's law, Charles's law, general gas law.

22.5d Identify the terms used and calculations associated with force and momentum.
Laws: Newton's law of motion.
Definitions: force, mass, acceleration, relationship between force/mass/acceleration (force = ma).
Momentum: principle of conservation of momentum, relationship between momentum/mass/velocity (momentum = mv).
Calculations: force, momentum, polygon of forces (resultant/equilibrium of three/more forces).

22.6d Identify the terms used and calculations associated with heat.
Definitions: coefficient of expansion, specific heat capacity, sensible/latent heat (difference), specific latent heat.
Materials: different coefficients of expansion (eg. aluminium alloy piston in a cast iron cylinder).
Calculations: linear/superficial/cubic expansion, specific heat capacity, specific latent heat.

22.7d Identify the types and properties of hydro-carbon fuels.
Definitions: volatility, calorific value, flash point, octane number, cetane number, volatile/non-volatile fuels.
Materials: hydro-carbon fuels (carbon/hydrogen content as used in the internal combustion engine).
Additives: purpose of lead in fuel, leaded/unleaded fuel (differences/effects), alternative additives.

22.8d Identify the types and properties of lubricants.
Definitions: thin film concepts, viscosity, viscosity index, multigrade.
Temperature: effect on viscosity, temperature/viscosity graphs.
Additives: detergent, dispersant, anti-oxidant, corrosion inhibitors, anti-foaming agents, anti-wear, extreme pressure.
Calculations: coefficient of friction, linear friction, frictional torque (bearings, clutch, disk brakes).

22.9d Identify the terms used and calculations associated with hydraulics.
Laws: Pascal's law.
Definitions: incompressibility of fluids, pressure (= force per unit area), force ratio, movement ratio.
Principles of operation: jack, lifting hoist, braking system, intensifier.
Calculations: work done (piston in cylinder).

22.10d Identify the terms used and calculations associated with hydrostatics.
Definitions: density, relative density.
Laws: Archimedes' principle.
Relative density: petrol, alcohol, paraffin, engine oil, cast iron, steel, aluminium, zinc, lead, brass, mercury, glass/carbon fibre reinforce plastics, acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC), ceramics.

22.11d Identify the terms used and calculations associated with electricity.
Definitions: magnetism, self/mutual induction.
Laws: Ampere's rule, Fleming's rule.
Magnetic fields: direction in current carrying conductor.
Chemical effects: electrolytic action (voltaic cell, electroplating, corrosion).
Ohm's Law: function of current (I)/potential difference (V)/resistance (R), V = IR.
Power: product of potential difference/current (direct current circuits), dissipation in simple circuits.
Calculations: Ohm's law, formulae for equivalent resistance of resistors in series/parallel, current/voltage in series/parallel/combined circuits.

22.12d Identify the principles of engineering drawing.
Purpose: detail/assembly/location drawings, relationship between drawing office and workshop.
Information: projection (orthographic first/third angle, isometric, oblique, exploded, free hand sketches), unit of measurement, scale, material/specification, warning notes.
Conventions/abbreviations: types of line, representations of common features, abbreviations in common use.
Dimensioning: from a datum, avoidance of accumulated errors.
Draw: orthographic first/third angle, isometric, oblique, exploded, single plane sectioned views, free hand sketches.

Test specification for written paper Chassis Systems 2 (3905-03-022 and 3905-04-022)

This is a written multiple choice examination paper, lasting 1½ hours and containing 60 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
22a Braking, Steering and Suspension Systems	30
22b Transmission Systems	30
22c Vehicle Bodywork	30
22d Associated Studies (Maths and Science)	10

23 Mathematics, Science and Electronics 1
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

23.1a Apply arithmetic operations to binary/denary numbers.

23.2a Perform algebraic operations.

23.3a Perform and apply graphical operations.

23.4a Perform and apply mensuration operations.

23.5a Perform and apply trigonometric operations.

23.6a Use logarithms and logarithmic expressions.

Knowledge requirements

The instructor must ensure the candidate is able to:

23.1a Identify arithmetic operations to binary/denary numbers.
Definitions/comparisons: binary/denary numbers.
Arithmetic operations: addition/subtraction/multiplication/division of binary numbers.
Convert: denary numbers to binary, binary numbers to denary.

23.2a Identify apply algebraic operations.
Definitions: quadratic equation, factorisation. **Algebraic operations:** factorise by grouping/extraction of common factors.
Calculations: quadratic equations by use of formula, check solutions by substitution into original quadratic equations.

23.3a Identify apply graphical operations.
Definitions: graphs, axis, point of origin, scale, positive/negative coordinates, mid-ordinate rule, Simpson's rule.
Graphs: select axis, determine scale, plot coordinates.
Straight line graphs: corresponding values on each axis, interpolate intermediate values.
For equation y = mx + c (where m/c are given): calculate three coordinates/plot three points, draw a straight line, identify the intercept with the *y* axis/relate to value *c*, calculate the gradient/relate to value m. **Gradients:** positive, negative, zero.
Area under a curve: mid-ordinate rule, Simpson's rule.
Applications: distance-time, velocity-time, determine average values, engine/vehicle performance data.

23.4a Identify apply mensuration operations.
Definitions: cube, cuboid, prism, cone, pyramid, sphere, hemisphere, composite figure/solid, frustum/frusta, segment/sector of a circle.

Calculations.
Surface area: cube, cuboid, prism, cone, pyramid, frustum cone/pyramid, sphere, hemisphere, composite figures.
Volume: cube, cuboid, prism, cone, pyramid, frustum cone/pyramid, sphere, hemisphere, composite solids.
Arc: length of arc of circle (formula s = *r*e).
Segment of circle: area.
Sector of circle: area (formula $A = \frac{1}{2} r^2$e).

23.5a Identify apply trigonometric operations.
Definitions: fractional/surd form, sine/cosine wave.
Sine wave: draw one complete cycle (relating angle of a rotating unit radius to the vertical projection).
Cosine wave: draw one complete cycle (relating angle of a rotating unit radius to the horizontal projection).
Relationships: cos e = sin (90° + e), sin u = cos (90° – e).

Calculations.
Angles: sine/cosine using sin e = cos (90° – e), cos e = sin (90° + e).
Fractional/surd form: sine/cosine/tangent (30°, 45°, 60°).
Electronic calculator: sine/cosine/tangent for a given acute angle, acute angle given its sine/cosine/tangent.

23.6a Identify apply logarithms and logarithmic expressions.
Definitions: logarithms (common, hyperbolic/Napierian/natural), characteristic, mantissa, modulus, for $y = a^x$ $x = log_a y$, for $y = 10^x$ x = lg y, for $y = e^x$ $x = ln\, y$.
Laws of indices (for m and n as positive/negative integers):
$a^m a^n = a^{m+n}$, $a^m/a^n = a^{m-n}$, $(a^m)^n = a^{mn}$, $a^o = 1$, $a^{-n} = 1/a^n$.
Laws of indices (for fractional indices where m/n are positive integers): $a^{1/n} = \sqrt[n]{a}$, $a^{m/n} = \sqrt[n]{a^m}$.
Laws of logarithms: $log_b(MN) = log_b M + log_b N$, $log_b(M/N) = log_b M - log_b N$, $log_b(Na) = a\ log_b N$, (where *b* is any base).
Change of base rule: $log_a(x) = log_b(x) / log_b(a)$.

Calculations.
Indices: evaluate expressions which combine positive/negative/fractional indices.
Laws of logarithms: solve equations using common/natural logarithms.
Write: exponential equations in logarithmic form, logarithmic equations in exponential form.
Calculators/tables: common/natural logarithms/anti-logarithms for given numbers.

Unit 23 Mathematics, Science and Electronics 1
Vehicle Science Module (b)

Practical competences

The candidate must be able to do the following:

23.1b Collect information identifying the types and properties of materials used in motor vehicle engineering.

23.2b Use calculations associated with gas laws and engine power and prepare a report identifying the terms used.

23.3b Use calculations associated with force and momentum and prepare a report identifying the terms used.

23.4b Use calculations associated with heat and prepare a report identifying the terms used.

23.5b Collect information identifying the types and properties of hydro-carbon fuels.

23.6b Collect information identifying the types and properties of lubricants.

23.7b Use calculations associated with hydraulics and prepare a report identifying the terms used.

23.8b Use calculations associated with hydrostatics and prepare a report identifying the terms used.

23.9b Use calculations associated with electricity and prepare a report identifying the terms used.

Knowledge requirements

The instructor must ensure the candidate is able to:

23.1b Identify the types and properties of materials used in motor vehicle engineering.
Definitions: strength, elasticity, plasticity, ductility, malleability, brittleness, toughness, hardness.
Materials.

Metals: ferrous/non-ferrous (differences), cast iron, steel, steel alloys, aluminium alloys, brass, bronze.
Steels: low/medium/high carbon, ability to be hardened/tempered, mechanical properties after hardening/tempering, case hardening, alloys, alloying elements (nickel, chromium, tungsten, manganese).
Non-ferrous metals: brass/bronze (composition), use/applications (aluminium alloys), copper, brass, bronze, zinc).
Corrosion: main forms, causes, methods of surface protection, effects of acid salt solution/paraffin/petrol/brake fluid/grease on protective surfaces.
Non metals: thermosetting/thermo plastics (differences), glass/carbon fibre reinforced plastics, acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC), ceramics.

23.2b Identify the terms used and calculations associated with gas laws and engine power.
Laws: Boyle's law, Charles's law, general gas law.
Definitions: absolute pressure, gauge pressure, indicated mean effective pressure, brake mean effective pressure, indicated power, mechanical efficiency (engine).
Tests: Morse test (estimate indicated power).
Calculations: Boyle's law, Charles's law, general gas law.

23.3b Identify the terms used and calculations associated with force and momentum.
Laws: Newton's law of motion.
Definitions: force, mass, acceleration, relationship between force/mass/acceleration (force=ma).
Momentum: principle of conservation of momentum, relationship between momentum/mass/velocity (momentum=mv).
Calculations: force, momentum.

23.4b Identify the terms used and calculations associated with heat.
Definitions: coefficient of expansion.
Materials: different coefficients of expansion (eg. aluminium alloy piston in a cast iron cylinder).
Calculations: linear/superficial/cubic expansion.

23.5b Identify the types and properties of hydro-carbon fuels.
Definitions: volatility, distillation, calorific value, flash point, octane number, cetane number, volatile/non-volatile fuels.
Materials: hydro-carbon fuels (carbon/hydrogen content as used in the internal combustion engine).
Additives: purpose of lead in fuel, leaded/unleaded fuel (differences/effects), alternative additives.

23.6b Identify the types and properties of lubricants.
Definitions: thin film concepts, viscosity, viscosity index, multigrade.
Temperature: effect on viscosity, temperature/viscosity graphs.
Additives: detergent, dispersant, anti-oxidant, corrosion inhibitors, anti-foaming agents, anti-wear, extreme pressure.

23.7b Identify the terms used and calculations associated with hydraulics.
Laws: Pascal's Law.
Definitions: incompressibility of fluids, pressure (=force per unit area), force ratio, movement ratio.
Principles of operation: jack, lifting hoist, braking system, intensifier.
Calculations: work done (piston in cylinder).
Experiment: hydraulic jack (movement/force ratios).

23.8b Identify the terms used and calculations associated with hydrostatics.
Definitions: density, relative density.
Laws: Archimedes' principle.
Relative density: petrol, alcohol, paraffin, engine oil, cast iron, steel, aluminium, zinc, lead, brass, mercury, glass/carbon fibre reinforce plastics, acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC) ceramics.
Experiments: relative density/volume of bodied immersed in water, floating bodies (carburettor float chamber).

23.9b Identify the terms used and calculations associated with electricity.
Definitions: magnetism, self/mutual induction.
Laws: Ampere's rule, Fleming's rule.
Magnetic fields: direction in current carrying conductor.
Chemical effects: electrolytic action (voltaic cell, electroplating, corrosion).
Calculations: shape of magnetic field (long straight conductor, single/multi turn coil, permanent magnet).
Experiments: current being used for magnetic/chemical effect.

Unit 23 Mathematics, Science and Electronics 1
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

23.1c Use resistors identifying the types and their functions.

23.2c Use capacitors identifying the types and their functions.

23.3c Collect information identifying the types of electro-magnetic and inductive devices and their functions.

23.4c Collect information identifying the types of semi-conductor devices and their functions.

23.5c Collect information identifying the types of electrical switches and their functions.

23.6c Using test equipment identify the effects of over current and the functions of various protective devices.

23.7c Use terminals, connectors and heat sinks identifying the various types and their functions.

23.8c Inspect vehicle systems and identify the construction/operation of devices found in electronic fuel injection systems.

23.9c Inspect vehicle systems and identify the construction/operation of electronic devices found in ignition circuits.

23.10c Inspect vehicle systems and identify the construction/operation of electronic devices found in braking systems.

23.11c Inspect vehicle systems and identify the construction/operation of electronic devices found in charging systems.

23.12c Select and use test equipment.

23.13c Use testing techniques for electrical and electronic components.

23.14c Use testing techniques for sensors, transducers, actuators, input and output devices.

Knowledge requirements

The instructor must ensure the candidate is able to:

23.1c Identify the features of resistors.
Definitions: unit of resistance (Ohms, Ω).
Types/use: carbon composite, wirewound, metal film, variable.
Selection factors: ohmic value, power rating, stability, tolerance.
Identification: British Standard (BS3939)/International symbols, colour/printed codes.

23.2c Identify the features of capacitors.
Definitions: unit of capacitance (Farad, F).
Types/use: electrolytic, tantalum, mica, ceramic, polyester, variable, trimmer.
Selection factors: capacitance value, working voltage, leakage current, polarised, non-polarised, frequency of operation, stability, tolerance.
Identification: British Standard (BS3939)/International symbols, colour/printed codes.

23.3c Identify the types and features of electro-magnetic and inductive devices.
Definitions: unit of inductance/self inductance (henry, H), electro-magnetism, inductance (mutual, self).
Devices/use: solenoid, electro-magnet, choke, inductive switch, transformer, relay, ignition coil.
Identification: British Standard (BS3939)/International symbols.

23.4c Identify the types and features of semi-conductor devices.
Definitions: N-type material, P-type material, NTC (N-type semi-conductor), PTC (P-type semi-conductor), LED (light emitting diode).
Devices/use: P-N junction diode, zener diode, LEDs, rectifier/signal, photo-diode, transistor, thyristor, diac, triac, thermistor, heat sink.
Identification: British Standard (BS3939)/International symbols.

23.5c Identify the types and features of electrical switches.
Definitions: S.P.S.T. (single pole single throw), S.P.D.T. (single pole double throw), D.P.S.T. (double pole single throw), D.P.D.T. (double pole double throw).
Types/use: normally open, normally closed, operation (make before break, break before make), toggle, slide, micro, reed, barrel key, mercury, push button.
Identification: British Standard (BS3939)/International symbols.

23.6c Identify the effects of overcurrent and the types/features of protective devices.
Definitions: overcurrent, (overload/short circuit situations).
Devices/use: fuse (glass, blade, ceramic), fusible links, circuit breakers.
Selection factors: operating/fusing time/current, current rating.
Identification: British Standard (BS3939)/International symbols.

23.7c Identify the types and features of terminals, connectors and heat sinks.
Definitions: terminals, connectors, heat sinks.
Terminals/connectors: single/multi pin connectors, component terminal block, harness block connector.
Selection factors: light/heavy current, polarisation, waterproofing.

23.8c Identify the construction and operation of devices found in electronic fuel injection systems.
Devices: fuel injector (injection valve/injection mixer types), cold start valve, fuel pump, fuel pump relay, air flow meter/sensor, air temperature sensor, fuel pump switch, throttle position sensor, throttle valve switch, air valve/bypass air control valve, fuel level indicator, engine temperature sensor, thermo time switch.

23.9c Identify the construction and operation of electronic devices found in ignition circuits.
Devices: inductive pick-up (Hall effect, LED/photodiode ignition distributor), engine speed sensor, engine vacuum sensor, air conditioning switch, crankshaft sensor, knock sensor.

23.10c Identify the construction and operation of electronic devices found in braking systems.
Devices: wheel speed sensor, solenoid valve, pressure switch, stroke switch.

23.11c Identify the construction and operation of electronic devices found in charging systems.
Devices: diode rectifier, voltage regulator.

23.12c Identify the selection, use and care of test equipment.
Test equipment: multimeter (analogue, digital), power supply unit (PSU), thermometers.
Specifications: devices to be tested, operation/range of test equipment.

23.13c Identify the testing techniques for electrical/electronic components.
Components: resistors (various), capacitors (polarised, non-polarised), coils/ solenoids/transformers, diodes (various), transistors (two diode theory), thyristors (various), thermistors (NTC, PTC), switches (various), fuses/circuit breakers (various).

23.14c Identify the testing techniques for sensors, transducers, actuators, input and output devices.
Devices: fuel injector, cold start valve, fuel pump, relay (various), temperature sensor (various), solenoid device (various), position sensor, fuel level indicator.

Test specification for written paper Mathematics, Science and Electronics 1 (3905-04-023)

This is a written multiple choice examination paper, lasting 1½ hours and containing 60 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
23a Mathematics	34
23b Vehicle Science	33
23c Vehicle Electronic Systems	33

Vehicle Systems Practical (3905-03-024 and 3905-04-024)

Assessment of the practical skills at each level of this programme is by completion of the tasks listed under practical competences. For each unit there is a competence checklist against which successful performance is recorded. It is expected that a candidate will have successfully completed each of the activities before being credited with a specific skill. Wherever possible competence should be demonstrated in the workplace or in a realistic work environment.

Candidates must demonstrate competence in all of the topics.

Centres should copy the practical assessment sheets for EACH candidate. Completed sheets for each candidate must be available for inspection by the Visiting Assessor, or submission to City & Guilds on request.

The Visiting Assessor must make a visit to the assessment centre on at least one occasion each year at a time when practical assessments are taking place. The main purpose of this visit is to ensure that the competence checklists are being completed accurately and in accordance with the regulations for assessment of this programme.

Please refer to the **Role and Duties of the Visiting Assessor** in Appendix B.

Unit 21 Engine Systems 2
Petrol/Diesel Engines and Fuel Systems Module (a)

Practical competences

The candidate must be able to do the following:

21.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of petrol/diesel engines and fuel systems. ☐

21.2a Identify the operating principles, main constructional features and operation of main components for petrol/diesel engines and fuel systems. ☐

21.3a Carry out routine maintenance and system adjustments on petrol/diesel engines and fuel systems. ☐

21.4a Carry out a vehicle inspection identifying the effects of incorrect adjustments/faults on petrol/diesel engines and fuel systems. ☐

21.5a Carry out systematic testing procedures using test equipment on petrol/diesel engines and fuel systems. ☐

21.6a Use vehicle manufacturers' specifications in the maintenance and testing of petrol/diesel engines and fuel systems. ☐

21.7a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 21 Engine Systems 2
Spark Ignition and Electrical/Electronic Systems Module (b)

Practical competences

The candidate must be able to do the following:

21.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle spark ignition and electrical/electronic systems. ☐

21.2b Identify the operating principles, main constructional features and operation of main components for vehicle spark ignition and electrical/electronic systems. ☐

21.3b Carry out routine maintenance and running adjustments necessary on vehicle spark ignition and electrical/electronic systems. ☐

21.4b Carry out vehicle inspections identifying the effects of incorrect adjustments/faults on spark ignition and electrical/electronic systems. ☐

21.5b Carry out systematic testing procedures using test equipment for vehicle spark ignition and electrical/electronic systems. ☐

21.6b Use vehicle manufacturers' specifications in the maintenance and testing of vehicle spark ignition and electrical/electronic systems. ☐

21.7b Use mathematics and science in the above Practical Competences.

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 21 Engine Systems 2
Cooling Systems Module (c)

Practical competences

The candidate must be able to do the following:

21.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of cooling systems. ☐

21.2c Identify the operating principles, main constructional features and operation of main components for vehicle cooling systems. ☐

21.3c Carry out routine maintenance and running adjustments necessary on vehicle cooling systems. ☐

21.4c Carry out vehicle inspections identifying the effects of incorrect adjustments/faults on vehicle cooling systems. ☐

21.5c Carry out systematic testing procedures using test equipment for vehicle cooling systems. ☐

21.6c Use vehicle manufacturers' specifications in the maintenance and testing of vehicle cooling systems. ☐

21.7c Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 22 Chassis Systems 2
Braking, Steering and Suspension Systems Module (a)

Practical competences

The candidate must be able to do the following:

22.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle braking, steering and suspension systems. ☐

22.2a Identify the operating principles, main constructional features and operation of main components for vehicle braking, steering and suspension systems. ☐

22.3a Carry out routine maintenance and running adjustments necessary on vehicle braking, steering and suspension systems. ☐

22.4a Carry out a vehicle inspection identifying the effects of incorrect adjustments/faults on vehicle braking, steering and suspension systems. ☐

22.5a Carry out systematic testing procedures using test equipment for vehicle braking, steering and suspension systems. ☐

22.6a Use vehicle manufacturers' specifications in the maintenance and testing of vehicle braking, steering and suspension systems. ☐

22.7a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 22 Chassis Systems 2
Transmission Systems Module (b)

Practical competences

The candidate must be able to do the following:

22.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units. ☐

22.2b Identify the operating principles, main constructional features and operation of main components for vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units. ☐

22.3b Carry out routine maintenance and running adjustments necessary on vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units. ☐

22.4b Carry out vehicle inspections identifying the effects of incorrect adjustments/faults on vehicle clutch, gearbox, propeller/drive shafts and final drive/differential units. ☐

22.5b Carry out systematic testing procedures using test equipment for vehicle, clutch, gearbox, propeller/drive shafts and final drive/ differential units. ☐

22.6b Use vehicle manufacturers' specifications in the maintenance and testing of vehicle clutch, gearbox, propeller/drive shafts and final drive/ differential units. ☐

22.7b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 22 Chassis Systems 2
Vehicle Bodywork Module (c)

Practical competences

The candidate must be able to do the following:

22.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle bodywork and constructional alignment. ☐

22.2c Identify the operating principles, main constructional features and operation of main components for vehicle bodywork. ☐

22.3c Carry out routine maintenance and running adjustments necessary on vehicle bodywork. ☐

22.4c Carry out vehicle inspections identifying misalignment of vehicle body components. ☐

22.5c Prepare a report identifying alignment test procedures using test equipment for vehicle bodywork. ☐

22.6c Prepare a report identifying vehicle manufacturers' specifications in the maintenance and testing of vehicle bodywork and constructional alignment. ☐

22.7c Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 23 Mathematics, Science and Electronics 1
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

23.1a Apply arithmetic operations to binary/ denary numbers. ☐

23.2a Perform algebraic operations. ☐

23.3a Perform graphical operations. ☐

23.4a Perform mensuration operations. ☐

23.5a Perform trigonometric operations. ☐

23.6a Use logarithms and logarithmic expressions. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 23 Mathematics, Science and Electronics 1
Vehicle Science Module (b)

Practical competences

The candidate must be able to do the following:

23.1b Collect information identifying the types and properties of materials used in motor vehicle engineering. ☐

23.2b Use calculations associated with gas laws and engine power and prepare a report identifying the terms used. ☐

23.3b Use calculations associated with force and momentum and prepare a report identifying the terms used. ☐

23.4b Use calculations associated with heat and prepare a report identifying the terms used. ☐

23.5b Collect information identifying the types and properties of hydro-carbon fuels. ☐

23.6b Collect information identifying the types and properties of lubricants. ☐

23.7b Use calculations associated with hydraulics and prepare a report identifying the terms used. ☐

23.8b Use calculations associated with hydrostatics and prepare a report identifying the terms used. ☐

23.9b Use calculations associated with electricity prepare a report identifying the terms used. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 23 Mathematics, Science and Electronics 1
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

23.1c Use resistors identifying the types and their functions. ☐

23.2c Use capacitors identifying the types and their functions. ☐

23.3c Collect information identifying the types of electro-magnetic and inductive devices and their functions. ☐

23.4c Collect information identifying the types of semi-conductor devices and their functions. ☐

23.5c Collect information identifying the types of electrical switches and their functions. ☐

23.6c Using test equipment identify the effects of over current and the functions of various protective devices. ☐

23.7c Use terminals, connectors and heat sinks identifying the various types and their functions. ☐

23.8c Inspect vehicle systems and identify the construction/operation of devices found in electronic fuel injection systems. ☐

23.9c Inspect vehicle systems and identify the construction/operation of electronic devices found in ignition circuits. ☐

23.10c Inspect vehicle systems and identify the construction/operation of electronic devices found in braking systems. ☐

23.11c Inspect vehicle systems and identify the construction/operation of electronic devices found in charging systems. ☐

23.12c Select and use test equipment. ☐

23.13c Use testing techniques for electrical and electronic components. ☐

23.14c Use testing techniques for sensors, transducers, actuators, input and output devices. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 25 Engine Systems 3
Petrol/Diesel Engines and Fuel Systems Module (a)

Practical competences

The candidate must be able to do the following:

25.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of petrol/diesel engines and fuel systems.

25.2a Prepare a report describing the operating principles and main components of four stroke petrol/diesel engines and fuel systems.

25.3a Carry out fault testing procedures using test equipment and diagnostic techniques for petrol/ diesel engines and fuel systems.

25.4a Carry out the use, care, calibration and storage of petrol/diesel engines and fuel systems diagnostic equipment.

25.5a Carry out systematic overhaul procedures for petrol/diesel engines and fuel systems.

25.6a Prepare a report identifying the standard terms and definitions for petrol/diesel engines and fuel systems.

25.7a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

25.1a Describe safe working practices using tools, equipment and consumable materials when working on petrol/diesel engines and fuel systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Electrical/electronic systems: isolation of battery/external sources during work, electric shock, shorts to earth, correct polarity, heat sinks, damage to components/ units due to removal/testing procedures.

Tools/equipment.
Measurement: engineers' rule, internal/external/vernier callipers, feeler gauges, dial test indicators, vee blocks, surface plates/tables, external/internal micrometers, feeler/ cylinder/pressure gauges.
Spanners: open-ended, ring, combination, lock, adjustable.
Socket: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic, timber (mallet), sliding.
Miscellaneous: power tools, levers, supports, stud removers, greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

25.2a Describe the operating principles and main components of four stroke petrol/diesel engines and fuel systems.
Engine systems.
Camshafts: bearing, thrust face, variable valve timing.
Pistons: compression height, thrust face, crown, ring lands/grooves, expansion slots, skirt, gudgeon pin (semi/fully floating), nominal size/oversize.
Piston rings: material/construction of compression/scraper rings.
Connecting rods: big/little end, retaining cap.
Crankshaft: main journal, crank pin, nominal/oversize thrust bearings, web, balance, flywheel/camshaft drive location.
Oil pump: common types, driving methods, release valves.
Oil filters: strainers, by-pass/full flow types. **Gaskets/fluid seals:** cylinder head to block, sump to block, valve cover to block, timing case to block, dynamic oil throwers, oil returns, poppet valves, crankshafts.

Fuel systems.
Principles: fuel feed, fuel ignition, exhaust gas products (correct/rich/weak mixtures).
Petrol systems: fuel tank, filters, fuel lines, carburettor/injector, external mechanical/electronic control systems, mechanical/electrical fuel pumps, sensors.
Diesel systems: fuel tank, fuel filters/agglomerators, low pressure fuel lines/unions, fuel lift pump, in line (multi plunger) fuel injection pump, rotary fuel injection pump, governor (mechanical/hydraulic/electronic), high pressure fuel lines/unions, fuel injectors (multi/single hole), fuel line heaters, cold start aids, sensors.

25.3a Describe fault testing procedures using test equipment and diagnostic techniques for petrol/diesel engines and fuel systems.
Engine systems.
Symptoms: poor/non-starting, over/under revving, resistance to crank rotation, misfire/uneven running, cutting-out, hesitation, detonation/pinking/knocking, excessive fuel consumption, lack of power, running-on, oil/coolant leaks/contamination, exhaust leaks/pollutants, black/blue/white smoke, excessive oil consumption, overheating/overcooling, fuel leaks/odours, abnormal mechanical noises.

Fuel systems.
Symptoms: poor/non-starting, misfire/uneven running, cutting-out, hesitation, detonation/ pinking/knocking, excessive fuel consumption, lack of power, running-on, oil/fuel leaks, oil/fuel contamination, exhaust leaks/pollutants, black/blue/white smoke, overheating/overcooling, fuel leaks/odours, abnormal mechanical noises.

25.4a Identify the use, care, calibration and storage of petrol/diesel engines and fuel systems diagnostic equipment.
Diagnostic equipment: oscilloscopes, engine analysers, emission analysers, smoke meters, hand-held system testers (including fault code readers), multimeters, electronic diagnostic equipment, dedicated test equipment.
System functions: automatic choke operation, idle speeds, induction manifold pressure, fuel consumption, exhaust emissions.

25.5a Identify systematic overhaul procedures for petrol/diesel engines and fuel systems.
Sequence of dismantling/assembly: technique of joining, position of joints, inter-relationship/identification of parts, tolerances, protection of parts against damage/corrosion/contamination.
General rules for disassembly/assembly: operation of unit/component, assembly drawings/specifications, plan sequence of operations, parts/tools kept clean, contamination prevention, correct fasteners/tools.
Tools/test equipment: stripping to gain access to sub-assemblies, assessment of condition by visual means, assessment of wear using instruments.
Jointing application: strength, nature/type/size of materials to be joined, permanent/non-permanent, proximity to other unit parts, damage to other parts/components, cleanliness, burr removal, anti-corrosive measures, dry soldered joints, over-tightening, misalignment, stress/failure.

25.6a Identify the standard terms and definitions for petrol/diesel engines and fuel systems overhaul.
Technical drawings, line/block diagrams, operations schedules, datasheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures/parts lists, electrical wiring diagrams.
Applications: shape/characteristics of component, dimensions/location/layout of components, constructional features/methods of repair, procedures, settings/standards, tolerances (limits/fits).

25.7a The use of mathematics and science is applied to the above Knowledge Requirements.

Unit 25 Engine Systems 3
Spark Ignition and Electrical/Electronic Systems Module (b)

Practical competences

The candidate must be able to do the following:

25.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle spark ignition and electrical/electronic systems.

25.2b Prepare a report describing the operating principles and main components of vehicle spark ignition and electrical/electronic systems.

25.3b Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle spark ignition and electrical/electronic systems.

25.4b Carry out the use, care, calibration and storage of vehicle spark ignition and electrical/ electronic systems diagnostic equipment.

25.5b Carry out systematic overhaul procedures for vehicle spark ignition and electrical/electronic systems.

25.6b Prepare a report identifying the standard terms and definitions for vehicle spark ignition and electrical/electronic systems.

25.7b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

25.1b Describe safe working practices using tools, equipment and consumable materials when working on vehicle spark ignition and electrical/electronic systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Electrical/electronic systems: isolation of battery/external sources during work, electric shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal/testing procedures, electric welding.

Tools/equipment.
Measurement: engineers' rule, internal/external/vernier callipers, dial test indicators, vee blocks, surface plates/tables, external/internal micrometers, feeler/cylinder/pressure gauges.
Spanners: open-ended, ring, combination, lock, adjustable.
Socket: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screw drivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports,
stud removers, greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

25.2b Describe the operating principles and main components of vehicle spark ignition and electrical/electronic systems.

Spark ignition systems.

Systems: contact breaker, contact breakerless.
Contact breaker: with/without ballast resistor.
Contact breakerless: magnetic reluctor, Hall effect trigger/amplifier.
Components: ignition switch, ballast resistor, resistive cable, ignition coil, distributor/cap, contact breaker assembly, rotor arm (resistive/speed limiting), vacuum advance/retard unit, centrifugal advance mechanism, high tension leads/connectors, radio interference suppression devices, spark plugs (heat ranges), capacitor, amplifier, magnetic reluctor, Hall effect trigger.

Electrical/electronic systems.

Electrical/electronic circuits/components/units: parallel/series/earth return circuits, generator/storage, starter systems, motor/drive assemblies, lights, heating elements, switches/relays, conductors/terminations, circuit protection devices, driver information circuits.
Generator: basic types of alternator with voltage regulator only.
Battery: lead acid, low/no maintenance types.
Motors/drivers: starter, wipers, pumps, accessories.
Lamps: bulbs, bulb holders, housing, lenses.
Heating: glass elements (front/rear screens, external mirrors), seats.
Switches/relays: intermittent/continuous/time delay relays, direction indicator flasher, hazard warning.
Cables: sizes, ratings, colour coding, loom/ harness.
Terminations: ratings, common crimped, clamped, soldered, cable connectors.
Fuses: glass encased, ceramic, cartridge, fusible link, reset overloads.
Gauges/instruments: temperature, pressure, speed, fluid level, thermal/air cooled, voltage stabilisers, warning lamps.
Sensors: pressure, temperature, fluid levels, wear, rotation, position.
Control: electronic control units (ECU).
Ignition switch: barrel/lock assembly.
Horns: high frequency, windtone, air.

In-car entertainment.

Types: radio, tape player, compact disc player, single/multiple speaker.
Layout: systems/major components.
Components: radio, tape cassette player, compact disc player, integrated units, power amplifiers, equalisers/boosters, speakers/speaker fittings, suppression devices, aerials (manual, electric, screen type, single/twin).
Mobile telephones: hands free.

Central locking system.

Types: transistorised control, capacitor control.
Layout: systems/major components.
Components: door locking solenoid/switch, lock/unlock relay/control unit.

25.3b Describe fault testing procedures using test equipment and diagnostic techniques for vehicle spark ignition and electrical/electronic systems.

Spark ignition systems.

Symptoms: poor/non starting, lack of power, hesitation, misfire/uneven running, running on, cutting out, detonation/pinking/knocking, exhaust leaks/pollutants, radio interference, overheating.

Electrical/electronic systems.

Battery: under/over charging, corrosion of terminals, casing cracks/leaks.
Alternator: noisy operation, operation of warning system (meter/warning light), incorrect output.
Lighting: non/intermittent operation, low lighting intensity, headlight beam misalignment.
Starting: low engine cranking speed, unusual noise during operation, non-operation of starting system, incorrect pinion engagement/disengagement.
Instrumentation/driver information circuitry: non/intermittent/slow operation, incorrect readings, driver information symbols.
Horns: non/continuous operation, poor tone quality.
Wipers/washers: non/intermittent/slow operation, unusual noise, incorrect parking/swept area, blade lift, screen smearing, arm/blade judder, faulty spray pattern.
In-car entertainment: non operation of units (display does/does not illuminate), CD/cassette operates but radio system does not, individual speakers do not operate, electrical radio aerial fails to extend/retract correctly, loss of 'security code'.
Central locking: individual/all locks fail to operate, continuous cycling of door locking mechanism.

25.4b Identify the use, care, calibration and storage of vehicle spark ignition and electrical/electronic systems diagnostic equipment.

Diagnostic equipment: oscilloscopes, engine analysers, hand-held system testers (including fault code readers), multimeters, electronic diagnostic equipment, dedicated test equipment.
Screen patterns: superimposed, parade, raster, primary/secondary circuits.
System functions: reluctor/pick up air gap, dwell time period, Hall effect, optical switching voltage.

25.5b Identify systematic overhaul procedures for vehicle spark ignition and electrical/electronic systems.
Sequence of dismantling/assembly: technique of joining, position of joints, inter-relationship/identification of parts, tolerances, protection of parts against damage/ corrosion/contamination.
General rules for disassembly/assembly: operation of unit/component, assembly drawings/specifications, plan sequence of operations, parts/tools kept clean, contamination prevention, correct fasteners/tools.
Tools/test equipment: stripping to gain access to sub-assemblies, assessment of condition by visual means, assessment of wear using instruments.
Jointing application: strength, nature/type/size of materials to be joined, permanent/non-permanent, proximity to other unit parts, damage to other parts/components, cleanliness, burr removal, anti-corrosive measures, dry soldered joints, over-tightening, misalignment, stress/failure.

25.6b Identify the standard terms and definitions for vehicle spark ignition and electrical/electronic systems overhaul.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.
Applications: shape/characteristics of component, dimensions/location/layout of components, constructional features, methods of repair, procedures, settings/standards, tolerances (limits/fits).

Unit 25 Engine Systems 3
Engine Auxiliary Systems Module (c)

Practical competences

The candidate must be able to do the following:

25.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of engine auxiliary systems.

25.2c Prepare a report describing the operating principles and main components of engine auxiliary systems.

25.3c Carry out fault testing procedures using test equipment and diagnostic techniques for engine auxiliary systems.

25.4c Carry out the use, care, calibration and storage of engine auxiliary systems diagnostic equipment.

25.5c Carry out systematic overhaul procedures for engine auxiliary systems.

25.6c Prepare a report identifying the standard terms and definitions for engine auxiliary systems.

25.7c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

25.1c Describe safe working practices using tools, equipment and consumable materials when working on engine auxiliary systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Electrical/electronic systems: isolation of battery/external sources during work, electric shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal/testing procedures, electric welding.

Tools/equipment.
Measurement: engineers' rules, internal/external/ vernier callipers, dial test indicators, vee blocks, surface plates/tables, external/internal micrometers, feeler/cylinder/pressure gauges.
Spanners: open-ended, ring, combination, lock, adjustable.
Socket: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports,
stud removers, greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

25.2c Describe the operating principles and main components of engine auxiliary systems.
Systems: heat exchangers/intercoolers, oil coolers, emission control, positive crankcase ventilation, air induction (into exhaust manifold), exhaust gas re-circulation, induction/exhaust systems, catalytic converters, programmed engine management systems, turbochargers/superchargers, cold start devices, retarders (electrical/hydraulic), exhaust brakes.

25.3c Describe fault testing procedures using test equipment and diagnostic techniques for engine auxiliary systems.
Symptoms: poor/non starting, lack of power, hesitation, noise, misfire/uneven running, running on, cutting out, detonation/pinking/knocking, exhaust leaks/pollutants, radio interference, overheating, oil leakage, excessive fuel consumption.

25.4c Identify the use, care, calibration and storage of engine auxiliary systems diagnostic equipment.
Systems: heat exchangers, oil coolers, emission control, positive crankcase ventilation, air induction (into exhaust manifold), exhaust gas re-circulation, catalytic converters, programmed engine management systems, intercoolers, induction/exhaust systems, turbochargers/superchargers, cold start devices, retarders (electrical/hydraulic), exhaust brakes.

25.5c Identify systematic overhaul procedures for engine auxiliary systems.
Sequence of dismantling/assembly: technique of joining, position of joints, inter-relationship/identification of parts, tolerances, protection of parts against damage/ corrosion/contamination.
General rules for disassembly/assembly: operation of unit/component, assembly drawings/specifications, plan sequence of operations, parts/tools kept clean, contamination prevention, correct fasteners/tools.
Tools/test equipment: stripping to gain access to sub-assemblies, assessment of condition by visual means, assessment of wear using instruments.
Jointing application: strength, nature/type/size of materials to be joined, permanent/non-permanent, proximity to other unit parts, damage to other parts/components, cleanliness, burr removal, anti-corrosive measures, dry soldered joints, over-tightening, misalignment, stress/failure.

25.6c Identify the standard terms and definitions for engine auxiliary systems overhaul.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.
Applications: shape/characteristics of component, dimensions/location/layout of components, constructional features, methods of repair, procedures, settings/standards, tolerances (limits/fits).

Test specification for written paper Engine Systems 3 (3905-03-025 and 3905-04-025)

This is a written examination paper, lasting 2 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
25a Petrol/Diesel Engines and Fuel Systems	30
25b Spark Ignition and Electrical/Electronic Systems	30
25c Engine Auxiliary Systems	30
26d Associated Studies (Maths and Science)	10

Unit 26 Chassis Systems 3
Braking, Steering and Suspension Systems Module (a)

Practical competences

The candidate must be able to do the following:

26.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle braking, steering and suspension systems.

26.2a Prepare a report describing the operating principles and main components of vehicle braking, steering and suspension systems.

26.3a Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle braking, steering and suspension systems.

26.4a Carry out the use, care, calibration and storage of vehicle braking, steering and suspension systems diagnostic equipment.

26.5a Carry out systematic overhaul procedures for vehicle braking, steering and suspension systems.

26.6a Prepare a report identifying the standard terms and definitions for vehicle braking, steering and suspension systems.

26.7a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

26.1a Describe safe working practices using tools, equipment and consumable materials when working on vehicle braking, steering and suspension systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton). Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components. Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Electrical/electronic systems: isolation of battery/external sources during work, electric shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal/testing procedures, electric welding.

Tools/equipment.
Measurement: engineers' rules, internal/external/ vernier callipers, dial test indicators, vee blocks, surface plates/tables, external/internal micrometers, feeler/cylinder/pressure gauges.
Spanners: open-ended, ring, combination, lock, adjustable.
Socket: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports,
stud removers, greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, brake efficiency test equipment (portable), roller type brake testers, brake bleeding devices, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

26.2a Describe the operating principles and main components of vehicle braking, steering and suspension systems.

Braking systems.

Types: disc brakes, drum brakes, rear brake pressure limiting/regulating devices, vacuum/hydraulic servo assisted, diagonal split operation, anti-lock braking system (ABS).

Purpose: reduce vehicle speed, stop vehicle. **Operating principles:** use of friction to slow/stop/hold vehicle, use of levers/rods/ cables/hydraulics to transmit driver's effort, use of levers/ hydraulics/engine manifold depression/vacuum pump to supplement driver's effort, means of compensating/equalising braking force, use of split systems, calculation of braking efficiency from a given total retarding force/vehicle mass.

Factors affecting stopping distance: weight transference when braking, brake fade, vehicle stability when braking.

Layout: basic braking systems/major components, parking brake.

Components: master cylinder (single/tandem), wheel cylinder, fixed/swinging/sliding callipers (single/tandem), pipes/flexible hoses, brake shoes (leading/trailing), asbestos/ asbestos free linings, brake pads, brake discs, brake drum, handbrake operating mechanism, pedal, limiting/load sensitive regulating valves, adjusters/self adjusting mechanisms, brake fluid, stop lamp actuator switch, wear/level/pressure indicating circuits.

Steering systems.

Non-assisted: single track rod, divided track rod.

Assisted: constant pressure, constant flow. **Four wheel:** power assisted front steering box mechanical rear steering box, power assisted/electronic control front/rear steering box.

Layout: steering systems/major components.

Components: steering wheel/column, steering gearboxes, rack and pinion, boxes using idlers, steering idlers, steering joints, swivel/king pin assemblies, McPherson struts, front hubs, bearings/seals, drop arms, drag links, track arms, track rods.

Power assisted components.

Constant flow system: pump, control, reactive valve, ram cylinder.

Constant pressure: hydraulic accumulator, pump, control valve.

Power assisted rack and pinion: pump, spool control valve, steering box/ram.

Four wheel steering components.

Mechanical systems: front/centre/rear steering box.

Hydraulic/electronic systems: front/rear power steering box, steering angle transfer shaft, reservoir, power steering pump, speed sensor, electronic control unit (ECU), relay, timer.

Front/rear suspension systems.

Types: independent, non-independent.

Layout: suspension systems/major components,

Components: beam axle, live axle, strut/McPherson strut, wishbone, trailing arm/semi trailing arm, swinging arm, torsion beam, De-Dion, manually adjusted ride height, manually adjustable damper type, rear wheel steering systems, suspension arms/links, springs (leaf, coil, torsion, rubber, gas with mechanical/hydraulic operation), suspension dampers (telescopic/lever arm), swivel pins/McPherson struts, swivel pins/ball joints, bushes, location rods/linkages, anti-roll bars, sub-frame assemblies, leaf spring shackles/locating devices, axles/hubs/struts acting as suspension members/chassis mounting points, bound/rebound stops.

Self-levelling hydro pneumatic system (including active suspension systems): electronic control unit (ECU), solenoid valves, regulating valves, pumps, accumulators, height connection valves.

26.3a Describe fault testing procedures using test equipment and diagnostic techniques for vehicle braking, steering and suspension systems.

Braking systems.

Symptoms: reduced braking efficiency, uneven braking, brake judder/vibration/drag/ grab/fade, illumination of brake symbol on instrument panel (including failure of anti-lock braking system – ABS), excessive brake pedal/lever travel, spongy pedal movement, brake fluid loss, total loss of braking, premature component failure, drum wear/ovality, disc wear/run out.

Steering systems.

Symptoms: abnormal/uneven tyre wear, heavy steering, pulling to one side, inadequate self centring, wandering, misalignment of the steering wheel, excessive free play, vibration, noise, lack of power assistance, lack of four wheel steering.

Suspension systems.

Symptoms: excessive tyre/component wear, premature component failure, vibration/noise, uneven braking, steering pull, incorrect trim height, axle misalignment, excessive pitch/roll, vehicle instability, poor handling/ ride quality.

26.4a Identify the use, care, calibration and storage of vehicle braking, steering and suspension systems diagnostic equipment.
Braking systems.
Diagnostic equipment: hand instruments (measuring devices), oscilloscopes, hand-held system testers (including fault code readers), multimeters, electronic diagnostic equipment, portable/roller type brake testers, axle/suspension alignment, pressure test, shuffle plates, damper test, dedicated test equipment.

Steering systems.
Diagnostic equipment: turn plates, optical wheel alignment (laser/light projection).
Measurements: steering geometry (wheel alignment, toe out on turns, castor, camber, swivel/king pin inclination, wheel base, front/rear axle alignment, hub end float/torque settings, wheel balance, wheel nut torque, power steering system operation).

Suspension systems.
Diagnostic equipment: axle/suspension alignment, pressure test, shuffle plates, damper test, dedicated test equipment, hand-held system testers (including fault code readers).

26.5a Identify systematic overhaul procedures for vehicle braking, steering and suspension systems.
Sequence of dismantling/assembly: technique of joining, position of joints, inter-relationship/identification of parts, tolerances, protection of parts against damage/ corrosion/contamination.
General rules for disassembly/assembly: operation of unit/component, assembly drawings/ specifications, plan sequence of operations, parts/tools kept clean, contamination prevention, correct fasteners/tools.
Tools/test equipment: stripping to gain access to sub-assemblies, assessment of condition by visual means, assessment of wear using instruments.
Jointing application: strength, nature/type/size of materials to be joined, permanent/non-permanent, proximity to other unit parts, damage to other parts/components, cleanliness, burr removal, anti-corrosive measures, dry soldered joints, over-tightening, misalignment, stress/failure.

26.6a Identify the standard terms and definitions for vehicle braking, steering and suspension systems overhaul.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.
Applications: shape/characteristics of component, dimensions/location/layout of components, constructional features, methods of repair, procedures, settings/standards, tolerances (limits/fits).

Unit 26 Chassis Systems 3
Manual and Automatic Gearboxes Module (b)

Practical competences

The candidate must be able to do the following:

26.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle manual and automatic gearboxes.

26.2b Prepare a report describing the operating principles and main components of vehicle manual and automatic gearboxes.

26.3b Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle manual and automatic gearboxes.

26.4b Carry out routine maintenance and running adjustments necessary on vehicle automatic gearboxes.

26.5b Carry out the use, care, calibration and storage of vehicle manual and automatic gearbox diagnostic equipment.

26.6b Carry out systematic overhaul procedures for vehicle manual and automatic gearboxes.

26.7b Prepare a report identifying the standard terms and definitions for vehicle manual and automatic gearboxes.

26.8b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

26.1b Describe safe working practices using tools, equipment and consumable materials when working on vehicle manual and automatic gearboxes.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Electrical/electronic systems: isolation of battery/external sources during work, electric shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal/testing procedures, electric welding.

Tools/equipment.
Measurement: engineers' rule, internal/external/vernier callipers, dial test indicators, vee blocks, surface plates/tables, external/internal micrometers, feeler/cylinder/pressure gauges.
Spanners: open-ended, ring, combination, lock, adjustable.
Socket: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports,
stud removers, greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, hydraulic system bleeding equipment, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

26.2b Describe the operating principles and main components of vehicle manual and automatic gearboxes.

Automatic gearboxes.

Purpose: multiply engine torque to suit varying load, reverse, permanent neutral, automatic gear changing.

Operating principles: power flow through gears, layout of gear shaft/bearings/pulley/belts, fixed ratio with torque converter, constantly variable, epicyclic gear arrangements (direct drive, increase/reduction in speed, reverse direction).

Layout: front engine rear wheel drive, front engine front wheel drive, rear engine rear wheel drive, fixed ratio/constant variable (stepless), semi/fully automatic.

Components: types of gears (including epicyclic), torque converter, unidirectional clutch, shafts, bearings, seals, gaskets, inhibitor/reverse light switch, brake band clutches/actuating mechanisms, pump/control mechanisms, throttle signalling devices, oil coolers, valve blocks, transmission drive belts, pulleys, load/speed sensing devices, speedometer drive devices, gear selector mechanism.

Manual gearboxes.

Purpose: utilise engine torque characteristics effectively, reverse, neutral.

Operating principles: torque multiplication using different gear sizes/simple epicyclic gear set, selection of gears, four/five speed synchromesh gearboxes, difference between manual/automatic gearboxes.

Layout: front engine rear wheel drive, front engine front wheel drive, rear engine rear wheel drive, mid engine rear wheel drive.

Components: direct/indirect mechanically operated gear change mechanisms, speedometer drive arrangements, reversing light switch, mountings.

Clutch.

Layouts: operating mechanisms/assemblies.

Components: cables, self-adjusting mechanisms, master cylinders, slave cylinders, pressure plate/cover, centre plate, release bearings, first motion shaft front support bearing (spigot), release bearing, hydraulic pipes.

26.3b Describe fault testing procedures using test equipment and diagnostic techniques for vehicle manual and automatic gearboxes.

Automatic gearboxes.

Symptoms: loss of gear change, flare, slip, gear change at wrong speed/load condition, rough gear change, abnormal creeping/noise, slow acceleration, kickdown inoperative/ delayed, parking facility inoperative, oil leaks, overheating, ineffective engine braking.

Manual gearboxes.

Symptoms: lack of drive, abnormal noise, difficulty in engaging/disengaging gears, jumping out of gear, oil leaks, vibration, excessive movement of gear lever, speedometer reading fluctuating/intermittent/no reading.

Clutch.

Symptoms: slip, drag, judder, snatch, squeak, rattle, spin, abnormal vibration.

26.4b Identify the routine maintenance and running adjustments necessary on vehicle automatic gearboxes.

Purpose: improved efficiency, extended automatic transmission life, reduced risk of failure, maintain to manufacturers' specifications.

Lubricants/fluid: selection, changing, replenishing, check levels, clean oil cooler fins.

Mountings: security, condition.

Selector mechanism: security, adjustment. **Filters:** removal, cleaning/replacement. Inhibitor/reverse light switch: operation, adjustment.

26.5b Identify the use, care, calibration and storage of vehicle manual and automatic gearbox diagnostic equipment.

Instruments: pressure gauge, tachometer, multimeters, dial test indicator, linear measuring equipment, hand instruments.

Measurements: pressure plate finger height, pedal height, release lever free play, flywheel run-out, hydraulic fluid.

26.6b Identify systematic overhaul procedures for vehicle manual and automatic gearboxes.

Sequence of dismantling/assembly: technique of joining, position of joints, inter-relationship/identification of parts, tolerances, protection of parts against damage/ corrosion/contamination.

General rules for disassembly/assembly: operation of unit/component, assembly drawings/ specifications, plan sequence of operations, parts/tools kept clean, contamination prevention, correct fasteners/tools.

Tools/test equipment: stripping to gain access to sub-assemblies, assessment of condition by visual means, assessment of wear using instruments.

Jointing application: strength, nature/type/size of materials to be joined, permanent/non-permanent, proximity to other unit parts, damage to other parts/components, cleanliness, burr removal, anti-corrosive measures, dry soldered joints, over-tightening, misalignment, stress/failure.

26.7b Identify the standard terms and definitions for vehicle manual and automatic gearbox overhaul.

Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.

Applications: shape/characteristics of component, dimensions/location/layout of components, constructional features, methods of repair, procedures, settings/standards, tolerances (limits/fits).

Unit 26 Chassis Systems 3
Transmission Systems Module (c)

Practical competences

The candidate must be able to do the following:

26.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle transmission systems.

26.2c Prepare a report describing the operating principles and main components of vehicle transmission systems.

26.3c Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle transmission systems.

26.4c Carry out the use, care, calibration and storage of vehicle transmission systems diagnostic equipment.

26.5c Carry out systematic overhaul procedures for vehicle transmission systems.

26.6c Prepare a report identifying the standard terms and definitions for vehicle transmission systems.

26.7c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

26.1c Describe safe working practices using tools, equipment and consumable materials when working on vehicle transmission systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Electrical/electronic systems: isolation of battery/external sources during work, electric shock, shorts to earth, correct polarity, heat sinks, damage to components/units due to removal/testing procedures, electric welding.

Tools/equipment.
Measurement: engineers' rules, internal/external/vernier callipers, dial test indicators, vee blocks, surface plates/tables, external/internal micrometers, feeler/cylinder/pressure gauges.
Spanners: open-ended, ring, combination, lock, adjustable.
Socket: hexagon.
Wrenches: torque, socket, impact, special purpose.
Screwdrivers: blade, posidrive, crosshead, torx.
Pliers: plain, long nose, internal, external. **Hammers:** planishing, ball pein, cross pein, metal, plastic/rubber, timber (mallet), sliding. **Miscellaneous:** power tools, levers, supports, stud removers, greasing plant, fuel/oil dispensers, cleaning tanks.
Electrical test meters: multimeter (analogue/digital).
Special: tools/spanners, clamps, gear pullers, presses, heating equipment, dedicated test equipment, tachometer.
Materials: cleansing agents, dyes/markers, penetrating oils.

26.2c Describe the operating principles and main components of vehicle transmission systems.
Propeller/drive shafts.
Layout: front wheel drive (independent), front engine rear wheel drive (live axle/ independent), rear engine rear wheel drive (independent), four wheel drive (excluding off- road vehicles).
Components: propeller/drive shafts, centre bearings, torque tube/housings/casings, telescopic joints, universal joints (Hooke's, flexible, constant velocity).
Driven hubs: front wheels, rear wheels, semi floating, three-quarter floating, fully floating.

Final drive/differential units.
Purpose: provide final gear reduction/torque multiplication, allow driven wheels to rotate at different speeds whilst transmitting equal torque, change direction of drive (where appropriate), support load (where appropriate), provide limited slip (where appropriate).
Layout: rear mounted live axle, rear mounted trans-axle, front wheel drive, chassis mounted, third differential, viscous coupling.
Components: helical gear, straight bevel, spiral bevel, hypoid bevel, worm and wheel, bevel-type differential, limited slip differential.

26.3c Describe fault testing procedures using test equipment and diagnostic techniques for vehicle transmission systems.
Symptoms: abnormal mechanical noise, oil/grease leaks, vibration, loss of drive.

26.4c Identify the use, care, calibration and storage of vehicle transmission systems diagnostic equipment.
Diagnostic equipment: hand held instruments, vee blocks, dial test indicator, straight edge, pre-load gauges.

26.5c Identify systematic overhaul procedures for vehicle transmission systems.
Sequence of dismantling/assembly: technique of joining, position of joints, inter-relationship/identification of parts, tolerances, protection of parts against damage/ corrosion/contamination.
General rules for disassembly/assembly: operation of unit/component, assembly drawings/specifications, plan sequence of operations, parts/tools kept clean, contamination prevention, correct fasteners/tools.
Tools/test equipment: stripping to gain access to sub-assemblies, assessment of condition by visual means, assessment of wear using instruments.

Jointing application: strength, nature/type/size of materials to be joined, permanent/non-permanent, proximity to other unit parts, damage to other parts/components, cleanliness, burr removal, anti-corrosive measures, dry soldered joints, over-tightening, misalignment, stress/failure.

26.6c Identify the standard terms and definitions for vehicle transmission systems overhaul.
Technical drawings, line/block diagrams, operations schedules, data sheets/charts, standard/manufacturers' tables/graphs, microfilm, microfiche, CD ROM, video tapes, micro processors, manufacturers' servicing schedules, repair procedures, parts lists, electrical wiring diagrams.
Applications: shape/characteristics of component, dimensions/location/layout of components, constructional features, methods of repair, procedures, settings/standards, tolerances (limits/fits).

Unit 26 Chassis Systems 3
Associated Studies Module (d)

Practical competences

The practical competences are incorporated into the modules for this unit.

Knowledge requirements

The instructor must ensure the candidate is able to:

26.1d Identify arithmetic operations to binary/denary numbers.
Definitions/comparisons: binary/denary numbers.
Arithmetic operations: addition/subtraction of binary numbers.
Convert: denary numbers to binary, binary numbers to denary.

26.2d Identify algebraic operations.
Definitions: expression, equation, identity, sum, difference, product, quotient, linear equations, factorisation, quadratic equation.
Rules: deducing sum/difference/product/quotient of algebraic symbols/terms, brackets.
Algebraic operations: factorise equations. **Laws of indices:** applied to algebraic symbols. **Equations:** represent quantities by symbols/translate phrases involving associated quantities into algebraic expressions, transpose simple equations.
Calculations: balance of equations whilst applying arithmetic operations, linear equations with one unknown, quadratic equations.

26.3d Identify trigonometric operations.
Definitions: sine/cosine/tangent (right angled triangles).
Plane figures: square, rectangle, triangle (acute angled, right angled, obtuse angled, equilateral, isosceles).
Angles: right angle, oblique (acute, obtuse), complementary, angle of the sum of a triangle.

Calculations.
Right angled triangles: angle/length of side (using sine/cosine/tangent).
Triangles: construct from given information (three sides, two sides/included angle, one side/two angles).

26.4d Identify graphical operations.
Definitions: graphs, axis, point of origin, scale, positive/negative coordinates, mid-ordinate rule, Simpson's rule.
Graphs: select axis, determine scale, plot coordinates.
Straight line graphs: corresponding values on each axis, interpolate intermediate values.
Gradients: positive, negative, zero.
Area under a graph: mid-ordinate rule, Simpson's rule.
Applications: distance-time, velocity-time, determine average values, engine/vehicle performance data.

26.5d Describe the types and properties of materials used in motor vehicle engineering and associated calculations.
Definitions: tensile stress, yield stress, shear force, percentage elongation, percentage reduction in area.
Plain carbon steels: physical/mechanical properties, heat treatment processes (hardening, tempering, annealing, normalising).
Fatigue: factors causing fatigue in metals, fatigue failure in motor vehicle components.
Shear force/bending moments: simple horizontal cantilever, simply supported horizontal beam, vertical point loads, shear force/bending moment diagrams.
Solid/tubular shafts: reasons for use, torsional/bending/shear stress, applied torque, shaft diameter, bending/torsional qualities.
Tests: tensile, impact, hardness.
Calculations: tensile stress, yield stress, percentage elongation.

26.6d Identify the terms used and calculations associated with combustion processes.
Laws: 1st Law of Thermodynamics.
Definitions: isothermal, adiabatic, combustion process for petrol/diesel engines, volumetric efficiency.
Isothermal/adiabatic processes: compression/expansion, theoretical/practical engine cycles.
Fuels: octane/cetane number, need for higher/lower octane/cetane rating for different engine types, additives to control detonation/deposits.
Tests: detonation, pre-ignition, diesel knock.
Calculations: petrol/diesel engines (change in pressure/volume/temperature), volumetric efficiency.

26.7d Identify the terms used and calculations associated with tractive effort and tractive resistance.
Definitions: tractive effort, tractive resistance, braking efficiency.
Tractive resistance: components (rolling/gradient/air resistance).
Calculations: energy dissipated/power required at constant velocity on level plane, accelerating/braking forces applied on level plane, braking efficiency (stopping distance, retardation).

26.8d Identify the terms used and calculations associated with electronics.

Definition: electronics, resistors, capacitors, inductors, diodes, rectifiers, wave forms, semiconductors, transistors.

Components (symbols/values): resistors (carbon, wire wound, variable), capacitors (electrolytic, ceramic, mica, polystyrene, variable), inductors (air cooled, ferrite cored, iron cored), transformers, diodes.

Diodes: PN junction (low, high power), Zener, LED, transistors, bi-polar (npn, pnp), FET, rectifiers (thyristor, thermistors, light sensitive diodes).

Integral circuit: circuit building.

Wave forms (symbols/values): wavelength (l, m), frequency (f, H), period (T, s), amplitude (a, m), relationship (frequency – period/waveform, root mean square (rms), peak, peak-to-peak, average, and instantaneous values).

Circuits: units, multiples/submultiples, symbols (resistance/inductance, capacitance).

Current: direct, alternating, effects, resistance, inductance, capacitance, time, LR, CR.

Calculations: resistance (series/parallel/combinations), capacitance (series/parallel/ combinations).

Semiconductors.

Materials: silicon/germanium/impurities (p, n), properties (semi-conductor/ conductor/insulator).

Diodes: unidirectional effect, graphs (voltage current – pn/Zener/LED), Zener diode (graph – stabilisation/ barrier unit).

Transistors: pnp, npn, current, collector output/base input (using emitter amplifier), action (switch).

Circuits: configuration (basic amplifier/oscillator circuit/LC oscillator using an FET), signals (input/output).

Rectification: circuits; half-wave, full wave, smoothing (bridge/transformer/diode circuits).

Digital: logic gates (AND, OR, NOR), symbols, truth tables (single/up to three gate combinations).

Test specification for written paper Chassis Systems 3 (3905-03-026 and 3905-04-026)

This is a written examination paper, lasting 2 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
26a Braking, Steering and Suspension Systems	30
26b Manual and Automatic Gearboxes	30
26c Transmission Systems	30
26d Associated Studies (Maths and Science)	10

Unit 27 Mathematics, Science and Electronics 2
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

27.1a Perform algebraic operations.

27.2a Perform trigonometric operations.

27.3a Perform statistical operations.

Knowledge requirements

The instructor must ensure the candidate is able to:

27.1a Identify algebraic operations.

Definition: sequence, Fibonacci sequence, arithmetic progression, geometric progression, Binomial Theorem.
Sequence: formula for the '*nth*' term.
Arithmetic progression: formula to represent the sum of '*n*' terms.
Geometric progression: formula to represent the sum of '*n*' terms.
Binomial Theorem: expand terms of the form $(1 + x)^n$ where '*n*' is a positive/negative integer, apply to relevant problems.

Calculations.
Sequence: deduce relationships in simple sequence of the type 1, 2, 3, 4, 5 that can be represented as $a\,(n) = n$ where $n = 1$ to 5, Fibonacci sequence in the form 1, 1, 2, 3, 5, 8, 13 that can be represented as $a_{(n+1)} = a_n + a_{(n-1)}$.
Arithmetic progression: evaluate the sum of series of '*n*' terms
$S_n = n\,[2a + d\,(n\text{-}1)] / 2$ where a is the first term, d is the common factor, n is the number of terms.
Geometric progression: evaluate the sum of a series of '*n*' terms $S_n = a\,(1\text{-}r^n) / (1\text{-}r)$ where a is the first term, r is the common ratio, n is the number of terms.

27.2a Identify trigonometric operations.

Definitions: secant/cosecant/cotangent (right angled triangles), quadrant rule, semi-perimeter of a triangle (s).
Sine rule: a/sin A = b/sinB = c/sinC, conditions of use.
Cosine rule: $a^2 = b^2 + c^2 - 2bc$ cosA, conditions of use.
Relationship: tan e = sin e / cos e, $\sin^2 e + \cos^2 e = 1$.
Tangent graph: draw from e = -90° to +270°.
Triangles: area (formula Area = $\frac{1}{2}\,ab$ sinC, Area = $[s(s-a)(s-b)(s-c)]$ using semi-perimeter of the triangle (s), where $s = \frac{1}{2}\,(a + b + c)$).

Calculations.
Quadrant rule: sine/cosine/tangent for angles of any magnitude.
Angles: sine/cosine/tangent using tan e = sin e / cos e, $\sin^2 e + \cos^2 e = 1$.
Triangles: using sine/cosine rules, Area = $\frac{1}{2}\,ab$ sinC, Area = $[s(s-a)(s-b)(s-c)]$.
Electronic calculator: secant/cosecant/cotangent (angles between 0° – 90°).

27.3a Identify statistical operations.

Definitions: discrete/continuous data, sample/population, appropriate groups, frequency, relative frequency, frequency table, cumulative frequency data/curve (ogive), tally chart, bar chart/histogram, pie chart, line graph, pictogram, arithmetic mean, median, mode, central tendency, median, quartiles, percentiles, standard deviation, variance.
Central tendency: appropriate measure (arithmetic mean, median, mode).
Data sources: practical course work, publications.
Applied forms: tally chart, frequency table, bar chart/histogram, pie chart, line graph, pictogram.

Calculations.
Appropriate groups: equal/unequal from given data.
Tally count: frequency, relative frequency of objects in each group.
Ungrouped data: arithmetic mean, rank order, median/modal values, standard deviation.
Grouped data: arithmetic mean, mode (using histogram), standard deviation.
Cumulative frequency data: draw curve (ogive), determine median/quartiles/percentiles.

Unit 27 Mathematics, Science and Electronics 2
Vehicle Science Module (b)

Practical competences

The candidate must be able to do the following:

27.1b Prepare a report identifying the types and properties of materials used in motor vehicle engineering and apply calculations.

27.2b Prepare a report identifying the terms used and apply calculations associated with combustion processes.

27.3b Prepare a report identifying the terms used and apply tests/calculations associated with the internal combustion engine.

27.4b Prepare a report identifying the terms used and apply calculations associated with tractive effort and tractive resistance.

27.5b Prepare a report identifying the terms used and apply calculations associated with centripetal and centrifugal force.

27.6b Prepare a report identifying the terms used and apply calculations associated with load transfer.

27.7b Prepare a report identifying the terms used and apply calculations associated with the energy of rotation.

27.8b Prepare a report identifying the terms used and apply calculations associated with simple harmonic motion.

Knowledge requirements

The instructor must ensure the candidate is able to:

27.1b Describe the types and properties of materials used in motor vehicle engineering and apply calculations.
Definitions: tensile stress, yield stress, shear force, percentage elongation, percentage reduction in area.
Plain carbon steels: physical/mechanical properties, heat treatment processes (hardening, tempering, annealing, normalising).
Fatigue: factors causing fatigue in metals, analyse fatigue failure in motor vehicle components.
Shear force/bending moments: simple horizontal cantilever, simply supported horizontal beam, vertical point loads, shear force/bending moment diagrams.
Solid/tubular shafts: reasons for use, torsional/bending/shear stress, applied torque, shaft diameter, bending/torsional qualities.
Tests: tensile, impact, hardness.
Calculations: tensile stress, yield stress, percentage elongation, percentage reduction in area, moment of inertia, modulus of section, solid/hollow shafts (torque, stress, shaft diameter).

27.2b Identify the terms used and calculations associated with combustion processes.
Laws: 1st Law of Thermodynamics.
Definitions: isothermal, adiabatic, combustion process for spark ignition/compression ignition engines, volumetric efficiency.
Isothermal/adiabatic processes: compression/expansion, theoretical/practical engine cycles.
Fuels: octane/cetane number, need for higher/lower octane/cetane rating for different engine types, additives to control detonation/deposits.
Tests: detonation, pre-ignition, diesel knock. **Calculations:** changes in pressure/volume/temperature in spark ignition/compression ignition engines ($PV^n = C$, $P_1V_1/T_1 = P_2V_2/T_2$ ..... $= P_NV_N/T_N$), volumetric efficiency.

27.3b Identify the terms used and tests/calculations associated with the internal combustion engine.
Definitions: electronic engine indicator, brake mean effective pressure (bmep), indicated power, specific fuel consumption, air-fuel ratios.
Electronic engine indicator: operation (include sketches/block diagrams).
Diagrams: indicator diagrams (mean effective pressure), pressure-crank angle diagram, pressure-volume diagram. Pressure-crank/pressure-volume diagrams: comparison, affect of varying throttle openings/ignition settings/fuel injection pump settings (diesel engines)/compression ratios/ pressure charging.
Combustion process: hydro-carbon fuels (air-fuel ratios), products of combustion (exhaust products), graphs for practical range of air-fuel ratios (spark ignition/compression ignition), limits of air-fuel ratios on spark ignition engines/effect on exhaust products, requirement for excess air (compression engines), cylinder interference/overlap (cylinder robbing/ dilution).
Engine tests/calculations: brake mean effective pressure (bmep)/indicated power/specific fuel consumption at varying engine speeds, heat balance of engine, air-fuel requirement for maximum thermal efficiency/power output by varying mixture strength of a petrol engine (constant speed), effect on power output by varying air-fuel mixture strength, effect of rich/weak air- fuel mixtures on engine components (valves, combustion chambers, spark plugs).

27.4b Identify the terms used and calculations associated with tractive effort and tractive resistance.
Definitions: tractive effort, tractive resistance, braking efficiency.
Tractive resistance: components (rolling/gradient/air resistance).
Calculations: energy dissipated/power required at constant velocity on level/inclined plane, accelerating/braking forces applied on level/inclined plane, braking efficiency (stopping distance, retardation).

27.5b Identify the terms used and calculations associated with centripetal and centrifugal force.
Definitions: centripetal force/acceleration, centrifugal force/acceleration, mass-radius polygons.
Centripetal: centripetal acceleration = v^2/r.
Centrifugal: force applied to wheel balancing/clutches/governors.
Curved tracks: vehicles overturning/sliding on level track, vehicles on banked track (no lateral inward forces applied).
Calculations: centripetal force when balancing several masses rotating in the same plane, mass-radius polygons (several masses rotating in the same plane).

27.6b Identify the terms used and calculations associated with load transfer.
Definitions: load transfer, linear retardation/acceleration.
Calculations: load transfer (linear retardation/acceleration/cornering).

27.7b Identify the terms used and calculations associated with the energy of rotation.
Definitions: angular/linear acceleration, angular motion, kinetic energy, radius of gyration (k), moment of inertia (I).
Angular motion: equations ($w_2 = w_1 + at$, $e = w_1t + \frac{1}{2}at^2$, $w_2^2 = w_1^2 + 2ae$).
Kinetic energy: single mass rotating in a circular path, $KE = \frac{1}{2}mr^2w^2 = \frac{1}{2}Iw^2$.
Moment of inertia: = mass x (radius of gyration)^2.
Torque: = moment of inertia x angular acceleration.
Work: = torque x angle (radians).
Power: = torque x angle (radians/time).
Calculations: angular motion (eg. road wheel movement), kinetic energy, moment of inertia, torque, work, power, flywheel (kinetic energy, energy change).
Turning moment diagrams: produce graphically for single/four cylinder engines, use to explain design/purpose of a flywheel.

27.8b Identify the terms used and calculations associated with simple harmonic motion.
Definitions: simple harmonic motion, frequency, amplitude, velocity/acceleration/force at an instant in terms of displacement.
Calculations: simple harmonic motion.

Unit 27 Mathematics, Science and Electronics 2
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

27.1c Prepare a report describing analogue and digital systems.

27.2c Prepare a report describing the binary (electronic) system of digital computers.

27.3c Prepare a report identifying and applying numbers using a range of numbering systems.

27.4c Prepare a report and convert numbers from one number base to another.

27.5c Collect information identifying and applying addition and subtraction in binary.

27.6c Collect information describing the function and role of microelectronic systems within motor vehicles.

27.7c Collect information identifying, with the use of diagrams, the main components of microprocessor based systems.

27.8c Prepare a report identifying, with the use of diagrams, the functions of microcomputer systems.

27.9c Prepare a report identifying how machine language instructions are coded and stored.

27.10c Collect information identifying the steps required to execute machine language instructions.

27.11c Prepare a report describing machine code programming.

27.12c Prepare a report identifying and applying instructions and addressing.

27.13c Collect information identifying and applying subroutines and the stack.

27.14c Collect information identifying and applying interrupts.

27.15c Prepare a report describing the principles and use of electronics in electronic ignition systems.

27.16c Prepare a report describing the principles and use of electronics in electronic fuel injection systems.

27.17c Prepare a report describing the principles and use of electronics in anti-lock braking (ABS) systems.

Knowledge requirements

The instructor must ensure the candidate is able to:

27.1c Describe analogue and digital systems.
Definition: analogue system, digital system, difference, AND, OR, NOT, NAND, NOR, XOR, BUFFERS.
Logic gates: AND, OR, NOT, NAND, NOR, XOR, BUFFERS.
Calculations: truth tables, AND, OR, NOT, NAND, NOR, XOR, BUFFERS.

27.2c Describe the binary (electronic) nature of modern digital computers.
Definition: binary numbering system, bit, nibble, byte, word.
Calculations: binary system.

27.3c Identify numbers using a range of numbering systems.
Definitions: number bases (octal, hexadecimal).
Calculations: octal, hexadecimal.

27.4c Describe the conversion of numbers from one number base to another.
Definitions: denary system.
Conversions: binary to denary, denary to binary, binary to octal, octal to binary, binary to hexadecimal, hexadecimal to binary.

27.5c Describe addition and subtraction in binary.
Definitions: one's/two's complement arithmetic.
Calculations: adding/subtracting binary numbers, one's/two's complement arithmetic.

27.6c Describe the function and role of microelectronic systems within motor vehicles.
Microelectronic systems: development, advancement, advantages.

27.7c Describe the main components of microprocessor based systems.
Definitions: RAM, ROM, KAM, EPROM, A/D, D/A, CPU, ALU.
Components: memory (RAM, ROM, KAM, EPROM), timing of memory (read, write), Input/Output sections (A/D, D/A), CPU (ALU, registers, accumulator), information buses.

27.8c Identify the functions of microcomputer systems.
Function: block diagram (microcomputer), operation of adding two numbers, flag registers.

27.9c Identify how machine language instructions are coded and stored.
Definitions: program counter, instruction register, operation codes, op. codes, operand, most/least significant bit.
Function: program counter, instruction register.

27.10c Identify the steps required to execute machine language instructions.
Sequence of events: two byte instruction execution, flow charts.

27.11c Describe machine code programming.
Operations: machine code mnemonics (data transfer instructions, arithmetic/logical instructions, test/branch instructions), illustrate a typical fetch execute cycle for three instruction program (add the contents of two successive memory locations and store the sum into a third location).

27.12c Describe instructions and addressing.
Instructions/addressing: data transfer, test and branch, immediate addressing, absolute addressing, implied addressing, relative addressing, indexed addressing.

27.13c Describe subroutines and the stack.
Definition: stack (area of RAM), stack point register, subroutine.
Purpose/operation: subroutines, stack (last-in first-out store), stack/stack point register (used to store/retrieve data).
Program: simple program showing use of stack during a subroutine.

27.14c Describe interrupts.
Definitions: interrupt.
Purpose/operation: interrupt function.
Program: simple program showing use of interrupt instruction.

27.15c Describe the function of electronic ignition systems.
Block diagram: showing input/output devices, components, component links to ECU.

27.16c Describe the function of electronic fuel injection systems.
Block diagram: showing input/output devices, components, component links to ECU.

27.17c Describe the function of anti-lock braking (ABS) systems.
Block diagram: showing input/output devices, components, component links to ECU.

Test specification for written paper Mathematics, Science and Vehicle Electronics 2 (3905-04-027)

This is a written examination paper, lasting 2 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
Mathematics, Science and Vehicle Electronics 2 (Unit 27)	
27a Mathematics	33
27b Vehicle Science	33
27c Vehicle Electronic Systems	34

Unit 25 Engine Systems 3
Petrol/Diesel Engines and Fuel Systems Module (a)

Practical competences

The candidate must be able to do the following:

25.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of petrol/diesel engines and fuel systems. ☐

25.2a Prepare a report describing the operating principles and main components of four-stroke petrol/diesel engines and fuel systems. ☐

25.3a Carry out fault testing procedures using test equipment and diagnostic techniques for petrol/diesel engines and fuel systems. ☐

25.4a Carry out the use, care, calibration and storage of petrol/diesel engines and fuel systems diagnostic equipment. ☐

25.5a Carry out systematic overhaul procedures for petrol/diesel engines and fuel systems. ☐

25.6a Prepare a report identifying the standard terms and definitions for petrol/diesel engines and fuel systems. ☐

25.7a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 25 Engine Systems 3
Spark Ignition and Electrical/Electronic Systems Module (b)

Practical competences

The candidate must be able to do the following:

25.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle spark ignition and electrical/electronic systems. ☐

25.2b Prepare a report describing the operating principles and main components of vehicle spark ignition and electrical/electronic systems. ☐

25.3b Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle spark ignition and electrical/electronic systems. ☐

25.4b Carry out the use, care, calibration and storage of vehicle spark ignition and electrical/electronic systems diagnostic equipment. ☐

25.5b Carry out systematic overhaul procedures for vehicle spark ignition and electrical/electronic systems. ☐

25.6b Prepare a report identifying the standard terms and definitions for vehicle spark ignition and electrical/electronic systems. ☐

25.7b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 25 Engine Systems 3
Engine Auxiliary Systems Module (c)

Practical competences

The candidate must be able to do the following:

25.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of engine auxiliary systems. ☐

25.2c Prepare a report describing the operating principles and main components of engine auxiliary systems. ☐

25.3c Carry out fault testing procedures using test equipment and diagnostic techniques for engine auxiliary systems. ☐

25.4c Carry out the use, care, calibration and storage of engine auxiliary systems diagnostic equipment. ☐

25.5c Carry out systematic overhaul procedures for engine auxiliary systems. ☐

25.6c Prepare a report identifying the standard terms and definitions for engine auxiliary systems. ☐

25.7c Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 26 Chassis Systems 3
Braking, Steering and Suspension Systems Module (a)

Practical competences

The candidate must be able to do the following:

26.1a Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle braking, steering and suspension systems. ☐

26.2a Prepare a report describing the operating principles and main components of vehicle braking, steering and suspension systems. ☐

26.3a Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle braking, steering and suspension systems. ☐

26.4a Carry out the use, care, calibration and storage of vehicle braking, steering and suspension systems diagnostic equipment. ☐

26.5a Carry out systematic overhaul procedures for vehicle braking, steering and suspension systems. ☐

26.6a Prepare a report identifying the standard terms and definitions for vehicle braking, steering and suspension systems. ☐

26.7a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 26 Chassis Systems 3
Manual and Automatic Gearboxes Module (b)

Practical competences

The candidate must be able to do the following:

26.1b Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle manual and automatic gearboxes. ☐

26.2b Prepare a report describing the operating principles and main components of vehicle manual and automatic gearboxes. ☐

26.3b Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle manual and automatic gearboxes. ☐

26.4b Carry out routine maintenance and running adjustments necessary on vehicle automatic gearboxes. ☐

26.5b Carry out the use, care, calibration and storage of vehicle manual and automatic gearbox diagnostic equipment. ☐

26.6b Carry out systematic overhaul procedures for vehicle manual and automatic gearboxes. ☐

26.7b Prepare a report identifying the standard terms and definitions for vehicle manual and automatic gearboxes. ☐

26.8b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 26 Chassis Systems 3
Transmission Systems Module (c)

Practical competences

The candidate must be able to do the following:

26.1c Carry out safe working practices using tools, equipment and consumable materials in the maintenance and testing of vehicle transmission systems. ☐

26.2c Prepare a report describing the operating principles and main components of vehicle transmission systems. ☐

26.3c Carry out fault testing procedures using test equipment and diagnostic techniques for vehicle transmission systems. ☐

26.4c Carry out the use, care, calibration and storage of vehicle transmission systems diagnostic equipment. ☐

26.5c Carry out systematic overhaul procedures for vehicle transmission systems. ☐

26.6c Prepare a report identifying the standard terms and definitions for vehicle transmission systems. ☐

26.7c Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 27 Mathematics, Science and Electronics 2
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

27.1a Perform algebraic operations. ☐

27.2a Perform trigonometric operations. ☐

27.3a Perform statistical operations. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 27 Mathematics, Science and Electronics 2
Vehicle Science Module (b)

Practical competences

The candidate must be able to do the following:

27.1b Prepare a report identifying the types and properties of materials used in motor vehicle engineering and apply calculations. ☐

27.2b Prepare a report identifying the terms used and apply calculations associated with combustion processes. ☐

27.3b Prepare a report identifying the terms used and apply tests/calculations associated with the internal combustion engine. ☐

27.4b Prepare a report identifying the terms used and apply calculations associated with tractive effort and tractive resistance. ☐

27.5b Prepare a report identifying the terms used and apply calculations associated with centripetal and centrifugal force. ☐

27.6b Prepare a report identifying the terms used and apply calculations associated with load transfer. ☐

27.7b Prepare a report identifying the terms used and apply calculations associated with the energy of rotation. ☐

27.8b Prepare a report identifying the terms used and apply calculations associated with simple harmonic motion. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 27 Mathematics, Science and Electronics 2
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

27.1c Prepare a report describing analogue and digital systems. ☐

27.2c Prepare a report describing the binary (electronic) system of digital computers. ☐

27.3c Prepare a report identifying and applying numbers using a range of numbering systems. ☐

27.4c Prepare a report and convert numbers from one number base to another. ☐

27.5c Collect information identifying and applying addition and subtraction in binary. ☐

27.6c Collect information describing the function and role of microelectronic systems within motor vehicles. ☐

27.7c Collect information identifying, with the use of diagrams, the main components of microprocessor-based systems. ☐

27.8c Prepare a report identifying, with the use of diagrams, the functions of microcomputer systems. ☐

27.9c Prepare a report identifying how machine language instructions are coded and stored. ☐

27.10c Collect information identifying the steps required to execute machine language instructions. ☐

27.11c Prepare a report describing machine code programming. ☐

27.12c Prepare a report identifying and applying instructions and addressing. ☐

27.13c Collect information identifying and applying subroutines and the stack. ☐

27.14c Collect information identifying and applying interrupts. ☐

27.15c Prepare a report describing the principles and use of electronics in electronic ignition systems. ☐

27.16c Prepare a report describing the principles and use of electronics in electronic fuel injection systems. ☐

27.17c Prepare a report describing the principles and use of electronics in anti-lock braking (ABS) systems. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Advanced Diplomas in Diagnostic Techniques (3905-05-041 to 3905-06-049)

These units cover the following topic areas:

Unit 41 – Petrol Engines and Fuel Systems

- Petrol Engine and Fuel Systems Diagnostic Techniques — Module 41

Unit 42 – Light Vehicle Chassis Systems

- Light Vehicle Braking, Steering and Suspension Systems Diagnostic Techniques — Module 42a
- Light Vehicle Manual Transmission Diagnostic Systems Techniques — Module 42b
- Light Vehicle Automatic Transmission Systems Diagnostic Techniques — Module 42c

Unit 43 – Diesel Engines and Fuel Systems

- Diesel Engine Diagnostic Techniques — Module 43a
- Diesel Fuel Injection Systems Diagnostic Techniques — Module 43b

Unit 44 – Heavy Vehicle Chassis Systems

- Heavy Vehicle Braking Systems Diagnostic Techniques — Module 44a
- Heavy Vehicle Steering Systems Diagnostic Techniques — Module 44b
- Heavy Vehicle Suspension Systems Diagnostic Techniques — Module 44c

Unit 45 – Heavy Vehicle Transmission Systems

- Heavy Vehicle Manual Transmission Systems Diagnostic Techniques — Module 45a
- Heavy Vehicle Semi-Automatic and Automatic Transmission Systems Diagnostic Techniques — Module 45b

Unit 46 – Electrical and Electronic Systems

- Batteries, Charging and Starting Systems Diagnostic Techniques — Module 46a
- Electrical, Electronic and Auxillary Systems Diagnostic Techniques — Module 46b
- Vehicle Electronic and Microprocessor Systems Diagnostic Techniques — Module 46c

Unit 47

- Service Reception — Module 47

Unit 48 – Mathematics, Science and Electronics 3

- Mathematics — Module 48a
- Vehicle Science — Module 48b
- Vehicle Electronics Systems — Module 48c

Unit 41 Petrol Engines and Fuel Systems 4
Petrol Engines and Fuel Systems Diagnostic Techniques

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on light vehicles powered by petrol engines.

Practical competences

The candidate must be able to do the following:

41.1 Carry out the safe working practices when working with petrol engines and fuel systems.

41.2 Inspect vehicle systems and prepare a report describing the design features and constructional details of petrol and fuel systems.

41.3 Carry out pressure charging diagnostic techniques and rectification procedures.

41.4 Inspect vehicle systems and prepare a report comparing the fuel characteristics for carburettor and fuel-injection systems of petrol engines.

41.5 Carry out a series of scheduled services on petrol engines and fuel systems according to the manufacturers' specifications.

41.6 Carry out removal and replacement of petrol engines and fuel system components.

41.7 Inspect vehicle systems and prepare a report identifying the diagnostic equipment to be used for carrying out diagnostic techniques.

41.8 Carry out repair techniques on petrol engines and fuel system components.

41.9 Diagnose/correct faults on petrol engines and fuel systems using analysers, gauges and meters. Prepare a report on engine condition, fault location and appropriate rectification procedures.

41.10 Diagnose/correct faults using appropriate diagnostic equipment and techniques on petrol engine valve mechanisms, cooling systems, emission systems, injection systems and electrical/electronic systems, including interpretation of circuit diagrams.

41.11 Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

41.1 Describe the safe working practices when working with petrol engines.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.

41.2 Describe the design features and constructional detail of petrol engines and components.
Systems: normally aspirated, pressure charged.
Components: crankcase, cylinder block, overhead valve/camshaft, twin overhead camshafts.
Piston rings: material and construction of types of compression/scraper rings.
Compression height: thrust face, crown skirt, gudgeon pin, nominal size and oversize connecting rods.
Camshafts: bearings and thrust face types, timing drives, chain belts, gears, cam followers, push rods, valve rotators.
Valves and operating systems: rockers, levers, fingers, direct operating cams, hydraulic lifters, rotators, guides seats.
Crankshafts: main journal, crank pin, nominal/oversize thrust bearings, web, bearings – main/big end balance, flywheel location, crankshaft location, flywheels, starter ring gear.
Oil pumps: driving methods, release valves, coolers.
Oil filters and strainers: by-pass/full flow types.
Gaskets and fluid seals: cylinder head to block, sump to block, valve cover to block, timing case to block, dynamic oil throwers, oil returns, poppet valves, crankshafts.
Cylinder liners: wet/dry, inlet/exhaust manifolds, tuned manifolds, auxiliary drive mechanisms, fuel supply, alternator pumps.

41.3 Compare the cycles of operation and fuel characteristics for carburettor and fuel-injection systems of petrol engines.
Types of combustion chambers, combustion/ignition process, main features of fuel mixture formation diagrams. Pressure charging systems used with petrol engines – intercoolers, aftercoolers, regulators and control devices, instrumentation.
Effects on petrol engine power output and efficiency: excessive or insufficient fuel delivery, poor atomization, ignition advance or retard, combustion knock, air/fuel ratios, injection timing variations. Petroleum fuel (DIN 51600): viscosity, volatility, flash point, cloud point, calorific value, cetane rating.
Valve timing; lead, lag, overlap, timing diagrams, variable valve timing.
Exhaust gas emission/pollutants, stratified charge.

41.4 Describe scheduled servicing of petrol engines and fuel systems according to the manufacturer's specifications.
PDI (pre-delivery inspection), first service, distance based, time based, computer controlled.

41.5 Describe the equipment used for carrying out diagnostic techniques.
Testing techniques to diagnose engine faults, road/dynamometer tests, fault code analysers to evaluate engine performance, fuel consumptions construct/use fault tracing charts.
Safety precautions/preliminary checks, exhaust gas analysers.

41.6 Describe the diagnostic and repair techniques of petrol engines and fuel systems using dedicated analysers, gauges and meters.
Analysers, gauges and meters: tests to diagnose engine condition/serviceability Procedures/methods: fitting/using to perform engine diagnostic tests.
Readings for the following engine conditions: serviceable engine condition, correct ignition timing for carburettor/adjustment, correct mixture adjustment for ignition timed engines, leaking induction system, engine deceleration from 50 rev/s (3000rpm) with a closed throttle, exhaust systems, sensors, catalytic converters, exhaust gas recirculation.

Faults that may produce abnormal readings.
Compression tester: tests to diagnose engine and fuel systems condition/serviceability. **Procedures/methods:** wet/dry tests, compression readings for serviceable/unserviceable engine cylinder condition using compression testers and cylinder leakage gauges, tests for abnormal oil pressure, high/low/intermittent, causes and rectification, exhaust gas recirculation.

Further tests to locate faults and appropriate rectification procedures.

Cylinder balance tests: tests to diagnose engine condition/serviceability, with specialised equipment,

41.7 Describe the audible diagnostic techniques of petrol engines.
Conditions of engine speed/load under which the following, when defective, produce abnormal noises: big-end bearings, main bearings, camshaft/driving mechanisms, valve mechanisms, piston assemblies, distributor, water pump, generator.
Engine noises: incorrect ignition timing, incorrect mixture setting, incorrect valve clearances, exhaust gas leakage.
Valve clearances: procedures for checking/adjusting, causes of incorrect clearances, effects of incorrect clearances on engine performance.
Valve timing: procedures for checking/adjusting, causes of incorrect timing, effects of incorrect timing on engine performance, compile valve timing diagrams from manufacturer's data/examination of engines.
Procedure for fitting a new timing belt/chain, checking valve timing with and without manufacturers' timing marks.

41.8 Describe faulty components which affect system performance.
Cylinder block: pitting/distortion of machined face, distortion/misalignment of bearing housing/cap, blocked galleries, leaking core plug, broken stud/thread condition, cracks. Cylinder bore/linings: worn/damaged bore/liner, cavitation damage, defective liner location/seal, carbon deposit, heat damage/distortion.
Pistons/rings: surface wear/defects/damage, blocked oil way, worn groove, incorrect ring gap, side clearance/ring position, carbon/other deposits, heat damage/cracks.
Connecting rods: bent/twisted, worn bearing/pistons pin, blocked oil way, security retainer.
Crankshafts: bow, twist, cracks, journal ovality/taper/wear/condition, blocked oil way, security of counterbalance weight, damaged drive taper/spline/keyway/thread, incorrect end float, fillet radius, face condition.
Flywheel and starter ring gear: wear at stud/dowel hole, run-out, worn/damaged starter ring teeth, friction face damage, cracks/blueing.
Bearings: wear/picking up/scoring/looseness in shell/bush/roller/ball/thrust washer.
Seals, gaskets and joints: leak, hardening, wear, pitting, looseness, distortion.
Sump: accident damage, crack, leak, distortion, sump plug seat/thread.
Cylinder head: pitting/distortion of machined face, distortion/misalignment of bearing housing/cap, blocked galleries, leaking core plug, crack, broken stud, carbon deposit, worn/pitted/burnt valve seat/face/stem, worn valve guide, broken/weak valve spring, worn valve seal, loose valve seat insert.

Camshaft and tappets: blocked oil way, worn journal/lobe/bearing, bowed camshaft/push rod, wear at splines/keyway/stud/dowel hole, insecure tappet adjusting screw/stud/nut, wear of tappet/rocker hardened surface, inoperative hydraulic adjuster, incorrect end float.
Timing drives: worn drive sprockets/chains/belts/pulleys/tensioner/gears/injection pump couplings.

41.9 Describe the diagnostic and repair techniques for petrol engine cooling systems.
Causes of overheating/overcooling, difference between cooling system and engine defects, effects on engine of faults in cooling system operation.
Test procedures: system pressure, radiator cap, expansion tank, pressure cap, thermostat, radiator flow (vertical/cross flow radiator), electric fan thermal switch, cylinder head gasket/cooling system leakage.
Effects of cooling system operation: defective pressure cap, defective thermostat, blockage in water passage, blockage in air passage.

41.10 Describe diagnostic techniques for petrol engines fuel economy and emission systems.
Factors affecting fuel consumption.
'On the road' tests, analyse tests, identify possible causes of high fuel consumption.
Testing: fuel pumps/system for flow, pressure/vacuum.
Methods of checking/adjusting mixture strength/CO emissions (without specialised equipment, use of exhaust gas analyser, causes of incorrect emissions.
Checking crankcase emissions systems.
Operation and testing anti run-on devices.

41.11 Describe the diagnostic and repair techniques for petrol engine fuel injection systems.
Testing: systems to diagnose correct operation/faults, fault code analysers.
Components: injectors, cold-start injector, auxiliary valve, thermal sensors, automatic air intake temperature control system (coolant/air), pressure regulator.
Causes: difficult cold starting, lack of acceleration, erratic tick-over control, lack of performance, high fuel consumption, poor control of exhaust gas emissions.

41.12 Describe the diagnostic and repair techniques for petrol engine electrical/electronic systems.
Interpret/draw circuit diagrams, circuit symbols in common use, fault code analysis.
Test procedures: involving test meters/lamps in series/parallel to determine correct operation of systems/components.

41.13 Describe the diagnostic and repair techniques for petrol engine ignition circuits.
Operation and construction of alternative types of system: ballast resistive coil, electronic with CB (contact breaker) points, electronic with magnetic/optical switching, distributorless types.
Interpret circuit diagrams (electrical/electronic). **Tests:** procedures to determine correct operation of ignition systems (meters, test lamps, cathode-ray oscilloscope, fault code analysers), readings produced by faults, procedure to determine correct operation of auto-advance/retard mechanisms.
Electronic engine analyser: procedure for complete series of tests, compile a report on condition of ignition system.
Effect: incorrect timing on engine performance, faulty components on system operation, reversed coil/battery polarity on coil performance.

Spark plugs: types, (with or without gasket) heat ranges, faults.
High tension (HT) leads: effect of different lengths/routing/resistance, test procedures. Engine condition, fault location/appropriate rectification procedures
Procedure to replace/re-time ignition distributor.

41.14 The use of mathematics and science is applied to the above Knowledge Requirements.

Test specification for written paper Petrol Engines and Fuel Systems (3905-05-041, 3905-07-041, 3905-09-041 and 3905-11-041)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
41.1 Safety	5
41.2 Design features and constructional detail	6
41.3 Fuel characteristics of petrol engines	8
41.4 Schedule servicing on petrol engines	6
41.5 Diagnostic equipment	8
41.6 Diagnosis of faults using analysers, gauges and meters	8
41.7 Diagnosis of faults using audible techniques	8
41.8 Diagnosis of faults on petrol engine valve mechanisms	8
41.9 Diagnosis of faults on petrol engine cooling systems	8
41.10 Diagnosis of faults on petrol engine fuel economy and emissions	6
41.11 Diagnosis of faults on petrol engine fuel injection systems	8
41.12 Diagnosis of faults on petrol engine and fuel systems electrical/electronic systems	8
41.13 Diagnosis of faults on petrol engine and fuel systems ignition/interpret circuit diagrams	8
41.14 Mathematics and Science	5

Unit 42 Light Vehicle Chassis Systems
Light Vehicle Braking, Steering, Suspension Systems and Diagnostic Techniques Module (a)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on light vehicle braking, steering and suspension systems.

Practical competences

The candidate must be able to do the following:

42.1a Carry out safe working practices when working on light vehicle braking, steering and suspension systems.

42.2a Inspect vehicle systems and prepare a report describing light vehicle braking, steering and suspension systems and their layout.

42.3a Inspect vehicle systems and prepare a report describing the constructional features and operational principles of light vehicle braking, steering and suspension systems.

42.4a Carry out routine maintenance of light vehicle braking, steering and suspension systems to manufacturers' specification and legal operation.

42.5a Carry out logical fault diagnosis techniques using diagnostic equipment for light vehicle braking, steering and suspension systems.

42.6a Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for light vehicle braking, steering and suspension systems.

42.7a Use diagnostic test equipment on light vehicle braking, steering and suspension systems for workshop and road tests.

42.8a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

42.1a Describe the safe working practices when working on light vehicle braking, steering and suspension systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.

42.2a Describe light vehicle braking, steering and suspension systems and their layout.
Braking systems.
Single/dual line systems, pressure limiting/regulating valves, friction materials, brake shoe adjuster (manual/automatic).
Power braking systems, vacuum servos, methods of producing a vacuum.
Systems: anti-lock, transmission brake.
Handbrake/parking brake: systems (front/rear), linkage, inboard/outboard disc, inboard/outboard drum.
Warning devices: failure, friction material thickness.

Steering systems.
Systems: non-assisted, power assisted.
Steering boxes: rack and pinion (including variable ratio), worm and roller, recirculating ball.
Steering geometry: castor angle, camber angle, swivel/king pin inclination, negative/positive offset, wheel alignment, toe-in/toe-out on turns.

Suspension systems.
Suspension systems layout: metal spring, pneumatic, gas (other than air), rubber based, composite spring.
Dampers (including integral, interlinked, adjustable rate).
Spring assisted devices.
Non-independent suspension systems: rear live axle, dead axle.
Independent suspension systems: front/rear, swinging arm, trailing arm, semi-trailing arm, parallel link, traverse spring.
Subframes and mountings.
Torque reaction linkage/rods, anti-roll bars.

Tyres/Wheels.
Tyres: tyre/sidewall markings (legislation), carcase construction, tread patterns (different conditions/climates), tyre size/loading, air pressures.
Wheels: pressed steel, cast/forged light alloy, mountings for concentricity, tyre rims.

42.3a Describe the constructional features and operating principles of light vehicle braking, steering and suspension systems.
As in 42.2a above.

42.4a Describe the routine maintenance and servicing of light vehicle braking, steering and suspensions systems to ensure satisfactory and legal operation.
Braking systems.
Hydraulic fluid: removing air, changing contaminated/unserviceable fluid.
Hoses, pipes and seal: leaks, serviceability. **Friction material:** wear, contamination, suitability. **Braking efficiency:** dynamometer, decelerometer. **Warning devices:** systems/circuits tests (failure, friction material thickness).
System operation/serviceability: vacuum servo, power brake, anti-lock brakes, handbrake/parking, manual/automatic brake adjusters, disc to pad clearance tolerances.

Steering system. **Operation/serviceability:** free play, inefficient/worn/faulty/loose components, bent/damaged tracks rods.

Suspension systems.
System operation/serviceability: inefficient/worn/faulty/loose components, static height.

Wheels and tyres.
Operation/serviceability: fitness for purpose, wear, damage, balance, air pressures.

42.5a Describe fault diagnosis techniques and use of equipment necessary to locate faults on light vehicle braking, steering and suspension systems.
Braking systems: reduction in braking efficiency, worn/damaged drums/discs, fluid leakage, air ingress, contamination of hydraulic fluid, master cylinder efficiency, wheel cylinders/callipers, hoses/pipes/seals, brake pedal free play/glazed/contaminated/incorrect friction material, brake pressure limiting/regulating valves, servo.
Power/anti-lock braking systems: pump/drive arrangement, accumulator, valves (control, pressure limiting), adjusters (manual, automatic), anti-lock control unit, wheel speed ring/sensor unit, load/motion sensing valve.
Handbrake/parking brake.
Brake fade, judder, fierceness, pull, uneven braking, faulty adjustment/adjusters, incorrectly adjusted/faulty linkages.
Steering systems: steering boxes, power assisted steering, ball joints, track rods, steering arms, idler boxes.
Suspension systems: suspension units, joints, steering/suspension linkage, sub-frame and mountings,
Vehicle handling/performance systems: wheels/tyres, castor angle, camber angle, swivel/king pin inclination, negative/positive offset, wheel alignment, toe-out on turns, vehicle ride, tyre wear.

42.6a Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for light vehicle braking, steering and suspension systems.
As in 42.5a above.

42.7a Describe the use of diagnostic test equipment on light vehicle braking, steering and suspension systems for workshop and road tests.
Braking systems: analyser, dynamometer, rolling road, deaccelerator.
Steering systems: alignment/tracking (mechanical/electronic).
Suspension systems: alignment/tracking (mechanical/electronic).

Unit 42 Light Vehicle Chassis Systems
Light Vehicle Manual Transmission Systems Diagnostic Techniques Module (b)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on light vehicle transmission systems.

Practical competences

The candidate must be able to do the following:

42.1b Carry out safe working practices when working on light vehicle transmission systems.

42.2b Inspect vehicle systems and prepare a report describing light vehicle transmission systems and their layout.

42.3b Inspect vehicle systems and prepare a report describing the constructional features and operational principles of light vehicle transmission systems.

42.4b Carry out routine maintenance of light vehicle transmission systems.

42.5b Carry out logical fault diagnostic techniques using diagnostic equipment for light vehicle transmission systems.

42.6b Carry out logical fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for light vehicle transmission systems.

42.7b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

42.1b Describe the safe working practices when working on light vehicle transmission systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassembly/repair/overhaul of light vehicle transmission systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.

42.2b Describe light vehicle transmission systems and their layout.
Clutch.
Gearboxes: front wheel drive, rear wheel drive, four wheel drive.
Driving/propeller shafts.
Final drive units: front/rear/four wheel drive, axles, driving hubs.

42.3b Describe the design features and constructional details of light vehicle transmission systems.
Clutches.
Types, withdrawal mechanisms, flywheels, clutch housings.

Gearboxes.
4/5 speed gearbox layout: gear train, speedometer driving gears, bearing arrangements.
Power flow through gears/method of overdrive, synchromesh/epicyclic units, gear selection/gear change mechanisms, lubricating/sealing methods.
Reversing light circuit.

Range units.
Layout of gears/epicyclic trains, bearings/selector arrangements, power flow through 4/5 speed gearboxes (range change unit in high/low ratio).

Propeller/drive shafts.
Constant/non-constant velocity joints/flexible couplings.
Propeller shafts/driving shafts (sliding joints, damping masses, centre bearings).

Final drive assemblies.
Crown wheels/pinions/methods of achieving correct meshing.
Helical final drive gears/methods of achieving correct meshing.
Conventional differentials/ power flow.
Limited slip differential types/power flow: plate, viscous coupling, worm gear (Torsen).
Speedometer driving gears.

Drive transmission systems.
Four wheel drive arrangements.
Transfer box: high/low ratios, power flow (in all ratios).
Third differential/differential lock.
Viscous coupling (different torque transmissions to each axle).
Axles, shafts and hubs.
Hubs/bearings: types, adjustment of non-driving.
Drive arrangements: front wheel, rear wheel.
Axle: casings, shafts, breathing, sealing.

42.4b Describe the routine maintenance and servicing of light vehicle transmission systems.
Clutch: mechanisms, hydraulic fluid levels/contamination (liquids, air, solids).
Engine/gearbox: mounts, torque reaction linkages, connections.
Propeller/drive shafts: bearing/joint wear, spline wear, drive shaft damping mass looseness, gaiter integrity.
Gear change linkage: wear, adjustment.
Lubricant: levels, vents.

42.5b Describe fault diagnostic techniques using diagnostic equipment for light vehicle transmission systems.
Clutch.
Slip, judder, drag, snatch, squeak, rattle, spin.
Effects: high temperature, wear, contamination, seizure, looseness of components, unsuitable friction facings (clutch), front/rear wheel drive performance.
Hydraulic fluid: incorrect, contaminated.
Alignment: flywheel, mountings, housing.
Mountings: engine, gearbox, axle/stub axle, torque reaction linkages.
Operating mechanisms: engaging/disengaging, noise, vibration.

Gearbox.
Damaged gear teeth/bearings, excessive end float, gear train/bearing noise.
Damaged/worn synchromesh/epicyclic unit components.
Gear selection linkage, 'jump out'.
Distinguish between gear selection mechanism/ clutch faults.
Lubrication: levels, incorrect lubricants.

Propeller/drive shafts.
Effects of wear on operation: flexible constant/non-constant velocity joints, sliding joints, centre bearings.
Imbalance, incorrect meshing of crown wheel and pinion/helical final drive gears.
Crown wheel and pinion: incorrect bearing pre-load, damage.

Final drive.
Worn/damaged differential gears.
Incorrect lubrication: final drive, axle hubs.
Limited slip differentials: plate clutch, viscous coupling, worm gear.
Transfer box: excessive noise, gear selection, gear , 'jump out' (ratio selection).
Third differential/differential lock.

Four wheel drive.
Wind-up, incorrect driving technique.

Auxiliaries.
Reversing lamp circuit, incorrect speedometer operation.

Towing.
Legal requirements when towing (assessment restricted to basic principles).
Safe and correct vehicle: manufacturers' procedures (towing, recover of defective manual transmission system/defective engine).

42.6b Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for light vehicle transmission systems.
As in 42.5b above.

Unit 42 Light Vehicle Chassis Systems
Light Vehicle Automatic Transmission Systems Diagnostic Techniques Module (c)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on light vehicle automatic transmission systems.

Practical competences

The candidate must be able to do the following:

42.1c Carry out the safe working practices when working with light vehicle automatic transmission systems.

42.2c Inspect vehicle systems and prepare a report describing light vehicle automatic transmission systems and components.

42.3c Inspect vehicle systems and prepare a report describing the constructional features and operational principles of light vehicle automatic transmission systems and components.

42.4c Carry out routine maintenance of light vehicle automatic transmission systems.

42.5c Carry out logical fault diagnostic techniques using diagnostic equipment for light vehicle automatic transmission systems.

42.6c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure that the candidate is able to:

42.1c Describe safe working practices when working on light vehicle automatic transmission systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, chassis dynamometer, pressure gauges, tachometer, multimeter, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, automatic transmission fluid, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of automatic transmission systems/ components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing, stall test.
Starting: neutral (N)/park (P)/other gears.
Safe/legal road test/towing (automatic/manual transmission) procedures.

42.2c Describe light vehicle automatic transmission systems and components.
Transmission systems single/multistage torque converters, fluid couplings, fixed ratio transmission gearbox, clutch operated automatic transmission gearbox, semi automatic/constantly variable transmission gearbox.
Components: mountings, sump (oil pan), torque converter housing, extension housing seal, starter inhibitor switch, reversing lamp switch, governor/seals, accumulator, fluid flywheel, starter ring gear/drive plate assembly, clutch/operating piston assembly, brake bands/operating servo/s, control valve assembly, simole compound epicyclic gear sets, power flow in all gears, pulleys/belts, hydraulic pump, parking lock mechanism, selector lever cables/mechanisms, kick down cable/linkage/s, vacuum diaphragm unit, speedometer drive cable/drive gears, pulleys/pulley size variation, transmission drive belts, electronic control units, operating solenoids, oil pump, transmission fluid, oil flow paths.

42.3c Describe the constructional features and operational principles of light vehicle automatic transmission systems and components.
As in 42.2c above.
Function: slip curve characteristics, stall condition, driving up to coupling point, speeds at coupling point, converter efficiency, torque ratio, torque converter pressure, testing torque converter at stall/high speeds, temperature range.

42.4c Describe routine maintenance of light vehicle automatic transmission systems.
Tests: time, distance, stall, hydraulic pressure, chassis dynamometer, road.
Fluid: levels, type/s, tolerance measurements.
Components: casings, castings, clutch drive, plates, brake bands, oil pump, gear sets, splines, pulleys, belts, towing, modifications, oil cooler.
Removal/refitting of transmission systems/components.

42.5c Describe logical fault diagnostic techniques using diagnostic equipment for light vehicle automatic transmission systems.
Fault diagnosis: obstruction to selector lever movement, malfunction to starter motor isolator circuit, no drive in specified selector positions, loss of gear change, flare up, slip, tie up, gear change inappropriate for load/speed conditions, rough gear changes, abnormal creeping, abnormal noise/s, failure to achieve acceptable stall test conditions, slow acceleration, kickdown inoperative/delay, parking facility inoperative, oil leaks in torque converter/filler tube, internal oil loss without external leaks, oil contamination, ineffective engine braking, overheating.
Test equipment/systems: chassis dynamometer, pressure gauges, tachometer, multimeter.

Test specification for written paper Light Vehicle Chassis Systems (3905-05-042, 3905-07-042, 3905-09-042 and 3905-11-042)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
Light Vehicle Chassis Systems (Unit 42)	
42 Light vehicle braking, steering and suspension systems	35
42b Light vehicle manual transmission systems	35
42c Light vehicle automatic transmission systems	30

Unit 43 Diesel Engines and Fuel Systems
Diesel Engine Diagnostic Techniques Module (a)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on light/heavy/bus vehicle diesel engines.

Practical competences

The candidate must be able to do the following:

43.1a Carry out safe working practices when working on diesel engines.

43.2a Inspect vehicle systems and prepare a report describing the design features and constructional details of diesel engines and their components.

43.3a Carry out pressure charging techniques on diesel engines.

43.4a Carry out a series of scheduled services on diesel engines.

43.5a Carry out the removal and replacement of diesel engines.

43.6a Carry out diagnostic techniques of diesel engines.

43.7a Carry out repair techniques on diesel engines and pressure charging systems.

43.8a Diagnose and rectify faulty components which affect system performance.

43.9a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

43.1a Describe safe working practices when working on diesel engines.
Safe use: jacking, stands/chocking blocks/lifting equipment, tools, equipment, repair procedures, tools, engine/chassis dynamometer, measuring instruments, compression tester, cylinder leakage tester, pressure gauges, vacuum gauges, tachometer, multimeter, diesel smoke emission tester, timing light, timing gauges/alignment pins.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Safe: Removal/dismantle/reassemble/repair/overhaul of diesel engines and settings/ clearance (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Vehicle stability: loading, jack-knifing, trailer swing.

43.2a Describe the design features and constructional details of diesel engines and their components.
Systems: normally aspirated, pressure charged, direct/indirect injection.
Components. crankcase, cylinder block, pistons/rings, connecting rods/gudgeon pins, crankshafts, seals/gaskets, sump (oil pan), oil coolers, camshafts, tappets, pushrods, valve rotators, valves/guides/seats, engine mountings, flywheel/starting ring gear.
Bearings: main, big end, camshaft.
Cylinder liners: wet, dry, cast in (open deck).
Timing drives: gear/chain/belt types.
Manifolds: exhaust, inlet.
Auxiliary drive mechanisms: fuelling (supply) pump, lift pump, oil pump, alternators, compressors.
Cylinder head: overhead valve (OHV)/overhead cam (OHC), direct/indirect injection layouts.
Cold start devices: excess fuel, glow plugs, thermostat.
Engine brakes: retarders (electric/hydraulic), exhaust brakes.

43.3a Describe pressure charging systems used with diesel engines.
Systems: exhaust, gas, turbo-charging.
Components: exhaust gas turbo charger (air/liquid cooled), piping/ducting, intercooler/aftercoolers, regulators/control devices, seals, bearings, pressure regulators (waste gates), instrumentation.

43.4a Describe scheduled servicing of diesel engines according to the manufacturer's specifications.
Types: PDI (pre-delivery inspection), first service, distance based, time based.
Time/distance test reports, chassis dynamometer, fluid levels, filters, pulleys, drive belts, timing belts, valve clearances, timing; valve, pump.

43.5a Describe the process for the removal and replacement of diesel engine systems and components.
As in 43.2a above.

43.6a Describe diagnostic and repair techniques for diesel engines and pressure charging systems.
Engine fault diagnosis: cold starting, starting at normal operating temperature, lack of power, stalling, misfire/uneven running, excessive vibration, oil/coolant leaks, contaminated exhaust emissions, excessive fuel consumption, oil contamination, excessive blow/crank case dilution, overheating/overcooling, abnormal mechanical noise, resistance to crank rotation.

Pressure charging system fault diagnosis: poor starting, low power, uneven running, oil/coolant leaks, excessive exhaust emissions (black/blue/white smoke), excessive fuel consumption, overheating/melting of components, abnormal noises/vibration, lag.

43.7a Describe repair techniques on diesel engines and pressure charging systems.As in 43.2a above.

43.8a Describe faulty components which affect system performance.
Cylinder block: pitting/distortion of machined face, distortion/misalignment of bearing housing/cap, blocked galleries, leaking core plug, broken stud/thread condition, cracks.
Cylinder bore/linings: worn/damaged bore/liner, cavitation damage, defective liner location/seal, carbon deposit, heat damage/distortion.
Pistons/rings: surface wear/defects/damage, blocked oil way, worn groove, incorrect ring gap, side clearance/ring position, carbon/other deposits, heat damage/cracks.
Connecting rods: bent/twisted, worn bearing/pistons pin, blocked oilway, security retainer.
Crankshafts: bow, twist, cracks, journal ovality/taper/wear/condition, blocked oil way, security of counterbalance weight, damaged drive taper/spline/keyway/thread, incorrect end float, fillet radius, face condition.
Flywheel and starter ring gear: wear at stud/dowel hole, run-out, worn/damaged starter ring teeth, friction face damage, cracks/blueing.
Bearings: wear/picking up/scoring/looseness in shell/bush/roller/ball/thrust washer.
Seals, gaskets and joints: leak, hardening, wear, pitting, looseness, distortion.
Sump: accident damage, crack, leak, distortion, sump plug seat/thread.
Cylinder head: pitting/distortion of machined face, distortion/misalignment of bearing housing/cap, blocked galleries, leaking core plug, crack, broken stud, carbon deposit, worn/pitted/burnt valve seat/face/stem, worn valve guide, broken/weak valve spring, worn valve seal, loose valve seat insert.
Camshaft and tappets: blocked oil way, worn journal/lobe/bearing, bowed camshaft/push rod, wear at splines/keyway/stud/dowel hole, insecure tappet adjusting screw/stud/nut, wear of tappet/rocker hardened surface, inoperative hydraulic adjuster, incorrect end float.
Timing drives: worn drive sprockets/chains/belts/pulleys/tensioner/gears/ injection pump couplings.

Unit 43 Diesel Engines and Fuel Systems
Diesel Fuel Injection Systems Diagnostic Techniques Module (b)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on light/heavy/bus diesel fuel injection systems.

Practical competences

The candidate must be able to do the following:

43.1b Carry out safe working practices when working on diesel fuel injection systems.

43.2b Inspect vehicle systems and prepare a report describing the types of diesel engine, cycles of operation and characteristics of fuels.

43.3b Inspect vehicle systems and prepare a report describing the design features and constructional details of diesel fuel injection system components.

43.4b Inspect vehicle systems and prepare a report describing alternative diesel fuel supply and return systems, position, function and operation of main components.

43.5b Inspect vehicle systems and prepare a report describing the design features and constructional details of diesel fuel injection system main components.

43.6b Carry out dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for diesel fuel injection system components.

43.7b Carry out routine maintenance procedures to manufacturers' specifications on diesel fuel injection systems.

43.8b Carry out logical fault diagnosis techniques using diagnostic equipment to locate and correct a variety of faults on diesel fuel injection systems.

43.9b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

43.1b Describe safe working practices when working on diesel fuel injection systems.
Safe use: jacking, stands/chocking blocks/lifting equipment, tools, equipment, repair procedures, tools.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of diesel fuel injection systems and settings/clearance (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Vehicle stability: loading, jack-knifing, trailer swing.

43.2b Describe the design features and constructional details of diesel engines and their components.
Combustion chamber: types, combustion process, main features of pressure/volume diagrams/effects of advanced/retarded/no fuel injection.
Effects on engine performance: excessive/insufficient fuel delivery, poor atomization, ignition delay, incorrect adjustment of governor stops, air/fuel ratios, variations in injection timing, cause/effects of diesel knock.
Fuel oil: composition, effects of low temperature, viscosity, volatility, flash point, pour point, cloud point, calorific value, cetane rating.

43.3b Describe the design features and constructional details of diesel fuel injection system components.
Systems/components: construction/operation of air cleaners, air intake/exhaust systems, turbo chargers, mechanically driven blowers, boost/altitude control devices, pressure timed (eg. Cummins), combined injector/pump (eg. Detroit diesel).

43.4b Describe alternative diesel fuel supply and return systems, position, function and operation of main components.
Layouts: in-line, rotary, pressure time, combined pump/injector.
Components: fuel tanks, water stops, sedimenters, agglomerators, filters, associated pipe layouts, fuel lift pumps/drive arrangements.
High pressure fuel lines: lines, unions, cold swaging, bending, support, location, heaters.
Cold start devices: excess fuel, glow plugs, thermostart.
Environmental: additional filtering (quarry/site work), fuel heating, fuel shut off valve (PPV).

43.5b Describe the design features and constructional details of diesel fuel injection system main components.
Flange mounted/enclosed camshaft in-line pumps: injection advance/retard mechanisms, lubrication methods, excess fuel/fuel cut-off devices.
Distributor (rotary) pumps: hydraulic/mechanical/electrical governors, devices (light load, start/retard, combined load/speed, idling dampers, anti-stall, road speed limiting).
Pressure-time/combined pump/injector systems: air venting arrangements, timing fuel injectors, in-situ testing arrangements, speed/load control methods.
Governors: mechanical, hydraulic, electronically controlled (in-line pumps), terminology, position/function of stops/adjusting devices.
Injectors: types (pintaux, multi-hole, delay), electronic control methods, locating/ sealing arrangements, injection pressures/spray patterns, needle lift/seat angles.

43.6b Describe dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for diesel fuel injection system components.
Fuel injection pumps: in-line, rotary, pressure-time/combined pump/injector systems.
Components: governors, injectors, fuel lift pumps.
Test benches: operation, specification, instrumentation.
Test equipment: methods of fitting pumps/injectors, typical test sequences.
Storage of overhauled components.

43.7b Describe routine maintenance procedures to manufacturers' specifications on diesel fuel injection systems.
Emission/noise control legislation, pump/engine timing, injector testing, fuel filtration units/supply systems, governor stops, cold starting devices.

43.8b Describe logical fault diagnosis techniques using diagnostic equipment to locate and correct a variety of faults on diesel fuel injection systems.
Smoke colour, air venting (bleeding) procedure, pump/engine timing.
Portable diagnostic equipment: exhaust gas analyzers, timing devices, tachometers, pressure/vacuum gauges, pyrometers.
Fault diagnosis charts: construction, use.

Test specification for written paper Diesel Engines and Fuel Systems (3905-06-043, 3905-08-043, 3905-10-043 and 3905-12-045)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
Diesel Engines and Fuel Systems (Unit 43)	
43a Diesel engine systems	50
43b Diesel fuel injection systems	50

Unit 44 Heavy Vehicle Chassis Systems
Heavy Vehicle Braking Systems Diagnostic Techniques Module (a)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on heavy/bus vehicle braking systems.

Practical competences

The candidate must be able to do the following:

44.1a Carry out safe working practices when working on heavy vehicle braking systems.

44.2a Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle braking systems.

44.3a Carry out routine maintenance of heavy vehicle braking systems and their components to manufacturers' specification and legal operation.

44.4a Carry out logical fault diagnosis techniques using diagnostic equipment for heavy vehicle braking systems.

44.5a Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for heavy vehicle braking systems.

44.6a Inspect vehicle systems and prepare a report describing the statutory requirements for heavy vehicle braking systems and their components.

44.7a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

44.1a Describe safe working practices when working on heavy vehicle braking systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures, DTI torque wrench, multimeter, pressure gauges, pressure bleeding equipment, digital thermometer, pipe bending/flaring equipment, load simulator, roller brake test, brake dust extraction.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Vehicle stability: loading, jack-knifing, trailer swing.

44.2a Describe the constructional features and operational principles of heavy vehicle braking systems.
Systems: air (two/three line), air versus hydraulic, full-power brakes, anti-lock brakes, exhaust brakes, electrical/hydraulic retarders.
Components: drums/discs, shoes/pads, air compressor (single/twin cylinder), governor valve, unloader valve, air dryer/condenser, safety valve, air reservoir, low pressure warning device, single/double diaphragm actuators, spring brake actuator, slack adjusters (fixed/automatic), 'S' cam/roller, pressure inverter, air pressure gauge, air-actuator/master cylinder, pump, hydraulic reservoir, accumulators, alcohol injectors/evaporators, coupling head/cock, speed sensors/pulse rings, electronic control unit.
Valves: foot (single/dual), pressure regulating, single/double check, relay, differential protection, multi-circuit protection, handbrake, quick release (trailer coupling), one way, load sensing, system protection, emergency relay, drain.

44.3a Describe routine maintenance of heavy vehicle braking systems and their components to manufacturers' specification and legal operation.
Time/distance test reports, roller brake tester/simulated load tester.
Fluid levels, water traps, draining air tanks, drain valves, filters, compressor drive belts, brake adjustment, warning/indicating devices, condition/security.

44.4a Describe logical fault diagnosis techniques using diagnostic equipment for heavy vehicle braking systems.
Reduced braking efficiency/brake fade, unbalanced braking, premature component wear, abnormal noise, judder, vibration, drag, grab, excessive pedal/lever travel, load related imbalance, excessive oil/water in system, brake fluid/air loss, total loss of braking, impaired/total loss of anti-lock facility, incorrect pressure in system.

44.5a Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for heavy vehicle braking systems.
Brake drum/disc: distortion, excessive wear, scoring.
Brake shoes/pads: excessive wear, contamination, irregular wear.
Air compressor: air leaks (O rings/seals), worn piston rings, worn/damaged inlet/delivery valves, unloader mechanism, blocked pipes/breathers/filters, driving belts worn/incorrect adjustment, overheating (liquid cooled compressors).
Unloader/governor valves: air leaks (O rings/seals), incorrect cut in/out pressures, blocked/partially blocked filter.
Air dryer/condenser: air leaks (O rings/seals), blocked/partially blocked air filter, blocked open/closed purge/exhaust valve (automatic drain), blocked desiccant cartridge, pressure relief valve (premature discharge).
Safety valve: air leaks (O rings/seals), premature/late discharging.
Air reservoir: air leaks (O rings/seals), blocked/open automatic drain valves.
Low pressure warning devices: heavy vehicle braking systems leaking diaphragm, contact disc distorted/contaminated, sticking piston.
Foot valves: air leaks (O rings/seals), exhaust blockage, sticking, defective inlet/exhaust valves.
Pressure regulating valves: air leaks (O rings/seals), blocked breather hole, incorrect pressure adjustment, leaking diaphragm.
Check valves: air leaks (O rings/seals), damaged valve/seal, damaged return spring.
Relay emergency valve: air leaks (O rings/seals), damaged diaphragm, blocked/partially blocked ports, worn/damaged inlet/exhaust seats, damaged non-return valve, damaged relay-piston/seals.
Relay valve: air leaks (O rings/seals), damaged piston/seals, exhaust blockage, worn/ damaged inlet/exhaust valves.
Differential protection valve: air leaks (O rings/seals), inner/outer piston worn/ damaged/sticking.
Handbrake valve: air leaks (O rings/seals), exhaust port blocked, worn/damaged inlet/exhaust valve assemblies, worn/damaged piston/seals.

Quick release valve (trailer couplings): air leaks (O rings/seals), damaged diaphragm, blocked exhaust port, worn/damaged diaphragm seats.
One way valve: air leaks (O rings/seals), worn/damaged valve/seats, broken return spring.
Load sensing valve: air leaks (O rings/seals), incorrect push rod linkage adjustment, worn/damaged inlet/exhaust valve, worn/damaged control piston.
Single/double diaphragm actuators: air leaks (O rings/seals), damaged service/secondary diaphragm, broken return spring.
Spring brake actuator: air leaks (O rings/seals), broken compression/return spring.
System protection valve: air leaks (O rings/seals), incorrect unloader adjustment, worn/damaged non-return valve.
Pressure inverter valve: air leaks (O rings/seals), worn/damaged piston.
Slack adjusters (fixed/automatic): incorrect adjustment, worn worm/worm gear, worn/damaged shaft lock, worn/damaged ratchet device (automatic).
'S' cam and roller: damaged/worn cam/roller/cross shaft.
Air pressure gauge: air leaks, calibration, needle return. Air actuator, master cylinder and hydraulic reservoir: air leaks, air actuator diaphragm damaged, blocked/partially blocked air inlet pipe, worn/damaged control valve, worn/damaged master cylinder seals/bore, worn/damaged compensating valve, hydraulic reservoir leaks/sealing breather cap blocked.
Pump: worn/damaged seals/vain/gears/internal surfaces.
Accumulators: worn/damaged seals, worn piston, damaged air bag/compression spring, defective cut out valve.
Alcohol injectors/evaporators: injector (Note: alcohol vapour is poisonous and should not be inhaled), blocked/partially blocked filter, leaking reservoir, defective valve (O ring seals), gaskets, worn/damaged plunger springs.
Evaporator: leaking (O rings/seals), worn/damaged check valve spring/seats, leaking/ damaged bottle, blocked/partially blocked filter.
Emergency relay valve: air leaks (O rings/seals), blocked/partially blocked emergency port filter, worn/damaged piston, worn/damaged inlet/exhaust seats.
Speed sensors: faulty connections, corrosion, dampness.
Electronic control unit: designatory fault codes, faulty connections, corrosion, dampness.

44.6a Describe the statutory requirements for heavy vehicle braking systems and their components.
As contained in heavy vehicle manufacturers' test requirements.

Unit 44 Heavy Vehicle Chassis Systems
Heavy Vehicle Steering Systems Diagnostic Techniques Module (b)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on heavy/bus vehicle steering systems.

Practical competences

The candidate must be able to do the following:

44.1b Carry out safe working practices when working on heavy vehicle steering systems.

44.2b Inspect vehicle systems and prepare a report describing heavy vehicle manual and power assisted steering systems and their layouts.

44.3b Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle steering systems.

44.4b Carry out routine maintenance of heavy vehicle steering systems.

44.5b Carry out logical fault diagnostic techniques using diagnostic equipment for heavy vehicle steering systems.

44.6b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment and test procedures for heavy vehicle steering systems.

44.7b Using diagnostic test equipment, workshop and road tests on heavy vehicle steering systems.

44.8b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

44.1b Describe safe working practices when working on heavy vehicle steering systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures, steering/axle alignment equipment, pressure gauges, flow meters, special power assisted steering tools.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of power assisted steering units and settings/clearance (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Vehicle stability: loading, jack-knifing, trailer swing.

44.2b Describe heavy vehicle steering systems.
Manual.
Single/divided track rod (independent front suspension – IFS).

Power assisted.
Further reduction of driver effort, providing driver 'feel' of the road, 'fail safe' system (hydraulic/pneumatic failure), load spreading/reducing in multi-axle systems.

44.3b Describe the principles and operation of heavy vehicle steering systems.
Manual systems.
Track rod: single, double.

Twin axle.
Ackermann steering principle: true rolling motion of road wheels, twin steering.
Twin steer connection linkage to ensure front wheels turn through common centre.

Power assisted steering systems.
Types: ram, integral.
Fluid/air supply, control valve mechanisms, relief/pressure limiting valves, power rams/cylinders, connecting pins/unions, seals, gaiters.

Independent and non-independent heavy vehicle steering systems.
Camber angle/swivel (king) pin inclination: approximate centre point steering.
Castor angle: directional stability, self-centring action.
Wheel alignment: toe-in/toe-out. Front wheel alignment methods of **measurement/adjustment:** toe-out on turns, camber, king pin inclination, castor.

Steering gearboxes.
Worm and peg, worm and sector, worm and roller, re-circulating ball, rack and pinion.

Steering components.
Swivel (pin) assemblies, drop arms, drag links, track rods, track arms, front hubs/ bearings/seals.

44.4b Describe the routine maintenance and servicing of heavy vehicle steering systems.
As in 44.2.b above.

44.5b Describe fault diagnostic techniques using diagnostic equipment for heavy vehicle steering systems.
Manual systems.
Excessive free play at steering wheel, misalignment of the steering wheel, steering wander, lack of self-centring action, pulling to near/offside, heavy steering, abnormal/uneven tyre wear.

Power assisted steering systems.
Fluid/air loss, fluid overheating, fluid foaming, total loss of power assistance, intermittent loss of power assistance, excessive 'free play' at steering wheel, restricted lock in one direction only, noisy operation of system.

44.6b Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment and test procedures for heavy vehicle steering systems.
As in 44.2b above .

44.7b Describe and interpret performance tests on heavy vehicle steering systems.
Systems: ram, integral.
Road tests: safe, legal, overall quality of system. **Visual inspection:** leakage, security, serviceability.
Static/dynamic tests: effectiveness of power steering (pressure/flow measurements).

Unit 44 Heavy Vehicle Chassis Systems
Heavy Vehicle Suspension Systems Diagnostic Techniques Module (c)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on heavy/bus vehicle suspension systems.

Practical competences

The candidate must be able to do the following:

44.1c Carry out safe working practices when working on heavy vehicle suspension systems.

44.2c Inspect vehicle systems and prepare a report describing heavy vehicle suspension systems and their layout.

44.3c Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle suspension systems.

44.4c Carry out routine maintenance of heavy vehicle suspension systems.

44.5c Carry out logical fault diagnostic techniques using diagnostic equipment for heavy vehicle suspension systems.

44.6c Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment and test procedures for heavy vehicle suspension systems.

44.7c Using diagnostic test equipment, workshop and road tests on heavy vehicle suspension systems.

44.8c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

44.1c Describe safe working practices when working on heavy vehicle suspension systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures, spring compressors/clamps/spring spreaders (ensure spring force is restrained whilst working on system).
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Vehicle stability: loading, jack-knifing, trailer swing.

44.2c Describe heavy vehicle suspension systems and their layout.
Beam axle layout, unequal length/transverse wishbone, trailing arm, semi-trailing arm.

44.3c Describe the construction and operational principles of heavy vehicle suspension systems.
Springs: laminated/multi-leaf, single/taper leaf, helical coil, torsion bars, rubber main suspension/ auxiliary, pneumatic.

Hydraulic dampers.
Types: lever arm, telescopic, single/double acting.
Effect of faulty dampers on the system.
Routine inspections/maintenance.
Testing: on vehicle, bench testing/test equipment.

Axle/hub location arrangements.
Radius arms, transverse stabilisers, front to rear axle alignment/measurement/adjustment.
Driving and braking forces/torque reaction.
Leaf springs, wishbones, tie bars, locating arms.

Multi-rear suspension systems.
Live/dead axles, compensated/uncompensated axles.
Systems: Reactive balance beam, single/double inverted leaf spring, pivoted beam, compressed rubber spring, torsion rubber spring.

Air suspension systems.
Air supply systems, levelling valves, isolator valves, air springs, bump stops, visual inspection/testing, systematic fault finding procedure with test equipment.

Lift axles.
Alternative layouts, routine servicing, systematic fault diagnosis repair.

44.4c Describe the routine maintenance and servicing of heavy vehicle suspension systems.
As in 44.3c above.

44.5c Describe fault diagnosis, identification of symptoms and corrective action of heavy vehicle suspension systems using diagnostic equipment.
Alignment/tracking (mechanical/electronic).

44.6c Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for heavy vehicle suspension systems.
As in 44.3c above.

44.7c Describe the use of diagnostic equipment on heavy vehicle suspension systems.
Dynamometer (mechanical/electronic).

Test specification for written paper Heavy Vehicle Chassis Systems (3905-06-044, 3905-08-044, 3905-10-044, 3905-12-044)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
44a Heavy vehicle braking systems	40
44b Heavy vehicle steering systems	30
44c Heavy vehicle suspension systems	30

Unit 45 Heavy Vehicle Transmission Systems
Heavy Vehicle Manual Transmission Systems Diagnostic Techniques Module (a)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on heavy/bus vehicle transmission systems.

Practical competences

The candidate must be able to do the following:

45.1a Carry out safe working practices when working on heavy vehicle manual transmission systems.

45.2a Inspect vehicle systems and prepare a report describing heavy vehicle manual transmission systems and their layout.

45.3a Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle manual transmission systems.

45.4a Carry out routine maintenance of heavy vehicle manual transmission systems and compare air versus hydraulic system serviceability.

45.5a Carry out logical fault diagnostic techniques using diagnostic equipment for heavy vehicle manual transmission systems.

45.6a Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for heavy vehicle manual transmission systems.

45.7a Use diagnostic test equipment on heavy vehicle manual transmission systems for workshop and road tests.

45.8a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

45.1a Describe the safe working practices when working on heavy vehicle manual transmission systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of heavy vehicle transmission systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Vehicle stability: loading, jack-knifing, trailer swing.

45.2a Describe heavy vehicle manual transmission systems and their layout.
Clutches.
Types: single/multi plate, diaphragm, coil spring. **Centre plate:** solid, spring drive rim, facing material (asbestos, non-asbestos, organic, ceramic, cerametallic). Withdrawal mechanisms: push and pull air versus hydraulic clutch brake.
Flywheels, clutch housings.

Gearboxes.
Layout: main gearbox (various locations including twin layshaft), range of change boxes, splitter boxes, transfer boxes.
Power flow through gears/speedometer/tachograph driving gears.
Bearing/thrust arrangements, power take-off mechanisms, synchromesh/epicyclic units, lubrication, sealing arrangements.
Gearshift methods and mechanisms: manual (direct/remote), hydraulic, pneumatic, electric, electronic.
Reversing light circuit.

Propeller shafts.
Universal joints.
Propeller shafts/driving shafts (sliding joints, centre bearings).

Final drive assemblies.
Crown wheels/pinions/methods of achieving correct meshing.
Worm and wheel final drive gears/methods of achieving correct meshing.
Torque multiplication: double reduction, two speed axle.
Methods of driving two axles, third differential/lock-up.

Wheels/mountings, tyres.
Axles, shafts and hubs.
Axle: casings, shafts, breathing, sealing.
Torque multiplication in hubs.
Hubs/bearings: types, adjustment.

45.3a Describe the constructional features and operational principles of heavy vehicle manual transmission systems:
As in 45.2a above.

45.4a Describe the routine maintenance and servicing of heavy vehicle manual transmission systems.
Clutch: mechanisms/adjustments, brake adjustment, hydraulic fluid levels/contamination (liquids, air, solids).
Air versus hydraulic system serviceability.
Engine/gearbox: mounts, torque reaction linkages, connections.
Propeller/drive shafts: bearing/joint wear, spline wear, security of flange connections.
Gear change mechanisms: wear, adjustment.
Lubricant: levels, vents.

45.5a Describe fault diagnostic techniques using diagnostic equipment for heavy vehicle manual transmission systems.
Clutch.
Slip, judder, drag, snatch, squeak, rattle, spin. **Effects:** high temperature, wear, contamination, seizure, looseness of components, unsuitable friction facings (clutch/clutch brake).
Hydraulic fluid: incorrect, contaminated.
Unserviceable: air/electric/electronic clutch operating mechanisms.
Alignment: flywheel, mountings, housing.
Mountings: engine, gearbox, axle/stub axle, torque reaction linkages.
Operating mechanisms: engaging/disengaging gear/power take-off, noise, vibration.

Gearbox.
Damaged gear teeth/bearings, excessive end float, gear train/bearing noise.
Damaged/worn synchromesh/epicyclic unit components.
Gear selection linkage, 'jump out'.
Distinguish between gear selection mechanism/clutch faults.
Lubrication: levels, incorrect lubricants.

Propeller and drive shafts.
Effects of wear on operation: universal joints. sliding joints, centre bearings.
Imbalance, incorrect meshing of crown wheel and pinion.
Crown wheel and pinion: incorrect bearing pre-load, damage.

Final drive.
Worn/damaged differential gears.
Incorrect lubrication: final drive, axle hubs.
Two speed axle: incorrect action.

Third differential/differential lock.
'Wind-up': incorrect driving technique.
Reversing lamp/warning device circuits, incorrect speedometer operation.

Towing.
Legal requirements when towing (assessment restricted to basic principles).
Safe and correct vehicle: manufacturers' procedures; towing, recovery of defective manual transmission system/defective engine.

45.6a Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for heavy vehicle manual transmission systems.
As in 45.2a above.

45.7a Describe the use of diagnostic test equipment on heavy vehicle manual transmission systems for workshop and road tests.
Dynamometer (mechanical/electronic).

Unit 45 Heavy Vehicle Transmission Systems
Heavy Vehicle Semi-Automatic and Automatic Transmission Systems Diagnostic Techniques Module (b)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on heavy/bus vehicle and semi-automatic and automatic transmission systems.

Practical competences

The candidate must be able to do the following:

45.1b Carry out safe working practices when working on semi-automatic and automatic transmission systems.

45.2b Inspect vehicle systems and prepare a report describing semi-automatic and automatic transmission systems and their layout.

45.3b Carry out routine maintenance of semi-automatic and automatic transmission systems to manufacturers' specification and legal operation.

45.4b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the mechanical running gear of semi-automatic and automatic transmission systems.

45.5b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the hydraulic components of semi-automatic and automatic transmission systems.

45.6b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the pneumatic (compressed air) components of semi-automatic and automatic transmission systems.

45.7b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the electrical/electronic components of semi-automatic and automatic transmission systems.

45.8b Carry out logical fault diagnostic techniques using diagnostic equipment for semi-automatic and automatic transmission systems.

45.9b Carry out the correct procedure for recovery/towing of vehicles fitted with semi-automatic and automatic transmission systems.

45.10b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

45.1b Describe the safe working practices working on semi-automatic and automatic transmission systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, automatic transmission fluid, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of semi-automatic and automatic transmission systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Vehicle stability: loading, jack-knifing, trailer swing.

45.2b Describe semi-automatic and automatic transmission systems and their layout.
Components: fluid flywheel, charged coupling, single stage/multi-stage torque converter, torque converter with fixed stator (eg. Voith), torsional vibration dampers, epicyclic gear components, brake bands/types of adjuster, multi-plate clutch, one-way clutch, speedometer/tachometer drives.
Oil: filters, filler, drainage points, pumps, oil/air; operating pistons (servo), test points.
Control: valve blocks, electro-pneumatic valves, mechanical governor/electronic output speed sensors, kick down/load sensors, electronic control units, inhibitor switches, brake retarder switches, air pressure reducing valves, throttle dip valves, mechanical/electronic selectors.
Heat exchangers: air, water.

45.3b Describe the routine maintenance of semi-automatic and automatic transmission systems to manufacturers' specification and legal operation.
Oil: pressure check/report readings, drainage/replenishment, grade/type, level, overheated, leaks.
Slip in one/multi gears.
Gearbox breather.
Heat exchangers: leaking, blocked, damaged.
Road test: procedure for transmission operation.

45.4b Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the mechanical running gear of semi-automatic and automatic transmission systems.
Complete running gear: removal, dismantling, assess wear/tear, assembly, drum clearance.
Epicyclic gear train: describe the operation of speed reduction/direct drive/overdrive/ multiply torque.
Compound gear train: describe power flow.
Multi-plate clutch system, brake band adjustment (automatic/manual), one-way clutch systems, thrust washer/bearing.

45.5b Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the hydraulic components of semi-automatic and automatic transmission systems.
Torque converters, oil pumps, valve blocks, servos/delay servos, governors.
Valves: regulator, control, spool, accumulator, selector, torque converter drain.

45.6b Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the pneumatic (compressed air) components of semi-automatic and automatic transmission systems.
Valves: air pressure reducing, electro pneumatic, throttle dip, air restrictor, attenuation.
Air operating pistons.

45.7b Describe fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the electrical/electronic components of semi-automatic and automatic transmission systems.
Components: solenoid, inductive pick-up, electric load sensor, electronic control unit, fuses, earth strap.
Switches: control, brake retarder, inhibitor.

45.8b Describe logical fault diagnostic techniques using diagnostic equipment for semi-automatic and automatic transmission systems.
Stall test/report, oil pressure checks, analysis of symptoms from road test report, correct use of vehicle/manufacturers' diagnostic charts.
Test meters: multi-meter, light emitting diode (LED) light box.
Loss of drive: all positions, specified selector position.
Restricted drive: pulling away, maximum gear/road speed.
Gear change: inappropriate to load/speed, harsh.
Starter motor isolator circuit malfunction.
Gear slip: single gear, multi gear.
Kickdown: delay, inoperative.
Oil leaks: external, internal.
Brake retarders: harsh, inoperative.
Symptoms: abnormal noises, gear flair up, overheating, oil contamination, air leaks, door interlock inoperative, control linkage obstruction.

45.9b Describe the correct procedure for recovery/towing of vehicles fitted with semi-automatic and automatic transmission systems.
Legal requirements when towing.
Safe and correct vehicle/manufacturers' procedure: towing, recovery with defective transmission/engine.

Test specification for written paper Heavy Vehicle Transmission Systems (3905-06-045, 3905-08-045, 3905-10-045 and 3905-12-045)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
45a Heavy vehicle manual transmission systems	55
45b Heavy vehicle semi-automatic and automatic transmission systems	45

Unit 46 Electrical and Electronic Systems Batteries, Charging and Starting Systems Diagnostic Techniques Module (a)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on vehicle batteries, charging and starting systems.

Practical competences

The candidate must be able to do the following:

46.1a Carry out safe working practices when working with batteries, charging and starting systems.

46.2a Use of a range of meters and test equipment/ instruments when working with batteries, charging and starting systems.

46.3a Inspect vehicle systems and prepare a report describing the constructional features, operational principles and maintenance of batteries, charging and starting systems.

46.4a Carry out testing procedures when working on batteries, charging and starting systems and components.

46.5a Carry out logical fault diagnosis techniques using diagnostic equipment and data on batteries, charging and starting systems.

46.6a Carry out the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for batteries, charging and starting systems.

46.7a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

46.1a Describe safe working practices when working on batteries, charging and starting systems.
Safe use: jacking, stands/chocking blocks/lifting equipment, tools, equipment, repair procedures, tools.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of batteries, charging and starting systems (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.

46.2a Describe the use of a range of meters and test equipment/instruments when working with batteries, charging and starting systems.
Analogue/digital meters: multi-meter, volt-meter, ammeter, ohm-meter.
Cathode ray oscilloscope (CRO), hydrometer. Battery capacity discharge test instruments measuring: electromotive force (EMF), potential difference (PD), current flow, resistance, waveforms, specific gravity, capacity.

46.3a Describe the constructional features, operational principles and maintenance of batteries, charging and starting systems.
Lead acid batteries: conventional, low maintenance, maintenance free.
Alternators/output control regulation devices: battery sensed output regulation, machine sensed output regulation, combined battery/machine sensed output regulation (fail safe type).
Pre-engaged starter motors/operational control devices: permanent magnet field, wound field, over-running protection devices (plate/roller type clutches), relays, solenoids, starter inhibitor protection devices.

46.4a Describe testing procedures when working on batteries, charging and starting systems to manufacturer's specification data.
Lead acid batteries: serviceability, state of charge, condition, capacity. Initial charging/commission procedures for dry charged/uncharged lead acid batteries, recharging methods/procedures.
Alternators: serviceability, output control devices (output charge rate, maximum output rate).
Starter motors: vehicle cranking condition.

Note: Applications/situations should be identified where the inappropriate use of test apparatus can result in damage to the apparatus, circuit, component or vehicle system.

46.5a Describe logical fault diagnosis techniques using diagnostic equipment and data on batteries, charging and starting systems.
Battery: overcharging, sulphation, high internal resistance, internal open/short circuit, incorrect acid/electrolyte strength/loss of acid, high resistance/terminal corrosion, plate deterioration.
Charging system: distinguish between battery/charging system faults, incorrect main output lead external connections, overcharging, undercharging, no output, noisy operation, excessive voltage drop in system, charge warning lamp/indictor; non-operation when ignition on, remain on when running engine, flicker when engine running.
Starting system: distinguish between battery/starting system faults, increased/ decreased cranking current consumption, non-operation of system, abnormal low engine cranking speed, unusual noise during engagement/operation, failure of pinion to disengage with flywheel when engine starts, excessive voltage drop in system.

46.6a Describe the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for batteries, charging and starting systems.
Battery systems/component parts: lead acid batteries, heavy duty connection terminals, main connecting cables.
Charging systems/component parts: alternators, output control regulators, warning lamps/indicators, alternator drive belts, switches, relays, wiring harness/loom.
Starting systems/components: starter motors, solenoids, start inhibitor protection devices, switches, relays, wiring harness/loom.

46.7a The use of mathematics and science is applied to the above Knowledge Requirements.
Watt's law, Ohm's law, series/parallel circuit arrangements, conductors, insulators, semi-conductors, transformers.
Use of electrical cables/terminal connections in electrical wiring circuits: cable current rating, cable cross sectional area/length, change of temperature, terminal/connector rating, material, cable identification methods.
Manufacturers' specification data/wiring diagrams/associated symbols (electrical/electronic).
Circuit protection devices: fuses, fusible links, circuit breakers.
Circuit switching control devices: manually controlled on/off switches, electro-magnetically controlled switches (relays, solenoids).
Resistors: rating identification methods, effects of change of temperature.
Capacitors/rating identification methods: polarised, non-polarised.
Electronic devices: diodes, avalanche diodes, Zener diodes, bipolar transistors, thyristors.

Unit 46 Electrical and Electronic Systems
Electrical, Electronic and Auxiliary Systems Diagnostic Techniques Module (b)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on vehicle electrical, electronic and auxiliary systems.

Practical competences

The candidate must be able to do the following:

46.1b Carry out safe working practices when working with electrical, electronic and auxiliary systems.

46.2b Use of a range of meters and test equipment/instruments when working with electrical, electronic and auxiliary systems.

46.3b Inspect vehicle systems and prepare a report describing the constructional features, operational principles and maintenance of electrical, electronic and auxiliary systems.

46.4b Carry out testing procedures when working on electrical, electronic and auxiliary systems.

46.5b Carry out logical fault diagnosis techniques using diagnostic equipment and data on electrical, electronic and auxiliary systems.

46.6b Carry out the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for electrical, electronic and auxiliary systems.

46.7b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

46.1b Describe the safe working practices when working on electrical, electronic and auxiliary systems.
Safe use: jacking, stands/chocking blocks/lifting equipment, tools, equipment, repair procedures, tools.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle electrical, electronic and auxiliary systems (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.

46.2b Describe the use of a range of meters and test equipment/instruments when working with electrical, electronic and auxiliary systems.
Analogue/digital meters: multi-meter, volt-meter, ammeter, ohm-meter.
Cathode ray oscilloscope (CRO), hydrometer.
Battery capacity discharge test instruments measuring: electromotive force (EMF), potential difference (PD), current flow, resistance, waveforms, specific gravity, capacity.

46.3b Describe the constructional features, operational principles and maintenance of electrical, electronic and auxiliary systems.
Ignition systems: contact breaker, magnetic breakerless, Hall effect.
Vehicle lighting systems/lamps: headlamps, spotlamps, mainbeam driving, side, tail, number plate, front/rear fog, internal/courtesy.
Direction indicator/hazard warning lamps: control (thermal, capacitor, electronic).
Audible/horn systems: windtone, high/low frequency, air horn.
Windscreen/headlamp wiper/washer systems: link mechanical/flexible rack drive mechanisms, wound field/permanent magnet field wiper motor, variable/intermittent speed control, washer system.
Cooling, heating and ventilation motor systems/components: wound field/permanent magnet field motor, variable/intermittent speed control, front/rear windscreen heating elements.
Actuator systems: central door locking, window lift, sun roof, petrol flap, tailgate/hatchback/boot lid, air bags, seat belt tensioners.
Air conditioning systems: compressor, pipes, tubes, heat exchangers, refrigerants (charging/discharging), cooling fan, thermostat, switches, relays, wiring harness/loom, sensors, actuators, flaps.
Information/warning instrumentation systems: fuel, temperature, oil pressure, speed/revolutions per minute (rpm), battery voltage/current, low fluid levels, low brake pad thickness, traffic information/navigation systems.
In-car entertainment systems/components: radios, radio cassettes, compact disc (CD) players, amplifiers, speakers, manual/electrical operated aerials.
Vehicle security alarm systems: remote/key switch/time delay control, immobilisers, tracking systems. Electrical seat systems: adjustment, heating.

46.4b Describe testing procedures when working on electrical, electronic and auxiliary systems.
Batteries, ignition, lighting, signalling, motor/actuators, passenger restraint systems, air conditioning, instrumentation, in-car entertainment, security systems.

Note: Applications/situations should be identified where the inappropriate use of test apparatus can result in damage to the apparatus, circuit, component or vehicle system.

46.5b Describe logical fault diagnosis techniques using diagnostic equipment and data on electrical, electronic and auxiliary systems.
Ignition: engine fails to start/starts and cuts out/misfires, reduced system performance, excessive voltage drop in system.
Lighting: failure to operate when switched on, continuous operation when switched off, intermittent operation, reduced lighting intensity, lamp misalignment, excessive voltage drop in system.
Signalling: failure to operate when switched on, continuous operation when switched off, defective tone, excessive voltage drop in system.
Motors/actuators: failure to operate when switched on, continuous operation when switched off, intermittent operation, reduced system performance, excessive voltage drop in system.
Instruments: failure to operate when switched on, continuous operation when switched off, intermittent operation, reduced system performance, incorrect reading/display, excessive voltage drop in system.
In-car entertainment: failure to operate (display illuminated/not illuminated), loss of code, reduced system performance, poor sound quality, non-operation of speakers/individual speaker, interference (line borne, radiated), non-operation/reduced operation of electric aerial, excessive voltage drop in system.
Security system: failure to activate/deactivate, intermittent operation, excessive voltage drop in system.

46.6b Describe the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for electrical, electronic and auxiliary systems.
Ignition systems/components: distributor, amplifier, contact breaker points, spark plugs, ignition coil, ignition leads, ballast resistor, switches, wiring harness/loom.
Lighting system/components: switches, relays, wiring harness/loom, lamps (headlamps, mainbeam driving, side, tail, number plate, front/rear fog, spot).
Direction indicator/hazard warning lamp systems/components: lamps, bulbs, switches, relays, wiring harness/loom.
Horn systems/components: horn, compressor, switches, relays, wiring harness/loom.
Windscreen/headlamp wiper systems/components: windscreen/headlamp wipers, switches, relays, wiring harness/loom.
Windscreen/headlamp washer systems/components: windscreen washer (front/rear), headlamp washer, switches, relays, wiring harness/loom.
Heating/ventilation systems/components: heating/ventilation motors, switches, relays, wiring elements/harness/loom.
Electric motor cooling fan systems/components: electric motor, temperature switches, warning light, switches, relays, wiring harness/loom.
Actuator systems/components: actuators, warning light, switches, relays, wiring harness/loom.
Air conditioning systems/components: compressor, cooling fan, thermostat, pipes/tubes, refrigerant, switches, relays, wiring harness/loom.
Instrumentation information systems/components: gauges, displays, voltage stabilisers, sensors, switches, relays, wiring harness/loom.
In-car entertainment systems/components: radios, radio cassettes, compact disc (CD) players, amplifiers, speakers, manual/electric aerials, switches, relays, wiring harness/loom.
Vehicle security systems/components: alarms, remote control devices, sensors, switches, relays, wiring harness/loom.

46.7b The use of mathematics and science in relation applied to the above Knowledge Requirements.
Watt's law, Ohm's law, series/parallel circuit arrangements, conductors, insulators, semi-conductors, transformers.
Use of electrical cables/terminal connections in electrical **wiring circuits:** cable current rating, cable cross sectional area/length, change of temperature, terminal/connector rating, material, cable identification methods.
Manufacturers' specification data/wiring diagrams/associated symbols (electrical/electronic).
Circuit protection devices: fuses, fusible links, circuit breakers.
Circuit switching control devices: manually controlled on/off switches, electro-magnetically controlled switches (relays, solenoids).
Resistors: rating identification methods, effects of change of temperature.
Capacitors/rating identification methods: polarised, non-polarised.
Electronic devices: diodes, avalanche diodes, Zener diodes, bipolar transistors, thyristors, photo-diodes, photo-transistors, light emitting diodes (LED), liquid crystal display (LC)), vacuum fluorescent display.

Unit 46 Electrical and Electronic Systems
Vehicle Electronic and Microprocessor Systems Diagnostic Techniques Module (c)

All vehicle systems and components must be checked and tested for working status before applying diagnostic techniques.

The candidate must also be given the opportunity to examine, test, adjust and diagnose faults on vehicle electronic and microprocessor systems.

Practical competences

The candidate must be able to do the following:

46.1c Carry out safe working practices when working with vehicle electronic and microprocessor systems.

46.2c Use a range of meters and test equipment/instruments when working with vehicle electronic and microprocessor systems.

46.3c Inspect vehicle systems and prepare a report describing the constructional features, operational principles and maintenance of vehicle electronic and microprocessor systems.

46.4c Carry out testing procedures when working on vehicle electronic and microprocessor systems.

46.5c Carry out logical fault diagnosis techniques using diagnostic equipment and data on vehicle electronic and microprocessor systems.

46.6c Carry out the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for vehicle electronic and microprocessor systems.

46.7c Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

46.1c Describe safe working practices when working on vehicle electronic and microprocessor systems.
Safe use: jacking, stands/chocking blocks/lifting equipment, tools, equipment, repair procedures, tools.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassembly/repair/overhaul and repair of vehicle electronic and microprocessor systems (to manufacturers' spectifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.

46.2c Describe the use of a range of meters and test equipment/instruments when working with electrical, electronic and auxiliary systems.
Analogue/digital meters: multi-meter, volt-meter, ammeter, ohm-meter.
Cathode ray oscilloscope (CRO), hydrometer.
Battery capacity discharge test instruments measuring: electromotive force (EMF), potential difference (PD), current flow, resistance, waveforms, specific gravity, capacity.
Logic pulsers/probes.

46.3c Describe the constructional features, operational principles and maintenance of vehicle electronic and microprocessor systems.
Sensors (speed/position): Hall effect, inductor/reductor, opto-electronic, quenched oscillator.
Sensors (air flow): variable induction/transformer, air flow meter (flap), hot wire, variable resistor/potentiometer, strain gauge/piezo resistive.
Senors (engine running conditions): fluid level, exhaust gas oxygen, temperature, fuel flow, oil pressure.
Sensors (other): brake pad wear, lamp failure, seat belt tensioning, air bag, vehicle impact.
Actuators: vacuum operated throttle, stepping motor, solenoid.
Ignition systems: inductive storage, capacity discharge.
Electronic fuel control systems: petrol injection multi-point/throttle body.
Engine management systems/control systems: open-loop control, closed loop proportional control, closed loop limit cycle control.
Vehicle speed control systems: cruise control.
Instrumentation information systems: fuel, temperature, oil pressure, speed/revolutions per minute (rpm), battery voltage/current, low fluid levels, trip computers, traffic information/navigation.
Timer circuits: flashing indicator, intermittent wipe control, delay devices, vehicle security alarms.

46.4c Describe testing procedures when working on vehicle electronic and microprocessor systems.
Batteries, sensors, actuators, ignition, electronic fuel control, engine management systems, speed control, instrumentation, timer circuit devices.

Note: Applications/situations should be identified where the inappropriate use of test apparatus can result in damage to the apparatus, circuit, component or vehicle system.

46.5c Describe logical fault diagnosis techniques using diagnostic equipment and data on vehicle electronic and microprocessor systems.
Sensors: open/short circuit, incorrect adjustment, nil/reduced/distorted output signal.
Actuator: internal short circuit/open circuit, incorrect adjustment.
Ignition: engine fails to start/starts and cuts out/misfires, reduced system performance.
Electronic fuel control: engine fails to start, incorrect idle speed, increased fuel consumption, excessive weak air/fuel mixture, incorrect operation of sensors/actuators.
Engine management systems: electronic control unit (ECU) malfunction; internal fault, incorrect sensor data to electronic control unit (ECU).

Variable speed control system.
Speed sensor: short/open circuit, incorrect adjustment, nil/reduced/distorted output signal.
Throttle actuator: internal short/open circuit, incorrect adjustment.
Electronic control unit malfunction: internal fault, incorrect sensor data to electronic control unit (ECU).

Instrumentation: inoperative, intermittent/retarded operation, incorrect reading/display information.
Timer circuit: activation/deactivation failure, intermittent operation.

46.6c Describe the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for vehicle electronic and microprocessor systems.

Sensors (pressure, position, flow, temperature): oil pressure, manifold absolute pressure (MAP), strain gauge pressure, crankshaft angular position/movement, throttle position, gearbox output shaft movement, engine oil level, fuel level/flow, air flow, emissions (Lambda), engine temperature, air intake/coolant/fuel temperature, knock control.

Actuators: vacuum operated throttle actuators, stepping motors, solenoid types, switches, relays, wiring harness.

Ignition systems/components: distributor, amplifier, electronic control units (ECU), contact breaker points, spark plugs, ignition coil, ignition leads, ballast resistor, switches, wiring harness/loom.

Electronic fuel control systems: injectors, coolant temperature thermistors, throttle potentiometers, throttle valves, stepper motors, start valves, auxiliary air devices, air flow sensors, inertia switches, fuel temperature switches/pipes/filters/pressure regulators, relays, wiring harness/loom.

Engine management systems/control systems: electronic control unit (ECU), in out sensors, switches, relays, wiring harness/loom.

Vehicle speed control systems/components: speed sensors, throttle actuators, electronic control unit (ECU), switches, relays, wiring harness/loom.

Instrumentation information systems: gauges, displays, voltage stabilisers, sensors, switches, relays, wiring elements/harness/loom.

Timer circuit applications: electronic control unit (ECU), sensors, switches, relays, wiring harness/loom.

46.7c Describe the use of mathematics and science in relation applied to the above Knowledge Requirements.

Watt's law, Ohm's law, series/parallel circuit arrangements, conductors, insulators, semi-conductors, transformers.

Inductance/resistance/capacitance in direct current (DC)/alternating current (AC) circuits.

Reactance, impedance.

Use of electrical cables/terminal connections in electrical **wiring circuits:** cable current rating, cable cross sectional area/length, change of temperature, terminal/connector rating, material, cable identification methods.

Manufacturers' specification data/wiring diagrams/associated symbols (electrical/electronic).

Circuit protection devices: fuses, fusible links, circuit breakers.

Circuit switching control devices: manually controlled on/off switches, electro-magnetically controlled switches (relays, solenoids).

Resistors: rating identification methods, effects of change of temperature.

Capacitors/rating identification methods: polarised, non-polarised.

Electronic devices: diodes, avalanche diodes, Zener diodes, bipolar transistors, thyristors, photo-diodes, photo-transistors, light emitting diodes (LED), liquid crystal display (LC)), vacuum fluorescent display.

Basic digital principles: analogue/digital signals, binary/denary numbers, voltage levels for digital data, logic gates, bistable(flip flops), random access memory (RAM), read only.

Test specification for written paper Electrical and Electronic Systems (3905-05-046 to 3905-12-046)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
46a Batteries, charging and starting systems	30
46b Electrical, electronic and auxiliary systems	35
46c Vehicle electronic and microprocessor systems	35

Unit 47 Service Reception
Service Reception

The candidate must be given the opportunity to examine modern service reception areas, their functional activity in relation to the customer, their vehicle and the repair workshops.

Practical competences

The candidate must be able to do the following:

47.1 Carry out safe working practices when working in the service reception department.

47.2 Draw an organisational chart showing the structure of a motor vehicle service organisation.

47.3 Prepare a job/person specification report describing the professional knowledge and interpersonal skills required by a motor vehicle technical service receptionist.

47.4 Prepare a report describing the organisational systems and administration of a motor vehicle service reception department.

47.5 Produce promotional literature for a given promotional activity in a motor vehicle service reception.

47.6 Carry out research into the commercial practices associated with a motor vehicle service reception department.

47.7 Carry out effective customer service in a service reception. Describe the key issues of customer service from the observation and make recommendations for an effective service.

Knowledge requirements

The instructor must ensure the candidate is able to:

47.1 Describe safe working practices when working in the service department and reception area.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, automatic transmission fluid, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of semi-automatic and automatic transmission systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Safe/legal road test/towing (automatic/manual transmission) procedures.
Fire and safety precautions in reception area, information signs, customer safety. Identification of potential safety hazards in reception area, restricted areas.

47.2 Describe the structure of motor vehicle service organisations.
Departments: service/repair workshop, stores/parts, body repair workshop, sales new/second hand, accounts, administration.
Relationship within the organisational structure: vehicle manufacturer, service/repair organisation, location (city, town, rural).

Organisational Objectives.
Personnel: executive management, departmental heads, managers, supervisors (eg. each service reception will have a different management structure/staff).
Staff: recruitment of apprentice/trainee/semi-skilled/skilled/trades person.
Authority/responsibility of workshop manager/supervisor/technician/trades person.
Types of service outlet: vehicle manufacturer's dealership, independent vehicle retail/repair organisation's service reception departments.
Motor trade membership: associations, institutes.

47.3 Describe the professional knowledge and interpersonal skills of a motor vehicle service receptionist.
Professional knowledge: diagnostic techniques, vehicle manufacturers' specifications/data, use of diagnostic equipment, vehicle legislation (eg. roadworthiness, licences).
Qualifications: academic/vocational, work experience.
Effective organisation of work: estimation/work report, record keeping, systematic approach to work.
Membership of motor industry trade associations/institutions, updating knowledge/skills, membership (self).
Interpersonal skills: importance of image (cleanliness, pride in appearance), positive attitude, self motivated, punctual, reliable, honesty, enthusiasm, responsible, friendly manner.
Effective communication skills: verbal, face-to-face, telephone, questioning and listening skills.
Effective liaison: repair workshop/departmental staff.

47.4 Describe the administration and workshop organisational systems of a motor vehicle service reception department.
Administration systems: service reception, parts/sales, workshop control, costing/estimating, insurance/accident repair procedures, charge out rate, labour rate/bonus/incentive scheme.
Communication process: verbal, listening, written (hand/computer). reports/invoices/warranty procedures, telephone/facsimile/computer (local/national/ worldwide).

Documentation.
Types (manual/computerised): job sheets set, invoicing, stores/parts issue/sales, manufacturer's warranty, insurance, quotations/estimates.
Customer booking system/authorisation procedures, staff/workshop loading, prioritising, parts, warranty agreement procedures.

47.5 Describe the methods of marketing and promoting a motor vehicle service department.
Marketing mix: products, place, price, promotion, people.
Market segmentation: customers, vehicle types, sales/repair outlets, marketing strategy/plan, competition.
Assessing customer needs: customer relations, customers (existing, future).
Methods of advertising services: reputation (eg. by word of mouth), media (TV, radio, journals, newspapers, posters, mail shots, brochures, leaflets).
Sales promotions: seasonal, safety checks, regular service/maintenance, special offers, matching sales with workshop capacity, incentives for service receptionist, overselling versus underselling.
Image: visual location of service reception, customer facilities (seating area, refreshments, toilets).

47.6 Describe the commercial practices associated with a motor vehicle service reception department.
Administration of documentation/systems of work: invoice, orders (parts/materials), estimates, quotations, warranties, filing systems, confidentiality/security of systems.
Communication/correspondence: written (manual/computerised), telephone, facsimile, telex, internet, reports, charts, graphs, presentations.
Accounting procedures: clearing payment of invoices, legal tender/negotiability, transactions; cash, credit/debit card, cheque, direct debit, bankers draft, foreign currency, exchange rates, conversions, security.
Calculations: invoices, estimates, quotations, orders, warranty, discounts, sales tax.
Legislation and regulations.
Insurance: company, employees, customers property, buildings/equipment.
Licences: (eg. fire, petroleum, toxic materials).
Legal contract: valid/invalid, unenforceable, void/voidable, agreement, offer/treat discharge, verbal/written.
Agency: agent, third party, principal's liabilities, breach of authority, action binding by principal.
Sale of goods: sale of services, customer protection, responsibilities, legal implications, codes of practice.
Trade description: false trading, legal implications, misleading/false statements, marking of goods, consumer/seller rights, codes of practice.
Unfair contract: reasonableness/negligence, liability.
Contractual legal agreements/arrangements with customers, the right to retain goods by the service reception through non-payment of invoice by customer (eg. right of lien), conditions/applications, disposing of uncollected goods, codes of practice.
Health and safety: safe working practices, legal liability, employer/employee obligations.
Trade licence: trade plates, codes of practice.
Motor vehicle: construction, road worthiness certificates, use on public roadways, plating/testing, lighting.

47.7 Describe key issues of customer service.

Customer focused strategies: systems created with the customer in mind, staff training/development, creating a service that meets/exceeds customer expectations.

Positive/negative influences: customer impressions of service reception.

Environment: image, queuing/waiting times, (what is acceptable/unacceptable waiting time).

Staff: motivated/demotivated, well trained/untrained.

Information provision: effective/accurate, poor/inaccurate.

Satisfied/dissatisfied customers: exceeding/failing to meet expected standards of service.

External customers: individuals, group, companies, vehicle manufacturers' (in person, telephone, facsimile, electronic/E-mail).

Internal customers: management, senior/middle, workshop/accounts, stores/parts, vehicle manufacturer.

First impressions: caring for the customer, assessing customer needs, exceeding customers expectations, achieving customer satisfaction, maintaining safety/security, providing information.

Dealing with a customer: interpretation of customer instructions, work scheduling, time management.

Queries: sales, car recovery, difficult issues, (eg. costs, and extra costs incurred by customer).

Test specification for written paper Service Reception (3905-05-047 to 3905-12-047)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
47.1 Safety practices	10
47.2 Structure of motor vehicle service organisations	10
47.3 Professional knowledge and interpersonal skills	15
47.4 Administration workshop organisational systems	15
47.5 Methods of marketing and promoting	10
47.6 Commercial practices in service reception department	20
47.7 Key issues of customer service	20

Unit 48 Mathematics, Science and Electronics 3
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

48.1a Perform graphical operations.

48.2a Perform calculus operations.

48.3a Perform mensuration operations.

Knowledge requirements

The instructor must ensure the candidate is able to:

48.1a Describe graphical operations.

Definitions: reduction of laws to linear form, cubic equation, specified interval, range.

Simultaneous equations.

Two linear equations: two unknowns, plot curves, determine point of intersection.

Quadratic/linear equations: plot curves, determine points of intersection.

Quadratic equation: plot curve, determine roots from intersections with x-axis.

Reduction of laws to linear form: equations of type $y = ax^k$, show there is a linear relationship, plot tabular values of *log x* and *log y*, determine values for a and k.

Cubic equation: plot curve (specified interval/range), determine values of x for $y = o$, test answers in original equation.

48.2a Describe calculus operations.

Definitions: average/instantaneous gradient, differentiation, incremental changes (ox, oy), dy/dx as limiting value of the ratio oy/ox when $ox \rightarrow 0$, 'function of a function' rule, integration (reverse of differentiation), definite/indefinite integral.

Differentiation: show from first principles $\lim ox \rightarrow 0\ oy/ox = dy/dx$, differential property of exponential/logarithmic functions, product rule, quotient rule.

Integration: importance of a constant, express area under a graph between ordinates $x = a$ and $x = b$ as approximately the sum of the strips of length y and width ox, define $\int_a^b y\,dx$ as area under the graph between ordinates $x = a$ and $x = b$.

Calculations.

Graphs: average/instantaneous gradients of curves ($y = ax + b$, $y = ax^2$), deduce that the cord reduces to the tangent at a point as the arc reduces to zero, incremental changes in x and y directions (ox, oy), value of the ratio oy/ox as interval of ox is reduced, dy/dx is gradient of graph at a particular point, rate of change at maximum/minimum point of a curve is zero.

Differentiation: differentiate algebraic functions, determine maximum/minimum values for y, exponential/logarithmic functions, product rule, quotient rule.

Function of a function rule: find derivatives with respect to x of given functions.

Integration: indefinite integral of algebraic functions/functions involving cose and sine, value of $\int ax\,dx$ $\int$sine de $\int$cose de for limits a and b.

48.3a Describe mensuration operations.

Definitions: trapezoidal rule, mid-ordinate rule, Simpson's rule, centroids, Theorems of Pappus.

Calculations.

Diagrams: draw from given data to a suitable scale.

Irregular sections: area (mid-ordinate rule, Simpson's rule).

Graphs: area under a curve between stated limits (trapezoidal rule, mid-ordinate rule).

Position of centroids: rectangles, triangles, circles, semicircles, composite areas, use of integration, volumes of revolution.

Theorems of Pappus: area/volume/mass of simple solids of revolution.

Unit 48 Mathematics, Science and Electronics 3
Vehicle Science Module (b)

Practical competences

48.1b Research information analysing the terms used and calculations associated with the deflection of beams.

48.2b Research information analysing the terms used and calculations associated with the power transmitted by clutches and belt drive systems.

48.3b Research information analysing the terms used and calculations associated with turning moment diagrams.

48.4b Research information analysing the terms used and calculations associated with the principles of epicyclic gear trains.

48.5b Research information analysing the terms used and calculations associated with tractive effort and tractive resistance.

48.6b Research information analysing the terms used and calculations associated with relative velocity.

48.7b Research information analysing the terms used and calculations associated with shear force and bending moments.

Knowledge requirements

The instructor must ensure the candidate is able to:

48.1b Analyse information identifying the terms used and calculations associated with the deflection of beams.
Definitions: Macaulay expressions for bending moments, boundary conditions, slope/ deflection diagrams.
Calculations: bending moments (concentrated/uniformly distributed loads), unknowns (inserting known boundary conditions), slope/deflection diagrams, maximum deflection (position/value).

48.2b Analyse information identifying the terms used and calculations associated with the power transmitted by clutches and belt drive systems.
Definitions: constant wear/pressure concepts, power transmission clutch/belt drive, lap/vee angle (belt drive), size/number/configuration (belt drive), initial tension (belt drive).
Formula: frictional torque in clutch, belt tension (flat/vee belts), centripetal tension in belts.
Principle: single/multi plate clutch, cone clutch, flat/vee drive belts.
Calculations: frictional torque in clutch, belt tension (flat/vee belts), lap angle (belt drive), limiting value of vee angle (belt), centripetal tension in belts, power transmitted in cone clutch/vee belt drives, size/number/configuration (belt drive), initial tension (belt drive).

48.3b Analyse information identifying the terms used and calculations associated with turning moment diagrams.
Definitions: flywheel (energy storing device), turning moment diagrams, energy fluctuation (during a cycle), coefficient of fluctuation of speed, moment of inertia (flywheel).
Calculation: turning moment diagrams (single/multi-cylinder/in-line/vee engines), maximum energy fluctuation (during a cycle), fluctuation coefficient of speed, moment of inertia (flywheel), flywheel specifications.
Relationship: moment of inertia (flywheel)/maximum energy fluctuation (during a cycle)/coefficient of fluctuation of speed.

48.4b Analyse information identifying the terms used and calculations associated with the principles of epicyclic gear trains.
Definitions: simple/compound epicyclic gear trains, gear ratios, engine speed ratio.
Principle: engine speed ratio as common ratio between successive speeds in gearbox.
Calculations: gear ratios, speed/direction (members/shafts).

48.5b Analyse information identifying the terms used and calculations associated with tractive effort and tractive resistance.
Definitions: tractive effort, tractive resistance, constant power, resistance curves, road speed curves, power available at road wheels, performance curves, under/over gearing.
Principle: engine torque/power curves in selecting suitable gear ratios, reasons why actual ratios differ from ideal ratios (family saloon, high performance sports car, commercial vehicle, bus/coach, off-road vehicle).
Overall top gear ratio: = top gear x final drive ratio (allowing for road wheel diameter), constant power, tractive effort/road speed curves.
Calculations: tractive effort, tractive resistance, resistance curves, power available at road wheels, maximum speed, performance curves (under/over gearing, effect on maximum speed), engine speed ratio (RPM maximum torque/RPM maximum power), first gear ratio (maximum gradient/rolling resistance), intermittent gear ratios (engine speed ratio).

48.6b Analyse information identifying the terms used and calculations associated with relative velocity.
Definitions: relative velocity, velocity diagrams.
Calculations: relative velocity/velocity diagrams (vehicles on the road, engine connecting rod/crank mechanism).

48.7b Analyse information identifying the terms used and calculations associated with shear force and bending moments.
Definitions: centroid, first moment of area, second moment of area, modulas of section, maximum allowable stresses, bending moments, loading conditions, load diagrams.
Principles: simple bending theory (first principles), M/I = d/Y = E/R.
Calculations: centroid, first moment of area, second moment of area, rectangular/circular/ I-section beams (maximum allowable stresses, bending moments, loading conditions), modulas of section, bending moment/load diagrams/reactions (simple horizontal cantilever/beam carrying point loads/uniformly distributed loads), shear force (loaded beams), shear force diagrams (locating points of zero shear force).

Unit 48 Mathematics, Science and Electronics 3
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

48.1c Research information analysing the operation of electronic ignition (EST) systems.

48.2c Research information analysing the operation of electronic fuel injection (EFI) systems.

48.3c Research information analysing the operation of anti-lock braking (ABS) systems.

48.4c Research information analysing open and closed loop engine systems.

48.5c Research information analysing engine management systems and their operation.

48.6c Research information analysing and applying the methods employed to diagnose faults in electronic systems.

48.7c Research information analysing and applying computer fault codes and code reading equipment.

48.8c Research information analysing and applying faults in electronic component/unit or sensor operation.

48.9c Research information analysing and applying circuit testing.

Knowledge requirements

The instructor must ensure the candidate is able to:

48.1c Analyse, with the use of diagrams, information identifying the operation of electronic ignition systems.
Definition: electronic spark timing (EST), Hall effect trigger, DFI, LED/photo-diode trigger.
EST ignition computer: inductive triggering from flywheel, Hall effect triggering in distributor/ignition unit, LED/photo-diode triggering in distributor/ignition unit, Hall effect triggering from crankshaft sensors with DFI unit/without distributor.

48.2c Analyse, with the use of diagrams, information identifying the operation of electronic fuel injection (EFI) systems with consideration of air/fuel ratio.
Definition: EFI.
Operation: starting, idling, part/full throttle load, cruising, deceleration.

48.3c Analyse, with the use of diagrams, information identifying the operation of anti-lock braking (ABS) systems with consideration to the three conditions controlled by the ECU.
Definition: ABS, ECU.
Operating conditions: vehicle speed, wheel speed, hydraulic pressure.

48.4c Analyse, with the use of diagrams, information identifying open and closed loop engine systems.
Definitions: open loop, closed loop.

48.5c Analyse, with the use of diagrams, information identifying engine management systems and their operation.
Definitions: vortex theory.
Sensors: MAP, hotwire air flow.

Systems.
Central fuel injection systems using vortex theory air flow sensor and filtered to turbocharged engine.
Multi-point fuel injection system utilising MAP sensor, Hall effect ignition triggering and EST.
Multi-point fuel injection system with hotwire type air flow sensor, optical ignition triggering and EST.
Mulit-point fuel injection system linked with direct fire ignition and EST.

48.6c Analyse information identifying the methods employed to diagnose faults in electronic systems.
Visual warnings: warning lights, information displays, nil operation.
Verbal: information from driver.
Specifications/data: manufacturers' charts/diagrams.
Fault codes: stored in computers memory. **Inspection:** electronic component/units, sensors.

48.7c Analyse information identifying computer fault codes and code reading equipment.
Computer fault diagnostics: fault detection, pre-set code storage in memory, diagnostic links, vehicle computer diagnostic mode, manufacturers' fault code data.
Test equipment: diagnostic computer, decoders, low wattage globe (LED), multimeter, digital display.

48.8c Analyse information identifying faults in electronic component/unit or sensor operation.
Physical/visual checks: moving parts, open circuits, illuminated lights, noisy component, sensor heater elements.
Technical data: manufacturers' specifications.

48.9c Analyse information identifying circuit testing techniques.
Test equipment: multimeter, hand tools.
Technical data: manufacturers' specifications/wiring diagrams.
Procedures: determine nature of circuit, test equipment connections, observe/record/ compare meter readings, removal for further testing, wiring tests, voltage checks at computer inputs/outputs.

Test specification for written paper Mathematics, Science and Electronics 3 (3905-07-048 to 3905-12-048)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
48a Mathematics module	30
48b Vehicle science module	35
48c Vehicle electronic systems module	35

Vehicle Systems Practical (3905-05-049 to 3905-12-049)

Assessment of the practical skills at each level of this programme is by completion of the tasks listed under practical competences. For each unit there is a competence checklist against which successful performance is recorded. It is expected that a candidate will have successfully completed each of the activities before being credited with a specific skill. Wherever possible competence should be demonstrated in the workplace or in a realistic work environment.

Candidates must demonstrate competence in all of the topics.

Centres should copy the practical assessment sheets for EACH candidate. Completed sheets for each candidate must be available for inspection by the Visiting Assessor, or submission to City & Guilds on request.

The Visiting Assessor must make a visit to the assessment centre on at least one occasion each year at a time when practical assessments are taking place. The main purpose of this visit is to ensure that the competence checklists are being completed accurately and in accordance with the regulations for assessment of this programme.

Please refer to the **Role and Duties of the Visiting Assessor** in Appendix B.

Practical competences

The candidate must be able to do the following:

41.1 Carry out the safe working practices when working with petrol engines and fuel systems. ☐

41.2 Prepare a report describing the design features and constructional details of four, five and six cylinder engines and fuel systems. ☐

41.3 Carry out pressure charging diagnostic techniques and rectification procedures. ☐

41.4 Inspect vehicle systems and prepare a report comparing the fuel characteristics for carburettor and fuel-injection systems of petrol engines. ☐

41.5 Carry out a series of scheduled services on petrol engines and fuel systems according to the manufacturers' specifications. ☐

41.6 Carry out removal and replacement of petrol engines and fuel system components ☐

41.7 Inspect vehicle systems and prepare a report identifying the diagnostic equipment to be used for carrying out diagnostic techniques. ☐

41.8 Carry out repair techniques on petrol engines and fuel system components. ☐

41.9 Diagnose/correct faults on petrol engines and fuel systems using analysers gauges and meters. Prepare a report on engine condition, fault location and appropriate rectification procedures. ☐

41.10 Diagnose/correct faults using appropriate diagnostic equipment and techniques on petrol engine valve systems, cooling systems, emission systems, injection systems and electrical/electronic systems, including interpretation of circuit diagrams. ☐

41.11 Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 42 Light Vehicle Chassis Systems
Light Vehicle Braking, Steering, Suspension Systems and Diagnostic Techniques Module (a)

Practical competences

The candidate must be able to do the following:

42.1a Carry out safe working practices when working on light vehicle braking, steering and suspension systems. ☐

42.2a Inspect vehicle systems and prepare a report describing light vehicle braking, steering and suspension systems and their layout. ☐

42.3a Inspect vehicle systems and prepare a report describing the constructional features and operational principles of light vehicle braking, steering and suspension systems. ☐

42.4a Carry out routine maintenance of light vehicle braking, steering and suspension systems to manufacturers' specification and legal operation. ☐

42.5a Carry out logical fault diagnosis techniques using diagnostic equipment for light vehicle braking, steering and suspension systems. ☐

42.6a Carry out fault diagnosis in the dismantling, assessment,repair/replacement, reassembly, adjustment using test procedures for light vehicle braking, steering and suspension systems. ☐

42.7a Use diagnostic test equipment on light vehicle braking, steering and suspension systems for workshop and road tests. ☐

42.8a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 42 Light Vehicle Chassis Systems
Light Vehicle Manual Transmission Systems Diagnostic Techniques Module (b)

Practical competences

The candidate must be able to do the following:

42.1b Carry out safe working practices when working on light vehicle transmission systems. ☐

42.2b Inspect vehicle systems and prepare a report describing light vehicle transmission systems and their layout. ☐

42.3b Inspect vehicle systems and prepare a report describing the constructional features and operational principles of light vehicle transmission systems. ☐

42.4b Carry out routine maintenance of light vehicle transmission systems. ☐

42.5b Carry out logical fault diagnostic techniques using diagnostic equipment for light vehicle transmission systems. ☐

42.6b Carry out logical fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for light vehicle transmission systems. ☐

42.7b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 42 Light Vehicle Chassis Systems
Light Vehicle Automatic Transmission Systems Diagnostic Techniques Module (c)

Practical competences

The candidate must be able to do the following:

42.1c Carry out the safe working practices when working with light vehicle automatic transmission systems. ☐

42.2c Inspect vehicle systems and prepare a report describing light vehicle automatic transmission systems and components. ☐

42.3c Inspect vehicle systems and prepare a report describing the constructional features and operational principles of light vehicle automatic transmission systems and components. ☐

42.4c Carry out routine maintenance of light vehicle automatic transmission systems. ☐

42.5c Carry out logical fault diagnostic techniques using diagnostic equipment for light vehicle automatic transmission systems. ☐

42.6c Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 43 Diesel Engines and Fuel Systems
Diesel Engine Diagnostic Techniques Module (a)

Practical competences

The candidate must be able to do the following:

43.1a Carry out safe working practices when working on diesel engines. ☐

43.2a Inspect vehicle systems and prepare a report describing the design features and constructional details of diesel engines and their components. ☐

43.3a Carry out pressure charging techniques on diesel engines. ☐

43.4a Carry out a series of scheduled services on diesel engines. ☐

43.5a Carry out the removal and replacement of diesel engines. ☐

43.6a Carry out diagnostic techniques of diesel engines. ☐

43.7a Carry out repair techniques on diesel engines and pressure charging systems. ☐

43.8a Diagnose and rectify faulty components which affect system performance. ☐

43.9a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 43 Diesel Engines and Fuel Systems
Diesel Fuel Injection Systems Diagnostic Techniques Module (b)

Practical competences

The candidate must be able to do the following:

43.1b Carry out safe working practices when working on diesel fuel injection systems. ☐

43.2b Inspect vehicle systems and prepare a report describing the types of diesel engine, cycles of operation and characteristics of fuels. ☐

43.3b Inspect vehicle systems and prepare a report describing the design features and constructional details of diesel fuel injection system components. ☐

43.4b Inspect vehicle systems and prepare a report describing alternative diesel fuel supply and return systems, position, function and operation of main components. ☐

43.5b Inspect vehicle systems and prepare a report describing the design features and constructional details of diesel fuel injection system main components. ☐

43.6b Carry out dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for diesel fuel injection system components. ☐

43.7b Carry out routine maintenance procedures to manufacturers' specifications on diesel fuel injection systems. ☐

43.8b Carry out logical fault diagnosis techniques using diagnostic equipment to locate and correct a variety of faults on diesel fuel injection systems. ☐

43.9b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 44 Heavy Vehicle Chassis Systems
Heavy Vehicle Braking Systems Diagnostic Techniques Module (a)

Practical competences

The candidate must be able to do the following:

44.1a Carry out safe working practices when working on heavy vehicle braking systems. ☐

44.2a Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle braking systems. ☐

44.3a Carry out routine maintenance of heavy vehicle braking systems and their components to manufacturers' specification and legal operation. ☐

44.4a Carry out logical fault diagnosis techniques using diagnostic equipment for heavy vehicle braking systems. ☐

44.5a Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for heavy vehicle braking systems. ☐

44.6a Inspect vehicle systems and prepare a report describing the statutory requirements for heavy vehicle braking systems and their components. ☐

44.7a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 44 Heavy Vehicle Chassis Systems
Heavy Vehicle Steering Systems Diagnostic Techniques Module (b)

Practical competences

The candidate must be able to do the following:

44.1b Carry out safe working practices when working on heavy vehicle steering systems. ☐

44.2b Inspect vehicle systems and prepare a report describing heavy vehicle manual and power assisted steering systems and their layouts. ☐

44.3b Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle steering systems. ☐

44.4b Carry out routine maintenance of heavy vehicle steering systems. ☐

44.5b Carry out logical fault diagnostic techniques using diagnostic equipment for heavy vehicle steering systems. ☐

44.6b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment and test procedures for heavy vehicle steering systems. ☐

44.7b Using diagnostic test equipment, carry out workshop and road tests on heavy vehicle steering systems. ☐

44.8b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 44 Heavy Vehicle Chassis Systems
Heavy Vehicle Suspension Systems Diagnostic Techniques Module (c)

Practical competences

The candidate must be able to do the following:

44.1c Carry out safe working practices when working on heavy vehicle suspension systems. ☐

44.2c Inspect vehicle systems and prepare a report describing heavy vehicle suspension systems and their layout. ☐

44.3c Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle suspension systems. ☐

44.4c Carry out routine maintenance of heavy vehicle suspension systems. ☐

44.5c Carry out logical fault diagnostic techniques using diagnostic equipment for heavy vehicle suspension systems. ☐

44.6c Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment and test procedures for heavy vehicle suspension systems. ☐

44.7c Using diagnostic test equipment, carry out workshop and road tests on heavy vehicle suspension systems. ☐

44.8c Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 45 Heavy Vehicle Transmission Systems
Heavy Vehicle Manual Transmission Systems Diagnostic Techniques Module (a)

Practical competences

The candidate must be able to do the following:

45.1a Carry out safe working practices when working on heavy vehicle manual transmission systems. ☐

45.2a Inspect vehicle systems and prepare a report describing the heavy vehicle manual transmission systems and their layout. ☐

45.3a Inspect vehicle systems and prepare a report describing the constructional features and operational principles of heavy vehicle manual transmission systems. ☐

45.4a Carry out routine maintenance of heavy vehicle manual transmission systems and compare air versus hydraulic system serviceability. ☐

45.5a Carry out logical fault diagnostic techniques using diagnostic equipment for heavy vehicle manual transmission systems. ☐

45.6a Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for heavy vehicle manual transmission systems. ☐

45.7a Use diagnostic test equipment on heavy vehicle manual transmission systems for workshop and road tests. ☐

45.8a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 45 Heavy Vehicle Transmission Systems
Heavy Vehicle Semi-Automatic and Automatic Transmission Systems
Diagnostic Techniques Module (b)

Practical competences

The candidate must be able to do the following:

45.1b Carry out safe working practices when working on semi-automatic and automatic transmission systems. ☐

45.2b Inspect vehicle systems and prepare a report describing semi-automatic and automatic transmission systems and their layout. ☐

45.3b Carry out routine maintenance of semi-automatic and automatic transmission systems to manufacturers' specification and legal operation. ☐

45.4b Carry out fault diagnosis in the dismantling, assessment, repair/ replacement, reassembly, adjustment using test procedures for the mechanical running gear of semi-automatic and automatic transmission systems.

45.5b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the hydraulic components of semi-automatic and automatic transmission systems. ☐

45.6b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the pneumatic (compressed air) components of semi-automatic and automatic transmission systems. ☐

45.7b Carry out fault diagnosis in the dismantling, assessment, repair/replacement, reassembly, adjustment using test procedures for the electrical/electronic components of semi-automatic and automatic transmission systems. ☐

45.8b Carry out logical fault diagnostic techniques using diagnostic equipment for semi-automatic and automatic transmission systems. ☐

45.9b Carry out the correct procedure for recovery/towing of vehicles fitted with semi-automatic and automatic transmission systems. ☐

45.10b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 46 Electrical and Electronic Systems Batteries, Charging and Starting Systems Diagnostic Techniques Module (a)

Practical competences

The candidate must be able to do the following:

46.1a Carry out safe working practices when working with batteries, charging and starting systems. ☐

46.2a Use a range of meters and test equipment/ instruments when working with batteries, charging and starting systems. ☐

463a Inspect vehicle systems and prepare a report describing the constructional features, operational principles and maintenance of batteries, charging and starting systems. ☐

46.4a Carry out testing procedures when working on batteries, charging and starting systems and components. ☐

46.5a Carry out logical fault diagnostic techniques using diagnostic equipment and data on batteries, charging and starting systems. ☐

46.6a Carry out the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for batteries, charging and starting systems. ☐

46.7a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 46 Electrical and Electronic Systems
Electrical, Electronic and Auxiliary Systems Diagnostic Techniques Module (b)

Practical competences

The candidate must be able to do the following:

46.1b Carry out safe working practices when working with electrical, electronic and auxiliary systems. ☐

46.2b Use a range of meters and test equipment/ instruments when working with electrical, electronic and auxiliary systems. ☐

463b Inspect vehicle systems and prepare a report describing the constructional features, operational principles and maintenance of electrical, electronic and auxiliary systems. ☐

46.4b Carry out testing procedures when working on electrical, electronic and auxiliary systems. ☐

46.5b Carry out logical fault diagnostic techniques using diagnostic equipment and data on electrical, electronic and auxiliary systems. ☐

46.6b Carry out the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for electrical, electronic and auxiliary systems. ☐

46.7b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 46 Electrical and Electronic Systems
Vehicle Electronic and Microprocessor Systems Diagnostic Techniques Module (c)

Practical competences

The candidate must be able to do the following:

46.1c Carry out safe working practices when working with vehicle electronic and microprocessor systems. ☐

46.2c Use a range of meters and test equipment/ instruments when working with vehicle electronic and microprocessor systems. ☐

463c Inspect vehicle systems and prepare a report describing the constructional features, operational principles and maintenance of vehicle electronic and microprocessor systems. ☐

46.4c Carry out testing procedures when working on vehicle electronic and microprocessor systems. ☐

46.5c Carry out logical fault diagnostic techniques using diagnostic equipment and data on vehicle electronic and microprocessor systems. ☐

46.6c Carry out the dismantling, assessment, reassembly, repair/replacement, bench testing and adjustment procedures for vehicle electronic and microprocessor systems. ☐

46.7c Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 47 Service Reception
Service Reception

Practical competences

The candidate must be able to do the following:

47.1 Carry out safe working practices when working in the service reception department. ☐

47.2 Draw an organisational chart showing the structure of a motor vehicle service organisation. ☐

47.3 Prepare a job and person specification report describing the professional knowledge and interpersonal skills required by a motor vehicle technical service receptionist. ☐

47.4 Prepare a report describing organisational systems and administration of a motor vehicle service reception department. ☐

47.5 Produce promotional literature for a given promotional activity in a motor vehicle service reception. ☐

47.6 Carry out research into the commercial practices associated with a motor vehicle service reception department. ☐

47.7a Carry out effective customer service in a motor vehicle service reception. Describe the key issues of customer service from the observation and make recommendations for an effective service. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 48 Mathematics, Science and Electronics 3
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

48.1a Perform graphical operations. ☐

48.2a Perform calculus operations. ☐

48.3a Perform mensuration operations. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 48 Mathematics, Science and Electronics 3
Vehicle Science Module (b)

Practical competences

The candidate must be able to do the following:

48.1b Research information analysing the terms used and calculations associated with the deflection of beams. ☐

48.2b Research information analysing the terms used and calculations associated with the power transmitted by clutches and belt drive systems. ☐

48.3b Research information analysing the terms used and calculations associated with turning moment diagrams. ☐

48.4b Research information analysing the terms used and calculations associated with the principles of epicyclic gear trains. ☐

48.5b Research information analysing the terms used and calculations associated with tractive effort and tractive resistance. ☐

48.6b Research information analysing the terms used and calculations associated with relative velocity. ☐

48.7b Research information analysing the terms used and calculationsassociated with shear force and bending moments. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 48 Mathematics, Science and Electronics 3
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

48.1c Research information analysing the operation of electronic ignition (EST) systems. ☐

48.2c Research information analysing the operation of electronic fuel injection (EFI) systems. ☐

48.3c Research information analysing the operation of anti-lock braking (ABS) systems. ☐

48.4c Research information analysing open and closed loop engine systems. ☐

48.5c Research information analysing engine management systems and their operation. ☐

48.6c Research information analysing and applying the methods employed to diagnose faults in electronic systems. ☐

48.7c Research information analysing and applying computer fault codes and code reading equipment. ☐

48.8c Research information analysing and applying faults in electronic component/unit or sensor operation. ☐

48.9c Research information analysing and applying circuit testing. ☐

Advanced Technician Diplomas in Motor Vehicle Engineering (3905-09-061 to 3905-12-069)

These units cover the following topic areas:

Unit 61 – Engine Systems 4

• Engine Design Parameters and Performance Testing	Module 61a
• Alternative Power Unit Sources	Module 61b

Unit 62 – Chassis Systems 4

• Braking, Steering, Suspension and Transmission Systems	Module 62a
• Vehicle Body Systems	Module 62b

Unit 63 – Mathematics, Science and Electronics 4

• Mathematics	Module 63a
• Vehicle Science	Module 63b
• Vehicle Electronic Systems	Module 63c

Unit 65 – Management Skills	Module 65
Unit 66 – Business Systems	Module 66
Unit 67 – Financial Systems	Module 67

Unit 61 Engine Systems 4
Engine Design Parameters and Performance Testing Module (a)

Practical competences

The candidate must be able to do the following:

61.1a Research information analysing and apply safe working practices when working with engine systems.

61.2a Research information analysing component design features/factors that influence the shape/size of an engine package.

61.3a Research information analysing the factors that influence effective combustion chamber design in petrol engines.

61.4a Research information and describe the lean-burn combustion approach.

61.5a Research information analysing the combustion chamber features necessary in a diesel engine to promote efficient combustion.

61.6a Research information analysing engine performance data/characteristics and apply to petrol/diesel engine vehicle applications.

61.7a Research information identifying that piston movement is not simple harmonic motion.

61.8a Research information identifying the principles of harmonic balancing.

61.9a Research information and describe the causes for crankshaft torsional vibration.

61.10a Research information identifying engine mountings and stabilizer constraints.

61.11a Research information analysing engine tests to verify operating parameters.

61.12a Carry out engine tests to verify operating parameters.

61.13a Research information analysing and applying engine test performance data and characteristics.

61.14a Prepare conclusive engine test reports.

61.15a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

61.1a Analyse safe working practices when working with engine systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/lung irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Report/log: use of equipment, faulty equipment/machinery/tools.
Safe/legal road test/towing (automatic/manual transmission) procedures.

61.2a Analyse information identifying component design features/factors that influence the shape/size of an engine package.
Influencing factors: bore diameter, stroke, con-rod/crank throw ratio.
Layout: number/arrangement of cylinders, engine wear, weight, overall package size, breathing, brake mean effective pressure (bmep).
Purpose/principle: off-setting gudgeon pin relative to bore axis, off-setting crankshaft relative to bore axis. **Design considerations:** cater for change in compression ratio/capacity without major component change.

61.3a Analyse information identifying the factors that influence good combustion chamber design in petrol engines.
Inductive swirl methods: deflector porting, masked valve, distinguish between swirl/ turbulence/squish.
Factors influencing combustion chamber shape/size and **good combustion:** quench faces/zone, surface area/volume ratio, stroke/bore ratio, hot/cool regions, flame propagation/travel, combustion ratio, spark plug location, squish zones, smallest surface area for given volume, petrol injection systems.
Combustion chambers: pancake, wedge, bath-tub, hemispherical, pentroof, 2/3/4/5/6 valve heads, split level chambers.

61.4a Analyse information and describe the lean-burn combustion approach.
Definition: stratification.
Principle: stratified charging of combustion chamber to achieve efficient burning of fuel.
Conflicting outcomes: power, fuel consumption, carbon monoxide (CO), hydro-carbons (HC), nitrogen oxides (NO_x).
Design features: stratified type combustion chambers with carburettor.

61.5a Analyse information identifying the combustion chamber features necessary in a diesel engine to promote efficient combustion.
Definition: heterogeneous charge mixing.
Injector spray development: idling, light load, full load.
Injection: direct (open chamber), indirect (divided chamber).
Combustion chamber features which promote: air swirl, compression squish, turbulence, heat regeneration.

61.6a Analyse information identifying engine performance data/characteristics and compare/relate to petrol/diesel engine vehicle applications.
Engine types: petrol, diesel.
Performance curves: torque, brake power, specific fuel consumption (sfc).
Applications: light vehicle (private cars, vans, pick-up trucks), light/heavy goods vehicles, buses/coaches.
Principle: use of larger capacity engine for given application may reduce smoke particulate emission levels.

61.7a Analyse information identifying that piston movement is not simple harmonic motion.
Piston movement: primary/secondary displacement.
Imbalanced forces: crankshaft pitching couples.

61.8a Analyse information identifying the principles of harmonic balancing.
Principles: shaft location/supports, speed relationship to crankshaft, timing/phasing.

61.9a Analyse information and describe the causes for crankshaft torsional vibration.
Principles: torque-pulses generated/sequence orders along crankshaft.
Terms: critical speed (minor/major), natural frequency, resonance, harmonic order.
Devices to suppress critical torsional vibrations: viscous/friction damping, rubber mounted inertia ring damping.

61.10a Analyse information identifying engine mountings and stabilizer constraints.
Terms: centre of suspension, centre of percussion, principle axis (role line), static/vibratory load capacities.
Engine installations: mounting types/number, location/position, fasteners/locking devices.
Selection: engine mountings using provided specifications/data.
Stabilisers: reasons for use, types/numbers, location/position.

61.11a Analyse information identifying engine tests to verify operating parameters.
Parameters: constant/variable engine operating speed/throttle position/load (torque).

Tests.
Engine running characteristics: torque, power developed, fuel consumption, specific fuel consumption (sfc), volumetric efficiency, thermal efficiency (heat balance), emissions, noise level, vibration.
Research/investigative: endurance, system checks, effects of water injection on combustion process, comparison checks, quality control.

61.12a Describe engine tests to verify operating parameters.
Test schedules: design/prepare three different tests from 61.11a above.
Tests: carry out three different tests from 61.11a above.
Reports: three tests above (computer word processor/graphics).

61.13a Analyse information identifying and applying engine tests performance data and characteristics.
Comparisons: manufacturers' engine performance data/characteristics to test results.
Analysis: manufacturers' engine performance data/characteristics to test results.

61.14a Describe engine test reports.
Contents: introduction, test criteria, facilities/resources, test procedures, measured results, analysis of results, conclusions/comments/observations, forecast.

Unit 61 Engine Systems 4
Alternative Power Unit Sources Module (b)

Practical competences

The candidate must be able to do the following:

61.1b Research information analysing the advantages of 'continuous' combustion.

61.2b Research information and state the operating cycle of the Stirling engine.

61.3b Research information and describe the construction and component assemblies of a single acting Stirling engine.

61.4b Research information and state how the cylinders of a Stirling engine may be interconnected.

61.5b Research information and describe the operating principles of the gas turbine engine.

61.6b Research information and describe how the gas turbine engine can be modified for motor vehicle applications.

61.7b Research information and state the operating cycle of the rotary engine.

61.8b Research information and describe the construction and component assemblies of a rotary engine.

61.9 b Research information and state the methods adopted to improve breathing over the useful working speed range of a rotary engine.

61.10b Research information and state the limitations to combustion chamber design of a rotary engine and the necessity for advanced ignition timing.

61.11b Research information and state the procedures for conducting mechanical component efficiency tests on Stirling, gas turbine and rotary engines.

61.12b Research information and compare technical/economical factors for the Stirling, gas turbine and rotary engines with those for the conventional reciprocating piston disrupted combustion engine.

61.13b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

61.1b Analyse information identifying the advantages of 'continuous' combustion.
Advantages: simplicity of combustion chamber design, better control of flame propagation, eliminates complex ignition systems, eliminates valve/energy absorbing drive mechanisms, quiteness, smoothness, reduced harmful emissions.

61.2b Analyse information and describe the operating cycle of the Stirling engine.
Piston/displacer: induction of working gas into cold space, compression of working gas, transfer of working gas into hot space, expansion of gas (pressure rise).
Movement phasing of displacer with respect to piston: create change of volume of working gas, maximise pressure rise to generate driving force.
P-V diagram: construct from functional movements of piston/displacer.
Engine speed control with respect to load: increasing/decreasing fuel supply/circulating coolant.
Technical operating data: torque/power characteristics, specific fuel consumption (sfc), capacity, thermal efficiency (heat balance), compression ratio.

61.3b Analyse information and describe the function/operation of component assemblies of a single acting Stirling engine.
Components: air pre-heater assembly, regenerator/cooling unit, combustion chamber, fuel supply, ignition, working gas (helium, hydrogen), drive mechanism (rhombic drive, swashplate principle, slider crank).

61.4b Analyse information and describe how the cylinders of a Stirling engine may be interconnected.
Alternative configuration: pistons acting as driving/displacing members, cylinder layout.

61.5b Analyse information and describe the operating principles of the gas turbine engine.
Components/function: compressor, turbine, combustor, regenerator.
Systems: cooling, lubricating.

61.6b Analyse information and describe how the gas turbine engine can be modified for motor vehicle applications.
Principles: Single shaft turbine, 'free turbine' two shaft drive, gearing ratio to cater for high turbine speeds.

61.7b Analyse information and describe the operating cycle of the rotary engine.
P-V diagram: geometric movement of rotor (epitrochoidal).
Process: induction, compression, expansion, exhaust.

61.8b Analyse information and describe the construction and component assemblies of a rotary engine.
Components: eccentric drive shaft, triangular rotor/internal gear, stationary side gear, rotor side seal assembly, rotor apex seal assembly, bearings.
Systems: induction/porting , ignition, cooling, lubrication, auxiliary drive.

61.9b Analyse information and describe the methods adopted to improve breathing over the useful working speed range of a rotary engine.
Methods: side porting, twin porting (primary/secondary carburettor feeds), triple porting (twin rotor/6 ports), induction pressure charging.

61.10b Analyse information identifying the limitations to combustion chamber design of a rotary engine and the necessity for advanced ignition timing.
Inherent design features: rotor action causing extra compression of trailing charge in chamber, backward flame travel (against rotor movement), combustion chamber moves across stationary spark plug.
Ignition system: special electrode spark plugs, possible dual spark plugs, simultaneous/ phased spark plug firing.

61.11b Analyse information and describe the procedures for conducting mechanical component efficiency tests on Stirling, gas turbine and rotary engines.
Tests: compression, cylinder leakage.

61.12b Analyse information and compare technical/economical factors for the Stirling, gas turbine and rotary engines with those for the conventional reciprocating piston disrupted combustion engine.
Technical: performance figures/characteristics.
Manufacture: costs, precision build/finish.
Maintenance: retail training, equipment.
Harmonic balancing: Stirling, gas turbine and rotary engines.

Test specification for written paper Engine Systems 4 (3905-09-061 and 3905-10-061)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
Engine Systems 4 (Unit 61)	
61a Engine design parameters and performance testing	55
61b Alternative power unit sources	45

Unit 62 Chassis Systems 4
Braking, Steering, Suspension and Transmission Systems Module (a)

Practical competences

The candidate must be able to do the following:

62.1a Research information analysing and apply safe working practices when working with braking, steering, suspension and transmission systems.

62.2a Research information analysing component design features and factors that influence the design of mechtronic braking/steering/suspension control systems.

62.3a Research information analysing braking, steering and suspension tests to verify operating parameters.

62.4a Carry out braking, steering and suspension tests to verify operating parameters.

62.5a Research information analysing and apply braking, steering and suspension test performance data and characteristics.

62.6a Prepare conclusive braking, steering and suspension test reports.

62.7a Research information analysing component design features and factors that influence the design of mechtronic transmission control systems.

62.8a Research information analysing transmission tests to verify operating parameters.

62.9a Carry out transmission tests to verify operating parameters.

62.10a Research information analysing and apply transmission test performance data and characteristics.

62.11a Prepare conclusive transmission test reports.

62.12a Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

62.1a Analyse safe working practices when working with braking, steering, suspension and transmission systems.
Safe use: jacking, stands/chocking blocks, tools, equipment, repair procedures.
Use, storage and disposal of hazardous materials: battery acids/electrolyte, fuels, lubricants, sealants, asbestos, non-metallic materials, refrigerants (air conditioning units), fluorolastomec (Veton).
Removal/dismantle/reassemble/repair/overhaul of vehicle systems/components (to manufacturers' specifications).
Cleanliness: self, vehicle systems, components.
Precautions against skin/respiratory irritants.
Running engines/transmissions: enclosed spaces, ventilation, unguarded moving parts, heat (burns/scalding), liquids/gases under pressure, fire, bench/static testing.
Report/log: use of equipment, faulty equipment/machinery/tools.
Safe/legal road test/towing (automatic/manual transmission) procedures.

62.2a Analyse information identifying component design features and factors that influence the design of mechtronic braking/steering/suspension control systems.
Systems: electronic actuating systems (EAS), vehicle dynamic control systems (VDCS), electronic stability systems (ESS).
Influencing factors: climate, performance, use, cost, manufacturing, available technology, legislation.
Purpose/principle: reducing driver error/fatigue, increased performance, improved levels of comfort.

62.3a Analyse information identifying braking, steering and suspension tests to verify operating parameters.
Parameters: legal requirements, correct operation/manufacturers' specifications.
Tests: braking (efficiency, heat dissipation), steering/suspension/wheels/tyres (load, torque, bi-axial forces, balance/torsional vibrations), noise.
Research/investigation: endurance, system checks, comparison checks, quality control.

62.4a Describe tests to verify braking, steering and suspension operating parameters.
Systems: braking, steering, suspension, wheels/tyres.
Test schedules: design/prepare one test for each of the above systems.
Tests: carry out one test for each of the above systems.
Reports: one test for each of the above systems (using computer word processor/graphics).

62.5a Analyse information identifying braking, steering and suspension test performance data and characteristics.
Comparisons: manufacturers' braking/steering/suspension/wheels/tyres performance data/characteristics to test results.
Analysis: manufacturers' braking/steering/suspension/wheels/tyres performance data/characteristics to test results.

62.6a Describe braking, steering and suspension test reports.
Contents: introduction, test criteria, facilities/resources, test procedures, measured results, analysis of results, conclusions/comments/observations, forecasts.

62.7a Analyse information identifying component design features and factors that influence the design of mechtronic transmission control systems.
Systems: electronic actuating systems (EAS), vehicle dynamic control systems (VDCS).
Influencing factors: climate, performance, use, cost, manufacturing, available technology, legislation.
Purpose/principle: reducing driver error/fatigue, increased performance.

62.8a Analyse information identifying transmission tests to verify operating parameters.
Systems: manual transmission, semi/fully/constantly variable transmission, control units (mechanical/electronic assistance).
Parameters: legal requirements, correct operation/manufacturers' specifications.
Tests: efficiency, torque, load, balance/torsional vibrations, noise, heat dissipation.
Research/investigation: endurance, system checks, comparison checks, quality control.

62.9a Describe tests to verify transmission operating parameters.
Test schedules: design/prepare three different tests from 62.8a above.
Tests: carry out the above three different tests.
Reports: three tests above (using computer word processor/graphics).

62.10a Analyse information identifying transmission test performance data and characteristics.
Comparisons: manufacturers' transmission performance data/characteristics to test results.
Analysis: manufacturers' transmission performance data/characteristics to test results.

62.11a Describe transmission test reports.
Contents: introduction, test criteria, facilities/resources, test procedures, measured results, analysis of results, conclusions/comments/observations, forecasts.

62.12a The use of mathematics and science is applied to the above Knowledge Requirements.

Unit 62 Chassis Systems 4
Vehicle Body Systems Module (b)

Practical competences

The candidate must be able to do the following:

62.1b Research information and describe the manufacturing process of low/medium/mass produced vehicle bodies.

62.2b Research information and describe the advantages of separate construction/unitary vehicle bodies and their variants.

62.3b Research information and describe the construction of component assemblies for separate construction/unitary vehicle bodies and their variants.

62.4b Research information and describe the process of body conception/styling of a new vehicle.

62.5b Research information and describe the principles of aerodynamics.

62.6b Research information and describe how the level of vehicle noise (internal/external) is controlled.

62.7b Research information and describe the principles of elimination of moisture from the body structure.

62.8b Research information and describe construction of component assemblies for interior trim.

62.9b Research information and describe the principles of occupant safety/security.

62.10b Research information and describe methods adopted to maximise driver visibility.

62.11b Research information and describe the procedures for conducting mechanical tests on vehicle body structures.

62.12b Research information and compare technical/economical factors for the materials used in the manufacture of vehicle body structures.

62.13b Use mathematics and science in the above Practical Competences.

Knowledge requirements

The instructor must ensure the candidate is able to:

62.1b Analyse information and describe the manufacturing process of low/medium/mass produced vehicle bodies.
Production methods: low/medium/mass.
Vehicle construction: unitary/monocoque, separate chassis (rigid/articulated), legislation.

62.2b Analyse information and describe the advantages of separate construction/unitary vehicle bodies and their variants.
Construction: monocoque/unitary (one piece load bearing frame/unit), separate/composite (chassis/body).
Light vehicle: two door saloon, four door saloon, three door hatchback, five door hatchback, three door estate, five door estate, two door coupé, three door hatchback coupé and other combinations.
Commercial: rigid, articulated, pick-up/utility, flat platform, drop side platform, box van, Luton van, integral (walk-through), curtainsider, tipper (front, centre, side ram positions), tanker (insulated/non-insulated), temperature controlled (refrigerated).
Public Passenger Vehicles (PPV): mini bus, omnibus/coach (single deck, double deck).
Special Purpose Vehicles (SPV): ambulance, breakdown/towing, fire tender.
Advantages: cost, manufacture, occupancy levels, payloads, vehicle weight, aesthetics, aerodynamics.

62.3b Analyse information and describe the construction of component assemblies for separate construction/unitary vehicle bodies and their variants.
Body types: monocoque/unitary (one piece load bearing frame/unit), separate/composite (chassis/body).
Assemblies: roof, floor (underfloor/underframe/floorpan), front end/bulkhead/frame, rear end/bulkhead/frame, doors/closures/hatches, bodysides, wings/fenders, bonnet/hood, boot/tail lid.

62.4b Analyse information and describe the process of body conception/styling of a new vehicle.
Concept: design/styling, marketing group, market forces.
Style: ergonomics, computer aided design/manufacture (CAD/CAM), finite element analysis (FEA), modelling (computer/clay), size (full/scale), body-in-white.

62.5b Analyse information and describe the principles of aerodynamics.
Principles: aerodynamics, vehicle dynamics (stability).
Methods: drag coefficient, coefficient of rolling resistance, body styling, air flow, spoilers/windshields/deflectors.
Advantages: stability, design, driver control/vision/comfort, noise levels, vehicle performance/economy, component/unit (cooling/ventilation) efficiency.

62.6b Analyse information and describe how the level of vehicle noise (internal/external) is controlled.
Principles: acoustics, propagation (air-borne/mechanical-borne), measurement (power/pressure/intensity).
Methods: insulation/absorption/shielding/active noise reduction, flexible mountings, unit/component position.
Tests: noise levels, legal requirements.

62.7b Analyse information and describe the principles of elimination of moisture from the body structure.
Principles: deflecting, sealing.
Methods: body styling (door pillars, cant rails, front/side/rear screen rake angle), rubber/plastic seals/gaiters/mouldings, adhesives/sealants, body panel joint design/position.

62.8b Analyse information and describe the construction of component assemblies for interior trim.
Materials: plastics, fabrics/cloths, leather, foam rubber/plastic/padding, carpet, wood, metal, glass.
Construction: hand made, automatic manufacturing process, plastic forming/mouldings, cutting/sewing/welding, leather tooling, veneering/polishing.
Assemblies: seats, floor covering (passenger/luggage/cargo area), dashboard, head-lining, interior trim (hard/soft), safety design features (energy absorption/padding/radiused edges), switches/gauges/vents.
Fixing methods: bonded/adhesive, hook and loop (Velcro), mechanical (screw/bolt/rivet), spring devices (clips/pins/washers/inserts).

62.9b Analyse information and describe the principles of occupant safety/security.
Definition: active, passive.
Methods: driver training/education, body design (crumple/reinforced zones, high strength metals), restraints (seat belts/tensioners/air bags), collapsible steering columns/pedals, seat mounting, safety glass, fuel cut-off sensors.
Security: door/steering/gear change locks, engine immobilisers, electronic alarms.

62.10b Analyse information and describe methods adopted to ensure driver visibility.
Methods: windscreen wipers (front single/double, rear), front/side/rear screen rake angles, A/BC/D pillar design, aerodynamics, front wing/door mirror, rear view mirror, legislation.

62.11b Analyse information and describe the procedures for conducting mechanical tests on vehicle body structures.
Materials: structural/non-structural, metals/non-metals.
Tests: road (actual/simulated road surface/weather conditions), static (computer/servo-hydraulic test bench, actual/simulated road surface/weather conditions), impact/crash safety, body/material fatigue.

62.12b Analyse information and compare technical/economical factors for the materials used in the manufacture of vehicle body structures.
Technical: material properties/characteristics.
Manufacture: costs, precision build/finish.
Maintenance/repair: manufacturers' specifications, warranty (corrosion/paint), repair techniques/training, repair equipment.

62.13b The use of mathematics and science is applied to the above Practical Competences.

Test specification for written paper Chassis Systems 4 (3905-09-062 and 3905-10-062)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
62a Braking, steering, suspension and transmission systems	65
62b Vehicle body systems	35

Unit 63 Mathematics, Science and Electronics 4
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

63.1a Apply calculus operations.

63.2a Apply algebraic operations.

Knowledge requirements

The instructor must ensure the candidate is able to:

63.1a Describe calculus operations.

Definitions: first/second derivative, d^2y/dx^2, mean, root mean square, first order differential equation.
Differentiation: second derivative obtained by differentiation of first the derivative, state from equations of displacement that dx/dt expresses instantaneous velocity and d^2x/dt^2 expresses instantaneous acceleration, determine whether a turning point is a maximum or minimum by examination of gradient at either side of turning point, describe why the sign of the second differential coefficient at the turning point indicates a maximum or a minimum.
First order differential equations: show for equations of the form $dQ/dt = kQ$ the solution is $Q = Ae^{kt}$ where A is a constant, verify by substitution.

Calculations:
Graphs: $x = f(t)$, dx/dt, d^2x/dt^2 where $f(t)$ is of the form $at \pm b^2$, family of curves given their differential equation.
First/second derivative: algebraic functions, velocity/acceleration at given times from equations of displacement, turning points/maximum/minimum (for functions having the forms $y = a + b\sin x$, $y = ax + bx^2$, $y = ax - bx^3$).
First order differential equations: apply to natural laws (eg. Newton's law of cooling, decay of current in an inductive circuit, linear expansion).
Integration: integrate differential equations of the type $dy/dx = f(x)$ (given boundary conditions), determine the mean/root mean square of periodic functions (over a given range).

63.2a Describe algebraic operations.

Definitions: remainder theorem, quotient, remainder, compound/partial fractions, Cartesian/polar coordinates, complex number, Argand diagram, modulas, argument, Boolean algebra, 'AND', 'OR', 'NOT', symbols, truth tables. Boolean algebra: logic/switching systems, apply to 'AND'/'OR'/'NOT' systems.

Calculations.
Remainder theorem: determine factors of algebraic expressions.
Partial fractions: express compound fractions in partial fraction form.
Cartesian/polar coordinates: express Cartesian coordinates in polar coordinate form, polar coordinates in Cartesian coordinate form.
Complex numbers: quadratic equations (solutions expressed as complex numbers), sum, difference, product, quotient, reciprocal, Argand diagrams (modulas/argument), express in polar/Cartesian form.
Boolean algebra: 'AND'/'OR'/'NOT' systems (lamp circuit, truth tables), apply Boolean expressions as switching systems/for given switching systems, apply switching systems to meet the requirements of Boolean expressions.

Unit 63 Mathematics, Science and Electronics 4
Vehicle Science Module (b)

Practical competences

The candidate must be able to do the following:

63.1b Research information analysing the terms used and calculations associated with energy and fluids.

63.2b Research information analysing the terms used and calculations associated with vibration.

63.3b Research information analysing the terms used and calculations associated with engine balance.

63.4b Research information analysing the terms used and calculations associated with acoustics and noise.

63.5b Research information analysing the terms used and calculations associated with aerodynamics.

Knowledge requirements

The instructor must ensure the candidate is able to:

63.1b Analyse information identifying the terms used and calculations associated with energy and fluids.
Laws: Bernoulli's Law.
Definitions: absolute pressure, gauge pressure, pressure in liquid = rgh, potential energy (PE = mgh), kinetic energy (KE = $\frac{1}{2}mv^2$), pressure energy = pressure x m/r), quantity of fluid flow through an orifice (Q = velocity of fluid x area of orifice), venturi, Bernoulli's Law (pressure drop at a venturi), coefficient of velocity, vena contracta, coefficient of contraction, coefficient of discharge.
Principles: manometer.
Gas flow rate: internal combustion engine (mean piston speed, bore diameter, manifold diameter).
Calculations: absolute pressure, gauge pressure, pressure in liquid, potential energy, kinetic energy, pressure energy, quantity of fluid flow through an orifice, Bernoulli's Law (pressure drop at a venturi), venturi (measure flow of liquids/gases), coefficient of velocity, vena contracta, coefficient of contraction, coefficient of discharge.

63.2b Analyse information identifying the terms used and calculations associated with vibration.
Definitions: simple harmonic motion, angular displacement, torsional vibrations (elastic systems), transfer vibrations (beams subject to single point load at its centre/uniformly distributed load along its length), Dunkerley's empirical method (transverse frequency of oscillation).
Calculations: simple harmonic motion, angular displacement, torsional vibrations (elastic systems), transfer vibrations (beams subject to single point load at its centre/uniformly distributed load along its length), Dunkerley's empirical method (transverse frequency of oscillation for a beam subject to a number of loads), whirling speed (for various rotating shafts/rotor assemblies).

63.3b Analyse information identifying the terms used and calculations associated with engine balance.
Definitions: primary/secondary inertia forces, balancing (rotating/reciprocating masses).
Secondary inertia forces: significance of the ratio of connecting rod length to crank throw.
Balancing: sketches of rotating/reciprocating masses (180˚ vertical twin, 360˚ vertical twin, horizontally opposed twin, 4/6 cylinder in-line, 90˚ V-twin, 60˚ V6).
Calculations: primary/secondary inertia forces (conventional multi-cylinder engines), balancing (rotating/reciprocating masses).

63.4b Analyse information identifying the terms used and calculations associated with acoustics and noise.
Definitions: sound, velocity of sound, wavelength, particle velocity, sound pressure (Newtons/m^2), sound power, sound intensity (watts/m^2), specific acoustic impedance, Doppler effect (moving sound sources), logarithmic scale, standard pure tone (phon), perceived loudness levels, doubling of loudness (8-10dBA).

Principle: weighting of decibel scale to compensate for non-linear sensitivity to varying frequencies of the human ear.

Calculations: sound, sound level (dB), velocity of sound, wavelength, particle velocity, sound pressure, sound power, sound intensity, specific acoustic impedance, Doppler effect (moving sound sources), logarithmic scale (noise levels), standard pure tone (phon), perceived loudness levels, doubling of loudness (8-10dBA).

Testing: noise emissions (moving/stationary vehicles, cabin noise).

63.5b Analyse information identifying the terms used and calculations associated with aerodynamics.
Definitions: coefficient of aerodynamics drag (Cd), frontal area (A), dynamic pressure ($p = \frac{1}{2}pv^2$), aerodynamic drag ($= Cd\ A\ \frac{1}{2}pv^2$), yaw/pitch/roll moments, aerodynamics forces (drag/lift/side), aerodynamic centre of pressure, coefficient of lift/side force, boundary layer, velocity gradient, laminar/turbulent flow, skin friction, shear stress (in air), pressure distribution diagram, Reynold's number, Reynold's effect.
Principle: aerodynamics forces are resolved into three components of drag/lift/side forces acting through the aerodynamic centre of pressure, measures to reduce the coefficient of drag/lift/side force.
Calculations: coefficient of aerodynamic drag (various shapes/types of vehicle), frontal area (A), dynamic pressure ($p = \frac{1}{2}pv^2$), aerodynamics drag ($= Cd\ A\ \frac{1}{2}pv^2$), yaw/pitch/roll moments , aerodynamics forces (drag/lift/side), aerodynamic centre of pressure, coefficient of lift/side force, boundary layer, velocity gradient, laminar/turbulent flow, skin friction, shear stress (in air within the boundary layer), Reynold's number, Reynold's effect.
Pressure distribution diagram (typical modern saloon car): various pressure values, significance (lift/drag, internal ventilation/cooling).

Unit 63 Mathematics, Science and Electronics 4
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

63.1c Research information analysing and apply testing/fault diagnostic techniques on electronic ignition systems.

63.2c Research information analysing and apply testing/fault diagnostic techniques on electronic fuel injection (EFI) systems.

63.3c Research information analysing and apply testing/fault diagnostic techniques on engine management systems.

63.4c Research information analysing and apply testing/fault diagnostic techniques on electronic anti-lock braking (ABS) systems.

63.5c Research information analysing and applying the operation of electronically controlled steering systems and apply testing/fault diagnostic techniques.

63.6c Research information analysing and applying the operation of electronically controlled automatic transmission systems and apply testing/fault diagnostic techniques.

63.7c Research information analysing and applying the operation of instrument displays/system information panels and apply testing/fault diagnostic techniques.

63.8c Research information analysing and applying the operation of electronically controlled cruise control systems and apply testing/fault diagnostic techniques.

63.9c Research information analysing and applying the operation of electronically controlled automatic climate control systems and apply testing/fault diagnostic techniques.

Knowledge requirements

The instructor must ensure the candidate is able to:

63.1c Analyse, with the use of maufacturers data, information identifying testing/fault diagnostic techniques on electronic ignition systems.
Components: ECU, ignition assemblies, sensors, actuators.

63.2c Analyse, with the use of maufacturers data, information identifying testing/fault diagnostic techniques on electronic fuel injection (EFI) systems.
Components: ECU, EFI assemblies, sensors, actuators.

63.3c Analyse, with the use of maufacturers data, information identifying testing/fault diagnostic techniques on engine management systems.
Components: ECU, engine management assemblies, sensors, actuators.

63.4c Analyse, with the use of maufacturers data, information identifying testing/fault diagnostic techniques on electronic anti-lock braking (ABS) systems. **Components:** ECU, ABS assemblies, sensors, actuators.

63.5c Analyse, with the use of diagrams, information identifying the operation and testing/fault diagnostic techniques on electronically controlled steering systems.

63.6c Analyse, with the use of diagrams, information identifying the operation and testing/fault diagnostic techniques on electronically controlled automatic transmission systems.

63.7c Analyse, with the use of diagrams, information identifying the operation and testing/fault diagnostic techniques on instrument displays/system information panels.

63.8c Analyse, with the use of diagrams, information identifying the operation and testing/fault diagnostic techniques on electronically controlled cruise control systems.

63.9c Analyse, with the use of diagrams, information identifying the operation and testing/fault diagnostic techniques on electronically controlled automatic climate control systems.

Test specification for written paper Mathematics, Science and Electronics 4 (3905-09-063 and 3905-10-063)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
63a Mathematics	30
63b Vehicle science	30
63c Vehicle electronic systems	40

Unit 65 Management Skills
Management Skills

Practical competences

The candidate must be able to do the following:

65.1 Research information and prepare a report analysing information on the formation of teams working in motor vehicle service and repair organisations.

65.2 Use effective leadership methods to manage individuals/teams working in motor vehicle service and repair organisations.

65.3 Research and evaluate information on motivational theories to improve the performance of individuals/teams working in motor vehicle service and repair organisations.

65.4 Work within the team environment to achieve agreement with individuals/teams. Make recommendations to improve the performance of the team.

65.5 Communicate effectively to improve individual/team performance in motor vehicle service and repair organisations.

65.6 Set work targets/objectives for an individual, review completion of work and set new targets/objectives for improvements in performance in a motor vehicle service and repair organisation.

65.7 Research information on quality standards and prepare a report applying the standards to a motor vehicle service and repair organisations.

65.8 Prepare a strategy, recruit and select new members of staff.

65.9 Research information, plan, carry out and evaluate a training and development activity for motor vehicle service and repair organisation staff.

65.10 Research information and prepare a report on project work, detailing the stages of how projects can be managed effectively.

Knowledge requirements

The instructor must ensure the candidate is able to:

65.1 Analyse information on the formation of teams.
Teams: stages of development, reasons, basic needs (survival, security, social, affiliation/feeling of belonging/involvement, self-esteem), abilities of team members, personalities, characteristics of team members, team sizes, team building, objectives/goal achievement.

65.2 Analyse information identifying effective methods of leadership.
Functions of leaders/managers: interpersonal skills, communication, styles of leadership, action centred leadership (task/team/individual needs), function, focus, delegation, evaluating/decision making.

65.3 Analyse information identifying motivational theories to improve the performance of individuals and teams.
Theory/needs: drives, motives, self-actualisation/the whole self, hierarchy of needs (survival, security, feelings of belonging, self esteem, self actualisation), expectancy theory, job enrichment, effects of praise/recognition, satisfaction of hygiene/motivational needs (eg different needs for individuals), stress management.

65.4 Analyse information and evaluate methods for achieving agreement.
Interpersonal skills: negotiation, argument/controlled discussion, competitive, assertive, identification of causes of conflict (objectives, role definitions, poor communication, supervisory relationships, similar roles, hidden objectives, territorial, overcrowding, work conditions, personal prejudice).
Strategies for dealing with conflict: common objectives, coordination, communication, remove territorial/role conflicts, arbitration, negotiation, liaison, confrontation, understanding negative factors, separation, ignore/neglect (conflict is avoidable/unavoidable, conflict is detrimental, conflict is useful, organisational policies/rules dealing with conflict, cultural aspects of conflict).

65.5 Analyse information identifying management communication methods.
Formal/informal methods: written, consultation, discussion, face-to-face, presentations, meetings, telephone, electronic (computer, E-mail, Internet, facsimile, telex), visual aids.
Selection/evaluation: advantages/ disadvantages, training, applications, suitability, costs, efficiency, effectiveness.
Skills: communication, use of feedback/language/ management style, visual aids, presentation, negotiation, questioning techniques, listening.
Methods adopted to cascade information through organisational structure: internal public relations, company newspaper, newsletters, bulletins, notice boards.
Meetings: relevant people invited, convenient location, agenda, purpose/outcomes clearly established, information presented in chronological order, timed, effective leadership/chairing, management of keeping to agenda, overcoming arguments/ digressions, minutes taken with actions, avoid time wasting, take decisions within area of responsibility, circulate the record of the meeting, evaluation of the actions taken.

65.6 Describe and evaluate methods of setting targets.
Objectives: number, nature (subjective/objective), time limits, SMART (specific, measurable, agreed, realistic, timescale), linking team/group/individual objectives to those of the organisation.
Appraisal/performance review: formal/informal, type, structure, process, self-appraisal, performance measurement, rating scales, frequency, use of appraisal, style of approach (dominating/abdicating, self-assessment, joint, counselling), assessing strengths/weaknesses, developing related training/development programmes, provide praise/constructive criticism/personal development plan.

65.7 Analyse information analysing issues relating to quality standards.
Issues: quality levels, customer satisfaction/dissatisfaction, reasons for poor quality (policy, personnel, procedures, knowledge, monitoring, assessment), characteristics of service quality (reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding/knowing the customer, tangibles), quality as gaps between customer perceptions and customer expectations, total quality management, customers' experience of quality standards (eg. ISO 9000, International quality standards, local standards).

65.8 Analyse/evaluate information analysing recruitment/selection methods and factors influencing future staffing requirements.
Recruitment factors: job description, person/job specifications, career history, selection criteria, equality of opportunity, legal requirements.
Methods of recruitment: internal, advertising, existing records, external agencies, personal recommendation, schools, recruitment agencies.
Selection methods: application forms/letters, telephone screening, testing, interviewing, group selection, work sampling, references, short listing.
Future staffing factors: identification of training/development needs, job analysis, competence standards, performance standards, knowledge/skills/attitude requirements, constraints (skills, people, finance, physical resources), change in business (increase/ decrease staff).

65.9 Analyse/evaluate information and describe training and development activities.
Activities: induction, formal education/training, individual/team learning, project, planned experience, job share, job rotation, case studies, mentoring, coaching, simulation, on/off-the-job training, competency based training.
Planning: needs, method, programme, assessment/evaluation.
Evaluate: pre/post-training objectives, individuals' reactions to training, medium/long term, training cycle, questionnaires, tests (qualitative/quantitative methods), costs/benefits.

65.10 Analyse information identifying the stages of managing a project.
Project planning: setting goals, defining the project, aligning needs to timescale, organising project team, project scheduling, aligning resources to activities, linking activities to each other, regular updating of progress.
Project controlling: monitoring resources, revising/changing plans, shifting resources to meet time, cost/quality demands.
Decision making: steps (observe, recognise problem, set objectives, analyse problem, determine/evaluate options, make decisions, implement, monitor), elements of a decision (who makes a decision, what are the choices, what cannot be controlled, what are the consequences of the decision), types of decision (strategic/operational, structured/unstructured, dependent/independent), individual/group decision making, creativity in decision making, analysis (analysing facts) undertaken in decision making.

Test specification for written paper Management Skills (3905-11-065 and 3905-12-065)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
65.1 Formation of teams	5
65.2 Effective methods of leadership	10
65.3 Motivational theories to improve performance	10
65.4 Working within team environment	10
65.5 Management communication methods	20
65.6 Setting and evaluating targets	5
65.7 Quality standards	10
65.8 Recruitment and selection methods/staffing requirements	10
65.9 Training and development activities	10
65.10 Stages of managing a project	10

Unit 66 Business Systems
Business Systems

Practical competences

The candidate must be able to do the following:

66.1 Research/evaluate information and prepare a report on the administration/communication systems used in motor vehicle service and repair organisations.

66.2 Identify electronic/information processing systems and their uses within a given motor vehicle service and repair organisations.

66.3 Prepare a report identifying how financial performance is monitored, the factors affecting performance and the terms used in motor vehicle service and repair organisations.

66.4 Identify and compare different types of financial accounts used in motor vehicle service and repair organisations.

66.5 Carry out budgeting from given financial data for a motor vehicle service and repair organisation.

66.6 Research information and select one technological development which would impact on business systems in motor vehicle service and repair organisations.

66.7 Research information and prepare a report identifying marketing techniques used in motor vehicle service and repair organisations.

66.8 Carry out effective sales service with customers.

Knowledge requirements

The instructor must ensure the candidate is able to:

66.1 Analyse information identifying administration and communication systems.
Support systems: information provision, marketing/sales, finance, personnel, management decision making, provide links with external organisations/individuals.
Communication systems: internal/external one/two way (sign, notice, written correspondence, face-to-face, telephone, electronic systems, personnel address systems), management/operational support, facilitate (training, coaching, development of staff), links with external organisations/individuals.
Evaluate: fitness for purpose, value for money, accuracy, efficiency, security, ease of use, user opinion.

66.2 Analyse information identifying electronic and information processing systems.
Systems: service/repair booking, car hire reservation, communication networks (including Internet, electronic/E-mail, telecommunications).
Effects: speed, accuracy, reliability, cost, productivity, access to information, ability (training, competence).
Information processing systems: manual/electronic (receiving/storing/distributing information, customer service information, management information, presentation of information, protection of data).
Evaluate: fitness for purpose, value for money, accuracy, efficiency, security, ease of use, user opinion.

66.3 Analyse information identifying financial performance monitoring, the factors affecting financial performance and the terms used.
Monitoring: balance sheet, profit and loss, cash flow, financial targets, budgets, break-even analysis.
Factors: external (recession, economic growth, local conditions, seasonal factors, competitor activity), internal (volume of sales, levels of credit/debt, employee costs, fixed/variable costs, stock control).
Financial terms: assets (fixed, current), capital, costs (fixed, variable), depreciation, equity, gearing, liabilities (current, long term), profit (gross, net), shares, turnover.

66.4 Analyse information identifying the different types of financial accounts used.
Financial accounts: trading account, profit and loss account, balance sheet, annual/periodic reports, income and expenditure statement.

66.5 Analyse information identifying budgeting from given financial data.
Budgets: principle, divisional (sales, marketing, wages), specific projects.
Structure: expense headings, breakdown within headings, budget period.

66.6 Analyse information identifying technological developments which would impact on business systems.
Developments: Internet, teleconferencing/video/satellite links, global distribution system (GDS), home booking systems, virtual reality.

66.7 Analyse information identifying marketing techniques used in motor vehicle service and repair organisations.
Principles: marketing mix (products/place/price/promotion/people), business orientation (production/selling/product/market/customer led), finance/budgeting.
Strategy: marketing plan/position/leadership, promotion/sales (normal/seasonal/special services), finance/budgeting.
Market research: information systems, market intelligence/research/decision support, customers, competitors.
Market analysis: PEST (political/legislation, economic, socio/cultural, technology/ environment), SWOT (strengths, weaknesses, opportunities, threats), competition/ competitors, measurement/forecasting, time based planning cycle, performance criteria.

66.8 Analyse information identifying sales techniques used in motor vehicle organisations.
Principles: vehicle sales (new/used/trade/fleet/contract hire/lease), spares/accessories/ services, distribution (manufacturers' /retail), warranty (manufacturers'/dealership organisations'), promotion/marketing, customer service, presentation of products (vehicles/services/accessories).
Costing: vehicle appraisal (value, finance/budgeting), accounting systems, legal obligations.

Test specification for written paper Business Systems (3905-11-066 and 3905-12-066)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
66.1 Administration and communication systems	20
66.2 Electronic and information processing systems	20
66.3 Financial performance	10
66.4 Different types of financial accounts	10
66.5 Budgeting from financial data	10
66.6 Technological developments	10
66.7 Marketing techniques	10
66.8 Sales techniques	10

Unit 67 Financial Systems
Financial Systems

Practical competences

The candidate must be able to do the following:

67.1 Prepare a report on the flow of funds within motor vehicle service and repair organisations.

67.2 Prepare a balance sheet and assess the financial position of a motor vehicle service and repair organisation.

67.3 Prepare profit/loss statements and assess the financial position of motor vehicle service and repair organisations.

67.4 Prepare cashflow reports identifying the elements of cashflow forecasts/compare with the actual cashflow in a motor vehicle service and repair organisation.

67.5 Prepare a report on the use of key ratios to evaluate the performance of a motor vehicle service and repair organisation.

67.6 Prepare a report explaining the costings of products and services within a given motor vehicle service and repair organisation.

67.7 Prepare budget plans for a motor vehicle service and repair organisations.

Knowledge requirements

The instructor must ensure the candidate is able to:

67.1 Analyse information identifying the flow of funds.
Finances: capital, loans, investment, dividends, tax, interest, stock, fixed assets, costs, turnover, debtors, liabilities, foreign exchange rates, electronic transactions, management of cash.

67.2 Analyse information identifying the key financial terms used in balance sheets.
Terms: capital, equity, shares, loans, interest, fixed assets, current assets/liabilities, profit, creditors, debtors, reserves, working capital, net capital employed, depreciation, stock.

67.3 Analyse information identifying the key financial terms used in profit and loss statements.
Terms: income, revenue expenditure, consist approach, going concern concept, opening/closing stock, gross profit, net profit, profit before tax, expenses, depreciation.

67.4 Analyse information identifying the elements of cashflow forecasts.
Elements: cash flow budgets, balance, receipts (cash/credit sales, miscellaneous), payments (wages, purchases, interest, loan repayments, expenses, capital payments), actual cashflows.

67.5 Analyse information identifying the key ratios.
Terms: profitability (Return of Capital Employed – ROCE, profit to net capital employed, profit on sales), liquidity ratios (current/quick ratio), long-term solvency (capital gearing, time interest earned), efficiency (debtors, stock, turnover), employee ratios.

67.6 Analyse information and explain the costing of products and services.
Costs: labour/staff, material, overheads/expenses, direct/indirect, absorption (percentage methods, hourly methods, unit method), marginal costing (break even analysis), standard costing, differential costing, job costing.

67.7 Analyse information identifying the use of budgetary control.
Budgets: functional, cash, capital (financial planning – year end forecast, profit and loss, sales), fixed costs, variable costs, fixed assets, depreciation, direct/indirect taxation (goods/ services), stock control.
Provision of finance: financial planning, costs (loans, interest, cashflow, banks, raising capital, overdrafts), types of accounts, short/long term loans, bank rates, bank charges.
Assessment of investments: payback periods, return on investments, net present value, discounted cashflow.

Test specification for written paper Financial Systems (3905-11-067 and 3905-12-067)

This is a written examination paper, lasting 3 hours and containing 10 questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
Financial Systems (Unit 67)	
67.1 Flow of funds	10
67.2 Balance sheets	15
67.3 Profit/loss statements	10
67.4 Cashflow reports	15
67.5 Key ratios and performance evaluation	15
67.6 Costings of products and services	10
67.7 Budget plans	25

Vehicle Systems Practical (3905-09-064 to 3905-12-064)

Assessment of the practical skills at each level of this programme is by completion of the tasks listed under practical competences. For each unit there is a competence checklist against which successful performance is recorded. It is expected that a candidate will have successfully completed each of the activities before being credited with a specific skill. Wherever possible competence should be demonstrated in the workplace or in a realistic work environment.

Candidates must demonstrate competence in all of the topics.

Centres should copy the practical assessment sheets for EACH candidate. Completed sheets for each candidate must be available for inspection by the Visiting Assessor, or submission to City & Guilds on request.

The Visiting Assessor must make a visit to the assessment centre on at least one occasion each year at a time when practical assessments are taking place. The main purpose of this visit is to ensure that the competence checklists are being completed accurately and in accordance with the regulations for assessment of this programme.

Please refer to the **Role and Duties of the Visiting Assessor** in Appendix B.

Unit 61 Engine Systems 4
Engine Design Parameters and Performance Testing Module (a)

Practical competences

The candidate must be able to do the following:

61.1a Research information analysing and apply safe working practices when working with engine systems. ☐

61.2a Research information analysing component design features/factors that influence the shape/size of an engine package. ☐

61.3a Research information analysing the factors that influence effective combustion chamber design in petrol engines. ☐

61.4a Research information and describe the lean-burn combustion approach. ☐

61.5a Research information analysing the combustion chamber features necessary in a diesel engine to promote efficient combustion. ☐

61.6a Research information analysing engine performance data/characteristics and apply to petrol/diesel engine vehicle applications. ☐

61.7a Research information analysing that piston movement is not simple harmonic motion. ☐

61.8a Research information analysing the principles of harmonic balancing. ☐

61.9a Research information and describe the causes for crankshaft torsional vibration. ☐

61.10a Research information and describe the limitations to combustion chamber design of a rotary engine and the necessity for advanced ignition timing. ☐

61.11a Research information analysing engine tests to verify operating parameters. ☐

61.12a Carry out engine tests to verify operating parameters. ☐

61.13a Research information analysing and applying engine test performance data and characteristics. ☐

61.14a Prepare conclusive engine test reports. ☐

61.15a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 61 Engine Systems 4
Alternative Power Unit Sources Module (b)

Practical competences

The candidate must be able to do the following:

61.1b Research information analysing the advantages of 'continuous' combustion. ☐

61.2b Research information and state the operating cycle of the Stirling engine. ☐

61.3b Research information and describe the construction and component assemblies of a single acting Stirling engine. ☐

61.4b Research information and state how the cylinders of a Stirling engine may be interconnected. ☐

61.5b Research information and describe the operating principles of the gas turbine engine. ☐

61.6b Research information and describe how the gas turbine engine can be modified for motor vehicle applications. ☐

61.7b Research information and state the operating cycle of the rotary engine. ☐

61.8b Research information and describe the construction and component assemblies of a rotary engine. ☐

61.9b Research information and state the methods adopted to improve over the breathing useful working speed range of a rotary engine. ☐

61.10b Research information and state the limitations to combustion chamber design of a rotary engine and the necessity for advanced ignition timing. ☐

61.11b Research information and state the procedures for conducting mechanical component efficiency tests on Stirling, gas turbine and rotary engines. ☐

61.12b Research information and compare technical/economical factors for the Stirling, gas turbine and rotary engines with those for the conventional reciprocating piston disrupted combustion engine. ☐

61.13b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 62 Chassis Systems 4
Braking, Steering, Suspension and Transmission Systems Module (a)

Practical competences

The candidate must be able to do the following:

62.1a Research information analysing and apply safe working practices when working with braking, steering, suspension and transmission systems. ☐

62.2a Research information analysing component design features and factors that influence the design of mechtronic braking/steering/suspension control systems. ☐

62.3a Research information analysing braking, steering and suspension tests to verify operating parameters. ☐

62.4a Carry out braking, steering and suspension tests to verify operating parameters. ☐

62.5a Research information analysing and apply braking, steering and suspension test performance data and characteristics. ☐

62.6a Prepare conclusive braking, steering and suspension test reports. ☐

62.7a Research information analysing component design features and factors that influence the design of mechtronic transmission control systems. ☐

62.8a Research information analysing transmission tests to verify operating parameters. ☐

62.9a Carry out transmission tests to verify operating parameters. ☐

62.10a Research information analysing and apply transmission test performance data and characteristics. ☐

62.11a Prepare conclusive transmission test reports. ☐

62.12a Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 62 Chassis Systems 4
Vehicle Body Systems Module (b)

Practical competences

The candidate must be able to do the following:

62.1b Research information and describe the manufacturing process of low/medium/mass produced vehicle bodies. ☐

62.2b Research information and describe the advantages of separate construction/unitary vehicle bodies and their variants. ☐

62.3b Research information and describe the construction of component assemblies for separate construction/unitary vehicle bodies and their variants. ☐

62.4b Research information and describe the process of body conception/styling of a new vehicle. ☐

62.5b Research information and describe the principles of aerodynamics. ☐

62.6b Research information and describe how the level of vehicle noise (internal/external) is controlled. ☐

62.7b Research information and describe the principles of elimination of moisture from the body structure. ☐

62.8b Research information and describe construction of component assemblies for interior trim. ☐

62.9b Research information and describe the principles of occupant safety/security. ☐

62.10b Research information and describe methods adopted to maximise driver visibility. ☐

62.11b Research information and describe the procedures for conducting mechanical tests on vehicle body structures. ☐

62.12b Research information and compare technical/economical factors for the materials used in the manufacture of vehicle body structures. ☐

62.13b Use mathematics and science in the above Practical Competences. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 63 Mathematics, Science and Electronics 4
Mathematics Module (a)

Practical competences

The candidate must be able to do the following:

63.1a Apply calculus operations. ☐

63.2a Apply algebraic operations. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 63 Mathematics, Science and Electronics 4
Vehicle Science Module (b)

Practical competences

The candidate must be able to do the following:

63.1b Research information analysing the terms used and calculations associated with energy and fluids. ☐

63.2b Research information analysing the terms used and calculations associated with vibration. ☐

63.3b Research information analysing the terms used and calculations associated with engine balance. ☐

63.4b Research information analysing the terms used and calculations associated with acoustics and noise. ☐

63.5b Research information analysing the terms used and calculations associated with aerodynamics. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Unit 63 Mathematics, Science and Electronics 4
Vehicle Electronic Systems Module (c)

Practical competences

The candidate must be able to do the following:

63.1c Research information analysing and apply testing/fault diagnostic techniques on electronic ignition systems. ☐

63.2c Research information analysing and apply testing/fault diagnostic techniques on electronic fuel injection (EFI) systems. ☐

63.3c Research information analysing and apply testing/fault diagnostic techniques on engine management systems. ☐

63.4c Research information analysing and apply testing/fault diagnostic techniques on electronic anti-lock braking (ABS) systems. ☐

63.5c Research information analysing and applying the operation of electronically controlled steering systems and apply testing/fault diagnostic techniques. ☐

63.6c Research information analysing and applying the operation of electronically controlled automatic transmission systems and apply testing/fault diagnostic techniques. ☐

63.7c Research information analysing and applying the operation of instrument displays/system information panels and apply testing/fault diagnostic techniques. ☐

63.8c Research information analysing and applying the operation of electronically controlled cruise control systems and apply testing/fault diagnostic techniques. ☐

63.9c Research information analysing and applying the operation of electronically controlled automatic climate control systems and applying testing/fault diagnostic techniques. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Management Systems Practical (3905-11-068)

Assessment of the practical skills at each level of this programme is by completion of the tasks listed under practical competences. For each unit there is a competence checklist against which successful performance is recorded. It is expected that a candidate will have successfully completed each of the activities before being credited with a specific skill. Wherever possible competence should be demonstrated in the workplace or in a realistic work environment.

Centres should copy the practical assessment sheets for EACH candidate. Completed sheets for each candidate must be available for submission to City & Guilds on request.

At certificate level the candidate will be expected to keep an organised folder/or portfolio of work for the instructors reference during assessment.

Practical competences

The candidate must be able to do the following:

65.1 Research information and prepare a report analysing information on the formation of teams working in motor vehicle service and repair organisations. ☐

65.2 Use effective leadership methods to manage individuals/teams working in motor vehicle service and repair organisations. ☐

65.3 Research and evaluate information on motivational theories to improve the performance of individuals/teams working in motor vehicle service and repair organisations. ☐

65.4 Work within the team environment to achieve agreement with individuals/teams. Make commendations to improve the performance of the team. ☐

65.5 Communicate effectively to improve individual/team performance in motor vehicle service and repair organisations. ☐

65.6 Set work targets/objectives for an individual, review completion of work and set new targets/objectives for improvements in performance in a motor vehicle service and repair organisation. ☐

65.7 Research information on quality standards and prepare a report applying the standards to motor a vehicle service and repair organisation. ☐

65.8 Prepare a strategy, recruit and select new members of staff. ☐

65.9 Research information, plan, carry out and evaluate a training and development activity for motor vehicle service and repair organisation staff. ☐

65.10 Research information and prepare a report on project work, detailing the stages of how projects can be managed effectively. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Practical competences

The candidate must be able to do the following:

66.1 Research/evaluate information and prepare a report on the administration/communication systems used in motor vehicle service and repair organisations. ☐

66.2 Identify electronic/information processing systems and their uses within a given motor vehicle service and repair organisation. ☐

66.3 Prepare a report identifying how financial performance is monitored, the factors affecting performance and the terms used in motor vehicle service and repair organisations. ☐

66.4 Identify and compare different types of financial accounts used in motor vehicle service and repair organisations. ☐

66.5 Carry out budgeting from given financial data for a motor vehicle service and repair organisation. ☐

66.6 Research information and select one technological development which would impact on business systems in motor vehicle service and repair organisations. ☐

66.7 Research information identifying marketing techniques used in motor vehicle service and repair organisations. ☐

66.8 Carry out effective sales service with customers. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Practical competences

The candidate must be able to do the following:

67.1 Prepare a report on the flow of funds within motor vehicle service and repair organisations. ☐

67.2 Prepare a balance sheet and assess the financial position of a motor vehicle service and repair organisation. ☐

67.3 Prepare profit/loss statements and assess the financial position of motor vehicle service and repair organisations. ☐

67.4 Prepare cashflow reports identifying the elements of cashflow forecasts/compare with the actual cashflow in a motor vehicle service and repair organisation. ☐

67.5 Prepare a report on the use of key ratios to evaluate the performance of a motor vehicle service and repair organisation. ☐

67.6 Prepare a report explaining the costings of products and services within a motor vehicle service and repair organisation. ☐

67.7 Prepare budget plans for a motor vehicle service and repair organisation. ☐

This is to confirm that the candidate has successfully completed the above tasks:

Candidate signature

Candidate name (please print)

Instructor signature

Instructor name (please print)

Completion date

Motor Vehicle Engineering – Project (3905-10-069)

Project
The project is a required assessment for candidates completing the Advanced Technician Diplomas in Motor Vehicle Engineering and in Motor Vehicle Management. It is not a requirement for the Advanced Technician Diplomas in Diagnostic Techniques.

The purpose of the project is to provide additional evidence of knowledge and practical skills covered in the advanced technician diploma programmes. This evidence may be used to support applications for jobs, or for entry to continuing education.

The project can be in a ring binder or box file.

The project should be well laid out so that someone seeing it for the first time can easily find what they are looking for. The person evaluating the project will be looking for evidence to confirm competence and experience at the appropriate level, and that the criteria, project structure and guidelines given below have all been met. It is therefore important that all work is appropriately marked, referenced and filed.

Criteria for the project

- The topic is 'Motor Vehicle Engineering'. The content must include some factors and elements which cover an international perspective.
- 4000 – 6000 words, typed or word processed and desk top published material can be included.
- Visual aids accompanying the project may include photographs, graphics and design. Audio or visual aids are also accepted, eg a video presentation with project documentation (VHS video tape is required). For conversion of video tape please seek advice from a large photographic shop regarding the National Television System Corporation (NTSC) system which will convert video tape from different versions to meet VHS standards.

Project structure and guidelines
Candidates may find the following structure useful:

Title of project

Aim of project

Summary of project
(About 50 – 100 words)

The issues/problem(s)/proposals

- in general terms
- in specific terms

The research conducted: generation of facts

- variety of research
- methodology used

Analysis of issues
Proposals or solutions
Benefits
Conclusions and evaluation
Recommendations (where applicable)
References/glossary

The knowledge and competence involved in preparing a project

- logical/creative thinking
- researching data/information
- organising data
- setting objectives and time scales
- analysing needs
- effective writing skills

Submission of the project
It is the RESPONSIBILITY OF THE CANDIDATE TO

- ensure that entry has been made with City & Guilds, by the examination centre, for this part of the assessment programme
- submit the completed project to the person responsible for receiving it

It is the RESPONSIBILITY OF THE CENTRE to

- ensure that entries have been made to City & Guilds for all candidates wishing to submit a project (See Appendix B)
- receive the project, keep them safely, and send them to City & Guilds for assessment. The project or projects must be accompanied by a separate, completed copy of Form M which shows that an entry has been made for this part of the programme but which does not give a result.

Appendix A

Motor Vehicle Engineering Progression Routes

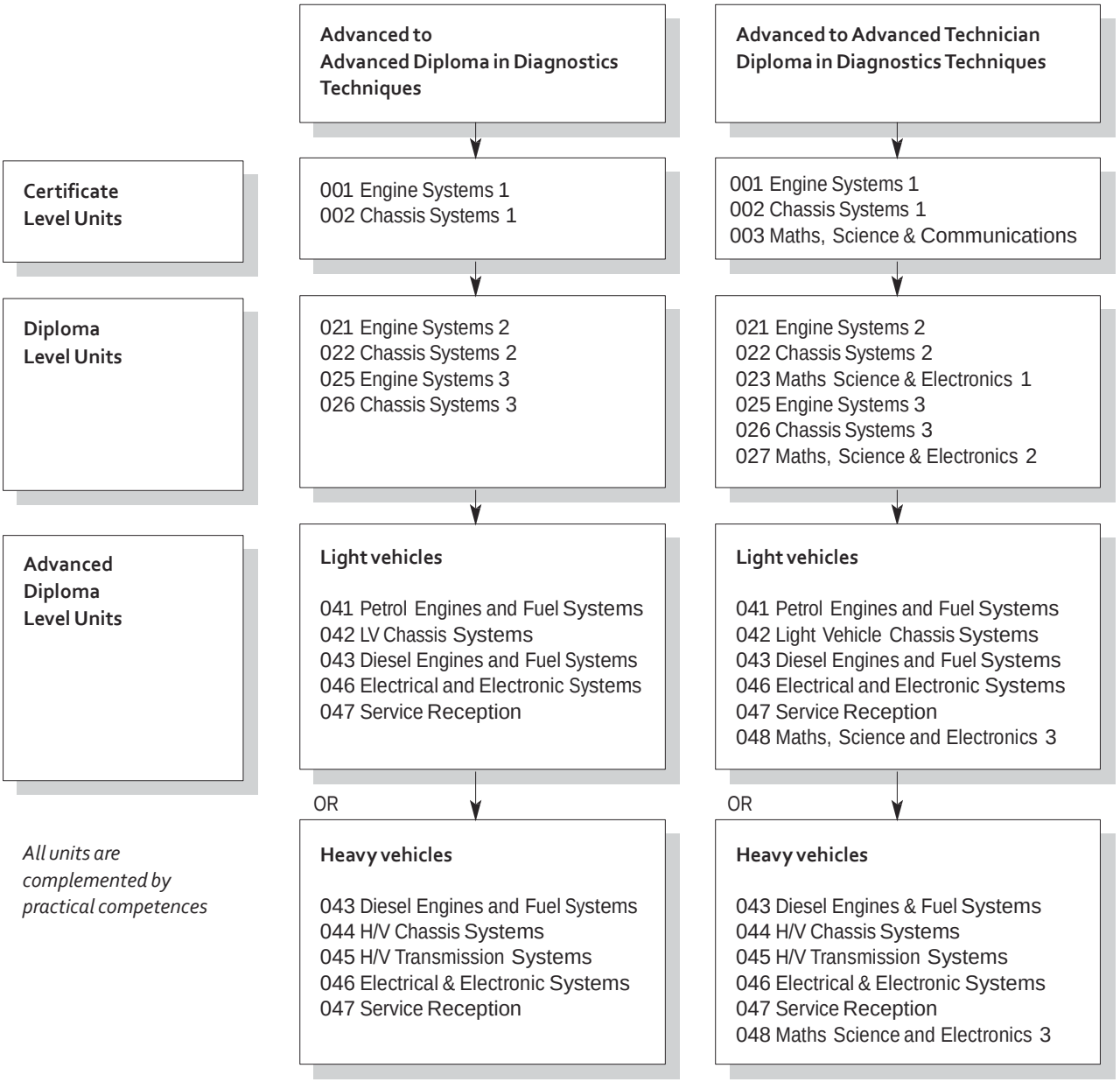
Progression Route charts

Diagnostic Techniques (General and Technician charts)

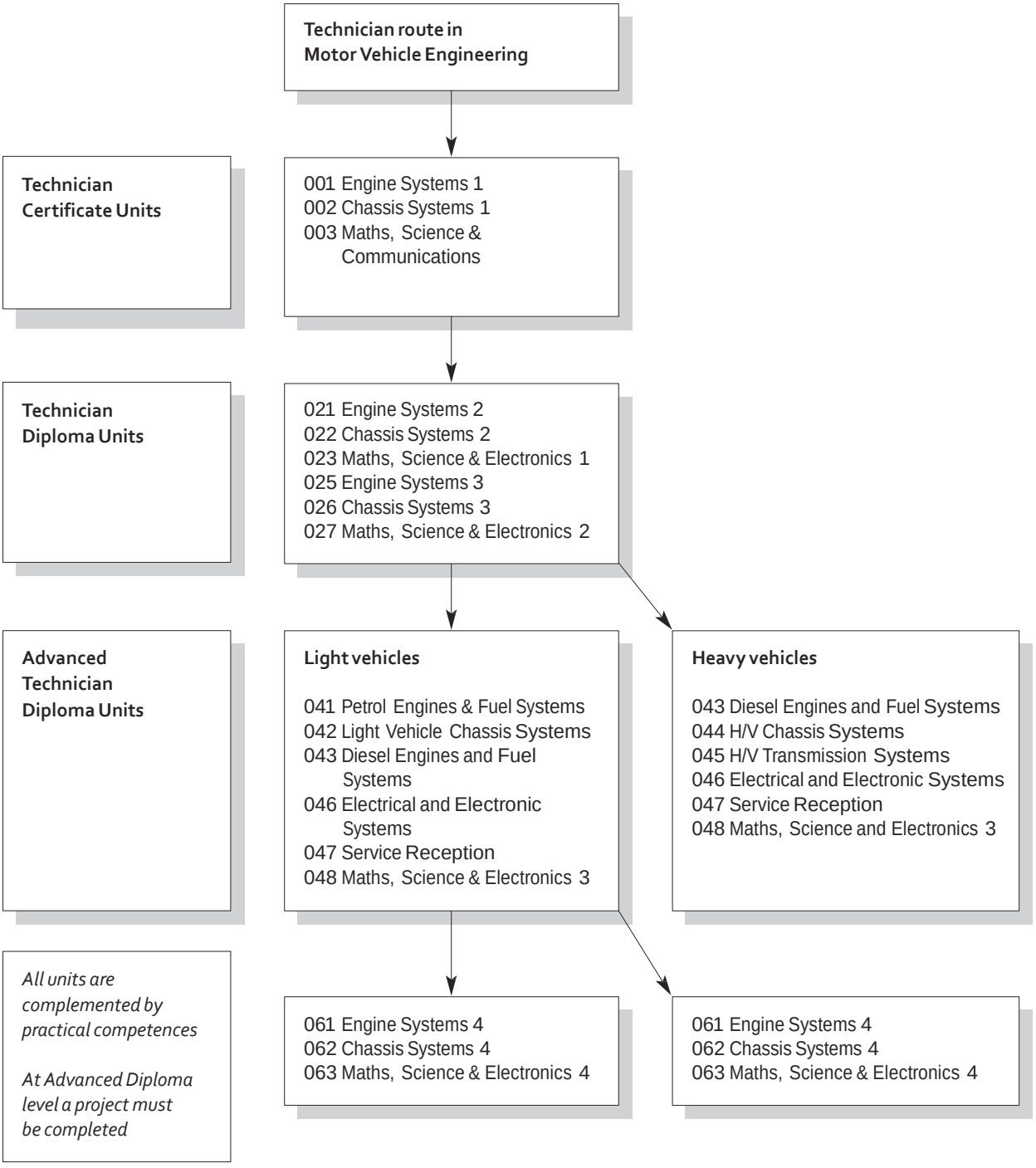
Motor Vehicle Engineering

Motor Vehicle Management

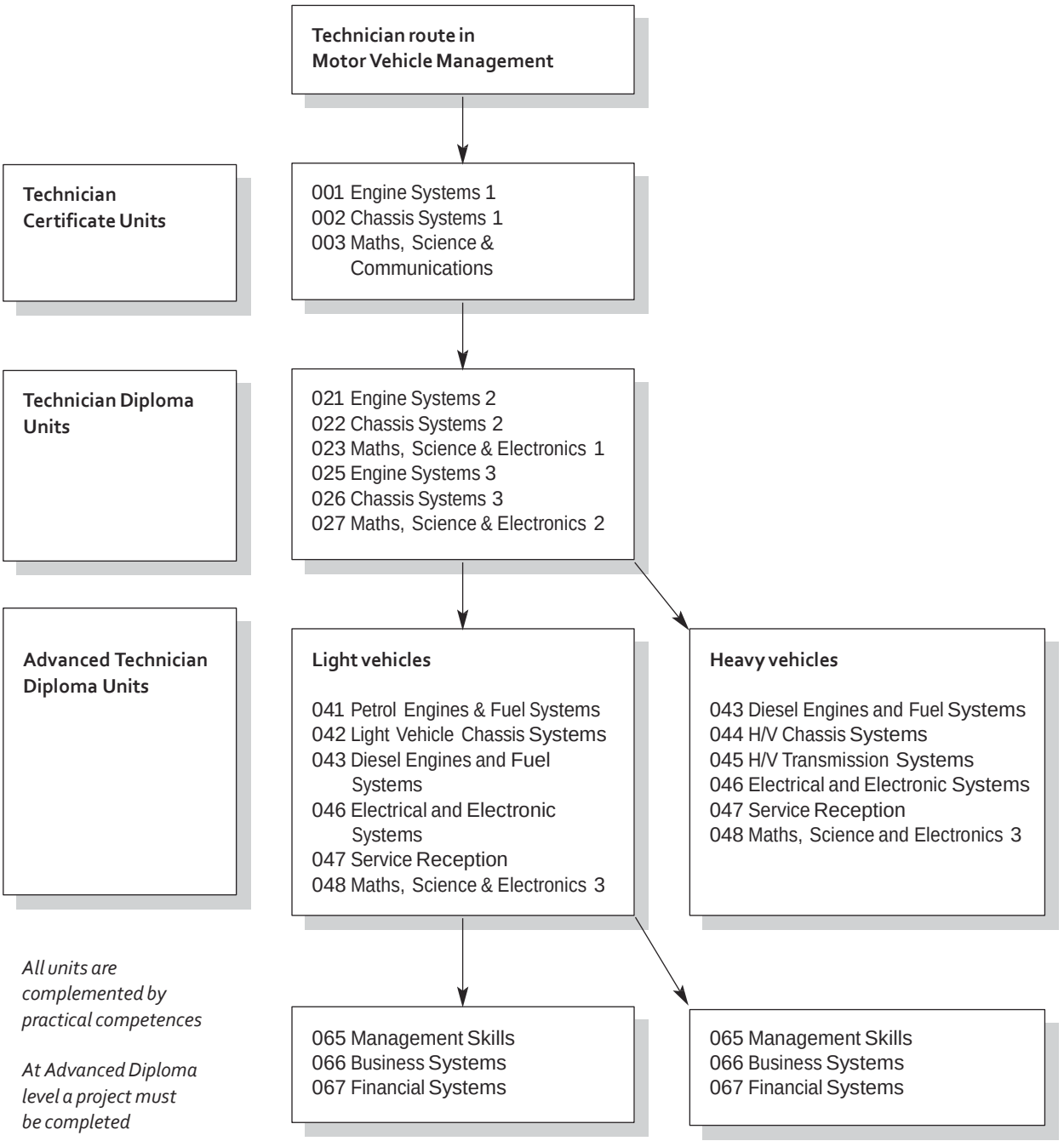
3905 Motor Vehicle Engineering



3905 Motor Vehicle Engineering



3905 Motor Vehicle Engineering



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