

Qualification: 1145-530 Level 3 Engineering – Theory exam (1)

1145-30 Level 3 Advanced Technical Certificate in Engineering

1145-31 Level 3 Advanced Technical Diploma in Engineering (540)

1145-32 Level 3 Advanced Technical Extended Diploma in Engineering (720)

Marking scheme

1a	State the mechanical property that means the ability of a material to resist wear, abrasion and being scratched.		
	Acceptable answer(s)	Guidance	Max mks
	Hardness (1)		(1 mark)
1b	State the term that refers to how easily a material melts.		
	Acceptable answer(s)	Guidance	Max mks
	Fusibility (1)		(1 mark)
2a	Explain the difference between a ferrous and a non-ferrous metal.		
	Acceptable answer(s)	Guidance	Max mks
	Ferrous metals contain <u>iron</u> as their primary element (1); Non-ferrous metals do not contain iron (1).		(2 marks)

2b	In the table below, give an example of a ferrous metal and a non-ferrous metal. For each , give an example of a typical application.											
	<table border="1"> <thead> <tr> <th>Type of metal</th> <th>Example</th> <th>Typical Application</th> </tr> </thead> <tbody> <tr> <td>Ferrous</td> <td></td> <td></td> </tr> <tr> <td>Non-ferrous</td> <td></td> <td></td> </tr> </tbody> </table>			Type of metal	Example	Typical Application	Ferrous			Non-ferrous		
	Type of metal	Example	Typical Application									
	Ferrous											
Non-ferrous												
Acceptable answer(s)		Guidance	Max mks									
Award 1 mark for each cell appropriately completed.		Ferrous metals could include, for example, cast iron (used in engine blocks) or stainless steel (used in cutlery or medical equipment). Non-ferrous metals could include, for example, aluminium alloys (used in aircraft frames) or copper (used in wiring).	(4 marks)									
2c	Explain why thermochromic pigment is a smart material.											
	Acceptable answer(s)		Max mks									
	1 mark each, up to 2 marks: <ul style="list-style-type: none"> Smart materials change their properties when their environment changes (1). Thermochromic materials change colour (1) as the temperature changes (1). 		(2 marks)									
3a	Describe the process of quenching a high carbon steel tool.											
	Acceptable answer(s)		Max mks									
	Award up to 3 marks as follows: The tool is heated to above the upper critical temperature (1) then cooled rapidly (1) by being plunged into water or oil (1).		(3 marks)									
3b	Explain why it is often necessary to carry out tempering after quenching.											
	Acceptable answer(s)		Max mks									
	Award up to 4 marks as follows: Quenching results in a martensitic structure (1) which is very brittle (1). Tempering is used to allow some materials to convert to ferrite (1) increasing the toughness (1).		Any other appropriate response (4 marks)									

4	State three health and safety considerations when manufacturing composite materials.		
	Acceptable answer(s)	Guidance	Max mks
	1 mark each, up to 3 marks: <ul style="list-style-type: none"> • Chemical vapours/ventilation of the work area • Protection of the respiratory system • Temperature control • Fire protection • Safe disposal of waste • Implications of exposure to fibres • COSHH • Any other appropriate point 		(3 marks)
5	Describe how a plasma conducts electricity.		
	Acceptable answer(s)	Guidance	Max mks
	Award up to 3 marks as follows: Plasma is an ionized gas (1) which contains charged particles / electrons and ions (1). These can move independently, allowing the flow of charge (1)		(3 marks)
6	Name three common types of electrical cable.		
	Acceptable answer(s)	Guidance	Max mks
	1 mark each, up to 3 marks: <ul style="list-style-type: none"> • Mains • Coaxial • Ribbon cable • Twin lead 		(3 marks)

7a	Explain why jigs and fixtures are used during batch manufacturing.		
	Acceptable answer(s)	Guidance	Max mks
	Award up to 6 marks as follows: <ul style="list-style-type: none"> To save time (1) and therefore labour costs (1) when marking out (1) To position products in the same way each time for machining (1) ensuring consistency (1) and repeatability (1) To hold products in position (1) so they can be machined safely (1) Any other appropriate point. 		(6 marks)
7b	Explain why a manufacturer might carry out quality control by sampling rather than 100 % inspection.		
	Acceptable answer(s)	Guidance	Max mks
	Award up to 3 marks as follows: <ul style="list-style-type: none"> To reduce the time needed for inspection (1) and therefore the cost (1) Testing may be destructive (1) Any other appropriate point. 		(3 marks)
7c	Explain one advantage to a manufacturing company of using 'six sigma' as a strategy to improve quality.		
	Acceptable answer(s)	Guidance	Max mks
	Award 2 marks as follows: <ul style="list-style-type: none"> Greater proportion of parts in tolerance (1) reducing scrap or cost (1) Less rejected products at the customer (1) Any other appropriate reason 		(2 marks)

8	<p>A company is to design and manufacture a bottle that will package a new fruit juice drink. They hope to sell 5,000 bottles per day.</p> <p>Suggest a suitable material to make the bottle and the main process needed to manufacture it. Give reasons for your suggestions.</p>		
	Acceptable answer(s)	Guidance	Max mks
	Award 1 mark each for a suitable material and the manufacturing process. Award a further mark each for a reason. E.g. polypropylene (1) as it is recyclable/less brittle than glass (1); blow moulding (1) as it is suitable for high volume production (1).	The mark for the process can be awarded if it is suitable for the material even if the material is inappropriate.	(4 marks)
9a	Explain what is meant by an 'iterative' design process.		
	Acceptable answer(s)	Guidance	Max mks
	Award up to 3 marks as follows: Iterative design uses a design-make-test cycle (1) where prototypes are made and progressively improved (1) until the product satisfies the design criteria (1). Any other appropriate point.		(3 marks)
9b	State three methods used to evaluate design ideas.		
	Acceptable answer(s)	Guidance	Max mks
	Award up to 3 marks as follows: <ul style="list-style-type: none"> • Comparison matrix (1) • Ranking (1) • Decision trees (1) 		(3 marks)
9c	Give two advantages of using CAD software compared to manual drawing.		
	Acceptable answer(s)	Guidance	Max mks
	1 mark each, up to 2 marks: <ul style="list-style-type: none"> • Speed of drawing creation (1) • Ease of modification (1) • Accuracy (1) • Ability to save (1) or share electronically (1) • Compatibility with CAM systems (1) 		(2 marks)

9d	Explain two advantages and one limitation of using block modelling to make a prototype.		
	Acceptable answer(s)	Guidance	Max mks
<p>Award 1 mark each for two advantages and 1 limitation and a second mark for each suitable reason. E.g. Advantages</p> <ul style="list-style-type: none"> • Very quick to use (1) allowing products to reach market faster (1) • Can be used to assess dimensions (1) and allow rapid modifications of the design style (1) <p>Limitation</p> <ul style="list-style-type: none"> • Does not function like the product (1) so cannot be used to assess operational performance (1) <p>Any other relevant point.</p>		(6 marks)	
10	Discuss how the development of the steam engine contributed to social and economic development.		
	Acceptable answer(s)	Guidance	Max mks
<p>Intention: <i>To elicit responses that demonstrate how knowledge and understanding across a range of areas relate to the question context. For example, this may involve application of knowledge and understanding of how material choices, process selection, and design and manufacturing considerations, each influence social and economic considerations.</i></p> <p>Level 1 (1-3 marks) Largely descriptive response based on recall of knowledge. A few influences, either mainly social or mainly economic, are stated but their implications are not explained. Candidates at the top of this level may be characterised by describing some influences more in detail, but showing understanding of the implications of just one contribution.</p> <p>Level 2 (4-6 marks) More detailed response, including statements of influences that show understanding of most of their direct implications. Both social and economic influences discussed with some evaluation. Candidates at the top of this level may be characterised by stating and explaining a variety of influences or causal links contributing to or resulting from influences; they may evaluate the broader implications beyond manufacturing of a few of these influences.</p>	<p>Indicative content:</p> <ul style="list-style-type: none"> • Facilitating mechanisation of manufacturing processes, with impact on worker skill needs • Centralising manufacturing resources, creating localised demand for employment • Facilitating the production of items in volume for consumer consumption, giving broader access to manufactured products • Led to the development of railways, allowing distribution of products and relocation of people (for economic and social reasons). <p>For no awardable content, award 0 marks.</p>	(9 marks)	

Level 3 (7-9 marks)

Fully detailed response including statements of influences that show understanding of both their direct and secondary implications. Both social and economic influences discussed, with linking and conclusions drawn.

Candidates at the top of this level may be characterised by evaluating and substantiating how a broad range of influences or causal links have affected society both directly and through secondary effects.

11a An engineer measured an electrical waveform, Figure 1, and identified that it was a sine function.

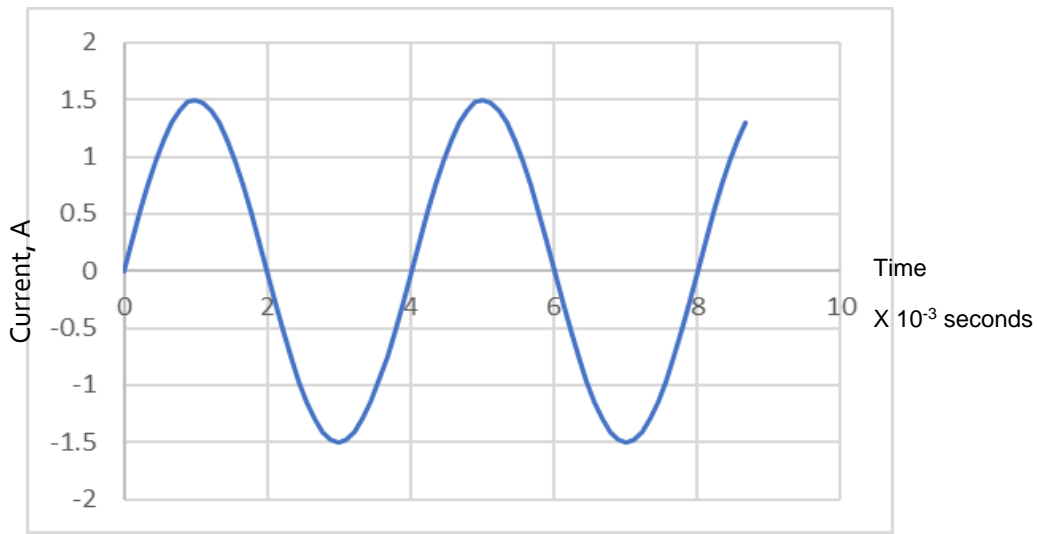


Figure 1

For the waveform shown, determine the:

- i) amplitude
- ii) frequency
- iii) periodic time.

Acceptable answer(s)

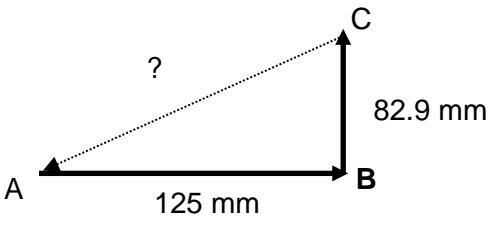
- i) 1.5 amps
- ii) $1/4 \times 10^{-3} = 250$ hertz
- iii) 4×10^{-3} seconds

Guidance

1 mark for each

Max mks

(3 marks)

11b	<p>Multiply the following complex numbers.</p> $(4 + 3j)(2 - 2j)$		
	Acceptable answer(s)	Guidance	Max mks
	$(4 + 3j)(2 - 2j)$ $= (4 \times 2) + (4 \times -2j) + (3j \times 2) + (3j \times -2j)$ $= 8 - 8j + 6j - 6j^2 = 8 - 2j - 6j^2$ $= 8 - 2j - -6$ $= 14 - 2j$	Award 1 mark for the method, 1 mark for resolving j^2 and 1 mark for the solution.	(3 marks)
11c	<p>An inspection was carried out on a trial batch of cast products.</p> <ul style="list-style-type: none"> • 90 % of the products were satisfactory and contained no defects. • 5 % of the total quantity of products contained inclusion defects. • 8 % of the total quantity of products contained crack defects. <p>Some of the products contained both types of defect.</p> <p>Calculate the probability that a product selected at random contained only one defect.</p>		
	Acceptable answer(s)	Guidance	Max mks
	<p>Probability of a defect = $100 - 90 = 10\%$ (1)</p> <p>Total quantity of defects = $8 + 5 = 13\%$ (1) therefore the proportion of products with 2 defects must equal $13 - 10 = 3\%$ (1)</p> <p>Thus the probability of a product containing only a single defect is $10 - 3 = 7\%$ (1)</p>	Award 1 mark for calculating the probability of a defect, 1 mark for calculating the total quantity of defects, 1 mark for calculating the proportion of products with two defects, and 1 mark for calculating the probability of a product containing a single defect. Accept alternate methods.	(4 marks)
11d	<p>A machine tool moves from A to B then, after turning at a right angle, from B to C as shown on Figure 2.</p> <p>Calculate the magnitude of the polar vector for the tool to return directly to A from C.</p> <div style="text-align: center;">  </div> <p>Figure 2 – Not to scale</p>		

	Acceptable answer(s)	Guidance	Max mks																
	Magnitude = $\sqrt{(125^2 + 82.9^2)} = \sqrt{22497.41}$ Magnitude = 150 mm (to 3 sig. fig.)	1 mark for method, 1 mark for answer. Allow trigonometric methods as an alternative.	(2 marks)																
11e	The linear acceleration of a tool in a machine in mm s^{-2} is given by the function: Acceleration, $a = 6t^2 - 6 \sin(3t)$ Using integration, determine the velocity of the tool at $t = 4$ s.																		
	Acceptable answer(s)	Guidance	Max mks																
	$v = 2t^3 + 2\cos(3t)$ so for $t = 4$ s, $v = 2(4)^3 + 2\cos(12)$ $= 130 \text{ mm s}^{-1}$	1 mark for $2t^3$, 1 mark for $2\cos(3t)$, 1 mark for answer.	(3 marks)																
11f	Using the chain rule, differentiate $y = (x + 3)^4$.																		
	Acceptable answer(s)	Guidance	Max mks																
	Let $u = x+3$ and $y = u^4$ $du/dx = 1$ and $dy/du = 4u^3$ hence $dy/dx = 4u^3 \times 1 = 4(x+3)^3$	1 mark for each line shown	(3 marks)																
12	Figure 3 is a plot of the rate of tool wear for a machining operation. The variables x and y have been plotted as logarithms to base 10. Determine an equation for the relationship between x and y .																		
	<table border="1"> <caption>Data points from Figure 3</caption> <thead> <tr> <th>$\text{Log}_{10}x$</th> <th>$\text{Log}_{10}y$</th> </tr> </thead> <tbody> <tr><td>0.0</td><td>0.7</td></tr> <tr><td>0.1</td><td>1.0</td></tr> <tr><td>0.2</td><td>1.3</td></tr> <tr><td>0.3</td><td>1.6</td></tr> <tr><td>0.4</td><td>1.9</td></tr> <tr><td>0.5</td><td>2.2</td></tr> <tr><td>0.6</td><td>2.5</td></tr> </tbody> </table>			$\text{Log}_{10}x$	$\text{Log}_{10}y$	0.0	0.7	0.1	1.0	0.2	1.3	0.3	1.6	0.4	1.9	0.5	2.2	0.6	2.5
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	Figure 3																		

	Acceptable answer(s)	Guidance	Max mks
	Up to 6 marks: <ul style="list-style-type: none"> • The intercept is 0.7 • The gradient is $(2.5-1)/0.5 = 3$ • The relationship is therefore $\log_{10}y = 0.7 + 3 \log_{10}x$ • Taking antilogs: $\text{antilog}_{10} 0.7 = 5$ • Taking antilogs: $\text{antilog}_{10} 3 \log_{10}x = x^3$ • Therefore $y = 5x^3$ 	Allow other values to be used when calculating the gradient – the calculated value will be the same.	(6 marks)
13	Mobile phones have changed substantially over the last 30 years. <ul style="list-style-type: none"> • They are now much smaller. • They weigh less. • In real terms, they cost less. • They have many more functions. <p>Discuss the possible reasons for these changes.</p>		
	Acceptable answer(s)	Guidance	Max mks
	<p>Intention: <i>To elicit responses that demonstrate how knowledge and understanding across the full range of technical content in the qualification relate to the question context. For example, this may involve application of knowledge and understanding of how progressive changes in customer requirements, materials and microtechnology, and process developments have influenced the development of the phone.</i></p> <p>Level 1 (1-3 marks) Descriptive response based on recall of knowledge, relating only to a single development, e.g. customer demand, manufacturing processes or microtechnology. Candidates at the top of this level may be characterised by showing some understanding of one reason that facilitated the development.</p> <p>Level 2 (4-6 marks) Mainly descriptive response showing knowledge recall relating to a range of different influences on the development of the product. Candidates at the top of this level may demonstrate understanding of the reasons how or why some of the influences affected the design of the phone.</p> <p>Level 3 (7-9 marks)</p>	Indicative content: <ul style="list-style-type: none"> • Changes in customer needs • Developments in materials, such as conductive screens • Developments in microtechnology • Developments in assembly process, such as pick and place equipment • Improvements in the capability of machining processes • Development in CAD software and CAD/CAM • Increase in volume of production facilitating investment in production resources <p>For no awardable content, award 0 marks.</p>	(12 marks)

	<p>Detailed response, showing both knowledge recall and understanding of how phone design has been affected by a variety of different contributing developments.</p> <p>Candidates at the top of this level may be characterised by considering the relative impact of different types of development on the phone design.</p> <p>Level 4 (10-12 marks)</p> <p>Fully detailed response, showing understanding of how phone design has been affected by a wide variety of different contributing developments. Evaluation of which factors have had the greatest influence, producing supporting conclusions.</p> <p>Candidates at the top of this level may be characterised by analysing and comparing how conflicting considerations have affected the phone design.</p>		
		Total marks	100