

1145-530 - March 2023

Level 3 Advanced Technical Certificate in Engineering

Level 3 Advanced Technical Extended Diploma in Engineering (720)

Level 3 Engineering - Theory exam (1)

March 2023 Mark Scheme

Question number	Acceptable answer(s)	Guidance	Max mks	Ref
Q1 a)	1 mark for elasticity.		1	301 1.1 AO1
Q1 b)	1 mark for the ability of a material to resist wear/abrasion/scratches. Any other correct definition.		1	301 1.1 AO1
Q1 c)	1 mark each for any of the following points, up to 4 marks in total: <ul style="list-style-type: none"> E.g. for Vickers hardness (1): a tool is pushed into the surface of the material (1) using a set load (1). After this is removed, the dimensions of the indentation are measured (1). Any other appropriate response (including descriptions of other hardness testing methods, such as Brinell and Rockwell). 		4	301 3.1/3 .2 AO1
Q2	1 mark each for up to 4 points in the description, e.g.: <ul style="list-style-type: none"> Heat the metal until cherry red (1). Add carbon either through a modified atmosphere or surface coating/powder/carburising compound (1). Allow soak time so that the carbon can be adsorbed into the surface (1). Cool quickly/quench (1). Any other appropriate point. 	Accept any appropriate alternative processes.	4	301 2.1 AO1
Q3 a)	1 mark each for up to 3 of: <ul style="list-style-type: none"> In a metal alloy, atoms of the constituents are mixed together at an atomic level whereas in a composite the constituents are mixed at a macrostructural level (1). 		3	301 1.2, 4.1 AO2

	<ul style="list-style-type: none"> In a composite the constituents can be separately identified within the microstructure whereas in a metal the individual elements are not visible within the microstructure (1). A composite may include different types of material (e.g. carbon fibre, polymer, metal) whereas an alloy typically contains mainly metals (1). The properties of a composite are typically a combination of the properties of the constituents whereas in an alloy the resultant properties may be outside the normal range of the properties of the constituents (1). Any other appropriate point. 			
Q3 b)	<p>1 mark each for up to 4 of:</p> <ul style="list-style-type: none"> Higher set up cost for dry fibre (1), as more manual labour is needed to lay out and coat the fibre matrix (1). Increased productivity/production rate when using pre-preg (1) as fibre matrix can be quickly cut to shape (1). Pre-preg can be cut to required shapes before application (1), reducing manufacturing time (1). Less volatile liquids to store (1), which may reduce hazards to workers from fumes /fire risks (1). Any other appropriate point. 	<p>1 mark each for stating two reasons without explanation; maximum of 2 marks for each reason</p>	4	301 4.2, 4.3 AO2
Q4	<p>1 mark each for up to 6 of:</p> <ul style="list-style-type: none"> Typically semiconductor materials have four electrons in their outer shell (1), which form perfect covalent bonds with their neighbouring atoms (1) resulting in poor ability to conduct electricity (1). A small amount of impurity is added to the material (doping) (1): <ul style="list-style-type: none"> In n-type materials, this adds an extra electron which is free to move around (1); typical n-type dopants include phosphorous or arsenic (1). In p-type materials, this takes away an electron, leaving a 'hole' which 		6	301 5.3 AO2

	<p>allows electrons from neighbouring atoms to move into the space/hole (1); typical p-type dopants include boron or gallium (1).</p> <ul style="list-style-type: none"> Any other appropriate answer. 			
Q5	<p>1 mark each for up to 6 points in the description, e.g.:</p> <ul style="list-style-type: none"> Metal core usually in a hollow square form (1) or a shell type-construction (1). Core usually soft iron or laminated steel to prevent losses (1); if laminated, each layer is assembled together from two metal parts (1) to facilitate access for the winding (1). These are produced by stamping from sheet (1). The laminations and any fixing studs or bolts are electrically insulated from each other (1) by a thin coating of insulating varnish or by the use of an oxide layer on the surface (1). Copper wire of suitable gauge wound onto the core (1) for a primary winding and one or more secondary windings opposite the primary (1). Windings each have a set number of turns (1), which are typically carried out by hand/on a lathe (1). Any other appropriate answer. 		6	304 1.2 AO1
Q6 a)	<p>1 mark each for up to 3 of:</p> <ul style="list-style-type: none"> A tube of thermoplastic is heated in the mould (1). Air is blown into the tube, expanding it to the shape of the mould (1). The product is allowed to cool, retaining its shape (1). Any other appropriate response. 		3	304 3.3 AO1

Q6 b)	<p>1 mark each for up to 5 marks in total:</p> <ul style="list-style-type: none"> • Kanban is used for stock management (1) and to manage workflow (1). • Reduces scrap (1) as there is less work in progress between processes it is detected quicker at the next process (1). • Reduces cash tied up in the business (1) as there is less inventory (1). • Reduces overproduction (1) as products are only manufactured when they are needed (1). • Provides flexibility of production (1) as there is greater responsiveness to demand (1). • Any other appropriate answer. 		5	304 4.2 AO2
Q7	<p>Award 1 mark for a suitable material, e.g. a named thermosetting plastic (1).</p> <p>Award up to 3 marks for suitable reasons, such as low electrical and thermal conductivity (1), low density/light weight (1), corrosion resistance from water (1), ability to be joined (1). Accept other suitable answers e.g. cost or sustainability.</p>	<p>Candidates may achieve 3 marks by giving three reasons.</p> <p>Candidates may also achieve up to 3 marks for giving one reason with two supporting explanatory points.</p> <p>Or any combination of reasons and points of explanation.</p>	4	AO4 301 1.1, 1.2, 3.4 304 1.1, 2.1, 2.4, 2.5, 3.3 305 2.2
Q8 a)	<p>1 mark each for up to 2 of:</p> <ul style="list-style-type: none"> • target audience (1). • functional requirements (1). • performance requirements (1). • materials (1). • quantity needed (1). • manufacturing methods to be used (1). • costs (1). • competitor products (1). • any other suitable point (1). 		2	305 2.1 AO1
Q8 b)	<p>Subjective criteria are assessed qualitatively (1) whereas objective criteria can be assessed quantitatively (1).</p> <p>Subjective criteria are based on opinion (1) whereas objective criteria can be measured (1).</p>	<p>Second mark can only be achieved if accurately linked as a difference to the first point raised.</p>	2	305 2.2 AO2
Q8 c)	<p>1 mark for each of the following, up to a maximum of 2 marks:</p>		2	305 3.3

	<ul style="list-style-type: none"> • A visual tool to show the main physical elements of a system (1). • Increases understanding of how the signal type changes as it passes through the system (1). • Facilitates identification of the input, process and output of a system (1). • Any other relevant point. 			AO1
Q8 d) i)	<p>Benefits:</p> <ul style="list-style-type: none"> • Will have the properties of the final product (1) allowing it to be tested in use (1). • Could look exactly like the final product (1) so could be shown to users for their feedback (1). • Allows difficulties in manufacturing to be identified (1) so the design can be changed before production (1). • Any other relevant point. 	<p>Award 1 mark for stating each benefit.</p> <p>Award a further mark for a valid explanation of each.</p>	4	305 3.4 AO2
Q8 d) ii)	<p>Limitations:</p> <ul style="list-style-type: none"> • Need to buy the physical components/materials (1) which may be high cost due to the small quantity required (1). • May take a long time to make (1) due to the set-up times on the processes used (1). • May be difficult to make changes to the prototype (1) especially where additions to the design are required (1). • May require highly skilled workers (1) as the small quantity may be made on manually controlled machines (1). • Any other relevant point. 	<p>Award 1 mark for stating each limitation.</p> <p>Award a further mark for a valid explanation of each.</p>	4	305 3.4 AO2
Q9	<p>For no awardable content, award 0 marks.</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</p>	<p>Indicative content:</p> <ul style="list-style-type: none"> • Increase in effective ‘usable time’ due to lighting, increasing working and leisure time. • Increased opportunities for employment in a wide range of activities, when no natural light is available; this results in increased income and associated impacts on consumption. • Reduced risks of fire due to less candles or open flames for lighting. • Risks of electrocution. 	9	AO4 301 1.2, 3.4, 5.1, 5.2 304 1.3, 2.1, 2.6 305 1.1, 1.2, 2.2, 4.1

	<p>economic influences discussed with some evaluation.</p> <p>Candidates at the top of this level may be characterised by stating and explaining a range of influences or causal links contributing to or resulting from influences; they may evaluate the broader implications of a few of these influences.</p> <p>Level 3 – (7-9 marks)</p> <p>Fully detailed response including statements of influences that show understanding of both the direct and secondary implications. Both social and economic influences discussed, with linking and conclusions drawn.</p> <p>Candidates at the top of this level may be characterised by evaluating and substantiating how a broad variety of influences or causal links have affected society and the economy both directly and through secondary effects.</p>	<ul style="list-style-type: none"> • Requirement for power generation; consumption of fossil fuels and associated pollution associated with this. • Development of associated technologies, such as the cinema, with their influence on culture and communication. • Changes in building design. • Requirements for volume manufacture to meet demand, with associated centralisation of manufacturing, development of automation and transport infrastructure. • Any other appropriate point. 		
Q10 a)	$= (5 \times 3) + (5 \times -3j) + (2j \times 3) + (2j \times -3j) \text{ (1)}$ $= 15 - 15j + 6j - 6j^2 = 15 - 9j - 6j^2$ $= 15 - 9j - -6 \text{ (1)}$ $= 21 - 9j \text{ (1)}$	<p>Award 1 mark for the method.</p> <p>Award 1 mark for resolving j^2.</p> <p>Award 1 mark for the solution.</p>	3	306 4.2 AO2
Q10 b)	<p>Magnitude = $\sqrt{(45^2+227^2)}$ (1)</p> <p>Magnitude = $\sqrt{53554} = 231.4$ (1)</p> <p>Angle $\theta = \tan^{-1} (227/45)$ (1)</p> <p>Angle $\theta = 78.8^\circ$ (1) relative to the x axis.</p> <p><u>Also accept:</u> Angle $\theta = \tan^{-1} (45/227)$ (1) = 11.2° (1) relative to the y axis.</p>	<p>Award 1 mark for method for magnitude.</p> <p>Award 1 mark for value of magnitude stated to one decimal place.</p> <p>Award 1 mark for method for angle.</p> <p>Award 1 mark for value of angle stated to one decimal place.</p> <p>Accept alternative methods.</p>	4	305 4.4 AO2
Q10 c)	<p>Area = $1/2ac \sin B$ (1)</p>	<p>Award 1 mark for stating formula (including other variants, such as Area = $1/2bc \sin A$).</p>	5	306 2.2 AO2

	<p>Rearranging $a = \text{Area} / (\frac{1}{2} \times 140 \times \sin 33^\circ)$ (1)</p> <p>$BC = 9912.43 / (\frac{1}{2} \times 140 \times 0.545)$ (1)</p> <p>$= 259.8 \text{ mm}$ (1)</p> <p>To the nearest millimetre $= 260 \text{ mm}$ (1)</p>	<p>Award 1 mark for rearranging formula.</p> <p>Award 1 mark for method.</p> <p>Award 1 mark for answer.</p> <p>Award 1 mark for rounding.</p>		
Q11	<p>$\sin^2 \theta + \cos^2 \theta = 1, \cos^2 \theta = 1 - \sin^2 \theta$ (1)</p> <p>$= (1 - \sin \theta)^2 / (\cos^2 \theta)$ (1)</p> <p>$= ((1 - \sin \theta) / \cos \theta)^2$ (1)</p> <p>$= (1 / \cos \theta - \sin \theta / \cos \theta)^2$ (1)</p> <p>As $1 / \cos \theta = \sec \theta$ and $\sin \theta / \cos \theta = \tan \theta$ (1)</p> <p>Substituting in these values $= (\sec \theta - \tan \theta)^2$ QED (1)</p>	<p>Award 1 mark for rearranging formula.</p> <p>Award 1 mark for substituting this into the left-hand side.</p> <p>Award 1 mark for moving the square.</p> <p>Award 1 mark resolving brackets.</p> <p>Award 1 mark for knowing relationship.</p> <p>Award 1 mark for substituting in values.</p>	6	306 2.1, 2.2 AO2
Q12	<p>Let $u = y^4$ and $v = \cos(2y)$ (1)</p> <p>$dx/dt = u \cdot dv/dt + v \cdot du/dt$</p> <p>$du/dt = 4y^3$ (1)</p> <p>$dv/dt = -2 \sin(2y)$ (1)</p> <p>$u \cdot dv/dt = -2y^4 \sin(2y)$ (1)</p> <p>$v \cdot du/dt = 4y^3 \cos(2y)$ (1)</p> <p>Therefore $dx/dt = 4y^3 \cos(2y) - 2y^4 \sin(2y)$ (1)</p>	<p>Award 1 mark per line up to 6 marks.</p> <p>Award marks for previous steps (without workings being seen), if you can infer that the step(s) have been carried out by the answer provided.</p> <p>Award full marks if final answer is correct.</p>	6	306 3.1 AO2
Q13	<p>For no awardable content, award 0 marks.</p> <p>Level 1 – (1-4 marks) Basic – largely descriptive response based on recall of knowledge, relating only to a few direct considerations of one type, e.g. changes in manufacturing processes or materials. Candidates at the top of this level may be characterised by showing some understanding of one reason for the identified change.</p>	<p>Indicative content:</p> <ul style="list-style-type: none"> • Scale of manufacture, including the use of jigs, fixtures and automation. • Availability and suitability of manufacturing processes, such as moving from vacuum forming to injection moulding. 	12	AO4 301 1.1, 1.2, 3.1, 3.4, 5.1, 5.2 304 1.1, 2.1, 2.2, 2.3, 2.4,

	<p>Level 2 – (5-8 marks) Clear – more detailed response showing knowledge recall relating to a range of different considerations (e.g. manufacturing processes, materials), with understanding of how the commercial production could be directly affected by different contributing considerations. Candidates at the top of this level may be characterised by considering the relative impact of a few different types of consideration.</p> <p>Level 3 – (9-12 marks) Detailed – fully detailed response, showing understanding of a wide variety of different considerations (e.g. process requirements, materials, design, packaging), considering both direct and indirect implications. Evaluation of which factors have had the greatest influence, with supporting conclusions. Candidates at the top of this level may be characterised by analysing and comparing how conflicting considerations may affect the commercial product.</p>	<ul style="list-style-type: none"> • Availability of materials and the form of the available materials. • Material cost (direct and manufacturing). • Design for manufacturing. • Consideration of process capabilities and manufacturing tolerances. • Quality control and assurance. • Conformance to any legal requirements and standards. • Packaging of the product. • Power supply options. • Sustainability. • Any other relevant point. 		2.5, 2.6, 3.3, 4.1, 4.2, 5.1, 5.2, 5.3 305 1.1, 2.2, 3.3, 3.4
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