

1145-530 - June 2023

Level 3 Advanced Technical Certificate in Engineering

Level 3 Advanced Technical Extended Diploma in Engineering (720)

Level 3 Engineering - Theory exam (1)

June 2023 Mark Scheme

Question number	Acceptable answer(s)	Guidance	Max mks	Ref										
Q1 a)	Award 1 mark for the ability of a material to deform permanently over a long time under the influence of mechanical stress. Accept alternative wording.		1	301 1.1 AO1										
Q1 b)	1 mark for brittleness.		1	301 1.1 AO1										
Q2	1 mark each for up to 4 points: <ul style="list-style-type: none"> In precipitation hardening, an impurity phase is taken into solution (1). Heat treatment is used to allow the impurity phase to precipitate (1) typically in areas where there are dislocations in the lattice (1). The precipitated particles impede the movement of dislocations (1) which would otherwise allow plastic deformation (1). This increases strength and hardness (1) and reduces plasticity (1). 		4	301 2.1, 2.2 AO2										
Q3 a) & b)	<p>i) Award 1 mark each for stating two smart materials to a maximum of 2 marks.</p> <p>ii) Award a second mark each for stating their smart property to a maximum of 2 marks.</p> <table border="1" data-bbox="261 1630 1042 1966"> <thead> <tr> <th>i) Smart material</th> <th>ii) Property</th> </tr> </thead> <tbody> <tr> <td>Thermochromic pigment (1)</td> <td>Changes colour with temperature (1).</td> </tr> <tr> <td>Photochromic pigment (1)</td> <td>Changes colour with light (1).</td> </tr> <tr> <td>Piezoelectric (1)</td> <td>Changes shapes with electrical energy (1).</td> </tr> <tr> <td>Shape memory alloy (1)</td> <td>Returns to original shape when heated (1).</td> </tr> </tbody> </table> <p>Accept other appropriate answers.</p>	i) Smart material	ii) Property	Thermochromic pigment (1)	Changes colour with temperature (1).	Photochromic pigment (1)	Changes colour with light (1).	Piezoelectric (1)	Changes shapes with electrical energy (1).	Shape memory alloy (1)	Returns to original shape when heated (1).	Do not accept polymorph or modern materials unless they have a smart property.	1 1 1 1	301 1.2 AO1
i) Smart material	ii) Property													
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Q4 a)	Award 1 mark each for: <ul style="list-style-type: none"> • Voids (1). • Disbonds/delamination (1). • Porosity (1). • Any other appropriate point. 		3	301 4.4 AO1
Q4 b)	Award 1 mark for each of the following up to 4 marks: <ul style="list-style-type: none"> • To add volume (1), reducing the density of the material (1). • To reduce the cost of the product by reducing the amount of matrix and reinforcement required (1) as fillers cost less than the matrix and reinforcement (1). • Any other appropriate point. 		4	301 4.1 AO2
Q5 a)	Award 1 mark for each of the following up to 4 marks: <ul style="list-style-type: none"> • Doping involves adding impurities to semiconductor materials to alter their properties (1). • There are two types of doped semiconductor, P- and N- type (1). • The addition of Trivalent elements creates a P-type semiconductor (1), which means the semiconductor is rich in holes/positive charged ions (1). • The addition of Pentavalent elements creates a N-type semiconductor (1) which means the semiconductor has excess electrons (1). • The holes or excess electrons facilitate the movement of charge through the semiconductor (1). • Any other appropriate answer. 		4	301 5.3 AO1
Q5 b)	<ul style="list-style-type: none"> • It is a material that can transmit electric force (1) but does not conduct electricity/is an insulator (1). • Any other appropriate answer. 		2	301 5.2 AO1

Q6 a)	<p>Award 1 mark each for up to 6 of:</p> <ul style="list-style-type: none"> • A mould is made of the shape to be formed (1). • A thermoplastic sheet is clamped into the vacuum former to achieve an airtight seal e (1). • The sheet is heated so that it becomes flexible (1). • The mould platen is raised so that it is in contact with the heated sheet (1). • The vacuum removes the air between the mould and polymer (1) so that the external air pressure pushes the polymer onto the mould (1). • The mould is allowed to cool so this it will retain its shape (1). • Any other appropriate response. 	<p>Additional marks up to the total can be given for detail at specific stages. Marks can only be awarded for steps that are presented in an appropriate sequence.</p>	<p>6</p>	<p>304 3.3 AO2</p>
Q6 b)	<p>Award 1 mark each for up to 4 of:</p> <ul style="list-style-type: none"> • The surface of one of the materials is spiked or rounded surface to act as an energy director (1). • The parts are sandwiched between a fixed shaped nest/anvil and a sonotrode/horn (1). • A low amplitude acoustic vibration is emitted (1) typically 15-70 kHz (1). • The contact point between the two polymers is melted by the absorption of vibrational energy (1). • Any other appropriate response. 	<p>Additional marks up to the total can be given for detail at specific stages. Marks can only be awarded for steps that are presented in an appropriate sequence.</p>	<p>4</p>	<p>304 3.7 AO1</p>
Q7	<p>Award 1 mark each for up to 4 of:</p> <ul style="list-style-type: none"> • Changes in processes/moving from manual/hand tools to machines (1) as the time for set up is offset by the quicker process times (1). • Use of jigs/fixtures/templates (1) to reduce marking up/checking time (1). • Changes in the level of skill of the workforce (1) as machining bespoke parts may require a higher level of expertise (1). • Any other appropriate answer. 	<p>1 mark each for identifying the differences up to a maximum of 2, plus 1 mark for detailing the explanation up to a maximum of 2.</p>	<p>4</p>	<p>304 2.1 AO2</p>
Q8	<p>Award 1 mark for a suitable material, such as: a named thermoplastic, CRP composite or aluminium alloy.</p> <p>Award up to 3 marks for suitable reasons, such as: hardness, toughness, low density/light weight, corrosion resistance to sweat, cost, availability of manufacturing processes, sustainability etc.</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>	<p>4</p>	<p>AO4 301 1.1, 1.2, 3.4 304 1.1, 2.1, 2.4, 2.5, 3.3 305 2.2</p>

Q9 a)	Award 1 mark each for up to 4 needs applicable to the stated type of research: <ul style="list-style-type: none"> • Cost (1). • Environmental issues (1). • Size (1). • Safety requirements (1). • Function (1). • Materials (1). • Limitations affecting the choice of manufacturing methods (1). • Dimensional requirements and tolerances (1). • Any other appropriate response. 		4	305 1.3, 2.2 AO2
Q9 b)	Award 1 mark for each point up to a maximum of 4 : A decision tree is a flowchart-like structure starting from a single node or decision point (1) which represents a test on an attribute (1) (e.g. in comparison with a need in the specification) (1). The branches represent the outcomes of the test (1). Subsequent nodes represent further tests to be carried out (1). The final outcomes represent the probabilities of achieving a desired result (1). <ul style="list-style-type: none"> • Any other appropriate point. 		4	305 3.2 AO1
10	Award 1 mark for each of the steps in the description, up to 6 marks, e.g.: <ul style="list-style-type: none"> • Produce a 3D model using CAD drawing software (1). • Include supports in the model if the geometry is complex (1), to prevent collapse during the process (1). • Process the model to create a stereolithography file (stl) (1) to split the model into lots of very small layers (1). • Check the stereolithography file for manifold errors to prevent discontinuities in the product surface (1). • The head of the 3D printer moves in two dimensions to deposit the base layer (1). It then moves up so that it can deposit the next layer on top (1). • The process is repeated building up layers in order to deposit the full product. (1). • Any other relevant point. 	Marks can only be awarded for steps that are presented in an appropriate sequence.	6	305 3.4 AO2

Question number	Acceptable answer(s)	Guidance	Max mks	Ref
Q11	<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 economic influences discussed with some evaluation. 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) 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. 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>	<p>Indicative content:</p> <ul style="list-style-type: none"> • Development of improved production capacity, providing faster access to goods and goods at lower prices. • Facilitating the production of high-volume items (and particularly electronic products) for consumer consumption. • Associated development of large factories, providing centralised employment opportunities. • Greater employment opportunities for unskilled staff, with associated income and expenditure. • Reduction in ‘customisation’ of goods – ‘one size fits all’ approach. • Allows for repair of faulty items by replacing only the failed/worn out part – reducing wastage and environmental impact. • Any other appropriate point. 	9	AO4 301 1.2, 3.4 304 1.1, 1.2, 1.3, 2.1, 2.2, 2.4, 2.5, 2.6, 4.1, 4.2, 5.1 305 2.2, 4.1

Question number	Acceptable answer(s)	Guidance	Max mks	Ref
Q12a)	$(Y^{4/3} \times Y^3) / Y^5 = (Y^{13/3}) / Y^5$ (1) $= Y^{13/3-5}$ (1) $= Y^{-2/3}$ (1)	Award 1 mark for addition, 1 mark for subtraction, 1 mark for solution. <i>Also accept $\frac{1}{Y^{2/3}}$ as a final answer.</i>	3	306 1.2 AO2
Q12 b)	$67.5^\circ / (180^\circ/\pi) = 67.5 \pi / 180$ (1) $= 3 \pi / 8$ radians (1) Accept 0.375π or 1.178 rad.	Award 1 mark for method. Award 1 mark for answer. Accept $360^\circ/2\pi$ method as an alternative.	2	306 2.2 AO2
Q12 c)	Taking natural logs, $\ln V = 2t/3 \ln(e)$ (1) By definition $\ln(e) = 1$ therefore $\ln(10) = 2t/3$ (1) rearranging $t = 3 \ln(10)/2$ (1) $t = 3.45$ seconds (1)		4	306 1.3 AO2
Q12 d)	Putting 7 into the polynomial to find the remainder $7^4 - (6 \times 7^3) - (7^2) + (7 \times 7) - 2$ (1) $= 341$ (1)	Award 1 mark for method. Award 1 mark for answer.	2	306 1.4 AO2
Q13 a)	64.1 mm (1)		1	306 5.1 AO2
Q13 b)	Mean = $\Sigma x/N = 64.06$ mm (1)		1	
Q13 c)	Population Standard Deviation: $\sigma = \sqrt{\frac{\Sigma(x_i - \mu)^2}{N}}$ (1) = 0.615 (1) Accept Sample Standard Deviation: $\sigma = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}$ (1) = 0.637 (1)	Award 1 mark for method. Award 1 mark for answer.	2	
Q13 d)	Median of lower range = 63.6 mm (1) Median of higher range = 64.5 mm (1) Interquartile range = $64.5 - 63.6 = 0.9$ mm (1)		3	
Q14	Taking $u = 6x - 2$ (1) $du = 6 dx$ (1) $y = \int (1/6) \cos(u) dx$ (1) $= (\sin(u) / 6) + c$ (1) Reinserting u , $y = (\sin(6x - 2) / 6) + c$ (1)	Award marks as indicated. Award 1 mark is for integral of cos, second mark is for addition of constant.	1 1 1 2 1	306 3.3 AO2

<p>Q15</p>	<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 limited number of similar approaches affecting product quality or quality of manufacture. May describe one or two processes or activities to support the production of a quality product. Candidates at the top of this level may be characterised by showing understanding of the benefits of one approach to improving quality.</p> <p>Level 2 – (5-8 marks) Clear – more detailed response showing knowledge recall relating to a range of different approaches to improving quality, with understanding of how the approaches directly influence the quality. Candidates at the top of this level may be characterised by evidence that they have considered how at least one approach to quality improvement will directly affect the performance of the company.</p> <p>Level 3 – (9-12 marks) Detailed – fully detailed response, showing understanding of a wide variety of approaches to quality improvement, with consideration of specific issues related to the context. Evaluation of which identified approaches would have the greatest influence, with supporting conclusions. Candidates at the top of this level may be characterised by analysing and comparing the direct and indirect implications of a broad range of different approaches to quality improvement on the performance of the company.</p>	<p>Indicative content:</p> <ul style="list-style-type: none"> • strategies used at a company level to improve quality, including statistical process control, total quality management, six sigma, lean and supplier quality management • tools and techniques applied to improve quality, such as quality circles, quality function deployment, poka yoke etc. • consideration of process capabilities and manufacturing tolerances • Design for Manufacture • measurement and testing, including equipment used • ‘Cost of Quality’ • impact of quality standards, such as BS5750 • culture of quality • difference between quality assurance and quality control • impact of quality on the customer. • Any other relevant point. 	<p>12</p>	<p>AO 4 301 1.1, 1.2, 3.1, 3.4 304 1.1, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 4.1, 4.2, 5.1, 5.2, 5.3 305 1.1, 2.2</p>
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