#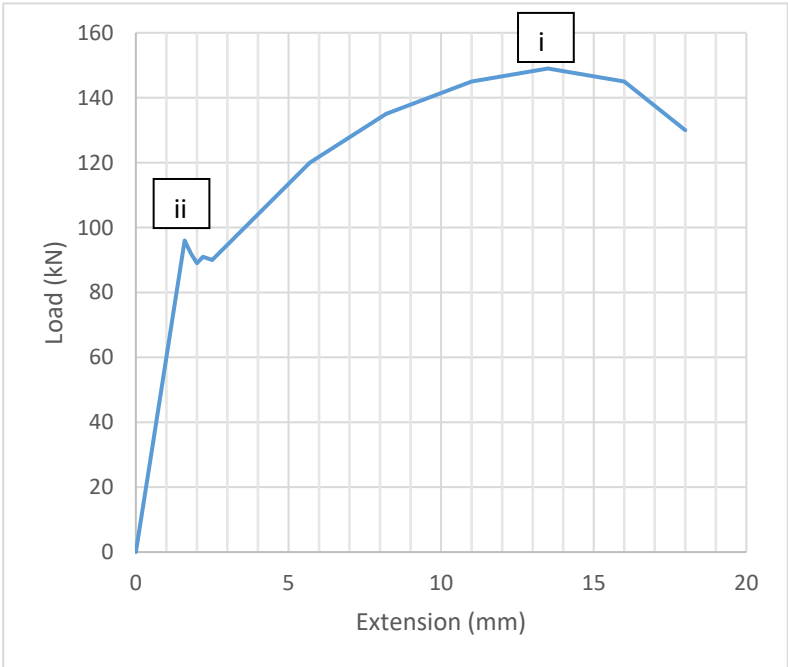 1145-30 Level 3 Advanced Technical Certificate in Engineering 1145-32 Level 3 Advanced Technical Extended Diploma in Engineering (720) 1145-530 Level 3 Engineering - Theory exam (1)

March 2022 Mark Scheme

Q	Acceptable answer(s)	Guidance	Max mks	Ref
Q1 a)	1 mark for plasticity	Accept malleability	1	301 1.1 AO1
Q1 b)	The separation of the material into two or more pieces under the action of stress (1)	Accept similar definitions. Accept broken.	1	301 1.1 AO1

Q1 c)	1 mark for correctly indicating the points as shown below.
	   i) ultimate tensile strength
	   ii) yield strength.
	
		Would accept value.
		i)145-150
		ii)90-99
			1
			1
				301 3.3 AO1

Q2 a)	1 mark each for **up to a maximum of 4 marks:** • The component is placed into a strong magnetic field (1), created using alternating current (1). • The magnetic field induces a current to flow in the surface layer of the material (1); this creates heat due to the I^2R losses in the material (1). • The component is then quenched (1) typically by immersion into water/ oil/ sometimes a polymer (1). • The surface layer is altered to become martensitic (1). • The depth of the hardened layer is related to the surface power density (1), the heat time (1) and the volume of component (1).		4	301 2.1 AO1

	• Any other appropriate point.			
Q2 b)	1 mark each for **up to a maximum of 3 marks**: • Induction hardening can selectively harden surface areas of a part (1) without modifying the properties of the part as a whole (1). • Induction hardening can be used with high carbon steels / different grades of steel, whereas case hardening is typically used with grades containing less carbon (1). • Any other appropriate response.	Answer must be an explanation to gain full marks.	3	301 2.1 AO2
3a)	1 mark each for each health and safety measure **up to a maximum of 3 marks,** e.g.: • Ventilation of work areas (1). • Temperature control of work areas (1). • Respiratory protection (1). • Wearing safety glasses (1). • Wearing gloves (1). • Safe disposal of waste (1). • Safety Boots (1) • Any other appropriate point. 1 mark each for each different reason **up to a maximum of 3** marks, e.g.: • Fumes from resins (1). • Reduce risk of fire (1). • Risk of breathing in fine particulates / fibres (1). • Risk of dermatitis / conditions arising from skin contact (1). • Reduce damage to clothing (1). • Pollution / environmental contamination (1). • Any other appropriate point.	Reason must match the measure to achieve the mark. Multiple different types in one box can be given multiple marks. 3 3		301 4.1 AO1 (3) AO2 (3)
Q3b)	1 mark each for **up to a maximum of 3 marks**: • To apply heat (1) and pressure to a composite material (1) • To cure the material (1) and achieve a high integrity structure (1) • Any other appropriate point.	Answer must be an explanation to gain full marks.	3	301 4.2 AO2
Q4	1 mark for each of the following, **up to a maximum of 3 marks**: • Metals have metallic bonding (1). • They have a closely packed lattice structure of positive ions (1) with a delocalised electron cloud (1), formed from the outer shell of the metal atoms (1).	Answer must be an explanation to gain full marks.	3	301 5.1 AO2

	• As these electrons are delocalised, they can move freely/flow within the metal structure when a current is applied (1). • Any other appropriate answer.			
Q5 a)	1 mark each for **up to a maximum of 2 marks**: • Plating (1). • Galvanising (1). • Painting (1). • Anodising (1). • Electroplating (1). • Plastic coating (1). • Shrink-wrap (1). • Packaging/Bubble wrap (1). • Organic/mineral coverings (1). • Any other appropriate answer.		2	304 2.5 AO1
Q5 b)	1 mark each for each step in the process **up to a maximum of 4 marks**, e.g.: • Fine powder is prepared by crushing/ grinding/ chemical reactions/ electrolytic deposition (1). • A mould is produced of the required shape (1). • The powder is compressed into the mould (1). • Heat is applied to sinter the green compact (1). • The sintering causes the material particles to fuse together (1). • Any other relevant point.	Marks can also be awarded for additional detail at each process step	4	304 3.8 AO1
Q6	1 mark each for **up to a maximum of 6 marks**: • 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.	Answer must be an explanation to gain full marks. Maximum of 3 marks for just stating advantages. Maximum of 1 mark for explaining each of the 3 advantages.	6	304 4.2 AO2
Q7	Award **1 mark** for a suitable material, e.g. grp composite, thermoplastic polymer.	Marks for the reasons can also be awarded for additional detail showing the	4	AO4 301 1.1, 1.2,

	Award **up to 3 marks** for suitable reasons, such as corrosion resistance, low weight, ability to be moulded, cost, toughness, availability of manufacturing processes etc.	understanding of the reason. Mark for the reasons must be related to the material selected. Suitable material must be named rather than generic type.		3.4, 4.1, 4.2, 4.3, 4.4 304 1.1, 2.1, 3.3 305 2.1, 2.2
Q8a)	1 mark for each for **up to a maximum of 3 marks**: • Aesthetic requirements (1) • Cost (1). • Environmental issues (1). • Size / dimensions (1). • Safety considerations (1). • Function / performance (1). • Materials (1). • Limitations affecting the choice of manufacturing methods (1). • Maintenance requirements (1). • Production volume (1). • Weight (1). • Any other appropriate response.		3	305 2.2 AO1
Q8b)	i) Circuit diagram/ wiring diagram/schematic diagram (1) ii) Systems diagram/flow chart (1) iii) General arrangement drawing / general assembly drawing / exploded view (1)		1 1 1	305 3.3 AO1
Q8c)	1 mark each for **up to a maximum of 4 marks**: • Speed of drawing creation (1). • Ease of modification (1). • Accuracy (1). • Ability to save (1). • Ability to share electronically (1). • Compatibility with CAM systems (1). • Ability to view around an object (1). • Any other appropriate response.		4	305 5.1 AO2

Q9)	1 mark for each of the steps in the description **up to a maximum of 6 marks**, e.g.: • Produce a 3D model using CAD drawing software (1). • Supports may need to be included in the model for some complex geometries (1). • Process the model to create a stereolithography file (.stl) (1) which splits the model into lots of very small layers (1). • The model is built on a platform in a tank of liquid resin (1). • A computer-controlled laser traces out the shape of a layer on the surface of the resin (1). This cures the resin to the shape required (1). • The platform is then lowered by the thickness of a layer (1) and the next layer is drawn on (1). • The process is repeated until all of the layers have been completed (1). • Any other relevant point.		6	304 3.1 AO2
Q10	For no awardable content, award 0 marks. **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. **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. **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.	Indicative content: • Development of improved transportation; this provides faster access to goods (and associated greater access to perishable goods); also facilitating urban living and growth of centres of population/towns and cities. • Increased ease of travel, facilitating greater geographic mobility; workers can live farther from their place of employment. • Development of the automotive industry and its supply chain, providing employment opportunities. • Transfer of manufacturing	9	AO4 301 1.2, 3.4 304 1.1, 2.1, 2.4, 2.6, 4.2, 5.2 305 2.2, 4.1

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.	approaches developed within the automotive industry has improved production efficiency and profitability in other industries. • Risks to health and environment from associated pollution or injuries caused by vehicle accidents. • Impact of fuel production on the national economy through taxation. • Any other appropriate point.		

Q11a)	i) 11mm ii) 6 seconds iii) 1/6 = 0.167 Hz	Allow 12 mm for reading error. The unit does not need to be correct.	1 1 1	306 2.3 AO2
Q11 b)	Rearranging $9^n = 27$ (1) Taking logs of both sides $n \log 9 = \log 27$ (1) Rearranging $n = \log 27 / \log 9$ (1) Hence n = 1.5 (accept 3/2) (1)	Working marks can only be given for using logarithms. Award full marks when using an alternative method e.g. $\log_9(27)$ if final answer is correct.	4	306 1.3 AO2
Q11c)	1 mark for each of the following **up to a maximum of 3 marks**: • It is used to analyse the root causes of a problem (1) such as imperfections, variations, defects, or failures (1). • The 'bones' of the diagram are identified as categories or groupings of issues (1). • The potential causes are written onto the individual 'bones' of the appropriate grouping (1). • It allows individual elements to be considered separate from the overall process/issue (1). • Any other appropriate point	If candidate uses a diagram, award marks as described.	3	306 5.6 AO2
Q12a)	1 mark for each of the following **up to a maximum of 5 marks**: • Identifying that the relationship is y = mx + c (1) • Identifying that $c = 8 \times 10^9$ (1) • Determining that $m = (20-8)/0.16 = 7.5 \times 10^{10}$ (1 mark for method, 1 mark for value) • Stating the relationship as $y = 7.5 \times 10^{10} x + 8 \times 10^9$ (1)	Award marks even if wrong order of magnitude is used.	5	306 1.4 AO2
Q12b)	Dx/dt = 24 sin 2t Velocity = 24 sin 6 = 2.51° s⁻¹	1 mark for giving the value as a positive (not -) and 1 mark for differentiating the trigonometric function 1 mark for answer	3	306 3.1 AO2
Q13	a) P(crack) = 27 / 250 (1) = 0.108 (accept 10.8%) (1) b) As the defects are mutually exclusive, P(defect) = P(porosity) + P(crack) (1) P(defect) = 18/250 + 27/250 = 0.18 (1) P(no defect) = 1 – P(defect) (1) P(no defect) = 1 – 0.18 = 0.82 (1)	1 mark for method and 1 mark for value for i) Accept percentages for final values Different methodologies can be used. Award marks if steps have	2 4	306 5.2 AO2

		Alternative method: 1 mark for stating methodology 1 mark for total amount of defect 1 mark for calculating number defect free 1 mark for stating the probability.	been included, but not done as specified lines. Probability can be expressed as a fraction. To get full marks must be expressed to the lowest denominator.		

| **Q14** | For no awardable content, award 0 marks.

Level 1 – **(1-4 marks)**
Basic – largely descriptive response based on recall of knowledge, relating only to a single approach, e.g. revision of design, material supply, testing during manufacturing or a named quality improvement strategy.
Candidates at the top of this level may be characterised by showing some understanding of how the stated approach may influence quality.

Level 2 – (5-8 marks)
Clear – more detailed response showing knowledge recall relating to a range of approaches to improve product quality (e.g., at least two of: revision of design, material supply, testing during manufacturing and named quality improvement strategies), with understanding of how the product quality could be affected by the different approaches.
Candidates at the top of this level may be characterised by considering the relative impact of different approaches on the product quality.

Level 3 – (9-12 marks)
Detailed – fully detailed response, showing understanding of how product quality can be affected by a wide variety of different contributing developments (e.g., at least three of: revision of design, material supply, testing during manufacturing and named quality improvement strategies). Evaluation of which approaches 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 choice of approach. | Indicative content:
• Sourcing of materials of higher quality and supplier quality management.
• Testing of received materials.
• Testing of manufactured products
• Market Research
• Quality control and quality assurance.
• Process capability and process selection.
• Poke yoke.
• Cost of quality.
• Statistical process control.
• Total quality management.
• Six sigma.
• Lean.
• Quality circles.
• Quality function deployment.
• Value stream management.
• Any other relevant point. | 12 | AO4
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