

1145-530 Level 3 Engineering Theory exam (1)

APRIL 2017 Marking Scheme

Question 1

- a) Toughness. **(1 mark)**
b) Hardenability. **(1 mark)**

Question 2

Award **one** mark for any of the following points, **up to five** in total:

- Reduces the hardness.
- Reduces the strength.
- Increases the ductility so it can be deformed more easily.
- Grain growth occurs in the microstructure.
- Atoms migrate within the crystal lattice reducing the number of dislocations.
- Any other relevant point.

(5 marks)

Question 3

One mark for **each** cell completed with accurate information.

Mechanical test	Property measured
Tensile	Tensile strength (1 mark) (accept strength)
Brinell / Rockwell / Vickers	Hardness (1 mark)
Izod / Charpy	Toughness (1 mark)
Wohler	Fatigue strength (1 mark) (accept fatigue)

(4 marks)

Question 4

One mark for **each** cell completed with accurate information. The action **must** be relevant to the stated risk.

Do **not** award marks for general health and safety issues that are not specific to composites.

e.g.

- Breathing in chemical vapours (1); ventilation/temperature control of work areas (1) or use of respiratory masks (1).
- Contact with liquid solvents or resins (1); use of protective gloves (1), COSHH procedures (1).
- Exposure to fibres (1); use of face mask (1).
- Any other appropriate response (including risk of fire, issues arising from disposal etc.).

(4 marks)

Question 5

a)

i. It controls or limits the current that flows through it. **(1 mark)**

ii. Award **one** mark for any of the following points, **up to four** in total:

- The colour code consists of four coloured bands.
- The first two bands represent numbers.
- The third band represents a multiplier in base 10 / the number of zeros after the numbers.
- The fourth band indicates the tolerance of the resistor.

Accept similar explanations relating to 3, 5 or 6 band coded resistors.

(4 marks)

b) Award **one** mark for **each** correctly completed cell:

INPUT			OUTPUT
A	B	C	Q
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

(2 marks)

c) Award **one** mark for **each** of the following points:

- Open loop control is where the system is initially set to achieve a required output.
- Closed loop control is where if output does not match the requirements, the performance of the system is changed (by changing the inputs or the controller).
- In open loop control the output may vary from the target.
- In closed loop control feedback is used to 'correct' the output back to the target if it varies.

(4 marks)

d) Award **one** mark for **each** of the following points, up to a **maximum** of **four** marks:

- Photonic devices use light for sensing or detection (1).
- LDRs and phototransistors can be used, for example, to create light curtains (1), when anything passing through the light source changes a count (1).
- Lasers can be used to provide accurate measurements (1) by measuring the time taken to move between two points or reflect back to the origin (1).
- Any other appropriate response.

(4 marks)

Question 6

a)

- i. The ratio of a distance through which any part of a machine moves, to which the driving part moves during the same time. **(1 mark)**
- ii. A quantity expressing a body's tendency to resist angular acceleration. **(1 mark)**

b) The force required to accelerate a mass of 1 kg at a rate of 1 ms^{-2} .

(1 mark)

Question 7

Award **one** mark for **each** of the following points, **up to eight** in total:

- During the isentropic processes 1-2, work energy is transferred into the system (1) by the piston compressing the air (1).
- During the constant pressure isobaric process 2-3, heat energy enters the system (1) due to the combustion of the fuel (1).
- During the isentropic processes 3-4, work energy is transferred out of the system (1) by pushing the piston (1).
- During the constant volume isochoric process 4-1, some heat energy flows out of the system through the depressurizing process (1) as gases are vented from the system (1).
- Overall the work that leaves the system is equal to the work that enters the system, plus the difference between the heat added to the system and the heat that leaves the system (1).

(8 marks)

Question 8

a) Award **one** mark **each**, for two of investment, gravity or low pressure casting.

(2 marks)

b) Award **one** mark **each** for **up to four** of the following:

- Sampling is less expensive.
- The batch or lot is processed faster by inspection (1), improving scheduling and delivery (1).
- Less inspector time required.
- Less handling of products (1), which may result in less damage (1).
- Less risk of inspector error due to monotony.
- Any other suitable reason.

(4 marks)

Question 9

a) Award **one** mark **each** for **up to three** of the following:

- Aesthetic requirements.
- Cost.
- Environmental requirements.
- Size.
- Safety requirements.
- Function.
- Materials.
- Manufacturing constraints.
- Maintenance requirements.
- Any other suitable point.

(3 marks)

b) **One** mark for **each** of the following points **up to** a total of **five** marks:

- Faster to produce than a traditional prototype.
- Can be used to quickly check that parts will fit together.

However –

- The materials are different to the final product (1), which means that the physical properties of the model will be different to the final product (1).
- Can produce configurations that cannot be made using traditional processes.
- Does not give experience of making/identify problems that will occur during production of the actual product.
- Any other suitable point.

To achieve five marks, candidates **must** give **at least one** advantage and **one** limitation, i.e. **one** advantage and **four** limitations or vice versa, or any other combination.

(5 marks)

c) Indicative content:

Examples of points that may be included in the answer are:

- Development of centralised manufacturing facilities.
- Employment and training opportunities (including apprenticeships) for local population, with resultant economic effects.
- Demand for consumables: metal ore, alloying elements, energy and water with economic and social effects on the supply chain.
- Impact of recycling.
- Impact on local environment and resultant impact on health of local population.
- Development of improved quality or new grades of steel facilitates, improvements in product design and the development of new products due to improved mechanical properties.
- Examples of products made from steel and their resultant social and economic impacts.
- Provision of structural steel allowing the construction of lower cost buildings and structures.
- Facilitation of availability of a wide range of products to wider markets.
- Any other suitable point.

Band descriptors

Award marks as follows:

No answer worthy of credit – e.g. insufficient work submitted, answer not relevant to the question, answer is factually incorrect.

(0 marks)

Band 1 – basic – largely descriptive response based on recall of knowledge. A few impacts, 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 impacts more in detail, but showing understanding of why only one of the impacts has resulted.

(1-3 marks)

Band 2 – clear – more detailed response, including statements of impacts that show understanding of most of their direct implications. Both social and economic impacts discussed with some evaluation. Candidates at the top of this level may be characterised by stating and explaining a variety of impacts or causal links contributing to or resulting from impacts; they may evaluate the broader implications on society of a few of these impacts.

(4-6 marks)

Band 3 – detailed – very detailed response including statements of impacts that show understanding of both their direct and secondary implications. Both social and economic impacts 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 impacts or causal links have affected society both directly and through secondary effects.

(7-9 marks)

Question 10

- a) Award **one** mark for method and **one** mark for the answer.

$$c = 30 \tan 55 = 30 \times 1.4281 = 42.8 \text{ cm}$$

(2 marks)

- b) Award **one** mark for the approximation and **one** mark for the answer.

$$400 \times 0.6 = 240 \text{ kg}$$

$$240/8 = 30 \text{ containers}$$

(2 marks)

- c) Award **one** mark for method and **one** mark for answer.

$$\begin{aligned} \text{Mass that the structure should be designed to support} &= M \times \text{safety factor} \\ &= 1640 \times 4 = 6560 \text{ N} \end{aligned}$$

(2 marks)

Question 11

- a) Award **one** mark for **each** line below:

$$(3 + 2j) \times (2 + 4j) = 6 + 12j + 4j + 8j^2 = 6 + 16j + 8j^2$$

$$\text{As } j^2 = -1 \text{ therefore} = 6 + 16j - 8$$

$$\text{Simplifying} = -2 + 16j$$

(3 marks)

- b) Award **one** mark for **each** line below:

$$\text{Acceleration} = dx / dt = 100 \sin (50t)$$

$$\text{After 0.8 seconds therefore acceleration} = -10 \sin 40$$

$$\text{Acceleration} = 64.3 \text{ m s}^{-2}$$

(3 marks)

- c) Award **one** mark for **each** line below:

$$\text{Taking natural logs } \ln (12) = 0.2t \ln (e)$$

$$\text{By definition } \ln (e) = 1 \text{ therefore } \ln (12) = 0.2t, \text{ rearranging } t = \ln (12)/0.2$$

$$t = 2.485 / 0.2 = 12.425 \text{ seconds} \quad (\text{accept } 12.5 \text{ seconds})$$

(3 marks)

Question 12

a) Award **one** mark for method and **one** mark for the correct value:

$$\text{Mean} = \text{sum of all values} / \text{number of values} = 536.9 / 30 = 17.9$$

(2 marks)

b) Award **one** mark for **each** of the following lines (method **and** values):

Calculate the difference from the mean:

$$X - \text{average} = 18.4 - 17.9 = 0.5$$

Divide the calculated value by the standard deviation to obtain z:

$$z = 0.5 / 0.434 = 1.15$$

Using the standard normal table, $z = 0.8749$

$$\begin{aligned} \text{The probability of being greater than } 18.4 &= 1 - z \\ &= 0.125 \end{aligned}$$

Note: marks can be awarded if an incorrect value was carried through from part a).

(7 marks)

Question 13

Indicative content:

Examples of points that may be included in the answer are:

- Microcontroller circuits can be reprogrammed for different uses, rather than modifying the circuit;
- this means that microcontroller-based production equipment can quickly adapt to (or be reprogrammed for) changes in task;
- this allows the potential of greater customisation or (planned) variations in products.
- A single microcontroller may functionally replace multiple microprocessors (such as a timer and a logic gate);
- this allows the number of components required to be reduced, facilitating size reductions in circuits and associated products;
- this also reduces the complexity of CAM machinery, enabling easier maintenance of electronic circuits.
- Implications of using programmable equipment on the skills of the workforce.
- Appropriate illustrative examples of the use of microcontrollers.

Band descriptors

Award marks as follows:

No answer worthy of credit – e.g. insufficient work submitted, answer not relevant to the question, answer is factually incorrect.

(0 marks)

Band 1 – basic – largely descriptive response based on recall of knowledge, stating a few benefits of using microcontrollers compared to integrated circuits for either design or manufacture. Candidates at the top of this level may be characterised by showing understanding of some of the reasons for using microcontrollers.

(1-4 marks)

Band 2 – clear – more detailed response, including a range of impacts on both design and manufacture. Shows recall of knowledge and understanding of the reasons why microcontrollers are used. Candidates at the top of this level may be characterised by considering and analysing the impact of microcontrollers in comparison to alternative options.

(5-8 marks)

Band 3 – detailed – very detailed response, showing understanding of a wide variety of impacts of the use of microcontrollers on design and manufacturing. A broad range of impacts are evaluated, with substantiation of which have the more significant effect and producing supporting conclusions. Candidates at the top of this level may be characterised by analysing and evaluating how the positive and negative implications of the development of microcontrollers in a broader context (such as, for example, on customers) influence their application in design and manufacturing.

(9-12 marks)

Total marks: 100