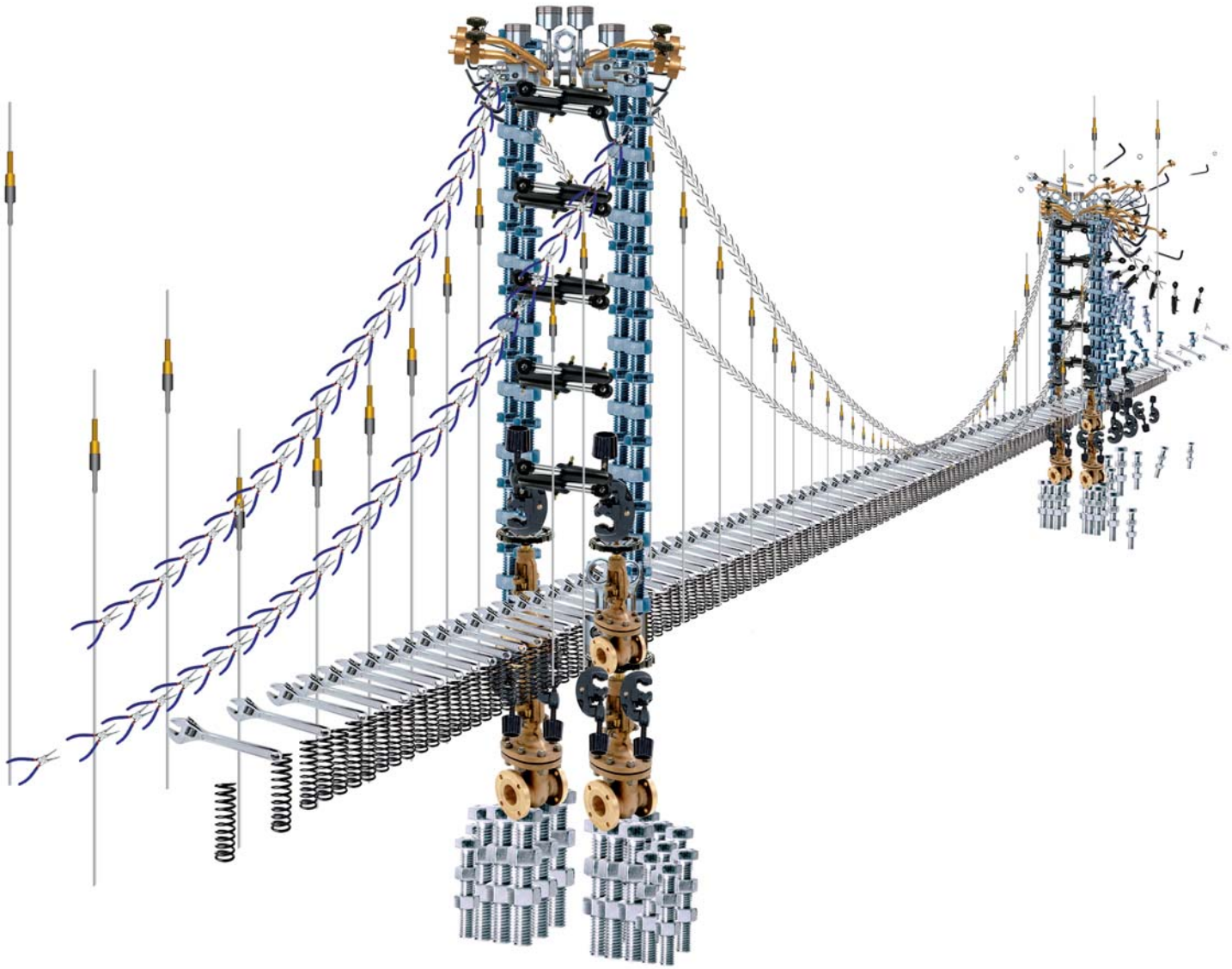
Level 3 - Principal Learning
Engineering (EN3U9W)

SPECIMEN PAPER

UNIT 9 - SCIENTIFIC PRINCIPLES AND APPLICATIONS FOR ENGINEERS



Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
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TOTAL	

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Level 3 Diploma Principal Learning
Specimen Paper

Engineering EN3U9W

Unit 9 Scientific principles and applications for engineers

Date Time

For this paper you must have:
- normal writing and drawing instruments and a calculator.

Time allowed
- 2 hours

Instructions
- Use black ink or black ball-point pen. Use pencil only for drawing.
- Answer **all** questions in Section A and three out of five questions in Section B.
- You must answer questions in the spaces provided. Answers written in margins or on blank pages will not be marked.

Information
- The maximum mark for this paper is 60.
- The marks for questions are shown in brackets.
- Show the rough working of your calculations.

Barcode

Formula Sheet

Electricity and Electronics Formulae

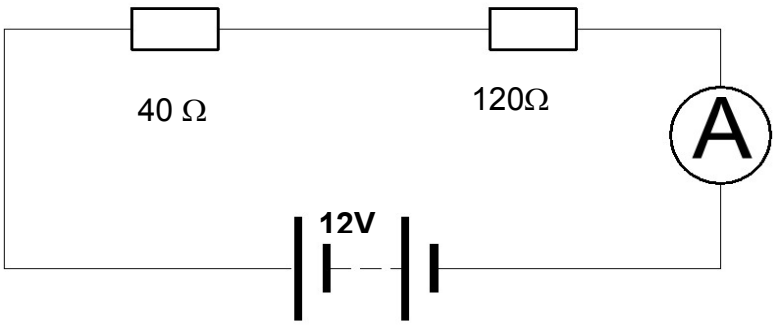
Series Circuits: $R_{Total} = R_1 + R_2 + R_3 + \ldots$ $V_{Total} = V_1 + V_2 + V_3 + \ldots$	**Parallel Circuits:** $\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots$ $R = \frac{R_1 R_2}{R_1 + R_2}$ $I_{Total} = I_1 + I_2 + I_3 \ldots$
Ohm's Law: $V = IR$	**Electrical Power:** $P = VI$ $P = I^2 R$ $P = \frac{V^2}{R}$
Resistance of a Conductor: $R = \frac{\rho L}{A}$	**Capacitors:** Growth of capacitor voltage, $v_C = V\left(1 - e^{\frac{-t}{CR}}\right) = V\left(1 - e^{\frac{-t}{\tau}}\right)$ Decay of resistor voltage, $v_R = Ve^{\frac{-t}{CR}} = Ve^{\frac{-t}{\tau}}$ and Decay of resistor current, $i = Ie^{\frac{-t}{CR}} = Ie^{\frac{-t}{\tau}}$.
Magnetic Circuits: $\phi =$ Flux (Wb) $B =$ Flux Density - Therefore, $B = \frac{\phi}{A}, \quad \frac{B}{H} = \mu_o \mu_r, \quad F = B\,I\,l$	**Reluctance:** $S = \frac{m.m.f.}{\phi} = \frac{l}{A\,\mu_o \mu_r}.$
AC Instantaneous Current and Voltage: $i = \frac{V_{Max} \sin(2\pi ft)}{R} \equiv i = \frac{V_{Max} \sin(\omega t)}{R}$ $v = V_{Max} \sin(2\pi ft) \equiv v = V_{Max} \sin(\omega t)$	**Voltage Division:** $V_{\text{Out}} = V_{\text{In}}\left(\frac{R_2}{R_1 + R_2}\right)$
Current Division: $I_{\text{Out}} = I_{\text{In}}\left(\frac{R_1}{R_1 + R_2}\right)$	**Angular Velocity:** $\omega = 2\pi f$
Frequency: $f = \frac{1}{T}(\text{T is the periodic time})$	**Transformer – Turns Ratio:** $\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$

SECTION A

Answer **all** questions in this section.

1

Figure 1



When designing or using electrical circuits it is usual to use both calculation and measurement.

1 Determine the reading on the ammeter shown in Figure 1.

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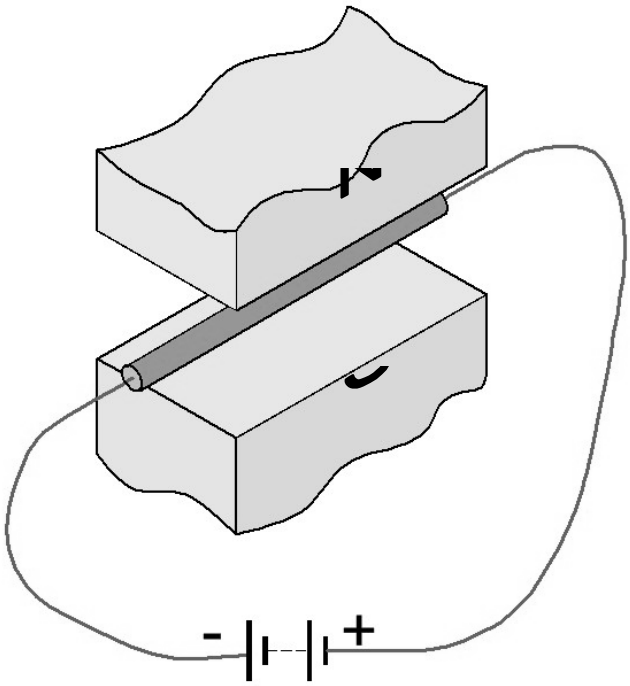
(4 marks)

2

Figure 2



Electro-magnetic effects are used by engineers to move and hold objects. To do this, engineers need to be able to predict effects.

Figure 2 shows a diagram of a conductor freely suspended within a magnetic field.

2 (a) On the diagram clearly show the pattern **and** direction of magnetic flux around the conductor.

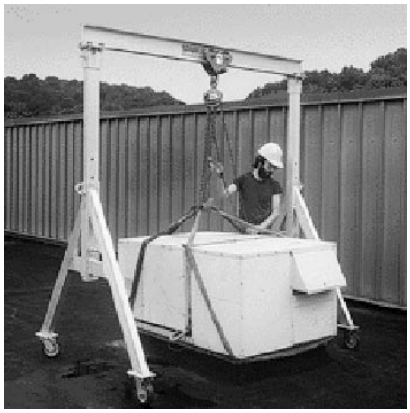
(3 marks)

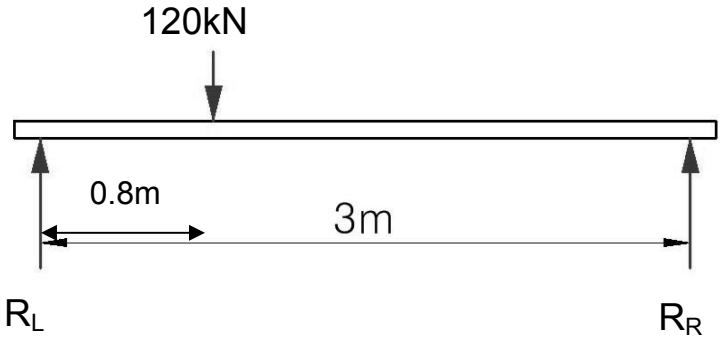
2 (b) On the diagram draw an arrow to show the direction that the conductor will tend to move when the current flows in the conductor.

(1 mark)

3

Figure 3





Before lifting equipment can be used, it is essential to calculate the forces involved to ensure safety.

Find the force on the right hand support R_R .

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(3 marks)

Turn over for the next question

4 Materials react differently under load. Graphs similar to the one shown below (Figure 4) are used to plot performance, so that decisions can be made at the design stage regarding the suitability of a material for a specific use.

Figure 4

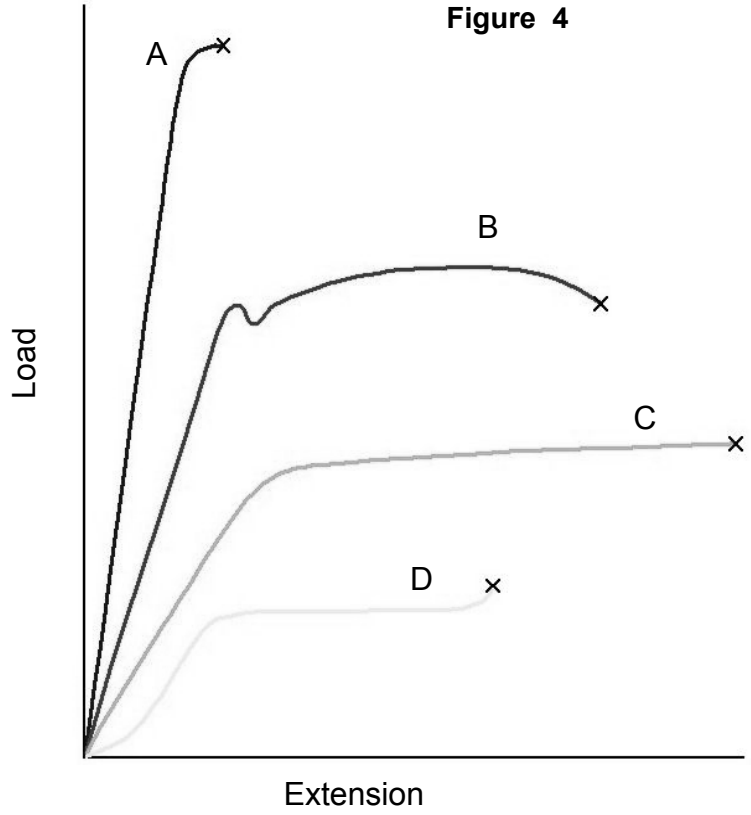

Figure 4 shows the characteristic load extension curves of four materials.

4 (a) Which is the most ductile material?

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(1 mark)

4 (b) Which line on the graph is most typical of mild steel?

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(1 mark)

4 (c) Which material is the most brittle?

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(1 mark)

5 When designing a component which will be placed under stress, it is essential to calculate if the material will be strong enough.

A 1.75m long, 2mm diameter wire is stretched 1.5mm by a force of 200N. Determine the stress on the wire.

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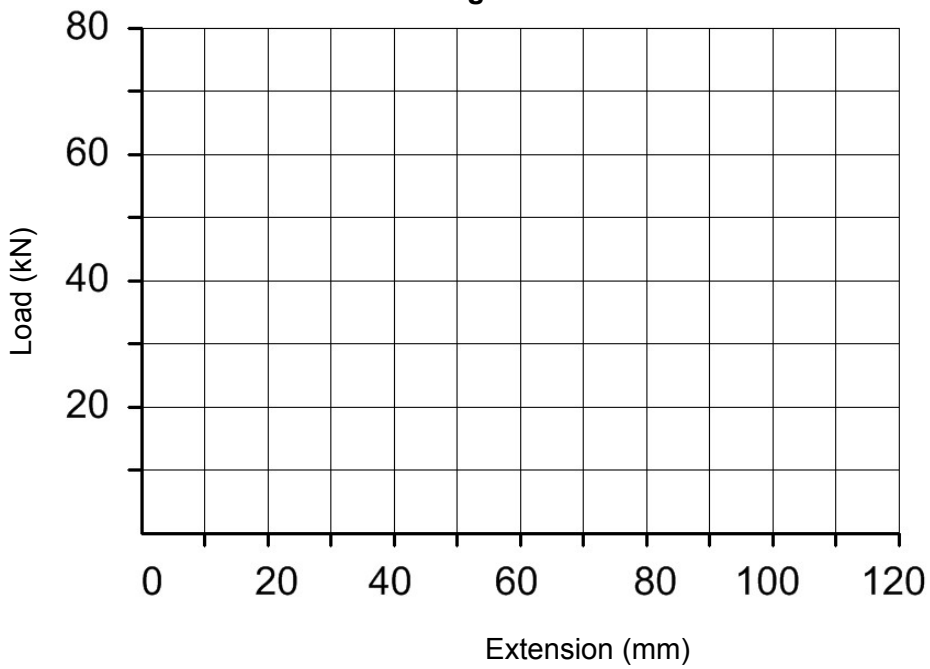
(3 marks)

6 A spring is loaded with 60kN so that it extends 90 mm.

6 (a) On the grid below, draw a graph to represent the load/extension of the spring.

Figure 5



(1 mark)

Question 6 continues on the next page

6 (b) Calculate the work or energy required to extend the spring 90mm.

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(2 marks)

7 The table below shows the thermal properties of a number of metals.

Material	**Melting point (K)**	**Specific heat capacity ($J\ kg^{-1}\ K^{-1}$)**	**Thermal Conductivity ($W\ m^{-1}\ K^{-1}$)**	**Linear expansion (K^{-1}) $x10^{-6}$**
Stainless steel	1800	510	150	16
Mild steel	1700	420	63	15
Aluminium alloy	800	880	180	23
Cast iron (white)	1420	500	75	11

7 (a) Which material would best be used for the cooling fins of a heat sink?

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(1 mark)

7 (b) Give the reasons for your choice.

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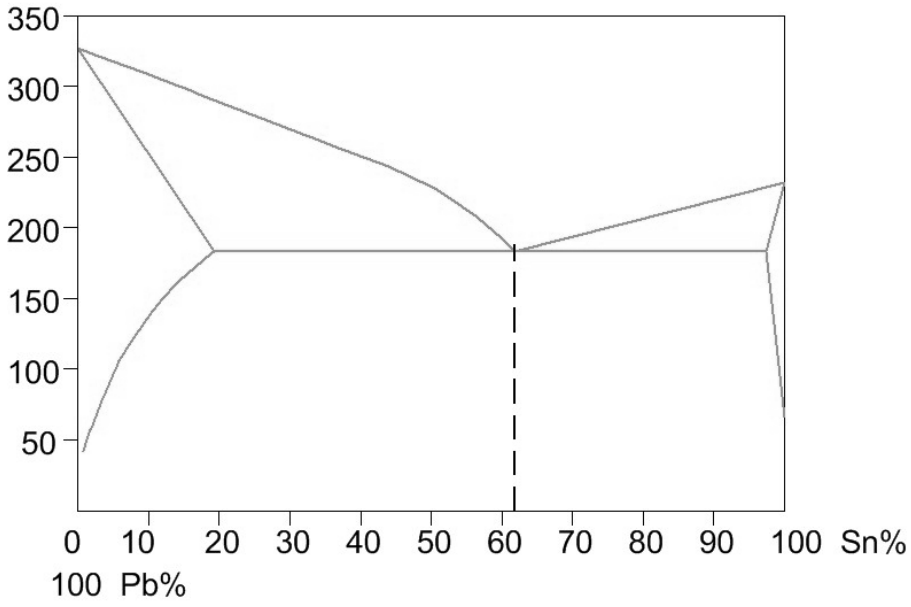
(2 marks)

8 Figure 6 below shows the equilibrium diagram for tin/lead alloy. On the diagram clearly mark the areas that represent:

- solid alloy
- pasty mixture of liquid and solid alloy.

(2 marks)

Figure 6



9 Explain the stages in precipitation or age hardening an aluminium alloy.

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(3 marks)

10 (a) What sort of fluid flow measuring device would you use to measure medical gas flow to a patient in a hospital.

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(1 mark)

10 (b) Give the reasons for your choice.

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(2 marks)

11 Designing exploration vehicles for under-sea operation, e.g. salvage or pipeline inspection, requires the designer to be aware of other factors.

When an object is immersed in water, what factors affect the pressure on the object?

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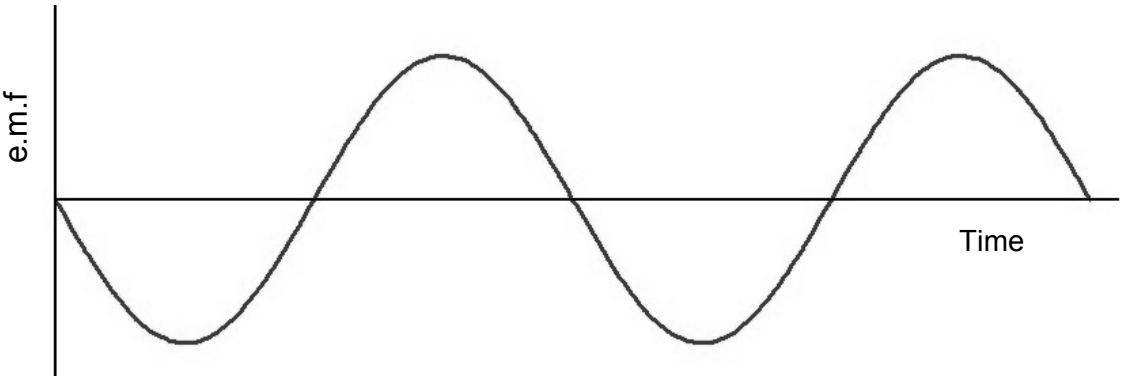
(2 marks)

12 Figure 7 show a sinusoidal signal. On the diagram clearly mark:

- Amplitude
- Peak to peak value
- Periodic time.

Figure 7



(3 marks)

Turn over for the next question

SECTION B

Answer any **three** questions.

13 When designing electro-magnetic devices such as motors and transformers, several factors need to be taken into account and calculations are required at the design stage.

13 (a) Give any **three** factors that effect the current induced in a conductor when it is moved within a magnetic flux.

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(3 marks)

13 (b) An ideal transformer is connected to 240v mains, to supply 12v to 100w lamp.

13 (b) (i) Determine the turn ratio of the transformer.

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(2 marks)

13 (b) (ii) Calculate the current drawn from the mains supply.

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(3 marks)

14 When designing structures such as cranes, the effect of the loading needs to be calculated.

A 100mm long, 24mm diameter steel pin is subjected to an axial load along its length of 10kN. The elastic modulus of steel is 210Gpa.

14 (a) Explain what is meant by the strain energy on the pin.

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(1 mark)

14 (b) Determine the stress on the pin.

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(3 marks)

Question 14 continues on the next page

14 (c) Determine the extension of the pin when loaded.

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(4 marks)

15 When designing products which use heat such as boilers, the quantity of energy used needs to be calculated.

15 (a) Explain what is meant by the term *latent heat of vaporisation*.

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(1 mark)

15 (b) A small boiler is used to create steam. Find the total energy required to heat ½ litre of water from 20°C to steam at 120°C.

Take: specific heat capacity of water to be 4.2 $kJkg^{-1}°K^{-1}$
Specific heat capacity of steam to be 2.01 $kJkg^{-1}°K^{-1}$
Latent heat of vaporisation of water 2260.0 $kJkg^{-1}$

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(7 marks)

16 **Figure 8**

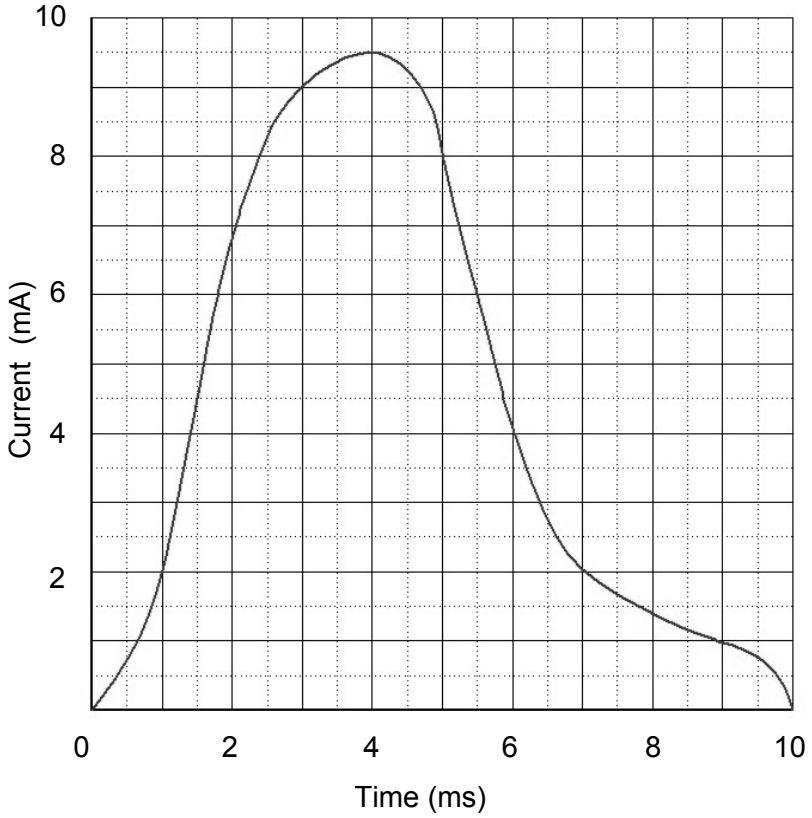

Figure 8 shows the half wave of an electrical signal detected from an alternating current. Determine:

16 (a) the instantaneous current after 4ms,

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(1 mark)

16 (b) the frequency of the signal,

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(2 marks)

16 (c) the rms value of the signal.

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(5 marks)

Turn over for the next question

17 When designing storage containers such as tanks, pressure and flow rates need to be calculated.

An open water tank 3m diameter has a 5m head of water above the outlet pipe, which is 20mm diameter at the bottom of the tank.

Take the density of water to be 1000kgm^{-3} and gravity to be 9.81Nkg^{-1}

17 (a) What is the pressure at the bottom of the tank?

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(2 marks)

17 (b) Determine the flow rate at the outlet pipe and explain any assumptions that you make about the system.

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(6 marks)

END OF QUESTIONS