BOSTES BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2015 HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A formulae sheet is provided at the back of this paper
- Write your Centre Number and Student Number at the top of pages 13, 17, 19, 21, 25, 27 and 35

Total marks – 100

Section I Pages 2–11

20 marks

- Attempt Questions 1–20
- Allow about 30 minutes for this section

Section II Pages 13–35

80 marks

- Attempt Questions 21–27
- Allow about 2 hours and 30 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 30 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

---

1 Which of the following has both magnitude and direction?

(A) Mass

(B) Scalar

(C) Speed

(D) Vector

2 Which of the following methods would be suitable to manufacture PET polymer bottles?

(A) Casting

(B) Pressing

(C) Stamping

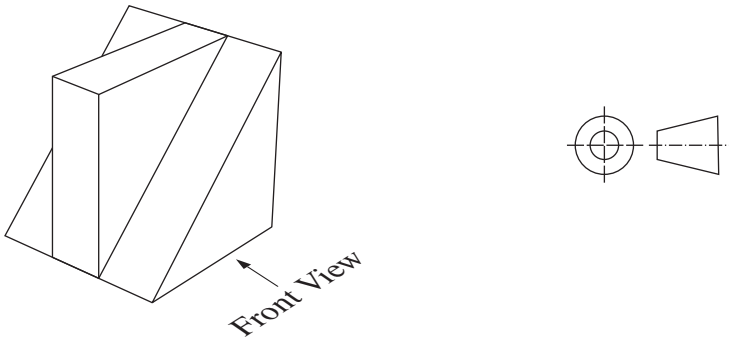
(D) Blow moulding

3 A motor vehicle is travelling along a horizontal road.

How does an increase in velocity affect its potential energy and kinetic energy?

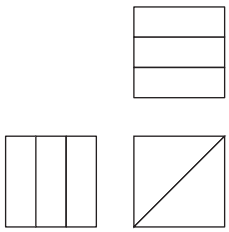
	Potential energy	*Kinetic energy*
(A)	Increases	Increases
(B)	Maintains	Increases
(C)	Increases	Decreases
(D)	Maintains	Decreases

4 A pictorial view of a block is shown.

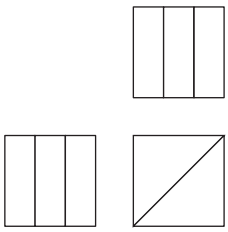


Which set of views represents the block in orthogonal projection?

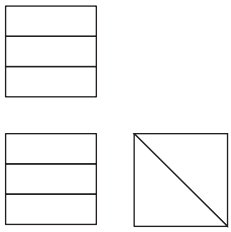
(A)



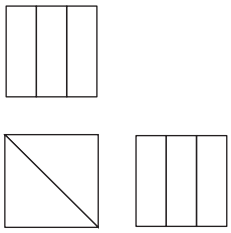
(B)



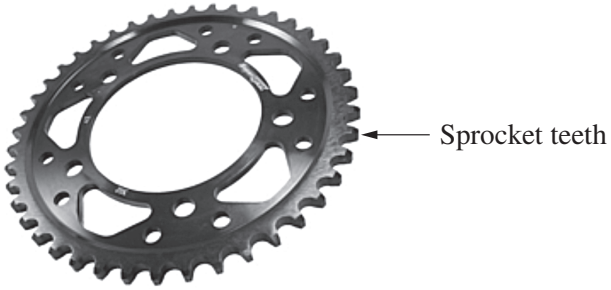
(C)



(D)



5 The teeth on a steel sprocket need to be hard.



Which heat treatment process is most suitable for hardening the teeth?

(A) Flame heating then air cooling

(B) Flame heating then oven cooling

(C) Induction heating then quenching

(D) Induction heating then slow cooling

6 Which process combines data and a carrier wave to form a television signal?

(A) Compressing

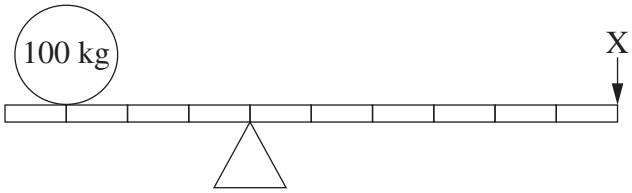
(B) Encryption

(C) Modulation

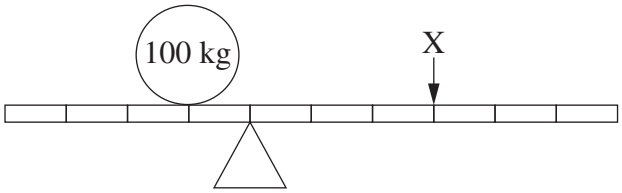
(D) Multiplexing

7 Which of the lever systems would require the least force at X to balance the 100 kg mass?

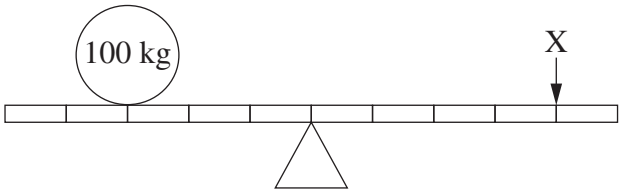
(A)



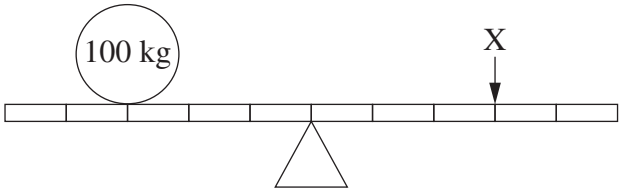
(B)



(C)



(D)



8 Which statement best describes the difference between cast iron and steel?

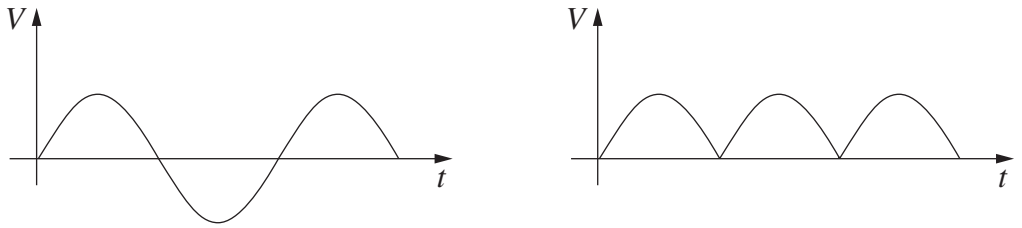
(A) Steel contains more free graphite.

(B) Cast iron has higher tensile strength.

(C) Steel has higher compressive strength.

(D) Cast iron has a higher percentage of carbon.

9 Which form of the AC to DC rectification process is shown by the graphs?



Before rectification

After rectification

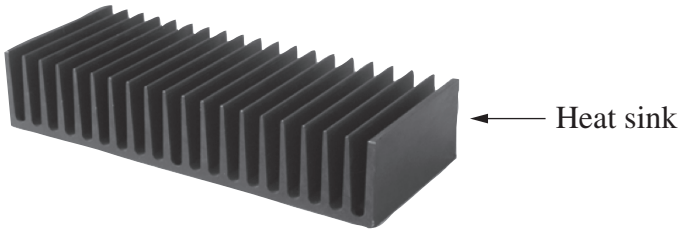
(A) Full wave

(B) Half wave

(C) Smooth full wave

(D) Smooth half wave

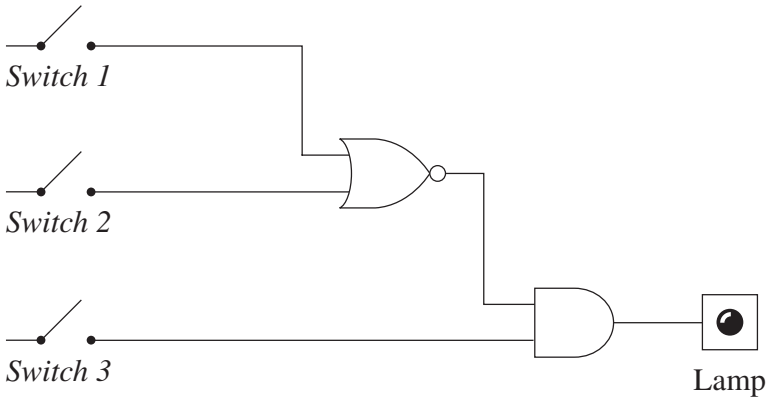
10 The heat sink shown is used to conduct heat away from components.



Which row of the table identifies a suitable material and manufacturing process for the heat sink?

	Material	*Manufacturing process*
(A)	Steel	Rolling
(B)	Nylon	Injection moulding
(C)	Aluminium alloy	Die casting
(D)	Ceramic	Compression moulding

11 Consider this logic circuit for turning a lamp on or off.

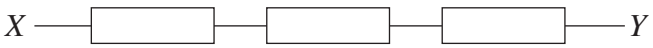


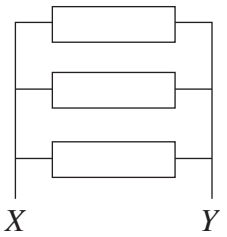
Which set of conditions will turn the lamp on?

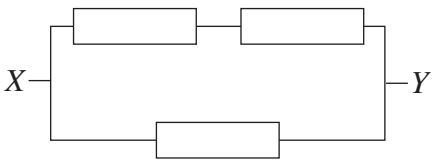
	Switch 1	*Switch 2*	*Switch 3*
(A)	Off	Off	Off
(B)	On	On	On
(C)	Off	Off	On
(D)	Off	On	On

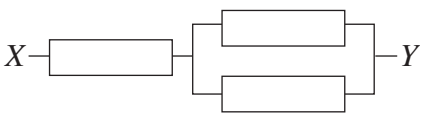
12 Each resistor in the diagrams below has a value of 10 Ω.

Which combination of resistors provides a total resistance of 15 Ω between *X* and *Y*?

(A) 

(B) 

(C) 

(D) 

13 In which direction does a reaction force act at a roller support?

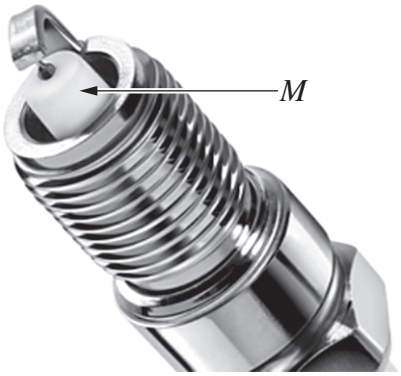
(A) Parallel to the supporting surface

(B) Vertical to the supporting surface

(C) Horizontal to the supporting surface

(D) Perpendicular to the supporting surface

14 The image shows one end of an electrical spark plug used in an internal combustion engine.



Which combination of properties would the component labelled *M* need to have?

(A) Electrical resistivity and machinability

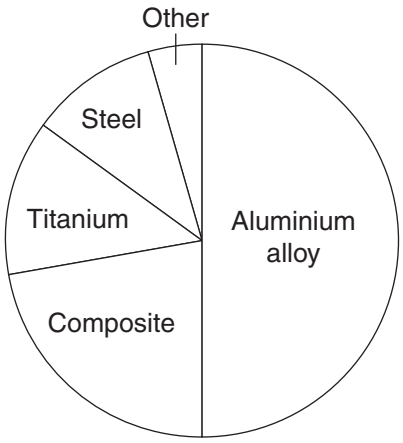
(B) Electrical conductivity and machinability

(C) Electrical resistivity and temperature stability

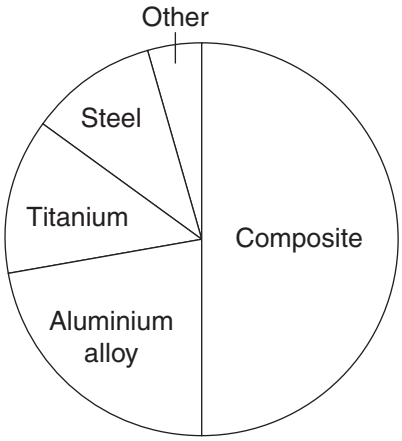
(D) Electrical conductivity and temperature stability

15 Which graph best represents the relative proportions of materials used in the construction of new, large passenger aircraft?

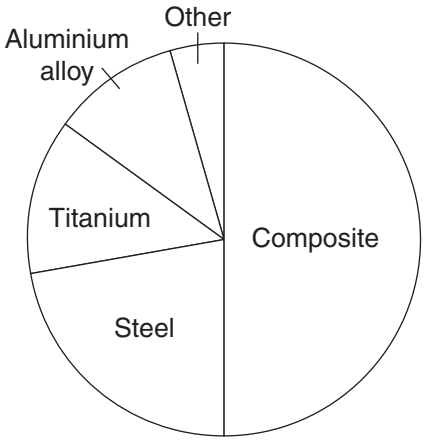
(A)



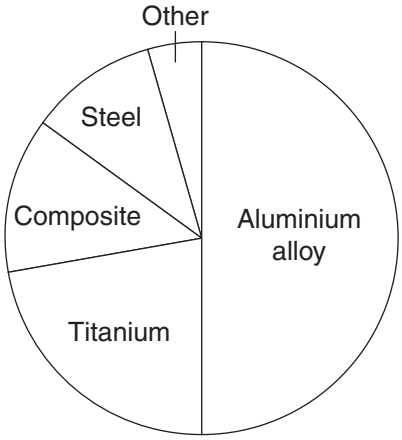
(B)



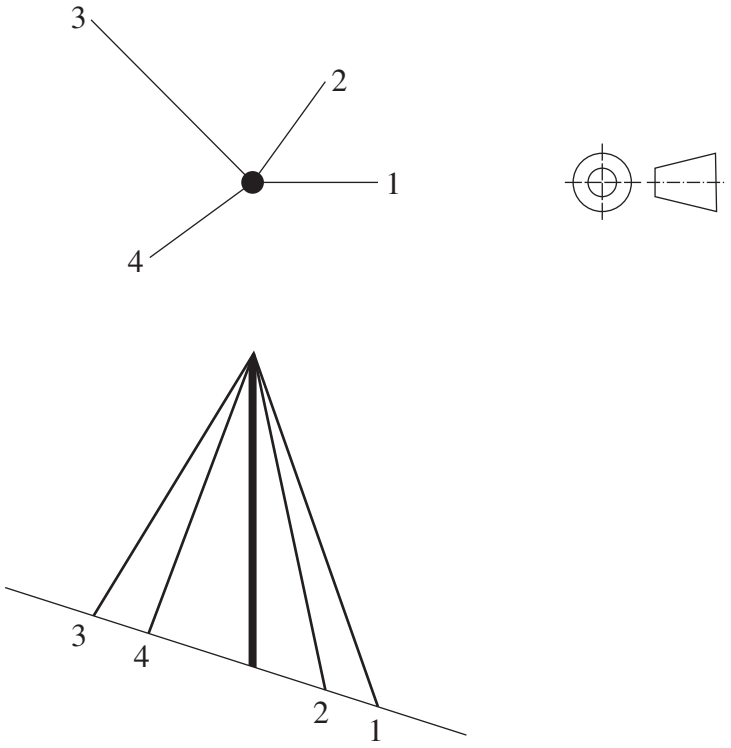
(C)



(D)



16 A pole is supported by four cables that are attached to its top and to the sloping ground.



Which cable is shown as true length?

(A) Cable 1

(B) Cable 2

(C) Cable 3

(D) Cable 4

17 Which of the following could cause fatigue cracking in a metal?

(A) A static tensile load

(B) A substantial shock load

(C) A high compression load

(D) A cyclically applied load

18 What are TWO advantages of using the powder forming process to manufacture a self-lubricating bearing?

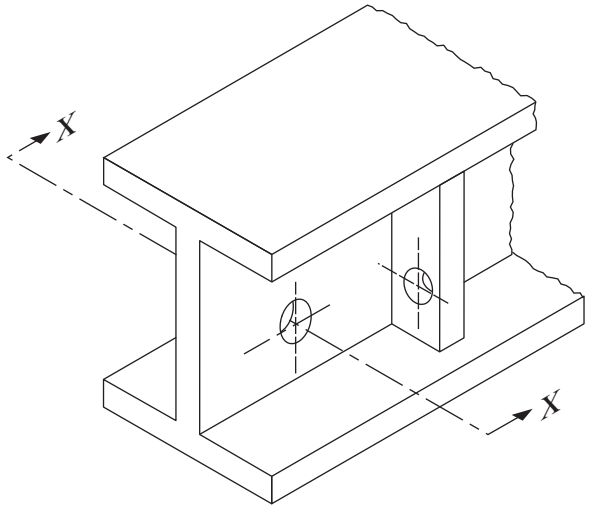
(A) Low material waste and high density

(B) High porosity and low material waste

(C) Low density and high tensile strength

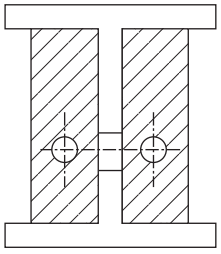
(D) High quality surface finish and high tensile strength

19 The diagram shows one end of a universal 'I' beam with access holes drilled and a supporting bracket fixed to each side.

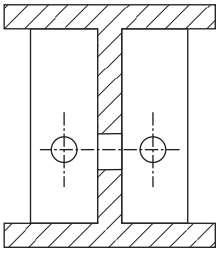


Which view shows the correct full section X–X of the beam viewed in the direction of the arrows?

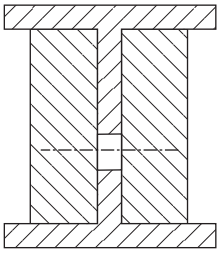
(A)



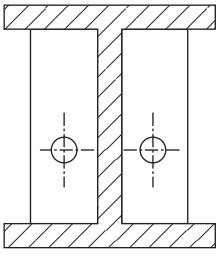
(B)



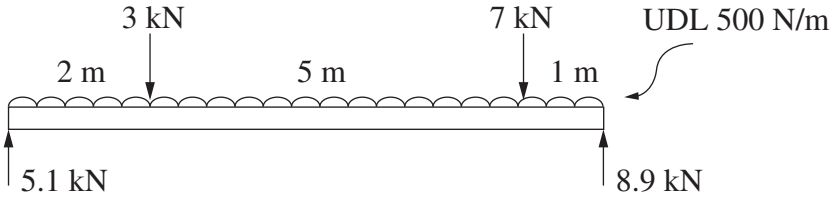
(C)



(D)

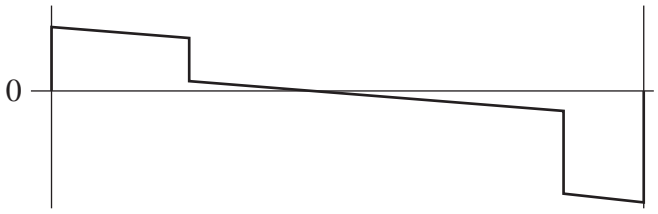


20 The drawing represents a loaded steel beam simply supported at each end.

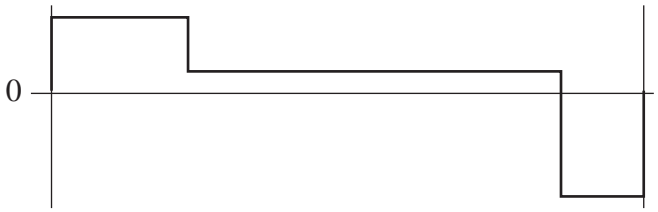


Which diagram best represents the distribution of shear forces along the beam?

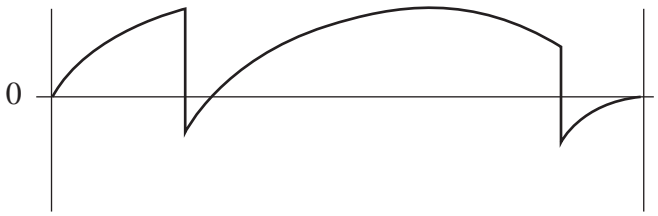
(A)



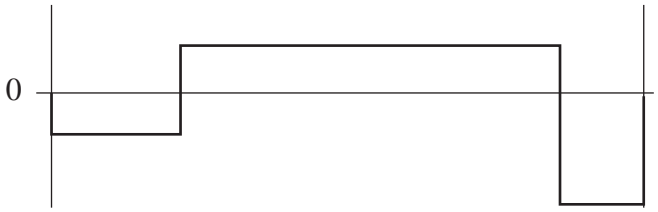
(B)



(C)



(D)



BLANK PAGE

Engineering Studies

Centre Number

Student Number

Section II

80 marks
Attempt Questions 21–27
Allow about 2 hours and 30 minutes for this section

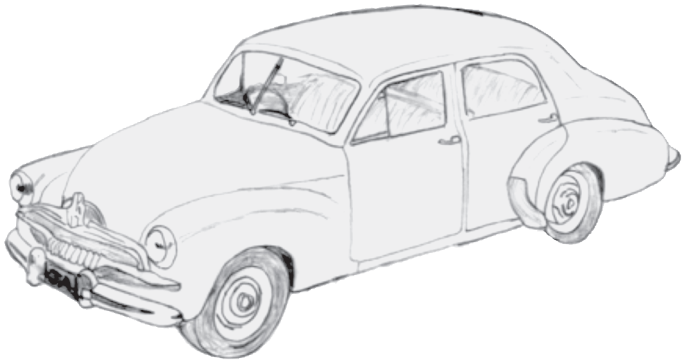
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Question 21 (11 marks)

Please turn over

Question 21 (11 marks)

(a) The sketch shows an early Australian-built car.



Explain how TWO features of this early Australian-built car have been modified in modern cars to improve their safety. **3**

.....

.....

.....

.....

.....

.....

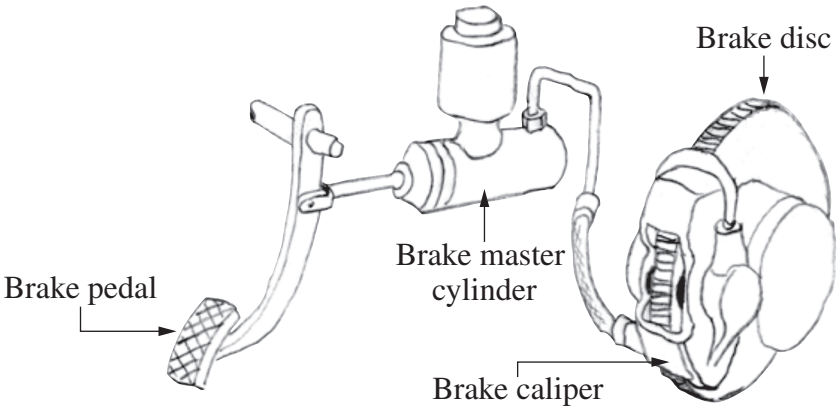
.....

.....

Question 21 continues on page 15

Question 21 (continued)

(b) The diagram represents part of a car's hydraulic braking system.



Outline the operation of this hydraulic system and its advantages over mechanical systems. **4**

.....

.....

.....

.....

.....

.....

.....

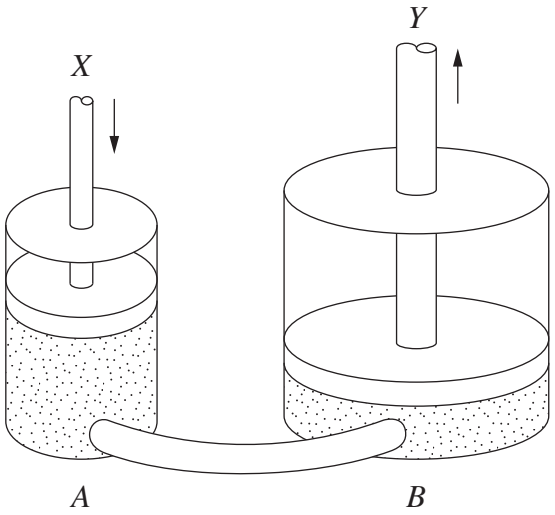
.....

Question 21 continues on page 16

Question 21 (continued)

(c) A hydraulic cylinder system is shown.

Cylinder *A* has a piston area of 100 mm^2. Cylinder *B* has a piston area of 700 mm^2.



(i) Calculate the force on rod *Y* when a force of 50 N is applied on rod *X*. **2**

..... N

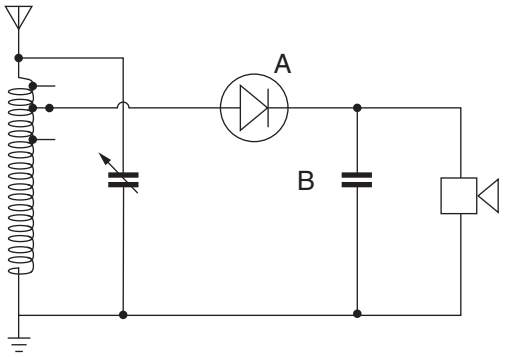
(ii) Calculate the distance rod *Y* would move when rod *X* moves 60 mm. **2**

..... mm

End of Question 21

Question 22 (12 marks)

(a) A circuit diagram of a simple radio receiver is shown.



Name the components labelled A and B and outline each component's function in this circuit. **4**

.....

.....

.....

.....

(b) How have semi-conductors influenced the design of modern telecommunications products? **2**

.....

.....

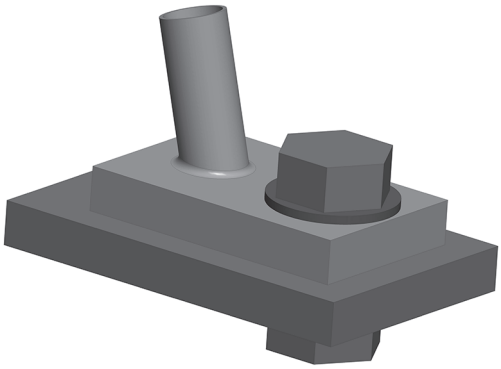
.....

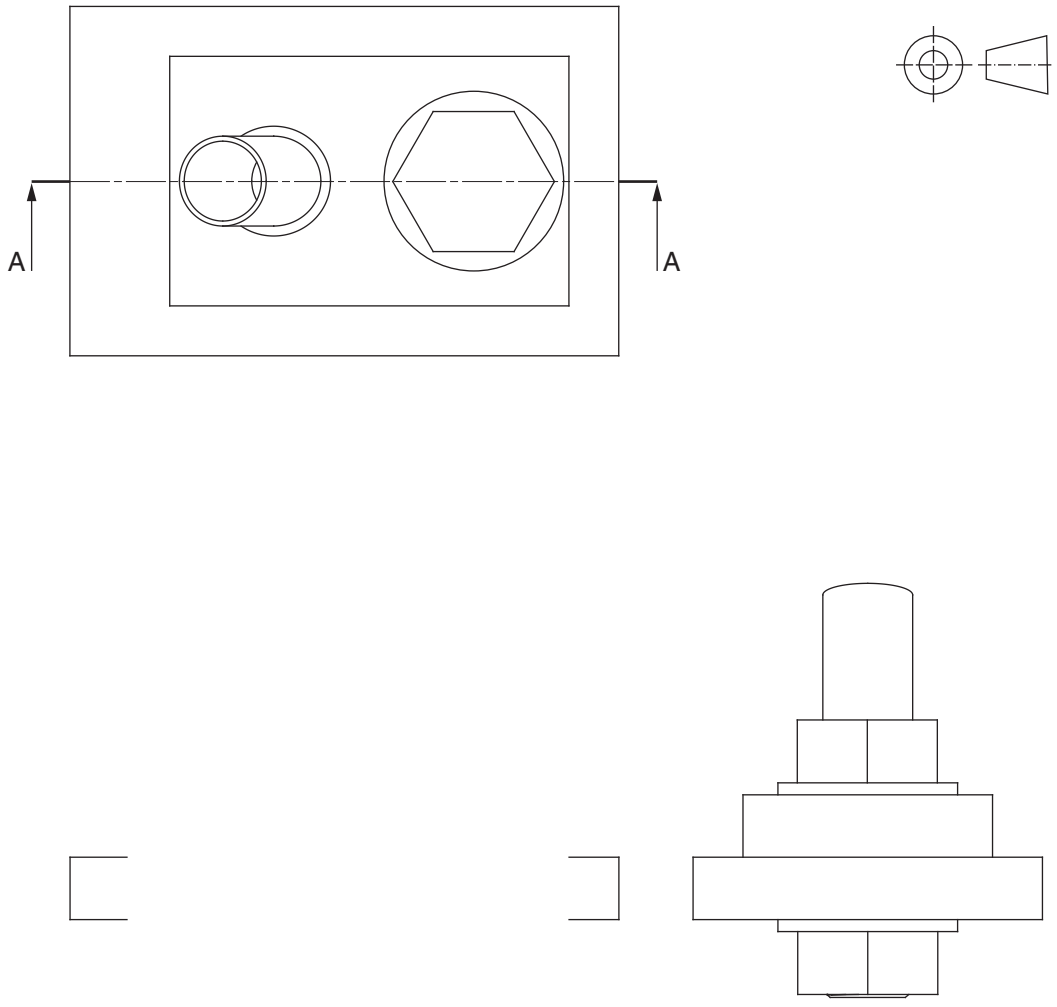
.....

Question 22 continues on page 18

Question 22 (continued)

(c) A radio aerial support bracket bolted to a steel plate is shown. Complete a fully sectioned front view of the bracket assembly. Apply AS1100. **6**





End of Question 22

Centre Number

Section II (continued)

Student Number

Question 23 (12 marks)

(a) An image of a telephone charger is shown.

(i) The material used for the electrical pins of the telephone charger needs to be a good conductor of electricity. **2**

List TWO other engineering properties that would be relevant when selecting the material for the pins.

.....

.....

(ii) The telephone charger cover is to be manufactured from a polymer. **3**

Name and describe a suitable manufacturing process.

.....

.....

.....

.....

.....

.....

Question 23 continues on page 20

Question 23 (continued)

(b) Contrast the key features of fixed and mobile telephone systems. **3**

.....

.....

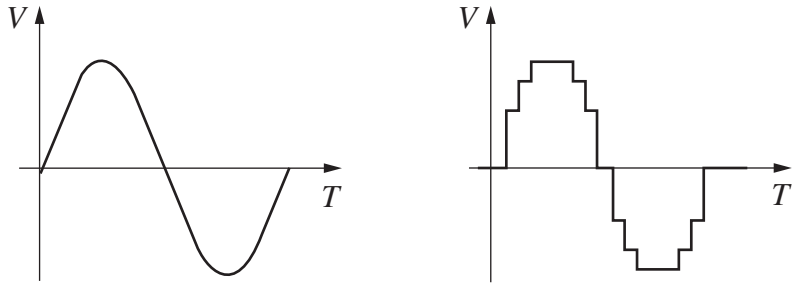
.....

.....

.....

.....

(c) A smart-phone transmits digital information. One step in this process is to convert analogue voice data to digitised data. **4**



Analogue signal Digitised signal

Outline how an analogue signal is digitised using *sampling* and *quantising*.

.....

.....

.....

.....

.....

.....

.....

.....

End of Question 23

Centre Number

Section II (continued)

Student Number

Question 24 (12 marks)

(a) The photograph shows railway power cables supported by a steel column.

(i) Suggest a suitable method that could be used to protect this steel column from corroding and explain how this method slows the corrosion process. **2**

.....

.....

.....

.....

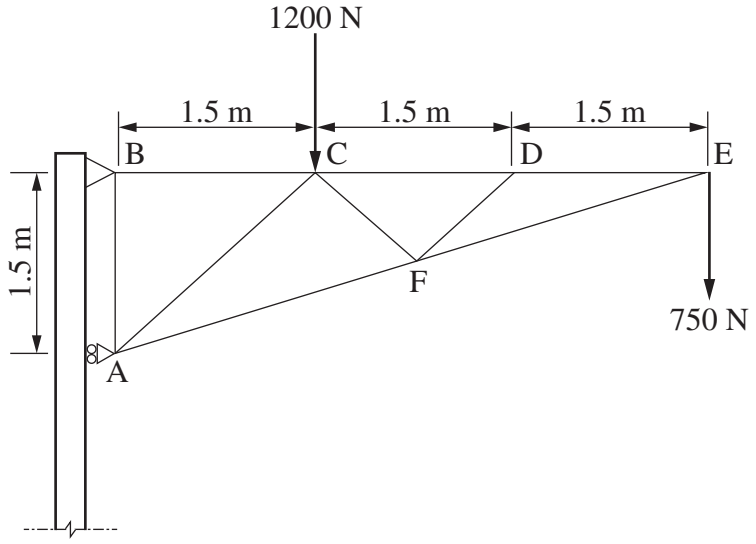
(ii) The column is manufactured by cold rolling 0.4% carbon steel. **2**

Sketch and label the resulting microstructure.

Question 24 continues on page 22

Question 24 (continued)

(b) A diagram of a pin-jointed, cantilever truss that supports overhead railway power cables is shown.



A weight of 1200 N is determined to be acting at joint C and the power cable weight of 750 N is acting at joint E.

(i) Determine the magnitude of the reaction at support A. **2**

Magnitude of reaction at A ..... N

Question 24 continues on page 23

(ii) Determine the magnitude and the direction of the reaction at the pin joint B. **3**

Reaction at B ..... N Direction .....

(iii) Determine the magnitude and the nature of the force in member AC. **3**

Force in AC ..... N Nature .....

End of Question 24

BLANK PAGE

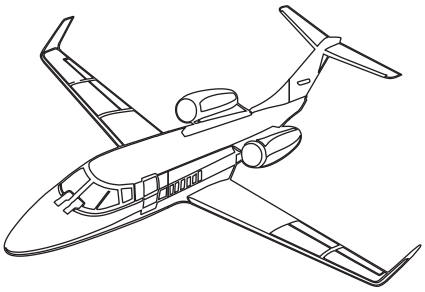
Centre Number

Section II (continued)

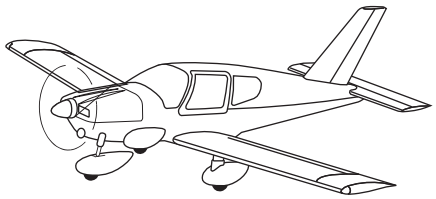
Student Number

Question 25 (12 marks)

(a) The two images show light aircraft powered by different propulsion systems. **3**



Business aircraft



Recreational aircraft

Identify a suitable propulsion system for each aircraft and justify your choice.

.....

.....

.....

.....

.....

.....

(b) Outline TWO control adjustments that can be made to vary the lift force acting on an aircraft during flight. **3**

.....

.....

.....

.....

.....

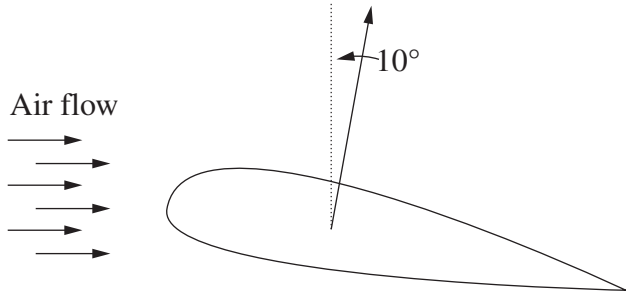
.....

Question 25 continues on page 26

Question 25 (continued)

(c) An aerofoil was tested in a wind tunnel. **2**

This test produced a resultant force of 350 N at an angle of 10° to the lift axis.



Calculate the lift to drag ratio.

Lift to Drag Ratio .....

(d) Outline the ultrasonic testing process and its advantages for use in testing aircraft components. **4**

.....

.....

.....

.....

.....

.....

.....

.....

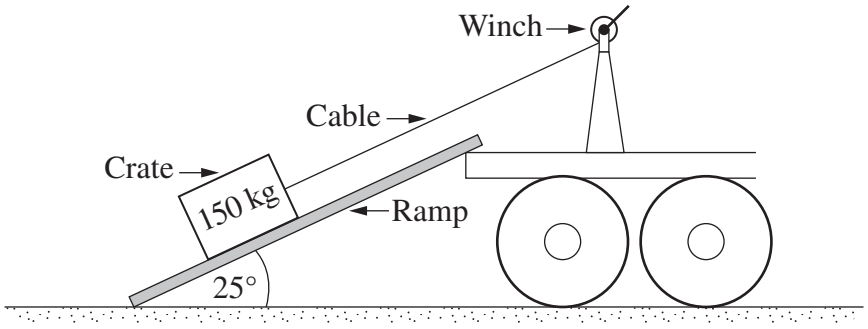
End of Question 25

Question 26 (13 marks)

Please turn over

Question 26 (13 marks)

(a) A winch mechanism is used to pull a 150 kg crate up a ramp and onto a transport vehicle.

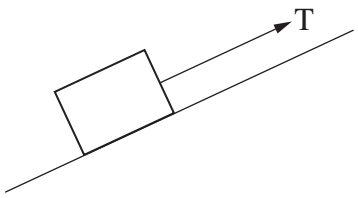


The winch cable is parallel to the ramp.

(i) A simplified sketch of the crate, ramp and the tensile force (T) in the cable is shown at the point of the crate sliding up the ramp. **2**

Add labelled arrows to the sketch to indicate the following forces:

- normal
- weight
- friction.



(ii) Calculate the tensile force in the cable at this point if the coefficient of friction between the crate and the ramp is 0.3. **3**

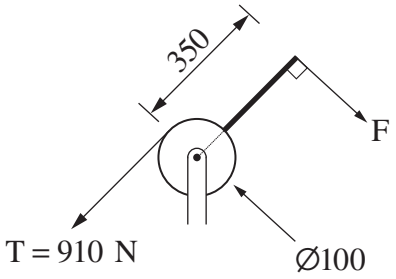
Tension in cable ..... N

Question 26 continues on page 29

Question 26 (continued)

(iii) For a different situation, the tension in the cable is 910 N. This winch is 85% efficient and has an effective drum diameter of 100 mm. **2**

What is the minimum force (F) required to operate this winch if the effective length of the winch handle is 350 mm?

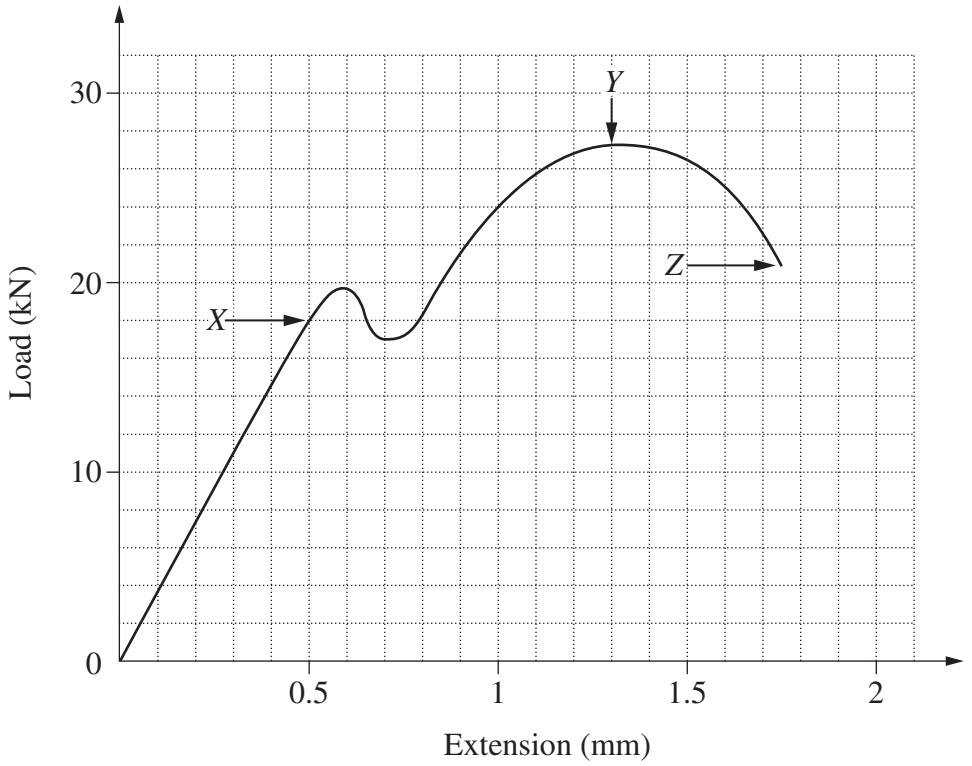


Force ..... N

Question 26 continues on page 30

Question 26 (continued)

(b) The steel used to manufacture the winch cable was tested using a tensometer and the resulting details are shown on the load–extension graph.



(i) State the significance of the three key points identified on the graph. **3**

X .....

.....

Y .....

.....

Z .....

.....

Question 26 continues on page 31

(ii) The original gauge length of the steel test piece was 55 mm with a cross-sectional area of 9.6 mm^2. **3**

Using data from the load–extension graph, calculate the value of Young's Modulus for this steel.

Young's Modulus ..... GPa

End of Question 26

Question 27 starts on page 35

BLANK PAGE

BLANK PAGE

BLANK PAGE

Question 27 (8 marks)

An engineering team consists of a civil engineer, an electrical engineer and an environmental engineer. They have been contracted by a local council to manage the design and construction of a five metre long pedestrian bridge across a narrow creek in a public park. **8**

Outline how each of these engineers would contribute to the successful completion of this project.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

End of paper

BLANK PAGE

FORMULAE SHEET

Force, Moments

$F = ma$; $M = Fd$

If a body is in equilibrium, then $\sum F_x = 0$; $\sum F_y = 0$; $\sum M = 0$

Friction

$F = \mu N$; $\mu = \tan\phi$

Energy, Work, Power

$KE = \frac{1}{2}mv^2$; $PE = mgh$; $W = Fs = \Delta PE + \Delta KE$; $P = \frac{W}{t}$; $P = \frac{Fs}{t}$; $P = Fv$

Pressure

$P = \frac{F}{A}$; $P = P_o + \rho gh$

Stress and Strain

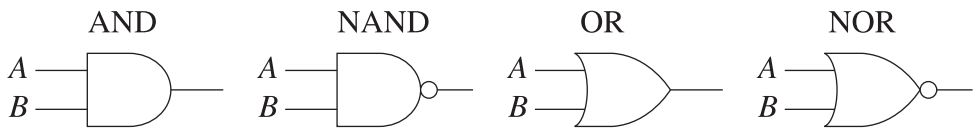
$\sigma = \frac{F}{A}$; $\varepsilon = \frac{e}{L}$; $E = \frac{\sigma}{\varepsilon}$; $\sigma = \frac{My}{I}$

$\sigma_{\text{allowable}} = \frac{\sigma_{yield}}{F \text{ of } S}$ (Ductile); $\sigma_{\text{allowable}} = \frac{\sigma_{UTS}}{F \text{ of } S}$ (Brittle)

Machines

$MA = \frac{L}{E}$; $VR = \frac{d_E}{d_L}$; $\eta = \frac{MA}{VR}$

Digital Electronics



Electricity, Electronics

$E = IR$ $P = I^2R$

Series $R_t = R_1 + R_2 + R_3 + R_4 + \cdots + R_n$

Parallel $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \cdots + \frac{1}{R_n}$

BLANK PAGE