NSW Education Standards Authority

2020 **HIGHER SCHOOL CERTIFICATE EXAMINATION**

Engineering Studies

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A formulae sheet is provided at the back of this paper

Total marks: 100

Section I – 20 marks (pages 2–10)

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

Section II – 80 marks (pages 13–36)

- 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.

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1 What is the main purpose of applying a polymer coating to a copper telecommunications cable?

A. To insulate it

B. To strengthen it

C. To increase its flexibility

D. To improve its conductivity

2 What is the main purpose of the flaps on the wings of an aircraft?

A. To make the aircraft safer at higher speeds

B. To decrease lift to allow faster take-off speeds

C. To increase lift at lower speeds for take-off and landing

D. To decrease drag to allow higher take-off and landing speeds

3 Which of the following manufacturing methods can be used to produce complex polymer components?

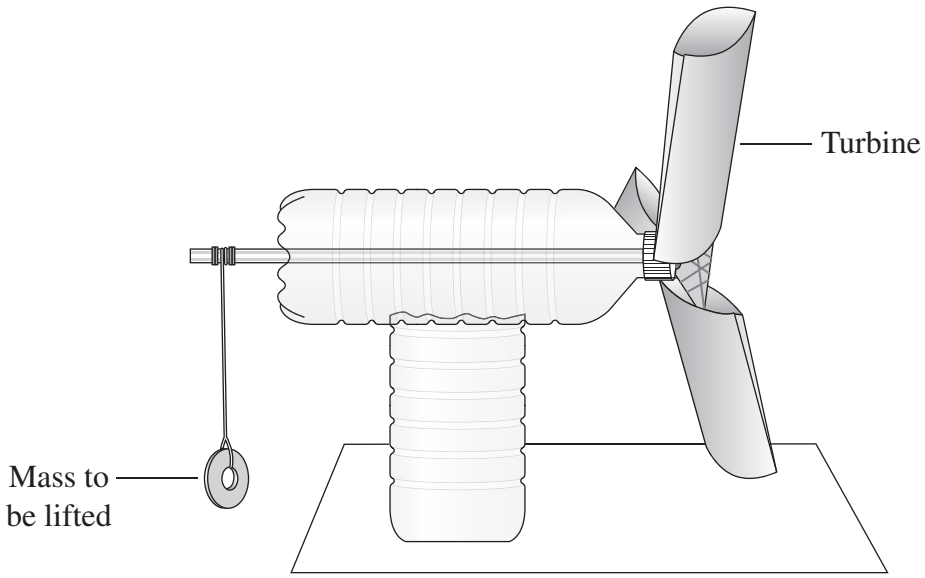
A. Sand casting

B. Blow moulding

C. Lost wax casting

D. Injection moulding

4 The diagram shows a model of a windmill which is designed to lift a mass as the turbine rotates.



A mass of 80 grams is lifted a distance of 200 mm by the windmill.

What is the work done by the windmill?

A. 0.16 J

B. 16 J

C. 160 J

D. 1600 J

5 To what must the professional services of telecommunications engineers be primarily dedicated?

A. Completing projects on time

B. Ensuring public health and safety

C. Designing efficient engineering systems

D. Reducing the legal liability of their employers

6 Which electronic component can be used to increase or decrease the speed of a train powered by an electric motor?

A. Diode

B. Capacitor

C. Transistor

D. Potentiometer

7 Which of the following best describes how an unpowered aircraft will glide, in a controlled descent, when the lift-to-drag ratio is high?

A. Long distance at a steep glide angle

B. Short distance at a steep glide angle

C. Long distance at a shallow glide angle

D. Short distance at a shallow glide angle

8 The photograph shows a transport viaduct based on a series of Roman arches.

By using the Roman arch, engineers today can design structures which

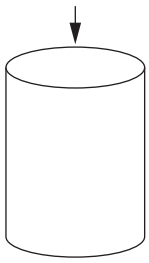
A. are easy to construct.

B. are quick to construct.

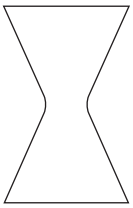
C. can span long distances.

D. place foundations in tension.

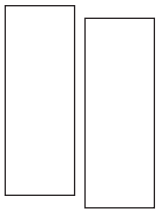
9 A cured cylindrical concrete specimen is tested under a compressive load through its vertical axis, until it fails.



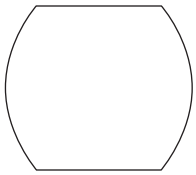
Which of the following is the most likely shape of the front view of the failed specimen?



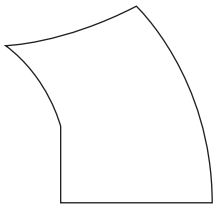
A.



B.



C.



D.

10 Which of the following only contains tasks performed by the aeronautical engineer?

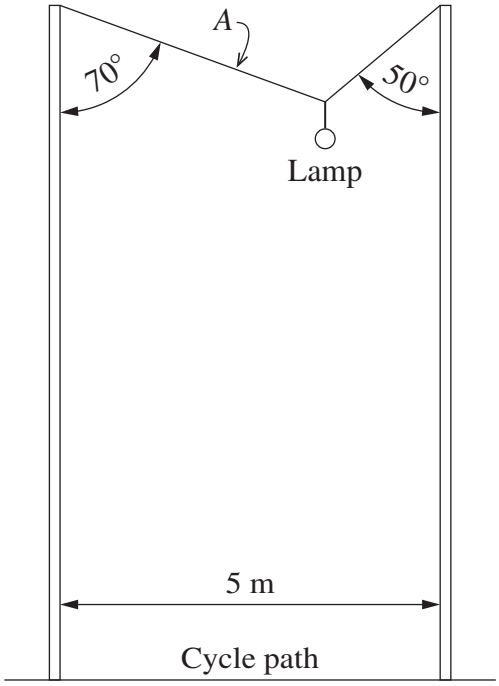
A. Provide technical advice, assemble aircraft, design aircraft

B. Assist in air traffic control, investigate crashes, pilot aircraft

C. Make good checklists, read training manuals, schedule flights

D. Write training manuals, assist in air traffic control, act as a public relations officer

11 The diagram shows a 10 kg lamp hanging from a cable over a cycle path.



What is the tension in cable *A*?

A. 44 N

B. 88 N

C. 100 N

D. 110 N

12 A geostationary satellite is positioned above the equator.

How many times does the satellite go around Earth's axis in a 24-hour period?

A. 0

B. 1

C. 2

D. 3

13 Which of the following can be safely transmitted by fibre optic cables?

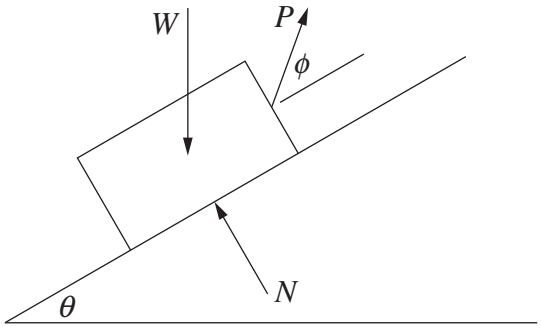
A. Microwaves

B. Radio waves

C. Gamma rays

D. Infrared waves

14 The diagram shows the forces acting on a block on an inclined plane. The block is held in a stationary position by force P.



What is the correct equation for the normal force, N?

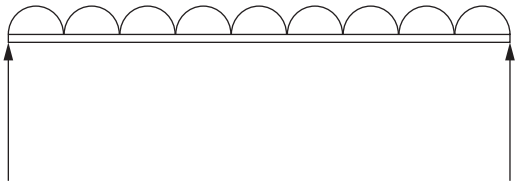
A. $N = W\cos\theta - P\sin\phi$

B. $N = W\cos\theta + P\sin\phi$

C. $N = W\sin\theta - P\cos\phi$

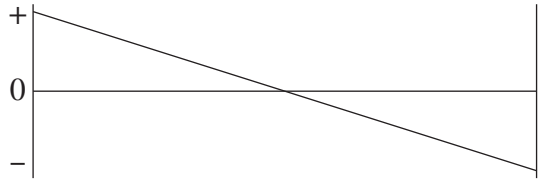
D. $N = W\sin\theta + P\cos\phi$

15 A uniformly distributed load is applied to a simply supported beam.

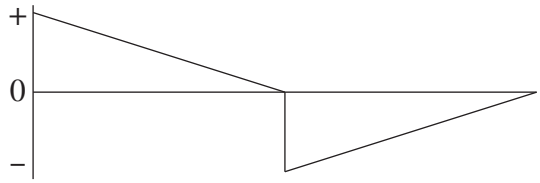


Which of the following is the correct shear force diagram for this load?

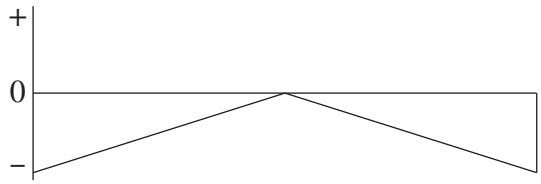
A.



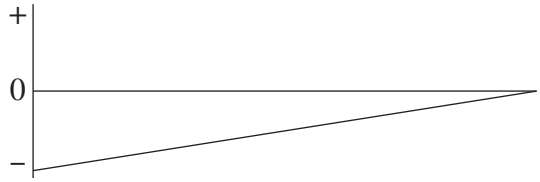
B.



C.



D.



16 Which of the following contributes to pitting or crevice corrosion in aircraft component joints?

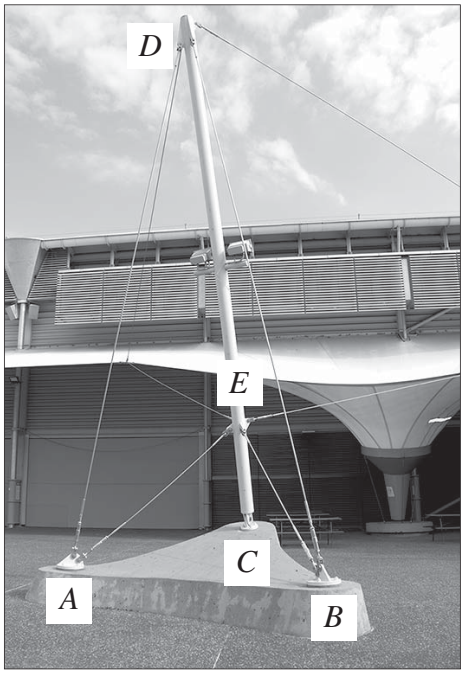
A. Water levels

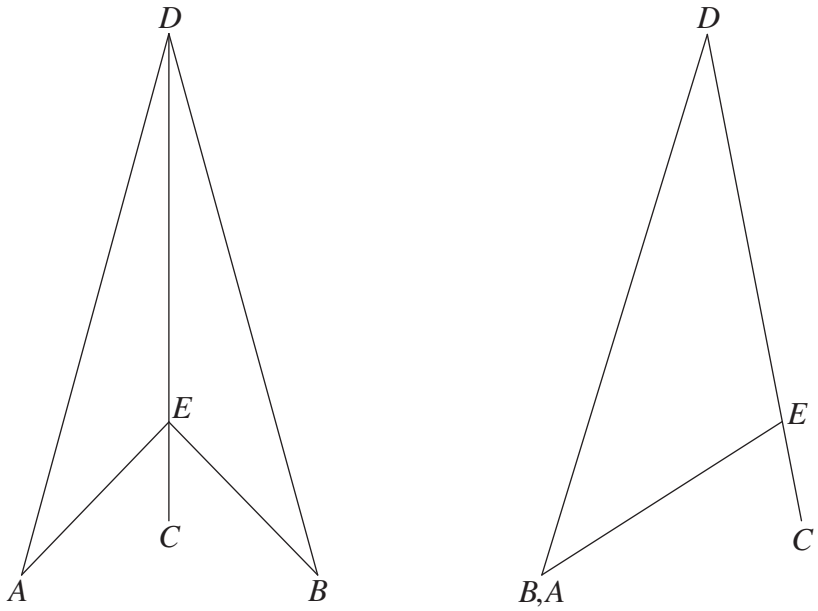
B. Alloy concentrations

C. Oxygen concentrations

D. Levels of static electricity

17 A photograph of a 6.5 m stanchion with guy wires is shown.





Front Side

Using the scaled orthogonal drawing, find the true length of wire *BD*.

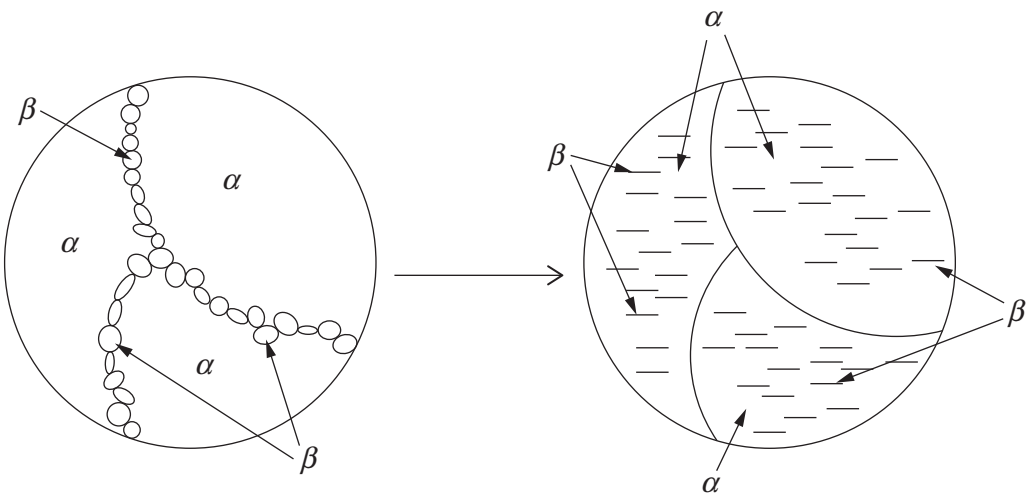
A. 7.3 m

B. 7.9 m

C. 8.3 m

D. 8.9 m

18 The grain structure of a material has changed over time from that shown in microstructure *A* to that shown in microstructure *B*.



Microstructure *A* Microstructure *B*

What heat treatment process has the material undergone to cause this change?

A. Tempering

B. Normalising

C. Quench hardening

D. Precipitation hardening

19 Turbofan engines are generally more fuel efficient than turbojet engines.

What causes this efficiency?

A. Smaller intake area

B. Higher combustion temperatures

C. Air bypassing the combustion system

D. Air directly entering the combustion area

20 Which of the following describes high frequency wireless transmission when compared to low frequency wireless transmission?

A. Faster data rates over longer distances with higher interference

B. Faster data rates over shorter distances with lower interference

C. Slower data rates over longer distances with lower interference

D. Slower data rates over shorter distances with higher interference

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2020 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Engineering Studies

Section II Answer Booklet

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

Instructions

- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (12 marks)

(a) Outline how ONE telecommunications engineering innovation has influenced traditional voice communication systems. **2**

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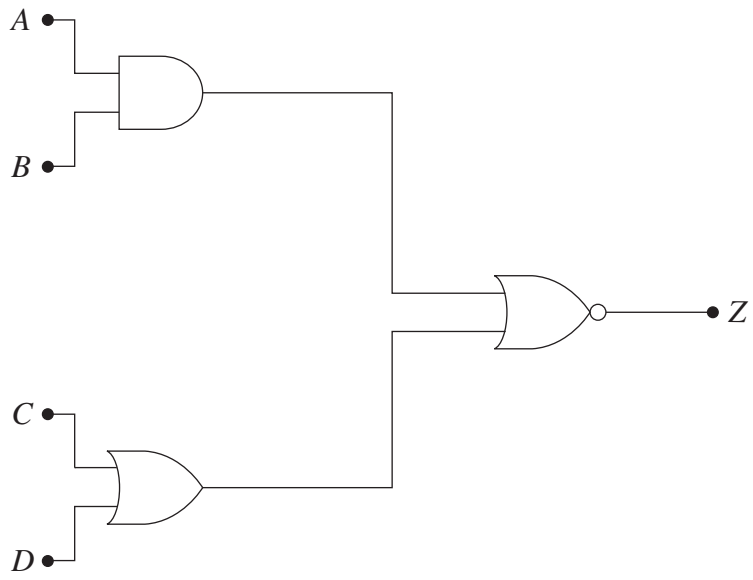
Question 21 continues on page 15

(b) The diagram shows a simple logic circuit with inputs *A*, *B*, *C* and *D*, and output *Z*. **3**



Inputs *A* and *D* are set to 'high' (1).

Determine, using the logic circuit diagram, the combination of inputs at *B* and *C* which will produce a high (1) output at *Z*. Use the truth table to support your answer.

A	*B*	*C*	*D*	*Z*
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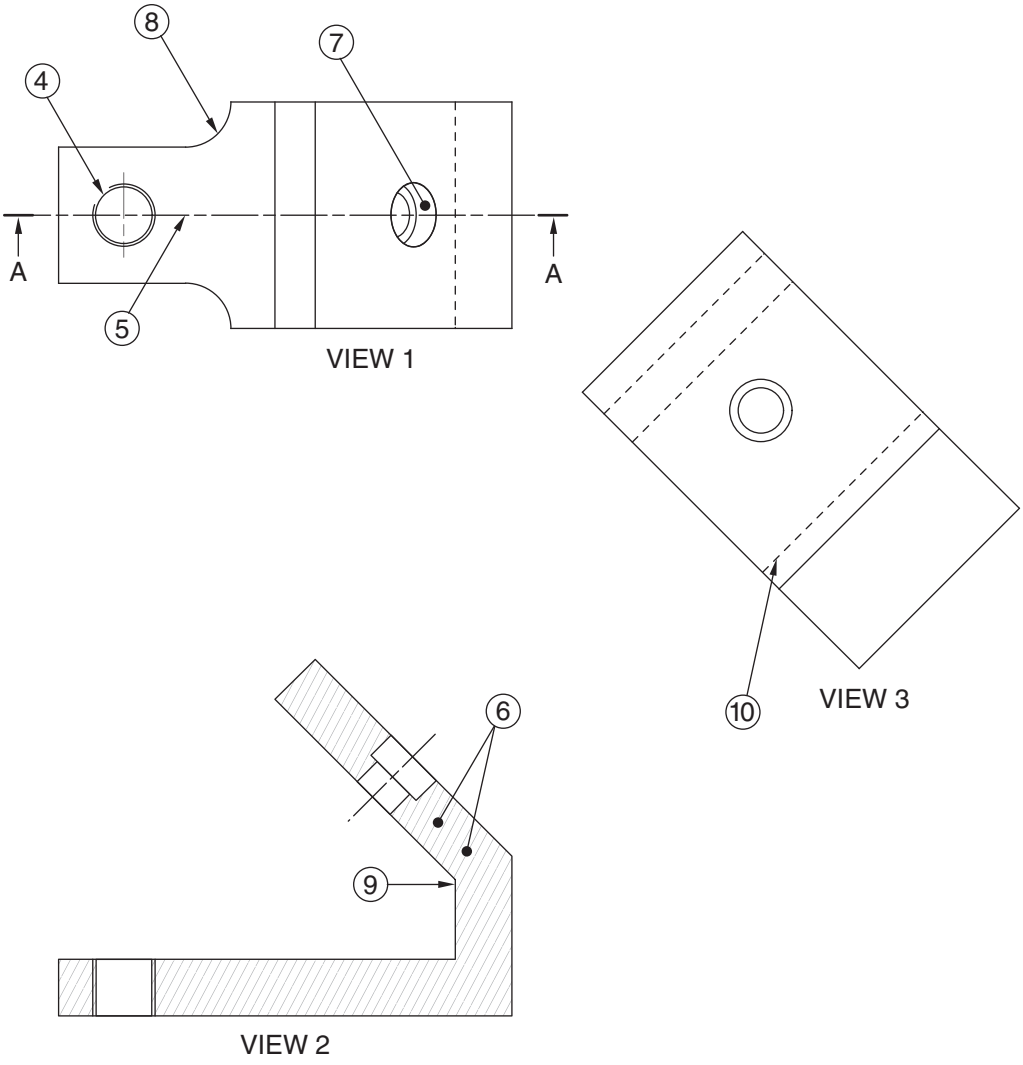
Question 21 continues on page 16

Question 21 (continued)

(c) The following drawing provides a series of orthographic views of a machine part, supported by a 'modified' title block. Some of the features have been labelled with the numbers 4 to 10. **4**



	AB ENGO SERVICES	
ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED	TITLE **ENCABULATOR PART**	
TOLERANCE ± 0.5 mm	Size: A4	DWG NO: 1
AS 1100	Scale: 2:1	SHEET: 1 of 1

Question 21 continues on page 17

Question 21 (continued)

With reference to the orthographic views and the modified title block, complete the table below.

Drawing title is Encabulator part	*AS 1100 indicates* Australian Drawing Standard
Angle of projection is	2 : 1 *indicates*
Feature 10 indicates	*Feature 5 indicates*
Correct name of View 2 is	*Feature 7 indicates*
Detail missing in View 2 is	*Feature 6 indicates*
Correct name of View 3 is	*Fillet curve is indicated as* *Feature .....*
Detail missing in View 3 is	*Feature 4 indicates*

Question 21 continues on page 18

Question 21 (continued)

(d) Electrolytic tough pitch (ETP) copper has many desirable properties that support its use in telecommunications. **3**

In the table, provide an explanation for the importance of each of the listed properties of ETP copper.

Property of ETP copper	*Explanation*
Electrical conductivity	The electrical conductivity of ETP copper is important in telecommunications because ....
Ductility	The ductility of ETP copper is important in telecommunications because ....
Corrosion resistance	The corrosion resistance of ETP copper is important in telecommunications because ....

End of Question 21

Question 22 (13 marks)

(a) Outline how ONE innovation in aeronautical engineering has contributed to improved performance of modern aircraft. **2**

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(b) Describe the use of different types of materials for the wings of aircraft over the last 100 years. **3**

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Question 22 continues on page 20

Question 22 (continued)

(c) A periodic aircraft maintenance inspection is to be carried out. **4**

Identify and justify an appropriate test that could be used to check the airworthiness of the landing gear.

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(d) An air gauge contains air at 750 kPa (gauge) while atmospheric pressure is at 100 kPa. The air at absolute pressure operates a piston of 15 mm diameter. **4**

Calculate the force the compressed air exerts on the piston.

Answer: ..... N

End of Question 22

Question 23 (11 marks)

(a) The diagrams show two bicycles, one from 1900 and one from 2020. **3**

1900

Due to copyright restrictions, this material cannot be displayed until permission has been obtained.

2020

The basic components of the bicycle frame have not changed for 120 years. However, manufacturing and materials technologies have evolved significantly during this period.

Compare TWO technologies used in the production of modern bicycle frames to those used in earlier times.

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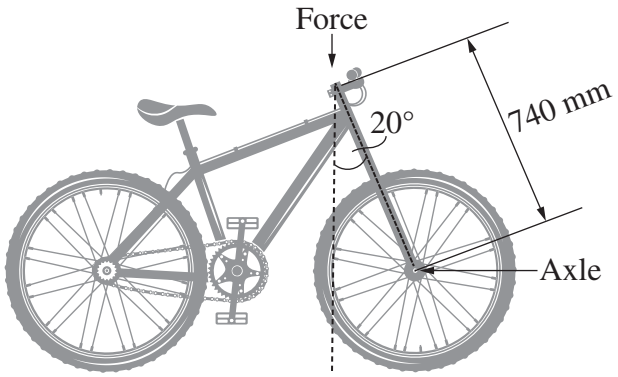
Question 23 continues on page 22

Question 23 (continued)

(b) A diagram of the front steering system of a bicycle is shown.



(i) A rider leans forward so that 55% of their mass is exerted as a force, as shown in the diagram. A turning moment of 132.19 N m is generated about the front axle. **3**

What is the mass of the rider?

Answer: ..... kg

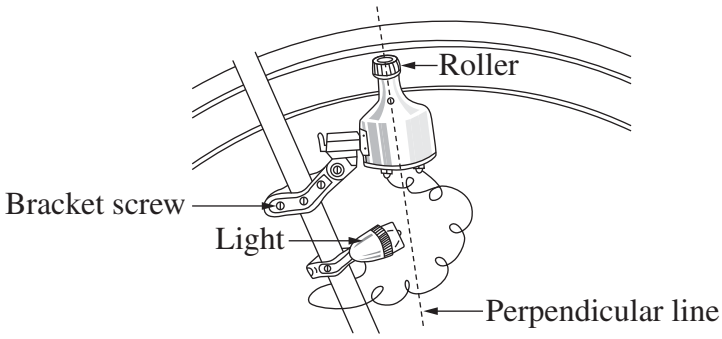
Question 23 continues on page 23

(ii) In overcoming the resistance due to gravity, drag and rolling resistance, a rider applies a force of 500 N on the pedals. This allows the rider to cover, in 5 seconds, a distance of 20 metres from the starting point. **2**

How much power was produced by the rider?

Answer: .....

(c) The diagram shows a dynamo mounted on the frame of a bicycle, with its roller positioned against the side of the tyre. Wires connect the dynamo to the bicycle light. **3**



Explain how the dynamo generates power to turn the bicycle light on.

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End of Question 23

Question 24 (12 marks)

(a) A photograph of a cast concrete pad is shown. **3**

Describe why concrete would have been selected for this situation.

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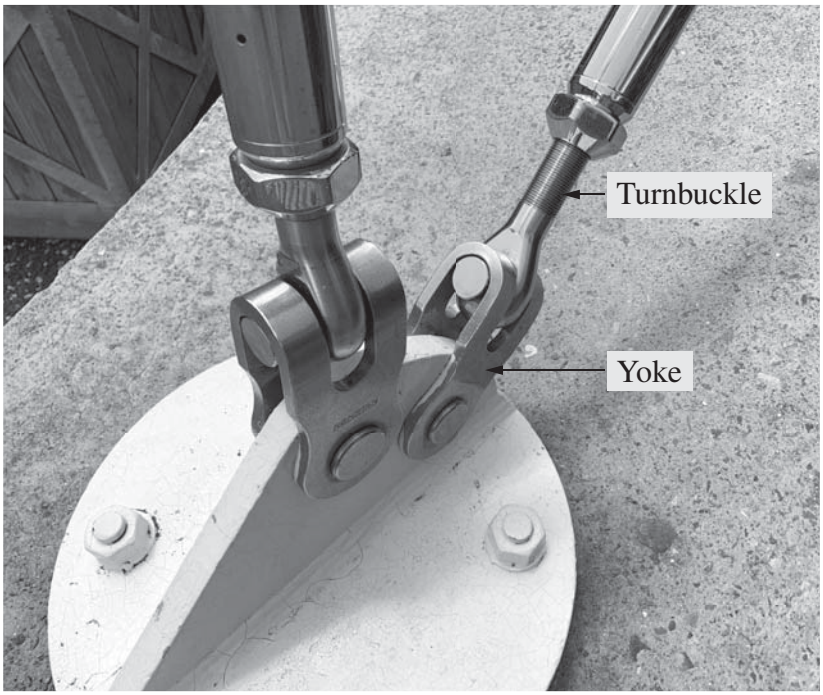
Question 24 continues on page 25

Question 24 (continued)

(b) The photograph shows two stainless steel yokes which attach a turnbuckle to a baseplate fixed to a concrete pad. **3**



Provide a step-by-step description of an appropriate method to manufacture the yoke.

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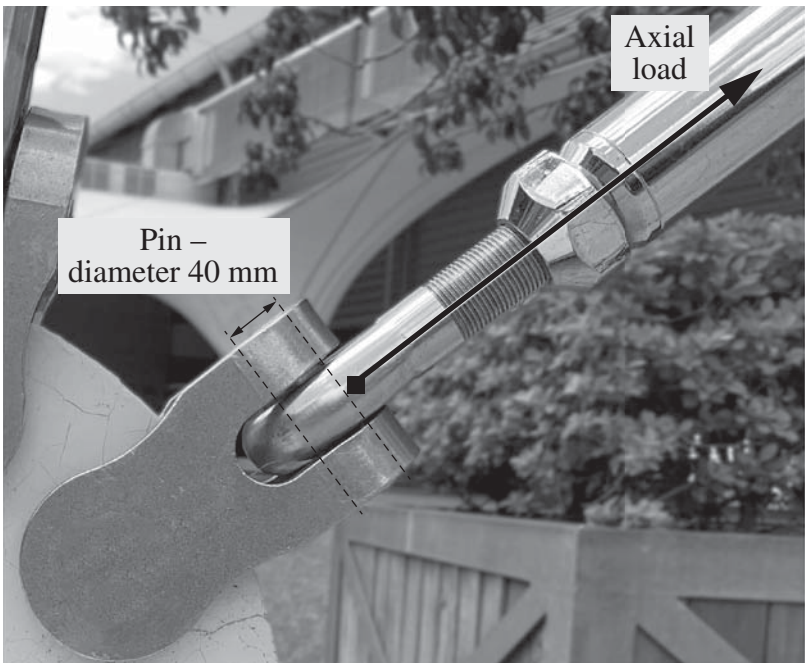
Question 24 continues on page 26

Question 24 (continued)

(c) The photograph shows a turnbuckle and yoke secured by a pin. **3**



The diameter of the pin in the turnbuckle is 40 mm and the shear stress across this pin is 55 MPa.

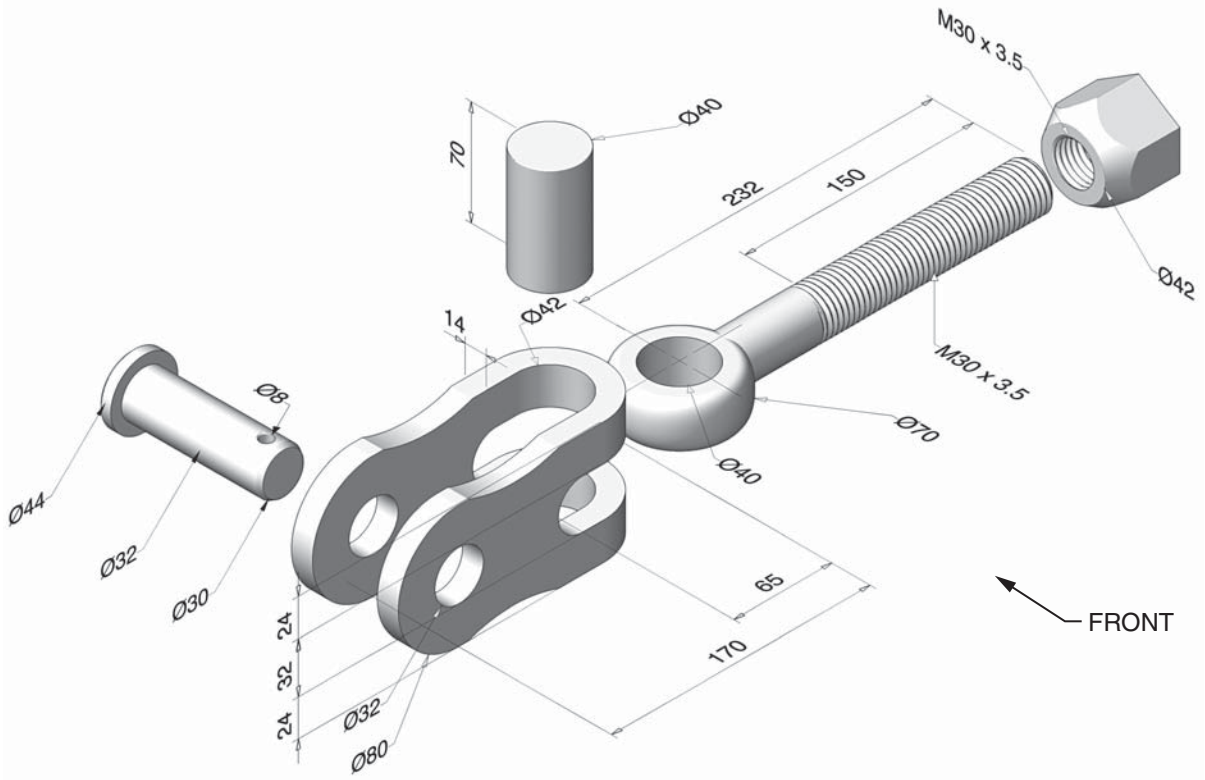
Find the magnitude of the axial load on the turnbuckle.

Answer: ..... kN

Question 24 continues on page 27

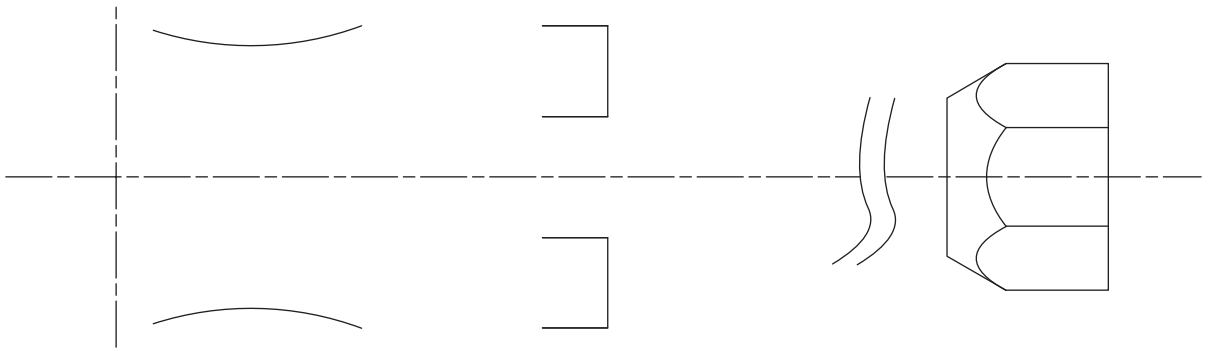
Question 24 (continued)

(d) An exploded view of a yoke and turnbuckle is shown. **3**



Complete the assembled front view in the space below. Apply AS 1100 drawing standards. Do NOT show hidden detail. Do NOT add dimensions.

Scale 1 : 2



End of Question 24

Question 25 (12 marks)

(a) Describe potential legal and ethical implications of a professional engineer failing to undertake ongoing training. **3**

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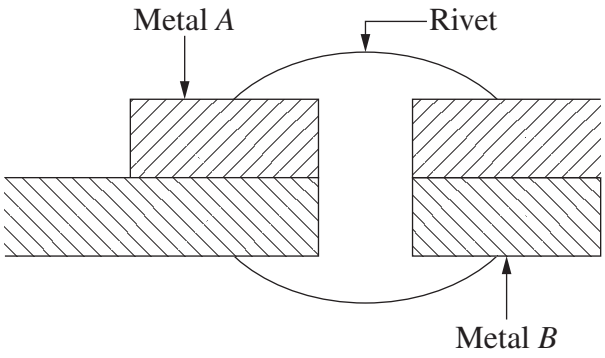
(b) Members of steel trusses are often connected using metal rivets as shown. **3**



Describe the hot working process that the rivet has undergone to create the resulting structure. Support your answer by completing and labelling the diagram of the sectioned rivet.

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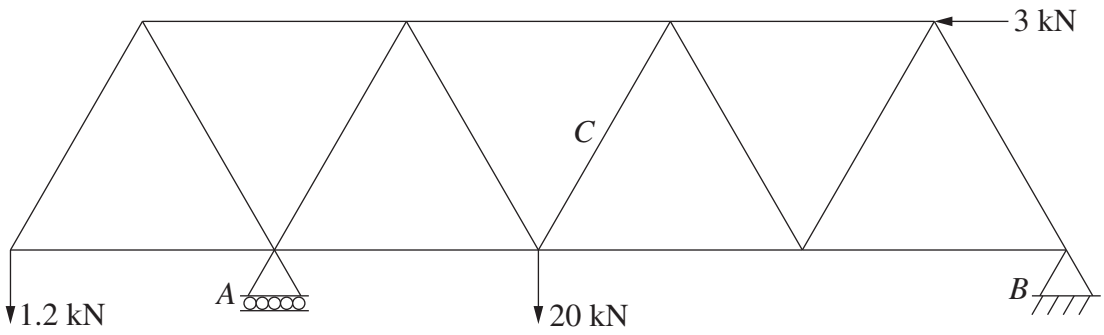
Question 25 continues on page 29

Question 25 (continued)

(c) A cycle bridge has been constructed using a Warren girder truss loaded as shown. The diagram is drawn to scale. **6**



By considering necessary loads and reactions, calculate the magnitude and nature of the force in member *C*.

Magnitude of force in *C*: ..... kN

Nature of force in *C*: .....

End of Question 25

Question 26 (12 marks)

(a) Describe methods used to protect civil structures against corrosion. Support your answer with examples. **3**

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(b) Outline benefits of digital signal transmission. **3**

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(c) Discuss methods for increasing the signal strength of a receiving antenna. **3**

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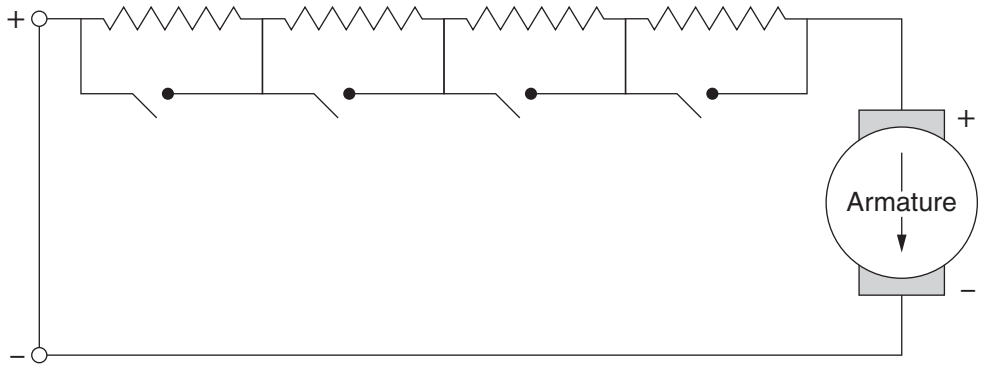
Question 26 continues on page 31

Question 26 (continued)

(d) The diagram shows an electrical circuit that is used to control the speed of a DC electric traction motor. **3**



Explain, with reference to the diagram, how the speed of the motor can be controlled.

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Question 27 (8 marks)

(a) Explain why engineering production drawings prepared for Australian use should adhere to AS 1100 drawing standards. **2**

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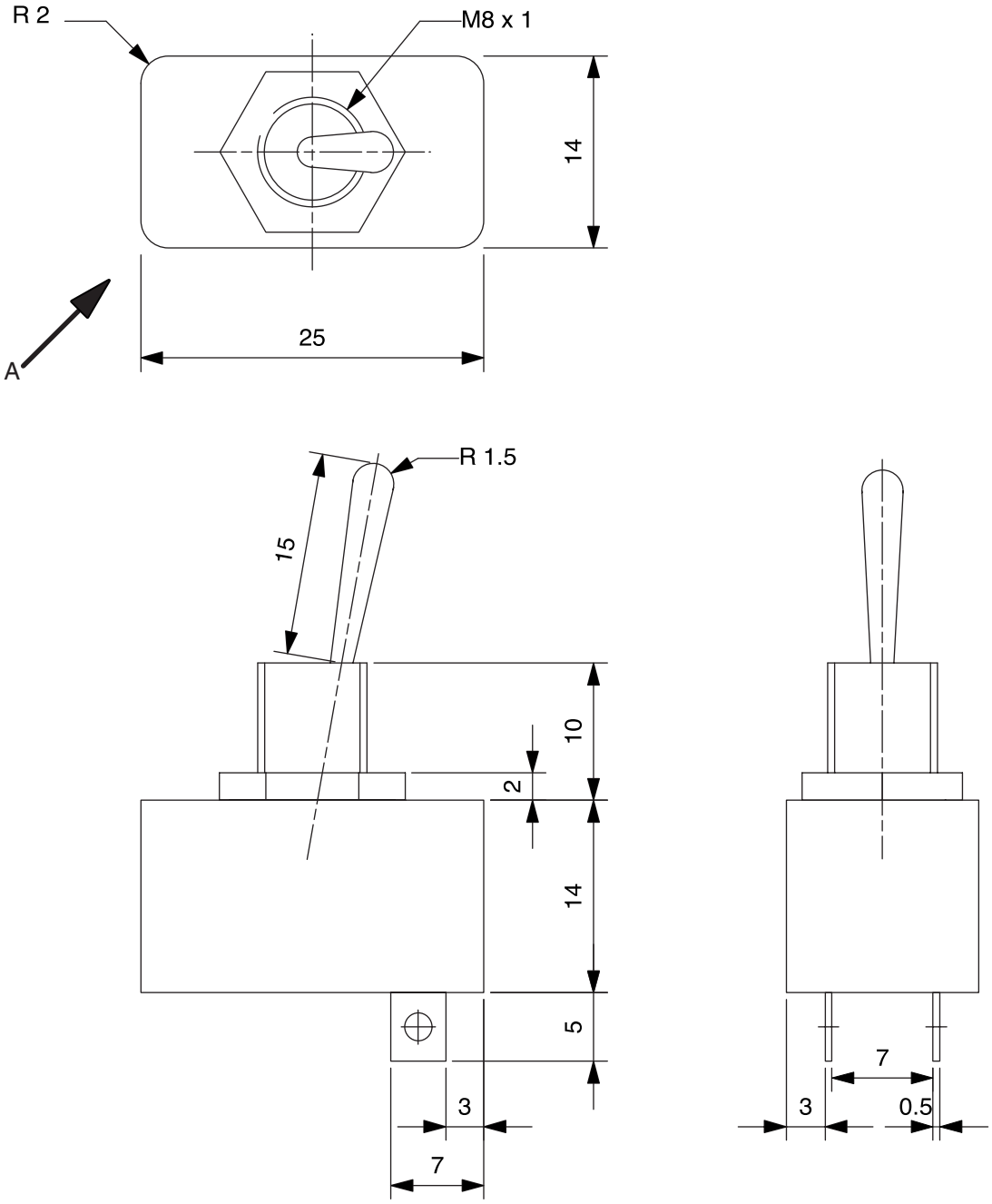
Question 27 continues on page 32

Question 27 (continued)

(b) An orthographic drawing of a toggle switch is shown. **6**



Question 27 continues on page 33

Question 27 (continued)

Produce a pictorial drawing of the toggle switch when viewed from the direction indicated by arrow A.

Use a scale of 2 : 1.

Do NOT write in this area.

End of paper

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Section II extra writing space

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Office Use Only – Do NOT write anything, or make any marks below this line.

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Do NOT write in this area.

Engineering Studies

FORMULAE SHEET

Force, Moments

$F = ma$; $\quad M = Fd$

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

Friction

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

Energy, Work, Power

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

Pressure

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

Stress and Strain

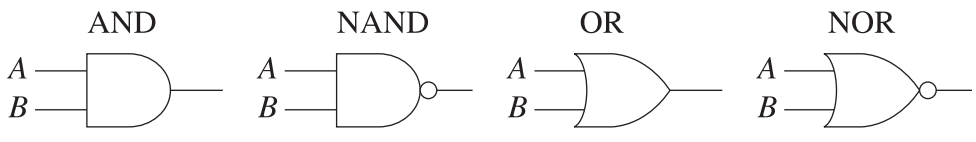
$\sigma = \frac{F}{A}$; $\quad \varepsilon = \frac{e}{L}$; $\quad E = \frac{\sigma}{\varepsilon}$; $\quad \sigma = \frac{My}{I}$

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

Machines

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

Digital Electronics



Electricity, Electronics

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

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

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

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