



# Engineering Studies

## 2018 Trial Examination

### General Instructions

- Reading time -5 minutes
- Working time -3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- Write your student number and/or name at the top of every page
- A formulae sheet is provided at the end of this paper

**Section I** Pages 2–6 Total marks (20)

**Attempt Questions 1-20**

Allow about 30 minutes for this section

**Section II** Pages 7–21 Total marks (80)

**Attempt Questions 21-27**

Allow about 2 hours 30 minutes for this section

**Total marks - 100**

This paper **MUST NOT** be removed from the examination room

STUDENT NUMBER/NAME:

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20 marks

Attempt Questions 1 - 20

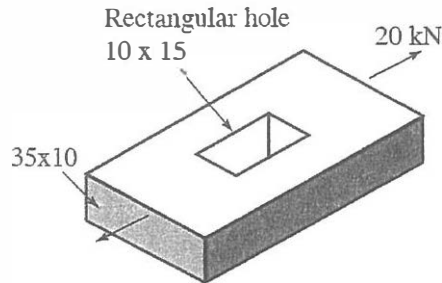
Allow about 30 minutes for this part

Answer Grid at back of paper (you tear the answer page off. Ensure it is stapled to paper at the end.)

1. Which best describes the reason why plasticisers are added to polymers?
  - (A) To provide fire resistance
  - (B) To increase flexibility and mouldability of the polymer
  - (C) To increase strength and add a variety of colours to the polymer
  - (D) To increase the resistance of the polymer to ultraviolet radiation from the sun
  
2. What is the best indication from a load/extension diagram of the toughness of a material?
  - (A) The total area under the graph
  - (B) The height to which the graph rises
  - (C) The degree of necking after the ultimate tensile load
  - (D) The area under the graph up to the proportional limit
  
3. Which new material was introduced into radio construction in the 1930's?
  - (A) Carbon fibre
  - (B) Porcelain
  - (C) Bakelite
  - (D) Polystyrene
  
4. Why are external threads manufactured by rolling in preference to cutting?
  - (A) Cutting threads produces too much waste material
  - (B) Rolling is quicker and produces a more durable thread
  - (C) Rolling is quicker, produces a more durable, stronger and more accurate thread
  - (D) Cutting requires too much energy and tends to overheat the metal which weakens the thread
  
5. A large gear, used in mining and made from a plain carbon steel with 0.5% carbon content, requires case (or surface) hardening heat treatment. Which is the most appropriate heat treatment process?
  - (A) Carburising
  - (B) Tempering
  - (C) Flame hardening
  - (D) Hardening and tempering
  
6. A box of machine parts rests on an inclined plane. The coefficient of friction for the box on the plane is 0.5. What is the angle of repose for the object on the plane?
  - (A) 65.4°
  - (B) 30°
  - (C) 23.8°
  - (D) 26.6

7. Where are electrons ultimately deposited in a galvanic corrosion cell?
- (A) At the anode
  - (B) At the cathode
  - (C) Into the electrolyte
  - (D) Into the conductor joining the anode and cathode
8. What value varies with the efficiency of a machine?
- (A) Velocity ratio
  - (B) Kinetic energy
  - (C) Potential energy
  - (D) Mechanical advantage
9. Which best describes electromagnetic induction?
- (A) The induction of a magnetic field in a conductor
  - (B) Production of an electric current in a conductor that is subjected to a changing magnetic field
  - (C) Production of a magnetic field due to an alternating current
  - (D) Production of a magnetic field in a conductor that is subjected to a changing current
10. Asphalt provides a durable and flexible surface for most roads. What are the constituents of asphalt?
- (A) Concrete and bitumen
  - (B) Bitumen and aggregate
  - (C) Sand, aggregate and cement
  - (D) Aggregate, sand and epoxy resin binder
11. What is the industry name for the public phone system?
- (A) Public switched telephone number or PSTN
  - (B) Public service telephone network or PSTN
  - (C) Portable switched telephone network or PSTN
  - (D) Public switched telephone network or PSTN

12. A machine part, with a shear strength of 200 MPa, has a rectangular hole punched through as shown. While in service, the machine part is subjected to a tensile force of 20 kN.



What is the force required to punch the rectangular hole?

- (A) 300 kN  
 (B) 10 kN  
 (C) 30 kN  
 (D) 100 kN
13. What is the maximum tensile stress in the machine part in Q12 above, when the part is subjected to the 20 kN tensile service load?

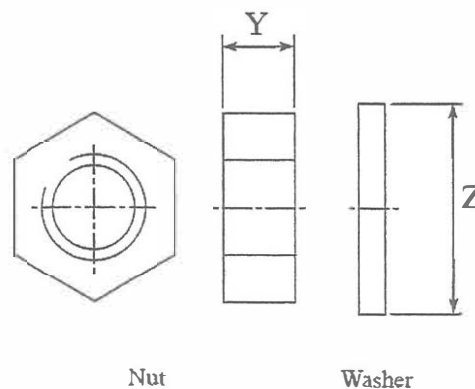
- (A) 100 MPa  
 (B) 80 MPa  
 (C) 57 MPa  
 (D) 20 MPa

14. What is an example of an Aramid?

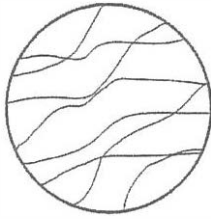
- (A) Polyester  
 (B) Kevlar  
 (C) Aggregate  
 (D) Polystyrene

15. An orthogonal drawing of a nut and washer is shown. What are the correct drawing sizes, Y and Z, for a bolt size M30 x 3.0?

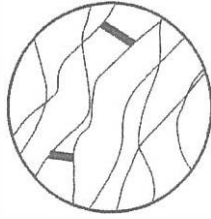
- (A) Y = 21; Z = 54  
 (B) Y = 21; Z = 60  
 (C) Y = 24; Z = 60  
 (D) Y = 28; Z = 50



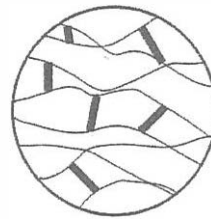
16. Which of the four macrostructures shown is most likely to be a thermosetting polymer?



Structure 1



Structure 2



Structure 3



Structure 4

- (A) Structure 1  
 (B) Structure 2  
 (C) Structure 3  
 (D) Structure 4
17. The elevator in an aeroplane can be controlled by:
- (A) a cable/pulley system  
 (B) an electric pump/hydraulic ram system  
 (C) an electric motor/gear system  
 (D) all of the above
18. An aircraft in flight can rotate in three dimensions: roll, pitch and yaw. What aircraft flight mechanisms control each of these movements?
- (A) Roll: ailerons; Pitch: elevators; Yaw: rudder  
 (B) Roll: elevators; Pitch: ailerons; Yaw: rudder  
 (C) Roll: rudder; Pitch: elevators; Yaw: ailerons  
 (D) Roll: ailerons; Pitch: rudder; Yaw: elevators
19. A sand cast machine component has to be checked for deep internal defects. What would be the most appropriate inspection technique to use?
- (A) Dye penetrant inspection  
 (B) Magnetic particle inspection  
 (C) Radiography (X-ray) inspection  
 (D) Eddy current inspection
20. What method is used to manufacture wide mouth glass jars and bottles?
- (A) Blow-and-blow moulding  
 (B) Press-and-blow moulding  
 (C) Extrusion blow moulding  
 (D) Vacuum and pressure forming

**End of Section I**

**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 (12 marks)**

**Marks**

Electric bicycles (or e-bikes) are becoming popular with cyclists. The bicycle shown below has a brushless electric motor that drives the front wheel with the battery pack secured within the frame. A control device on the handlebars varies the speed of the motor.



- (a) Describe TWO advantages and TWO disadvantages of e-bikes to society. 4

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Question 21 continues on the next page

Question 21 (continued)

Marks

- (b) If the battery provides 7 amps of current with a resistance of 5.1 ohms, calculate the power of the brushless electric motor? 2

Power of the electric motor = .....

- (c) Contrast universal electric DC motors and brushless DC electric motors. 2

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The frame of the e-bike is constructed from a heat treated aluminium alloy.

- (d) Explain how aluminium alloy is heat treated. 4

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**End of Question 21**



**Question 22** (12 marks)

**Marks**

Qantas' new fleet of Boeing 787 aircraft has provided the opportunity for the company to offer non-stop flights from Australia to London. The aircraft is made by weight from 50% composite, 20% aluminium alloy, 15% titanium alloy, 10% steel and 5% other materials.



- (a) Identify and explain two aspects of how passenger aircraft that are manufactured predominately from composite materials, benefits society. 4

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- (b) Contrast two properties of aluminium and titanium. 2

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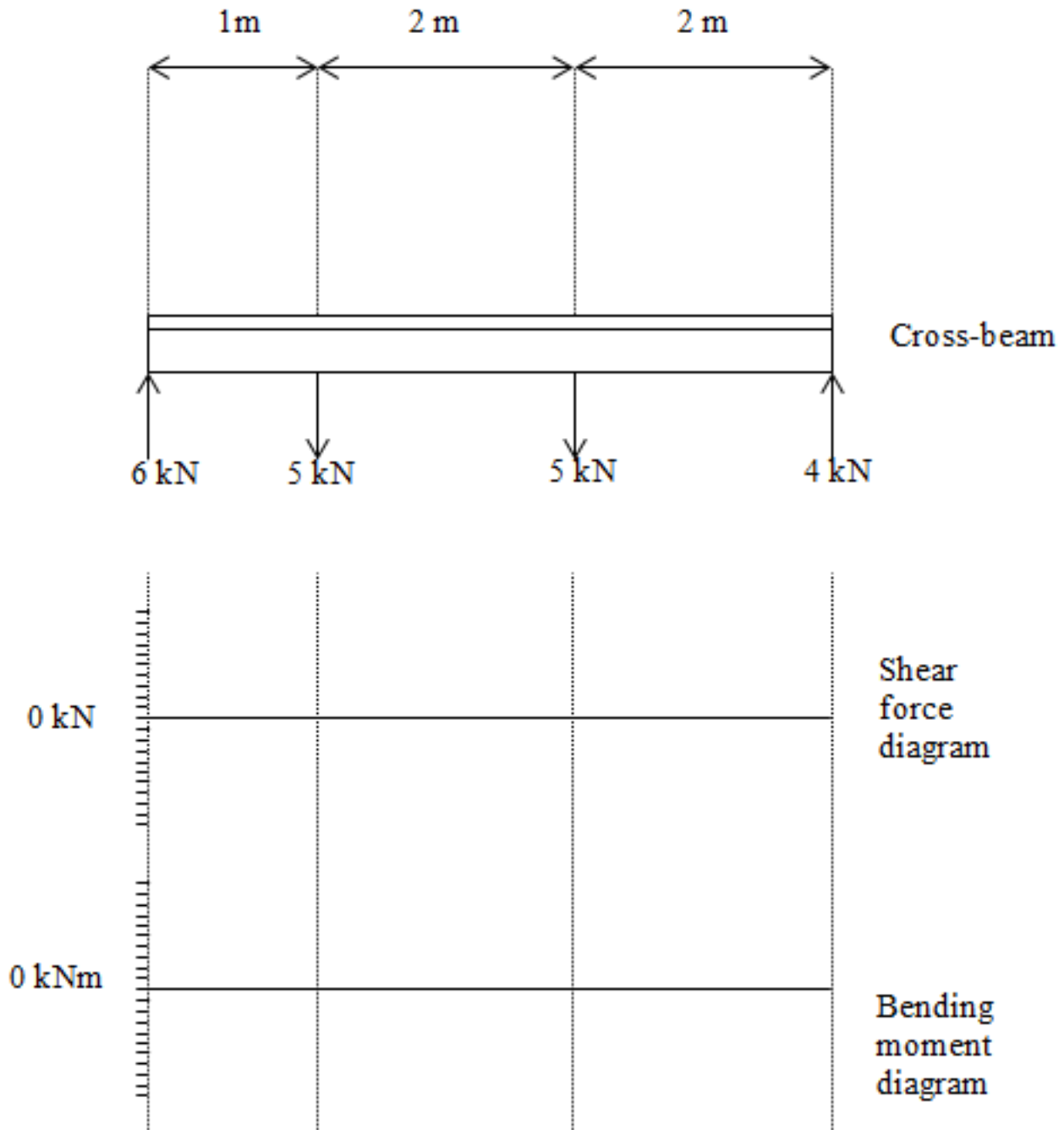
Question 22 continues on the next page

Question 22 (continued)

Marks

A structural beam in the aircraft has the loads applied as shown.

- (c) Construct a shear force and a bending moment diagram of the beam on the axes provided below the beam. 4

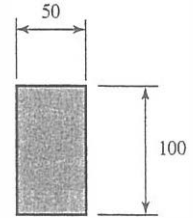


Question 22 continues on the next page

## Question 22 (continued)

Marks

For another loading situation, the beam in (c) has a maximum bending moment of 10 kNm and is 100 mm deep and 50 mm wide as shown. The second moment of area of the beam is  $2.0 \times 10^6 \text{ mm}^4$ .



- (d) Calculate the bending stress in the beam.

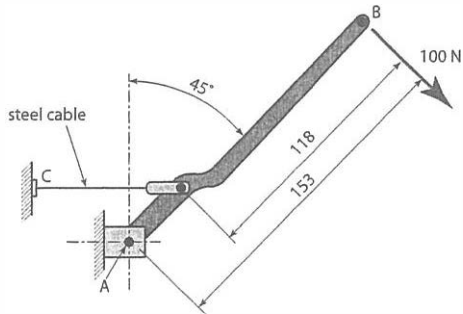
2

Bending stress in the beam = .....

**End of Question 22**

**Question 23** (12 marks)**Marks**

A lever is pivoted at A and supports a 100 N load at B. The structure is kept in equilibrium by a steel cable anchored at C as shown.



- (a) Determine the force in the steel cable and state whether it is tension or compression. **3**

Force in the cable = .....

- (b) Determine the force acting at the pivot A when the 100 N force acts at B. **4**

Force acting at the pivot A = .....

Question 23 continues on the next page

Question 23 (continued)

**Marks**

For another loading situation, the force in the steel cable is 2.5 kN and the strength of the cable is 200 MPa.

- (c) Determine a suitable diameter in mm, for the steel cable when the force in the cable is 2.5 kN. **3**

Diameter of the steel cable = .....mm

- (d) Determine the mechanical advantage of the lever if the efficiency of the system is 85%. **2**

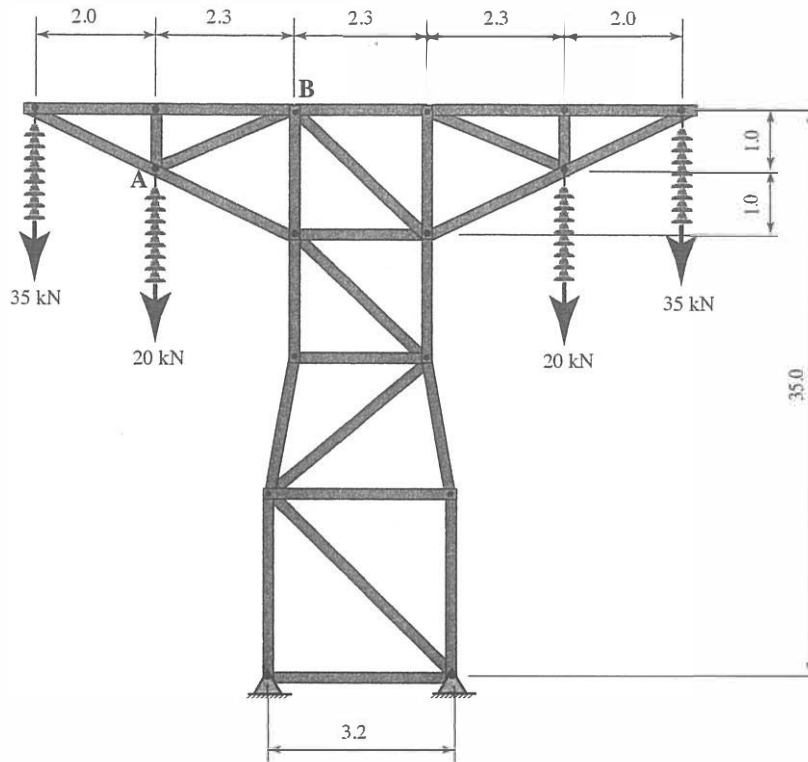
Mechanical advantage of the lever = .....

**End of Question 23**

**Question 24** (12 marks)

**Marks**

A lattice framed tower used for the transmission of high voltage electricity is shown. The forces on the tower result from the weight force of the four high voltage transmission cables that hang from the insulators. The tower rests on four pin jointed reactions.



- (a) Calculate the forces in the four pin jointed reactions at the base of the tower due to the loads exerted by the weights of the four high voltage conductors. Ignore the mass of the tower. 2

Reactions in the four pin joints at the base of the tower = .....

Question 24 continues on the next page



Question 24 (continued)

Marks

High voltage ceramic suspension insulator strings, as shown, can be manufactured by die pressing (or dust pressing).



- (c) Explain the process of die pressing and suggest an appropriate ceramic material for the insulator discs used in high voltage ceramic suspension insulator strings.

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Ceramic material used for suspension insulator strings: .....

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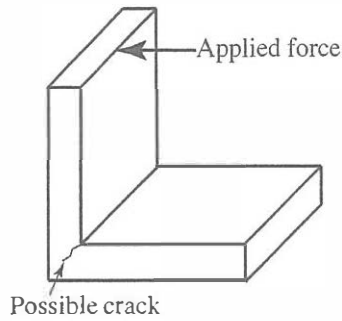
**End of Question 24**



**Question 25** (12 marks)

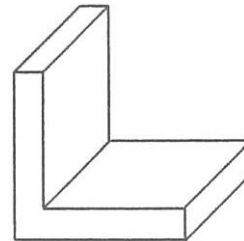
**Marks**

A bracket has a force applied as shown. A crack could form at the inside corner of the bracket due to the applied load.

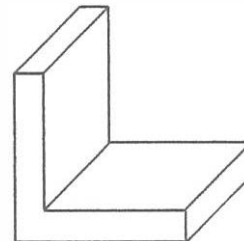


- (a) Explain and sketch on the drawings provided, two variations in the design of the bracket that will increase the resistance to cracking at the inside corner of the bracket when loaded as shown. 4

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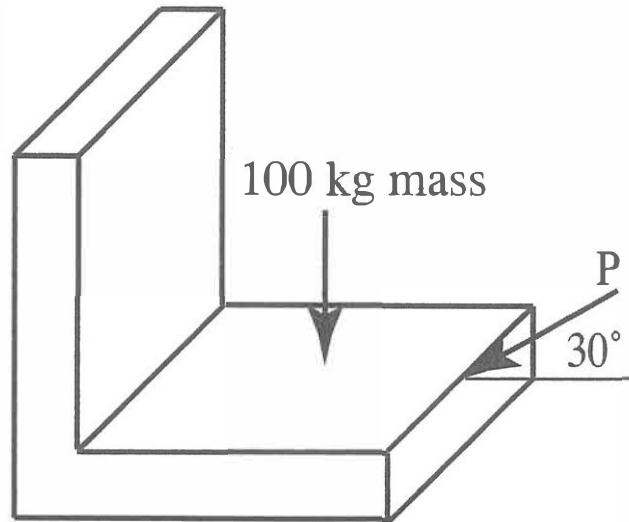
Question 25 continues on the next page

Question 24 (continued)

Marks

A mass of 100 kg has been applied to the bracket as shown.

- (b) Determine the force,  $P$ , acting at  $30^\circ$  to the horizontal, to just get the bracket on the verge of sliding. The coefficient of friction of the two contact surfaces is 0.4. **4**

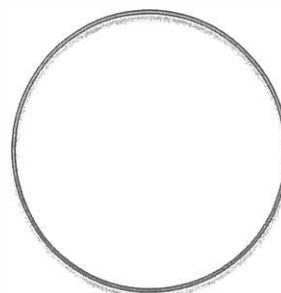


The bracket may be manufactured from grey cast iron or pearlitic malleable cast iron.

- (c) Sketch and label the microstructures of grey cast iron and pearlitic malleable cast iron. **4**



Grey cast iron microstructure



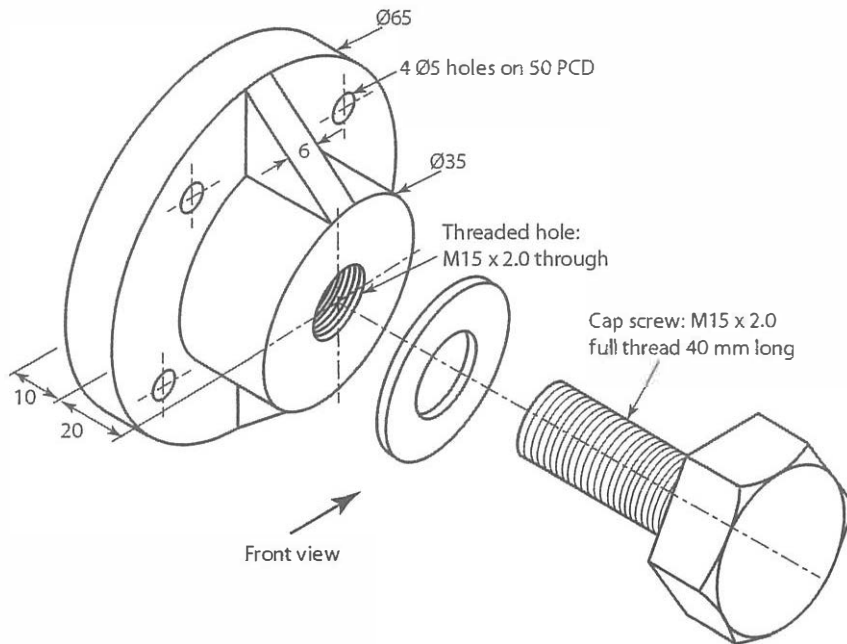
Pearlitic malleable cast iron microstructure

**End of Question 25**

**Question 26** (10 marks)**Marks**

An exploded pictorial drawing of an anchor used to secure cables for a radio mast is shown.

- (a) Sketch an orthogonal drawing showing a sectioned front view and a right side view, with the parts assembled using a scale of 1:1. The cap screw is to be placed 20 mm into the threaded hole. The washer is to be positioned under the head of the cap screw. Do not dimension the drawing. Use the centre line below for your drawing. 6



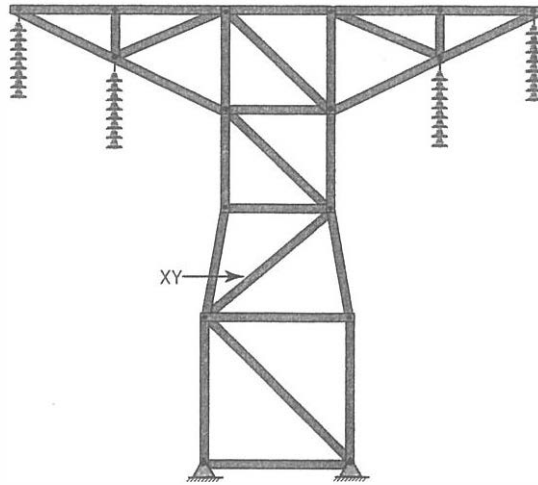
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Question 26 continues on the next page

Question 26 (continued)

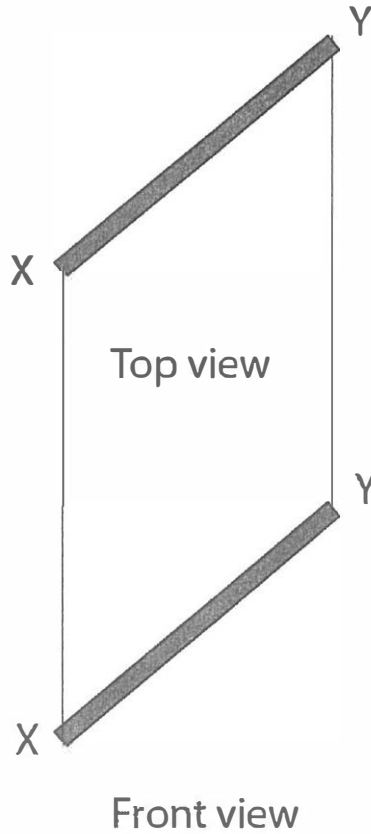
Marks

A bar, XY, used as a component in the lattice frame on a high voltage transmission tower is shown below.



- A top and front view of the bar, as it is positioned in the tower, are provided below.
- (b) Show, by construction on the diagram provided, how to determine the true length of the bar XY.

2



Question 26 continues on the next page

Question 26 (continued)

**Marks**

A hydraulic cylinder is used to position high voltage wires onto the tower insulators. The internal diameter of the cylinder is  $\text{Ø}100$  and the pressure in the hydraulic system is 12 MPa.

- (c) Calculate the force produced by the hydraulic cylinder. **2**

Force produced by the hydraulic cylinder = .....

**End of Question 25**

[Empty box for student number]

**Question 27** (10 marks)

**Marks**

(a) Name and describe two common applications of wireless technology. 4

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## 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

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

### Pressure

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

### Stress and Strain

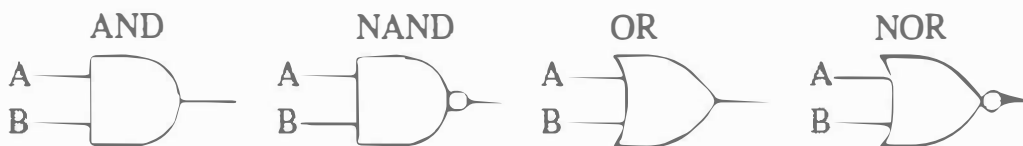
$$\sigma = \frac{F}{A}; \quad \epsilon = \frac{e}{L}; \quad E = \frac{\sigma}{\epsilon}; \quad \sigma = \frac{My}{I}$$

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

### Machines

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

### Digital Electronics



### Electricity, Electronics

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

$$\text{Series } R_1 = R_1 + R_2 + R_3 + R_4 \dots + R_n$$

$$\text{Parallel } \frac{1}{R_1} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \dots + \frac{1}{R_n}$$