



**2016**  
**Higher School Certificate**  
**Half Yearly Examination**

# Engineering Studies

## General Instructions

- Reading time – 5 minutes
- Working time – 2 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 separately

## Total marks – 78

### Section I

Total marks (20)

Attempt Questions 1 – 20

Allow about 30 minutes for this section

### Section II

Total marks (58)

Attempt Questions 21-26

Allow about 90 minutes for this section

Answer all questions on the examination paper,  
except for the Multiple Choice questions

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

STUDENT NUMBER: .....

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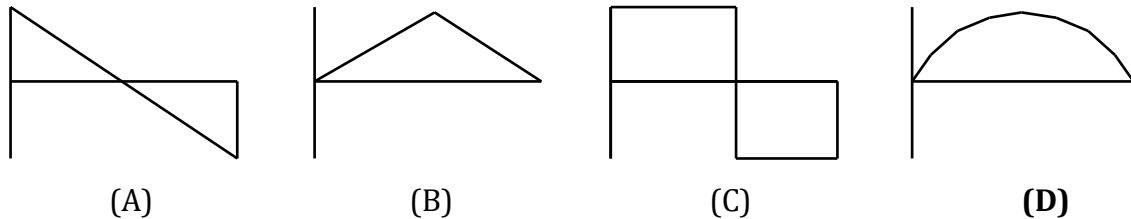
**Section I****Total marks (20)****Attempt Questions 1 – 20****Allow about 30 minutes for this part**

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space in the separate answer sheet at the end of this paper, and insert this loose sheet in your paper at the end.

1. Which best describes the microstructure of grey cast iron?

- (A) Graphite rosettes in a metal matrix
- (B) Cementite grains in a ferrite matrix
- (C) Graphite nodules in a pearlite matrix
- (D) Graphite flakes in a pearlite or ferrite matrix

2. Which of the four bending moment diagrams below most accurately demonstrates a beam with only uniformly distributed load (UDL) acting?



3. A  $\text{Ø}10$  mm hole is to be punched through an 8 mm thick steel plate that has a shear strength of 250 MPa. What is the compressive stress in the punch during the punching operation?

- (A) 525.5 MPa
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4. A bolt is shown on an engineering drawing as M15x1.5. What is the correct description of this bolt?

- (A) Metric thread profile, 15 mm diameter, 1.5 mm thread pitch
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- (C) Millimetre dimensions, 15 mm long, 1.5 mm thread lead
- (D) Martensite structure, 15 mm head thickness, 1.5 mm clearance required

5. Which of the following describes 'spalling' or 'concrete cancer'?
- (A) Breaking away of surface layers of concrete due to corrosion of the reinforcement bars mainly as a result of too little surface coverage of concrete
  - (B) Cracking of surface layers of cement due to the reinforcement not being sufficiently clean before placing the cement
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6. Which best describes the structure of thermosetting polymers?
- (A) Secondary bonds along and between the molecules forming a three dimensional net-like structure
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7. What are the main consequences of crystallisation in polymers?
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8. A  $\varnothing 15\text{mm}$  bar, 1 metre long, is subjected to a tensile load of 21 kN. The modulus of stiffness (E) of the bar is 290 GPa.

What is the extension of the bar due to the applied force?

- (A) 0.41 mm
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9. The diagram shows a ceramic insulator.

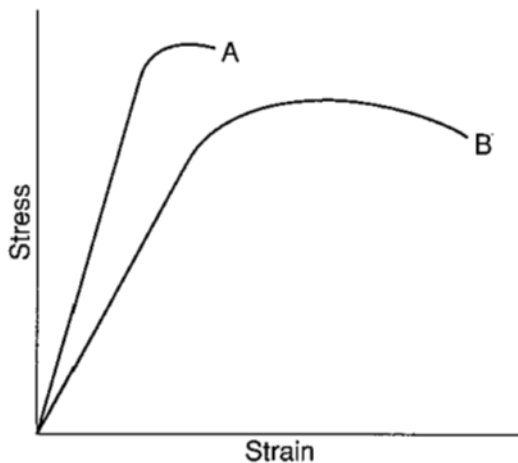


Why do ceramic insulators have this design?

- (A) This shape can be extruded.
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10.

The following stress-strain diagram shows the graph for some different materials.



- (A) material A is stiffer, stronger and tougher than material B
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11. Detection of an internal crack in a safety mechanism on a train is best found

- (A) Ultrasonics
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12. Two plain carbon steel microstructures are shown below. Material 1 has 0.16% carbon and material 2 has 0.8% carbon.



1. 0.16% Carbon



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Which statement best describes the relative mechanical properties of each material?

- (A) Material 1 is soft and strong; material 2 is more malleable and stronger.
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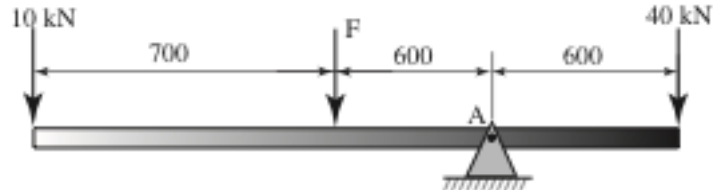
- (A) 30°
- (B) 40°
- (C) 20°
- (D) 50°

14. A hydraulic jack has an effort (input) piston diameter of  $\varnothing 12$  mm and a load (output) piston diameter of  $\varnothing 70$  mm.

What is the velocity ratio (VR) of the hydraulic system?

- (A) 5.83
- (B) 13.2
- (C) 44.5
- (D) 34

15. To keep the lever horizontal, what is the force,  $F$ , acting on the lever pivoting at A when 10 kN and 40 kN forces act as shown?



- (A) 10.0 kN  
(B) 17.5 kN  
(C) 18.3 kN  
(D) 30.1 kN
16. Calculate the current in an electrical circuit that has 100 V potential difference and 1 k $\Omega$  resistance?
- (A) 100 mA  
(B) 100 A  
(C) 200 mA  
(D) 250 mA
17. What will increase the force of friction between two surfaces?
- (A) Lubricate the two surfaces  
(B) Reduce the coefficient of friction of a surface  
(C) Reduce the normal reaction of the two surfaces  
(D) Increase the normal reaction of the two surfaces
18. What are the four generally accepted headings for a materials/parts list on drawings?
- (A) Date, scale, drawn by, cost  
(B) Item number, description, material, number required  
(C) Purchased by, checked by, name of company, material  
(D) Projection type, title of drawing, name of part, material cost

19. Heat treatment can be described as;

- (A) the adding of a material to obtain required properties the controlled
- (B) heating and cooling of a material to obtain required properties
- (C) the way a materials reacts when exposed to the natural elements
- (D) the controlled heating of a material to obtain its required properties

20. Corrosion is the chemical reaction between a material and the environment.  
Which is the best method of preventing corrosion?

- (A) Galvanising all parts of the structure
- (B) Use a sacrificial anode on all areas of possible corrosion
- (C) Eliminate potential corrosion sites during the design stage
- (D) Regularly apply a good quality corrosion resisting paint

**End of Section I**



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**Section II**

**Total marks (54)**

**Attempt Questions 21 - 26**

**Allow about 90 min for this section**

Answer the questions in the spaces provided.

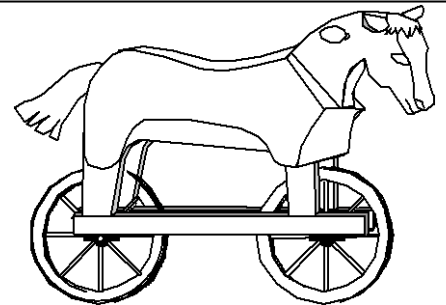
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**Marks**

**Question 11 — Historical and Societal Influences, and the Scope of the Profession**

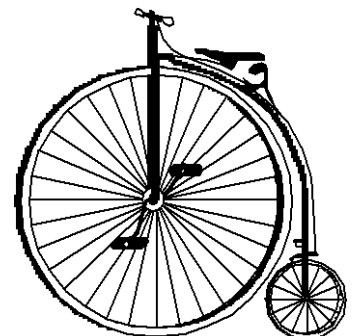
**(12 marks)**

Bicycles had their origins just over 200 years ago starting in 1791 with the appearance of a wooden two-wheeled 'toy' developed by the Count de Sivrac. It is difficult to say that this was the first bicycle but it did have two wheels and you could sit on it and push yourself along but it was never really a serious form of personal transport



Describe the improvements in performance, comfort and safety was in the following three bicycles compared to earlier designs. List the materials used in the construction of the frame and the wheels.

- (a) The ordinary or penny-farthing bicycle 1870



Improvements

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Materials used for:

Frame : \_\_\_\_\_

Wheels : \_\_\_\_\_

(b) A modern road bicycle



Improvements

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Materials used for:

Frame : \_\_\_\_\_

Wheels : \_\_\_\_\_

(c) A mountain bike – 2000



Improvements

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Materials used for:

Frame : \_\_\_\_\_

Wheels : \_\_\_\_\_

**End of Question 21**

**Question 22 – Civil Structures (10 marks)**

**Marks**

Two types of building, an old style from the 15<sup>th</sup> century and a modern style, are shown below:



- (a) Demonstrate, by using one example, how the development of materials has facilitated the construction of the modern style of building.

**2**

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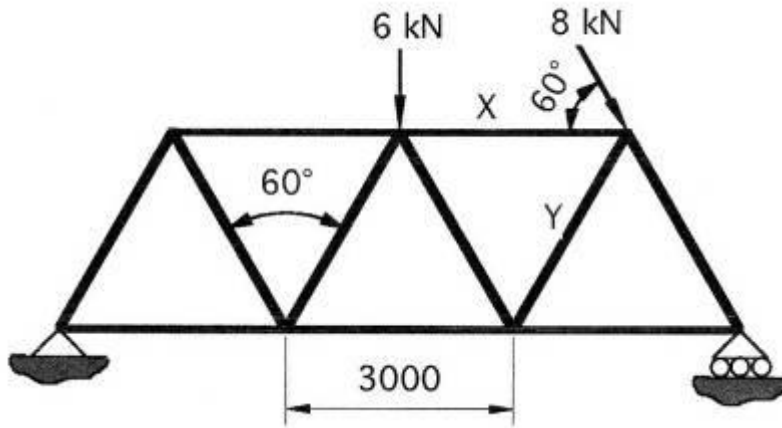
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**Question 22 continues on the next page**

Question 22 (continued)

Marks

A truss, one of many used to support a factory roof, is shown below.



- (b) Calculate the reaction force at the roller support on the right of the truss. 2

Reaction force at the roller support = ..... kN

- (c) Determine the force in EITHER member X OR Y of the truss and state the nature of the forces (ie. whether the member is in tension or compression). 2

Force in member X = ..... kN; Nature of force in member X = .....  
 Or: Force in member Y = ..... kN; Nature of force in member Y = .....

**Question 22 continues on the next page**

Question 22 (continued)

Marks

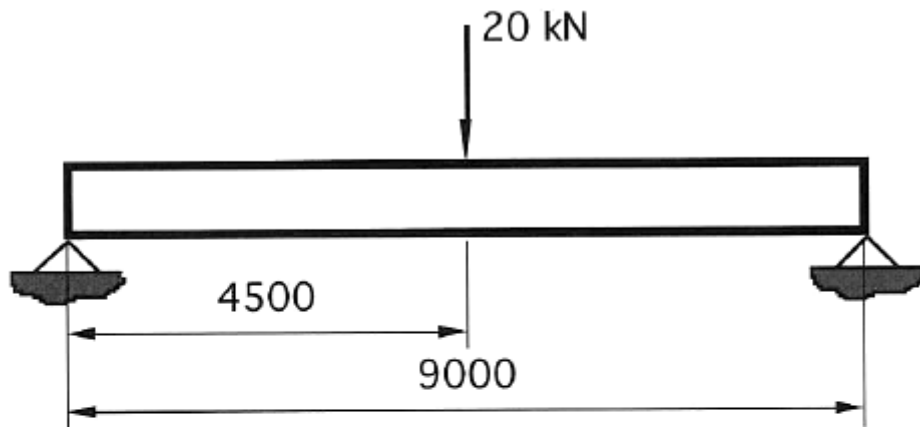
- (d) For a different loading system, the tensile force in one of the members of the truss is 30 kN and the cross sectional area of the member is 400 mm<sup>2</sup>. If the member extends 0.0009 m, calculate the Young's Modulus of the material used for the member.

2

Young's Modulus = ..... GPa

- (e) A simply supported beam is shown. Sketch the bending moment diagram on the diagram provided.

2



End of Question 22

**Question 23 – Personal and Public Transport (10 marks)**

**Marks**

Observe the following image which shows a single person, three wheeled electric car being recharged at a battery charging outlet in a large European city.



- (a) State ONE environmental advantage AND ONE environmental disadvantage of using this form of transport in large cities.

**2**

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- (b) Electric motors have many advantages other than environmental ones.

Explain ONE significant *non-environmental* advantage for using electric motors to power motor vehicles.

**1**

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**Question 23 continues on the next page**

Question 23 (continued)

(c) Electric motors are used widely in engineering.

Explain how electric motors convert electrical energy into mechanical energy. **2**

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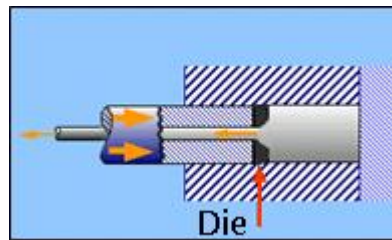
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(d) Observe the following image which shows a forming process.



Identify the process and give an example of what type of component can be made using this process. **2**

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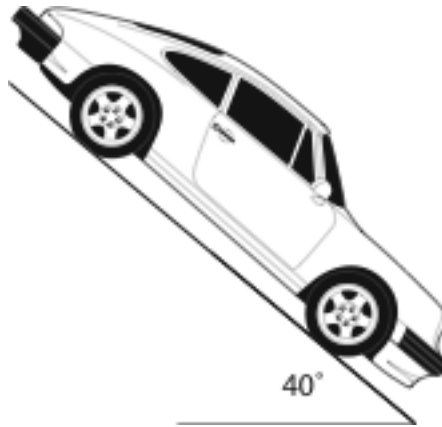
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**Question 23 continues on the next page**

Question 23 (continued)

**Marks**

- (e) A motor vehicle is held by the handbrake on a steep incline at  $40^\circ$  to the horizontal, as shown in the following diagram.



If the car has a mass of 1.5 tonne and is on the verge of sliding, what is the coefficient of friction between its tyres and the inclined surface?

**1**

Coefficient of friction = .....

- (f) A car of mass 1.5 tonne uses 115 kW of power to accelerate up to 100 km/h in 10 seconds on a level surface.

Calculate the power required by the brakes to stop the car in 4 seconds.

**2**

Power required by the brakes = .....

**Question 23 continues on the next page**

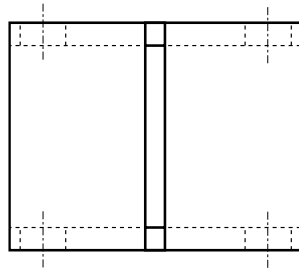


**Question 24 - Drawing (4 marks)**

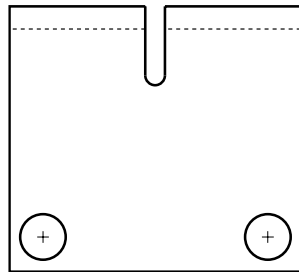
**Marks**

The top bracket from a scissor jack is shown below.  
 Taking sizes from the orthogonal drawing, sketch a pictorial drawing of the bearing plate so that maximum detail is shown.

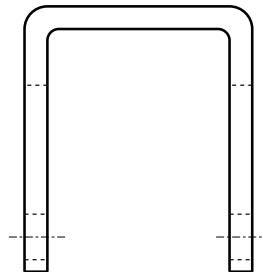
**4**



Top view



Front view



Right side view

**End of Question 23**

**Question 25 – Engineering and the Engineering Report (12 marks)**

**Marks**

The bridge shown below is a cantilever bridge with a suspended span which is shown being placed during construction in the photograph on the right. The bridge spans a deep, fast moving waterway.



- (a) The suspended span is a prestressed concrete section that was pre-tensioned off-site. Contrast pre-tensioning and post-tensioning of concrete.

**2**

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**Question 25 continues on the next page**

Question 25 (continued)

Marks

- (b) The suspended span on the bridge curves upwards as shown in the picture below. Suggest a structural reason why the roadway surface of the suspended span is not aligned with the rest of the bridge. 2



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- (c) The bridge guard rail is attached by two bolts on its anchorage as shown below. Suggest whether the roadway is in the foreground or background giving a reason for your suggestion. 2



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**Question 25 continues on the next page**

## Question 25 (continued)

Marks

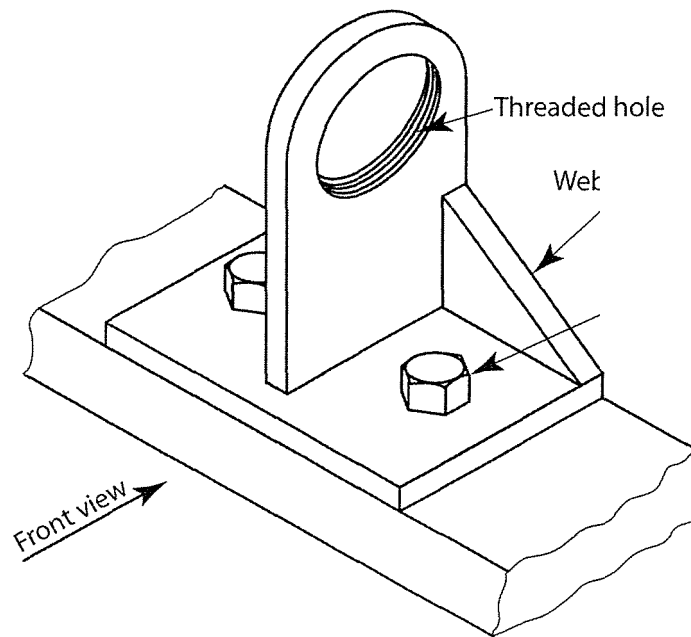
6

- (d) A pictorial drawing of a bracket with webs and a threaded hole is shown. The bracket is attached to a metal base by two hexagonal head cap screws. Sketch in third angle orthogonal projection, a front view and a right side view of the bracket. The front view is to be viewed from the direction shown.

Omit all hidden detail in both views.

Do not include any dimensions.

Take sizes directly from the pictorial drawing.



**End of Question 25**

**Question 26 – Engineering and the Engineering Report (10 marks)**

**Marks**

Shown below is a cable-stayed pedestrian walkway servicing a major shopping centre. It passes over a busy roadway and provides ramps for easy access to the walkway.



- (a) In an engineering report, what criteria might an engineer use to determine the type of external finish that should be applied to the structure? 2

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**Question 26 continues on the next page**

Question 26 (continued)

**Marks**

The nature of stresses within a structure such as this walkway include; tensile, compression, shear, torsion and bending.

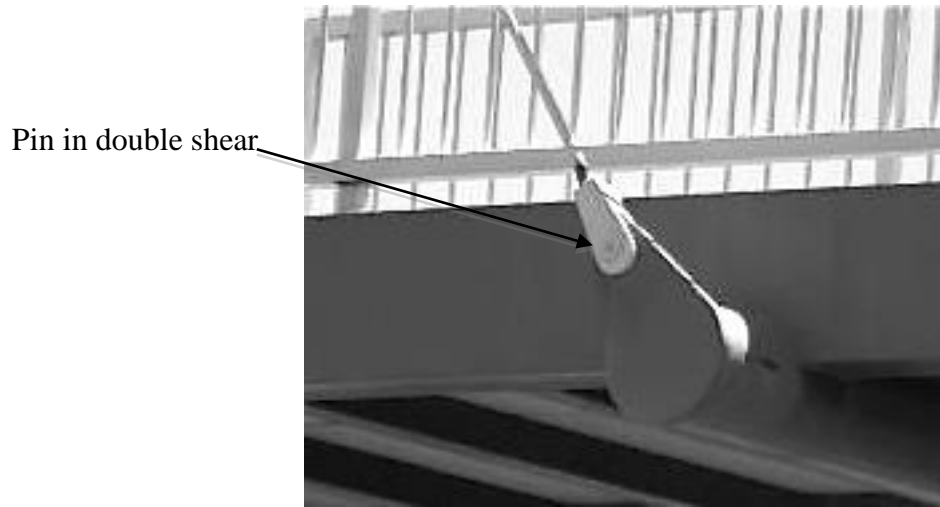
- (b) State the mode of stress (compression or tension) that would be predominant in the tower. As well, state the mode of stress (compression or tension) that would be predominant in the walkway support cables. **2**

.....  
.....

- (c) Using a force diagram, justify why the force in the cables anchored further from the towers support more load than those closer to the towers. **2**

**Question 26 continues on the next page**

The anchorage of one of the walkway cables to the deck of the image above is shown;



- (d) If the  $\text{Ø}20$  pin is in double shear and the force in the cable is 15 kN, calculate the shear stress acting on the pin.

2

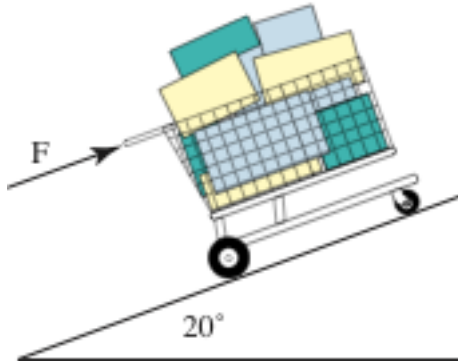
Shear stress in the pin = .....

**Question 26 continues on the next page**

Question 26 (continued)

**Marks**

- (e) The ramps leading to the walkway are inclined at  $20^\circ$ . Calculate the force (F) required to hold the 30 kg shopping trolley on the ramp if the fictional resistance of the wheels and axles on the trolley is 15 N.

**2**

Force = .....

**End of Question 26****End of paper**



STUDENT NUMBER: .....

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## Engineering Studies

### FORMULAE SHEET

#### Force, Moments

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

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

#### 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

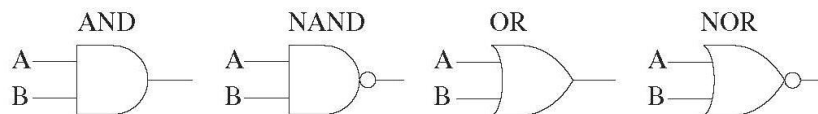
$$\sigma = \frac{F}{A}; \quad \epsilon = \frac{e}{L}; \quad E = \frac{\sigma}{\epsilon}; \quad \sigma = \frac{My}{I}$$

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

#### Machines

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

#### Digital electronics



#### Electricity, Electronics

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

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

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

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<b>1</b>				
<b>2</b>				
<b>3</b>				
<b>4</b>				
<b>5</b>				
<b>6</b>				
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<b>16</b>				
<b>17</b>				
<b>18</b>				
<b>19</b>				
<b>20</b>				

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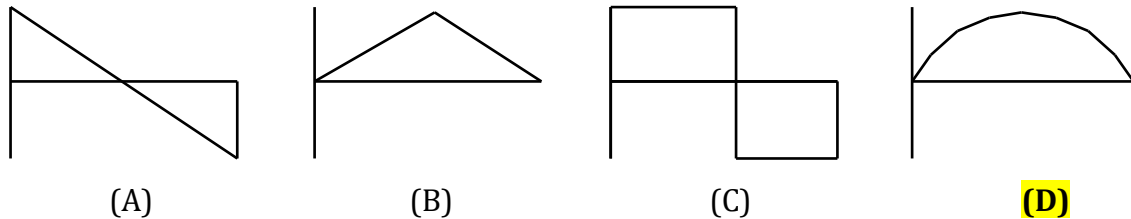
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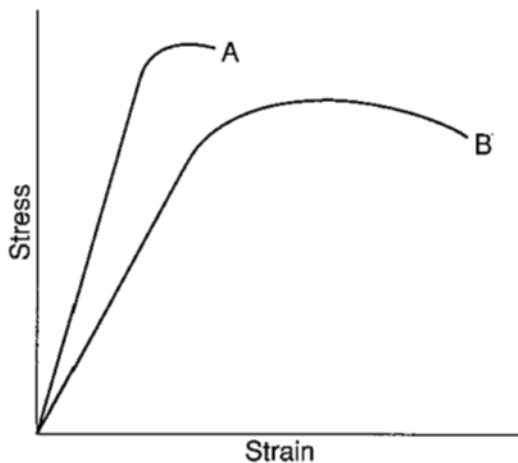


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13. Which is the correct angle of repose for rock fill used on a highway construction that has a combined coefficient of friction ( $\mu$ ) of 0.84?

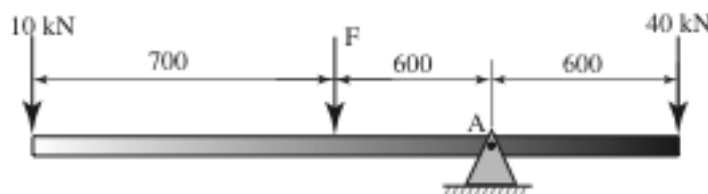
- (A) 30°  
 (B) 40°  
 (C) 20°  
 (D) 50°

14. An hydraulic jack has an effort (input) piston diameter of  $\varnothing 12$  mm and a load (output) piston diameter of  $\varnothing 70$  mm.

What is the velocity ratio (VR) of the hydraulic system?

- (A) 5.83  
 (B) 13.2  
 (C) 44.5  
 (D) 34

15. To keep the lever horizontal, what is the force,  $F$ , acting on the lever pivoting at A when 10 kN and 40 kN forces act as shown?



- (A) 10.0 kN  
(B) 17.5 kN  
(C) 18.3 kN  
(D) 30.1 kN
16. Calculate the current in an electrical circuit that has 100 V potential difference and 1 k $\Omega$  resistance?
- (A) 100 mA  
(B) 100 A  
(C) 200 mA  
(D) 250 mA
17. What will increase the force of friction between two surfaces?
- (A) Lubricate the two surfaces  
(B) Reduce the coefficient of friction of a surface  
(C) Reduce the normal reaction of the two surfaces  
(D) Increase the normal reaction of the two surfaces
18. What are the four generally accepted headings for a materials/parts list on drawings?
- (A) Date, scale, drawn by, cost  
(B) Item number, description, material, number required  
(C) Purchased by, checked by, name of company, material  
(D) Projection type, title of drawing, name of part, material cost
19. Heat treatment can be described as;
- (A) the adding of a material to obtain required properties the controlled  
(B) heating and cooling of a material to obtain required properties  
(C) the way a materials reacts when exposed to the natural elements  
(D) the controlled heating of a material to obtain its required properties
20. Corrosion is the chemical reaction between a material and the environment. Which is the best method of preventing corrosion?
- (A) Galvanising all parts of the structure  
(B) Use a sacrificial anode on all areas of possible corrosion  
(C) Eliminate potential corrosion sites during the design stage  
(D) Regularly apply a good quality corrosion resisting paint

STUDENT NUMBER: .....

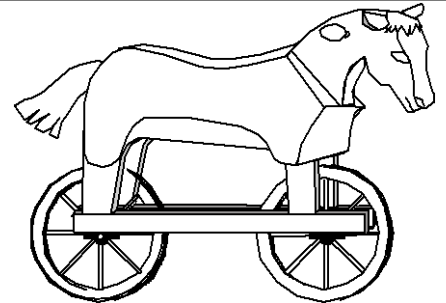
**End of Section I**

**Section II****Total marks (54)****Attempt Questions 21 – 26****Allow about 90 min for this section**

Answer the questions in the spaces provided.

**Marks****Question 11 — Historical and Societal Influences, and the Scope of the Profession  
(12 marks)**

Bicycles had their origins just over 200 years ago starting in 1791 with the appearance of a wooden two-wheeled 'toy' developed by the Count de Sivrac. It is difficult to say that this was the first bicycle but it did have two wheels and you could sit on it and push yourself along but it was never really a serious form of personal transport



Describe the improvements in performance, comfort and safety was in the following three bicycles compared to earlier designs. List the materials used in the construction of the frame and the wheels.

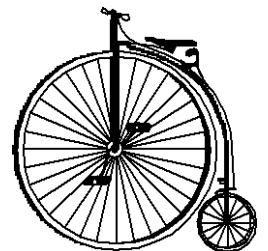
- (a) The ordinary or penny-farthing bicycle 1870

**Improvements**

large front wheels  
thin wrought iron spokes absorbs shock  
hollow wrought iron forks  
increased speed.  
braked rear wheel.

**Materials used**

wrought iron  
rubber  
leather seat.



(b) A modern road bicycle



Improvements

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---

Materials used for:

Frame : \_\_\_\_\_

Wheels : \_\_\_\_\_

(c) A mountain bike – 2000



Improvements

*aluminium alloy elliptical frame*

*front of rear suspension*

*lower front of rear tyre*

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Materials used

*Aluminium alloy*

*chrome moly bdenium alloy steel*

*carbon fibre*

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End of Question 21

**Question 22 – Civil Structures (12 marks)****Marks**

Two types of building, an old style from the 15<sup>th</sup> century and a modern style, are shown below:



- (a) Demonstrate, by using one example, how the development of materials has facilitated the construction of the modern style of building.

**2**

*Old style used ceramic which has a high compressive strength (such as stone) but the knowledge of the day was limited regarding tensile forces. The new style of building uses materials with a high tensile strength such as structural steels which were not available during the 15th century, allowing for increased height and greater structural strength of building.*

*(Glass could be another appropriate example)*

**Marking Guidelines**

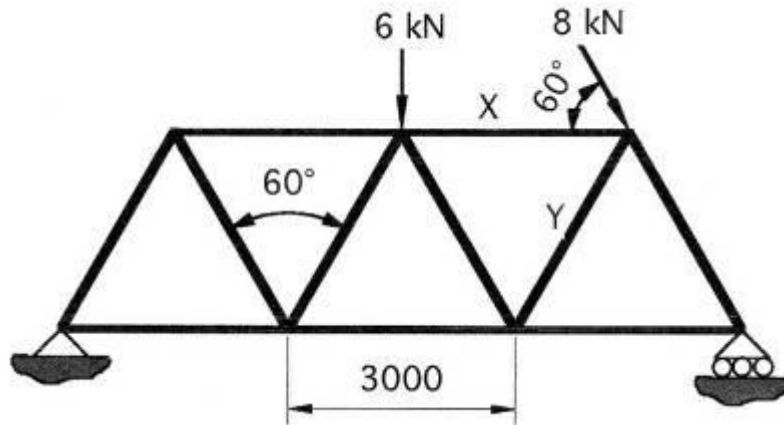
<b>Criteria</b>	<b>Marks</b>
Displays extensive knowledge and understanding by providing one example and applies it to both styles of building	2
Displays sound knowledge and understanding by providing one example but does not adequately relate it to both styles of building	1

**Question 22 continues on the next page**

## Question 22 (continued)

Marks

A truss, one of many used to support a factory roof, is shown below.



- (b) Calculate the reaction force at the roller support on the right of the truss. 2

$$\begin{aligned} \sum M_{Rl} &= 0 \text{ (clock +)} \\ (6 \times 4.5) + (4 \times 2.6) + (6.93 \times 7.5) - (R_r \times 9) &= 0 \\ \therefore R_r &= 9.93 \text{ kN } \uparrow \end{aligned}$$

## Marking Guidelines

Criteria	Marks
Calculates the correct force and sense/direction at the roller reaction	2
Correctly uses the equilibrium of moments concept OR initiates moments about Rl	1

- (c) Determine the force in EITHER member X OR Y of the truss and state the nature of the forces (ie. whether the member is in tension or compression). 2

$$\begin{aligned} \sum M_a &= 0 \text{ (clock +)} ; a = \text{joint where Y meets bottom chord; assume tension} \\ -(9.93 \times 3) - (X \times 2.6) + (8 \times 2.6) &= 0 \\ X &= -3.46 \text{ kN compression} \end{aligned}$$

$$\begin{aligned} \sum F_y &= 0 \text{ (}\uparrow\text{)} ; \text{breaking Y into components; assume tension} \\ -(0.866Y) - (6.93) + (9.93) &= 0 \\ Y &= 3.46 \text{ kN tension} \end{aligned}$$

## Marking Guidelines

Criteria	Marks
Correctly calculates force in member X OR Y and their nature	2
Initiates and equilibrium statement OR a mathematical error	1



Question 22 (continued)

**Marks**

- (d) For a different loading system, the tensile force in one of the members of the truss is 30 kN and the cross sectional area of the member is 400 mm<sup>2</sup>. If the member extends 0.0009 m, calculate the Young's Modulus of the material used for the member.

**2**

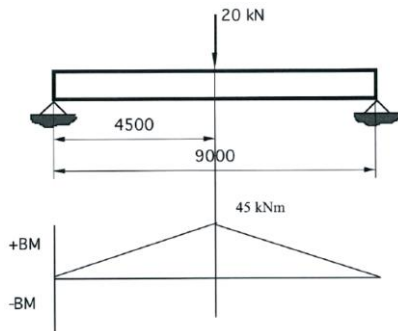
$$E = Fl/eA = 30 \times 10^3 \times 3 / 9 \times 10^{-4} \times 400 \times 10^{-6}$$

$$\therefore E = 250 \text{ GPa}$$

**Marking Guidelines**

Criteria	Marks
Correctly calculates Young's Modulus	2
Uses the PLEA formula OR makes a mathematical error with correct method	1

- (e) A simply supported beam is shown. Sketch the bending moment diagram on the axes below the diagram showing the value of the maximum bending moment. **2**



**Marking Guidelines**

Criteria	Marks
Calculates correct BM and shows correct diagram	2
Calculates BM OR shows correct diagram	1

**Question 23 – Personal and Public Transport (10 marks)****Marks**

Observe the following image which shows a single person, three wheeled electric car being recharged at a battery charging outlet in a large European city.

(a)

State ONE environmental advantage AND ONE environmental disadvantage of using this form of transport in large cities.

*Suggested answer: Environmental advantages: less pollution of cities, less impact on natural resources, Environmental disadvantages: increased pollution at power station, increase vehicle density in cities, provision of charging bays in cities, one person one vehicle etc*

S

2

Marking Criteria	Marks
Displays good knowledge and understanding by clearly stating one environmental advantage AND one environmental disadvantage	2
Displays good knowledge and understanding by clearly stating one environmental advantage OR one environmental disadvantage	1

**Question 23(b)**

*Suggested answer: Electric motors have torque independent of RPM so do not need gearboxes; no need for differential if motors are on each wheel, less moving parts than ICE; rotary motion rather than reciprocating motion, easier to maintain & more efficient than ICE etc*

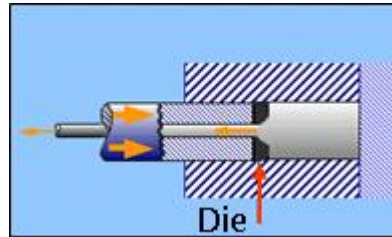
Marking Criteria	Marks
Explains one significant advantage of using electric motors to power motor vehicles.	1

Question 23 (continued) **Question 23(c)**

*Suggested answer: Current is supplied to a coil of wire (armature) which, when subjected to a magnetic field (stator), creates a torque resulting in the rotation of the armature.*

Marking Criteria	Marks
Displays good knowledge and understanding by clearly stating that current is supplied to the armature AND is rotated by the magnetic field.	2
Displays some knowledge of the process.	1

(d) Observe the following image which shows a forming process.



Identify the process and give an example of what type of component can be made using this process.

2

.....  
**Extrusion: Window frames in cars,**.....

Question 23 (continued)

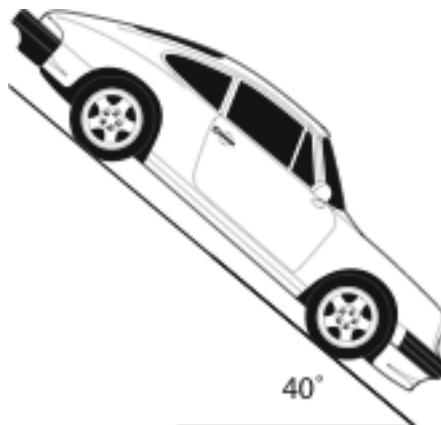
Marks

(e) A motor vehicle is held by the handbrake on a steep incline at 40° to the horizontal, as shown in the following diagram.

Marking Criteria	Marks
Correctly calculates the coefficient of friction	1

Suggested answer:

$$\tan 40^\circ = 0.84 = \mu$$



If the car has a mass of 1.5 tonne and is on the verge of sliding, what is the coefficient of friction between its tyres and the inclined surface?

1

- (f) A car of mass 1.5 tonne uses 115 kW of power to accelerate up to 100 km/h in 10 seconds on a level surface.

Calculate the power required by the brakes to stop the car in 4 seconds.

2

Marking Criteria	Marks
Correctly calculates the power to stop	2
Demonstrates some knowledge that power = energy / time	1

*Suggested answer:*

$$Power = KE/time = 0.5 \times 1.5 \times 10^3 \times (100/3.6)^2 / 4 = 144.68 \text{ kW}$$

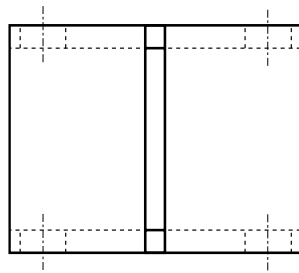
**Question 24 - Drawing (4 marks)**

**Marks**

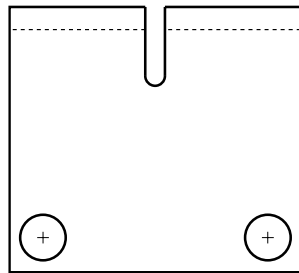
The top bracket from a scissor jack is shown below.

Taking sizes from the orthogonal drawing, sketch a pictorial drawing of the bearing plate so that maximum detail is shown.

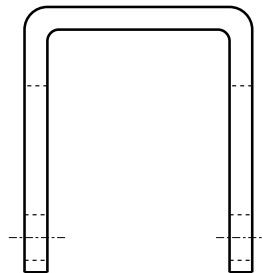
4



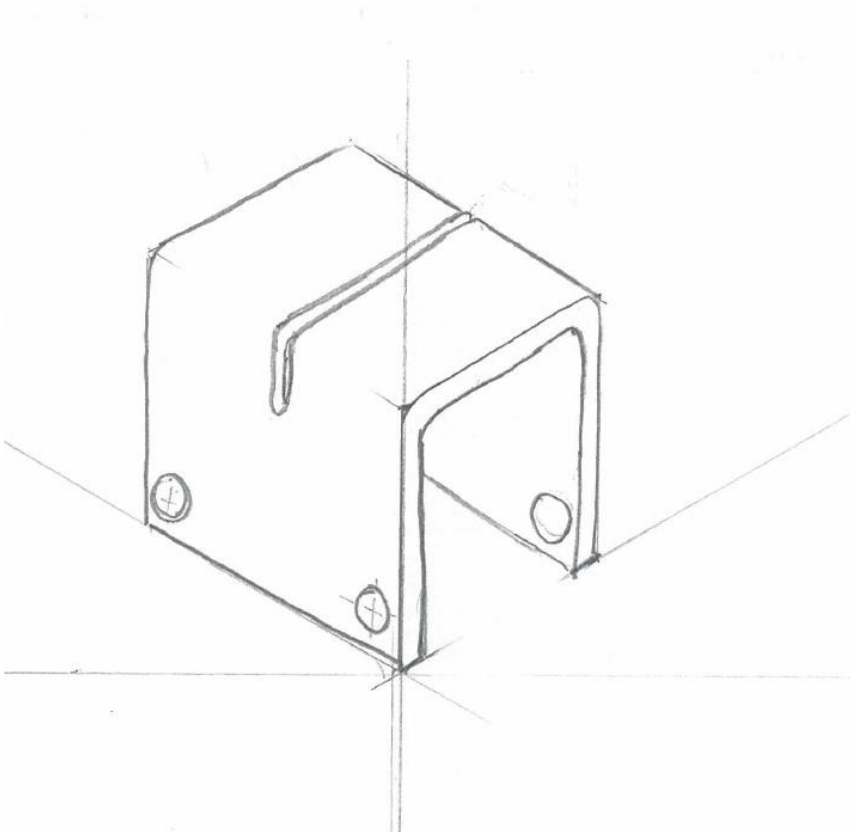
Top view



Front view



Right side view



**Question 25 – Engineering and the Engineering Report (12 marks)****Marks**

The bridge shown below is a cantilever bridge with a suspended span which is shown being placed during construction in the photograph on the right. The bridge spans a deep, fast moving waterway.



- (a) The suspended span is a prestressed concrete section that was pre-tensioned off-site. Contrast pre-tensioning and post-tensioning of concrete.

T

2

*Pre-tensioning is usually done off-site and the tendons are tensioned before the concrete is poured. Post-tensioning is done on-site and the tendons are tensioned after the concrete is placed and has cured. Pre-tensioned sections are smaller sections which can be transported to the site; post-tensioned sections are poured in situ or are preformed sections that are post-tensioned to other segments on the structure.*

**Marking Guidelines**

<b>Criteria</b>	<b>Marks</b>
Displays good knowledge and understanding by demonstrating clearly the difference between the two methods of pre-tensioning.	2
Displays limited knowledge and understanding by attempting to demonstrate the difference between the two methods of pre-tensioning.	1

Question 25 (continued)

Marks

- (b) The suspended span on the bridge curves upwards as shown in the picture below. Suggest a structural reason why the roadway surface of the suspended span is not aligned with the rest of the bridge.

2

*The suspended span is a pre-stressed pre-tensioned section and the pre-camber of the section during moulding was too large. When the suspended span was placed, the mass of the section was not great enough to eliminate the camber OR preformed to form an arch to increase compressive strength.*

**Marking Guidelines**

Criteria	Marks
Displays extensive knowledge and understanding by explaining a possible reason for the in-situ camber.	2
Displays some knowledge and understanding about pre-stressing and pre-cambering.	1

- (c) The bridge guard rail is attached by two bolts on its anchorage as shown below. Suggest whether the roadway is in the foreground or background giving a reason for your suggestion.

2

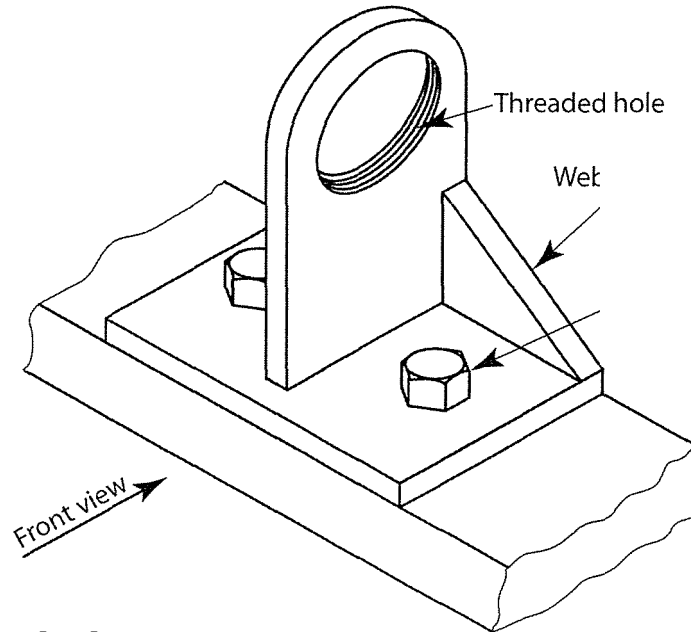


*The roadway is in the background because the largest bolt must be on the road side to resist the initial high moment of impact from a vehicle crashing into the guard rail. The smaller bolt provides only lateral support.*

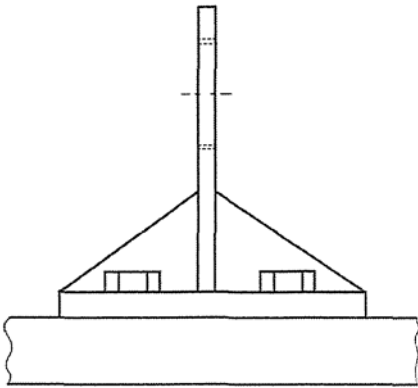
**Marking Guidelines**

Criteria	Marks
Displays good knowledge and understanding by explaining clearly the reason why the roadside is in the background.	2
Displays some knowledge and understanding of the forces on the guard rail anchorage.	1

- (d) A pictorial drawing of a bracket with webs and a threaded hole is shown. The bracket is attached to a metal base by two hexagonal head cap screws. Sketch in third angle orthogonal projection, a front view and a right side view of the bracket. The front view is to be viewed from the direction shown. Omit all hidden detail in both views. Do not include any dimensions. Take sizes directly from the pictorial drawing.



**REFER to 2015 Girra hyrly**





**Question 26 – Engineering and the Engineering Report (10 marks)****Marks**

Shown below is a cable-stayed pedestrian walkway servicing a major shopping centre. It passes over a busy roadway and provides ramps for easy access to the walkway.



- (a) In an engineering report, what criteria might an engineer use to determine the type of external finish that should be applied to the structure?

*Possible considerations: colour – aesthetics, blend with environment, consultation with locals/council etc; the type of surface to be coated – concrete/steel/stainless steel etc; corrosion resistance – and acceptable finish to provide low maintenance/durability; toxicity of the finish – to the public and environment etc*

**Marking Guidelines**

<b>Criteria</b>	<b>Marks</b>
Displays extensive knowledge and understanding by providing TWO acceptable criteria	2
Displays some knowledge and understanding by providing an acceptable response	1

Question 26 (continued)

**Marks**

The nature of stresses within a structure such as this walkway include; tensile, compression, shear, torsion and bending.

- (b) State the mode of stress (compression or tension) that would be predominant in the tower. As well, state the mode of stress (compression or tension) that would be predominant in the walkway support cables.

**2**

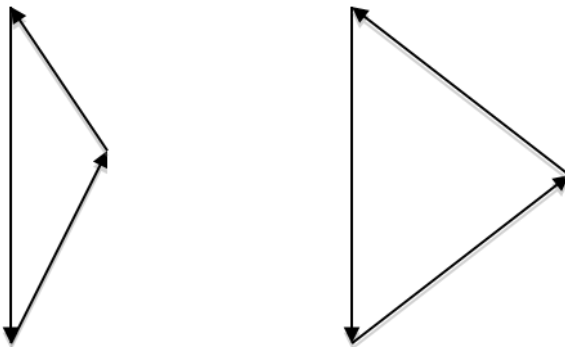
*Tower = compression; Cables = tension*

**Marking Guidelines**

Criteria	Marks
Correctly states BOTH types of stresses	2
Correctly states ONE type of stress	1

(c)

Using a force diagram, justify why the force in the cables anchored further from the towers support more load than those closer to the towers.



**2**

*Force diagram at left shows cables closer to the tower and shorter inclined vectors (force in cables). Force diagram on right shows longer inclined vectors representing larger forces in the cable further away from the towers.*

Criteria	Marks
Displays extensive knowledge and understanding by justifying the force difference WITH the use of a force diagram/s.	2
Displays some knowledge and understanding by providing one correct response	1

- (d) If the Ø20 pin is in double shear and the force in the cable is 15 kN, calculate the shear stress acting on the pin.

$$\sigma = P/Ax = 15 \times 10^3 / 2 \times \pi \times 10^2 \times 10^{-6} = 23.9 \text{ MPa}$$

**Marking Guidelines**

Criteria	Marks
Correctly calculates the shear stress in correct units	2
Displays some knowledge and understanding by providing one correct response	1

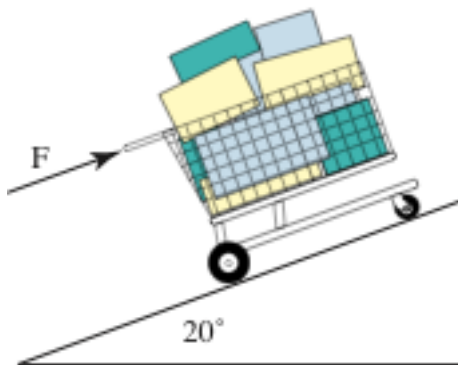
2

Question 26 (continued)

**Marks**

- (e) The ramps leading to the walkway are inclined at 20°. Calculate the force (F) required to hold the 30 kg shopping trolley on the ramp if the fictional resistance of the wheels and axles on the trolley is 15 N.

2



$$\sum F_{\text{along plane up}} = -mg \sin 20^\circ + 15 + F = 0; \therefore F = 300 \sin 20^\circ - 15 = 87.6 \text{ N}$$

**Marking Guidelines**

Criteria	Marks
Correctly calculates the force in correct units	2
Displays some knowledge and understanding by providing one correct response	1

STUDENT NUMBER: .....

Force = .....

**End of Question 26**

**End of paper**

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STUDENT NUMBER: .....

## Engineering Studies

### FORMULAE SHEET

#### Force, Moments

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

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

#### 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

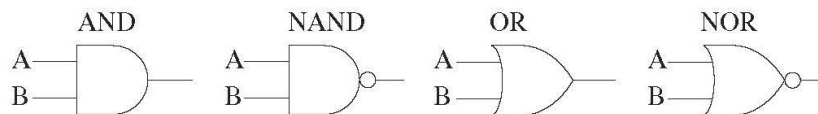
$$\sigma = \frac{F}{A}; \quad \epsilon = \frac{e}{L}; \quad E = \frac{\sigma}{\epsilon}; \quad \sigma = \frac{My}{I}$$

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

#### Machines

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

#### Digital electronics



#### Electricity, Electronics

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

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

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

STUDENT NUMBER: .....

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**Section I****Total marks (20)****Attempt Questions 1 - 20****Allow about 30 minutes for this part**

Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
1				
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