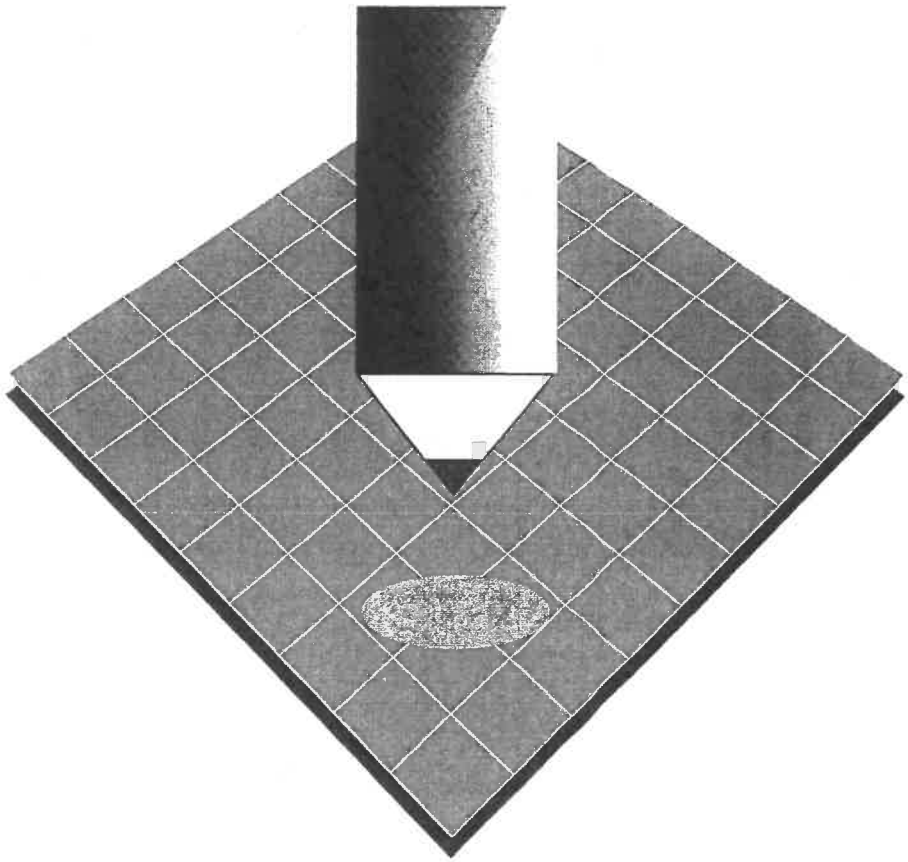
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STAGE 6

ENGINEERING STUDIES



TYPICAL HSC QUESTIONS & SOLUTIONS

JOHN ROCHFORD

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

John Rochford

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Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

Materials & Mechanics

1

Aim to complete each question many times in 2 years							
Question	**Page/s**	**Study register ✔**					
Multiple choice	3						
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Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

1. What are the *three primary bonds* which bond all materials?
   (A) Metallic bonds, covalent bonds, hydrogen bonds.
   (B) Ionic bonds, sulphur bonds, covalent bonds.
   (C) Ionic bonds, covalent bonds, metallic bonds.
   (D) Covalent bonds, Van der Waals bonds, metallic bonds.

2. Which statement best describes *ductility*?
   (A) The ability to be flattened by a compressive force without failing.
   (B) The ability to withstand an impact force without failing.
   (C) The ability to be stretched or drawn into wire by a tensile force without fracturing.
   (D) The ability to return to its original position and/or shape after removal of the deforming load.

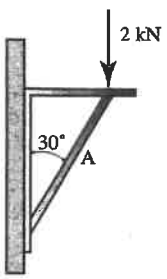
3. Which statement best describes a *face centred cubic structure* (FCC)?
   (A) Easier to deform and harder than a body centered cubic (BCC) structure.
   (B) Easier to deform than BCC structure because it has more slip planes and is less dense than the BCC structure.
   (C) Has 4 atoms per unit cell, is more dense therefore easier to deform than BCC structures.
   (D) Has 2 atoms per unit cell and is quite brittle.

4. Which statement best describes the result of *slow cooling of metals* from red heat?
   (A) Larger grains which generally results in a softer and weaker metal.
   (B) Larger grains which generally results in a harder and stronger metal.
   (C) Smaller and more numerous grains producing a harder and often a stronger metal.
   (D) Smaller and more numerous grains producing a harder and weaker metal.

5. Which statement best describes *work hardening of metals*?
   (A) Heating the metal until it is red hot and then quenching in water..
   (B) The 'tangling' of dislocations at grain boundaries, foreign atoms and other dislocations due to working such as hammering, rolling, bending and abrading.
   (C) Dislocations moving from one side of the metal to the other thereby distorting the metal.
   (D) Heating the metal until red hot and then cooling slowly in air.

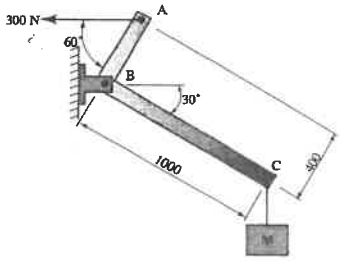
6. Which statement best describes the hierarchy of *waste management*?
   (A) Waste reduction followed by re-use, then recycling and finally disposal.
   (B) Re-use followed by waste reduction, then recycling and finally disposal.
   (C) Waste reduction followed by recycling, then re-use and finally disposal.
   (D) Waste reduction followed by disposal, then re-use and finally recycling.

7. What are the vertical and horizontal rectangular components of a 30 kN force acting upwards to the right at an angle of 30° to the horizontal?
   (A) Vertical = 15 kN up; horizontal = 26 kN right.
   (B) Vertical = 26 kN up; horizontal = 15 kN right.
   (C) Vertical = 15 kN down; horizontal = 26 kN right.
   (D) Vertical = 15 kN up; horizontal = 26 kN left.



8. What is the force in member A of the bracket when a 2 kN force acts as shown?
   (A) 23 N (B) 230 N (C) 2.3 kN (D) 23 kN

9. Assume the force in member A of the bracket shown above is 1 kN for a different loading situation. If member A is 15 mm wide, 8 mm thick and 300 mm long, what is the stress in member A?
   (A) 8.3 Pa (B) 8.3 MPa (C) 8.3 kN (D) 830 MPa

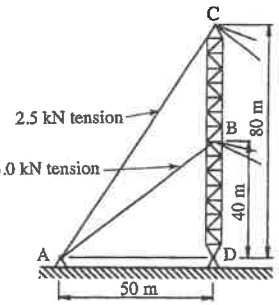


10. What is the mass, M, which will produce equilibrium on the bracket system if a force of 300 N is acting as shown?
    (A) 12 N (B) 12 kg (C) 120 N (D) 1.2 kN

Section II - Short structured response questions

Question 11

A tower is supported by a number of guy wires, two of which, AC and AB, are fixed to a bolt at A. Given that the tensions in AC and AB are as shown, determine the resultant force on the bolt at A.

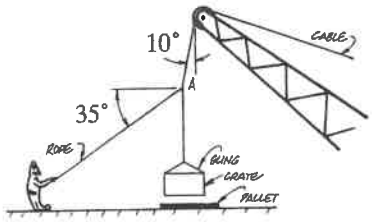


Question 12

A crane is lifting a crate of mass 500 kg and placing it onto a pallet. A rope is tied to the cable at point A and is pulled in the direction shown to locate the crate above the pallet. The angle between the rope and the horizontal is 35° whilst the cable is deflected 10° from the vertical.

(i) Draw and label a free body diagram about point A.

(ii) Determine the tension in the rope which the person is pulling.



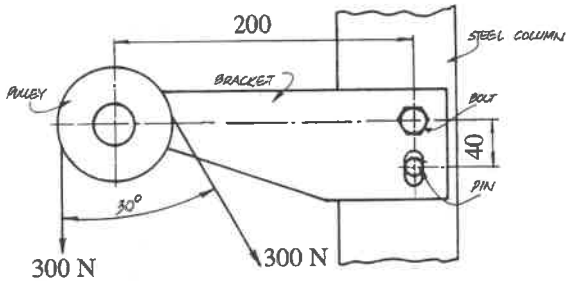
Question 13

A bracket bolted to a steel column with a pulley mounted on one face is shown. The pin prevents the bracket from rotating about the bolt.

(i) Draw a free body diagram of the pulley and axle.

(ii) Find the resultant of the 300 N forces acting on the pulley.

(iii) Determine the reaction at the pin assuming that it is horizontal.



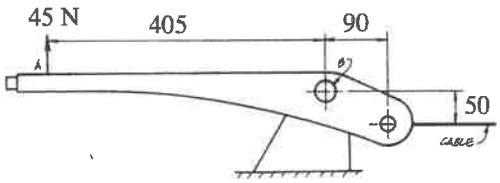
Question 14

A car driver applies a vertical force of 45 N to the floor mounted handbrake at A. The cable is horizontal.

(i) Find the tension in the cable.

(ii) Find the reaction force applied to the pin at B when the 45 N force is acting.

(iii) For another set of conditions the force applied to the pin at B is 800 N. The pin, which is in double shear, has a diameter of 5 mm. What is the shear stress in the pin?

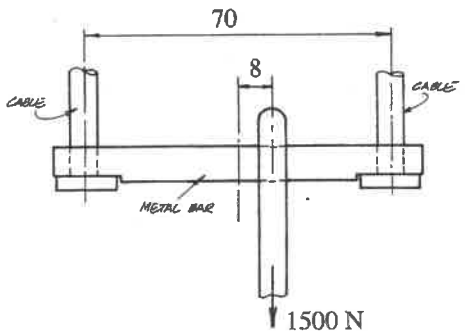


Question 15

The force-equalising system for a car's handbrake has a metal bar with a cable at each end. The force provided by the handbrake should act at the centre of the bar between the two cables.

(i) If the bar is moved 8 mm off centre, what are the forces in the cables when a force of 1500 N is applied by the handbrake?

(ii) Both of the cables are Ø5 mm, find the maximum tensile stress in the cables when the bar is 8 mm off centre.



Question 16

The guard rail of a bridge is hit by a motor car. The shape of the guard rail and the magnitude and position of the forces on impact are shown in the diagram.

(a)

(i) Determine the turning moment about point A created by the two impact forces?

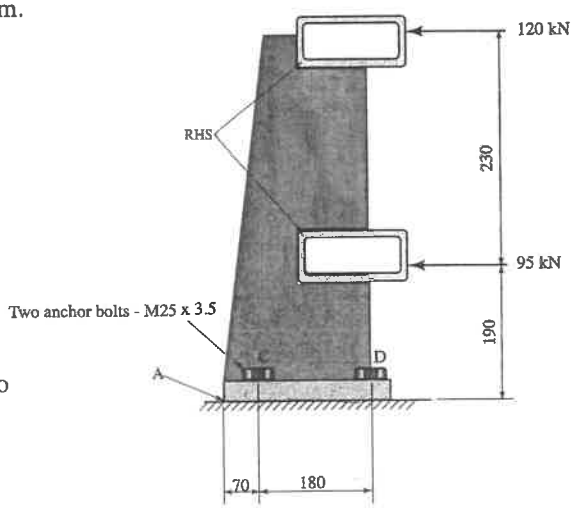
(ii) Determine the shear force acting in the two anchor bolts C and D?

(iii) Assuming the shear force to be the only force acting on the bolts, find the shear stress in each of the two anchor bolts.

(b) For another impact the combined horizontal force acting on the guard rail is 150 kN. The moment about A that results is 51 kNm anti clockwise.

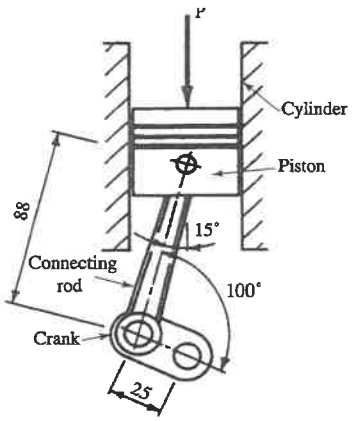
(i) Sketch the force and moment that must be provided at the base of the guard rail to maintain equilibrium during impact.

(ii) During impact, assume the tensile force resulting in anchor bolt D to be 4 times as great as the tensile force in anchor bolt C. Determine the tensile force in anchor bolt D at the time of impact.



Question 17

A force P of 2.45 kN acts on the top of the lawn mower piston shown. Determine the force in the connecting rod for the position shown. Assume the piston is moving with constant velocity and disregard frictional resistance. The connecting rod is 88 mm long and crank throw is 25 mm.



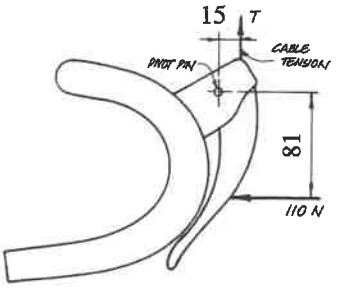
Question 18

A side view of a bicycle hand brake lever is shown. A force of 110 N is applied to the lever as shown producing a cable tension, T, and a reaction at the pivot pin.

(i) Determine the tension in the cable.

(ii) Calculate the diameter of cable required if the tensile stress in the cable is not to exceed 52.5 MPa.

(iii) Determine the reaction at the pivot pin of the lever.

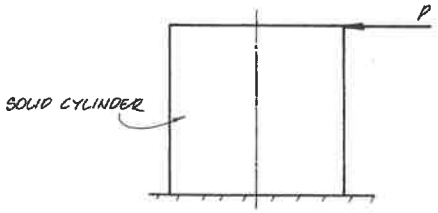


Question 19

A uniform solid circular cylinder, diameter 1700 mm and height 2100 mm has a mass of 500 kg. It stands vertically on a rough horizontal surface.

(i) Determine the magnitude of the horizontal force, P, applied at the top of the cylinder as shown in the diagram, which will just tilt the cylinder.

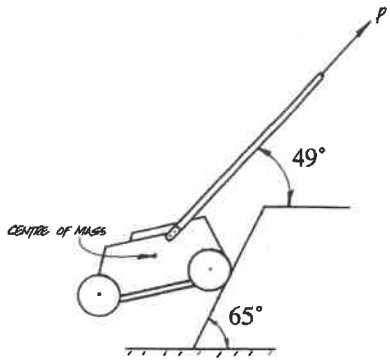
(ii) Determine the magnitude of the smallest force necessary to just begin to tilt the cylinder.



Question 20

A lawn mower, having a mass of 45 kg, is to be lifted up a retaining wall which is at an angle of 65° to the horizontal.

During the lift the mower is held at rest in the position shown by a force, P, acting along the handle. Determine the magnitude of the force P.

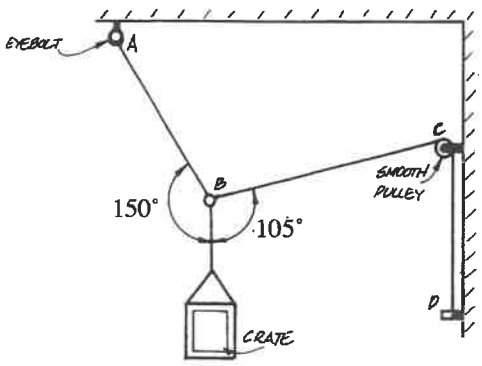


Question 21

The rope ABCD shown is used to support a crate of mass 80 kg which is to be loaded onto the back of a truck. The rope is attached to an eyebolt at A, passes over a smooth pulley at C and is tied to a support at D. The crate is slung from a rope tied at B.

(i) Determine the tension in the rope CD.

(ii) The vertical rope supporting the crate has a diameter of 15 mm. Find the tensile stress in the vertical rope at B.

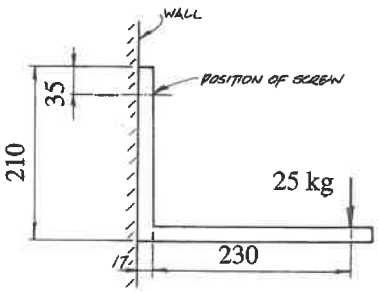


Question 22

A wall bracket is loaded as shown. The bracket is screwed to the wall by one screw in the position shown. Find:

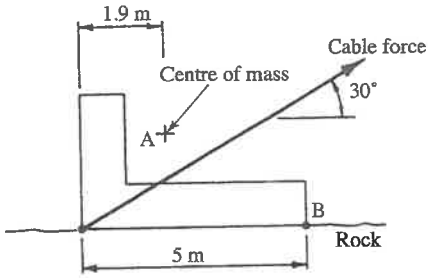
(i) The tensile force on the screw.

(ii) The shear force on the screw.



Question 23

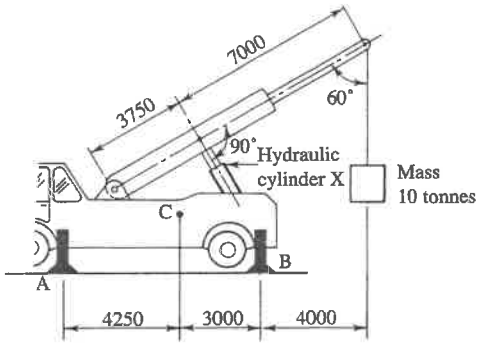
The anchor for the cable of a small suspension bridge consists of a concrete block resting on rock. The mass of the concrete is 94 tonnes. The centre of mass, A, is indicated on the diagram. If the block were to rotate about point B, determine the minimum cable force required to just start to rotate the block.



Question 24

The mobile crane shown has a mass of 25 tonnes which acts through the centre of gravity C. Determine:

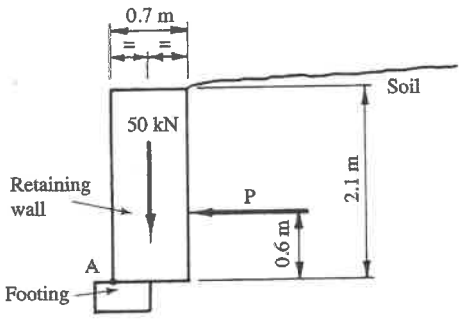
(i) The force acting on the hydraulic cylinder, X.
(ii) The reactions at supports A and B.
(iii) The stress in the Ø30 cable supporting the mass of 10 tonnes.



Question 25

A retaining wall holds back soil as shown. Determine:

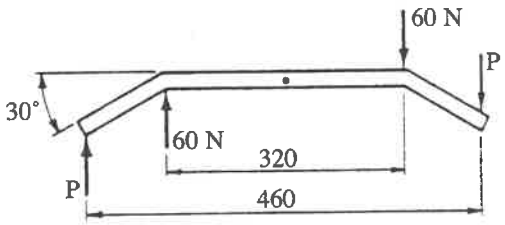
(i) The minimum force, P, such that the wall just tips about point A with no horizontal sliding.
(ii) For another set of conditions, the horizontal force P is 15 kN. Determine the thickness, x, of a new wall required to just prevent tipping. The weight of the new wall is 60 kN.



Question 26

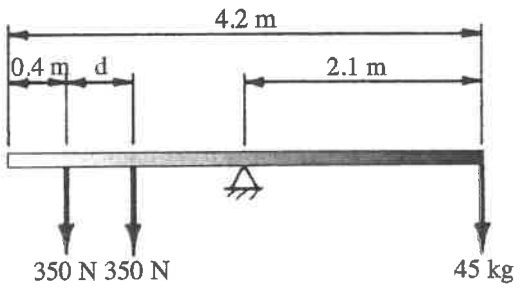
The handlebars of a bicycle are shown in the diagram. Determine:

(i) The magnitude of the couple formed by the 60 N forces.
(ii) The magnitude of P required to provide an equivalent couple to that calculated in (i) above.



Question 27

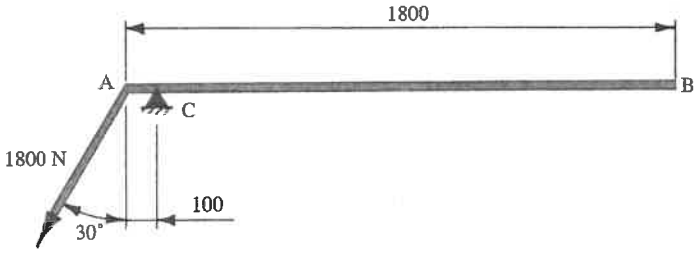
Three children are sitting on a see-saw and apply the forces and mass as shown. Determine the distance, d, so that the see-saw remains horizontal.



Question 28

A horizontal lever pivoted at C is shown. Determine:

(i) The magnitude of the minimum vertical force that must be applied to keep the lever horizontal.
(ii) The reaction at C when the lever is horizontal.

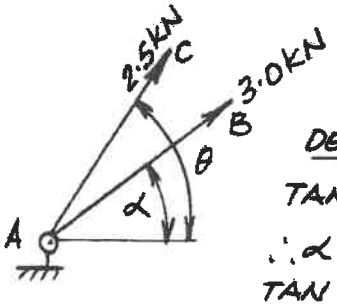


SECTION I - MULTIPLE CHOICE

1. C 2. C 3. C 4. A 5. B
6. A 7. A 8. C 9. B 10. B

SECTION II - EXTENDED RESPONSE QUESTIONS.

QUESTION 11



DETERMINE ANGLES

$\tan\alpha = \frac{40}{50}$

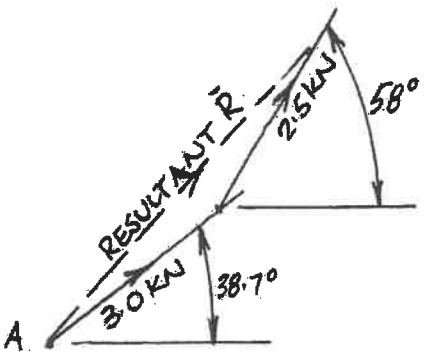
$\therefore \alpha = 38.7°$

$\tan\theta = \frac{80}{50}$

$\therefore \theta = 58°$

CONSTRUCT A FORCE POLYGON.

SCALE : 3.0 kN = 30 mm $\therefore$ 1 kN = 10 mm.

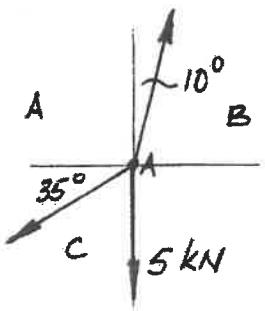


FORCE DIAGRAM

SCALE OFF DIAGRAM $\bar{R} = 5.42\text{kN} \angle 47°$

QUESTION 12

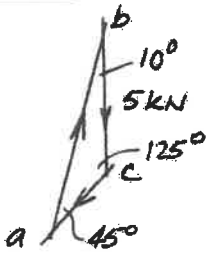
(i)



FREE BODY DIAGRAM

QUESTION 12

(ii)



FORCE DIAGRAM USING BOW'S NOTATION

USING THE SINE RULE :

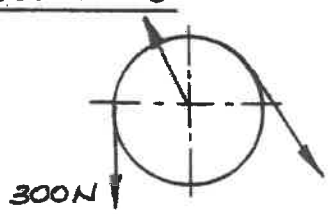
$\frac{a}{\sin A} = \frac{b}{\sin B} \Rightarrow \frac{6\times10^3}{\sin 45°} = \frac{B}{\sin 10°}$

$\therefore B = \frac{\sin 10° \times 5\times10^3}{\sin 45°}$

TENSION IN THE ROPE = 1227.9 N

QUESTION 13

(i)

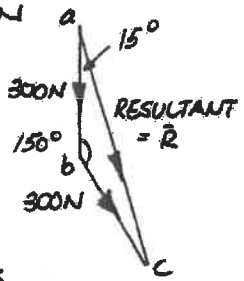


(ii) METHOD 1 :

CONSTRUCT A SCALED FORCE DIAGRAM

METHOD 2 :

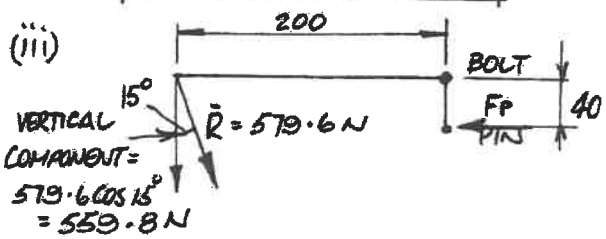
USING THE SINE RULE :



$\frac{a}{\sin A} = \frac{b}{\sin B} \therefore \frac{300}{\sin 15°} = \frac{\bar{R}}{\sin 150°}$

RESULTANT = 579.6 N

(iii)



BECAUSE THE BRACKET IS IN EQUILIBRIUM

$\Sigma M_{BOLT} = 0 \curvearrowright +$

$-(559.8 \times .2) + (Fp \times 0.04) = 0$

$Fp = \frac{559.8 \times 0.2}{0.04} = 2799\ N$

REACTION IN THE PIN = 2799 N.

QUESTION 14

(i) $\Sigma M_B = 0 \curvearrowright +$

$(45 \times 0.405) - (T \times 0.05) = 0$

$T = \dfrac{45 \times 0.405}{0.05} = 364.5\ N$

TENSION IN CABLE = 364.5 N

(ii) LET THE VERTICAL FORCE ON PIN = $F_{Y\,PIN}$

$\Sigma F_Y = 0 \uparrow +$

$-F_{Y\,PIN} + 45 = 0 \quad \therefore F_{Y\,PIN} = 45N \downarrow$

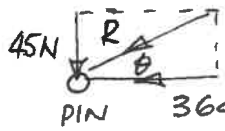
LET THE HORIZONTAL FORCE ON PIN = $F_{X\,PIN}$

$\Sigma F_X = 0 \rightarrow +$

$F_{CABLE} - F_{X\,PIN} = 0$

$364.5 - F_{X\,PIN} = 0 \quad \therefore F_{X\,PIN} = 364.5N$

(POSITIVE ANSWER $\Rightarrow$ ASSUMED DIRECTION IS CORRECT)



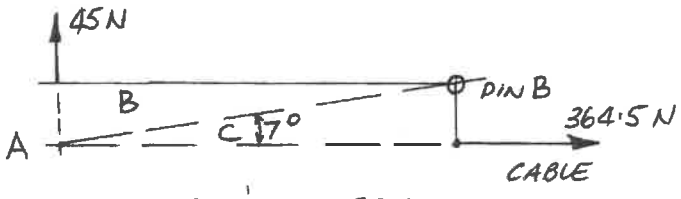
$\bar{R}$ = REACTION IN PIN $= \sqrt{45^2 + 364.5^2}$

$= 367.3\ N.$

$\tan\theta = \dfrac{45}{367.3} = 7^0$

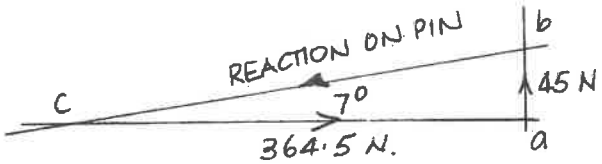
THE REACTION FORCE ON PIN = 367.3N $\angle 7^0$ B

AN EASIER METHOD = USE 3 FORCE RULE



USING BOW'S NOTATION, DRAW A SCALED FORCE DIAGRAM ON THE DIAGRAM GIVEN IN THE QUESTION.

SELECT AN APPROPRIATE SCALE & DRAW AN ACCURATE FORCE DIAGRAM. AND SCALE OFF REACTION.



FORCE DIAGRAM.

(iii) $\sigma_{SHEAR} = \dfrac{P}{A_S}$ WHERE $P = 800N$

$A_S = 2\pi r^2$ (DOUBLE SHEAR)

$= \dfrac{800}{2\pi \times 2.5^2 \times 10^{-6}}$ $= 2 \times \pi \times 2.5^2 \times 10^{-6} m^2$

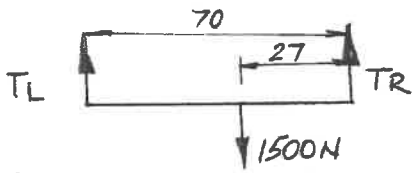
$= 20.4 \times 10^6\ Pa$

$= 20.4\ MPa$

SHEAR STRESS IN PIN = 20.4 MPa

QUESTION 15

(i)



T_L = TENSION IN LEFT CABLE

T_R = TENSION IN RIGHT CABLE

TAKE MOMENTS ABOUT T_R

$\Sigma M_{TR} = 0 \curvearrowright +$

$-(1500 \times 27) + (T_L \times 70) = 0$

$T_L = \dfrac{1500 \times 27}{70} = 578.6\ N$

ALSO $\Sigma F_Y = 0 \uparrow +$

$578.6 - 1500 + T_R = 0$

$T_R = 1500 - 578.6 = 921.4\ N$

TENSION IN RIGHT CABLE = 921.4 N
TENSION IN LEFT CABLE = 578.6 N

(ii) THE GREATEST STRESS WILL OCCUR IN THE CABLE WITH THE LARGEST LOAD SINCE BOTH CABLES ARE $\phi 5mm$.

$\sigma_{TENSILE} = \dfrac{P}{A_X}$ WHERE $P = 921.4\ N$

$A_X = \pi r^2$

$= \pi \times 2.5^2 \times 10^{-6} m^2$

$= \dfrac{921.4}{\pi \times 2.5^2 \times 10^{-6}}$

$= 46.3 \times 10^6\ Pa = 46.9\ MPa$

GREATEST TENSILE STRESS = 46.9 MPa.

QUESTION 16

(a) (i) $\circlearrowright^{+} \Sigma M_A = (120 \times 0.42) + (95 \times 0.19)$

$= 68.5 \text{ kNm}$

TURNING MOMENT ABOUT A = 68.5 kNm.

(ii) $\overset{+}{\rightarrow} \Sigma F_x = -120 - 95 = -215 \text{ kN}$

HORIZONTAL SHEAR FORCE IN BOLTS = 215 kN ←

(iii) $\sigma_{SHEAR} = \dfrac{P}{A_S}$ WHERE $P = 215 \times 10^3 \text{ N}$

$A = 2\pi r^2$

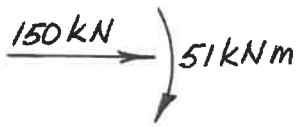
$= 2 \times \pi \times 12.5^2 \times 10^{-6} \text{ m}^2$

$= \dfrac{215 \times 10^3}{2\pi \times 12.5^2 \times 10^{-6}}$

$= 219 \times 10^6 \text{ Pa} = 219 \text{ MPa}$

SHEAR STRESS IN EACH BOLT = 219 MPa

(b) (i)



(ii) LET THE FORCE IN BOLT D = T

THEN THE FORCE IN BOLT C = $\dfrac{T}{4}$

TAKE MOMENTS ABOUT A

$\Sigma M_A = 0 \circlearrowright^{+}$

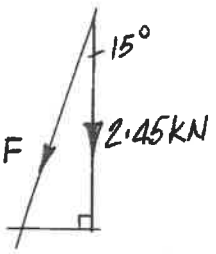
$\left(\dfrac{T}{4} \times 0.07\right) + (T \times 0.25) - 51 \times 10^3 = 0$

$0.0175T + 0.25T = 51 \times 10^3$

$T = 190.7 \text{ kN}$

TENSILE FORCE IN BOLT D = 190.7 kN

QUESTION 17



$\cos 15^\circ = \dfrac{2.45 \times 10^3}{F}$

$F = \dfrac{2.45 \times 10^3}{\cos 15^\circ}$

$= 2.54 \text{ kN}$

FORCE IN CONNECTING ROD IS 2.54 kN

QUESTION 18

(i) $\Sigma M_{PIN} = 0 \circlearrowright^{+}$

$(110 \times 81) - (T \times 15) = 0$

$T = \dfrac{110 \times 81}{15}$

$= 594 \text{ N}$

TENSION IN THE CABLE = 594 N

(ii) $\sigma_{TENSILE} = \dfrac{P}{A_X}$ WHERE $P = 594 \text{ N}$

$\sigma_T = 52.5 \times 10^6 \text{ Pa}$

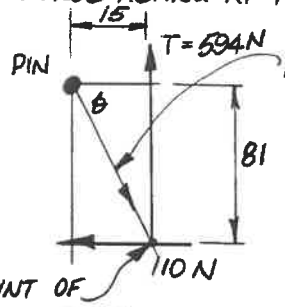
$52.5 \times 10^6 = \dfrac{594}{\frac{\pi D^2}{4} \times 10^{-6}}$ $A_X = \dfrac{\pi D^2}{4} \times 10^{-6} \text{ m}^2$

$D = \sqrt{\dfrac{594 \times 4}{\pi \times 52.5 \times 10^{-6} \times 10^6}} = 3.8$

DIAMETER OF CABLE = 3.8 mm

(iii) USING THE 3 FORCE RULE

WE CAN DETERMINE THE REACTION FORCE ACTING AT THE PIN



REACTION FORCE R

$R = \sqrt{594^2 + 110^2}$

$= 604 \text{ N}$

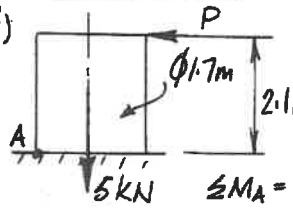
$\tan\theta = \dfrac{81}{15}$

$\theta = 79.5^\circ$

REACTION FORCE AT THE PIVOT = 604N 79.5°

QUESTION 19

(i)



$\Sigma M_A = 0 \circlearrowright^{+}$

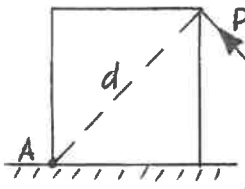
$-(P \times 2.1) + \left(5 \times 10^3 \times \dfrac{1.7}{2}\right) = 0$

$P = 2023.8 \text{ N}$

FORCE P TO JUST TILT THE CYLINDER = 2.02 kN

QUESTION 19

(ii)



MINIMUM FORCE DUE TO LONGEST LEVER ARM.

BY PYTHAGORAS

$d^2 = \text{DIAMETER}^2 + \text{HEIGHT}^2$

$d = \sqrt{1.7^2 + 2.1^2} = 2.7\,m$

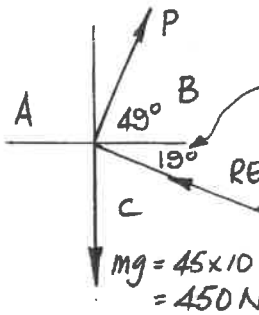
$\Sigma M_A = 0 \curvearrowright +$

$-(P_{MIN} \times 2.7) + (5\times10^3 \times \frac{1.7}{2}) = 0$

$P_{MIN} = 1.57\,kN$

SMALLEST FORCE TO JUST TILT CYLINDER = 1.57 kN

QUESTION 20



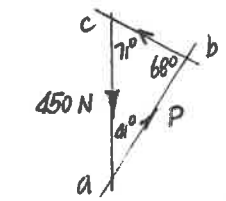
DETERMINE THIS ANGLE BY USING THE 3 FORCE RULE DIRECTLY OFF THE DIAGRAM

REACTION AT WALL

$mg = 45\times10 = 450\,N$

F.B.D.

CONSTRUCT A FORCE DIAGRAM USING BOW'S NOTATION.



FORCE DIAGRAM

EITHER SCALE OFF THE FORCE DIAGRAM OR USE THE SINE RULE TO DETERMINE P, THE FORCE IN THE HANDLE

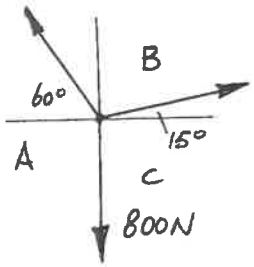
$\frac{b}{\sin B} = \frac{c\,(P)}{\sin C}$

$P = \frac{450 \times \sin 71^\circ}{\sin 68^\circ} = 459\,N$

THE FORCE P IN HANDLE IS 459 N

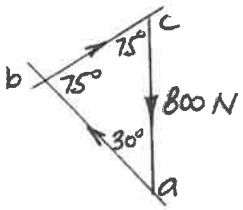
QUESTION 21

(i) BECAUSE THE ROPE ABCD IS CONTINUOUS, THE FORCE IN ANY SECTION OF THE ROPE IS THE SAME



F.B.D.

USING BOW'S NOTATION CONSTRUCT A FORCE DIAGRAM:



FORCE DIAGRAM

EITHER SCALE OFF THE FORCE DIAGRAM OR USE THE SINE RULE TO DETERMINE THE FORCE IN CD.

$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{T_{CD}}{\sin 30^\circ} = \frac{800}{\sin 75^\circ}$

$T_{CD} = \frac{800 \times \sin 30^\circ}{\sin 75^\circ} = 414\,N$

THE TENSION IN THE ROPE CD = 414 N

(ii) $\sigma_{TENSILE} = \frac{P}{A_X}$ WHERE $P = 800N$, $A_X = \pi r^2 = \pi \times 7.5^2 \times 10^{-6}\,m^2$

$= \frac{800}{\pi \times 7.5^2 \times 10^{-6}}$

$= 4.52 \times 10^6\,Pa = 4.52\,MPa.$

THE TENSILE STRESS IN THE VERTICAL ROPE = 4.52 MPa.

QUESTION 22

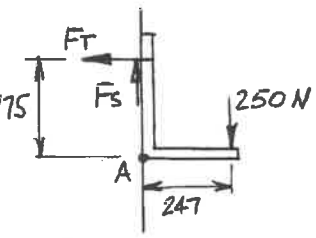
(i) F_T = TENSILE FORCE

$\Sigma M_A = 0 \curvearrowright +$

$(F_T \times .175) + (250 \times .247) = 0$

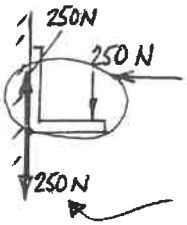
$F_T = \frac{250 \times .247}{.175}$

$= 353\,N$



THE TENSILE FORCE IN THE SCREW = 353 N

(ii) REPLACE THE SINGLE FORCE (250N) WITH A FORCE-COUPLE SYSTEM

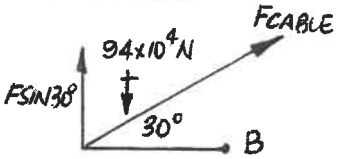


THESE TWO FORCES CREATES A COUPLE WHICH PRODUCES THE TENSILE FORCE ON SCREN

THIS FORCE PRODUCES THE SHEAR FORCE IN THE SCREN

THE SHEAR FORCE ON THE SCREN = 250N↓

QUESTION 23



F.B.D.

TAKE MOMENTS ABOUT B FOR EQUILIBRIUM

$\Sigma M_B = 0 \curvearrowright +$

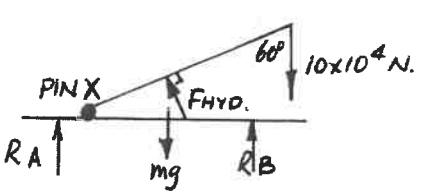
$(F\sin 30° \times 5) - (94\times10^4 \times 3.1) = 0$

$F = \dfrac{94\times10^4 \times 3.1}{\sin 30° \times 5} = 1166\ kN$

MINIMUM FORCE IN CABLE TO JUST START TO TIP THE BLOCK = 1166 kN

QUESTION 24

(i)



F.B.D.

$\Sigma M_{PIN\,X} = 0 \curvearrowright +$

$-(F_{HYD} \times 3.75) + (10\times10^4 \sin 60° \times 10.75) = 0$

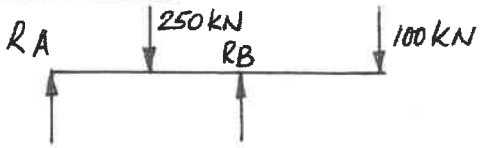
$F_{HYD} = \dfrac{10\times10^4 \sin 60° \times 10.75}{3.75}$

$= 248.3\ kN$

FORCE ACTING ON THE HYDRAULIC CYLINDER = 248.3 kN

QUESTION 24

(ii)



$\Sigma M_A = 0 \curvearrowright +$

$(250\times10^3 \times 4.25) - (R_B \times 7.25) + (100\times10^3 \times 11.25) = 0$

$R_B = \dfrac{(250\times10^3 \times 4.25) + (100\times10^3 \times 11.25)}{7.25}$

$R_B = 301.7\ kN$

$\Sigma F_Y = 0 \uparrow +$

$+R_A - 250\times10^3 + 301.7\times10^3 - 100\times10^3 = 0$

$R_A = 48.3\ kN$

REACTION AT SUPPORT A = 48.3 kN

REACTION AT SUPPORT B = 301.7 kN

(iii) $\sigma_{TENSILE} = \dfrac{P}{A_X}$ WHERE $P = 10\times10^4 N$

$A_X = \pi r^2$

$= \pi \times 15^2 \times 10^{-6} m^2$

$= \dfrac{10\times10^4}{\pi \times 15^2 \times 10^{-6}}$

$= 141.5\times10^6\ Pa$

$= 141.5\ MPa.$

STRESS IN CABLE WHEN THE LOAD IS STATIONARY = 141.5 MPa

QUESTION 25

(i) $\Sigma M_A = 0 \curvearrowright +$

$-(P \times 0.6) + (50 \times 0.35) = 0$

$\therefore P = 29.17\ kN$

(ii) $\Sigma M_A = 0 \curvearrowright +$

$-(15 \times 0.6) + (60 \times x/2) = 0$

$\therefore x = 0.3\ m$

QUESTION 26

(i) MOMENT OF COUPLE (M_c) = F x d WHERE F = 60N
d = 0.32 m

= 60 x 0.32

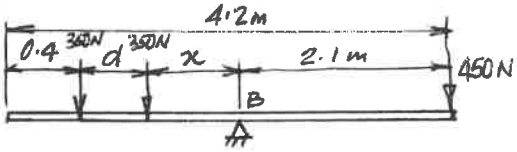
∴ MOMENT OF COUPLE = 19.2 Nm

(ii) $M_c = P \times d$ WHERE M_c = 19.2 Nm
P = ?
d = 0.46 m

$19.2 = P \times 0.46$

∴ P = 41.7 N

QUESTION 27



$x + d = 2.1 - 0.4 = 1.7$ m

$\Sigma M_B = 0 \curvearrowleft +$

$(450 \times 2.1) - (x \times 350) - (350 \times 1.7) = 0$

∴ x = 1.0 m

BUT x + d = 1.7 m

∴ d = 0.7 m

QUESTION 28

(i) MINIMUM VERTICAL FORCE MUST BE APPLIED AT B - MAXIMUM LEVER ARM

$\Sigma M_C = 0 \curvearrowright +$

$(1700 \times B) - (1800 \sin 60 \times 100) = 0$

∴ B = 91.7 N

(ii) $\Sigma F_Y = 0 \uparrow +$

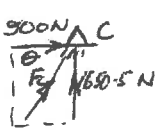
$-91.7 + F_{YC} - 1800 \sin 60° = 0$

∴ F_{YC} = 1650.5 N ↑

$\Sigma F_X = 0 \xrightarrow{+}$

$F_{XC} - 1800 \cos 60° = 0$

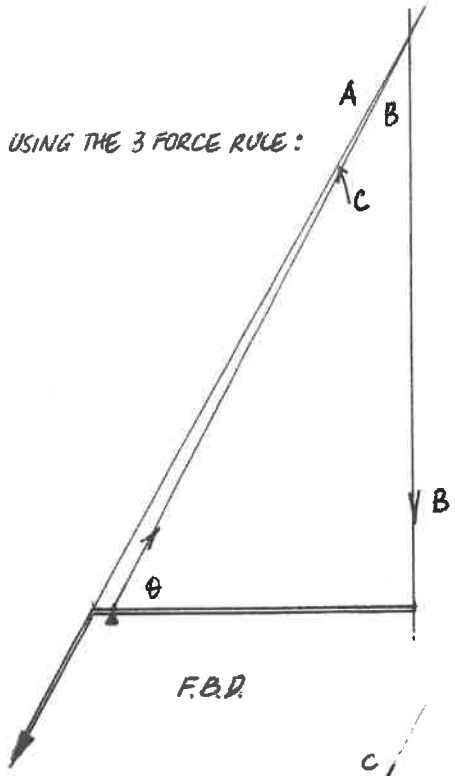
∴ F_{XC} = 900 N



$F_C = \sqrt{900^2 + 1650.5^2} = 1880$ N

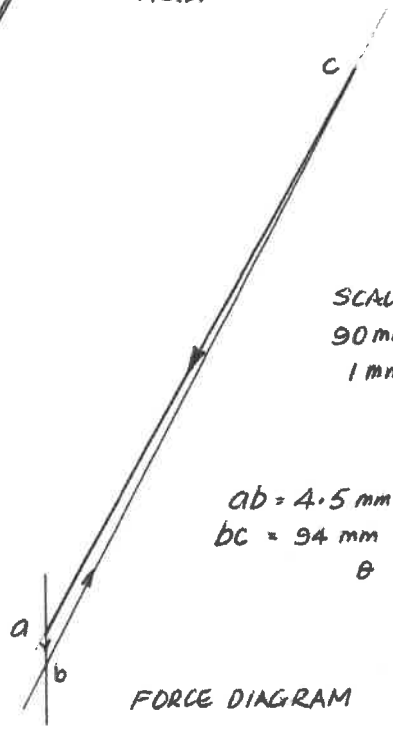
$\tan\theta = \frac{1650.5}{900}$ ∴ θ = 61.4°

F_C = REACTION AT C = 1880 N 61.4° C



USING THE 3 FORCE RULE:

F.B.D.



SCALE:
90 mm = 1800 N
1 mm = 20 N

ab = 4.5 mm = 90N = B
bc = 94 mm = 1880 N
θ = 62°

FORCE DIAGRAM

(i) B = 90 N

(ii) REACTION AT C = 1880 N 62° C

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

2

Testing & Inspection

Aim to complete each question many times in 2 years								
Question	Page/s	Study register ✓						
Multiple choice	14							
Question 11	15							
Question 12	15							
Question 13	15							
Question 14	15							
Question 15	15							
Question 16	16							
Question 17	16							
Question 18	16							
Question 19	16							
Question 20	17							
Question 21	17							
Question 22	17							
Question 23	17							
Solutions	18-20							

Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

1. Which statement best describes why *testing of materials before service* must be done using standardised tests?
   (A) The engineer knows what force a material can withstand without failing.
   (B) The engineer has accurate data on the mechanical properties of materials.
   (C) The engineer knows how much any possible mechanical failure will cost.
   (D) The engineer can apply a correct factor of safety to the material.

2. Which list of materials tests are all *non-destructive tests*?
   (A) Tensile test, compression test and crack tests.
   (B) Dye penetrant crack test, hardness test and X-ray (radiation) test.
   (C) Izod impact test, hardness test and ultra-sonic crack test .
   (D) Three point bend test, magnetic particle crack test and tensile test.

3. A metal bar with an original length of 100 mm is subjected to a tensile test and elongates to a length of 110 mm at failure. What is the *strain on the metal*?
   (A) 10% (B) 10 mm (C) 10 mm/m (D) 1 mm/m

4. Which statement best describes the application of *proof stress*?
   (A) For metals that have a definite yield point.
   (B) For metals that are always brittle.
   (C) For metals that have progressive yield.
   (D) For metals that do not obey Hooke's Law.

5. Which of the following can best test whether a milk crate can withstand a *service impact force*?
   (A) Conduct an Izod impact test on a sample of milk crate material.
   (B) Conduct Izod and Charpy impact tests on a sample of milk crate material.
   (C) Apply the service impact force to the milk crate.
   (D) Apply the impact force to the milk crate material.

6. A material has a proof strength of 400 MPa and a designed working strength of 160 MPa. What is the *factor of safety*?
   (A) 1.6 (B) 2.5 (C) 4 (D) 3.2

7. A Ø10 mm hole is to be punched into 5 mm thick mild steel plate. What is the *shear area in square metres*?
   (A) 157.1×10^{-6} m^2 (B) 0.1571 m^2 (C) 50×10^{-6} m^2 (D) 78.5×10^{-6} m^2

8. A Ø6 mm metal sample failed at a load of 10 kN. If the diameter at fracture point is 5 mm, what is the *engineering stress*?
   (A) 509.3 MPa (B) 353.7 MPa (C) 88.4 MPa (D) 127.3 MPa

9. Which statement best describes the tensile test results of a *strong and stiff material*?
   (A) High ultimate tensile strength and very ductile.
   (B) High ultimate tensile strength and high Young's Modulus.
   (C) High Young's Modulus and large percentage elongation.
   (D) High toughness and shows a definite yield point.

10. Which statement best describes the *indication of toughness* on a stress-strain tensile test curve?
    (A) The slope of the straight line section of the curve.
    (B) The height of the limit of proportionality.
    (C) The area under the necking zone.
    (D) The total area under the curve.

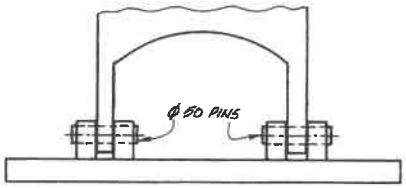
Section II - Short structured response questions

Question 11

A Ø15 mm cable is to be used in a lifting operation. The modulus of elasticity (E) of the cable material is 250 GPa. Calculate the tension when there is a strain of 0.2% in the cable.

Question 12

A bridge pin bearing is supported by two Ø50 mm pins as shown. Determine the shear stress in each pin if the bridge produces a vertical load of 200 kN.



Question 13

Briefly explain the following terms:

(i) Tensile stress, (ii) Young's Modulus, (iii) Ductility, (iv) Strain, (v) Hooke's Law

Question 14

The following results were obtained during a tensile test using a test sample with a gauge length of 50 mm and a cross sectional area of 160 mm^2:

Extension (mm)	0.40	0.80	1.20	1.40	2.0	3.0	3.5	4.0	5.0
Load (kN)	20	40	60	62	70	80	82	80	70 (failure)

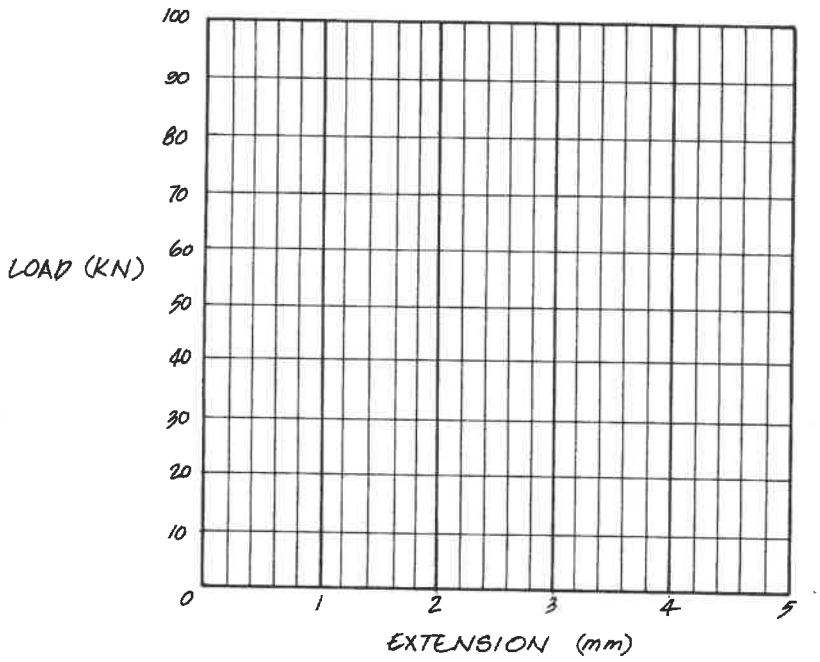
(i) Plot the load-extension curve on the graph given below.

(ii) Calculate the ultimate tensile strength of the material.

(iii) Calculate the Young's modulus for the material from the test results.

(iv) Calculate the strain at failure.

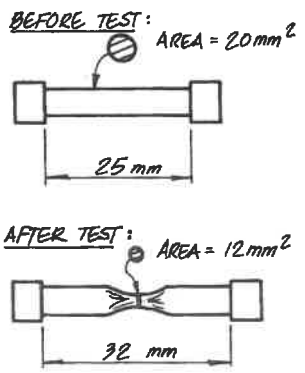
(v) Determine 0.2% proof stress

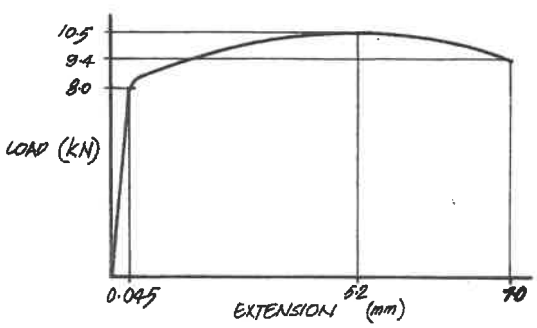


Question 15

The following data given below were collected during a tensile test on a metal specimen. Use this data to calculate:

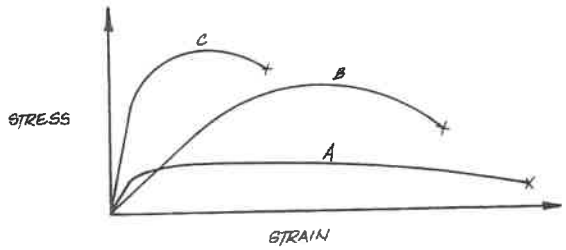
(i) percentage reduction in area; (ii) modulus of elasticity (E); (iii) ultimate tensile strength (UTS); (iv) strain at failure.





Question 16

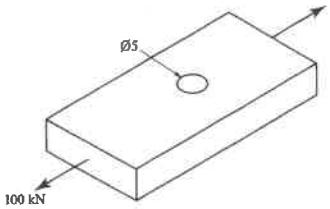
The stress-strain curves for three materials A, B and C are shown below.



(i) Which material is the most ductile and provide one reason for your answer?
(ii) Which material has the highest modulus of elasticity and provide one reason for your answer?
(iii) Which material is the toughest and provide one reason for your answer?
(iv) Which material has the highest tensile strength and provide one reason for your answer?

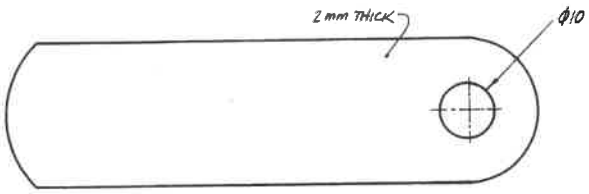
Question 17

A strip of brass 45 mm wide and 10 mm thick with a Ø5 mm hole drilled as shown, is to undergo tensile testing. The cross-sectional area at fracture was 350 mm^2. Calculate the engineering stress and true stress at fracture if the strip of brass failed when loaded with a force of 100 kN.



Question 18

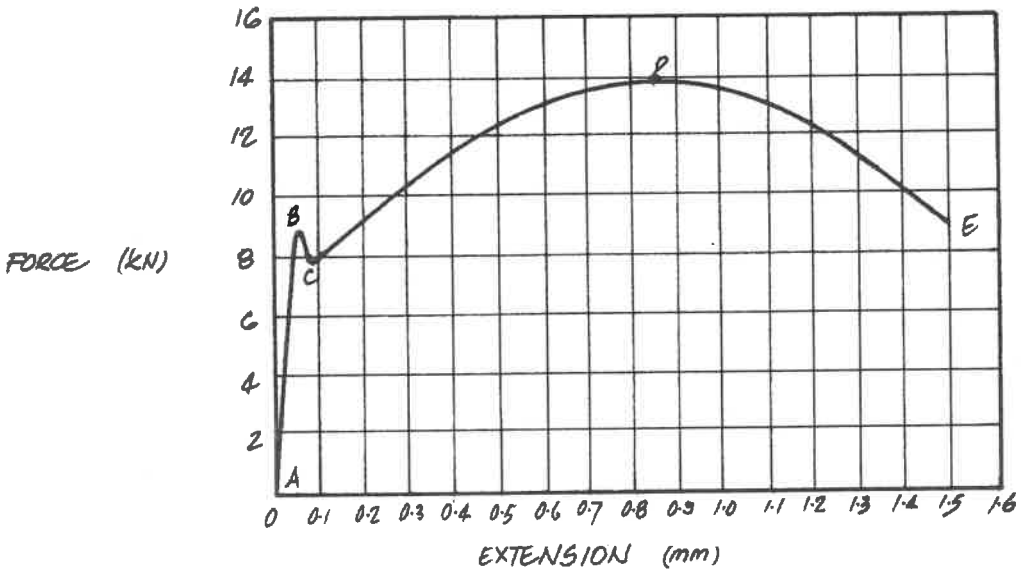
The lawn mower blade shown is punched from 2 mm thick sheet steel. The punching operation punches the hole, diameter 10 mm, and the outside shape which has a perimeter of 375 mm, in one operation.
If the ultimate shear strength for the steel is 270 MPa, determine the force required to punch the blade from 2 mm thick sheet steel.



Question 19

A tensile test using a sample of mild steel produced the following force-extension graph:

(i) Using the appropriate letters shown on the diagram, indicate the part of the force- extension curve corresponding to elastic deformation.
(ii) If the test piece had an original cross sectional area of 40 mm^2, a cross sectional area at the fracture surface of 30 mm^2, and a gauge length of 50 mm, calculate:
  (a) The ultimate tensile engineering stress.
  (b) The true stress.
  (c) The strain at fracture.
  (d) The Young's modulus for the material.



Question 20

A tensile test was conducted on an annealed low carbon steel test piece of gauge length 40 mm and cross sectional area of 30 mm^2. The following results were determined from the test:

Yield stress = 300 MPa
Ultimate tensile stress = 360 MPa
Stress at fracture = 330 MPa
Extension at the yield point = 0.058 mm
Extension at the point that necking commenced = 6 mm
Extension at fracture = 8 mm

Determine:

(i) The maximum load.
(ii) The modulus of elasticity.
(iii) The strain at fracture.

Question 21

Name a suitable test used to determine:

(i) The strength of a reinforced concrete beam.
(ii) The hardness of a carbon steel axle.
(iii) Possible internal cracking in a brass propeller.
(iv) Fine surface cracks on an alloy wheel of a racing car.
(v) Possible weld defects in an oil pipeline.

Question 22

The diagrams below show the orientation of 0.15% carbon steel test pieces for an impact test in an Izod and in a Charpy machine. The notch in the notched bar test has been omitted in each diagram.

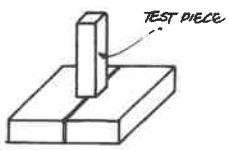


FIGURE 1

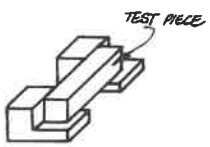


FIGURE 2

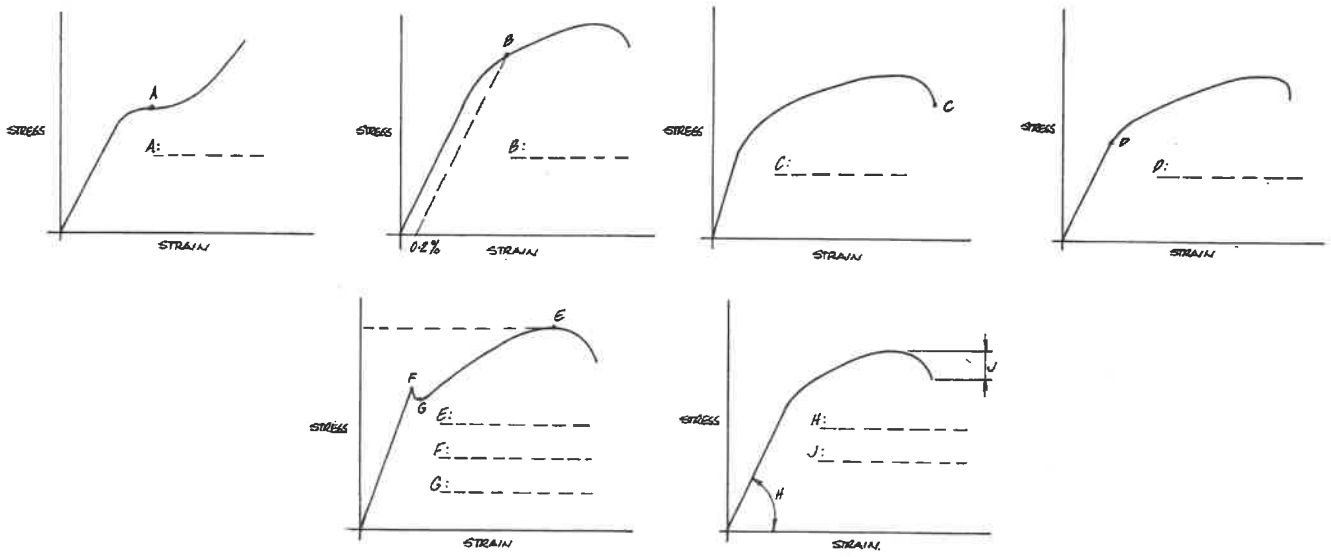
(i) Identify the impact test illustrated in each of the figures.

(ii) On each of the diagrams indicate by labelling the position of the notch in the notched bar test piece and the position of the striker as it strikes the test piece.

(iii) What property is tested in an impact test?

Question 23

Name the critical points shown on the stress-strain graphs shown below:



SECTION I - MULTIPLE CHOICE

1. B 2. B 3. A 4. C 5. C

6. B 7. A 8. B 9. B 10. D

SECTION II

QUESTION 11.

$$E = \frac{\sigma}{\varepsilon} = \frac{\frac{P}{A_x}}{\varepsilon} = \frac{P}{A_x . \varepsilon}$$

$P = A_x . E . \varepsilon$ WHERE $P = ?$ N

$= \pi \times 7.5^2 \times 10^{-6} \times 250 \times 10^6 \times .002$

$= 88.4$ kN

$A_x = \pi r^2$

$= \pi \times 7.5^2 \times 10^{-6} m^2$

$E = 250 \times 10^6$ Pa

$\varepsilon = 0.2\% = 0.002$

THE TENSION IS 88.4 kN

QUESTION 12

$\sigma_{SHEAR} = \frac{P}{A_{SHEAR}}$ WHERE $P = 200 \times 10^3$ N

$= \frac{200 \times 10^3}{4 \times \pi \times 25^2 \times 10^{-6}}$

$A_S = 4$ SHEAR AREAS

$= 4 \times \pi r^2$

$= 4 \times \pi \times 25^2 \times 10^{-6} m^2$

$= 25.5$ MPa FOR BOTH PINS.

$\sigma_{SHEAR} = 12.75$ MPa IN EACH PIN

QUESTION 13

(i) TENSILE STRESS IS THE TENSILE LOAD DIVIDED BY THE CROSS SECTIONAL AREA OF THE PART SUBJECTED TO THE LOAD

(ii) YOUNG'S MODULUS IS DEFINED AS STRESS DIVIDED BY STRAIN UP TO THE ELASTIC LIMIT. IT IS A MEASURE OF THE STIFFNESS OF THE MATERIAL.

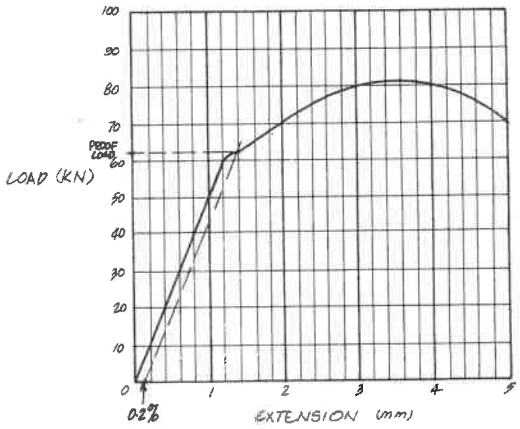
(iii) DUCTILITY IS THE ABILITY OF A MATERIAL TO BE STRETCHED ALONG ITS MAJOR AXIS WITHOUT FAILING. IE TO BE DRAWN INTO WIRE

(IV) STRAIN IS DEFINED AS THE CHANGE IN LENGTH DIVIDED BY THE ORIGINAL LENGTH WHEN THE MATERIAL IS SUBJECTED TO A FORCE.

(V) HOOKE'S LAW STATES THAT STRESS IS PROPORTIONAL TO STRAIN UP TO THE ELASTIC LIMIT.

QUESTION 14

(i)



(ii) $UTS = \frac{P}{A_x}$ WHERE $P = 82 \times 10^3$ N

$A_x = 160 \times 10^{-6} m^2$

$= \frac{82 \times 10^3}{160 \times 10^{-6}}$

$= 512.5$ MPa

THE ULTIMATE TENSILE STRENGTH = 512.5 MPa

(iii)

$E = \frac{\sigma}{\varepsilon} = \frac{\frac{P}{A_x}}{\frac{\Delta L}{L}} = \frac{PL}{A \Delta L}$ WHERE $P = 60 \times 10^3$ N

$L = 0.05$ m

$A_x = 160 \times 10^{-6} m^2$

$\Delta L = 1.2 \times 10^{-3} m$

$= \frac{60 \times 10^3 \times 0.05}{160 \times 10^{-6} \times 1.2 \times 10^{-3}}$

$= 15.6 \times 10^9$ Pa

YOUNG'S MODULUS = 15.6 GPa

(iv) STRAIN $\varepsilon = \frac{\Delta L}{L}$ WHERE $\Delta L = 5$

$L = 50$

$= \frac{5}{50}$

$= 0.1$ OR 10%

STRAIN = 0.1 m/m OR 100 mm/m OR 10%

(v) ON THE GRAPH AN EXTENSION OF 5mm = 10%. FIND 0·2% OF 50mm = 0·1 mm AND DRAW A LINE PARALLEL TO THE STRAIGHT LINE SECTION ON THE GRAPH AND DETERMINE THE PROOF LOAD AS SHOWN

NOW $0.2\%\ \text{PROOF STRESS} = \frac{\text{PROOF LOAD}}{\text{AREA}} = \frac{62\times10^{3}\ N}{160\times10^{-6}\ m^{2}}$

$= 387.5\times10^{6}\ Pa$

$= 387.5\ MPa.$

0·2% PROOF STRESS = 387·5 MPa

QUESTION 15

(i) $\%\ \text{REDN IN AREA} = \frac{(20-12)\times100}{20} = 40\%$

% REDUCTION IN AREA = 40%

(ii) $E = \frac{P.L}{A.\Delta L}$ WHERE $P = 8\times10^{3}\ N$, $A = 20\times10^{-6}\ m^{2}$, $L = 25\times10^{-3}\ m$, $\Delta L = 0.045\times10^{-3}\ m$

$= \frac{8\times10^{3}\times25\times10^{-3}}{20\times10^{-6}\times0.045\times10^{-3}}$

$= 222.2\times10^{9}\ Pa$

$= 222.2\ GPa$

YOUNGS MODULUS = MODULUS OF ELASTICITY = 222·2 GPa

(iii) $U.T.S = \frac{P}{A}$ WHERE $P = 10.5\times10^{3}\ N$, $A = 20\times10^{-6}\ m^{2}$

$= \frac{10.5\times10^{3}}{20\times10^{-6}} = 525\times10^{6}\ Pa$

$= 525\ MPa$

ULTIMATE TENSILE STRENGTH = 525 MPa

(iv) $\text{STRAIN } \varepsilon = \frac{\Delta L}{L}$ WHERE $\Delta L = 7\ mm$, $L = 25\ mm$

$= \frac{7}{25} = 28\ m/m = 28\%$

STRAIN AT FAILURE = 28%

QUESTION 16

(i) A - LARGEST ELONGATION

(ii) C - STEEPEST STRAIGHT LINE SLOPE

(iii) B - LARGEST AREA UNDER CURVE

(iv) C - HIGEST VALUE ON STRESS AXIS.

QUESTION 17

$\sigma_{ENG} = \frac{P}{A_O}$ WHERE $P = 100\times10^{3}\ N$, $A_O = (45-5)\times10\times10^{-6}\ m^{2} = 400\times10^{-6}\ m^{2}$

$= \frac{100\times10^{3}}{400\times10^{-6}}$

$= 250\times10^{6}\ Pa = 250\ MPa$

ENGINEERING STRESS = 250 MPa

$\sigma_{TRUE} = \frac{P}{A_F}$ WHERE $P = 100\times10^{3}\ N$, $A_F = 350\times10^{-6}\ m^{2}$

$= \frac{100\times10^{3}}{350\times10^{-6}} = 285.7\times10^{6}\ Pa$

$= 285.7\ MPa$

TRUE STRESS = 285·7 MPa

QUESTION 18

$\sigma_{SHEAR} = \frac{P}{A_{SHEAR}}$ WHERE $P = ?$

$A_S = (\text{PER OF BLADE} + \text{PER OF HOLE})\times T = (\pi D + 375)\times2\times10^{-6}\ m^{2}$

$\therefore P = \sigma_S \times A_S$

$= 270\times10^{6}\times812.8\times10^{-6}$, $\sigma_S = 270\times10^{6}\ Pa$

$= 219.5\times10^{3}\ N$

$= 219.5\ kN$

FORCE TO PUNCH THE HOLE = 219·5 kN

QUESTION 19

(i) A - B

(ii) (a) $\sigma_{UTS} = \frac{P}{A_x}$ WHERE $P = 14\times10^3\ N$, $A_x = 40\times10^{-6}\ m^2$

$= \frac{14\times10^3}{40\times10^{-6}} = 350\times10^6\ Pa$

$= 350\ MPa$

ULTIMATE TENSILE ENGINEERING STRESS = 350 MPa

(b) $\sigma_{TRUE} = \frac{P}{A_F}$ WHERE $P = 14\times10^3\ N$, A_F = AREA AT FRACTURE $= 30\times10^{-6}\ m^2$

$= \frac{14\times10^3}{30\times10^{-6}}$

$= 466.7\times10^6\ Pa = 466.7\ MPa$

TRUE STRESS = 466.7 MPa

(C) ε AT FRACTURE $= \frac{\Delta L}{L}$ WHERE $\Delta L = 1.5\ mm$, $L = 50\ mm$

$= \frac{1.5}{50}$

$= 0.03\ m/m = 3\%$

STRAIN AT FRACTURE = 3%

(d) YOUNGS MODULUS $E = \frac{P.L}{A_x.\Delta L}$

WHERE $P = 8.9\times10^3\ N$, $L = 50\times10^{-3}\ m$, $A_x = 40\times10^{-6}\ m^2$, $\Delta L = 0.05\times10^{-3}\ m$

$\therefore E = \frac{8.9\times10^3\times50\times10^{-3}}{40\times10^{-6}\times0.05\times10^{-3}}$

$= 222.5\times10^9\ Pa = 222.5\ GPa$

YOUNGS MODULUS = 222.5 GPa

QUESTION 20

(i) $\sigma_{UTS} = \frac{P}{A_x}$ WHERE $\sigma_{UTS} = 360\times10^6\ Pa$, $A_x = 30\times10^{-6}\ m^2$, $P_{MAX} = ?$

$\therefore P_{MAX} = A_x \times \sigma_{UTS}$

$= 30\times10^{-6}\times360\times10^6 = 10.8\ kN$

MAXIMUM LOAD = 10.8 kN

(ii) $E = \frac{PL}{A\,\Delta L}$ WHERE $\frac{P}{A} = 300\times10^6\ Pa$, $\frac{\Delta L}{L} = \frac{0.058}{40} = 0.00145$

$= \frac{300\times10^6}{1.45\times10^{-3}}$

$= 206.9\times10^9\ Pa = 206.9\ GPa$

MODULUS OF ELASTICITY = 206.9 GPa

(iii) $\varepsilon = \frac{\Delta L}{L}$ WHERE $\Delta L = 8\ mm$, $L = 40\ mm$

$= \frac{8}{40} = 0.2\ m/m = 20\%$

STRAIN AT FRACTURE = 0.2 m/m OR 20%

QUESTION 21

(i) 3 POINT BEND TEST

(ii) BRINELL, VICKERS, ROCKWELL HARDNESS TEST

(iii) X-RAY (RADIATION), ULTRA-SONIC TEST

(iv) DYE PENETRANT, VISUAL

(v) X-RAY (RADIATION)

QUESTION 22 PAGE 2-6

(i) IZOD TEST FIG 1 CHARPY TEST FIG 2

(ii)

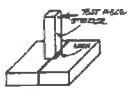


FIGURE 1

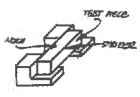


FIGURE 2

(iii) TOUGHNESS (OR NOTCH TOUGHNESS)

QUESTION 23 PAGE 2-6

A = YIELD POINT; B = 0.2% PROOF STRESS
C = FRACTURE POINT; D = LIMIT OF PROPORTIONALITY
E = ULTIMATE STRESS; F = UPPER YIELD POINT
G = LOWER YIELD POINT; H = YOUNGS MODULUS (STIFFNESS MODULUS)
J = NECKING ZONE

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

3 Ferrous & Non-ferrous Alloys

Aim to complete each question many times in 2 years								
Question	Page/s	Study register ✔						
Multiple choice	22							
Question 11	23							
Question 12	23-24							
Question 13	24							
Question 14	24							
Question 15	24							
Question 16	25							
Question 17	25							
Question 18	25							
Question 19	25-26							
Question 20	26							
Question 21	26							
Solutions	27-29							

Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

1. Which statement best describes the *plain carbon steel*?
   (A) An alloy of iron and carbon and exists as a body centered cubic lattice structure at room temperature.
   (B) An alloy of austenite and ferrite and exists as a face centered cubic lattice structure at room temperature.
   (C) An alloy of ferrite and iron and exists as a body centered cubic lattice structure at all temperatures.
   (D) An alloy containing more than 2% carbon.

2. Which statement best describes the *microstructure of annealed plain carbon steel* with approximately 0.4% carbon?
   (A) Grains of martensite in a matrix of ferrite.
   (B) Grains of equiaxed ferrite and pearlite.
   (C) Grains of cementite in a matrix of ferrite .
   (D) Graphite flakes in a pearlite matrix.

3. Why has stainless steel a *high resistance to corrosion*?
   (A) Because of the martensite content which resists corrosion.
   (B) Because of the austenite content which produces a stable oxide film.
   (C) Stainless steel has a stable oxide film formed due to the chromium content of the alloy.
   (D) Stainless steel provides a good surface bond for rust resisting paints .

4. Which best describes *recrystallisation* of grains in metals?
   (A) The growth of new elongated grains which produces a grainflow structure.
   (B) The growth of more grains which do not replace the existing elongated grains.
   (C) The growth of new equiaxed grains that replace the original work hardened elongated grains.
   (D) The growth of harder grains than the existing work hardened grains.

5. Which best describes the main differences between *normalising and process annealing*?
   (A) Normalised metals are quenched in water from red heat but process annealed metals are cooled in air from below red heat.
   (B) Process annealed metals are cooled in air from below red heat but normalised metals are cooled in air from red heat.
   (C) Processed annealed metals are quenched from red heat but normalised metals are cooled in air from red heat.
   (D) Processed annealed metals produce metals with smaller grains than the grains produced in normalised metals.

6. Which best describes the heat treatment process of *tempering hardened steel*?
   (A) Heating the hardened steel to below red heat which replaces brittleness with toughness.
   (B) Heating the hardened steel to red heat and replaces toughness with brittleness.
   (C) Heating the hardened steel to red heat producing a tougher, more usable steel.
   (D) Heating the hardened steel to below red heat and produces a harder, tougher steel.

7. *Non-ferrous alloys* generally exhibit which of the following properties?
   (A) Non-ferrous alloys cannot be hardened and offer better heat and electrical conductivity than ferrous metals.
   (B) Non-ferrous alloys are more suitable for welding and have better corrosion resistance than ferrous metals.
   (C) Non-ferrous alloys can be hardened and offer better heat and electrical conductivity than ferrous metals.
   (D) Non-ferrous alloys contain iron and are more dense than ferrous metals.

8. The processes of shaping metals by *rolling, forging and drawing* have which of the following advantages when compared to machining?
   (A) Rolling, forging and drawing are done while the metal is red hot which saves energy during the forming process compared to machining.
   (B) Rolling, forging and drawing are more rapid processes, produce a tougher component and result in less waste than machining.
   (C) Although machining does not cut grainflow, rolling, forging and drawing produces a stronger product.
   (D) Although rolling, forging and drawing requires the use of expensive dies, machining requires the use of more intricate dies.

9. Why is the joining of metal plate by *welding* preferred to riveting?
   (A) Riveting requires more preparation and equipment and does not produce joints of significant structural strength.
   (B) Riveting has to be done while the rivet is hot and is therefore more inconvenient than welding.
   (C) Riveting can only be used to join thin sheet metals whereas welding can join thick metal plate.
   (D) Riveting requires more preparation and equipment, it weakens the structure due to the necessity of drilling a hole, no fusion of metal occurs at the join and it is not as strong as welding.

10. What is the most important consideration for engineers when selecting an industrial process to *cut and/or join metals*?
   (A) How much the process will cost.
   (B) Whether the process will seriously weaken the parent metal.
   (C) Whether the process will produce waste material which cannot be recycled.
   (D) If the process can be used for a wide variety of materials.

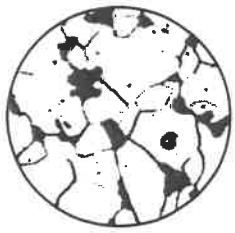
Section II - Short structured response questions

Question 11

(a) Explain the difference between iron and steel.

(b) Describe the following features for each of the following constituents of plain carbon steels.
   (i) Ferrite: lattice structure, two mechanical properties, composition.
   (ii) Austenite: lattice structure, two mechanical properties, composition.
   (iii) Cementite: lattice structure, two mechanical properties, composition.
   (iv) Pearlite: lattice structure, two mechanical properties, composition.

(c) Label all of the different grains on each of the photomicrographs shown below:



0.2% carbon steel



0.4% carbon steel



0.8% carbon steel

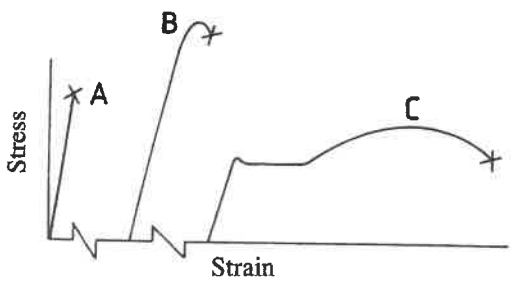


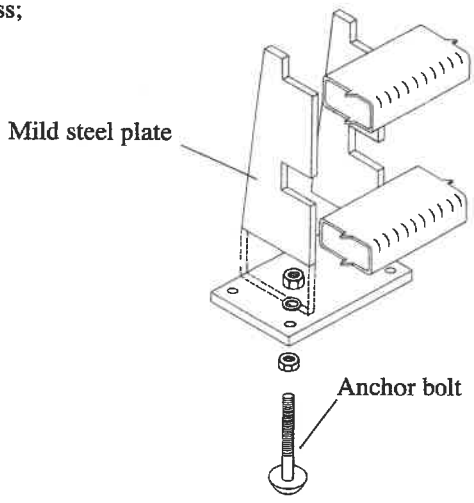
1.3% carbon steel

Question 12

Tests have been conducted on three ferrous metals A, B and C to be used to make a bridge guard rail bracket shown below. The results of these tests are shown on the stress/strain graph below.

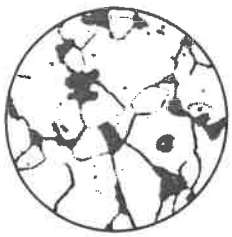
(a) Identify the curve that represents the most applicable steel for:
   (i) The MS plate; (ii) The anchor bolts; (iii) High strength; (iv) Toughness;
   (v) Low strength; (vi) Good ductility; (vii) Good wear resistance/brittle.





Bridge guard rail bracket

(b) Three microstructures are shown below and each represents one of the ferrous metals A, B and C shown on the stress/strain graph on the previous page. Identify these three microstructures by correctly labelling them A, B or C.



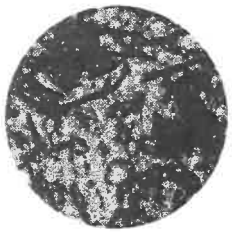
0.2% carbon steel

A, B or C?



0.8% carbon steel

A, B or C?



Grey cast iron

A, B or C?

Question 13

(a) From the alloys listed below, nominate the most suitable alloy for the following properties:
(i) Highest hardness; (ii) Best weldability; (iii) Most ductile; (iv) Softest; (v) Toughest; (vi) Highest tensile strength.

* Annealed 0.2% carbon steel
* Normalised 0.8% carbon steel
* Annealed 1.2% carbon steel
* White cast iron
* Spheroidal graphite (or nodular) cast iron

(b) With reference to the above alloys, state the alloy most suitable for the following applications. Also state the property of the alloy, other than cost, that makes the alloy most suitable for the application.
(i) Automobile body panel; (ii) Automobile suspension spring; (iii) Civil structure demolition ball;
(iv) Structural steel used for bolted and welded civil structures.

Question 14

(a) Explain the importance of silicon in cast irons.

(b) Provide the following features with reference to each of the four types of cast irons listed.
(i) Grey cast iron: Form of carbon; Shape of carbon; Two mechanical properties.
(ii) White cast iron: : Form of carbon; Shape of carbon; Two mechanical properties; A labelled sketch of the microstructure of white cast iron.
(iii) Spheroidal graphite (SG) or nodular cast iron: Form of carbon; Shape of carbon; Two mechanical properties; A labelled sketch of the microstructure of spheroidal graphite (SG) or nodular cast iron.
(iv) Malleable cast iron: Form of carbon; Shape of carbon; Two mechanical properties; A labelled sketch of the microstructure of malleable cast iron.

A labelled sketch of the microstructure of grey cast iron

A labelled sketch of the microstructure of white cast iron

A labelled sketch of the microstructure of nodular cast iron

A labelled sketch of the microstructure of malleable cast iron

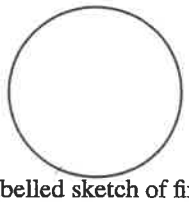
Question 15

Wire used for automotive cable (such as throttle cable) may be manufactured from 0.15% carbon cold-drawn steel. During the drawing process, the wire work hardens and must be process annealed.
(i) Describe the recrystallisation process of the cold-worked steel during process annealing.
(ii) Describe how the cold-drawn wire is process annealed.
(iii) Draw and label the microstructure of the process annealed 0.15% carbon steel wire.
(iv) Explain two important differences between the heat treatment processes of normalising and process annealing.
(v) A 0.6% carbon steel machine die used for making bolts has been severely work hardened in service and has to be machined. The die is soaked for several hours at 680°C and then cooled slowly.
Name this heat treatment process and sketch and label the final microstructure.

Question 16

Structural steel bolts with a carbon content of 0.45%, are hardened and tempered so that the bolts will have the required high tensile strength for use in structural steel work such as civil structures and automotive engineering applications.

(i) Describe the process of hardening the 0.45% carbon structural steel bolts.
(ii) Describe the process of tempering the 0.45% carbon structural steel bolts.
(iii) Explain why the bolts must be tempered after hardening.
(iv) Sketch and label the microstructure of the 0.45% carbon structural steel bolts after tempering.
(v) If the same process of hardening and tempering was conducted on 0.15% carbon steel bolts, what would be the expected outcome? Explain your answer.



Labelled sketch of final microstructure

Question 17

(a) Alloys of copper, aluminium, titanium and zinc are widely used in all areas of engineering. Provide:
(i) A significant property of each alloy listed.
(ii) A specific engineering application resulting from each property for the alloys.

(b) Non ferrous alloys have advantages and disadvantages when compared to ferrous alloys. State two advantages and two disadvantages of non-ferrous alloys over ferrous alloys.

(c) Many bicycle frames are now made from heat treated aluminium alloys. Describe the two processes of natural ageing and artificial ageing (or precipitation hardening) of aluminium alloys.

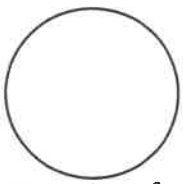
(d) A relatively inexpensive bicycle frame made from 0.4% carbon steel generally does not have the tensile, compressive, shear and torsional strength of a more expensive frame made from and alloy steel containing chromium and molybdenum. Explain the reason for this in terms of the structure of both types of steels.

(e) Copper water pipes for civil structures undergo annealing and hardening during manufacture. Explain how and why each of these processes are conducted.

(f) Titanium alloys are being used in larger quantities, particularly by the aeronautical engineering industry, despite the high cost of refining the metal. Give two reasons, in terms of specific properties, why titanium alloys are particularly appropriate for the aeronautical industry.

Question 18

(a) Some components of many hydraulic jacks are made from grey cast iron using the sand casting forming process.
(i) Briefly describe the sand casting process.
(ii) State a major advantage and a major disadvantage of the sand casting process.
(iii) Sketch and label the macrostructure of grains which have been sand cast.



Macrostructure of sand cast grains

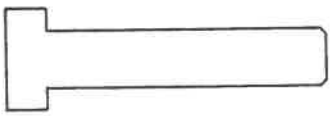
(b) Many turbine blades for gas turbine jet engines are made using the lost wax or investment casting process.
(i) Briefly describe the lost wax or investment casting process.
(ii) Give one significant advantage of the lost wax or investment casting process.

(c) Complex castings such as engine blocks for motor vehicle engines can be made using the full mould (or lost foam) casting process.
(i) What is the major advantage of this process over the sand casting process?
(ii) Gravity and pressure die casting uses permanent metal moulds into which the molten metal enters. State the one significant difference between the two processes and when one is used in preference to the other.

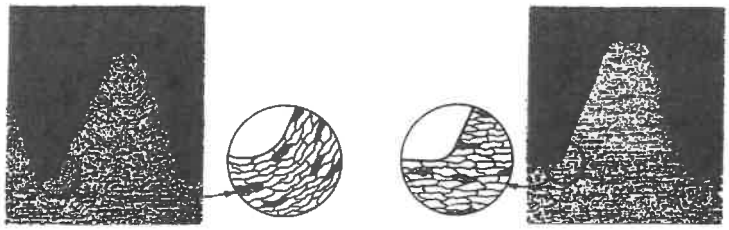
Question 19

Forging, rolling, extrusion and drawing produce grainflow in products formed by each of these metal forming processes.
(a) Explain the main advantage of grainflow in products such as bolts and machine components.

(b) Sketch the grainflow in the bolt drawn below after cold heading.



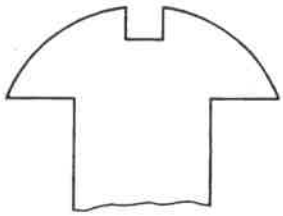
Photomicrographs of bolt threads that have been formed by either cold rolling or machining are shown below. Micrographs of magnification 150X are also given.



(c) Describe and justify the methods used to form both threads.

(d) Which method of forming threads is most widely used in industry? Give reasons to support your selection.

(e) The head of a round head screw has been cold formed by upsetting and then a slot cut to fit a flat blade screwdriver. Sketch a macroscopic view of the grainflow of the finished screw.



Question 20

Powder processing is used to mass produce small gears as well as in many other areas of industry.

(a) Briefly describe the 3 basic steps in forming components using powder processing.

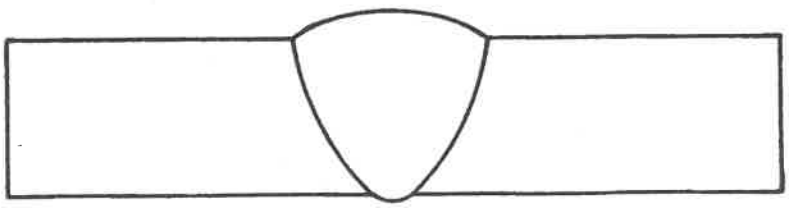
(b) Describe 4 specific and different applications where powder processing products are used.

Question 21

(a) State an industrial engineering process which best fits each of the following situations. Provide a reason for your selection.

(i) Cutting metal plates up to 40 mm thick with a 1.5 mm cut without excessively heating the parent metal.
(ii) Cutting metals and non-metals in the automotive industry without excessively heating the parent material.
(iii) Cutting microscopic electronic articles for the electronics industry.
(iv) An economical method of cutting any shape from thick metal plates where heating the metal is not of any major concern.
(v) Cutting 2D and 3D shapes in hardened and tempered metal up to 300 mm thick without heating the parent metal.
(vi) Joining thick metal plates for the hull of an ocean liner.
(vii) Providing a strong and water-tight join in sheet metal such as on the gutter seam on the roof of a motor vehicle.

(b) Two cold-rolled 0.15% carbon steel plates are joined by a single-run electric arc weld using a filler rod of the same composition. On the diagram below, sketch and label the resulting grain structure and the heat affected zone (HAZ).



SECTION I - MULTIPLE CHOICE

1. A, 2. B 3. C 4. C, 5. B,
6. A, 7. C, 8. B, 9. D, 10. B.

SECTION II

QUESTION 11

(a) IRON IS A PURE ELEMENT WHILE STEEL IS AN ALLOY OF IRON & CARBON AND, GENERALLY, OTHER ELEMENTS

(b) (i) FERRITE : BODY CENTRED CUBIC; SOFT, DUCTILE ; IRON (CAN CONTAIN UP TO 0·04% CARBON)

(ii) AUSTENITE : FACE CENTRED CUBIC ; SOFT, DUCTILE ; IRON WITH UP TO 2%C.

(iii) CEMENTITE : HARD, BRITTLE ; IRON & CARBON COMPOUND Fe_3C

(iv) PEARLITE : HARD & STRONG ; ALTERNATING BANDS OF FERRITE & CEMENTITE.

(c) SEE PAGE 44 OF WORKBOOK.

QUESTION 12

(a) (i) C, (ii) B, (iii) B, (iv) C, (v) A, (vi) C, (vii) A

(b) 0·2% CARBON STEEL = C
0·8% CARBON STEEL = B
GREY CAST IRON = A

QUESTION 13

(a) (i) WHITE CAST IRON
(ii) ANNEALED 0·2% CARBON STEEL
(iii) ANNEALED 0·2% CARBON STEEL
(iv) ANNEALED 0·2% CARBON STEEL.
(v) ANNEALED 0·2% CARBON STEEL.
(vi) NORMALISED 0·8% CARBON STEEL.

(b) (i) ANNEALED 0·2% CARBON STEEL ; HIGH DUCTILITY, WELDABLE, TOUGH.

(ii) NORMALISED 0·8% CARBON STEEL. RESILIENCE, FATIGUE STRENGTH, ELASTICITY.

(iii) WHITE CAST IRON WEAR RESISTANT, HARD, TOUGH IN MASSIVE VOLUME.

(iv) ANNEALED 0·2% CARBON STEEL ; TOUGH, WELDABLE, DOES NOT HEAT TREAT, EASY TO WORK (DRILL, CUT)

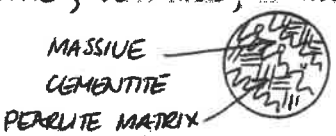
QUESTION 14

(a) SILICON IS A CATALYST WHICH FACILITATES THE FORMATION OF GRAPHITE FROM CEMENTITE - 1·5% SILICON CONTENT REQUIRED.

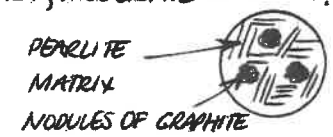
(b) (i) GRAPHITE ; FLAKES OR PLATES ; BRITTLE, GOOD DAMPING CHARACTERISTICS ;



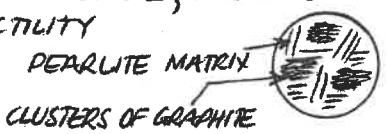
(ii) CEMENTITE ; MASSIVE AREAS OF CEMENTITE ; VERY HARD, BRITTLE.



(iii) GRAPHITE ; NODULES OR SPHERES ; HIGHER TENSILE STRENGTH THAN GREY C.I., MODERATE DUCTILITY.



(iv) GRAPHITE ; CLUSTERS ; HIGHER TENSILE STRENGTH THAN GREY C.I ; MODERATE DUCTILITY



QUESTION 15

(i) WORK HARDENED FERRITE GRAINS ARE RECRYSTALLISED WHEN HEATED TO BELOW RED HEAT & THEN COOLED IN AIR. PEARLITE GRAINS REMAIN ELONGATED WHILE THE FERRITE GRAINS RECRYSTALLISE TO EQUI-AXED GRAINS.

(ii) AS THE WIRE IS BEING DRAWN, HEATING ELECTRODES (ELEMENTS) HEAT THE WIRE TO BELOW RED HEAT & THE WIRE COOLS IN AIR.

(iii)



(iv) • NORMALISING HEATS TO RED HEAT WHILE PROCESS ANNEALING HEATS TO BELOW RED HEAT
• NORMALISING PRODUCES A STRONGER, HARDER MATERIAL DUE TO THE MORE RAPID COOLING

(v) SPHERODISED ANNEALING



QUESTION 16

(i) HEAT TO ABOVE RED HEAT AND COOL QUICKLY (= QUENCH) IN WATER, OIL, BRINE ETC.

(ii) HEAT TO BELOW RED HEAT (DEPENDING ON DEGREE OF HARDNESS/TOUGHNES REQ'D) AND COOL IN AIR.

(iii) THE BOLTS MUST BE TEMPERED TO REPLACE THE BRITTLENES OF THE MARTENSITIC STRUCTURE WITH THE TOUGHNESS OF THE TEMPERED MARTENSITIC STRUCTURE.

(iv)



(v) STEEL BELOW ABOUT 0.25% CARBON CONTENT CANNOT BE HARDENED BY HEAT TREATMENT BECAUSE OF INSUFFICIENT CARBON.

QUESTION 17

(a)

COPPER ALLOYS - EXCELLENT CONDUCTOR; USED FOR ELECTRICAL CABLES.

ALUMINIUM ALLOYS - LOW MASS; USED IN AERO INDUSTRY FOR AIRCRAFT FRAMES/CLADDING

TITANIUM ALLOYS - STRENGTH AT HIGH TEMPERATURES USED FOR TURBINE BLADES & JET ENGINE CASES.

ZINC ALLOYS - LOW MELTING POINT & HIGH CORROSION RESISTANCE; USED FOR DIE CAST COMPONENTS.

(b) ADVANTAGES:
LOWER DENSITY, BETTER CONDUCTORS, GOOD CORROSION RESISTANCE
DISADVANTAGES:
LOWER STRENGTH & STIFFNESS VALUES FERROUS ALLOYS WELD BETTER

(c) NATURAL AGEING:
- HEAT TO REQUIRED TEMPERATURE
- QUENCH TO ROOM TEMPERATURE
- ALLOW TO STAND AT ROOM TEMPERATURE FOR A PERIOD OF TIME WHILE THE ALLOY HARDENS.

ARTIFICIAL AGEING
- HEAT TO REQUIRED TEMPERATURE
- QUENCH TO ROOM TEMPERATURE
- HEAT TO SLIGHTLY ELEVATED TEMPERATURE TO ALLOW FOR AN ACCELERATED HARDENING PROCESS.

(d) THE CHROM/MOLY/STEEL ALLOY HAS MORE FOREIGN ATOMS WHICH PIN DISLOCATIONS THEREBY MAKING THE ALLOY STRONGER.

(e) ANNEALING OF COPPER:
• HEAT TO RED HEAT & COOL ANY WAY
• THIS IS NECESSARY BECAUSE CONTINUAL COLD WORKING THE COPPER WILL MAKE IT TOO BRITTLE FOR ANY FURTHER COLD WORK.

HARDENING OF COPPER:
• THE ONLY WAY COPPER CAN BE HARDENED IS BY WORK HARDENING BY COLD WORK.
• COPPER TUBE IS FINALLY SLIGHTLY WORK HARDENED BECAUSE ANNEALED COPPER IS TOO WEAK.

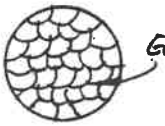
(f) - TITANIUM HAS A HIGH SPECIFIC STRENGTH.
- TITANIUM ALLOYS HAVE HIGH CORROSION RESISTANCE, HIGH MELTING POINT, HIGH TEMPERATURE STRENGTH, VERY TOUGH.

QUESTION 18

(a) (i) - SAND PACKED AROUND A PATTERN OF THE SAME SHAPE OF COMPONENT
- PATTERN WITHDRAWN LEAVING A CAVITY (MOULD) OF THE REQUIRED SHAPE
- MOLTEN METAL POURED INTO MOULD
- WHEN SOLIDIFIED THE MOULD IS BROKEN APART TO REVEAL THE CASTING

(ii) ADVANTAGE : AN INEXPENSIVE & QUICK WAY OF MAKING MANY DIFFERENT SHAPES
DISADVANTAGE : SURFACE FINISH IS POOR (SEE PAGE 55 OF WORKBOOK)

(iii)



(b) (i) - AN ACCURATE WAX PATTERN IS CAST IN A METAL MOULD
- THE WAX PATTERN IS COATED WITH A CERAMIC SLURRY/POWDER
- THE COATED PATTERN IS HEATED, THE CERAMIC FUSES & THE WAX FLOWS OUT TO LEAVE AN ACCURATE CAVITY (MOULD)
- MOLTEN METAL IS THEN POURED INTO THE MOULD & WHEN COOL THE MOULD IS BROKEN APART.

(ii) ALMOST PERFECT CASTINGS ARE PRODUCED WITH MINIMUM FURTHER MACHINING.

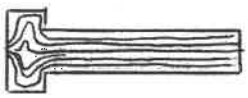
(c) (i) THERE IS NO NEED TO WITHDRAW THE PATTERN FROM THE CASTING BOX - THE POLYSTYRENE PATTERN DISSOLVES AS THE MOLTEN METAL POURS IN.

(ii) GRAVITY - METAL FLOWS INTO THE MOULD UNDER GRAVITY
- USED FOR SIMPLE SHAPES
PRESSURE - MOLTEN METAL IS FORCED INTO THE MOULD UNDER PRESSURE
- INTRICATE CASTINGS.

QUESTION 19

(a) GRAINFLOW IMPROVES MECHANICAL PROPERTIES PARTICULARLY IN THE DIRECTION OF WORKING - THE BOLTS WILL HAVE AN INCREASED TENSILE STRENGTH IN THE DIRECTION OF LOAD.

(b)



(c) THREAD A : - ROLLED
- GRAINFLOW
THREAD B : - MACHINED
- GRAINS ARE CUT

(d) ROLLING IS THE MOST COMMON ROLLING OF THREADS IS QUICKER, MORE ACCURATE, STRONGER, HARDER.

(e)



QUESTION 20

(i) BLENDING - MIXING POWDERS TO ACHIEVE THE REQUIRED PROPERTIES.
COMPACTING - PRESSING POWDERS AT ROOM TEMPERATURE - WEAK GREEN PRODUCT
SINTERING - BONDING BY HEAT

(ii) #2 = COMPLEX SHAPES SUCH AS GEARS
#3 = MATERIALS DIFFICULT TO MACHINE
#4 = JOINING MATERIALS WHICH DO NOT MIX IN THE LIQUID STATE.

QUESTION 21

(a) (i) PLASMA ARC CUTTING - DOES NOT EXCESSIVELY HEAT MATERIAL

(ii) LASER BEAM CUTTING - CUTS METALS & NON-METALS WITH MINIMUM HEATING

(iii) ULTRASONIC CUTTING - FINE DIAMOND CAN CUT MICROSCOPIC COMPONENTS

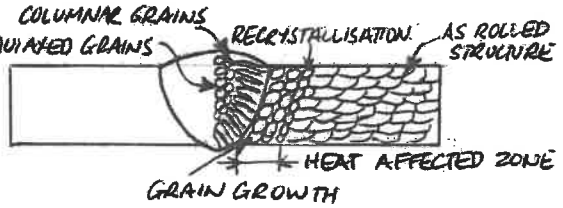
(iv) OXY-ACETYLENE CUTTING - ECONOMICAL METHOD WHICH HEATS THE METAL

(v) WIRE CUTTING - CAN CUT HARDENED DIE MATERIALS WITHOUT HEAT.

(vi) ELECTRIC ARC WELDING - A STRONG, CONVENIENT METHOD OF JOINING THICK PLATE

(vii) SEAM WELDING - A QUICK, ACCURATE WATERTIGHT METHOD OF JOINING SHEET METALS

(b)



Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

Machines

4

Aim to complete each question many times in 2 years								
Question	**Page/s**	**Study register ✔**						
Multiple choice	31							
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Solutions	35-38							

Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question (assume g = 10m/s^2)

1. An elevator in a high-rise building has a total mass of 1.3 tonnes and moves through a vertical height of 100m in 20 seconds. What is the *work done* by the elevator's lifting mechanism?
   (A) 65kJ (B) 1.3 kW (C) 1.3 kJ (D) 1.3 MJ

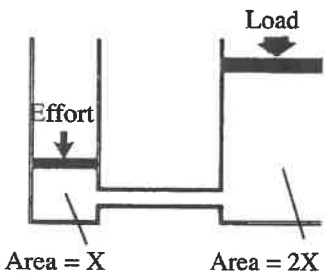
2. A motor vehicle of mass 1 tonne accelerates to 100 km/hr and then brakes to a stop. What is the *power required* to stop the car in 10 seconds?
   (A) 1.4 kW (B) 14 kW (C) 38.6 kW (D) 38.6 W

3. The velocity ratio of a screw jack is 60 and its efficiency is 30%. What is the *effort required* to lift a load of 1x10^4 N?
   (A) 555.6 N (B) 55.6 N (C) 333.3 N (D) 166.7 N

4. What is the *coefficient of friction*?
   (A) A number always between 0 and 1 and is the force required to overcome frictional forces.
   (B) A number usually between 0 and 1 and indicates the degree of interlocking between the contacting surfaces.
   (C) A number usually between 0 and 1 and indicates how much lubrication oil is required for the two surfaces.
   (D) A number between 0 and 1 and indicates the degree of roughness of the contacting surfaces.

5. Why are *hydraulic systems* preferred for applications such as automotive braking systems and drive mechanisms?
   (A) Liquids can be sufficiently compressed to allow for equal force to be transmitted throughout the liquid.
   (B) Hydraulic systems are unaffected by air in the system and can still effectively transmit equal forces throughout the system.
   (C) Pressure is evenly distributed throughout a liquid only if the liquid is a high quality brake fluid.
   (D) Pressure applied to a confined liquid is transmitted equally throughout the liquid.

6. What is the correct statement for the *hydraulic system* shown?
   (A) The load is half the effort but the load moves through twice the distance the effort moves.
   (B) The load is twice the effort but moves only half the distance the effort moves.
   (C) The load is equal to the effort but moves twice as far as the load.
   (D) The load is twice the effort and moves twice as far as the effort.



7. What is the *buoyant force* on a ship of mass 20,000 tonnes?
   (A) Equal to the weight of water the ship displaces.
   (B) Equal to the volume of water the ship displaces and must be greater than the volume of the ship's hull.
   (C) Equal to the mass of the ship.
   (D) Equal to the mass of water the ship displaces.

8. A 100 mm cube of concrete sinks to the bottom of a tank of water 1 m deep. If the density of water is 1x10^3 kg/m^3, what is the force of buoyancy on the concrete cube?
   (A) 100 kg/m3 (B) 100 N (C) 1000 N (D) 10 N

9. Which statement best describes the *'lift' force* on the wing of an aircraft?
   (A) Air being forced to rapidly change direction causing a low pressure region on top of the wing which produces 'lift'.
   (B) Air on top of the wing having a higher velocity than air below causing a low pressure region on top of the wing as well as the air being forced to change direction under the wing.
   (C) Air hitting the underside of the wing which produces a high pressure region under the wing causing the wing to be forced up.
   (D) Air being forced to accelerate under the wing as well as the air producing a low pressure region on top of the wing.

10. Which best describes the *Bernoulli principle*?
   (A) Where the velocity is low the pressure is low for all fluids.
   (B) Where the velocity is high the pressure is low for all fluids.
   (C) Where the velocity is high the pressure is high for all fluids.
   (D) Where the velocity is low the pressure is high only in a gas.

Section II - Short structured response questions

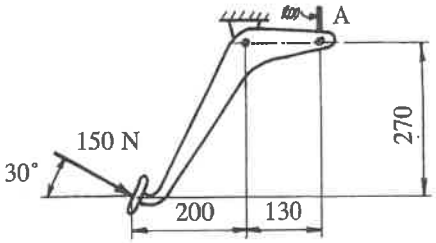
Question 11

A motor vehicle driver applies a force of 150 N to the foot brake as shown. Find:

(i) The reaction force in rod A.

(ii) The velocity ratio of the system.

(iii) The mechanical advantage if the efficiency of the system is 75%.



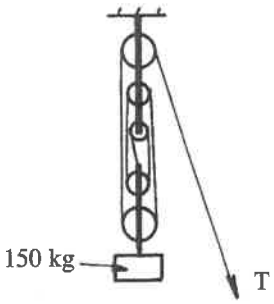
Question 12

A simple block and tackle system is shown. Find:

(i) The velocity ratio of the system.

(ii) The mechanical advantage if efficiency is 72%.

(iii) The tension, T, in the rope if efficiency is 72%.



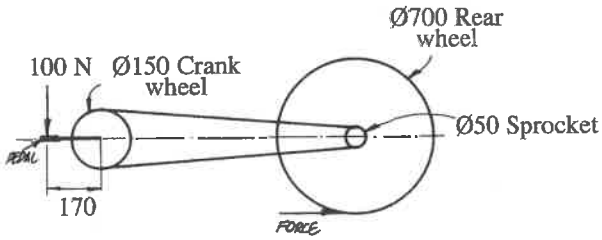
Question 13

A drive system of a bicycle with a vertical force of 100 N applied to the pedal is shown.

(i) Determine the velocity ratio of the system.

(ii) Calculate the mechanical advantage of the system assuming an efficiency of 60%.

(iii) Calculate the force exerted at the rear wheel when a force of 100 N is applied to the pedal assuming the efficiency of the system remains at 60%.



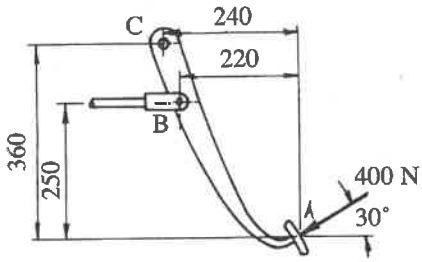
Question 14

A 400 N force is applied to the foot-brake of a car as shown. Determine:

(i) The reaction forces acting at B and C.

(ii) The mechanical advantage of the system assuming an efficiency of 75%.

(iii) The velocity ratio of the system.



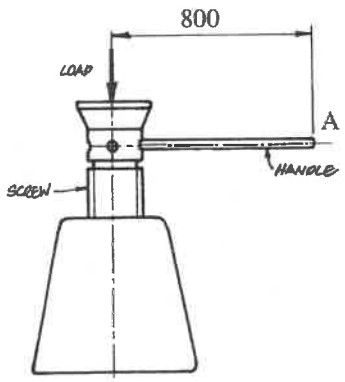
Question 15

The screw jack shown has a lever arm of 800 mm and a Ø25 mm screw thread with a pitch of 6 mm. Find:

(i) The velocity ratio of the system.

(ii) The velocity ratio of the screw thread.

(iii) The force necessary at A to just lift a mass of 2 tonnes if the jack has an efficiency of 70%.



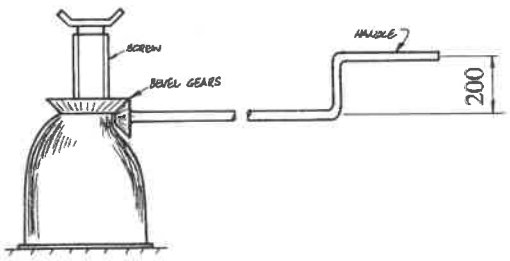
Question 16

The car jack shown below uses a 200 mm offset crank handle and bevel gears to raise the load. If the bevel gears have a velocity ratio of 3:1, the single start screw thread has a pitch of 7 mm and the efficiency of the jack is 20%, find:

(i) The velocity ratio of the jack.

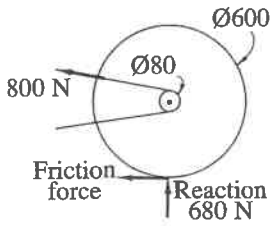
(ii) The mechanical advantage of the jack.

(iii) The effort required to raise a 500 kg load.



Question 17

The tension in the chain of a bicycle is 800 N and the vertical reaction at the rear wheel is 680 N. If the bicycle is travelling at a constant velocity, determine the coefficient of friction between the bicycle tyre and the road surface.

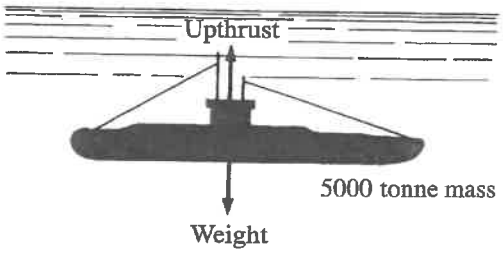


Question 18

A 5000 tonne submarine is completely immersed in sea water of density 1030 kg/m³. Determine:

(i) The volume of water displaced by the submarine.

(ii) The quantity of water which must be pumped from the submarine's ballast tanks if it is to just float in fresh water which has a specific gravity of 1.0.



Question 19

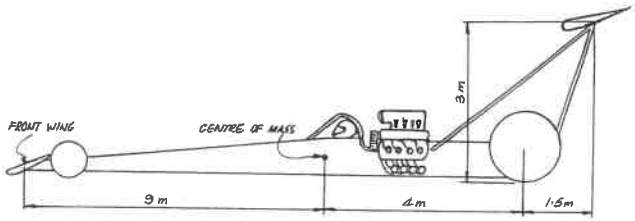
Castings for aluminium alloy motor vehicle sports wheels are to be made from a machined prototype of the final design. The design engineer must determine the volume of metal required for each casting for production purposes as well as to accurately cost each wheel.

(i) Suggest a method of determining the volume of the alloy wheel.

(ii) If the specific gravity of aluminium is 2.8 and the mass of each wheel is 5 kg, determine the volume of aluminium alloy required for each casting assuming 10% is allowed for contraction after casting.

Question 20

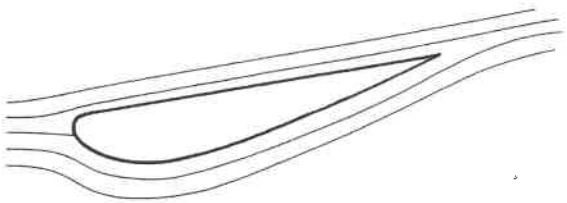
A top fuel dragster uses the Bernoulli and Newtonian principles to create high down-force during their 400 m runs. The down-force and drag at the rear wing at 480 km/hr is 22 kN and 5 kN respectively. If the mass of a top fuel dragster as shown is 800 kg, calculate the down-force required on the front wing for the car to maintain a horizontal attitude at 480 km/hr.
(Ignore lift on the front wheels produced by the torque of the engine).



Question 21

Drag and lift on an aeroplane wing, or down-force on the wing of a race car, results from the movement of air across the surface of the wing. Using the race car wing shown below, answer the following questions regarding the aerodynamics of a wing:

(i) On the diagram of the wing profile, show:
- the area of greatest air speed,
- the area of lowest air speed,
- the area of high pressure,
- the area of low pressure,
- the sense and direction of drag,
- the sense and direction of down-force,
- the sense and approximate direction of the total aerodynamic force.



(ii) Explain how the Bernoulli principle relates to the lift and down-force on an aerodynamic wing.

(iii) If the drag on the wing is 3.2 kN and the down-force is 11.2 kN, determine the total aerodynamic force which acts on the wing.

Question 22

An hydraulic automotive braking system for drum brakes is shown below. The master cylinder has a diameter of 50 mm and each of the double acting wheel cylinders has a diameter of 25 mm. If a force of 200 N acts at 30° on the brake pedal, find:

(i) The force acting along the push-rod in the master cylinder.

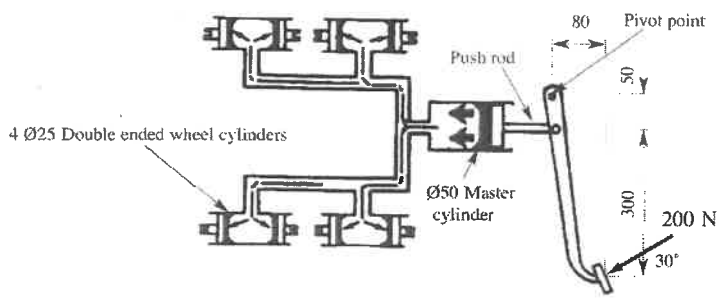
(ii) The velocity ratio of the brake lever.

(iii) The pressure in the system.

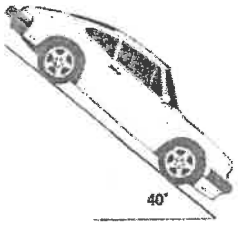
(iv) The force produced by each wheel cylinder.

(v) How far each wheel cylinder piston moves if the master cylinder piston moves 10 mm.

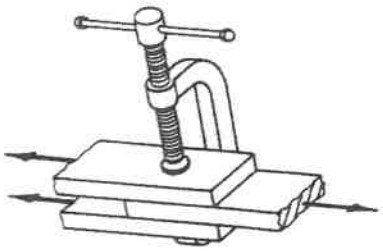
(vi) The velocity ratio of the hydraulic system.



Question 23
A motor vehicle is held by the handbrake on a steep incline at 40° to the horizontal as shown in the 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?

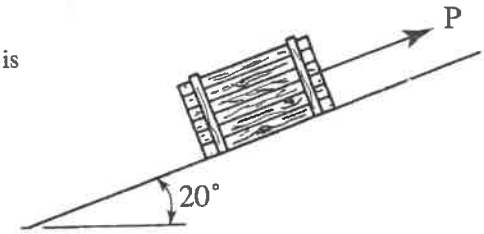


Question 24
The G-clamp applies a force of 500 N to the three pieces of wood as shown. If the coefficient of friction between the pieces is 0.4, determine to force required to just cause slip between the pieces.

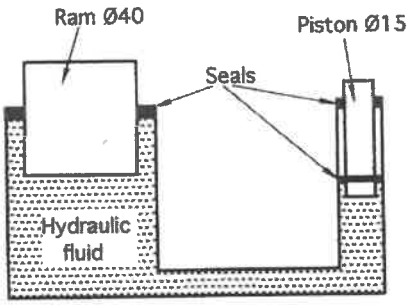


Question 25
A box of mass 100 kg is on the verge of moving up a 20° inclined plane when force P is applied as shown. The coefficient of friction between the surfaces is 0.5.

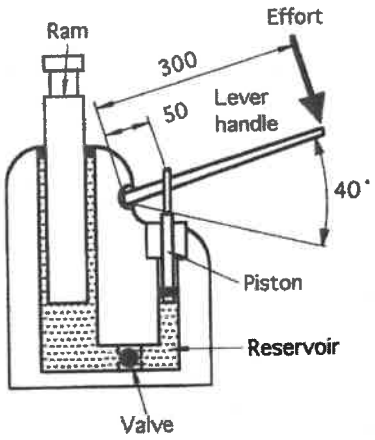
(i) On the diagram, show all forces acting on the box.
(ii) Determine the velocity ratio of the plane.
(iii) Determine the mechanical advantage of the plane.
(iv) Determine the efficiency of the inclined plane.



Question 26
Details of a 1.85 tonne capacity hydraulic bottle jack are shown:



Schematic drawing of the bottle jack



Partial section of a bottle jack

(i) Calculate the velocity ratio of the lever system on the jack.
(ii) Calculate the velocity ratio of the hydraulic system of the jack given the diameter of the effort piston is Ø15 and the diameter of the load piston is Ø40.
(iii) Calculate the mechanical advantage of the jack if the total efficiency of the lever and hydraulic systems is 70%.

Question 27
A box of mass 100 kg rests on an inclined plane as shown. A force P acts at 30° to the plane. The coefficient of friction between the plane surface and the box is 0.5.

(i) Calculate the force P if the block is just on the verge of moving up the plane when P acts away from the plane as shown in figure 1.

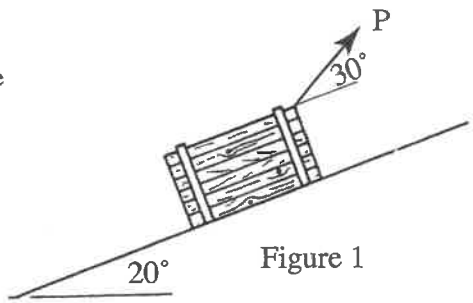


Figure 1

(ii) Calculate the force P if the block is just on the verge of moving up the plane when P acts towards the plane as shown in figure 2.

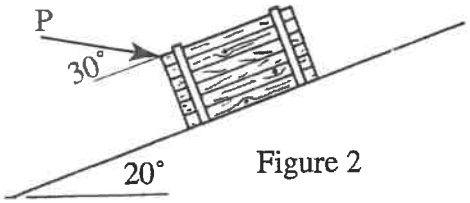


Figure 2

SECTION I - MULTIPLE CHOICE

1. D 2. C 3. A 4. B 5. D

6. B 7. A 8. D 9. B 10. B.

SECTION II

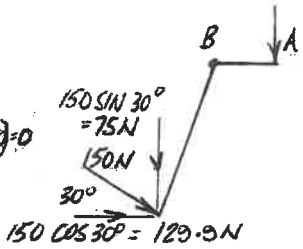
QUESTION 11

(i)

$\Sigma M_B = 0 \curvearrowright +$

$(A \times 130) - (75 \times 200) - (129.9 \times 270) = 0$

$A = 385.2\ N$



THE REACTION FORCE IN ROD A = 385.2 N

(ii) VR = MA @ 100% EFFICIENCY

$= \frac{L}{E}$ WHERE $L = 385.2\ N$, $E = 150\ N$

$= \frac{385.2}{150} = 2.57$

THE VELOCITY RATIO OF THE SYSTEM = 2.57

(iii) $\eta = \frac{MA}{VR}$ WHERE $\eta = .75$, $VR = 2.57$

$MA = \eta . VR$

$= 0.75 \times 2.57 = 1.93$

THE MA @ 75% EFFICIENCY = 1.93

QUESTION 12



(i) VR = N° OF FALLS OF ROPE OR = 5

$\Sigma F_Y = 0 \uparrow +$

$5T - L = 0$

$5T = L$

BUT T = EFFORT

$5E = L$

$MA = \frac{L}{E} = \frac{5E}{E} = 5 = VR @ 100\% \eta$

VELOCITY RATIO = 5

(ii) $MA = \eta \times VR$ WHERE $\eta = 0.72$, $VR = 5$

$= 0.72 \times 5 = 3.6$

MA AT 72% EFFICIENCY = 3.6

(iii) TENSION T = EFFORT & $MA = \frac{L}{E}$

$\therefore E = \frac{L}{MA}$ WHERE $L = 150 \times 10 = 1500\ N$, $MA = 3.6$

$= \frac{1500}{3.6} = 416.7$

TENSION IN THE ROPE = 416.7 N

QUESTION 13

(i) $VR = \frac{DE}{DL}$ WHERE $DE = \pi D = 340\pi$

$DL = \frac{150}{50} \times 700\pi$

$= \frac{340\pi}{\frac{150}{50} \times 700\pi} = 0.16$

VR OF THE SYSTEM = 0.16

(ii) $MA = \eta . VR$ WHERE $\eta = 0.6$

$= 0.6 \times 0.16$ $VR = 0.16$

$= 0.097$

MA AT 60% EFFICIENCY = 0.097

(iii) $MA = \frac{L}{E}$ WHERE $MA = 0.097$, $E = 100\ N$.

$L = MA \times E$

$= 0.097 \times 100 = 9.7\ N$

FORCE EXERTED AT REAR WHEEL = 9.7 N

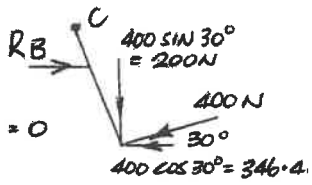
QUESTION 14

(i) REACTION AT B.

$\Sigma M_C = 0 \curvearrowright +$

$(200 \times 240) + (346.4 \times 360) - (R_B \times 110) = 0$

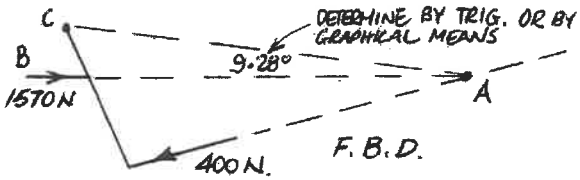
$R_B = 1570\ N$

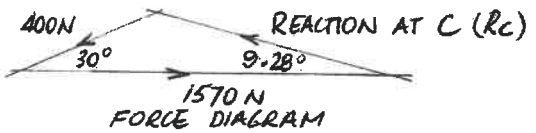


REACTION AT B = 1570 N

REACTION AT C

BY THE PRINCIPLE OF TRANSMISSIBILITY EXTENSION OF THREE FORCES WILL MEET AT A.





USING THE SINE RULE:

$\frac{R_C}{\sin 30°} = \frac{400}{\sin 9.28°}$

$R_C = 1240\ N$

REACTION AT C = 1240 N 9.28° C

$MA = \frac{L}{E}$ WHERE $L = 1570\ N$, $E = 400\ N$

$= \frac{1570}{400} = 3.925$ @ 100% EFFICIENCY

AT 75% η, $MA = 3.925 \times 0.75 = 2.94$

MA AT 75% EFFICIENCY = 2.94

VR = MA @ 100% EFFICIENCY

FROM ABOVE VR = 3.925

VR OF THE SYSTEM = 3.925

QUESTION 15

$VR = \frac{DE}{DL}$ WHERE $DE = \pi D = 1600\pi$ mm

DL = PITCH = 6 mm

$= \frac{1600\pi}{6} = 837.8$

VR OF THE SYSTEM = 837.8

ii) $VR = \frac{DE}{DL} = \frac{25\pi}{6}$

$= 13.1$

PITCH = DL = 6

CIRCUMFERENCE = DE = $\pi D = 25\pi$

VR OF THE SCREW THREAD = 13.1

ii) $MA = \eta . VR = \frac{L}{E}$ & FORCE AT A = EFFORT

$\therefore E = \frac{L}{\eta \times VR}$ WHERE $L = 2 \times 10^3 \times 10\ N$, $VR = 837.8$, $\eta = 0.7$

$= \frac{2 \times 10^4}{837.8 \times 0.7}$

$= 34.1\ N$

THE FORCE NECESSARY AT = 34.1 N

QUESTION 16 PAGE 4-3

i) $VR = \frac{DE}{DL}$ WHERE $DE = 3\pi D = 400\pi \times 3$ mm, DL = PITCH = 7 mm

$= \frac{400\pi \times 3}{7} = 538.6$

VR OF THE JACK = 538.6

QUESTION 16

(ii) $MA = \eta \times VR$ WHERE $VR = 538.6$, $\eta = 0.2$

$= 0.2 \times 538.6$

$= 107.7$

MA OF THE JACK = 107.7

(iii) $MA = \frac{L}{E} = 107.7$

$\therefore E = \frac{L}{107.7}$ WHERE $L = 500 \times 10\ N$

$= \frac{5000}{107.7} = 46.4\ N$

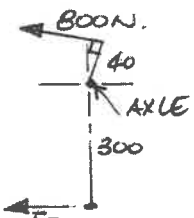
EFFORT REQUIRED TO RAISE 500 kg = 46.4N

QUESTION 17

$\Sigma M_{AXLE} = 0\ \curvearrowright +$

$(F_F \times 300) - (800 \times 40) = 0$

$F_F = 106.7\ N$



$F_F = \mu N$

$\mu = \frac{F_F}{N}$ WHERE $F_F = 106.7\ N$, $N = 680\ N$

$= \frac{106.7}{680} = 0.157$

COEFFICIENT OF FRICTION (μ) = 0.157

QUESTION 18

(i) MASS OF WATER DISPLACED = MASS OF SUB.

$\rho = \frac{M}{V}$ WHERE $\rho = 1030\ kg/m^3$, $M = 5000 \times 10^3\ kg$, $V = ?$

$V = \frac{M}{\rho} = \frac{5 \times 10^6}{1030}$

$= 4854.4\ m^3$

VOLUME OF WATER DISPLACED BY SUB = 4854.4 m³

(ii) MASS OF FRESH WATER DISPLACED = VOLUME × DENSITY (ρ)

$= 4854.4 \times 1000$

$= 4854.4$ TONNES.

$\therefore$ SUB. MUST REDUCE ITS MASS TO 4854.4 TONNES IF IT IS TO JUST FLOAT IN FRESH WATER

$\therefore$ QUANTITY OF WATER TO PUMP OUT = $5000 - 4854.4$

$= 145.6$ TONNES

QUANTITY OF WATER TO PUMP OUT = 145.6 TONNES

QUESTION 19

i) IMMERSING THE PROTOTYPE WHEEL IN FRESH WATER AND DETERMINE THE MASS OF WATER DISPLACED (WHICH, BY ARCHIMEDES' PRINCIPLE, WILL BE THE SAME AS THE MASS OF THE WHEEL)
USE THE FORMULA $\rho = \frac{M}{V}$ TO DETERMINE VOLUME.
ALTERNATIVELY IF THE S.G. IS KNOWN FOR THE ALUMINIUM ALLOY, THE SAME FORMULA CAN BE USED TO DETERMINE THE VOLUME OF THE WHEEL AFTER DETERMINING THE MASS OF THE WHEEL.

(ii) $\rho = \frac{M}{V}$ WHERE $\rho = 2.8 \times 10^3 \text{ kg/m}^3$, $M = 5 \text{ kg}$, $V = ?$

$$V = \frac{M}{\rho} = \frac{5}{2.8 \times 10^3}$$
$$= 1.786 \times 10^{-3} \text{ m}^3$$

ADD 10% $= 1.786 \times 10^{-4} + 1.786 \times 10^{-3} = 1.96 \times 10^{-3} \text{ m}^3$

VOLUME OF ALUMINIUM REQUIRED = $1.96 \times 10^{-3} \text{ m}^3$

QUESTION 20

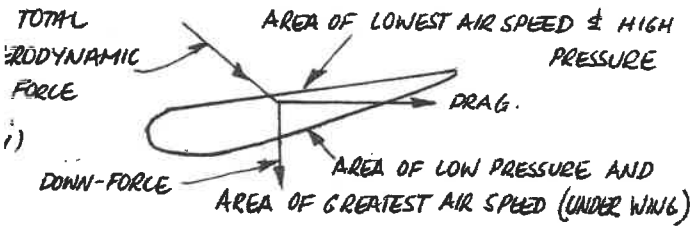


$\Sigma M_{\text{REAR WHEEL}} = 0 \curvearrowright +$

$$-(F_W \times 13) - (8 \times 10^3 \times 4) + (5 \times 10^3 \times 3) + (22 \times 10^3 \times 1.5) = 0$$
$$F_W = 1.23 \text{ kN}$$

DOWN-FORCE REQUIRED ON FRONT WING = 1.23 kN

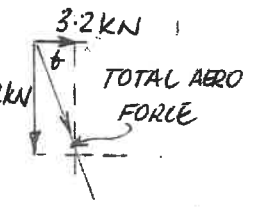
QUESTION 21



i)

ii) BECAUSE OF THE CONSERVATION OF PRESSURE ENERGY, THE AREA OF HIGH SPEED FLUID RESULTS IN A LOW PRESSURE REGION & THE AREA OF LOW SPEED FLUID RESULTS IN A HIGH PRESSURE REGION.

iii)



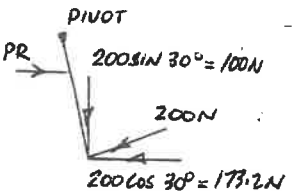
TOTAL FORCE $= \sqrt{3.2^2 + 11.2^2}$
$= 11.65 \text{ kN}$

$\tan\theta = \frac{11.2}{3.2}$ $\theta = 74.1^\circ$

TOTAL AERODYNAMIC FORCE = 11.65 kN ↘ 74.1°

QUESTION 22

(i) $\Sigma M_{\text{PIVOT}} = 0 \curvearrowright +$



F.B.D.

$$-(PR \times 50) + (100 \times 80) + (173.2 \times 350) = 0$$
$$PR = 1372.4 \text{ N}$$

FORCE IN PUSH ROD = 1372.4 N

(ii) VR = MA @ 100% EFFICIENCY

$$VR = MA = \frac{L}{E} \quad \text{WHERE } L = 1372.4 \text{ N}, \ E = 200 \text{ N}$$
$$= \frac{1372.4}{200}$$
$$= 6.86$$

VELOCITY RATIO OF THE BRAKE LEVER = 6.86

(iii) $\text{PRESSURE} = \text{STRESS} = \text{STRENGTH} = \frac{\text{LOAD}}{\text{AREA}}$

$$\therefore \text{PRESSURE} = \frac{P}{A_X} \quad \text{WHERE } P = 1372.4 \text{ N}, \ A_X = \pi r^2 = \pi \times 25^2 \times 10^{-6} \text{ m}^2$$
$$= \frac{1372.4}{\pi \times 25^2 \times 10^{-6}}$$
$$= 0.7 \text{ MPa.}$$

PRESSURE IN THE SYSTEM = 0.7 MPa.

(iv) $\text{PRESS.} = \frac{P}{A_X}$

$$\therefore P_{(\text{LOAD})} = \text{PRESS} \times A_X \quad \text{WHERE PRESS} = 0.7 \times 10^6 \text{ Pa}, \ A_X = \pi r^2 = \pi \times 12.5^2 \times 10^{-6} \text{ m}^2$$
$$= 0.7 \times 10^6 \times \pi \times 12.5^2 \times 10^{-6}$$
$$= 343.1 \text{ N}$$

FORCE PRODUCED BY EACH WHEEL CYLINDER = 343.1 N

(v) VOLUME OF FLUID MOVED BY MASTER CYLINDER $= A_X \times 10 \text{ mm}$
$= \pi r^2 \times 10$
$= \pi \times 25^2 \times 10 = 19634.95 \text{ mm}^3$

MOVEMENT OF ONE PISTON IN ONE WHEEL CYLINDER $= \frac{19634.95}{\pi \times 12.5^2} = 40 \text{ mm.}$

MOVEMENT OF B PISTONS $= \frac{40}{B} = 5 \text{ mm.}$

MOVEMENT OF EACH WHEEL CYLINDER PISTON = 5 mm.

(vi) $VR_{\text{HYD SYSTEM}} = \frac{D_E}{D_L}$ WHERE $D_E = 10$, $D_L = 5$

$$= \frac{10}{5} = 2$$

VELOCITY RATIO OF HYDRAULIC SYSTEM = 2

QUESTION 23

AT THE ANGLE OF REPOSE $\tan 40^\circ = \mu = 0.84$

QUESTION 24

LET F BE THE FORCE ON THE SINGLE PIECE
THEN $\frac{F}{2}$ WILL BE THE FORCE ON EACH OF THE OTHER TWO PIECES

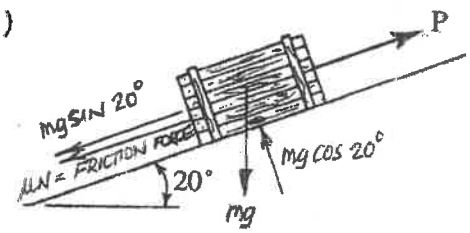
$\therefore F_F = \mu N = \frac{P}{2}$ WHERE $\mu = 0.4$, $N = 500\,N$

$P = 2 \times \mu \times N$
$= 2 \times 0.4 \times 500$

$\therefore P = 400\,N$

QUESTION 25

(i)



(ii) $VR = \frac{DE}{DL}$ WHERE $DE = \frac{DL}{\sin 20^\circ}$ SINCE $\sin 20^\circ = \frac{DL}{DE}$

$= \frac{DL}{\sin 20^\circ \times DL} = \frac{1}{\sin 20^\circ} = \frac{1}{0.342} = 2.92$

$\therefore VR = 2.92$

(iii) $MA = \frac{L}{E}$ WHERE $L = 1 \times 10^3\,N$

$= \frac{1 \times 10^3}{811.87}$

$\therefore MA = 1.23$

$E = mg \sin 20^\circ + \mu N$
$= mg \sin 20^\circ + \mu . mg \cos 20^\circ$
$= mg(\sin 20^\circ + 0.5 \cos 20^\circ)$
$= 811.87\,N$

(iv) EFFICIENCY $(\eta) = \frac{MA}{VR}$ WHERE $MA = 1.23$, $VR = 2.92$

$= \frac{1.23}{2.92}$

$\therefore \eta = 0.42$ OR 42%

QUESTION 26

(i) $VR = \frac{DE}{DL}$ WHERE $DE = 300\,mm$, $DL = 50\,mm$

$= \frac{300}{50} = 6$

$\therefore VR = 6$

(ii) $VR_{(HYDRAULIC\ SYSTEM)} = \frac{D^2}{d^2}$ WHERE $D = 40\,mm$, $d = 15\,mm$

$= \frac{40^2}{15^2}$

$\therefore VR = 7.1$

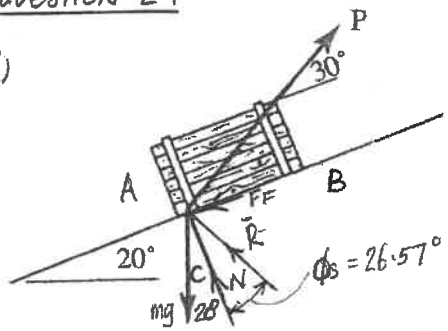
(iii) VR (JACK) = VR (LEVER) × VR (HYDRAULICS)
$= 6 \times 7.1$
$= 42.6$

MA @ 70% EFF $= 0.7 \times 42.6 = 29.8$

$\therefore$ VR (JACK) $= 29.8$

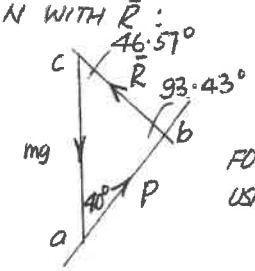
QUESTION 27

(i)



$\tan \phi_s = \mu = 0.5 \therefore \phi_s = 26.57$

FORCE DIAGRAM REPLACING F_F & N WITH $\vec{R}$:



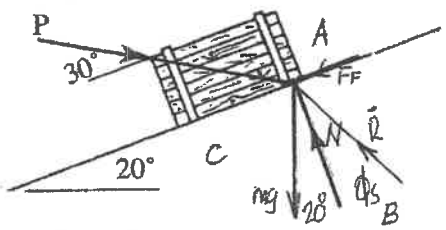
FORCE DIAGRAM USING BOW'S NOTATION

USING THE SINE RULE (OR YOU CAN SCALE)

$\frac{mg}{\sin 93.43^\circ} = \frac{P}{\sin 46.57^\circ}$

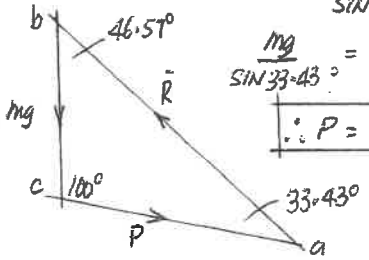
$\therefore P = 727.5\,N$

(ii)



$\tan \phi_s = \mu \therefore \phi_s = 26.57$

FORCE DIAGRAM:



SINE RULE:

$\frac{mg}{\sin 33.43^\circ} = \frac{P}{\sin 46.57^\circ}$

$\therefore P = 1318.2\,N$

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

Corrosion

5

Aim to complete each question many times in 2 years								
Question	Page/s	Study register ✔						
Multiple choice	40							
Question 11	41							
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Question 22	43							
Solutions	44-45							

Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

1. Which best describes *corrosion*?
   (A) The unintentional chemical reaction between any material and its environment.
   (B) The unintentional chemical reaction between a metal and its environment.
   (C) The unintentional chemical reaction between a metal and non-metal.
   (D) The breakdown of a metal due to the reaction of the material with water.

2. When does *dry corrosion* occur?
   (A) When any material reacts with water vapour in the atmosphere to form a layer of oxide on the surface of the metal
   (B) When a metal is subjected to high velocity gas which causes a breakdown of the surface of the metal.
   (C) When a metal reacts with atmospheric gases to form a layer of the metal oxide on the surface of the metal.
   (D) When two different metals are joined in a conducting liquid which causes corrosion of the more reactive metal.

3. When does *stress corrosion* occur?
   (A) In metals which have a high variation of stress within the metal with corrosion occurring at the more highly stressed area.
   (B) In metals which have a high variation of stress within the metal with corrosion occurring at the least highly stressed area.
   (C) When two metals come in contact and the strongest metal corrodes first.
   (D) In strong metals which cannot resist the highest stress.

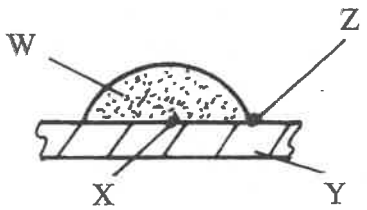
4. Where does the *movement of electrons* occur in wet corrosive environments?
   (A) Electrons move along the metal conductor from the cathode to the anode resulting in corrosion at the cathode.
   (B) Electrons move from the electrolyte to the anode causing the anode to corrode.
   (C) Electrons move into the electrolyte and then deposit on the anode causing the anode to corrode.
   (D) Electrons move along the metal conductor from the anode to the cathode resulting in corrosion at the anode.

5. Which best describes the *Standard EMF* (electromotive force) Series?
   (A) Metals and non-metals arranged in order of reactivity with the most reactive material highest on the list.
   (B) Metals and non-metals arranged in order of reactivity with the least reactive material highest on the list.
   (C) Metals arranged in order of reactivity with the most reactive material highest on the list.
   (D) Metals arranged in order of reactivity for a particular environment (such as in sea-water) with the most reactive metal highest in the series.

6. Which best describes the reaction if *two dissimilar metals are placed in contact* in a wet environment?
   (A) The more reactive metal is more likely to corrode.
   (B) The less reactive metal is more likely to corrode.
   (C) Both metals should corrode at the same rate depending on the thickness of the oxide film on each metal.
   (D) The least reactive metal will corrode first if it is supporting the greatest load.

7. What is the *type of corrosion* that occurs in both wet and dry environments and where the whole metal is attacked as a result of changing anode and cathode regions over the entire surface of the metal?
   (A) Stress corrosion. (B) Uniform attack. (C) Selective leaching. (D) Intergranular corrosion.

8. A concentration corrosion cell comprising a water droplet on metal is shown. Which is the region *most likely to corrode*?
   (A) Region W
   (B) Region X
   (C) Region Y
   (D) Region Z



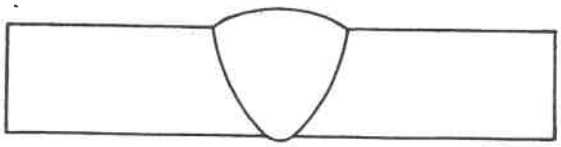
9. What is the most effective method of *preventing or reducing corrosion*?
   (A) Cathodic protection.
   (B) Alleviating corrosion problems by design.
   (C) Use of effective rust resisting paints.
   (D) Use of sacrificial anodes.

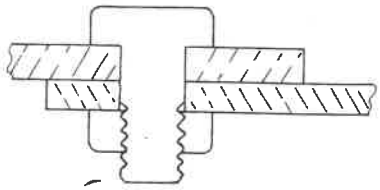
10. Which best describes metals that *resist corrosion* more than other metals?
    (A) Metals that have a non-porous oxide layer which insulates the metal from corrosive attack.
    (B) Metals that have an affinity with rust resisting paints.
    (C) Metals that are easily galvanised.
    (D) Metals which allow electrons to be removed from the surface of the metal.

Section II - Short structured response questions

Question 11

(a) Two methods of joining structural steel components for civil structures, such as the frame of a high rise building, are welding and high tensile bolts. Both of these methods may corrode in specific areas. On the sketches of a bolted joint and a welded joint below indicate the areas most susceptible to corrosion.





(b) Discuss the mechanism of corrosion in the areas that you have indicated above when subjected to wet corrosion, giving reasons why why these regions were selected.

(c) Gold and aluminium alloys are used in the manufacture of products and generally do not have to be protected against corrosion. Explain the reason for this.

(d) Gold occurs in nature as the metal whereas aluminium occurs as aluminium oxide or bauxite. Explain the reason for this using the EMF series on page 81 in your Engineering Studies Workbook to assist your explanation.

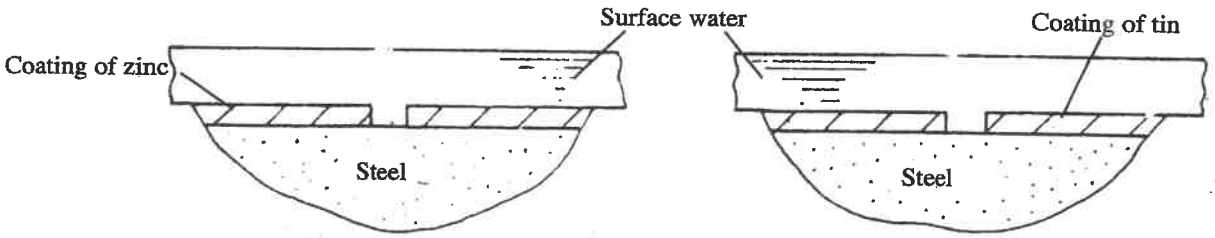
Question 12

Two diagrams of mild steel surface coated with zinc and tin, are shown below. A break in the coatings and surface moisture allows a galvanic cell to be established.

(a) Using labelled arrows indicate on the diagrams the cathodic and anodic areas.

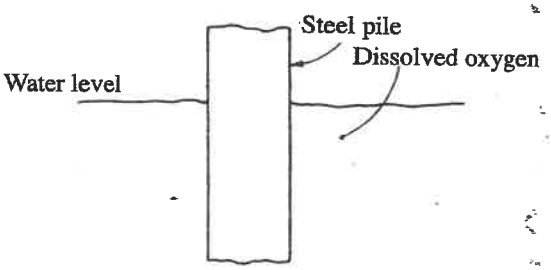
(b) In each of the galvanic couples shown which metal corrodes preferentially?

(c) In the absence of a protective coating, mild steel undergoes corrosion due to local variations of electrical potential. State two microstructural features of the mild steel which can produce such variations.



Question 13

A sketch of a steel wharf pile that is partly submerged in moving water is shown.



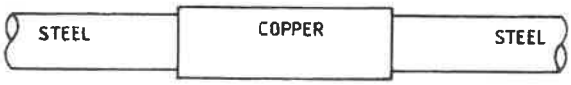
(a) Use labelled arrows to indicate on the sketch the location of the anodic area and the cathodic area of the steel wharf pile.

(b) The steel wharf pile is to be protected by an impressed voltage. Explain how the impressed voltage will prevent corrosion of the pile.

(c) Suggest another method which would protect the steel pile from corrosion.

Question 14

Two steel water pipes are joined by a copper socket as shown in the diagram.



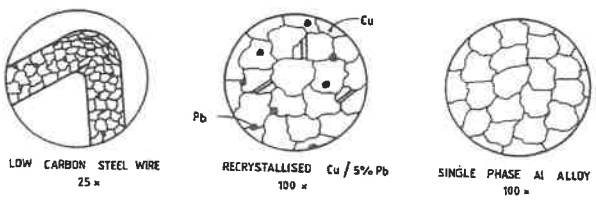
(a) Indicate on the diagram above, the sites at which corrosion would be expected to occur.

(b) Explain why this corrosion takes place. Use the EMF series on page 81 in your Engineering Studies Workbook to assist your explanation.

(c) Specify one method which may be used to prevent corrosion in this socket and pipe assembly.

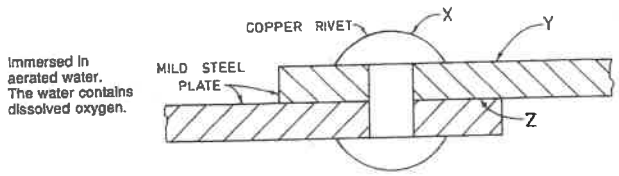
The microstructures of three metals are shown on the right. If each material is immersed in a corrosive solution, indicate on each of the diagrams:

(d) The area where preferential corrosion would occur and the anodic and cathodic areas.



Question 15

Mild steel plates are joined by copper rivets as shown in the diagram and immersed in aerated water.



(a) For X, Y and Z above indicate which are anodic and which are cathodic.
(b) Which metal corrodes preferentially and give a reason for your answer.
(c) Identify the position (X,Y or Z) where the corrosion is likely to be most severe and give a reason.

Question 16

In four separate experiments, steel is coupled with each of the metals zinc, cadmium, titanium and copper and immersed in fresh water.

- Experiment 1: Steel and zinc
- Experiment 2: Steel and cadmium
- Experiment 3: Steel and titanium
- Experiment 4: Steel and copper

(a) State in which experiment you would expect the steel to be least protected from corrosion. Explain your answer.
(b) State in which experiment you would expect the steel to be best protected from corrosion. Explain your answer.
(c) A metal is observed to be corroding and acting as an anode. State whether corrosion will be accelerated or retarded if the anode is smaller then the cathode. Explain your answer.
(d) Explain how chromium in alloy steels provides superior atmospheric corrosion resistance.

Question 17

(a) *'A structure made from copper sheet joined with steel rivets should have a longer service life against corrosion than a structure made of steel sheets joined with copper rivets'*. Justify whether this statement is true or false?
(b) *'The head of a nail is less likely to corrode than the shank when the nail is fully submerged in water'*. Justify whether this statement is true or false.

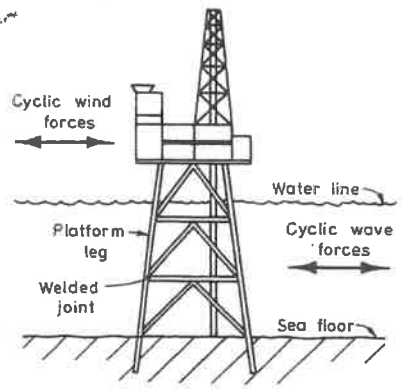
Potassium, magnesium and titanium have been suggested as metals that could be used as sacrificial anodes for the protection of the structural steelwork of a building.

(c) State the most suitable metal of those listed for use as a sacrificial anode (use the EMF series on page 81 in your Engineering Studies Workbook to assist your explanation).
(d) Explain why the two metals you have not selected are unsuitable as sacrificial anodes.
(e) A steel pipe is to be cathodically protected by attached zinc electrodes and then painted. The supervisor is undecided whether the anodes should be painted. Make a recommendation and support your decision.
(f) Brass screws used in a marine environment often appear red in colour after some years in service. Explain in terms of corrosion mechanisms, why this occurs.

Question 18

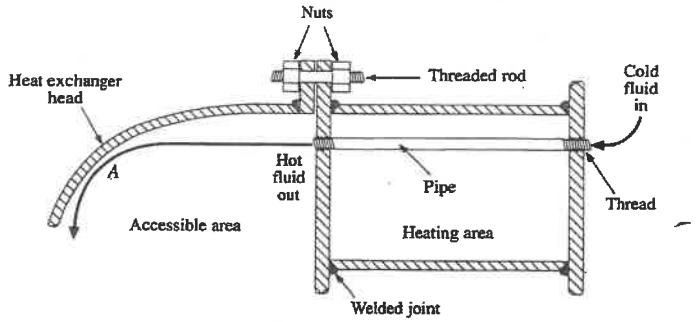
The offshore structure shown is subjected to cyclic loads from both wind and waves throughout its life. The platform legs are constructed of structural steel free from impurities. The welded joints on the platform legs have developed cracks, as observed by divers during routine inspections.

(a) Name and describe the type of corrosion that would occur at the cracked welded joints.
(b) Name and describe one type of corrosion that may occur on the platform legs.
(c) Name and describe two preventative measures that could be used to reduce corrosion on the platform legs.



Question 19

A simplified heat exchanger, made from low-carbon steel, is shown below. A fluid flows through the pipe at high velocity. The fluid strikes the heat exchanger head, at point A, which redirects the flow. The heat exchanger operates under high pressure and temperature.



(a) If corrosion occurs at point A on the heat exchanger head, name and describe this type of corrosion.

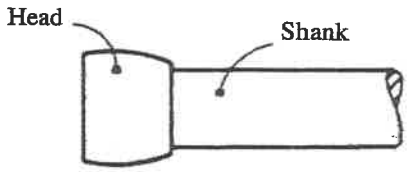
(b) Suggest a possible method of reducing corrosion at point A assuming that the velocity cannot be reduced.

(c) State two other types of corrosion that can occur in the heat exchanger giving reasons for your answers.

(d) Explain a method that could be used to reduce corrosion within the heating area.

Question 20

(a) A low-carbon steel nail is immersed in an aqueous solution. On the diagram indicate:
- the area where corrosion is most likely to occur
- the anodic and cathodic areas



(b) Explain the reason for this corrosion occurring.

Question 21

The microstructure of copper that has been polished and etched, is shown. Explain the reason for corrosion occurring during the etching process.



Equiaxed grains of copper

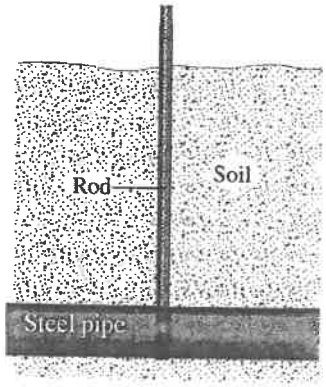
Question 22

To prevent corrosion of an underground low carbon steel pipe, a rod is connected to the pipe as shown in the diagram.

(a) Using the Standard E.M.F. Series on page 81 of the Engineering Studies Workbook, state the most suitable metal for the rod.

(b) Name and explain the process by which the rod aids in the prevention of corrosion.

(c) Aluminium is another metal that could be used for the rod but it would not be advisable. Explain why it would be an inappropriate selection.



SECTION I - MULTIPLE CHOICE

1. A 2. C 3. A 4. D 5. C
6. A 7. B 8. B 9. B 10. A

SECTION II

QUESTION 11

(a)



CORROSION AREAS

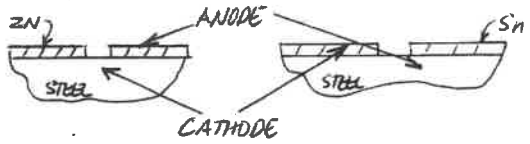
(b) WELD WILL CORRODE DUE TO THE INCREASED STRESS AT & NEAR THE WELD = STRESS CORROSION
INTERNAL AREAS OF THE BOLTED JOINT WILL CORRODE DUE TO A LACK OF OXYGEN IN THESE AREAS COMPARED TO THE OUTSIDE = CONCENTRATION CELL

(c) GOLD IS ALMOST INERT AND IS HIGHLY RESISTANT TO OXIDATION & ALUMINIUM DEVELOPS A NON POROUS OXIDE FILM WHICH PROTECTS THE METAL FROM CORROSION.

(d) GOLD, BECAUSE OF ITS UNREACTIVITY IS FOUND AS A PURE METAL WHEREAS ALUMINIUM IS MUCH MORE REACTIVE AND IS MINED AS AN ORE (BAUXITE). REFINING PRODUCES ALMOST PURE ALUMINIUM WHICH FORMS A STABLE OXIDE ON EXPOSURE TO THE AIR.

QUESTION 12

(a)

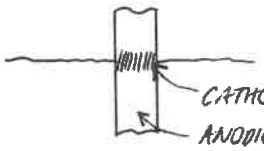


(b) ZINC ON STEEL : ZINC
TIN ON STEEL : STEEL

(c)
- DIFFERENT PHASES PRESENT: α & Fe_3C
- DIFFERENT GRAIN ORIENTATION
- GRAIN BOUNDARIES : AREAS OF HIGHER STRESS.

QUESTION 13

(a)

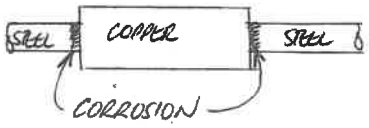


(b) FLOW OF ELECTRONS FROM EXTERNAL SOURCE PRODUCE INVERSION OF POLES – MAKES THE ANODIC AREA CATHODIC AND CATHODIC ANODIC THUS PREVENTING CORROSION OF THE PILE.

(c) GALVANISING THE PILE
USE OF SACRIFICIAL ANODE.

QUESTION 14

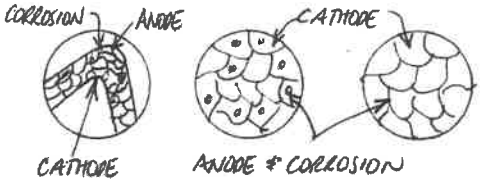
(a)



(b) IRON IS MORE REACTIVE THAN COPPER - IRON BECOMES THE ANODE & COPPER BECOMES THE CATHODE.

(c) SACRIFICIAL ANODE OR IMPRESSED VOLTAGE APPLIED TO THE CONNECTION.

(d)



QUESTION 15

(a) X = CATHODIC Y = CATHODIC
Z = ANODIC.

(b) MILD STEEL CORRODES PREFERENTIALLY BECAUSE IT IS MORE REACTIVE THAN COPPER.

(c) POSITION Z WOULD BE MOST SEVERE CORROSION SITE DUE TO A DEPLETION OF OXYGEN AT THIS SITE = CONCENTRATION CELL.

QUESTION 16

(a) EXPERIMENT 4: COPPER IS LEAST REACTIVE AND BELOW Fe ON EMF SERIES THUS COPPER BECOMES THE CATHODE & Fe THE ANODE

(b) EXPERIMENT 3: TITANIUM IS MORE REACTIVE THAN Fe (ABOVE Fe ON EMF SERIES) THUS TITANIUM BECOMES THE ANODE & STEEL THE (PROTECTED) CATHODE

(c) ACCELERATED BECAUSE A LARGER CATHODE CAN CONSUME MORE ELECTRONS AT A GREATER RATE FROM THE ANODE

(d) CHROMIUM (ALONG WITH TITANIUM, ALUMINIUM) FORMS AN OXIDE LAYER WHICH IS NON-POROUS, INSOLUBLE & SELF HEALING WHEN SCRATCHED THUS PROTECTING THE METAL FROM O_2 & H_2O.
THIS IS CALLED 'PASSIVITY'

QUESTION 17

(a) FALSE STATEMENT.
LARGE CATHODE WITH SMALL ANODE WILL RESULT IN ACCELERATED CORROSION AT THE ANODE - STEEL RIVETS WILL QUICKLY CORRODE AND FAIL

FALSE STATEMENT.
THE HEAD OF THE NAIL IS MORE LIKELY TO BE ANODIC DUE TO STRESSES FROM COLD FORMING

(b) MOST SUITABLE METAL IS MAGNESIUM

(c) POTASSIUM - IS TOO REACTIVE (AT TOP OF EMF SERIES) AND WOULD QUICKLY CORRODE LEAVING THE STEEL FRAME UNPROTECTED
TITANIUM - FORMS A NON-POROUS, INSOLUBLE & SELF HEALING OXIDE FILM, WHICH WILL ISOLATE IT FROM PROTECTING THE STEEL FRAME.

(d) RECOMMENDATION: MUST NOT PAINT ZINC (OR ANY) SACRIFICIAL ANODES.
REASON: PAINTING WILL PROTECT THE ZINC ELECTRODES AND THUS NOT ALLOW THE ELECTRODES TO CORRODE AND PROTECT THE PIPE

(e) THE MARINE ENVIRONMENT CAUSES DE-ZINCIFICATION (= SELECTIVE LEACHING)
WHICH LEAVES THE BRASS RICH IN COPPER THUS PRODUCING A REDDISH COPPER COLOUR.

QUESTION 18

(a) CONCENTRATION CELL CORROSION
- THE LOWER OXYGEN CONCENTRATION AT THE BOTTOM OF CRACK PRODUCES AN ANODIC REACTION; HIGHER OXYGEN CONCENTRATION ON THE TOP OF CRACK PRODUCES THE CATHODE POLE.

(b) GALVANIC CORROSION CAUSING INTERGRANULAR ATTACK IN PEARLITE ALONG GRAIN BOUNDARIES.

(c) METHOD 1: SACRIFICIAL ANODE - AN ANODE OF HIGH REACTIVITY SUCH AS ZINC OR MAGNESIUM IS FIXED TO THE STRUCTURE TO PROVIDE ELECTRICAL CONTACT PROVIDING CATHODIC PROTECTION.

METHOD 2: IMPRESSED VOLTAGE - A D.C. SOURCE OF VOLTAGE IS PROVIDED TO THE LEGS MAKING THE LEGS CATHODIC BY SUPPLYING ABUNDANT ELECTRONS FROM AN EXTERNAL POWER SOURCE.

QUESTION 19

(a) EROSION CORROSION - OCCURS IN BOTH WET & DRY ENVIRONMENTS & IS CAUSED BY THE ABRASION ACTION OF PARTICLES, STEAM OR BUBBLES IN A LIQUID OR GAS WHICH BREAKS DOWN THE PROTECTIVE COATINGS ON METALS & LEADS TO CORROSION AS A RESULT OF THE FORMATION OF CONCENTRATION CELLS

(b) SUGGESTED METHOD: SURFACE COATING THE HEAT EXCHANGER HEAT WITH AN ABRASION RESISTANT MATERIAL SUCH AS CHROMIUM SURFACING.

(c) INTERGRANULAR CORROSION - IN THE GRAIN BOUNDARIES OF PEARLITE
STRESS CORROSION - DUE TO COLD WORKING OF HEAT EXCHANGER HEAD & AT WELDED JOINTS & AT ROLLED THREADS.
CONCENTRATION CELL (DIFFERENTIAL AERATION) CORROSION - AT THE INTERFACE OF NUTS AND PLATE

(d) COATING THE SURFACE AT RISK WITH PAINTS, GALVANISING THE METAL BEFORE ASSEMBLY, CATHODIC PROTECTION BY IMPRESSED VOLTAGE & SACRIFICIAL ANODE.

QUESTION 20

(a)



(b) STRESS CORROSION OCCURS DUE TO WORK HARDENING. THE COLD HEADING INDUCES INTERNAL STRESSES THAT INCREASES ITS ELECTRODE POTENTIAL CAUSING THE HEAD TO BECOME ANODIC TO THE SHANK

QUESTION 21

CORROSION OCCURS AT THE GRAIN BOUNDARIES DURING ETCHING DUE TO THEIR IRREGULAR STRUCTURE & HIGHER POTENTIAL THAN THE REGULAR STRUCTURE OF THE GRAINS.

QUESTION 22

(a) MAGNESIUM

(b) CATHODIC PROTECTION - MAGNESIUM IS MORE ANODIC THAN THE STEEL PIPE (MAINLY IRON) & WILL CORRODE PREFERENTIALLY

(c) ALUMINIUM HAS A THIN PROTECTIVE OXIDE FILM AND EXHIBITS 'PASSIVITY'

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

Beams & Trusses

6

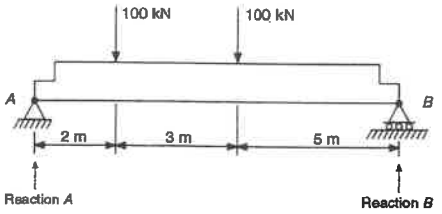
Aim to complete each question many times in 2 years							
Question	**Page/s**	**Study register ✔**					
Multiple choice	47-48						
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Section 1 - Multiple choice questions

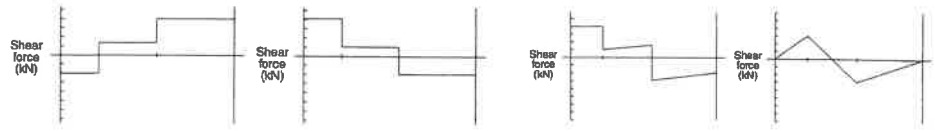
Select by circling the alternative A, B, C or D that best answers the question (use g = 10 m/s²)

1. Which best describes *equilibrium* in structures?
   (A) Forces up = forces down and forces left = forces right.
   (B) Forces up = forces down and anticlockwise moments = clockwise moments.
   (C) The algebraic sum of all forces acting on the structure = 0.
   (D) The algebraic sum of all forces and moments acting on the structure = 0.

2. A loaded beam is simply supported at A and B as shown.
   What are the *magnitudes of reaction A and reaction B*?
   (A) Reaction A = 70 kN reaction B = 130 kN.
   (B) Reaction A = 100 kN reaction B = 100 kN.
   (C) Reaction A = 70 kN reaction B = 120 kN.
   (D) Reaction A = 130 kN reaction B = 70 kN.

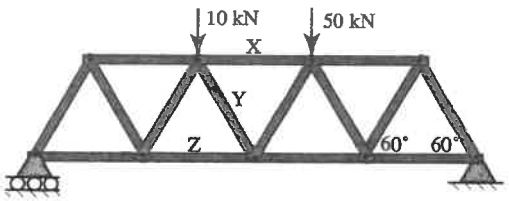


3. Which *shear force diagram* represents the shear forces acting on the beam shown in question 2 above?

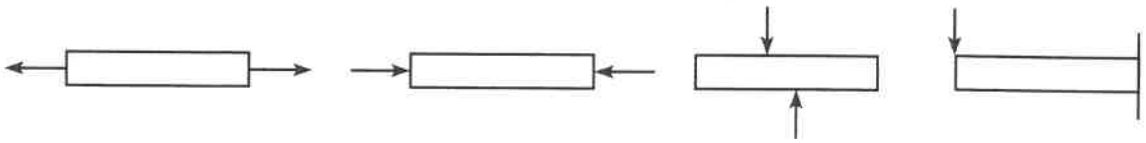


(A) (B) (C) (D)

4. What is the most appropriate method of *determining the force and the nature of the force* in members X, Y and Z in the truss shown below?
   (A) Analysing each joint (the method of joints).
   (B) Extending each force along its line of action (the principle of transmissibility).
   (C) Taking a section through the three members and taking moments (the method of sections).
   (D) Obtaining a common point of concurrence for only three forces (the three force rule).



5. Which diagram represents *shear force*?



(A) (B) (C) (D)

6. Which best defines the *bending moment* at any cross section A, in a straight beam?
   (A) The algebraic sum of all vertical forces acting to one side of A.
   (B) The algebraic sum of all horizontal forces acting to one side of A.
   (C) The algebraic sum of all inclined forces acting to one side of A.
   (D) The algebraic sum of the moments of all forces acting to one side of A.

7. When does a *shear force* have zero magnitude in a beam?
   (A) When the bending moment is a local maximum or local minimum.
   (B) When the algebraic sum of all moments is zero.
   (C) When the bending moment is zero.
   (D) When the beam has the least internal stress.

8. What would produce a *uniformly distributed load (UDL)* on a beam supporting a pre-tensioned concrete pavement of a multi-storey shopping centre car park?
   (A) The cars parked on the concrete pavement which is supported by the beam.
   (B) The columns supported by the floor and the beam.
   (C) The weight-force of the concrete pavement and beam.
   (D) The cars driving across the concrete pavement supported by the beam.

9. Where is the position of the *neutral axis* on a beam?
   (A) Where the tensile reactive force changes to a compression reactive force in the beam.
   (B) Where the shear reactive force changes to a compression reactive force in the beam.
   (C) Where the bending reactive force changes to a shear reactive force in the beam.
   (D) Where maximum strain occurs within the beam.

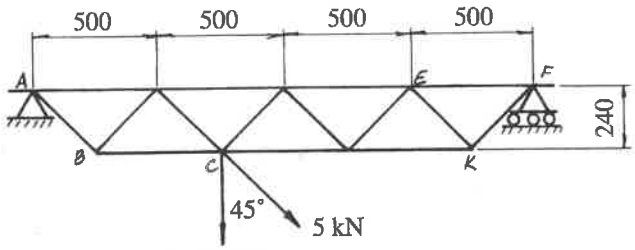
10. *Universal beams*, as shown, are used widely in structural engineering. What is the main reason for their high strength?
   (A) Universal beams have increased volume further away from the neutral axis.
   (B) Universal beams have increased volume at the neutral axis.
   (C) Universal beams have been hot rolled which increases their strength.
   (D) Universal beams have grainflow due to cold rolling.


Universal beam

Section II - Short structured response questions

Question 11

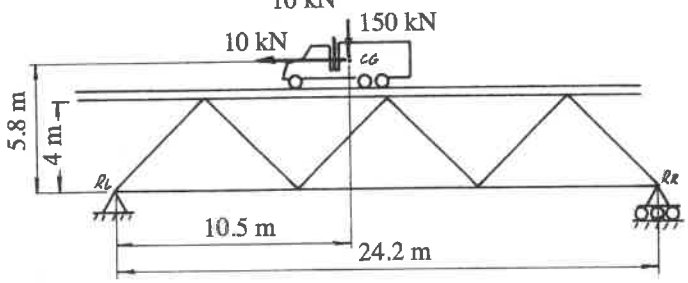
A small truss is to be used as a hoist beam in a workshop as shown.



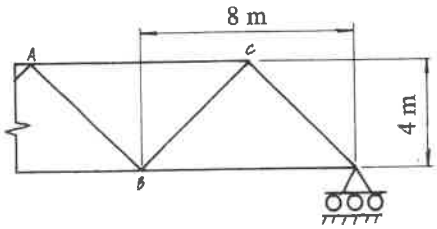
(i) Determine the reaction forces at A and F.
(ii) Determine the forces in members EF and KF and indicate whether they are in tension or compression.
(iii) For another loading, the force in member BC is 45 kN. If the cross-sectional area of the member is 520 mm^2, what is the change in length of the member when subjected to this load. Assume the value of Young's Modulus for the material is 220 GPa.

Question 12

A truck, having a weight-force of 150 kN, brakes heavily on a bridge. The braking force generated by the truck is 10 kN while in the position on the bridge as shown.



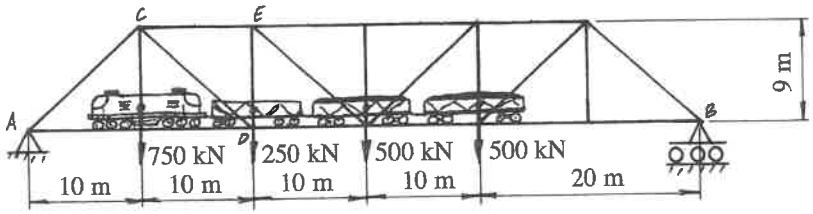
(i) Draw a free body diagram indicating the forces acting on the bridge.
(ii) Find the reactions R_L and R_R.
(iii) For another loading, the reaction at the roller support was 200 kN. Using the details shown below, find the force in members AB and AC.



Question 13

A railway bridge having a mass of 350 tonnes is loaded by a stationary train as shown in the diagram below.

(i) Determine the reactions at A and B.
(ii) For another set of conditions the reaction at A was found to be 1500 kN. Find the forces in the members AC and CD and state whether they are in tension or compression.
(iii) For another situation the force in member DE is 120 kN and the member is made from pipe with a wall thickness of 5 mm and outside diameter of 50 mm. Find the change in length of the pipe if the Modulus of Stiffness (Young's Modulus) is 250 GPa for the material from which the pipe is made.

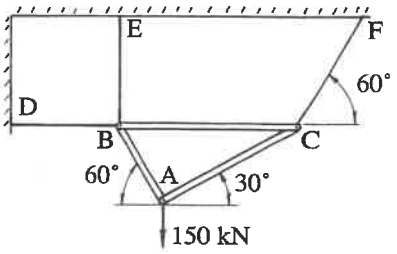


Question 14

The pin jointed frame ABC shown, is an elaborate method used to support a load of 150 kN.

(i) Find the forces in the three members AB, AC and BC stating whether they are in tension or compression.

(ii) Determine the forces in the support cables BD, BE and CF.

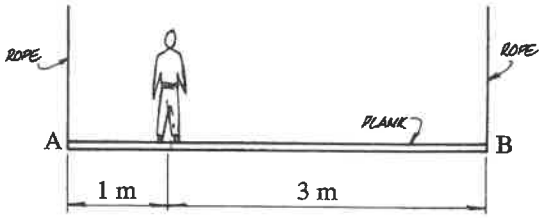


Question 15

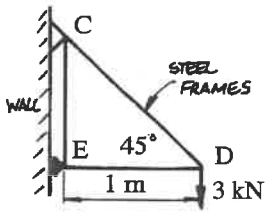
A window cleaner of mass 80 kg and standing on a plank of mass 30 kg, is supported by two ropes suspended from steel frames on the side of the building.

(i) Draw a free body diagram showing all of the forces acting on the plank AB.

(ii) Determine the tension in the ropes attached to A and B due to the mass of the window cleaner and the plank.

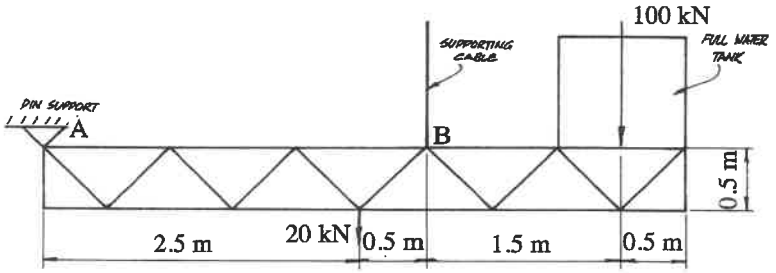


(iii) One of the two frames used to support each of the ropes is shown. For another set of conditions, the force in each of the supporting ropes is 3 kN as shown. Determine the force in the members CD and DE indicating whether the member is in tension or compression.



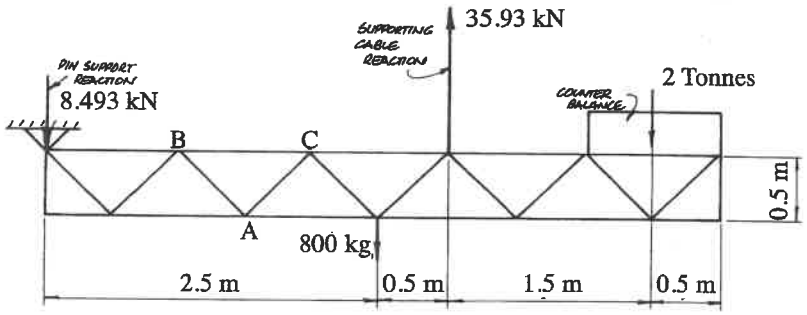
Question 16

The truss shown is used to support a water tank. The full tank exerts a downward force of 100 kN and the truss a downward force of 20 kN as shown in the diagram. Find the magnitude and direction of the reactions at the supports at A and B.



Question 17

A counter balance of mass 2 tonnes is used to balance the truss used for supporting a bank of outside lighting. The reactions at the cable and pin support are given. If the mass of the truss is 800 kg, determine the forces in members AB and BC.

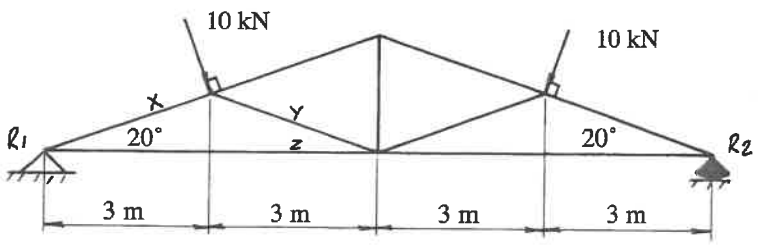


Question 18

A truss used for a domestic building is shown below. Find:

(i) The reactions at R_1 and R_2.

(ii) The forces in bars X, Y and Z and state whether they are in tension or compression.



QUESTION 13

(i) ALL VERTICAL FORCES ACTING - ONLY 2 STEPS:

$\Sigma M_{DINA} = 0 \curvearrowright +$

1. $-(R_B \times 60) + (750 \times 10) + (250 \times 20) + (500 \times 30) + (500 \times 40) + (3430 \times 30) = 0 \therefore R_B = 2506.7 \text{ KN} \uparrow$

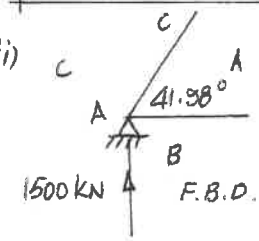
2. $\Sigma F_Y = 0 \uparrow +$

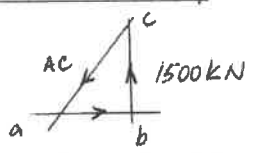
$R_A - 750 - 250 - 3430 - 500 - 500 + 2506.7 = 0$

$R_A = 2923.3 \text{ KN} \uparrow$

REACTION FORCE AT A = 2923.3 KN ↑
REACTION FORCE AT B = 2506.7 KN ↑

(ii)





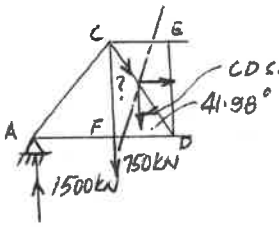
FORCE DIAGRAM.

$\sin 41.98° = \frac{1500}{AC}$

$AC = 2242.6 \text{ KN}$

FORCE IN MEMBER AC = 2242.6 KN COMPRESSION

FOR MEMBER CD, USE METHOD OF SECTIONS BECAUSE IT IS TOO FAR FROM A REACTION FORCE



BECAUSE THE TOP & BOTTOM CHORD OF TRUSS ARE HORIZONTAL

$\Sigma F_Y = 0 \uparrow +$

$+1500 - 750 - CD \sin 41.98° = 0$

$CD = 1121.3 \text{ KN}$

(CORRECT ASSUMED SENSE)

FORCE IN MEMBER CD = 1121.3 KN TENSION.

(iii) $\Delta L = \frac{PL}{EAx}$ WHERE ΔL = CHANGE IN LENGTH m

$= \frac{120 \times 10^3 \times 9}{250 \times 10^9 \times 706.9 \times 10^{-6}}$ $P = 120 \times 10^3 \text{ N}$

$= 6.1 \times 10^{-3} \text{ m}$ $E = 250 \times 10^9 \text{ Pa}$

$= 6.1 \text{ mm}$ $Ax = (\pi R^2 - \pi r^2) \times 10^{-6} \text{ m}^2$

$= \pi(25^2 - 20^2) \times 10^{-6} \text{ m}^2$

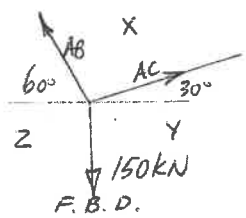
$= 706.9 \times 10^{-6} \text{ m}^2$

$L = 9 \text{ m}$

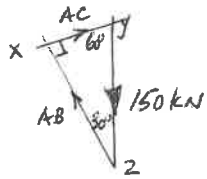
CHANGE OF LENGTH = 6.1 mm

QUESTION 14

(i) JOINT A



F.B.D.



FORCE DIAGRAM.

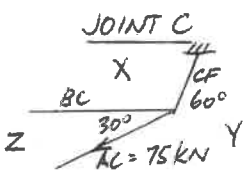
$\sin 30° = \frac{AC}{150}$

AC = 75 KN TENSION

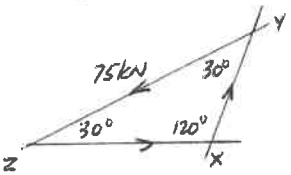
$\cos 30° = \frac{AB}{150}$

AB = 129.9 KN TENSION

JOINT C



F.B.D.



FORCE DIAGRAM

MEMBER BC

USING SINE RULE (OR YOU CAN SCALE GRAPHICALLY)

$\frac{X\,(AC)}{\sin X} = \frac{Y\,(BC)}{\sin Y} \therefore BC = \frac{75 \times \sin 30°}{\sin 120°}$

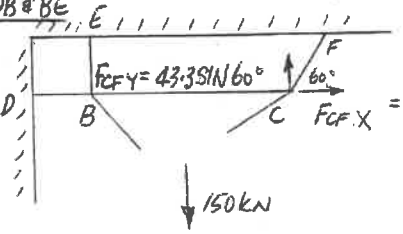
BC = 43.3 KN COMPRESSION

(ii) MEMBER CF (USE SIN RULE AND FORCE DIAGRAM)

$\frac{X\,(AC)}{\sin X} = \frac{Z\,(CF)}{\sin Z} \therefore CF = \frac{\sin 30° \times 75}{\sin 120°}$

CF = 43.3 KN TENSION

MEMBERS DB & BE



$\Sigma F_X = 0 \xrightarrow{+}$

$F_{CF}X - DB = 0$

$DB = 43.3 \cos 60° = 21.65 \text{ KN}$

DB = 21.65 KN TENSION

$\Sigma F_Y = 0 \uparrow +$

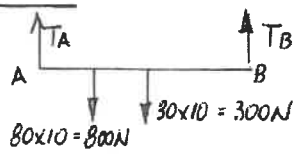
$BE + F_{CF}Y - 150 = 0$

$BE = 150 - 43.3 \sin 60° = 112.5 \text{ KN}$

BE = 112.5 KN TENSION

QUESTION 15

(i)



F.B.D

(ii) $\Sigma M_A = 0 \curvearrowright +$

$(800 \times 1) + (300 \times 2) - (T_B \times 4) = 0$

$T_B = 350\ N \uparrow$

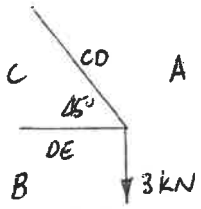
$\Sigma F_Y = 0 \uparrow +$

$T_A - 800 - 300 + 350 = 0$

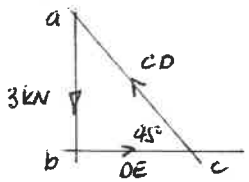
$T_A = 750\ N \uparrow$

TENSION IN ROPE A = 750N
TENSION IN ROPE B = 350 N

(iii)



F.B.D.



FORCE DIAGRAM

$\tan 45^\circ = \frac{3}{DE} \quad \therefore DE = \frac{3}{\tan 45^\circ} = 3kN$

FORCE IN DE = 3 kN COMPRESSION

$\sin 45^\circ = \frac{3}{CD} \quad \therefore CD = \frac{3}{\sin 45^\circ} = 4.2\ kN$

FORCE IN CD = 4.2 kN TENSION

QUESTION 16

$\Sigma M_{PIN} = 0 \curvearrowright +$

$(20 \times 2.5) - (R_B \times 3) + (100 \times 4.5) = 0$

$R_B = 166.7kN \uparrow$

$\Sigma F_Y = 0 \uparrow +$

$R_A + R_B - 20 - 100 = 0$

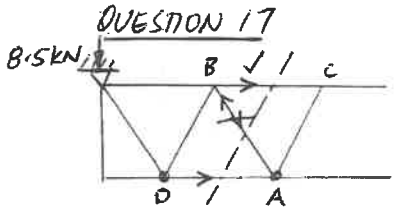
$R_A + 166.7 - 20 - 100 = 0$

$R_A = -46.7\ kN$ (NEGATIVE INDICATES INCORRECT ASSUMED SENSE FOR R_A)

$\therefore R_A = 46.7kN \downarrow$

FORCE IN PIN SUPPORT AT A = 46.7 kN ↓
FORCE IN CABLE AT B = 166.7 kN ↑

QUESTION 17



$\Sigma M_A = 0 \curvearrowright +$

$(BC \times 0.5) - (8.5 \times 1.5) = 0$

$BC = 25.5\ kN$ TENSION

FORCE IN MEMBER BC = 25.5 kN TENSION

$\Sigma M_D = 0 \curvearrowright +$

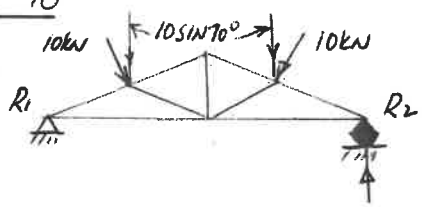
$(AB \times 0.707) + (25.5 \times 0.5) - (8.5 \times 0.5) = 0$

$AB = -12kN$ (ASSUMED SENSE WRONG)

FORCE IN MEMBER AB = 12 kN COMPRESSION

QUESTION 18

(i)

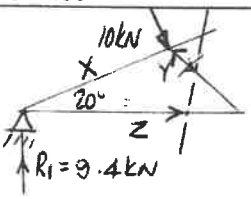


DUE TO SYMMETRICAL LOADING THE HORIZONTAL COMPONENTS WILL CANCEL

$R_1 = R_2 = \frac{2 \times 10 \sin 70^\circ}{2} = 9.4kN \uparrow$

REACTION R_1 & REACTION R_2 = 9.4 kN ↑

(ii)



USING METHOD OF SECTIONS

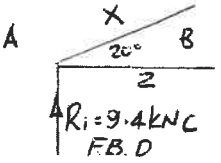
$\Sigma M_{R_1} = 0 \curvearrowright +$

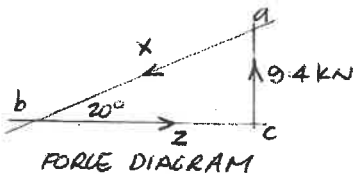
$(Y \times 6\sin 20^\circ) + (10 \times 3.2) = 0$

$Y = -15.6\ kN$

FORCE IN MEMBER Y = 15.6 kN COMPRESSION

USE METHOD OF JOINTS FOR X & Z (CLOSE TO REACTION)





FORCE DIAGRAM

$\tan 20^\circ = \frac{9.4}{Z} \quad \therefore Z = 25.8\ kN$ TENSION

FORCE IN MEMBER Z = 25.8 kN TENSION

$\sin 20^\circ = \frac{9.4}{X} \quad \therefore X = \frac{9.4}{\sin 20^\circ} = 27.5kN$

FORCE IN MEMBER X = 27.5 kN COMPRESSION.

QUESTION 19

(i) $\sigma = \frac{MY}{I}$ WHERE $M = 58 \times 10^3$ Nm

$Y = \frac{250}{2} = 0.125$ m

$= \frac{58.3 \times 10^3 \times 0.125}{45.3 \times 10^{-6}}$ $I = 45.3 \times 10^6$ mm^4

$= 45.3 \times 10^6 \times 10^{-12}$ m^4

$= 160.9 \times 10^6$ Pa $= 45.3 \times 10^{-6}$ m^4

$= 160.9$ MPa

MAXIMUM BENDING STRESS IN UPPER (C) & LOWER FLANGES (T) = 160.9 MPa

(ii) A UNIVERSAL BEAM HAS MORE VOLUME (MASS) FURTHER FROM THE NEUTRAL AXIS THAN THE OTHER SECTIONS SHOWN.

QUESTION 20

(i) $\Sigma M_A = 0 \curvearrowright +$

$-(R_B \times 9) + (90 \times 3) + (120 \times 5.5) + (80 \times 12) = 0$

$R_B = 210$ kN ↑

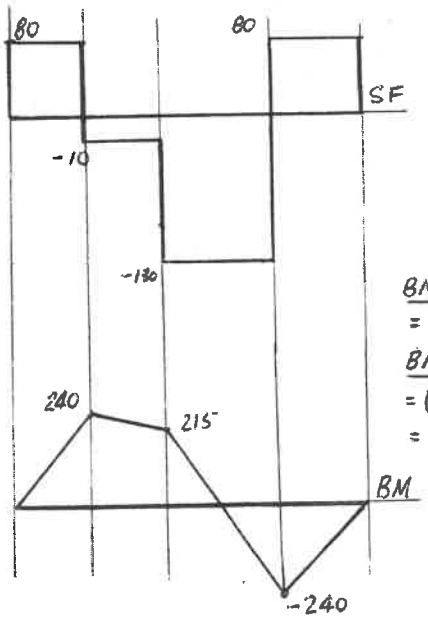
$\Sigma F_Y = 0 \uparrow +$

$R_A - 90 - 120 - 80 + 210 = 0$

$R_A = 80$ kN ↑

REACTION AT A = 80 kN
REACTION AT B = 210 kN

(ii)



BM AT 90kN (LHS) $= 80 \times 3 = 240$ kNm

BM AT 120kN (LHS) $= (80 \times 5.5) - (90 \times 2.5) = 215$ kNm

BM AT B (RHS) $= -(80 \times 3) = -240$ kNm

QUESTION 21

(i) $\Sigma M_B = 0 \curvearrowright +$

$(1.5 \times 1200) + (4.5 \times 3000) - (2.6 \times R_A) = 0$

$R_A = 5889$ N →

$\Sigma F_Y = 0 \uparrow +$

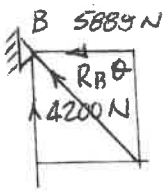
$R_{BY} - 3000 - 1200 = 0$

$R_{BY} = 4200$ N ↑

$\Sigma F_X = 0 \rightarrow +$

$-R_{BX} + 5889 = 0$

$R_{BX} = -5889$ N ←



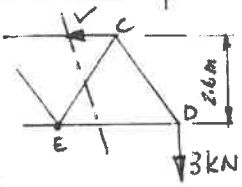
$R_B = \sqrt{5889^2 + 4200^2}$

$R_B = 7233$ N

$\tan\theta = \frac{4200}{5889}$ $\theta = 35.5^\circ$

REACTION AT A = 5889 N →
REACTION AT B = 7233 N 35.5°

(ii) USING METHOD OF SECTIONS



$\Sigma M_E = 0 \curvearrowright +$

$(3000 \times 3) - (BC \times 2.6) = 0$

FORCE BC = 3464 N TENSION

(iii) $F \text{ OF } S = \frac{\sigma_{PROOF}}{\sigma_{WORKING}}$ $\therefore \sigma_W = \frac{250}{1.5} = 166.7$ MPa

$\sigma_W = \frac{P}{A_X}$ WHERE $P = 3 \times 10^3$ N

$A_X = \frac{\pi D^2}{4} \times 10^{-6}$ m^2

$D = \sqrt{\frac{3 \times 10^3 \times 4}{166.7 \times \pi}} = 4.8$ mm

MINIMUM DIAMETER OF CABLE = 4.8 mm

QUESTION 22

(i) $\Sigma M_A = 0 \curvearrowright + = 100 \times 2 + 200 \times 4 - R_B \times 8$

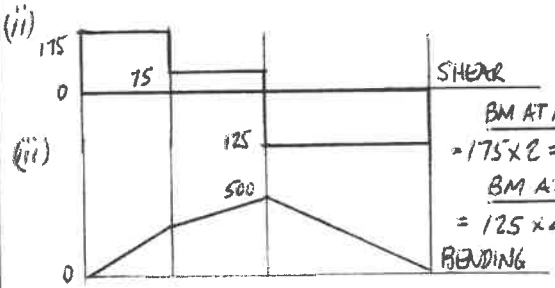
$R_B = 125$ kN ↑

$\Sigma F_Y = 0 \uparrow + = R_A - 100 - 200 + 125$

$R_A = 175$ kN ↑

REACTION AT A = 175kN ↑ REACTION AT B = 125kN ↑

(ii)



BM AT 100 kN LHS $= 175 \times 2 = 350$ kNm

BM AT 200kN RH $= 125 \times 4 = 500$ kN

(iii)

(iv) $\sigma = \frac{MY}{I}$ WHERE $M = 500 \times 10^3$ Nm

$I = 2.6 \times 10^{-3}$ m^4

$= \frac{500 \times 10^3 \times 0.25}{2.6 \times 10^{-3}}$ $Y = 0.25$ m

$= 48 \times 10^6$ Pa $= 48$ MPa

MAXIMUM BENDING STRESS AT C = 48 MPa

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

7

Electricity & Electronics

Aim to complete each question many times in 2 years							
Question	**Page/s**	**Study register ✔**					
Multiple choice	56-57						
Question 11	57						
Question 12	57						
Question 13	57-58						
Question 14	58						
Question 15	58						
Question 16	58-59						
Question 17	59						
Solutions	60-61						

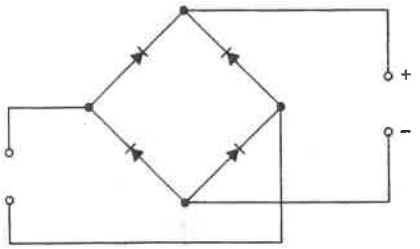
Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

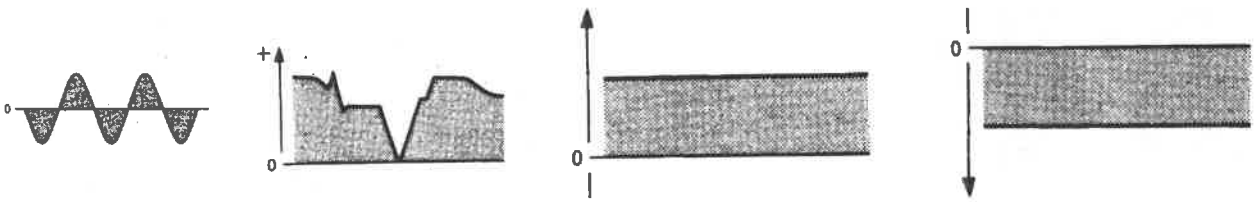
1. Which best describes an *electric current*?
   (A) An electric current is a flow of molecules along a conductor.
   (B) An electric current is an electromagnetic wave produced by a movement of electrons from the negative terminal to the positive terminal.
   (C) An electric current is a flow of electrons along a conductor from the positive terminal to the negative terminal.
   (D) An electric current is a flow of atoms along a conductor from the positive terminal to the negative terminal.

2. Which best describes the term *voltage* in an electrical circuit?
   (A) Voltage is the amount of resistance in an electrical circuit.
   (B) Voltage is the 'electrical pressure' in an electrical circuit.
   (C) Voltage is a measure of the charge or electron movement in a conductor.
   (D) Voltage is rate of movement of atoms along a conductor.

3. What is the *main function* of the electrical circuit shown?
   (A) Rectification of DC current to AC current.
   (B) Amplification of AC current to DC current.
   (C) Rectification of AC current to DC current.
   (D) Transforms AC current to high voltage AC current.



4. Which is the waveform for *alternating current* (AC)?

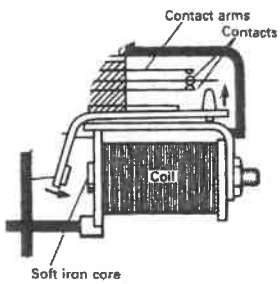


(A) (B) (C) (D)

5. What is the most effective method of reducing the possibility of a fatal *electric shock in domestic electrical circuits*?
   (A) Not having such a high resistance in the circuit.
   (B) Reducing the voltage in the circuit to below 240 volts.
   (C) Maintaining an earth link to the main switchboard.
   (D) Reducing the current flow to below 15 amps.

6. A diesel-electric locomotive uses a diesel engine to convert mechanical energy into electrical energy. Which best describes the *machines in the power train of the locomotive*?
   (A) Motor driving generator driving motor.
   (B) Generator driving motor driving generator.
   (C) Motor driving generator driving generator.
   (D) Generator driving generator driving motor.

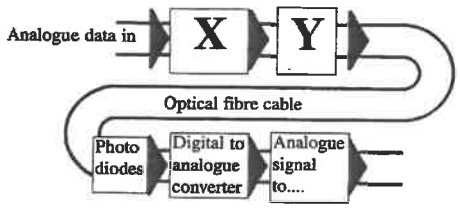
7. Which *electrical concept* is the basis for the function of the electrical component shown?
   (A) Electromagnetic induction.
   (B) Permanent magnetism of soft iron.
   (C) Switching using bi-metallic strips.
   (D) Storing electrical charge using capacitors.



8. Which best describes a main purpose of *Amplitude Modulation (AM) and Frequency Modulation (FM)*?
   (A) To allow for audio frequency to be received on large aerials.
   (B) So that high frequency (HF) carrier waves can more efficiently transmit message signals.
   (C) Allows for ultra high frequency (UHF) waves to be received without distortion.
   (D) Facilitates ultra high frequency signals to be received from satellite transmission.

9. Which best describes the advantages of the use of *optical fibre* compared to copper conducting cables?
(A) Optical fibre is more costly to produce than copper cables but it can transmit more messages, has a lower mass, is not a fire hazard when broken, is more secure from eavesdropping and is free from electromagnetic interference.
(B) Optical fibre is less costly to produce than copper cables and is a fire hazard when broken but it can transmit more messages, has a lower mass, is more secure from eavesdropping and is free from electromagnetic interference.
(C) Optical fibre is more costly to produce than copper cables and is still subject to electromagnetic interference but it can transmit more messages, has a lower mass, is not a fire hazard when broken, is more secure from eavesdropping .
(D) Optical fibre is less costly to produce than copper cables and can be a fire hazard when broken but it can transmit more messages, has a lower mass, is more secure from eavesdropping and is free from electromagnetic interference.

10. What are the two components, X and Y, in the digital transmission sequence of pulsed lightwave by optical fibre?
(A) X = ultra high frequency (UHF) converter to laser frequency; Y = pulsed laser diode.
(B) X = digital to analogue converter; Y = pulsed laser diode.
(C) X = pulsed laser diode; Y = very high frequency (VHF) converter to laser frequency.
(D) X = analogue to digital converter; Y = pulsed laser diode.



Section II - Short structured response questions

Question 11

(a) Explain why metals are generally good conductors of electricity and why ceramics and polymers generally are not.

(b) Explain the meaning of semiconduction as applied to electricity/electronics and give one example of a semiconducting material and its application.

(c) Explain the following terms which relate to electricity:
(i) Voltage or electromotive force (EMF).
(ii) Current or amperage.
(iii) Resistance.

(d) One of the most significant safety aspects regarding electricity is to maintain an earth link to all appliances through the main distribution switchboard. Explain how this is done using a well labelled drawing to assist your explanation.

Question 12

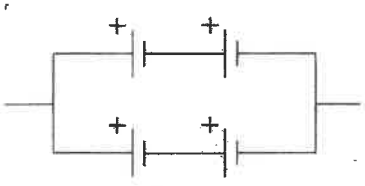
(a) Make a sketch of a simple series circuit and include the following labelled electrical components using the standard symbols: a cell, a simple switch, a variable resistor, a globe.

(b) Make a sketch of a parallel circuit and include the following labelled electrical components using the standard symbols: a battery, a fixed resistor, a fuse, a light emitting diode.

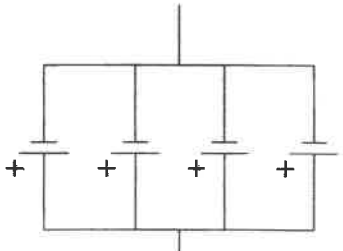
(c) On your drawing to answer part (b) above, show the direction of movement of the electrical charge in the circuit and explain why this is different to the conventional direction of current.

Question 13

(a) A 12 volt electrical appliance draws a current of 5 amps. A single battery is rated at 6 volts and 20 amp hours. Explain why circuit 1 would be appropriate in preference to circuit 2 to power the electrical appliance for 8 hours.



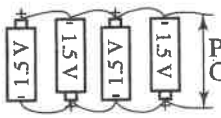
Circuit 1



Circuit 2

(b) Determine the potential difference and the output current for the two different connections of the 1.5 volt, 250 mA cells as shown.

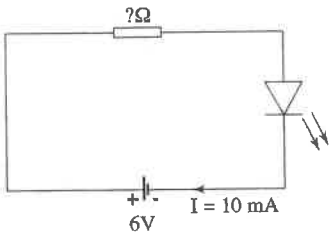
(i)



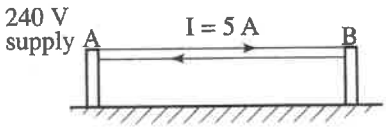
(ii)



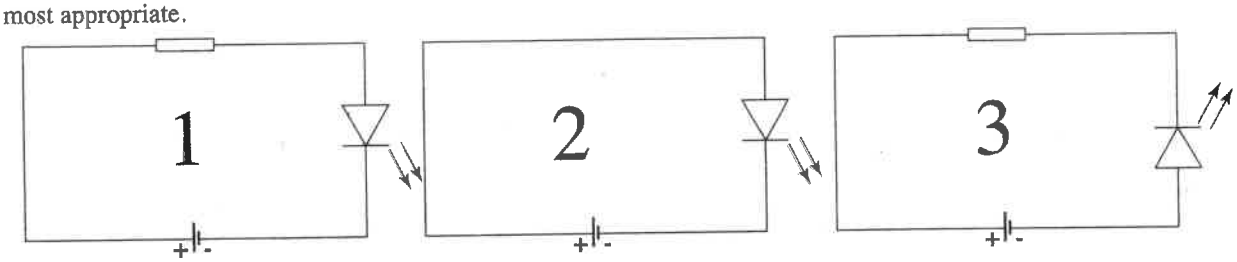
(c) A simple circuit with a single LED is shown. For the LED to operate efficiently it requires a voltage drop of 2 V. Determine the value of the resistor shown in the circuit.



(d) An electrical circuit from A to B and back to A draws 5 amps and requires 190 volts for correct operation. The power supply at A is 240 volts and the resistance of each wire is 0.05 Ω/m. Determine the maximum distance from A to B for correct operation of the electrical system.



(e) Three drawings of a simple circuit with an LED are shown. Select a circuit, either 1, 2 or 3, and explain why it is the most appropriate.



Question 14

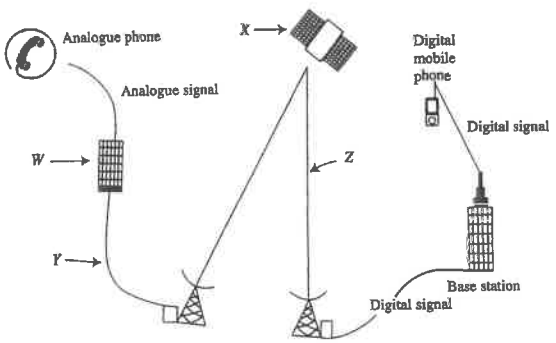
(a) Explain the purpose of electric motors and how they are different to electric generators.
(b) Explain the principle by which an electric motor functions.
(c) Explain three methods for the generation of electricity which are commonly used in Australia.
(d) List two alternative methods of generating electricity with an advantage and disadvantage for each method.
(e) Explain why power transmission must be done using very high voltages when transmitting over long distances.
(f) Explain why high voltage power cables have a steel core surrounded by numerous aluminium conductors.

Question 15

(a) Explain the main purpose for the following electronic components in electronic circuitry.
  (i) Capacitor
  (ii) Transistor
  (iii) Fuse
  (iv) Rectifier
  (v) Diode
(b) Explain the difference between analogue and digital electronics and give one advantage and one disadvantage of analogue systems.
(c) Explain how and why high frequency communication signals are modulated.
(d) Optical fibres are now used widely in communication systems. Give five reasons why optical fibres are more suited to this role when compared to copper cable.
(e) Contrast the two modulation techniques, amplitude modulation (AM) and frequency modulation (FM), used to vary the waveform in communication systems. Use diagrams to assist your answer.

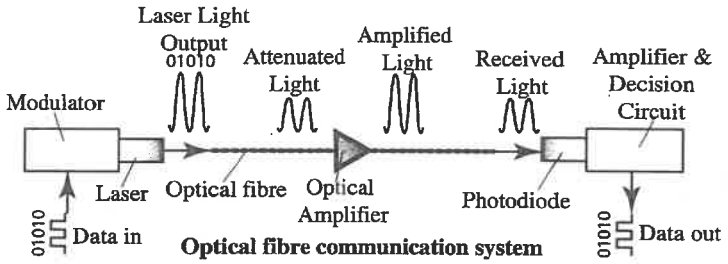
Question 16

(a) Mobile phone systems use cellular network structures. The diagram shows the flow of data from an analogue phone to a digital mobile phone in another country. Name the components, W and X and the data forms, Y and Z shown in the diagram.



(b) With the aid of diagrams, demonstrate how Amplitude Shift Keying (ASK) is used to modulate a digital signal.

(c) The diagram shows the elements of an optical fibre communication system. Explain how data is transferred in this system.



(d) Data security is an important consideration for individuals and businesses when transferring data across a telecommunications network. List one method of providing data security and outline one advantage and one disadvantage of the method.

(e) The diagram shows where modems fit into a computer communication network. Explain the function of modems in this network.

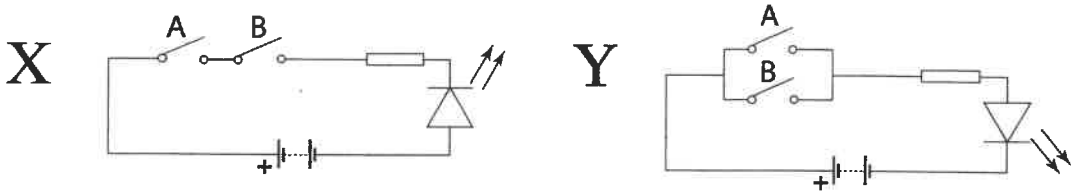


(f) Satellite systems have revolutionised the global communication of information. Compare the orbit altitude and the main applications for the following types of satellites:

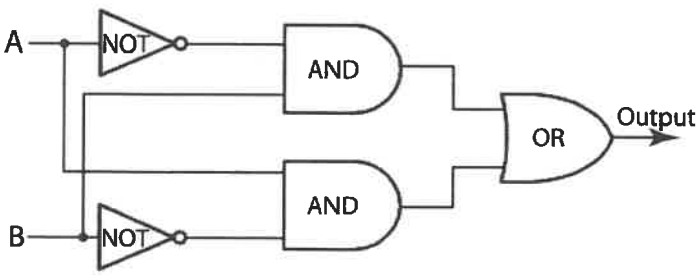
(i) Low earth orbit (LEO) satellites; (ii) Geosynchronous satellites.

Question 17

(a) The two electrical circuits, X and Y, represent an analogy for two different types of logic gates. Name the logic gate that they represent and write a truth table for each.



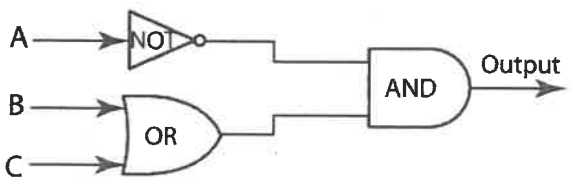
(b) Determine the truth table for the logic circuit shown:



(c) The digital logic circuit for the release of child safety locks on a car's rear doors is shown below. The three inputs for the release of the safety locks are:

- Airbag deployment during an accident
- Driver actuation
- Car moving

Determine the correct inputs for A, B and C.



SECTION I - MULTIPLE CHOICE

1. B 2. B 3. C 4. A 5. C
6. A 7. A 8. B 9. A 10. D

SECTION II

QUESTION 11

(a) POLYMERS & CERAMICS HAVE ELECTRONS TIGHTLY BOUND IN THE PRIMARY BONDS OF THE MATERIAL WHEREAS METALS HAVE MOBILE OUTER ELECTRONS DUE TO THE METALLIC (PRIMARY) BONDING IN METALS.

(b) A SEMICONDUCTOR IS A MATERIAL WHICH HAS AN ELECTRICAL RESISTANCE THAT FALLS SOMEWHERE BETWEEN THAT OF A CONDUCTOR & THAT OF AN INSULATOR

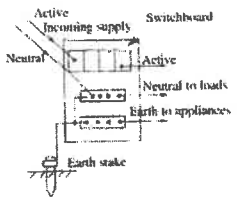
THE TWO MOST COMMON SEMICONDUCTING MATERIALS ARE SILICON & GERMANIUM. THESE ARE RARELY USED IN A PURE STATE & ARE 'DOPED' TO PRODUCE REQUIRED PROPERTIES. USED IN TRANSISTORS, DIODES, HEAT SENSORS, LIGHT EMITTERS, INTEGRATED CIRCUITS ETC.

(c) (i) VOLTAGE OR EMF IS THE POTENTIAL DIFFERENCE BETWEEN TWO TERMINALS WHICH CREATES THE 'ELECTRICAL PRESSURE' TO CAUSE ELECTRONS TO 'FLOW' CREATING ELECTRICITY.

(ii) CURRENT OR AMPHERAGE IS THE FLOW OF ELECTRONS IN THE CONDUCTOR AS A RESULT OF THE EMF. (ONE AMPHERE IS EQUAL TO 6.25×10^{18} ELECTRONS FLOWING PAST A GIVEN POINT EACH SECOND = 1 COULOMB)

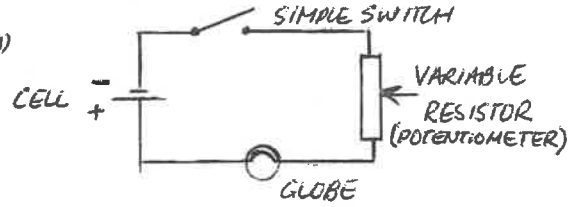
(iii) RESISTANCE IS THE OPPOSITION TO THE FLOW OF ELECTRONS IN A CONDUCTOR. GOLD, COPPER, SILVER, ALUMINIUM HAVE MUCH LOWER RESISTANCE VALUES THAN TUNGSTEN WHICH HAS A HIGH RESISTANCE. POLYMERS & CERAMICS (IE INSULATORS) HAVE VERY HIGH RESISTANCE VALUES.

(d) AN EARTH LINK IS CREATED BY CONNECTING ALL APPLIANCES TO AN EARTH CONNECTION IN THE SWITCHBOARD. THIS IS CONNECTED TO AN EARTH STAKE THAT IS DRIVEN INTO THE GROUND.



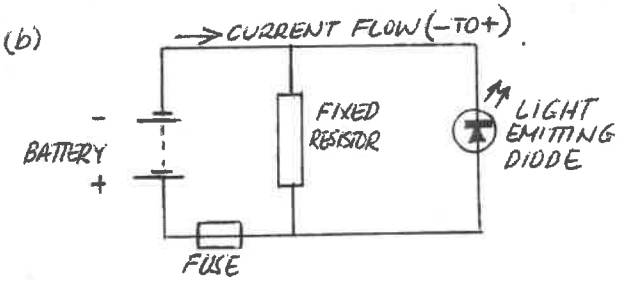
QUESTION 12

(a)



SIMPLE SERIES CIRCUIT

(b)



SIMPLE PARALLEL CIRCUIT

(c) CURRENT FLOW DIRECTION WAS 'GUESSED' TO BE FROM + TO – BEFORE THE TRUE NATURE OF AN ELECTRIC CURRENT WAS DISCOVERED.

QUESTION 13

(a) FOR BATTERIES IN SERIES - ADD VOLTAGE BUT THE CURRENT REMAINS CONSTANT
FOR BATTERIES IN PARALLEL - VOLTAGE REMAINS CONSTANT BUT ADD THE CURRENT
CIRCUIT 2 HAS THE BATTERIES ARRANGED PARALLEL SO WILL ONLY PRODUCE A VOLTAGE OF 6 V & WILL NOT DRIVE THE APPLIANCE
CIRCUIT 1 HAS BATTERIES IN SERIES WHICH PRODUCE 12 V & 40 AMP HOURS $\therefore 40/5 = 8$ HOURS

(b) (i) SERIES CONNECTION:
VOLTAGE = $4 \times 1.5 = 6$ V; CURRENT = 250 mA

(ii) PARALLEL CONNECTION:
VOLTAGE = 1.5 V ; CURRENT = $4 \times 250 = 1000$ mA = 1

(c) $V = IR \therefore 4 = 10R \therefore R = 4\ \Omega$

(d) VOLTAGE DROP = 240 - 190 = 50 V
$V = IR \therefore 50 = 5R$ SO $R = 10\ \Omega$
DISTANCE = $\frac{10}{0.05} = 200$ m $\therefore$ A TO B = $\frac{200}{2} = 100$ m

(e) CIRCUIT 1 IS THE MOST APPROPRIATE BECAUSE IT HAS A CURRENT LIMITING RESISTOR CORRECTLY PLACED TO PROTECT THE LED & THE LED IS FORWARD BIASED.
CIRCUIT 2 DOES NOT PROTECT THE LED WITH A RESISTOR & CIRCUIT 3 HAS THE LED REVERSE BIASE

QUESTION 14

(a) ELECTRIC MOTORS CONVERT ELECTRIC ENERGY INTO MECHANICAL ENERGY. ELECTRIC GENERATORS CONVERT MECHANICAL ENERGY INTO ELECTRICAL ENERGY.

(b) ELECTRICITY PASSING THROUGH A CONDUCTOR PRODUCES A MAGNETIC FIELD AROUND THE CONDUCTOR. WHEN THE CONDUCTOR PASSES THROUGH ANOTHER MAGNETIC FIELD, A FORCE IS PRODUCED WHICH ROTATES THE MOTOR.

c) 1. COAL FIRED BOILERS WHICH PRODUCE STEAM TO DRIVE STEAM TURBINE GENERATORS.
2. DIESEL/PETROL/NATURAL GAS ENGINES - MAINLY USED AS AUXILIARY OR STAND-BY GENERATORS
3. HYDRO ELECTRICITY GENERATION WHERE THERE IS ABUNDANT WATER STORAGE/SUPPLY

(d) 1. WIND GENERATORS
ADV: CLEAN, ABUNDANT SUPPLY, QUIET EFFICIENT, INEXPENSIVE
DISADV: WIND MUST BLOW, INVASIVE ON LANDSCAPE
2. SOLAR CELLS
ADV: CLEAN, QUIET, USES EXCESS SOLAR ENERGY
DISADV: EXPENSIVE TO MANUFACTURE CELLS, DO NOT OPERATE WITHOUT SUN, NEED A LARGE AREA FOR SIGNIFICANT CURRENT TO BE GENERATED.

e) HIGH POTENTIAL DIFFERENCE (EMF) OR PRESSURE REQUIRED TO FORCE THE ELECTRICITY THROUGH LONG LENGTH CONDUCTORS.

f) STEEL PROVIDES THE TENSILE STRENGTH TO SUPPORT THE MASS OF LONG SPANS OF CABLE.
ALUMINIUM PROVIDES A LOW MASS, HIGH CONDUCTIVITY MATERIAL COMPONENT TO THE CABLE.

QUESTION 15

a) (i) CAPACITOR - STORE ELECTRICAL CHARGE
(ii) TRANSISTOR - AMPLIFY & SWITCHING ELECTRICAL CURRENTS
(iii) FUSE - TO PROTECT COMPONENTS DUE TO CURRENT SURGES.
(iv) RECTIFIER - TO CHANGE AC TO DC.
(v) DIODE - ALLOW CURRENT TO FLOW IN ONE DIRECTION ONLY

(b) DIFFERENCE: ANALOGUE SYSTEMS ARE CONTINUOUS WHEREAS DIGITAL SYSTEMS ARE INTERMITTANT (ON/OFF).
ADVANTAGE OF ANALOGUE = CAN GET A 'FEEL' FOR THE VALUE BECAUSE IT INDICATES A BEFORE & AFTER READING (eg. FUEL GAUGE)
DISADVANTAGE OF ANALOGUE = THE SIGNAL BEING CONTINUOUS IS THUS SUBJECT TO INTERFERENCE.

(c) HIGH FREQUENCY SIGNALS ARE MODULATED SO THAT THEY CAN BE USED TO CARRY AUDIO FREQUENCY INFORMATION. THEY ARE MODULATED (OR VARIED) IN AMPLITUDE (AM) & FREQUENCY (FM) TO ACCOMMODATE THE LOW FREQUENCY AUDIO INFORMATION.

(d) OPTICAL FIBRES ARE:
- LESS EXPENSIVE PER BIT
- NOT A FIRE HAZARD WHEN BROKEN
- LESS MASS
- ABLE TO CARRY MUCH MORE COMMUNICATION TRAFFIC
- MORE DURABLE
- MORE SECURE FROM INTERFERENCE & EAVESDROPPING

(e) REFER TO PAGE 122 OF THE ENGINEERING STUDIES WORKBOOK FOR DIAGRAMS OF FM & AM & PAGE 121 FOR AN EXPLANATION.

QUESTION 16

(a) W = TELEPHONE EXCHANGE; X = SATELLITE
Y & Z = DIGITAL SIGNAL

(b) REFER TO PAGES 121 & 122 OF THE ENGINEERING STUDIES WORKBOOK FOR DIAGRAMS & EXPLANATION.

(c) DIGITAL DATA IN MODULATES A SEMICONDUCTOR LASER TO PRODUCE A SERIES OF LIGHT PULSES REPRESENTING A SERIES OF 0's & 1's ALONG THE OPTICAL FIBRE. THE SIGNAL IS AMPLIFIED (DUE TO ATTENUATION) AND THEN DETECTED BY A PHOTODIODE AT THE RECEIVER WHERE THE DECISION CIRCUIT DECIDES IF A '0' OR '1' BIT HAS BEEN RECEIVED.

(d) METHOD: PASSWORD OR ENCRYPTION
ADVANTAGES: - ONLY PEOPLE WITH PASSWORD CAN GAIN ACCESS
DISADVANTAGES: - PASSWORDS CAN BE EASILY CHANGED
- CAN BE ABUSED IF PEOPLE SHARE PASSWORDS
- PASSWORDS CAN BE 'HACKED'!

(e) MODEMS CONVERT DIGITAL SIGNALS FROM COMPUTERS TO ANALOGUE SIGNALS FOR THE TELEPHONE NETWORK & BACK AGAIN FROM THE TELEPHONE NETWORK TO COMPUTERS.

(f) SEE PAGE 128 OF THE ENGINEERING STUDIES WORKBOOK.

QUESTION 17

(a) X = AND

A	0	1	0	1
B	0	0	1	1
OUTPUT	0	0	0	1

Y = OR

A	0	1	0	1
B	0	0	1	1
OUTPUT	0	1	1	1

(b)

A	0	1	1	0
B	1	0	1	0
OUTPUT	1	1	0	1

(c) A = CAR MOVING, B = C = DRIVER ACTUATION OR AIRBAG DEPLOYMENT.

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

8

Polymers

Aim to complete each question many times in 2 years							
Question	Page/s	Study register ✔					
Multiple choice	63						
Question 11	64						
Question 12	64						
Question 13	64						
Question 14	65						
Question 15	65						
Question 16	66						
Question 17	66						
Solutions	67-69						

Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

1. What is a *linking process* to form polymers?
   (A) Substitution polymerisation.
   (B) Addition polymerisation.
   (C) Subtraction polymerisation.
   (D) Copolymer polymerisation.

2. What is the *predominate bond* in polymers?
   (A) Covalent bonding.
   (B) Hydrogen bonding.
   (C) Ionic bonding.
   (D) Metallic bonding.

3. Which best describes a *copolymer*?
   (A) A polymer made up of the same monomers.
   (B) A polymer made up of different monomers.
   (C) A polymer which will not soften when heated.
   (D) A polymer which will soften when heated.

4. Which best describes a *thermosoftening polymer (thermoplastic polymer)*?
   (A) A thermosoftening polymer has only secondary bonding along the chain.
   (B) A thermosoftening polymer has primary bonds only along the chains.
   (C) A thermosoftening polymer has primary bonds along and across the chains.
   (D) A thermosoftening polymer will not soften when heated.

5. Which best describes a *thermosetting polymer*?
   (A) A thermosetting polymer is linked mainly with secondary bonds.
   (B) A thermosetting polymer can be softened with heat.
   (C) A thermosetting polymer can be blow moulded to form soft drink bottles.
   (D) A thermosetting polymer has three dimensional cross linking.

6. Which process is used to *strengthen* thermoset rubbers?
   (A) Drying the rubber so that links form to strengthen the rubber.
   (B) Adding 5% phosphorous to saturate and strengthen the rubber.
   (C) Adding from 0.5 - 5% sulphur to promote moderate cross linking.
   (D) Adding 1% hydrogen to promote stronger hydrogen bonding.

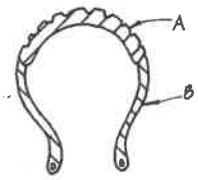
7. Which are some of the *additives* used in polymers to enhance their properties?
   (A) Stabilisers, plasticisers, flame retardants, pigments and fillers.
   (B) Stabilisers, crystallisation, flame retardants, pigments and fillers.
   (C) Copolymers, plasticisers, flame retardants, pigments and fillers.
   (D) Single bonds, cross links, flame retardants, pigments and fillers.

8. Which processes are used to *form* thermosetting polymers?
   (A) Blow moulding, transfer moulding and injection moulding.
   (B) Compression moulding, rotational moulding and injection moulding.
   (C) Compression moulding, transfer moulding and extrusion.
   (D) Compression moulding, transfer moulding and injection moulding.

9. What are the consequences of *crystallisation* in polymers?
   (A) A weaker, less rigid structure with increased clarity.
   (B) A stronger, more rigid structure with decreased clarity.
   (C) A stronger, less ductile structure with increased clarity.
   (D) A more ductile structure with decreased clarity.

10. Which best describes the *use* of engineering polymers?
    (A) Used for products which are produced in an engineering workshop.
    (B) Used for applications where corrosion is a problem.
    (C) Used in structural and engineering situations or in applications which replace metals.
    (D) Used in applications requiring colourful and durable materials.

Section II - Short structured response questions

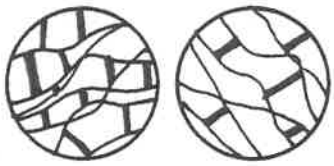


Question 11

The cross-section of a bicycle tyre shown is made up of part A (tread) joined to part B (walls). Both parts A and B are manufactured from rubber.

(a) List two significant properties required for each of A and B.

The molecular structure for two elastomers (rubbers) are shown in the diagrams.



Structure 1 Structure 2

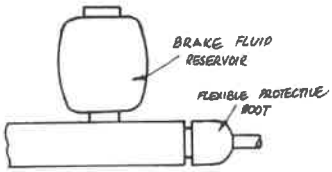
(b) Indicate which structure would be most suitable for parts A and B of the bicycle tyre and give a reason for each.

(c) Thermoset rubbers, as used for bicycle brake blocks, may be vulcanised to improve service properties. Explain the process of vulcanisation and give two service properties which are improved as a result of this process.

(d) When thermoset rubbers have a tensile force applied, the force generally increases considerably just before fracture point. Explain why this occurs making reference to the structure of thermoset rubbers.

Question 12

A drawing of a motor vehicle's brake master cylinder is shown. It has a polymer fluid reservoir and a rubber protective boot.



(a) Suggest the most appropriate method of manufacture for the reservoir and the boot.

(b) State two important service properties for the reservoir and the boot.

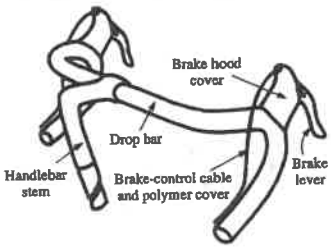
(c) Three molecular structures are shown. Select the most appropriate structure for use as the reservoir and for the boot giving a reason for your choice.

(d) Describe, with the aid of a labelled sketch, the method of manufacture of the reservoir.



Structure 1 Structure 2 Structure 3

A pictorial drawing of a bicycle handlebar is shown. The brake hood cover is manufactured by injection moulding from high-density polyethylene (HDPE).



(e) Describe the injection moulding process.

(f) An alternative material for the brake hood cover is polystyrene formed by compression moulding. What effect does temperature and pressure have in this process?

(g) Name and describe a process that may be used to form the polymer cover for the brake-control cable.

Question 13

(a) Explain the limitations of a thermoplastic polymer as a structural material.

(b) Sketch and describe the molecular structure of a thermoplastic polymer.

(c) What makes a thermoplastic polymer structurally different from a thermosetting polymer?

(d) Explain the following terms which apply to polymers: co-polymerisation, condensation polymerisation.

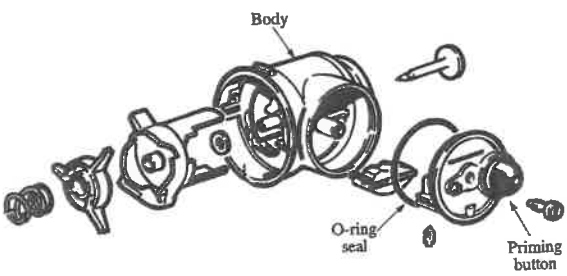
An exploded pictorial drawing of a lawn mower carburettor is shown. The body is made from 30% glass-filled polyester polymer. The priming button and the O-ring seal are made from neoprene rubber.

(e) List two service properties for the material used for the body.

(f) What is the purpose of adding 30% glass fibre to the polyester material used to make the body?

(g) Name the process and the additive used to change the properties of rubber to make it suitable for the O-ring seal.

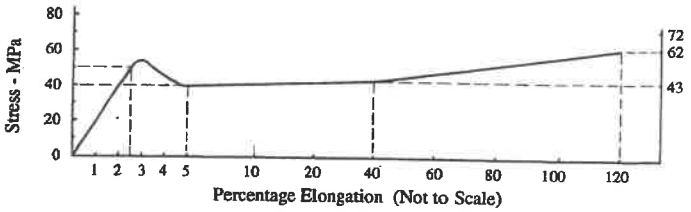
(h) Over a period of time in service, the rubber in the priming button is exposed to the atmosphere. State the effect that this exposure could have on the properties of the rubber.



Question 14

Data from a tensile test on a polycarbonate sample used in bullet and vandal proof glazing and lighting, are plotted on the stress and percentage elongation axes shown.

(a) Determine the strain at the elastic limit.



(b) Data from a tensile test on a 10% glass-filled polycarbonate sample used for police riot shields are listed below. On the stress-percentage elongation axes shown above, draw a possible curve from the given data for the 10% glass-filled polycarbonate sample.

- Stress at fracture = 80 MPa
- % elongation at fracture = 10%
- Modulus of elasticity = 3.1 GPa
- Stress at the elastic limit = 64 MPa

Polycarbonate and 10% glass-filled polycarbonate are both used in the manufacture of components for bicycle safety helmets.

(c) The visor is tough and transparent, while the helmet is rigid, has high impact strength and has good dimensional stability.
Determine which material would be used for the visor and which material would be used for the helmet. Justify your answer, using the relevant data from the tensile tests and your knowledge of materials.

(d) Name the type of polymerisation, (co-polymerisation, addition polymerisation, condensation polymerisation), used in the manufacture of the following polymers:
- Polyethylene;
- Phenol formaldehyde (Bakelite);
- Styrene-butadiene rubber (SBR)

(e) Suggest an appropriate additive/technique which will improve the following service properties of the specific polymers mentioned below.
(i) The mouldability of bakelite.
(ii) The toughness and strength of polyester resin.
(iii) The strength of thermoset rubbers.
(iv) The clarity of polypropylene.

(f) List a forming method used for the manufacture of the polymeric articles listed below.
(i) Phenol formaldehyde (Bakelite) electrical switch gear.
(ii) Polyethylene bottles.
(iii) Reinforced nylon water hose.
(iv) Polypropylene outdoor furniture.
(v) Polystyrene and polypropylene margarine containers.
(vi) Polypropylene grass catchers for motor mowers.
(vii) Acrylic (PMMA) household baths.

Question 15

(a) Most elastomers (rubbers), despite vulcanisation, are still unsaturated polymers. Explain the term 'unsaturated polymer'.

(b) Elastomers (rubbers) and other polymers will rapidly break down from ultra violet radiation (UV) if not protected. Explain how polymers are protected from UV radiation and give an example to support your explanation.

(c) The mower fuel tank shown is mass produced from high density polyethylene (HDPE); 70% of HDPE contains crystallites with the remaining 30% remaining amorphous.
(i) Explain the term 'crystallites' as applied to polymers.
(ii) Explain the term 'amorphous' as applied to the structure of materials.


Fuel tank

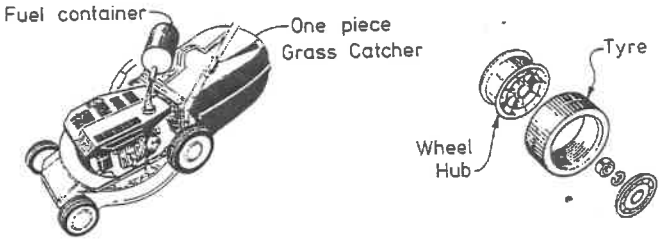
(d) Name and describe the type of primary bond in a polymeric material.

(e) State one reason why thermosetting polymers are more difficult to recycle than thermosoftening polymers. Explain your answer in terms of the structure of the polymer.

(f) Give one application where thermoset polymers are being recycled.

Question 16

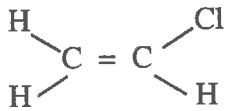
The wheel hub and grass catcher of a lawn mower are manufactured from polymers using different processes.



(a) From the list of manufacturing processes below, select the most appropriate method for manufacturing for the wheel hubs and grass catcher, then describe the selected process. Do not select the same process more than once.

- Calendering
- Compression moulding
- Blow moulding
- Rotational moulding
- Injection moulding
- Vacuum forming

The vinylchloride monomer is as shown:



(b) Explain what structural change occurs when the monomer molecules are transformed by polymerisation into the polymer molecules of polyvinylchloride (PVC).

(c) Sketch the arrangement of atoms following polymerisation, showing a minimum of two mers in the chain.

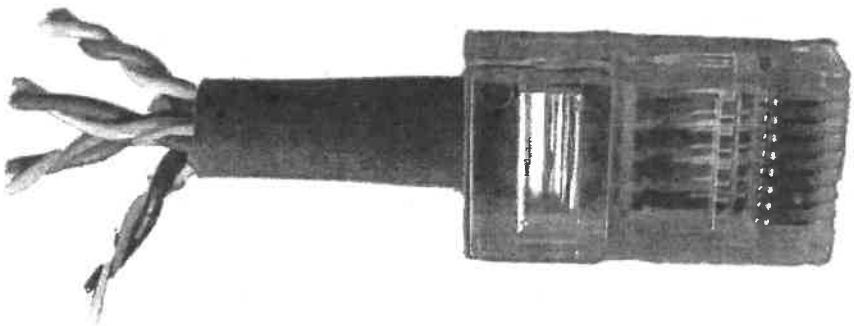
(d) Explain in terms of structure why the polymer PVC is a thermosoftening polymer.

(e) Name one material that can be added to PVC to improve its resistance to ultra-violet degradation.

(f) Thermosetting polymers are mainly processed and shaped by compression moulding. Describe the process of compression moulding.

Question 17

A section of twisted pair cable and an RJ connector are shown below. The copper wires are sheathed with polyvinyl chloride (PVC) polymer and the RJ connector case is made from polybutylene terephthalate (PBT).



(a) Explain why both PVC and PBT are classified as copolymers.

(b) Name and explain the process used to sheath the copper conductors with PVC polymer.

(c) The body of the RJ connector is made by injection moulding. Describe this process and suggest 3 reasons why it is the preferable method of manufacture.

(d) Explain why crystallinity is kept to a minimum in the body of the RJ connector.

(e) List the forming and service properties for both the PVC sheathing and PBT connector case.

(f) Explain why polymer electrical switches and fittings are generally manufactured from thermosetting polymers.

(g) Provide one reason why the RJ connector can be safely manufactured from a thermosoftening polymer.

SECTION I - MULTIPLE CHOICE

1. B, 2. A, 3. B, 4. B 5. D,
6. C, 7. A, 8. D, 9. B, 10. C

SECTION II

QUESTION 11

(a) PART A: WEAR RESISTANT, TOUGH, DURABLE (RESISTANT TO U.V., WEATHERING, HIGH COEFFICIENT OF FRICTION, PUNCTURE RESISTANT

PART B: FLEXIBLE, TENSILE STRENGTH (RIM AREA), DURABLE (RES. TO UV), PUNCTURE RESISTANT

(b) PART A (TREAD): STRUCTURE 1 BECAUSE MORE CROSS LINKING INCREASES HARDNESS & WEAR RESISTANCE.

PART B (WALLS): STRUCTURE 2 BECAUSE THE LESS CROSS LINKING PROVIDES MORE FLEXIBILITY.

(c) VULCANISATION IS THE ADDITION OF FROM 0.5 TO 5% SULPHUR TO THERMOSET RUBBER TO CREATE SULPHUR CROSS-LINKS WHICH INCREASES:
STRENGTH (TENSILE, COMPRESSIVE & SHEAR) HARDNESS, WEAR RESISTANCE & DECREASES FLEXIBILITY.

(d) THERMOSET RUBBERS ARE STRONG JUST BEFORE FRACTURE DUE TO:
- THE UNTANGLING OF THE CHAINS TENDS TO STRAIGHTEN THE CHAINS DURING STRETCHING WHICH THEN REQUIRES THE COVALENT BOND TO FRACTURE ON FULL STRETCH
- UNTANGLING THE CHAINS WHEN STRETCHING MAKES THE CHAINS ALIGN PRODUCING AREAS OF CRYSTALLITES WHICH TEND TO STRENGTHEN THE ELASTOMER AT FULL STRETCH.

QUESTION 12

(a) RESERVOIR - BLOW MOULDING
BOOT - COMPRESSION, INJECTION

(b) RESERVOIR - RESISTS BRAKE FLUID, NON POROUS, HEAT RESISTANT (MILDLY), TRANSLUSCENT
BOOT - OIL, BRAKE FLUID & MILD HEAT RESISTANT, FLEXIBLE, NON POROUS.

(c) RESERVOIR - STRUCTURE 1
REASON: THERMOPLASTIC - NO CROSS LINKING
BOOT - STRUCTURE 3
REASON: ELASTOMER - MODERATE CROSS LINKING.

(d) EXTRUSION BLOW MOULDING
SEE PAGE 141 OF ENGINEERING STUDIES WORKBOOK FOR DESCRIPTION.

(e) GRANULATED PLASTIC IS HEATED IN THE HEATING CHAMBER AND FORCED IN A FLUID STATE THROUGH A NOZZLE INTO THE MOULD WHERE IT SOLIDIFIES.
(KEY WORDS UNDERLINED - ALSO SEE PAGE PAGE 8-9 OF ENG. W'BOOK)

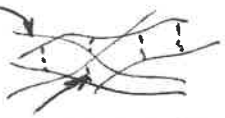
(f) TEMPERATURE & PRESSURE ACCELERATE THE CURING (POLYMERISATION) PROCESS OF THE POLYMER.

(g) NAME OF PROCESS: EXTRUSION OR CO-EXTRUSION.
DESCRIPTION: GRANULATED PLASTIC IS FED INTO THE HEATING CHAMBER AND IS FORCED BY A SCREW (TO GIVE CONTINUOUS FORCE) IN THE FLUID STATE THROUGH A DIE OF THE REQUIRED SHAPE.

QUESTION 13

(a) LOW HEAT RESISTANCE, LOW RIGIDITY, LOW TENSILE, COMPRESSIVE & SHEAR STRENGTH, LOW STIFFNESS (YOUNG'S MODULUS)

(b) MACROMOLECULE CHAINS COVALENTLY BONDED IN A LINEAR ARRANGEMENT WITH WEAK SECONDARY BONDS (VAN DER WAALS & HYDROGEN BONDS)



(c) THERMOSETTING POLYMER HAS A 3 DIMENSIONAL NETWORK OF STRONG PRIMARY BONDS; THERMOSOFTENING POLYMER HAS A 2D LINEAR ARRANGEMENT OF PRIMARY BONDS.

(d) CO-POLYMERISATION:
COMBINATION OF TWO OR MORE DIFFERENT MERS TO FORM THE CO-POLYMER.
CONDENSATION POLYMERISATION:
POLYMERISATION RESULTING IN THE PRODUCTION OF NON-POLYMERISABLE BY-PRODUCTS USUALLY H_2O.

(e) RESISTANT TO U.V., HEAT, PETROL, VIBRATION, MODERATE COMPRESSIVE STRENGTH (FOR CLAMPING), AIR & FLUID, & NON POROUS.

(f) - TO INCREASE STRENGTH & STIFFNESS.
- TO GIVE DIMENSIONAL STABILITY
- RESIST CRACK PROPOGATION.
- RESISTANCE TO CREEP

(g) VULCANISATION OR SULPHUR CROSS LINKING.
ADDITIVE USED IS SULPHUR (ZINC OXIDE OR MAGNESIUM OXIDE ACCEPTED).

(h) OXIDATION OF THE RUBBER (PERISH) CAUSING IT TO BECOME HARD & BRITTLE.

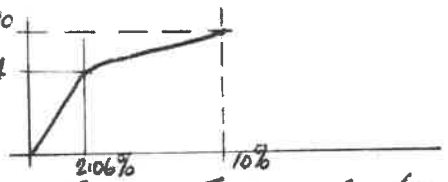
QUESTION 14

(a) % ELONGATION AT E.L. = 2.5%

$$\text{STRAIN} = \frac{2.5}{100} = 0.025 \text{ m/m OR } 2.5\%$$

STRAIN = 0.025 OR 2.5%

(b)



$$E = \frac{\sigma}{\varepsilon} \text{ & } \varepsilon = \frac{\sigma}{E} \quad \text{WHERE } \sigma = 64\times10^6 \text{ Pa}, \quad E = 3.1\times10^9 \text{ Pa}$$

$$\%\varepsilon = \frac{64\times10^6 \times 10^{-2}}{3.1\times10^9} = 2.06\%.$$

(c) VISOR MATERIAL = POLYCARBONATE
JUSTIFICATION = TOUGH - INDICATED BY THE AREA UNDER THE GRAPH
FLEXIBLE, DUCTILE - INDICATED BY LONG ELONGATION BEFORE FRACTURE

HELMET MATERIAL = 10% GLASS FILLED POLYCARBONATE
JUSTIFICATION = MORE RIGID & DIMENSIONALLY STABLE INDICATED BY THE INCREASED STIFFNESS - SLOPE OF STRAIGHT LINE SECTION ON GRAPH (= YOUNG'S MODULUS)
IMPACT, CRACK RESISTANT, GREATER STRENGTH - HIGHER YIELD & FRACTURE STRESS ON GRAPH.

(d) POLYETHYLENE = ADDITION
BAKELITE = CONDENSATION
S.B.R. = CO-POLYMERISATION

(e) (i) ADDITION OF PLASTICISER, FILLER.
(ii) ADDITION OF FILLER, FIBRE
(iii) ADDITION OF SULPHUR, ZnO, MgO TO CREATE MODERATE CROSS LINKING
ALSO CARBON BLACK & TiO_2 TO IMPROVE U.V. RESISTANCE
(iv) REDUCE CRYSTALLISATION

(f) (i) COMPRESSION, INJECTION OR TRANSFER MOULDING
(ii) BLOW MOULDING
(iii) CO-EXTRUSION
(iv) INJECTION MOULDING
(v) PRESSURE FORMING
(vi) ROTATIONAL MOULDING.
(vii) VACUUM FORMING.

QUESTION 15

(a) CONTAINS AT LEAST ONE DOUBLE BOND (SATURATED = ALL SINGLE BONDS)

(b) POLYMERS ARE STABILISED BY THE ADDITION OF CARBON BLACK OR TITANIUM DIOXIDE WHICH PREVENT THE ADMISSION OF UV RAYS INTO THE STRUCTURE OF THE POLYMER.
EXAMPLE: TiO_2 IN SKIN BLOCKOUT LOTIONS; CARBON BLACK IN CAR/BIKE TYRES & P.V.C. PLUMBING PIPING

(c) (i) CRYSTALLITES FORM IN POLYMERS WHEN COOLING DUE TO CLOSE ALIGNMENT OF THE MOLECULES. ONLY OCCURS IN SOME POLYMERS. CRYSTALLITES DESTROY CLARITY, CREATES MORE SHRINKAGE ON COOLING & PRODUCES A STRONGER, TOUGHER, LESS DUCTILE POLYMER.

(ii) AMORPHOUS REFERS TO A LACK OF ORDER IN THE STRUCTURE OF MATERIALS. NON CRYSTALLINE MATERIALS ARE AMORPHOUS.

(d) COVALENT BOND
OUTER (VALENCE) ELECTRONS ARE SHARED BETWEEN ATOMS.

(e) REASON: CROSS LINKING IN THERMOSETS CANNOT SOFTEN WITH HEAT
EXPLANATION: IF THE CROSS LINKING IN THERMOSETS ARE BROKEN IT DESTROYS THE STRUCTURE OF THE POLYMER.

') THERMOSET PLASTICS ARE BEING USED AS INERT FILLERS FOR CAR MOULDINGS, CONCRETE BUILDING PANELS ETC.

QUESTION 16

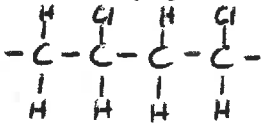
(a) WHEEL HUB : INJECTION MOULDED.
PROCESS : SEE PAGE 140 OF WORKBOOK
(KEY WORDS : HEAT / VISCOUS
BEADS / POWDER
FORCED INTO
DIE / MOULD.)

GRASS CATCHER : ROTATIONAL MOULDED
PROCESS : SEE PAGE 141-2 OF WORKBOOK
(KEY WORDS : POWDER / BEADS
INTO MOULD / DIE
ROTATED (360°)
HEATED / OVEN)

FUEL CONTAINER : BLOW MOULDED
PROCESS : SEE PAGE 141 OF WORKBOOK
KEY WORDS : POWDER / BEADS
HEAT / VISCOUS
INTO DIE / MOULD
BLOWN.)

(b) THE DOUBLE BOND BETWEEN THE CARBON ATOMS IS BROKEN.

(c)



(d) ONLY WEAK SECONDARY BONDS OCCUR BETWEEN THE LINEAR POLYMER CHAINS

(e) TITANIUM DIOXIDE, CARBON BLACK

') SEE PAGE 139 OF WORKBOOK
(KEY WORDS : POWDER OR PREFORM
HEAT
FORCE / PRESSURE
DIE / MOULD
CROSSLINKING)

QUESTION 17.

i) TWO OR MORE DIFFERENT MONOMERS ARE PRESENT IN THE MOLECULE

b) EXTRUSION IS THE NAME OF THE PROCESS & THE DESCRIPTION CAN BE FOUND ON PAGE 140 OF THE ENGINEERING STUDIES WORKBOOK.

(c) DESCRIPTION OF INJECTION MOULDING PROCESS : PAGE 140 OF THE ENGINEERING STUDIES WORKBOOK.
REASONS FOR USE :
(i) CAN ACCURATELY REPLICATE SMALL DETAILS
(ii) EASY TO PROCESS WITH LITTLE FINISHING
(iii) LOW COST FOR LARGE RUNS

(d) TO RETAIN TRANSPARENCY.

(e) PVC SHEATHING :
(i) FORMING - FLUIDITY
- FLEXIBILITY
(ii) SERVICE - INSULATOR
- FLEXIBLE
- UV RESISTANT
- NON POROUS
- DURABLE

PBT CONNECTOR :
(i) FORMING - FLUIDITY
- ACCURATE DIE REPRODUCTION
(ii) SERVICE - INSULATOR
- DURABLE
- TRANSPARENT
- CORROSION RESISTANT
- TOUGH

(f) THERMOSETTING POLYMERS HAVE A GREATER RESISTANCE TO HEAT / SPARKING THAN THERMOSOFTENING POLYMERS.

(g) RJ CONNECTORS ARE SUBJECTED TO VERY LOW AMPERAGE / VOLTAGES - VERY LITTLE (IF ANY) HEAT OR SPARKING.

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

9

Ceramics

Aim to complete each question many times in 2 years							
Question	**Page/s**	**Study register ✔**					
Multiple choice	71						
Question 11	72						
Question 12	72						
Question 13	72						
Question 14	72-73						
Question 15	73						
Question 16	73						
Question 17	73						
Solutions	74-76						

Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

1. Which ceramics are *predominately ionicly bonded*?
   (A) Ceramics made up of a combination of two or more non-metals.
   (B) Pure metallic elements such carbon (diamond).
   (C) Ceramics made up of a combination of metals and a non-metal usually oxygen.
   (D) Ceramics made up of a combination of two or more metals.

2. Which best describes the *properties of ceramics*?
   (A) Hard, brittle, high melting point, electrical insulators, resistance to weathering.
   (B) Hard, ductile, high melting point, electrical conductors, resistance to weathering.
   (C) Hard, brittle, high melting point, electrical insulators, low resistance to weathering.
   (D) Malleable, brittle, high melting point, electrical insulators, low resistance to weathering.

3. Which best describes the main reasons why *ceramics were used for ancient civil structures*?
   (A) Ceramics were easily cut, shaped and placed.
   (B) Ceramics were plentiful, easily cut, shaped, placed and the structures used mainly compressive forces.
   (C) Ceramics were plentiful, easily cut, shaped, placed and the structures only involved a knowledge of tensile forces.
   (D) Ceramics were long lasting and were an acceptable material for religious structures at the time.

4. Which best describes *vitrification* in ceramics?
   (A) Vitrification is the formation of ceramic grain boundaries.
   (B) Vitrification is the bonding of the ceramic by heat.
   (C) Vitrification is the formation of a ceramic by pressing and heating powdered ceramic.
   (D) Vitrification is the formation of glass in a ceramic.

5. Why is *'grog'* (or crushed, previously fired clay) added to clay based ceramics?
   (A) *'Grog'* is added to reduce firing and drying shrinkage.
   (B) *'Grog'* is added to develop a consistent colour from the fired ceramic.
   (C) *'Grog'* is added to reduce the mass of the finished product.
   (D) *'Grog'* is added to provide more resistance to weathering.

6. Which are the main methods used to *strengthen glass*?
   (A) Thermal and chemical toughening, laminating and process annealing.
   (B) Thermal and chemical toughening, normalising and crystallisation.
   (C) Thermal and chemical toughening, laminating and crystallisation.
   (D) Quench toughening, laminating and tempering.

7. Why is the the *water/cement ratio* for concrete so important?
   (A) Too much water will weaken the concrete.
   (B) Too much cement will weaken the concrete.
   (C) Too much water will reduce the slump and make the concrete too weak.
   (D) Too much water will accelerate the setting of the concrete.

8. Which best describes a *doped semicoductor*?
   (A) A material that has more electrons than protons.
   (B) A semiconductor that has had more electrons added to increase the number of positive charges.
   (C) A semiconductor that has had foreign atoms added to change the number of negative charges.
   (D) A semiconductor that has had foreign atoms added to change the number of positive and negative charges.

9. Which are the *elements* that have the most practical application as semiconductors in the electronics industry?
   (A) Zinc, silicon and boron.
   (B) Silicon and germanium.
   (C) Silicon carbide and gallium.
   (D) Silica, barium and tungsten.

10. Which statement best describes why *cracks propagate* in materials?
   (A) When the crack is blunt enough to create new surfaces.
   (B) When the energy to break bonds is less than the surface energy of the material.
   (C) When the energy to break bonds is less than the energy required to create new surfaces.
   (D) When the energy to break bonds is greater than the energy required to create new surfaces.

Section II - Short structured response questions

Question 11

(a) Ancient structures such as the Pyramids and the Great Wall of China were made using ceramic materials. Give three significant reasons why ceramic materials were used for ancient structures.

(b) Ceramics are covalently and ionicly bonded. Which ceramics have ionic bonds and which ceramics are covalently bonded? Give one example of each.

(c) Ceramics are poor conductors of heat and electricity. With reference to structure, explain why ceramics have these properties.

(d) During ceramic fabrication, sintering and vitrification occurs. Explain the meaning of sintering and vitrification.

Question 12.

(a) Clays are weathered remains of various types of rocks. Sketch the arrangement of clay particles with and without secondary bonded water.

(b) Pure clay is rarely used to make clay ceramics. Give three reasons why additives are included in pre-fired clay ceramics.

(c) (i) Describe the four stages of firing a clay ceramic explaining the structural changes for each of the four stages.

(ii) Make a labelled sketch of the final microstructure of the glass bonded clay ceramic.

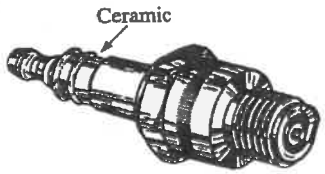
(d) Many thin walled items such as wash basins, toilet bowls and dinnerware are manufactured by slip casting and glazing. Describe the method of forming clay ceramics by slip casting. A diagram must be used to illustrate your answer.

(e) State two reasons for glazing clay ceramic products.

(f) On a graph with suitable axes sketch a graph to show at what temperature stages expansion and shrinkage occurs during the firing of a glass bonded clay ceramic.

Question 13

(a) State two service properties of the ceramic used in the automobile spark plug.



Spark plug

(b) Suggest a clay ceramic that may be used for the spark plug.

(c) Suggest an appropriate method of forming the ceramic insulator part of the spark plug.

(d) Two methods of strengthening glass is thermal tempering and chemical toughening. Compare and contrast both methods.

(e) Laminated glass is used extensively in motor vehicle windscreens and for bullet proof glass. Explain two mechanisms by which laminated glass inhibits the propagation of cracks from one surface to the other.

(f) Sketch the fracture pattern in laminated glass and thermal toughened glass.

(g) Most sheet glass used for civil structures and automobiles is made using the float process. Describe this process using well labelled diagrams to compliment your description.

Question 14

(a) Explain the difference between cement and concrete.

(b) Explain the reason for the addition of gypsum to cement during manufacture.

(c) Explain the manufacture of cement.

(d) Explain the importance of water in the strength and curing of concrete.

(e) Explain, using a well labelled diagram, the process and the purpose of the slump test for concrete.

Compression test cylinders are taken for most commercial concrete pours.

(f) Draw an expected fracture pattern of concrete when it fails in compression.

(g) Draw the stress/strain graph for the compression test of concrete.

(h) Explain, using your stress/strain graph in (g) above, the following three mechanical properties of concrete: brittleness, stiffness, toughness.

Question 15

(a) Ceramics are widely used in the electronics industry. List and describe how two ceramic materials are used in the electronics industry.

(b) Semiconductor ceramics are doped for use in electronic circuitry. Explain the process and the reason for doping semiconductor ceramics.

(c) Die pressing (or dust pressing) is now widely used for forming ceramic materials. Explain this process and list two examples where it is used.

(d) Open neck glass jars (such as a Vegemite jar) are made by the press and blow method. Explain this process and use a diagram to assist your explanation.

(e) Explain why glass fibres (or glass whiskers) have a much higher tensile strength and ductility than conventional plate glass.

(f) Explain in terms of surface energy and crack energy, the mechanism of crack propagation in brittle materials.

(g) Give four reasons why ceramic materials are more brittle than ductile metallic materials.

(h) Explain how continuous filament glass fibre is made. Use a diagram to assist your explanation.

Question 16

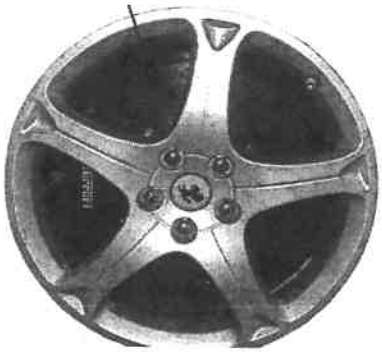
Many new high performance sports cars now use ceramic discs for their braking systems.

(a) Explain the advantages of using ceramic discs for high performance braking systems.

(b) Name a ceramic material that is used for the disc on some high performance braking systems.

(c) The ceramic disc shown has holes punched through the disc. Suggest a reason why these holes are present in the disc.

Ceramic disc



Question 17

The fracture patterns of three glass samples are shown below.

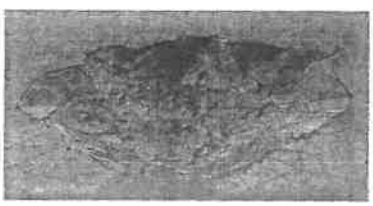
(a) Identify the modification process, if any, of the three samples of glass and justify your answer.

(b) Discuss the application of each glass sample and justify your answer in terms of the manufacture and/or modification of the glass product.

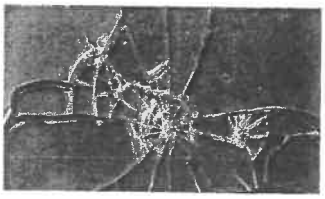
(c) Explain the terms 'amorphous' and 'crystalline' with reference to material structure and state whether each of the glass samples are either crystalline or amorphous.



Sample 1



Sample 2



Sample 3

SECTION I - MULTIPLE CHOICE

1. C, 2. A, 3. B, 4. D, 5. A,

6. C, 7. A, 8. D, 9. B, 10. D.

SECTION II

QUESTION 11

(a) CERAMICS HAVE HIGH COMPRESSIVE STRENGTH & ANCIENT BUILDINGS USED ONLY COMPRESSIVE FORCES; CERAMICS WERE PLENTIFUL, EASILY WORKED & THEIR MASS WAS USUALLY SUFFICIENT FORCE TO HOLD TOGETHER; CERAMICS RESIST WEATHERING BETTER THAN OTHER MATERIALS.

(b) IONIC BONDED CERAMICS: THOSE WHICH ARE MADE UP OF ONE OR MORE METALS WITH A NON-METALLIC COMPONENT USUALLY OXYGEN
EXAMPLES: MgO, Al_2O_3, ZnO_2

COVALENTLY BONDED CERAMICS: THOSE WITH A COMBINATION OF TWO NON-METALS
EXAMPLES: SiO_2, C (DIAMOND)

(c) HEAT: ATOMS ARE TIGHTLY BOUND BECAUSE OF THE COVALENT/IONIC BOND WHICH RESTRICTS THEM FROM VIBRATING DUE TO THERMAL ENERGY

ELECTRICITY: ELECTRONS ARE TIGHTLY BONDED WITHIN THE ATOMS DUE TO THE NATURE OF THE PRIMARY BONDS THUS ARE NOT FREE TO MOVE TO TRANSMIT AN ELECTRIC CURRENT.

(d) CERAMIC FABRICATION:
THE PROCESSING OF CERAMIC POWDERS SO THAT SPECIFIC PROPERTIES ARE PRODUCED. THIS IS NECESSARY BECAUSE, UNLIKE METALS, CERAMICS CANNOT HAVE THEIR PROPERTIES VARIED AFTER FORMATION.

SINTERING:
IS THE BONDING OF POWDERS BY HEAT TO PRODUCE MAXIMUM POSSIBLE DENSITY

VITRIFICATION:
IS THE FORMATION OF GLASS WHICH CAN PRODUCE ALMOST MAXIMUM DENSITY. APPLICABLE TO CLAY-BASED OR SILICA-BASED CERAMICS.

QUESTION 12

(a)



CLAY PARTICLE BONDED WATER

CLAY WITH SECONDARY BONDED WATER.



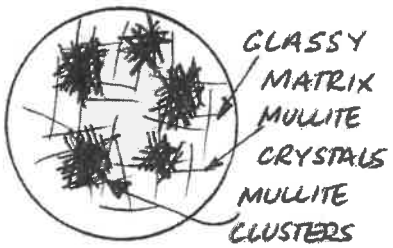
CLAY PARTICLES

CLAY WITHOUT SECONDARY BONDED WATER

(b)
- REDUCE DRYING & FIRING SHRINKAGE
- ALTER PLASTICITY SO THE CLAY IS EASIER TO SHAPE
- ACTS AS A FLUX WHICH PROMOTES BETTER BONDING BETWEEN THE GLASS AND OTHER COMPONENTS.

(c)(i) STAGE 1 = DRYING - CLAY LOSES SECONDARY BONDED WATER
STAGE 2 = DEHYDRATION - CLAY LOSES HYDRATED WATER FROM THE STRUCTURE
STAGE 3 = OXIDATION OF ALL IRON COMPOUNDS
STAGE 4 = VITRIFICATION - FORMATION OF GLASSY MATRIX AND MULLITE CRYSTALS

(ii)

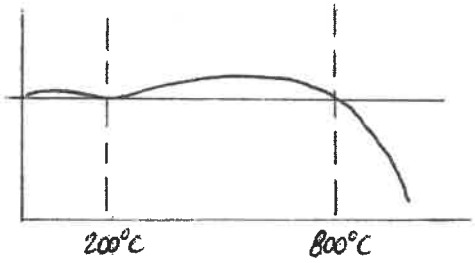


MICROSTRUCTURE OF A GLASS BONDED CLAY CERAMIC.

(d) SEE PAGE 157 OF WORKBOOK.
(KEY WORDS = PLASTER/POROUS MOULD
POUR SLIP/LIQUID
STAND/WAIT/REQ'D THICKNESS
POUR OUT/REMOVE

(e) REDUCE POROSITY, MORE HYGENIC, EASIER TO CLEAN, INCREASE STRENGTH, HARDNESS, WEAR RESISTANCE, SMOOTHER FINISH, EASIER TO DECORATE.

(f)



QUESTION 13

(a) ELECTRICAL INSULATION
ELECTRICAL RESISTANCE
EASILY CLEANED
HEAT RESISTANCE

(b) PORCELAIN, ALUMINA (Al_2O_3)

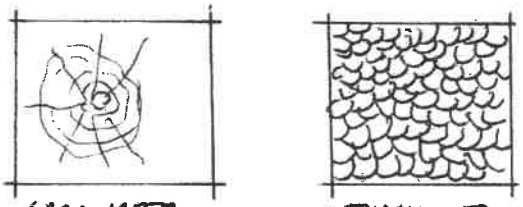
(c) DIE PRESSING (USING CERAMIC POWDER)

(d) BOTH METHODS PLACE THE OUTER ATOMS IN COMPRESSION
ONE METHOD (CHEMICAL) DOES THIS BY EXCHANGING THE SMALLER Na^+ WITH A LARGE K^+. THERMAL TOUGHENING CREATES THE COMPRESSIVE FORCE BY COOLING THE OUTER LAYERS OF GLASS RAPIDLY.

(e) MECHANISM 1 = THE CRACK ENERGY IS ABSORBED & DISSIPATED BY THE POLYMER SHEET (PVB) IN BETWEEN THE GLASS LAYERS

MECHANISM 2 = WHEN THE CRACK REACHES THE GLASS/PVB JOIN, THE TIP OF THE CRACK 'OPENS UP' THEREBY BLUNTENING THE CRACK & REDUCING ITS ENERGY BUT INCREASING THE ENERGY REQUIRED FOR FURTHER PROPOGATION.

(f)



LAMINATED GLASS

TOUGHENED GLASS

(g) SEE PAGE 158 OF WORKBOOK.
(KEY WORDS = MOLTEN GLASS
BED/LIQUID/TIN
SMOOTH/FLAT
ANNEALING/LEHR/FURNACE)

QUESTION 14

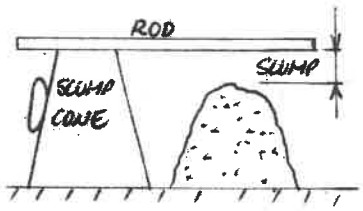
(a) CEMENT IS THE PASTE OR GLUE WHICH BINDS THE COMPONENT MATERIALS OF CONCRETE
CONCRETE IS THE MIX OF AGGREGATE, CEMENT, SAND, WATER & OTHER ADDITIVES.

(b) GYPSUM IS ADDED TO THE CEMENT TO RETARD THE CURING SPEED OF CONCRETE AFTER WATER IS ADDED.

(c) - PORTLAND CEMENT IS MADE FROM A MIXTURE OF ABOUT 75% LIMESTONE ($CaCO_3$) & 25% CLAY.
- THESE ARE GROUND TOGETHER & HEATED IN A LARGE ROTARY KILN (1400 - 1500°C)
- SMALL LUMPS OF CLINKER (5-10mm ϕ) ARE PRODUCED FROM THE KILN WHICH ARE MIXED WITH GYPSUM & GROUND TO A FINE POWDER.

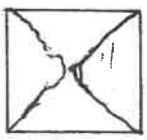
(d) STRENGTH: TOO MUCH WATER WILL WEAKEN THE CONCRETE - A WATER/CEMENT RATIO OF 0.5 IS NORMAL.
CURING: CONCRETE SHOULD BE KEPT MOIST FOR A FEW DAYS TO PROVIDE WATER FOR HYDRATION REACTIONS.

(e)



SLUMP TEST IS DONE ON SITE TO TEST THE WORKABILITY OF THE CONCRETE MIX.
THE CONCRETE IS PLACED IN THE SLUMP CONE TAMPED WITH A ROD & INVERTED. THE SLUMP IS THEN MEASURED AS SHOWN IN DIAGRAM
(SEE PAGE 9-9 OF WORKBOOK)

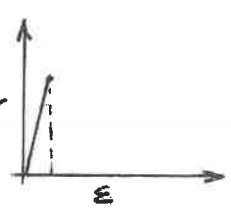
(f)



(SEE PAGE 33 OF WORKBOOK FOR OTHER POSSIBLE FRACTURE PATTERNS)

( ) BRITTLENESS - VERY BRITTLE SHOWN BY LOW STRAIN
STIFFNESS - VERY STIFF SHOWN BY STEEP GRAPH
TOUGHNESS - LOW TOUGHNESS SHOWN BY SMALL AREA UNDER GRAPH.

(g)



QUESTION 15

(a) SILICON CARBIDE - USED FOR VOLTAGE DEPENDENT RESISTORS (= VARISTORS)

FERROELECTRIC MATERIALS - BARIUM TITANATE USED IN CAPACITORS

SILICON & GERMANIUM - USED IN TRANSISTORS, RECTIFIERS, DIODES ETC.

(b) DOPING IS THE ADDITION OF OTHER MATERIALS (ATOMS) TO A SEMICONDUCTING MATERIAL IN ITS PURE STATE
DOPING IS DONE TO DELIBERATELY CHANGE THE ELECTRICAL PROPERTIES OF THE SEMICONDUCTOR TO SUIT A SPECIFIC PURPOSE SUCH AS MORE OR LESS CONDUCTIVITY & RESISTANCE.

(c) SEE PAGE 157 OF WORKBOOK.
(KEY WORDS = POWDER / DUST
IN MOULD / CAVITY
PRESSURE / FORCE APPLIED
EJECT / WITHDRAWN
'GREEN' PRODUCT
FIRED / SINTERED.)

(d) SEE PAGE 158 OF WORKBOOK
(KEY WORDS = MOLTEN GLASS
INTO MOULD
PRESS / CREATE CAVITY
BLOW / AIR BLAST
SPLIT MOULD / EJECT)

(e) PLATE GLASS HAS SURFACE DEFECTS (MICROCRACKS) WHICH CREATE STRESS RAISERS WHICH RESULT IN THE GLASS FAILING IN A BRITTLE MANNER. GLASS FIBRES ARE GENERALLY DEVOID OF SURFACE STRESS RAISERS.

(f) CRACKS WILL PROPAGATE THROUGH BRITTLE MATERIALS IF THE ENERGY PRODUCING THE CRACK IS GREATER THAN THE ENERGY REQUIRED TO CREATE NEW SURFACES OF THE CRACK.

(g) REASON 1

THE PRIMARY BOND IN CERAMICS DOES NOT ALLOW PLASTIC DEFORMATION BECAUSE THE ATOMS ARE HELD STRONGLY.

REASON 2

CERAMICS TEND TO HAVE SURFACE STRESS RAISERS WHICH INITIATE BRITTLE FAILURE. METALS DO NOT.

REASON 3

CERAMICS DO NOT HAVE HIGH ATOMIC DENSITY SLIP PLANES WHICH ARE PRESENT IN METALS.

REASON 4

METALS TEND TO DEFORM PLASTICALLY AT THE TIP OF THE CRACK WHICH TENDS TO BLUNTEN THE CRACK.

(h) SEE PAGE 159 OF WORKBOOK
(KEY WORDS: MOLTEN GLASS, SMALL HOLES, DIE, DRAWN DOWN, SPUN)

QUESTION 16

(a) HIGH OPERATING TEMPERATURES WITH LITTLE OR NO DISTORTION, LOW WEAR, LOW MASS, GOOD FRICTION

(b) CARBON FIBRE REINFORCED SILICON CARBIDE

(c) INCREASE SURFACE AREA TO HELP DISSIPATE HEAT, SCRUBS BRAKE PADS TO HELP REMOVE GLAZING OF THE SURFACE

QUESTION 17.

(a) SAMPLE 1: THERMAL OR CHEMICAL TOUGHENED GLASS.
THE HIGH COMPRESSIVE STRESS IN THE OUTER LAYERS WHEN EXCEEDED RESULTS IN THE INSIDE TENSILE STRESSES FRACTURING THE GLASS INTO SMALL RELATIVELY SAFE PARTICLES
SAMPLE 2: LAMINATED GLASS
THE PVB POLYMER MEMBRANE HOLDS THE GLASS TOGETHER AFTER FRACTURE
SAMPLE 3: FLOAT GLASS - UNMODIFIED
IRREGULAR FRACTURE PATTERN PRODUCING GLASS SHIVER

(b) SAMPLE 1 - VEHICLE SIDE & REAR WINDOWS - TOUGH AND FRACTURES INTO RELATIVELY HARMLESS PARTICLES, TRANSPARENT
SAMPLE 2 - VEHICLE WINDSCREENS & SAFETY GLASS PANELS - HOLD TOGETHER AFTER FRACTURE, TRANSPARENT REDUCTION OF UV TRANSFER, TOUGH.
SAMPLE 3 - GENERAL GLASS SHEET - RELATIVELY INEXPENSIVE, TRANSPARENT, LARGE SHEETS WITH GOOD DIMENSIONAL ACCURACY

(c) AMORPHOUS MATERIALS HAVE A LOW ORDER OF CRYSTALLINE STRUCTURE BUT GENERALLY HAVE A HIGH OPTICAL CLARITY. ALL OF THE SAMPLES SHOWN HAVE AN AMORPHOUS STRUCTURE.
CRYSTALLINE MATERIALS HAVE A HIGHLY ORDERED STRUCTURE. CRYSTALLINE GLASSES ARE TOUGHER, LESS BRITTLE THAN AMORPHOUS GLASSES BUT HAVE LESS OPTICAL CLARITY - NONE OF THE SAMPLES ARE CRYSTALLINE FOR THIS REASON.

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

Composites

10

Aim to complete each question many times in 2 years							
Question	Page/s	Study register ✔					
Multiple choice	78						
Question 11	79						
Question 12	79						
Question 13	79						
Question 14	80						
Question 15	80						
Solutions	81-82						

Section 1 - Multiple choice questions

Select by circling the alternative A, B, C or D that best answers the question.

1. Which are the materials that *composite materials* can be made from?
   (A) Only combinations of two or more non-metals.
   (B) Just pure elements like carbon and silicon.
   (C) Only combinations of metals and ceramics.
   (D) Mixtures of metals, ceramics and polymers.

2. Which are all *composite materials*?
   (A) Wood, iron, steel, glass reinforced plastic (GRP).
   (B) Wood, reinforced concrete, concrete, carbon fibre/epoxy, bone.
   (C) Wood, carbon fibre, glass reinforced plastic (GRP), brass.
   (D) Cement, bone, copper, polyethylene.

3. What are the advantages of *wood as an engineering material*?
   (A) Wood is easily handled, worked and joined; has a high specific strength; is regenerative.
   (B) Wood is easily handled, worked and joined; has a high tensile strength; is regenerative.
   (C) Wood is easily handled; is ductile; has a high specific strength; is regenerative.
   (D) Wood is consistent in quality; has a high specific strength; is regenerative.

4. What are the main functions of the *matrix in a composite material*?
   (A) Adhere to the fibres, expose the fibres and to absorb tensile forces.
   (B) Provide stiffness, protect the fibres from heat and to keep fibres apart to stop cracks.
   (C) Adhere to the fibres, absorb shear forces and to direct cracks away from the fibres.
   (D) Adhere to the fibres, protect the fibres, to keep fibres apart and to resist crack propagation.

5. Why is *steel* an excellent reinforcing material in concrete?
   (A) Steel has high strength, has similar thermal expansion as concrete and will not corrode if positioned correctly in the concrete.
   (B) Steel is almost as strong in tension as concrete, has similar thermal expansion as concrete and will not corrode if positioned correctly in the concrete.
   (C) Steel has a lower expansion rate than concrete and will increase the compressive strength of the concrete.
   (D) Steel makes the concrete more dense which provides greater weather resistance when the concrete is cured.

6. Which best describes *post-tensioned prestressed concrete*?
   (A) The steel tendons are stressed before and after the concrete is cast.
   (B) The reinforcing steel mesh is placed in the concrete during casting of the concrete.
   (C) The steel tendons are stressed before the concrete is poured.
   (D) The reinforcing steel tendons are stressed after the concrete has satisfactorily cured.

7. When are *pre-tensioned prestressed concrete beams* generally used for civil structures?
   (A) Where the beams can be pre-tensioned on site.
   (B) When the beams can be transported to the site after prestressing.
   (C) Where there is a water-way so that the beams can be floated into position.
   (D) When the beams are too large and have to be pre-tensioned at the factory.

8. What are the constituents of *asphalt* composite?
   (A) Aggregate with a matrix of bitumen.
   (B) Bitumen and a matrix of sand and aggregate.
   (C) Sand with a matrix of cement and bitumen.
   (D) Aggregate with a binder of black cement.

9. Which fibre will provide *uniform strength* (isotropic strength) in a composite?
   (A) Chopped strand mat.
   (B) Continuous fibres.
   (C) Fabric.
   (D) Woven mat.

10. Which is the most appropriate method of *forming a one-off product* such as a canoe using a composite material?
   (A) Pultrusion.
   (B) Filament winding.
   (C) Hand lay-up.
   (D) Sheet moulding using sheet moulding compound (SMC).

Section II - Short structured response questions

Question 11

(a) Wood is a naturally occurring composite material. Explain, in terms of structure, why wood is stronger in one direction than at 90° to that direction. Use a diagram to assist your answer.

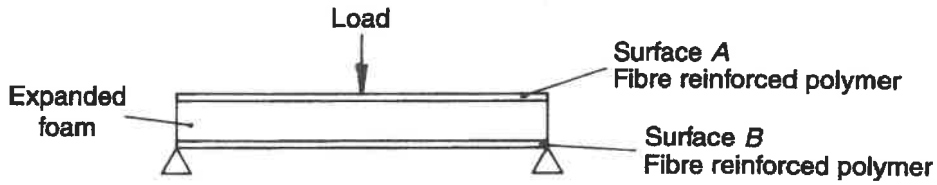
(b) Wood has long been a significant construction material. Give three advantages and three disadvantages for using wood as a structural material.

(c) One method of strengthening timber for use as beams is to laminate the timber beam. Explain how a laminated timber beam is formed and how it derives the extra strength over non-laminated timber.

(d) State two structural advantages of using laminated beams for long spans in building structures.

Question 12

A cross-section through a composite wall of a structural component is shown below.



(a) The panel is loaded as shown. Which surface (A or B) will require the greater number of fibres giving a reason to support your answer.

(b) State one structural reason for the use of the foam.

(c) State one service reason why expanded foam may have been used.

(d) Name a suitable material for the expanded foam.

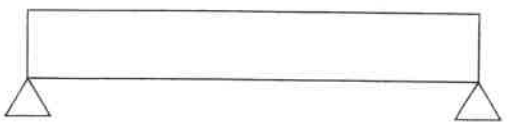
(e) Name a suitable material for the fibre in the reinforced polymer.

(f) Suggest a way of making the panel more rigid and stronger using the same materials and without significantly increasing the mass of the panel.

(g) Suggest an orientation of fibres to provide uniform strength over the surface of the panel. Use a labelled sketch to illustrate your answer.

Question 13

(a) A concrete beam is supported as shown. On the diagram, indicate the approximate position of a reinforcing rod to minimise tensile cracking.



(b) Draw and label the macrostructure of reinforced concrete.

(c) Suggest possible reinforcing materials which are used by industry to reinforce concrete.

(d) There are two methods of prestressing concrete beams. Name and describe both of these methods.

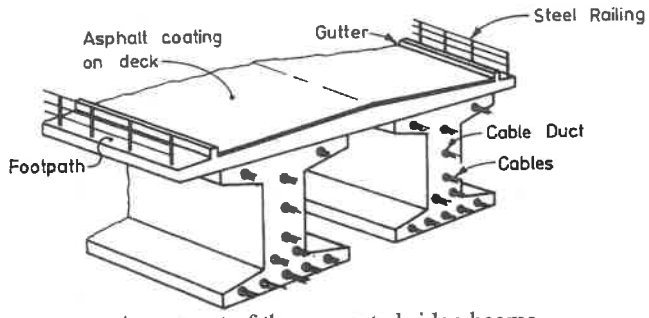
(e) Suggest appropriate applications for both methods of prestressing.

(f) In both prestressing methods the high tensile steel tendons are grouted. Explain the grouting process and give reasons why it is necessary to grout prestressed concrete tendons.

(g) Give three advantages of prestressing concrete compared to reinforced concrete.

Question 14

Prestressed concrete beams are used to support the roadway on a concrete bridge. The beams are supported at each end, and the diagram shows a segment of the beams at the centre of the bridge.



A segment of the concrete bridge beams

(a) State why there are more cables in the lower section of each beam.

(b) Explain why the beams are likely to have been post-tensioned.

(c) The deck has an asphalt coating on the concrete deck as a road surface. Give two reasons why asphalt is used as a road surface.

(d) Name two constituents of asphalt and state the purpose of each constituent in the asphalt composite.

Plywood is often used as formwork when casting concrete sections on bridges and many other civil structures.

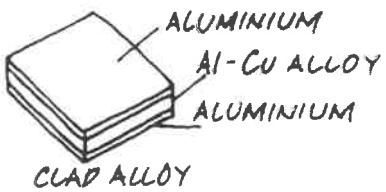
(e) Give three advantages of plywood over conventional timber.

(f) Give a reason why there is always odd numbers of plys in plywood.

(g) State one advantage of particle board and fibreboard (MDF) over plywood?

Question 15

(a) A metal-metal laminate called 'Alclad' used for the external lining of houses, has almost pure aluminium on the outside sandwiched to aluminium alloy sheet on the inside as shown. Give a reason why the pure metal and alloy have been used.



(b) Explain the term cermet and give an example of this type of composite.

(c) Explain the process of powder metallurgy and give an example of a product which has been manufactured using this forming process.

(d) Resin transfer moulding (RTM) is a forming method which moulds composites to provide an excellent surface finish. Explain the process using a diagram to assist your explanation.

(e) Explain how composites made from fibres in a polymeric matrix have excellent resistance to cracking when compared to conventional materials. Use a diagram to assist your answer.

SECTION I - MULTIPLE CHOICE

1. D, 2. B, 3. A, 4. D, 5. A,
6. D, 7. B, 8. A, 9. A, 10. C.

SECTION II

QUESTION 11

(a) WHEN A BENDING FORCE IS APPLIED ACROSS THE WIDTH ONLY THE LIGNIN RESISTS THE FORCE. WHEN THE FORCE IS AT 90° (IE ALONG THE LENGTH) BOTH THE CELLULOSE AND LIGNIN RESISTS THE FORCE



(b) ADVANTAGES:
- HIGH SPECIFIC STRENGTH
- WOOD IS REGENERATIVE
- EASILY HANDLED, WORKED & JOINED
- CAN BE LAMINATED & MADE INTO MANY PRODUCTS
- CAN BE TREATED TO IMPROVE DURABILITY

DISADVANTAGES:
- WOOD IS COMBUSTIBLE
- STRENGTH VARIES WITH SPECIES, DIRECTION
- SUBJECT TO DECAY, INSECT ATTACK
- SUBJECT TO MOVEMENT DUE TO ATMOSPHERIC HUMIDITY.

(c) FORMED BY GLUING LENGTHS OF TIMBER FACE TO FACE
STRENGTH DERIVED FROM THE GLUED INTERFACES IN THE BEAM.

(d)
- INCREASED STRENGTH DUE TO GLUE LINE
- MINIMISE MOVEMENT DUE TO HUMIDITY
- IMPROVED RIGIDITY
- RETAIN STRENGTH IN FIRE
- CAN LAMINATE CURVED SHAPES
- SMALLER SECTIONAL SIZE DUE TO INCREASED STRENGTH.

QUESTION 12

(a) B

SURFACE B IS THE TENSILE SURFACE & FIBRES ARE STRONG IN TENSION

(b) TO INCREASE THE DISTANCE OF THE OUTER FIBRES FROM THE NEUTRAL AXIS OF THE PANEL.

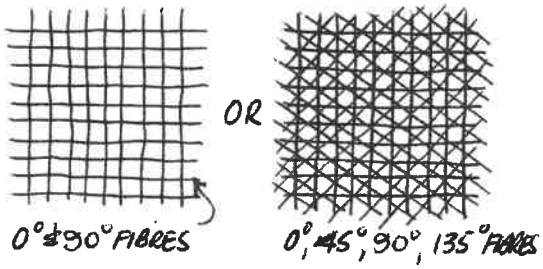
(c) BOUYANCY, LOW MASS, THERMAL INSULATION, RIGIDITY, SOUND INSULATION.

(d) POLYSTYRENE, POLYURETHANE, CLOSED CELL FOAM,

(e) KEVLAR, CARBON, GLASS, BORON, POLYESTER, POLYPROPYLENE.

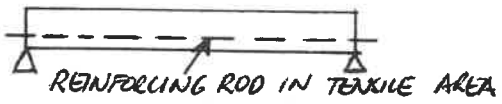
(f) INCREASE THE THICKNESS OF THE FOAM SO THAT THE OUTER FIBRE IS FURTHER AWAY FROM THE NEUTRAL AXIS.

(g)

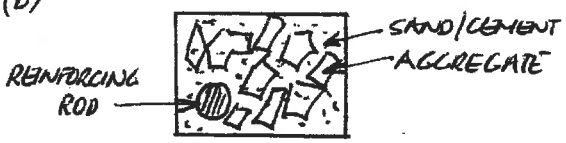


QUESTION 13.

(a)



(b)



(c) STEEL, CARBON FIBRE, KEVLAR, POLYPROPYLENE

(d) METHOD 1 = PRE-TENSIONING
DESCRIPTION + SEE PAGE OF WORKBOOK.
METHOD 2 = POST-TENSIONING
DESCRIPTION - SEE PAGE OF WORKBOOK.

(e) PRE-TENSIONING IS GENERALLY USED WHEN THE STRUCTURAL MEMBER CAN BE CAST & TENSIONED IN THE FACTORY & TRANSPORTED TO THE SITE

POST-TENSIONING IS GENERALLY DONE IN SITU WHERE IT IS TOO LARGE TO TRANSPORT OR WHEN IT IS MORE CONVENIENT TO CONSTRUCT USING PRE-CAST SECTIONS WHICH CAN BE TENSIONED IN SITU.

(f) GROUTING IS FILLING THE CAVITY OR TUBES ALONG WHICH THE TENDONS RUN. GROUTING IS DONE TO PREVENT CORROSION OF TENDONS & TO PREVENT THEM RUBBING TOGETHER DURING DYNAMIC LOADS. THE GROUT IS A WATERY CEMENT/WATER MIXTURE.

(g) PRESTRESSED CONCRETE IS STRONGER, REQUIRES LESS CONCRETE, LESS FORMWORK, LESS STEEL, FORMWORK CAN BE STRIPPED EARLIER.

QUESTION 14

(a) TO INCREASE THE TENSILE STRENGTH OF THE BEAM IN THIS REGION / PLACE BEAM IN COMPRESSION IN THIS REGION

(b) THE BEAMS ARE IN POST-TENSIONED SEGMENTS (FROM QUESTION) AS WELL AS THE INDICATION THAT THE BEAMS ARE MASSIVE AND TOO LARGE TO TRANSPORT AS AN ENTIRE PRE-TENSIONED BEAM.

(c) FLEXIBLE, DURABLE, WATER PROOF, EASY TO REPAIR, UV RESISTANT, EASY TO LAY & CAMBER.

(d) BITUMEN = BINDER OR MATRIX.

AGGREGATE = PROVIDES BULK, COMPRESSIVE STRENGTH, WEAR RESISTANCE

(e) STRONGER, IN SHEET FORM, LESS DIRECTIONAL PROPERTIES, CAN BE MADE WATERPROOF, CAN BE BENT & MOULDED, LESS AFFECTED BY THE ATMOSPHERE

(f) SO THAT THE OUTSIDE VENEERS HAVE THE SAME GRAIN DIRECTION

(g) PARTICLE BOARD & FIBREBOARD HAS EQUAL STRENGTH IN ALL DIRECTIONS (= ISOTROPIC)

QUESTION 15

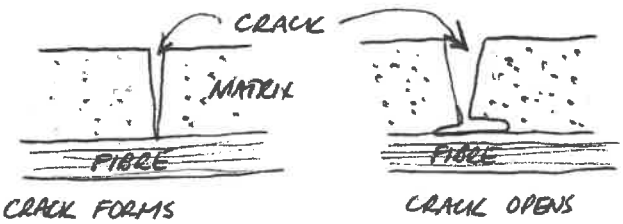
(a) THE ALMOST PURE METAL OFFERS SUPERIOR CORROSION RESISTANCE THAN THE ALLOY WHILE THE ALLOY PROVIDES GREATER STRENGTH TO THE COMPOSITE

(b) A CERMET IS A CERAMIC - METAL COMPOSITE USUALLY MADE BY POWDER METALLURGY. AN EXAMPLE OF A CERMET IS TUNGSTEN CARBIDE. THIS CERMET HAS THE CERAMIC TUNGSTEN CARBIDE PARTICLES IN A COBALT (METAL) MATRIX.

(c) SEE PAGE 58-59 OF WORKBOOK
(KEY WORDS = POWDER / BLENDING
COMPACTING / FORCE
DIE / MOULD
SINTERING / HEAT)
EXAMPLE - COPPER / GRAPHITE BRUSHES IN ELECTRIC MOTORS
- SELF LUBRICATING PHOSPHOR BRONZE BEARINGS
- COMPLEX SHAPES SUCH AS WC DIES, NUTS, GEARS.

(d) SEE PAGE 172 OF WORKBOOK.
(KEY WORDS = FIBRES / RESIN / MIX
INJECTED / FORCED
DIE / MOULD
CURED / SET / EJECTED)

(e) CRACKS IN COMPOSITE MATERIALS 'OPEN-UP' WHEN THE CRACK REACHES THE MATRIX / FIBRE INTERFACE THEREBY BLUNTENING THE CRACK WHICH HINDERS FURTHER PROPAGATION.



CRACK FORMS CRACK OPENS

Stage 6

Engineering Studies -

Typical HSC Questions & Solutions

Engineering & the Engineering Report

Section III

Aim to complete each question many times in 2 years								
Question	**Page/s**	**Study register ✔**						
Example A	**84**							
Question (a)	84							
Question (b)	84							
Question (c)	84							
Question (d)	84							
Question (e)	84							
Question (f)	84							
Question (g)	84							
Question (h)	84							
Question (i)	84							
Question (j)	84							
Example B	**85**							
Question 1 (a)	85							
Question 1 (b)	85							
Question 1 (c)	85							
Question 1 (d)	85							
Question 1 (e)	85							
Question 1 (f)	85							
Question 1 (g)	85							
Question 1 (h)	85							
Question 1 (i)	85							
Question 1 (j)	85							
Question 2 (a)	85							
Question 2 (b)	85							
Question 2 (c)	85							
Question 2 (d)	85							
Solutions to A & B	86-87							

Questions testing Engineering & Engineering Reports in the HSC Examination

These questions (generally questions 26 & 27 in the HSC) are based on all modules and Engineering Reports. They will consist of a number of short structured responses - fewer than the number of responses required in examples A and B below.

Example A

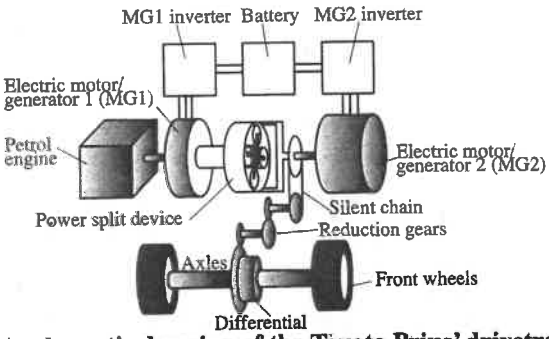
A hybrid-electric vehicle (HEV) combines a conventional internal combustion engine propulsion system with an electric propulsion system. The presence of the electric powertrain as well as other design features, are intended to achieve either a better fuel economy than a conventional vehicle, or better performance.

Other design features used for HEVs include:

- Using low mass materials
- Reclaiming some of the energy lost during braking
- Using 'slippery' aerodynamics and smaller wheels



Toyota Prius



A schematic drawing of the Toyota Prius' drivetrain

- Using solar assistance for air-conditioning.

The Toyota Prius is the most successful hybrid-electric vehicle. Shown below is a photograph of the Toyota Prius and a schematic drawing of the Prius' hybrid-electric drivetrain:

(a) An HEV reclaims part of the kinetic energy lost during braking via a regenerative braking system. Electric trains often use a similar process. Explain regenerative braking and how it makes the vehicle more efficient.

(b) If an HEV has a mass of 1.2 tonnes and is on a hill 500 m high and is allowed to roll down to sea level unassisted by the engine, how much energy must the brakes dissipate in stopping the vehicle assuming 70% of the energy is lost due to the incline of the hill and frictional losses?

(c) Mass reduction is a major focus for HEV design engineers. Explain why mass is a significant consideration for the efficiency of any vehicle.

(d) HEV engineers often use the following techniques to reduce mass. Explain how each innovation achieves the desired objectives.

(i) Construction of the floor using embossed (pressed to form a pattern) aluminium.
(ii) Use of polycarbonate for windows except the windscreen.
(iii) Use of carbon fibre/epoxy and glass reinforced plastic for body panels and structural members.

(e) Engineers design the body shape of HEVs to create a more 'slippery' shape. Explain how each of the following aerodynamic changes enhances efficiency.

(i) Lowering the roof line.
(ii) Use of smaller wheels.
(iii) Use of sharper edges on body work.
(iv) Use of flat under-body panels.
(v) Restrict air from accelerating over the roof during motion.

(f) The electric motors/generators used in the Toyota Prius are three-phase alternating current (AC) synchronous motors that help with the drive as well as charge the battery pack.

(i) Explain how an electric motor can also generate electricity.
(ii) State the purpose of the inverters in relation to the electric motors charging the battery pack.
(iii) Explain the advantage of electric motor input when the car is accelerating from standstill.

(g) Explain the advantage of using a silent chain drive in preference to using a gear drive to turn the reduction gears.

(h) The Prius uses high pressure tyres that have silica in their construction. Give one reason each for the high pressures and the silica content in the tyres.

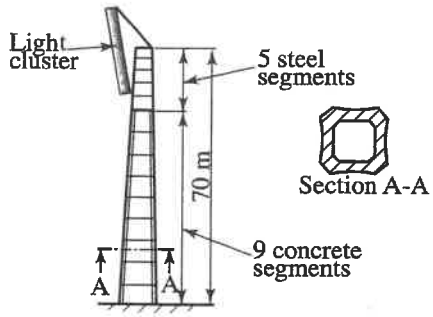
(i) A design engineer is required to write an engineering report on the higher incidences of HEVs being involved with

Example B

Question 1

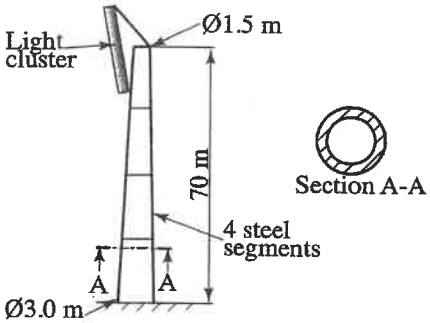
Light towers are used extensively for illumination during night time sporting events. The West Australian Cricket Association's (WACA) light towers in Perth use concrete/steel towers while the towers at the Sydney Cricket Ground (SCG) use an all steel construction. Details of both the WACA and SCG light towers are shown below.





WACA Light Tower





SCG Light Tower

(a) The light towers for both the WACA and SCG were constructed using segments. Suggest two reasons why this method of construction has been used.

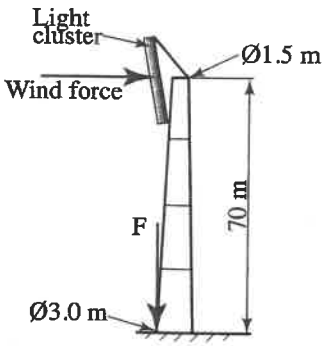
(b) Give two reasons why the towers at the WACA ground have more segments than the towers at the SCG.

(c) The materials used for for both types of towers require different methods to join the tower segments. Suggest a suitable method of joining the segments for each type of tower and justify your suggestion.

(d) Engineers refer to the light cluster at the top of the tower as the 'area of sail' with reference to the wind force on the towers. Explain the structural significance of the 'area of sail' on the light tower.

(e) Using the data given below, find the force F at the base of the tower which will produce equilibrium conditions if a wind force of 1 kN/m² acts on the light cluster.

- Mass of tower = 50 tonnes
- Dimensions of light cluster = 8 m x 3.2 m
- Assume the Centre of Mass acts at the centre of the tower
- Ignore the wind force which acts on the tower.



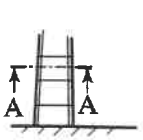
(f) Give one advantage and one disadvantage for the type of construction used for each tower.

(g) Suggest and describe a method of anchoring the towers to the ground. Use a diagram to assist your explanation.

(h) Give two reasons why both towers are hollow.

(i) Both towers use high tensile structural steel. Explain the difference between this material and plain carbon mild steel.

(j) Explain why sectional views, as shown, are used in orthogonal drawings.





Question 2

Some of the engineering personnel involved in the design and construction of the light towers are listed below:

- Structural engineer
- Architect
- Lighting engineer
- Mechanical engineer
- Project engineer

(a) Explain the role of each of these occupations in the light tower project.

(b) Select one of the engineering personnel from above and suggest a possible abstract for an Engineering Report involving the light tower which a person in that particular occupation could be expected to research and produce.

(c) Suggest how an engineering project such as the light towers at a sporting venue impacts on society and the environment. Give one significant impact for each area.

(d) Hydraulic light towers were tested at the Adelaide Oval where the towers were lifted, when required, by hydraulic rams from a cavity in the ground to a height of 70 m. Give one advantage and one disadvantage in terms of environmental impact of hydraulically operated light towers.

SECTION III

EXAMPLE A

i) REGENERATIVE BRAKING OCCURS WHEN THE ELECTRIC MOTOR IS CONVERTED TO A GENERATOR DURING BRAKING. THE ELECTRICITY GENERATED IS FED INTO THE BATTERIES AND STORED FOR LATER USE. THE RESISTANCE FORCE ON THE GENERATOR ALSO RETARDS THE VEHICLE.

REGENERATIVE BRAKING CONVERTS THE CAR'S KINETIC ENERGY INTO USEFUL ELECTRICAL ENERGY AS WELL AS REDUCING WEAR ON BRAKING SYSTEMS.

b) ENERGY ON TOP OF HILL = PE
= mgh WHERE
$= 1.2\times10^3 \times 10 \times 500$ $m = 1.2\times10^3$ kg
$= 6\times10^6$ J $g = 10$ m/s^2
70% LOSS $= 6\times10^6 \times 0.3$ $h = 500$ m
$= 1.8$ MJ

ENERGY DISPERSED BY BRAKES = 1.8 MJ

(c) THE GREATER THE MASS OF A VEHICE THE MORE ENERGY IS REQUIRED TO MOVE THE MASS WHICH EQUATES TO MORE FUEL (CHEMICAL ENERGY) CONSUMED PER KILOMETRE.

(d) (i) USE OF ALUMINIUM WHICH HAS ONE THIRD THE MASS OF STEEL. EMBOSSING THE SHEET ALUMINIUM PRODUCES GREATER STRENGTH/RIGIDITY
(ii) POLY CARBONATE HAS A HIGHER SPECIFIC STRENGTH THAN GLASS WITH ALMOST THE SAME OPTICAL CLARITY
(iii) CARBON FIBRE/EPOXY & GRP HAS A HIGHER SPECIFIC STRENGTH THAN STEEL.

(e) (i) REDUCTION OF THE VEHICLES FRONTAL AREA THEREBY REDUCING DRAG.
(ii) - REDUCTION OF MASS & KINETIC ENERGY
- LOWERS THE CENTRE OF MASS OF THE VEHICLE
- LESS FRICTION & ROLLING RESISTANCE
(iii) SHARPER EDGES IN SPECIFIC AREAS ON THE BODY PROVIDES RELEASE OF AIR THUS PROVIDING BETTER AIRFLOW SEPARATION.
(iv) CREATES LESS DRAG BY THE AIRFLOW NOT BEING IMPEDED BY ROUGH UNDERBODY PARTS.
(v) ACCELERATION OF AIR OVER THE ROOFLINE WILL PRODUCE LIFT ON THE VEHICLE WHICH ABSORBS ENERGY FROM THE MOVING VEHICLE.

(f) (i) IF THE ROTOR OF A SYNCHRONOUS ELECTRIC MOTOR IS SPUN BY AN OUTSIDE FORCE, AN ELECTRIC CURRENT WILL BE INDUCED IN THE STATOR COILS.
(ii) THE INVERTERS CONVERT THE 3 PHASE AC TO DC WHICH IS REQUIRED TO CHARGE ALL BATTERIES.
(iii) ELECTRIC MOTORS HAVE MAXIMUM TORQUE AT STANDSTILL WHEREAS INTERNAL COMBUSTION ENGINES REQUIRE REVS TO GENERATE TORQUE.

(g) A CHAIN DRIVE DOES NOT HAVE AN AXIAL THRUST WHICH NORMAL HELICAL GEARS PRODUCE. SPUR GEARS DO NOT HAVE AN AXIAL THRUST BUT THEY ARE NOISY.

(h) HIGH PRESSURE TYRES PRODUCE A LOW ROLLING RESISTANCE BUT LESS GRIP, ESPECIALLY IN THE WET. SILICA IS ADDED TO THE RUBBER TO ENHANCE THE COEFFICIENT OF FRICTION OF THE TYRES.

(i) ABSTRACT: IS A CONCISE SUMMARY OF THE CONTENT & THE PURPOSE OF THE REPORT
ASPECTS WHICH COULD BE INCLUDED:
- STATEMENT OF THE PROBLEM BEING INVESTIGATED
- A BRIEF REVIEW OF THE DATA ON WHICH THE REPORT IS BASED
- A BRIEF STATEMENT OF HOW THE PROBLEM/SUBJECT WAS STUDIED

APPENDIX: THE PART OF THE REPORT WHERE ALL CALCULATIONS, TABLES, DATA, DRAWINGS ETC ARE LOCATED IN THE REPORT
ASPECTS WHICH COULD BE INCLUDED IN THE APPENDIX FOR THIS REPORT COULD BE:
- TABLES FOR RESEARCH DATA
- DRAWINGS OF CRASH SITES SHOWING THE PATHS OF RESPECTIVE PARTICIPANTS.
- STATISTICAL ANALYSIS OF DATA.

EXAMPLE B

QUESTION 1

(a)
- EASIER TO ERECT
- EASIER TO TRANSPORT
- MORE CONVENIENT HANDLING/STORAGE
- EASY TO JOIN BOTH MATERIALS WHEN IN SEGMENTS.

(b)
- CONCRETE SECTIONS ARE THICK AND HAVE MORE MASS THAN STEEL SECTIONS THUS HAVE TO BE SMALLER FOR ERECTION/HANDLING.
- THE CONCRETE SECTIONS HAVE TO BE POST-TENSIONED AND THUS HAVE TO BE SHORTER IN LENGTH.

(c) WACA:

JOIN: POST-TENSIONED CABLES & GROUTED AT JOINTS USING EPOXY/SILICON POLYMER.

JUSTIFY: CONCRETE HAS HIGH COMPRESSIVE STRENGTH & POST-TENSIONING PLACES EACH SEGMENT IN COMPRESSION WITH THE HIGH TENSILE TENDONS ACCOUNTING FOR TENSILE LOADS

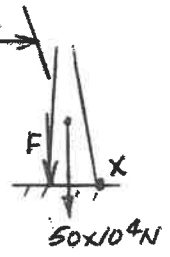
SCG:

JOIN: BOLTS THROUGH WELDED LUGS INSIDE THE TOWER

JUSTIFY: USE OF HIGH TENSILE BOLTS AND WELDED LUGS PROVIDES A STRONG METHOD OF ATTACHMENT AS WELL AS A CONVENIENT METHOD OF ERECTION

(d) 'AREA OF SAIL' REFERS TO THE SURFACE AREA WHICH A STRUCTURE OFFERS TO MOVING AIR (WIND). THE GREATER THE SURFACE AREA, THE MORE WIND FORCE ACTING ON A STRUCTURE

(e)



$\sum M_x = 0 \curvearrowright^+$

$(F_W \times 70) - (50\times10^4\times1.5) - 3F = 0$ $\quad F_{WIND} = 8\times312\times1 = 25.6\,kN$

$(25.6\times10^3\times70) - (50\times10^4\times1.5) - 3F = 0$

$\therefore F = 347\ kN$

FORCE AT F = 347 kN.

(f) WACA:

ADVANTAGE: DURABLE, LOW MAINTENCE, VERY STRONG (COMP. TENSION), FIRE RESISTANT.

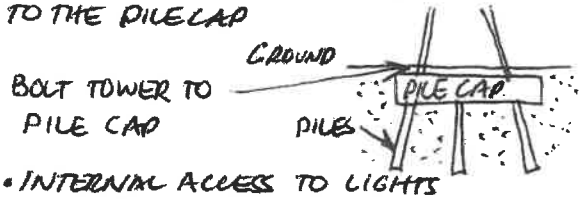
DISADVANTAGE: HIGH MASS LIFTING/HANDLING, INVOLVED JOINING METHOD, LARGER VOLUME OF STRUCTURE.

SCG:

ADVANTAGE: LOW MASS, EASY TO ERECT, PREFABRICATED, STRONG IN TENSION & COMPRESSION, RIGID, SMALLER VOLUME OF STRUCTURE

DISADVANTAGE: LESS DURABLE (CORRODES) HIGHER MAINTENCE THAN CONCRETE, BLAND APPEARANCE.

(g) USE OF PILES AND ANCHOR THE TOWER TO THE PILECAP



(h)
- INTERNAL ACCESS TO LIGHTS
- LOW MASS
- INSPECTION, MAINTENANCE

(i) HIGH TENSILE STEEL HAS ALLOYING ELEMENTS SUCH AS NICKEL, MANGANESE & SILICON TO STRENGTHEN THE STEEL WHEREAS PLAIN CARBON STEELS HAVE CARBON AS THE ONLY OTHER ADDED ELEMENT.

(j) USED IN DETAIL DRAWINGS SO THAT THE MAIN DRAWING DOES NOT SHOW TOO MUCH INFORMATION & CONFUSE VIEWERS. USED TO SHOW INTERNAL DETAIL.

QUESTION 2

(a) STRUCTURAL ENGINEER - DESIGN OF STRUCTURAL ELEMENTS
ARCHITECT - INITIAL DESIGN OF THE PROJECT
LIGHTING ENGINEER - NUMBER/INTENSITY/TYPE OF LIGHTS
MECHANICAL ENGINEER - METHOD OF CONSTRUCTION
PROJECT ENGINEER - SUPERVISION OF CONSTRUCTION.

(b) SEE PAGES 38 & 41 OF THE ENGINEERING STUDIES COMMUNICATION WORKBOOK FOR AN EXAMPLE OF AN ABSTRACT FOR AN ENGINEERING REPORT.

(c) SOCIETY - PROVIDES ADDED TIME (NIGHT) FOR PEOPLE TO ENJOY THEMSELVES.
- ALLOWS MORE TIME FOR SPORTING ACTIVITIES.

ENV. - HIGH TOWERS IMPACT ON LANDSCAPE
- MASSIVE LIGHT BANKS MAY INTERFERE WITH LOCAL RESIDENTS.
- ABSORBS A LOT OF POWER.

(d) ADVANTAGE - REMOVES UNSIGHTLY(?) TOWERS WHEN NOT IN USE

DISADVANTAGE - LARGE AMOUNT OF HYDRAULIC/MECHANICAL EQUIPMENT REQ'D
- POSSIBILITY OF HYDRAULIC FLUID LEAKAGE.

The Engineering Studies HSC examination

The written examination is 3 hours duration with an added 5 minutes reading time.
There will be approximately equal weighting of each of the four modules across the examination as a whole.
Questions may require students to integrate knowledge, understanding and skills developed through studying the entire course, rather than focusing on a particular module.

The written paper is divided into TWO sections:

Section I (20 marks)

- All questions are compulsory.
- This section will comprise TWENTY objective response (multiple choice) questions.

Section II (80 marks)

- All questions are compulsory.
- There will be approximately seven short-answer questions.
- Each question will consist of a number of parts requiring short structured responses.
- There will be approximately 25 items in total.
- At least two items will be worth from 6 to 8 marks.

Examination Technique

Examination technique is extremely important for every student if the student is to demonstrate full potential in the examination results. A few notes on examination technique have been included to assist you in this as well as other examinations:

- Divide the time for the examination by the total marks to determine the number of minutes per mark. For Engineering Studies it works out to be 1.8 minutes/mark so if you multiply the marks for each question by 1.5, this will leave you with 30 minutes at the end of the examination to check your answers as well as complete any question for which you ran out of time.
- For each question multiply the marks by 1.5 to determine how long you can spend on the question. Write next to each question the time that you must finish the question so that you do not have to waste time to recalculate times during the examination.
- It is generally better to spend time starting a new question than running over-time to finish the previous question. Mark each question which you must return to and use the remaining 30 minutes at the end of the exam to finish these questions or to check your answers - you will be fresher and more confident at this time of the exam to complete difficult questions.
- Do not leave any examination early - remain in the exam room and check all answers because you will generally gain extra marks by checking answers.
- A well organised approach such as this will give you confidence during the exam because you do not have to worry about running out of time. There is plenty of evidence to indicate that a calm and relaxed student will perform more efficiently during examinations than one who is stressed.
- Make sure that you read the question and answer exactly what the question is asking. If there are two parts such as sketch and label and you only sketch then you can only expect to receive about half the total marks for the question if your answer is correct. Also show all working; an incorrect answer in Engineering Studies may derive full marks if working is provided - ask your teacher about this.

A very important part of your HSC examination preparation:

- Obtain copies of previous HSC written examinations with answers and examiner's comments from your teacher or by purchasing them from the Board of Studies, Sydney, (phone 02 9367 8111) or by down-loading from the Board's Website (http:/www.boardofstudies.nsw.edu.au) - you must be familiar with all aspects of the examination before sitting for the paper.

Resources to assist in the learning of Engineering Studies

Teacher's Classroom Lessons DVD #1:



This is a Quicktime movie slide presentation on DVD of information and extra graphics from the Engineering Studies - A Student's Workbook in the same order as presented in the workbook.
This DVD can be used on a computer, data projector or smartboard and facilitates an easy, professional and attractive lesson presentation for teachers and students. Preview at **kjspublications.com.au**

Teacher's Classroom Lessons DVD #2:



This is a Quicktime movie slide presentation on DVD of the syllabus requirements for the *historical, scope and impacts* areas of the course for each of the 8 modules. It is designed to be used in conjunction with the new workbook: Engineering Studies - History, scope & Impacts for all Modules. This DVD can be used on a computer, data projector or smartboard and facilitates an easy, professional and attractive lesson presentation for teachers and students.
Preview at **kjspublications.com.au**

Engineering mechanics solutions DVD #3:



This one hour DVD demonstrates simpler methods of solving mechanics questions that many students find difficult.
Preview at **kjspublications.com.au**

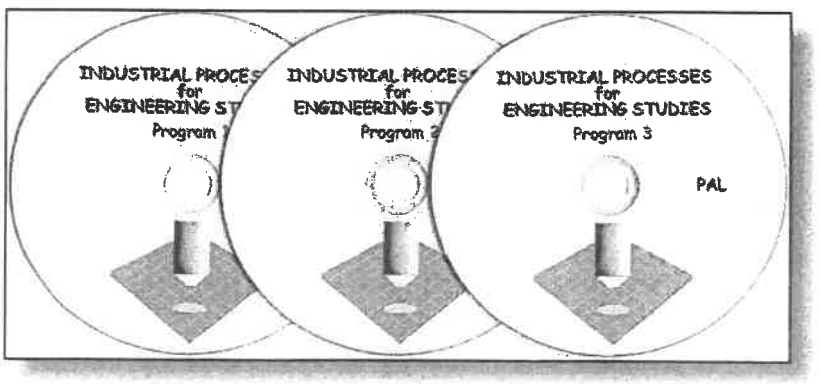
Solutions to analytical question to the ES workbook:



The CD provides solutions to all analytical questions in the Engineering Studies Workbook.

Industrial Processes DVDs:

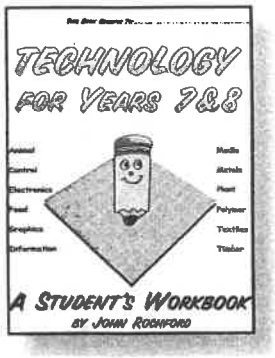
This 3 DVD package provides up-to-date movie presentation of Industrial Processes for Engineering Studies and co-ordinates with the presentation in the Engineering Studies - A Student's Workbook. These DVDs facilitate the reinforcement of information provided in class by viewing short movie presentations (about 5 minutes each) of industrial process covered in the same sequence as presented in this workbook.



Available from: **kjspublications.com.au**

Technology resources available from kjspublications.com.au

- providing resources that facilitate minimum work for teachers and maximum benefit for students



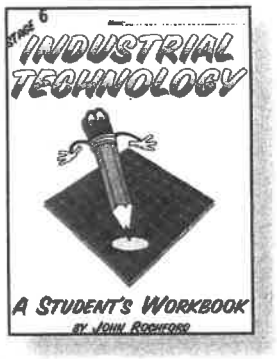
Technology for Years 7 & 8 - A Student's Workbook

ll the design-related, technology-related and orksheet/assignment content for 2 years is ovided in one inexpensive workbook. Why ep reinventing the wheel?



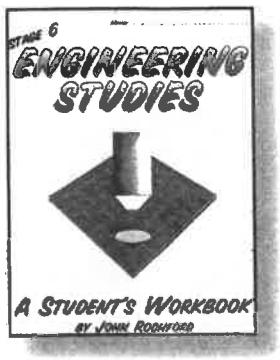
Stage 6 Design & Technology - A Student's Workbook

Students are provided with all the updated elements of the course so that they can gain confidence from private study of this subject.



Stage 6 Industrial Technology - A Student's Workbook

All updated elements of the course are covered so that students gain knowledge and confidence from private study.



Stage 6 Engineering Studies - A Student's Workbook

his Workbook provides all the up-)-date engineering mechanics and ngineering materials content for each iodule. Presentation is coherent and ser friendly.



Stage 6 Engineering Studies - History, Scope, Impacts for all Modules

This Workbook presents the syllabus requirements for the history, scope and impacts areas, for all modules, in user friendly language and presentation.



Stage 6 Engineering Studies Communication - A Student's Workbook

This Workbook aims to develop student skills in the nature and scope of engineering, engineering graphics and writing engineering reports.



Stage 6 Engineering Studies - Typical HSC Questions & Solutions

The purpose of this book is for students to practise typical HSC questions relevant to the 10 units in the Engineering Studies Workbook.

Stage 6 Engineering Studies DVDs & CD



VD #1 - Teacher's lesson esentations co-ordinating ith the Engineering tudies Workbook.



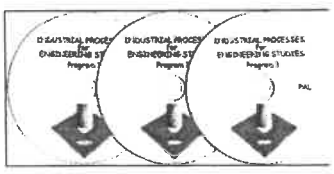
DVD #2 - Teacher's lesson presentations co-ordinating with the Engineering Studies Workbook - History, Scope, Impacts for all Modules.



DVD #3 - Demonstrates easier methods to solve engineering mechanics questions.

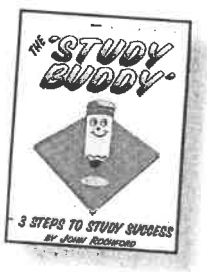


CD of solutions to all mechanics exercises in the Engineering Studies Workbook.



A 3 DVD set of short videos showing relevant engineering industrial processes.

he Study Buddy - 3 Steps to Study Success



he 'Study Buddy', written with the aid of year 12 students, is a user-friendly approach to help students learn and manage home study. is a simple guide that students find easy to understand and use.

or more information & previews, please visit: kjspublications.com.au