GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Section A

1. Simplify EACH of the following and rearrange to make x the subject of the expression:

   (a) $y = \frac{bx^3}{x^2} \times \frac{x^4}{4b}$ (4)

   (b) $y = \frac{x^2 \times z^3}{z^2} \div \frac{2x^5 \times z}{x^2}$ (4)

2. A lifeboat davit has a straight arm pivoting about P, at deck level as shown in Fig Q2. When launching the lifeboat, the davit arm, PD, makes an angle of 10° to the deck.

   Determine the required length of the davit arm so that there is a clearance of 0.8 m between the ships side and the lifeboat at launching. (6)

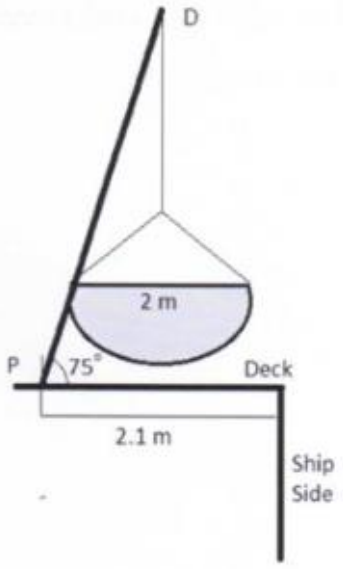


Fig Q2 (not to scale)

3. Determine the area of the shaded sector shown in Fig Q3 for the angles given. (9)

$$Angle\ a = \frac{\pi}{3}\ rads$$

$$Angle\ b = \frac{2\pi}{3}\ rads$$

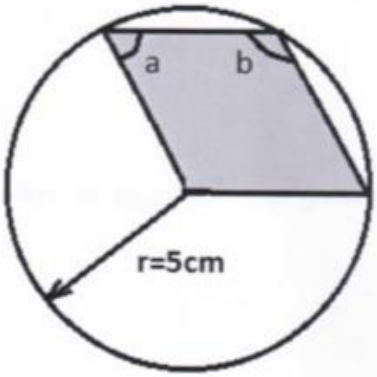


Fig Q3

4. (a) Plot the following (x,y) data on a graph: (4)

x	-2	-1	0	1	2	3
y	5.8	4.4	3	1.6	0.2	-1.2

(b) Determine an expression relating the x and y coordinates. (4)

(c) Determine the value of y when x = 1.5. (2)

5. A concrete beam is shown in Fig Q5.

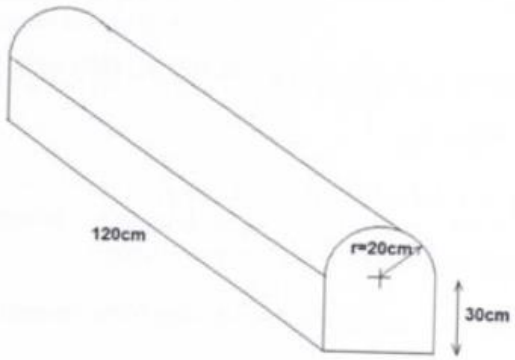


Fig Q5 (not to scale)

Determine EACH of the following:

(a) the volume of the beam; (4)

(b) the total surface area of the beam. (5)

6. Evaluate EACH of the following:

(a) $2\frac{6}{7} \div \left(3\frac{2}{3} + 2\frac{4}{5}\right)$ (4)

(b) $3\frac{1}{6} - \left(2\frac{2}{5} \times 1\frac{2}{3}\right)$ (4)

Section B

7. A turbine rotor has a diameter of 0.6 m and rotates at 400 rad/s.

Calculate EACH of the following:

(a) the linear velocity of a point on the rim in m/s; (3)

(b) the rotational speed of the turbine rotor in rev/min; (3)

(c) the number of radians turned when the turbine rotor rotates through 325°. (2)

8. A pump on the water main discharges through a pipe of 100 mm diameter against a head of 32 m at a constant velocity of 3.5 m/s. You can ignore the effects of friction in the pump and pipe-work.

Calculate EACH of the following:

(a) the power of the pump; (5)

(b) the motor power to drive the pump if the combined electrical and mechanical efficiency is 88%. (3)

Note: Density of seawater 1025 kg/m^3

9. A uniform beam with a mass of 800 kg is loaded as shown in Fig Q9.

Determine the reaction forces at the supports A and B. (10)

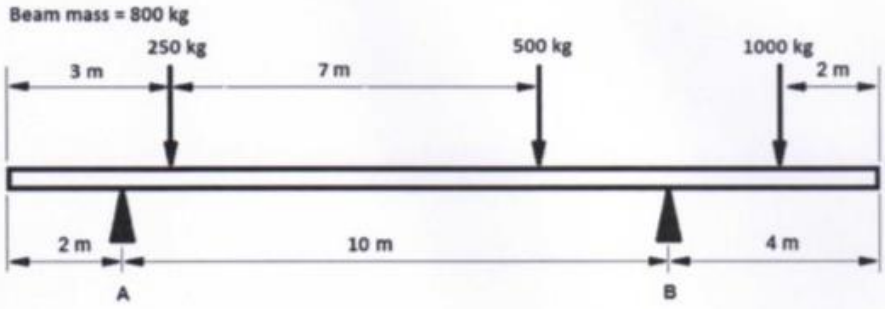


Fig Q9

10. A stationary block with a mass of 150 kg has a force applied to it which causes acceleration in an horizontal plane. The force of 1770 N is applied at an angle of 10° below the horizontal, pulling the block.

    Determine the acceleration of the block if the coefficient of friction is 0.2. (8)

11. In relation to the strength of materials, explain what is meant by EACH of the following terms:

    (a) Hooke's Law; (2)

    (b) Young's Modulus; (2)

    (c) stress; (2)

    (d) strain. (2)

12. A hoist has a pulley and axle with the following dimensions:

    Pulley diameter = 200 mm Axle diameter = 50 mm

    (a) Produce a simple dimensioned sketch of the lifting machine. (3)

    (b) Determine EACH of the following:

        (i) the movement ratio of the machine; (3)

        (ii) the efficiency of the machine if it requires an effort of 400 N to just lift a mass of 90 kg. (2)

Section A

1. Simplify EACH of the following and rearrange to make x the subject of the expression:

(a) $y = \frac{bx^3}{x^2} \times \frac{x^4}{4b}$ (4)

(b) $y = \frac{x^2 \times z^3}{z^2} \div \frac{2x^5 \times z}{x^2}$ (4)

a) $y = \frac{bx^3}{x^2} \times \frac{x^4}{4b} = \frac{bx^5}{4b}$

$y = \frac{x^5}{4}$

$\sqrt[5]{4y} = x$

b) $$y = \frac{x^2 z^3}{z^2} \times \frac{x^2}{2x^2 z}$$

$$y = \frac{z^3}{z^2 \; 2xz}$$

$$y = \frac{1}{2x}$$

$$2xy = 1$$

$$x = \frac{1}{2y}$$

2. A lifeboat davit has a straight arm pivoting about P, at deck level as shown in Fig Q2. When launching the lifeboat, the davit arm, PD, makes an angle of 10° to the deck.

Determine the required length of the davit arm so that there is a clearance of 0.8 m between the ships side and the lifeboat at launching. (6)

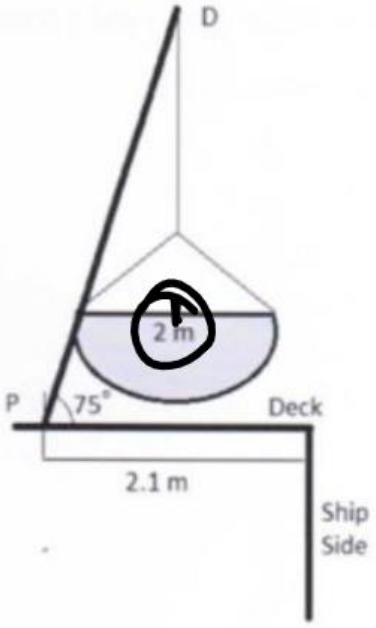
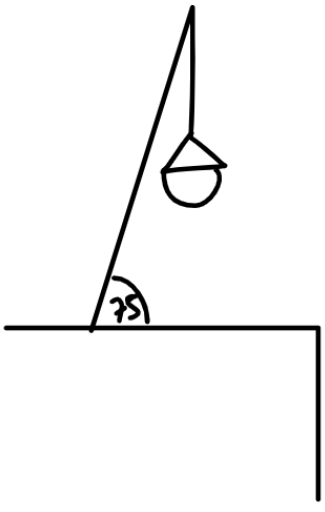
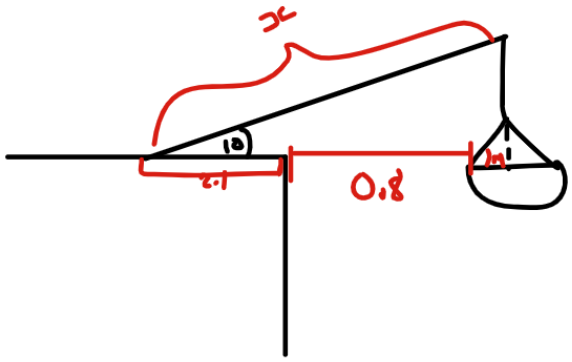
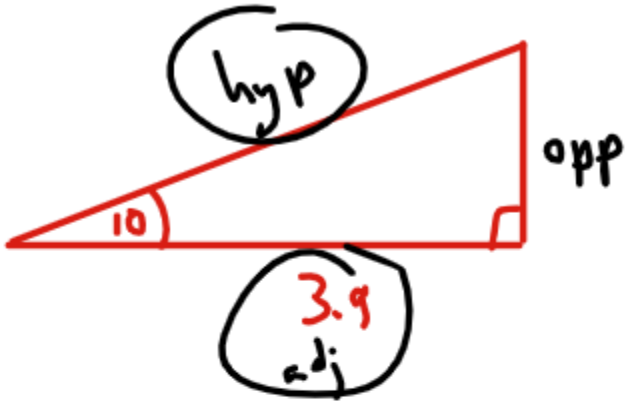


Fig Q2 (not to scale)







SOH
CAH
TOA

$$\cos 10 = \frac{3.9}{hyp}$$

$$hyp \cos 10 = 3.9$$

$$hyp = \frac{3.9}{\cos 10}$$

$$3.9601 \text{ m}$$

3. Determine the area of the shaded sector shown in Fig Q3 for the angles given. (9)

$$Angle\ a = \frac{\pi}{3}\ rads$$

$$Angle\ b = \frac{2\pi}{3}\ rads$$

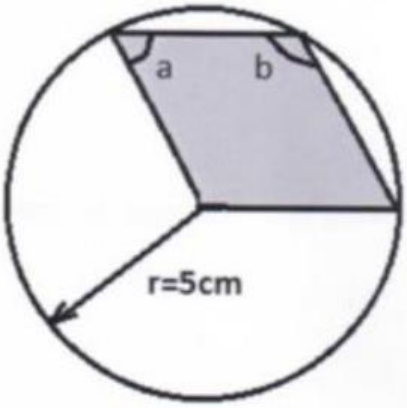
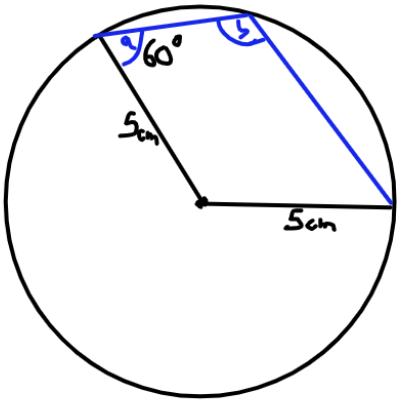


Fig Q3

$2\pi(\text{rads}) = 360(\text{degree})$

Rad → deg

$$\frac{x}{2\pi} \times 360$$



$a = \frac{\pi}{3}\ \text{radians} = 60°$

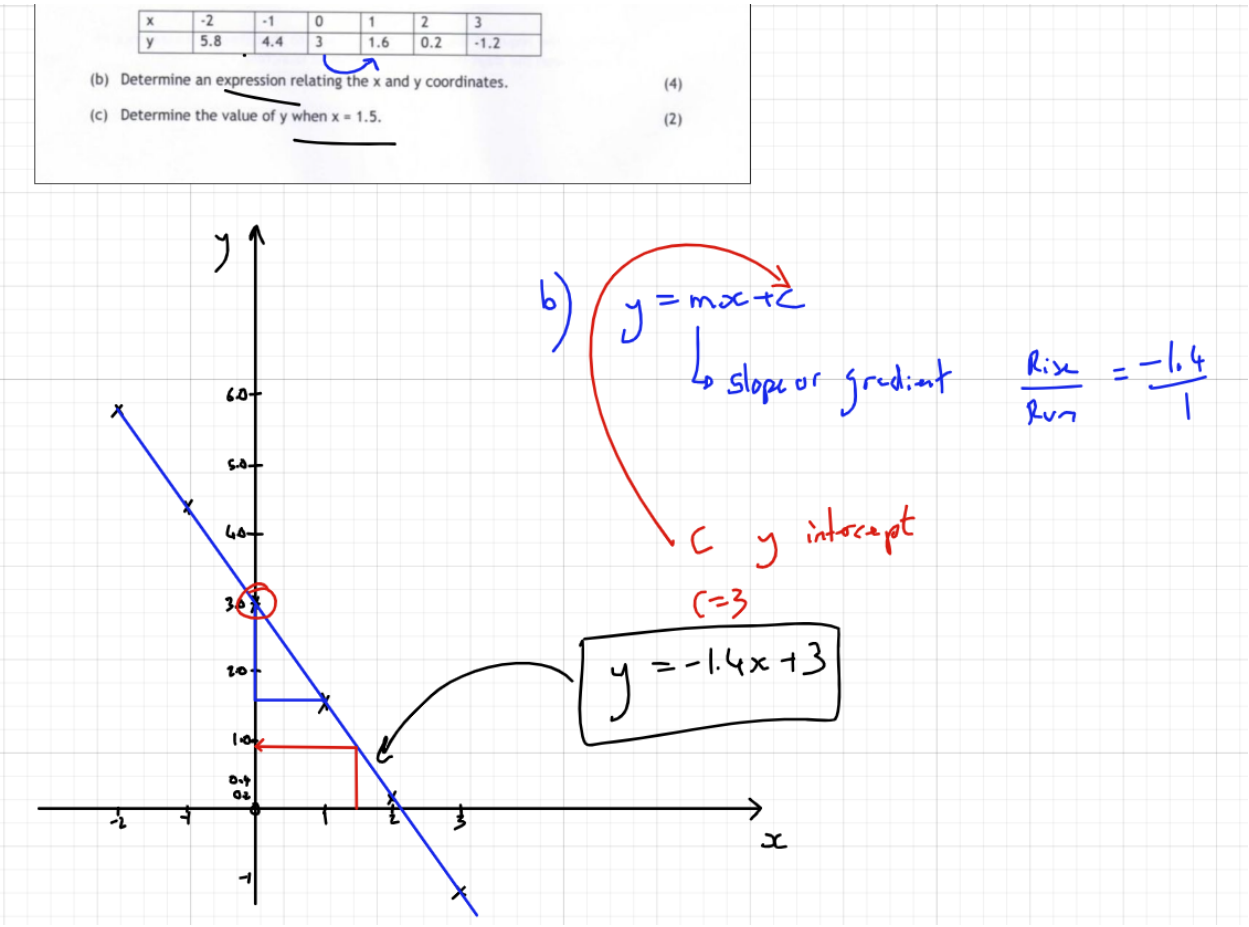
b $\frac{2\pi}{3}$ radians

$$\frac{\left(\frac{2\pi}{3}\right)}{2\pi} \times 360$$

x	-2	-1	0	1	2	3
y	5.8	4.4	3	1.6	0.2	-1.2

(b) Determine an expression relating the x and y coordinates. (4)

(c) Determine the value of y when x = 1.5. (2)



b) $y = mx + c$

↳ slope or gradient $\frac{\text{Rise}}{\text{Run}} = \frac{-1.4}{1}$

c y intercept

$c = 3$

$y = -1.4x + 3$

c) when $x = 1.5$

$y = -1.4(1.5) + 3$

5. A concrete beam is shown in Fig Q5.

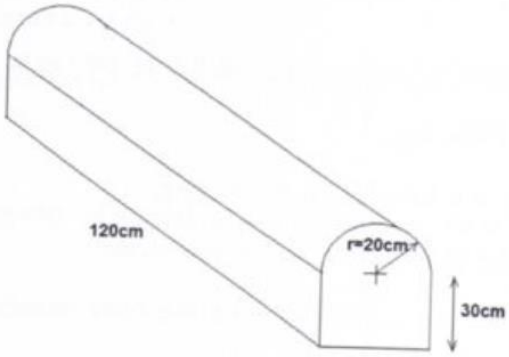
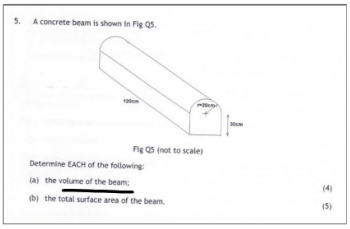


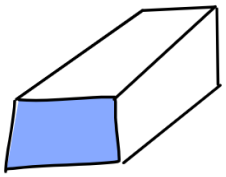
Fig Q5 (not to scale)

Determine EACH of the following:

(a) the volume of the beam; (4)

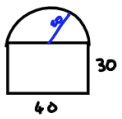
(b) the total surface area of the beam. (5)



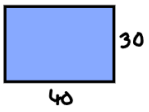


Volume

Cross section Area



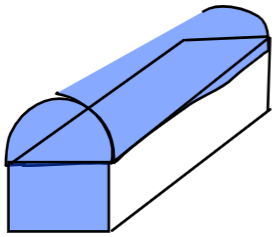
$\frac{\pi (20)^2}{2} = 200\pi \times 120 = 75398.22369 \text{ cm}^2$



$30 \times 40 \times 120 = 144000$

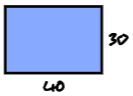
$V_{oil} = 219398 \text{ cm}^3$

Surface Area



Front + Back

$\frac{\pi r^2}{2} = \frac{\pi (20)^2}{2} = (628.3185307) \times 2 =$ **1256.637**



$L \times w = 30 \times 40 = 1200 \times 2 =$ **2400**

Left side + Right side

$2 \times (120 \times 30) = (3600) \times 2 =$ **7200**

bottom $40 \times 120 =$ **4800**

Curved Lid $\frac{\pi dh}{2} = \frac{\pi\, 40 \times 120}{2} =$ **7539.822**

Total surface area = **23196.4 cm^2**

6. Evaluate EACH of the following:

(a) $2\frac{6}{7} \div \left(3\frac{2}{3} + 2\frac{4}{5}\right)$ (4)

(b) $3\frac{1}{6} - \left(2\frac{2}{5} \times 1\frac{2}{3}\right)$ (4)

6.a) $\frac{20}{7} \div \left(\frac{11}{3} + \frac{14}{5} \right)$

$\frac{20}{7} \div \left(\frac{55}{15} + \frac{42}{15} \right)$

$\div \frac{97}{15}$

$\frac{20}{7} \times \frac{15}{97}$

$\frac{300}{679}$

b) $\frac{19}{6} - \left(\frac{12}{5} \times \frac{5}{3} \right)$

$3\frac{1}{6} - (4) = -\frac{5}{6}$

Section B

7. A turbine rotor has a diameter of 0.6 m and rotates at 400 rad/s.

Calculate EACH of the following:

(a) the linear velocity of a point on the rim in m/s; (3)

(b) the rotational speed of the turbine rotor in rev/min; (3)

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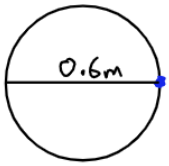
7.)



$$\text{Velocity} = \frac{\text{distance}}{\text{time}} = \frac{120}{1}$$

$$\text{distance} = \pi d = 0.6\pi = 1 \text{ Revolution}$$

$$\frac{400}{2\pi} = \text{Number of Revolutions per sec} = 63.66197724 \text{ Rev/s}$$

$$1 \text{ Rev} \times \text{Number of Revs}$$

$$0.6\pi \text{m} \times 63.66197724 = 120 \text{ m/s}$$

120m/s

b) $\frac{\text{Rev}}{\text{min}}$ $63.66197724 \times 60 = 3819.718634$ Rev/min

c) $\frac{325}{360} \times 2\pi = 5.672$ Rads

8. A pump on the water main discharges through a pipe of 100 mm diameter against a head of 32 m at a constant velocity of 3.5 m/s. You can ignore the effects of friction in the pump and pipe-work.

Calculate EACH of the following:

(a) the power of the pump; (5)

(b) the motor power to drive the pump if the combined electrical and mechanical efficiency is 88% (3)

Note: Density of seawater 1025 kg/m³

$$\text{Power} = \frac{\text{Work}}{\text{time}}$$

$$\text{Work} = F \times d$$

$$F = m \times 9.81$$

$$m = V \times \rho$$

$$V = \pi r^2 \times h$$

$$\text{Volume} = \pi(0.05)^2 \times 32 = 0.2513274123\ m^3$$

$$\text{mass} = 0.2513274123 \times 1025 = 257.61\ kg$$

$$F = 257.61 \times 9.81 = 2527.2\ N$$

$$\text{Work} = 2527.2 \times 3.5 = 8845.059$$

$$\text{Power} = \frac{8845.059}{1}\ \text{watt}$$

b)

$$8845 = 0.88x$$

$$\frac{8845}{0.88} = 10,051\ \text{watts}$$

9. A uniform beam with a mass of 800 kg is loaded as shown in Fig Q9.

Determine the reaction forces at the supports A and B. (10)

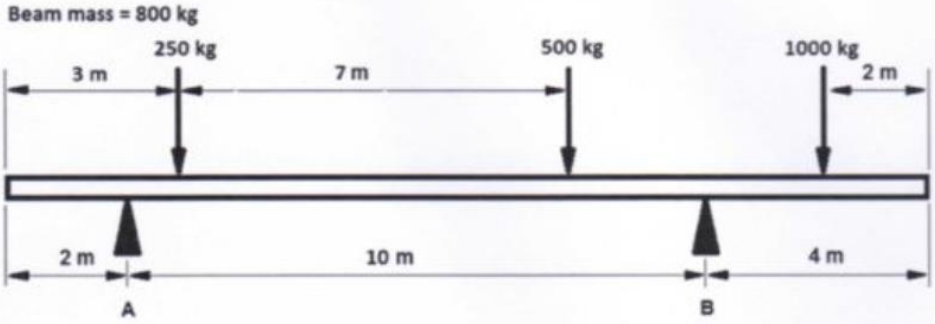
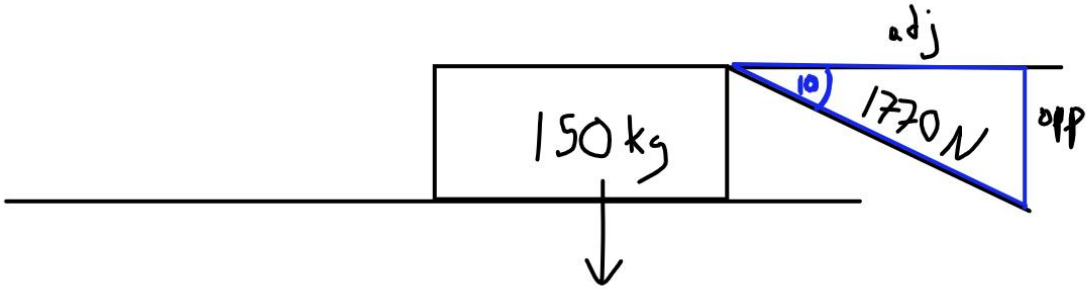


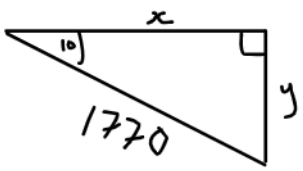
Fig Q9

10. A stationary block with a mass of 150 kg has a force applied to it which causes acceleration in an horizontal plane. The force of 1770 N is applied at an angle of 10° below the horizontal, pulling the block.

Determine the acceleration of the block if the coefficient of friction is 0.2. (8)



Horizontal Force



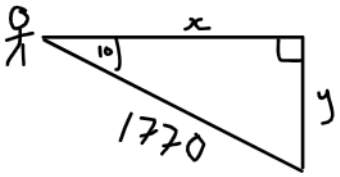
$\cos 10 = \frac{x}{1770}$

$1770 \cos 10 = x$

1743.10 N

SOH ✓✓
CAH
TOA

Vertical



$\sin 10 = \frac{y}{1770}$

$1770 \sin 10 = y$

307.357 N

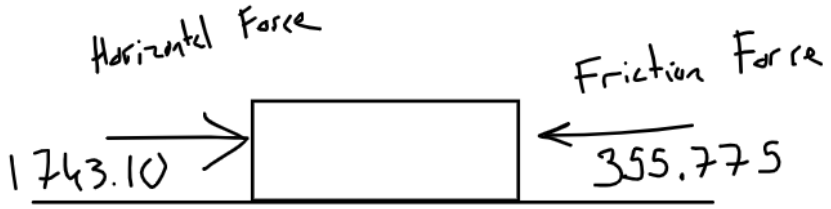
$+ 1471.5$

1778.875 N

Friction

Friction force = Vertical Force x Coefficient of Friction

$= 1778.875 \times 0.2 \quad = 355.775\ N$



$1743.10 - 355.775 = 1387.325\ N$

$F = ma$

$1387 = 150a$

$9.248\ m/s^2 = a$

11. In relation to the strength of materials, explain what is meant by EACH of the following terms:

(a) Hooke's Law; (2)

(b) Young's Modulus; (2)

(c) stress; (2)

(d) strain. (2)

a) $F = -K(x)$

hooks law is the direct proportion between the laod and extension of a material

b Youngs: $\frac{\text{stress}}{\text{Strain}}$

youngs modulus is the measure of elasticity

c) $\text{Stress} = \frac{\text{Force Applied}}{\text{Cross Sectional Area}}$

d) $\text{Strain} = \frac{\text{elongation}}{\text{origind length}}$

12. A hoist has a pulley and axle with the following dimensions:

Pulley diameter = 200 mm Axle diameter = 50 mm

(a) Produce a simple dimensioned sketch of the lifting machine. (3)

(b) Determine EACH of the following:

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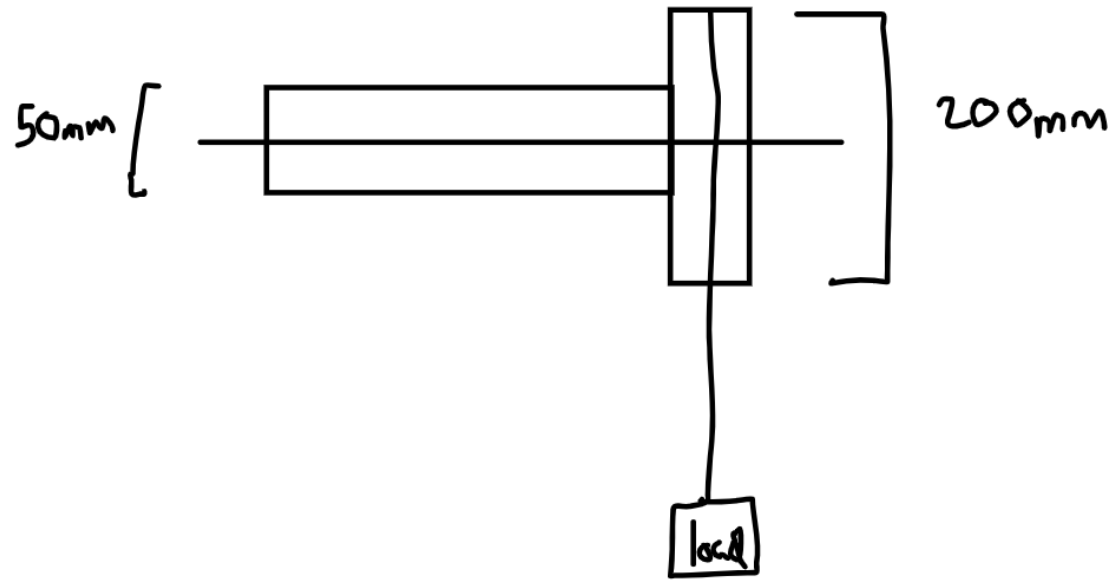
(ii) the efficiency of the machine if it requires an effort of 400 N to just lift a mass of 90 kg. (2)

12 a)



$$\text{Force Ratio} = \frac{\text{load Force}}{\text{Effort Force}} = \frac{90 \times 9.81}{400} = \frac{882.9}{400} = 2.20725 : 1$$

$$\text{Movement Ratio} = \frac{\text{Effort distance}}{\text{load distance}} = \frac{\cancel{\pi} d}{\cancel{\pi} d} = \frac{0.20}{0.05} = 4 : 1$$

$$E = \frac{F}{M} = \frac{2.20725}{4} \times 100 = 55.18\%$$