GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

Section A

(a) Simplify the following:

$$\left(\frac{2}{3}+\frac{1}{4}\right) \div 4 + \frac{3}{5}$$

(4)

(b) In a full class of students there should be 24 students. If three students are missing determine what percentage of students remain.

(4)

2. (a) Solve the following equation for x:

$$4(2x + 7) = 10 - x$$

(4)

(b) Three consecutive ODD numbers add up to a total of 87. Determine the Three numbers and show the algebraic method used to find them.

(4)

3. The equation for a straight line graph is given by the following expression:

$$y = mx + c$$

Where m is the slope of the graph and c is the intercept with the y axis:

(a) plot the points shown in Table Q3 using an appropriate scale and draw the best fit line;

(2)

(b) determine the values of *m* and *c* from your graph;

(3)

(c) state the law of the plotted straight line.

(3)

x	-2.00	0.00	2.00	4.00	6.00	8.00
y	-1.67	-1.00	-0.33	0.33	1.00	1.67

Table Q3

4. For the diagram shown in FIG Q4

Determine EACH of the following:

(a) the length of side x;   (3)

(b) the length of side y.   (5)
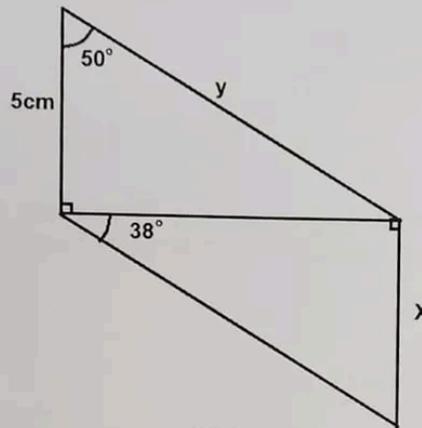
FIG Q4

5. FIG Q5 shows a quarter of a circle inscribed with two semi circles.

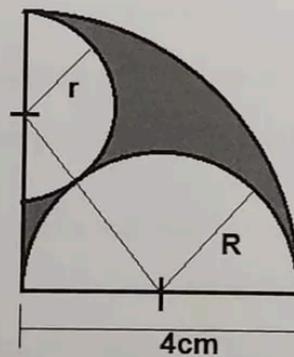Determine the area of the shaded remainder.   (10)

FIG Q5

6. The flow, Q, through a valve is given by:

$$Q = C \sqrt{\frac{P}{\rho}}$$

Where; C = British Standard flow coefficient, P = pressure drop across valve and ρ is the fluid density.

(a) rearrange the equation to make C the subject; (4)

(b) determine the value for C when P = 500,000 N/m² , ρ = 1025 kg/m³ and the flow rate is 0.005 m³/sec. (4)

Note: [n.b. units may be ignored]

Section B

7. Ignoring any effects of friction, the velocity of a 50 kg mass is uniformly increased from 1.5 m/s to 2.0 m/s in 5 seconds.

   (a) Calculate the accelerating force required. (2)

   (b) The mass is now uniformly retarded at 0.3 m/s² from 2.0 m/s until the mass just comes to rest.

   Determine, for the retardation period, EACH of the following:

   (i) the time taken to come to rest, (3)

   (ii) the distance travelled. (3)
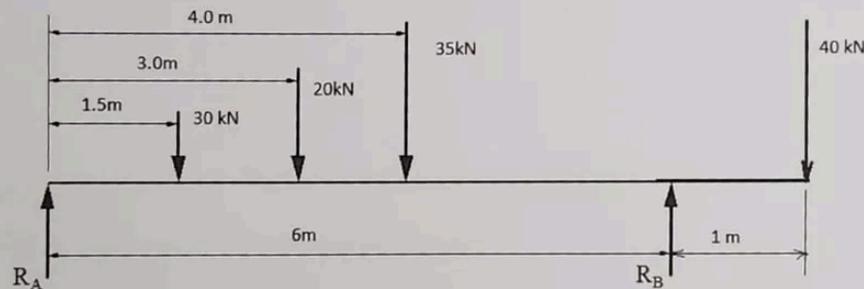
8. FIG Q8 shows a loaded uniform beam with a mass 800 kg

FIG Q8 (not to scale)

Determine EACH of the following:

(a) the reaction force, R$_A$; (5)

(b) the reaction force, R$_B$. (3)

9. A single drive wheel of a vehicle carries a load of 500 kg and has a tyre diameter of 600 mm. The contact surface with the road has a coefficient of friction of 0.55.

Determine EACH of the following:

(a) the limiting force that may be applied to the wheel without slippage; (4)

(b) maximum torque the transmission system may apply to the wheel without slippage. (4)

10. A lifeboat has a mass of 600 kg and is pulled alongside a distance of 90 m using a winch using a force of 150 N. It takes 1 minute and 20 seconds to complete this. Effects of friction can be ignored.

Determine EACH of the following:

(a) the acceleration of the lifeboat;   (2)

(b) the average speed;   (2)

(c) the work done;   (2)

(d) the power required.   (2)

Its

11. 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.   (2)

(b) Determine EACH of the following:

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

    (ii) the efficiency of the machine if it requires an effort of 310 N to just lift
          a mass of 75 kg.   (3)

12. A hydraulic ram has a working length of 1.4 m. It is to be made of steel with a yield strength of 560 MPa and a Modulus of Elasticity of 210 GPa. To avoid buckling the design requires a factor of safety of 4.5 for a working load 210 kN.

Determine EACH of the following:

(a) the maximum working stress;   (3)

(b) the minimum diameter of the rod;   (4)

(c) the direct strain in the rod.   (3)

(a) Simplify the following:

$$\left(\frac{2}{3}+\frac{1}{4}\right)\div 4+\frac{3}{5}$$ (4)

(b) In a full class of students there should be 24 students. If three students are missing determine what percentage of students remain.   (4)

a)

$$\left(\frac{4\times 2}{4\times 3} + \frac{1\times 3}{4\times 3}\right)\div 4 + \frac{3}{5}$$

$$\frac{8}{12} + \frac{3}{12}$$

$$\frac{11}{12} \div \frac{4}{1} + \frac{3}{5}$$ B od mas

          K FC

$$\frac{11}{12} \times \frac{1}{4}$$

$$\frac{5\times 11}{5\times 48} + \frac{3\times 48}{5\times 48}$$

$$\frac{55}{240} + \frac{144}{240} = \boxed{\frac{199}{240}}$$

(a) Simplify the following:

$$\left(\frac{2}{3}+\frac{1}{4}\right) \div 4 + \frac{3}{5}$$

(4)

(b) In a full class of students there should be 24 students. If three students are missing determine what percentage of students remain.

(4)

b) $24 - 3 = 21$

$$\frac{21}{24} \times 100 = 87.5\%.$$

(a) Solve the following equation for x:

$$4(2x + 7) = 10 - x$$

(4)

(b) Three consecutive ODD numbers add up to a total of 87. Determine the Three numbers and show the algebraic method used to find them.

(4)

a)

$$4(2x + 7) = 10 - x$$

$$8x + 28 = 10 - x$$

$$9x = -18$$

$$\boxed{x = -2}$$

a) Solve the following equation for x:

$$4(2x + 7) = 10 - x \qquad (4)$$

b) Three consecutive ODD numbers add up to a total of 87.   Determine the
Three numbers and show the algebraic method used to find them.   (4)

$$\left(2n - 1\right) + \left(2n + 1\right) + \left(2n + 3\right) = 87$$

$$6n + 3 = 87$$

$$6n = 84$$

$$n = 14$$

$$28 - 1$$

| 27 , | 29 , | 31 |

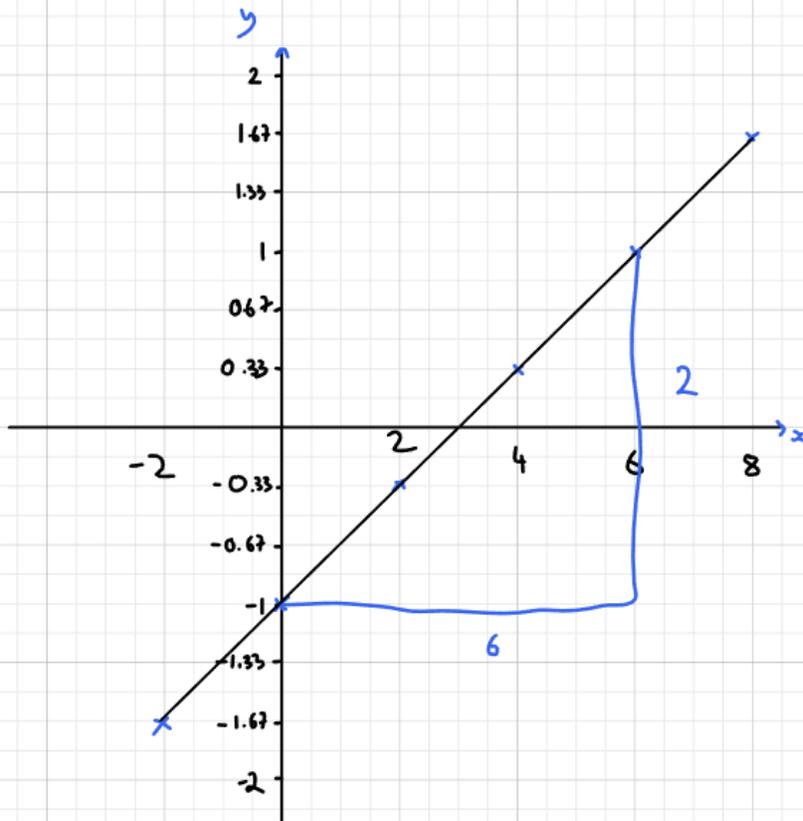3.   The equation for a straight line graph is given by the following expression:

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Where m is the slope of the graph and c is the intercept with the y axis:

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x	-2.00	0.00	2.00	4.00	6.00	8.00
y	-1.67	-1.00	-0.33	0.33	1.00	1.67

Table Q3

a)

b) $m = \dfrac{2}{6} = \dfrac{1}{3}$

$c = -1$

c) $y = \dfrac{1}{3} x - 1$

4. For the diagram shown in FIG Q4

Determine EACH of the following:

(a) the length of side x;   (3)
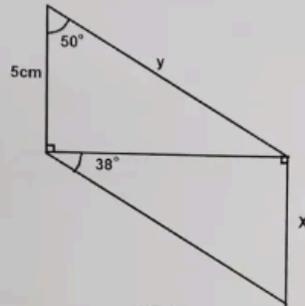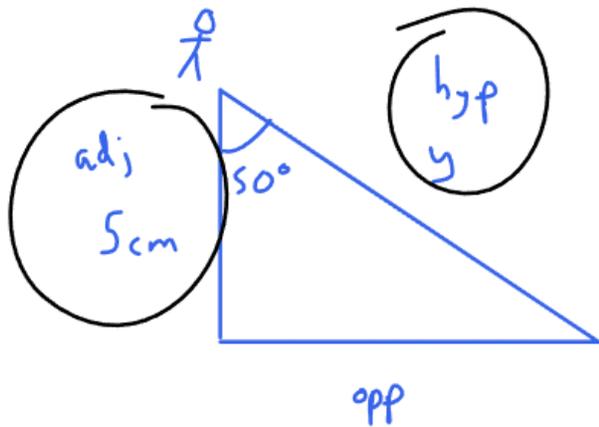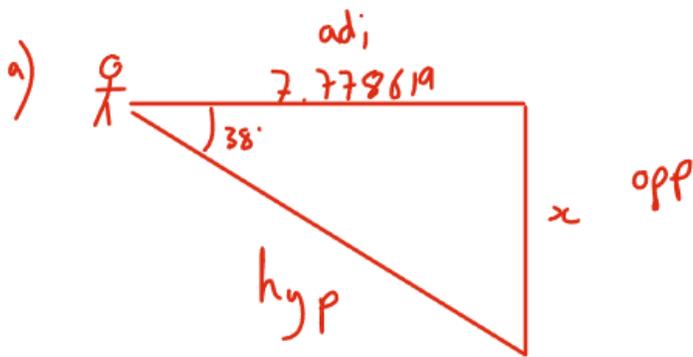
(b) the length of side y.   (5)

50°

5cm

y

38°

x

FIG Q4

SOH

CAH

TOA

$\cos \theta = \dfrac{A}{H}$

$\cos 50 = \dfrac{5}{y}$

$y = \dfrac{5}{\cos 50}$

b) $\boxed{7.778619 \text{ cm}}$

a)

adj
7.778619

38°

x   opp

hyp

SOH

CAH

TOA

$\tan \theta = \dfrac{opp}{Adj}$

$\tan 38 = \dfrac{x}{7.778619}$

$7.778619 \ \tan 38 = x$

$\boxed{x = 6.07732 \ cm}$

5.   FIG Q5 shows a quarter of a circle inscribed with two semi circles.

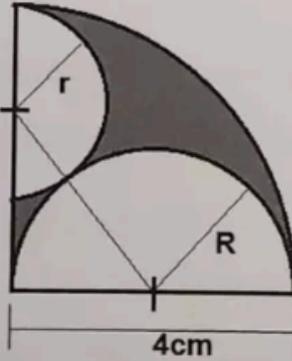Determine the area of the shaded remainder.   (10)

X

r

R

4cm

FIG Q5

4

r

r

R

2cm

4

r

r

4-r

R

2cm

r+2

4-r
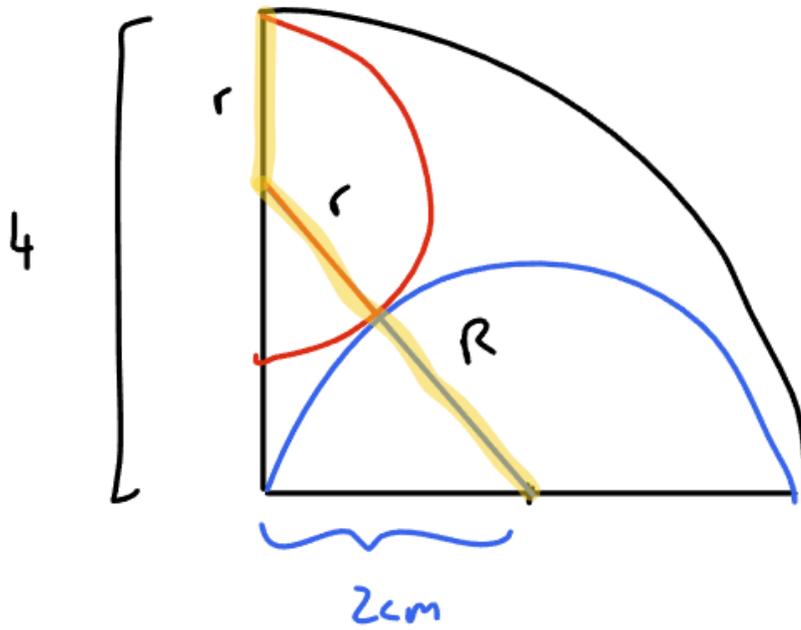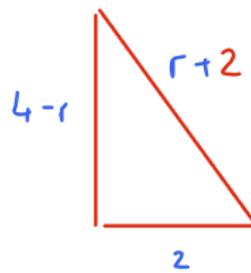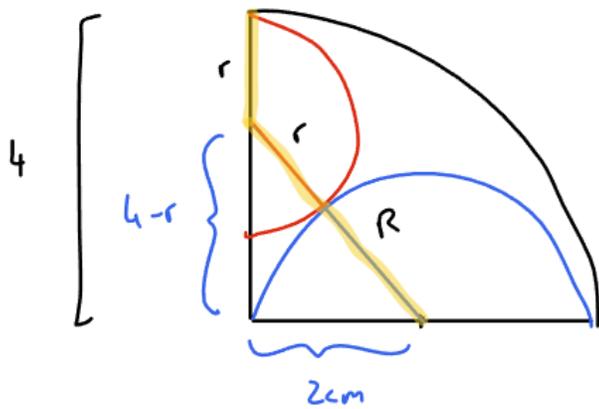
2

$$a^2 + b^2 = c^2$$

$$2^2 + (4-r)^2 = (r+2)^2$$

$$4 + (4-r)(4-r) = (r+2)(r+2)$$

$$4 + 16 - 4r - 4r + r^2 = r^2 + 2r + 2r + 4$$

$$\cancel{4} + 16 - 4r - 4r + \cancel{r^2} = \cancel{r^2} + 2r + 2r \cancel{+4}$$

$$16 - 8r = 4r$$

$$16 = 12r$$

$$4 = 3r$$

$$\frac{4}{3} = r$$

$$\text{Area} = \frac{\pi r^2}{2} = \frac{\pi \left(\frac{4}{3}\right)^2}{2}$$

$$= 2.792526 \text{ cm}^2$$

$$\text{Area} = \frac{\pi \, 2^2}{2} = 6.283185 \text{ cm}^2$$

$$\text{Area} = \frac{\pi \, 4^2}{4} = 12.56637 \text{ cm}^2$$

Shaded Area $= 12.56637 - 6.283185 - 2.792526$

$$= \boxed{3.49066 \text{ cm}^2}$$

6. The flow, Q, through a valve is given by:

$$Q = C \sqrt{\frac{P}{\rho}}$$

Where; C = British Standard flow coefficient, P = pressure drop across valve and ρ is the fluid density.

(a) rearrange the equation to make C the subject;   (4)

(b) determine the value for C when P = 500,000 N/m², ρ = 1025 kg/m³ and the flow rate is 0.005 m³/sec.   (4)

Note: [n.b. units may be ignored]

6) a) $$Q = C \sqrt{\frac{P}{\rho}}$$

one step........

$$\frac{Q}{\sqrt{\frac{P}{\rho}}} = C$$

b) $$\frac{0.005}{\sqrt{\frac{500,000}{1025}}} = C$$

7. Ignoring any effects of friction, the velocity of a 50 kg mass is uniformly increased from 1.5 m/s to 2.0 m/s in 5 seconds.

(a) Calculate the accelerating force required.   (2)

(b) The mass is now uniformly retarded at 0.3 m/s² from 2.0 m/s until the mass just comes to rest.

Determine, for the retardation period, EACH of the following:

(i) the time taken to come to rest,   (3)

(ii) the distance travelled.   (3)

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$s = \left(\frac{u+v}{2}\right)t$

a)

$s =$

$u = 1.5 \ m/s$

$v = 2 \ m/s$

$a = x$

$t = 5 \ sec$

$v = u + at$

$2 = 1.5 + 5x$

$0.5 = 5x$

$0.1 = x$

$0.1 \ m/s^2$

$F = ma$

$F = 50 \times 0.1$

$\boxed{5 \ N}$

b) i)   S

$u = 2$

$V = 0$

$a = -0.3$

$t = x$

$v = u + at$

$0 = 2 - 0.3x$

$0.3x = 2$

$x = \dfrac{2}{0.3}$

$x = \boxed{6.6667 \ sec}$

b ii) $S = x$

$u = 2$

$v = 0$

$a = -0.3$

$t = 6.6666 \ 7$

$S = \left(\dfrac{u+v}{2}\right)t$

$\left(\dfrac{2+0}{2}\right)6.6666$

$\boxed{S = 6.6667 \ m}$

W_1 W_2 W_3 W_4
30kN 20kN 35kN 40kN

8. FIG Q8 shows a loaded uniform beam with a mass 800 kg

FIG Q8 (not to scale)

Determine EACH of the following:

(a) the reaction force, R_A; (5)

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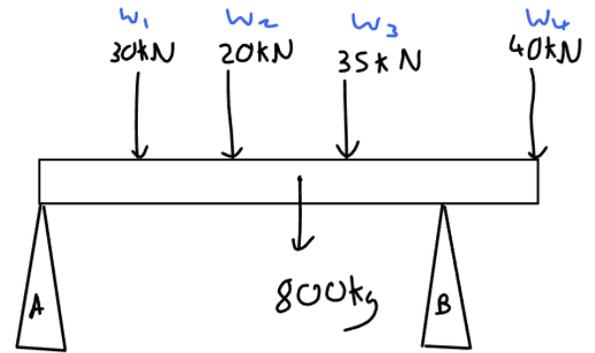
taking moments about A

Name	Mass (t)	Force (kN)	Distance (m)	Moment (kNm)	Direction AC/C
W_1		30	1.5	45	C
W_2		20	3	60	C
W_3		35	4	140	C
W_4		40	7	280	C
Beam	0.8	7.848	3.5	27.468	C
R_B		x	6	$6x$	A

sum of the clockwise moments = Sum of Anticlockwise moments

$$\left.\begin{matrix}45\\60\\140\\280\\27.468\end{matrix}\right\} = 6x$$

$$552.468 = 6x$$

$$\boxed{92.078 kN = R_B}$$

Sum of Downwards forces = Sum of Upwards forces

$$\left.\begin{matrix}30\\20\\35\\40\\7.848\end{matrix}\right\} = R_A + R_B$$

$$132.848 = R_A + 92.078$$

$$\boxed{40.77 kN = R_A}$$

9. A single drive wheel of a vehicle carries a load of 500 kg and has a tyre diameter of 600 mm. The contact surface with the road has a coefficient of friction of 0.55.

Determine EACH of the following:

(a) the limiting force that may be applied to the wheel without slippage;   (4)

(b) maximum torque the transmission system may apply to the wheel without slippage.   (4)

600mm

a)

500kg

0.3m
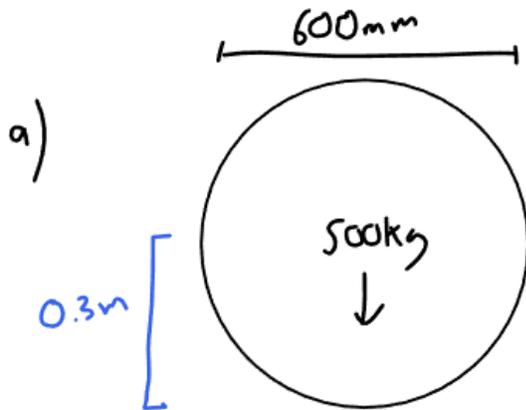
$$Friction = \mu \times N$$

$$= 0.55 \times 9.81 \times 500$$

$$= 2697.75 \ N$$

b)

$$Torque = F \times d$$

$$(moment) = 2697.75 \times 0.3$$

$$= 809.325 \ Nm$$

10. A lifeboat has a mass of 600 kg and is pulled alongside a distance of 90 m using a winch using a force of 150 N. It takes 1 minute and 20 seconds to complete this. Effects of friction can be ignored.

Determine EACH of the following:

(a) the acceleration of the lifeboat;   (2)

(b) the average speed;   (2)

(c) the work done;   (2)

(d) the power required.   (2)

a) $F = ma$

$150 = 600\,x$

$\dfrac{150}{600} = x$

$\boxed{0.25 \text{ m/s}^2}$

b) $Speed = \dfrac{dis}{time} = \dfrac{90 \text{ m}}{80 \text{ sec}} = 1.125 \text{ m/s}$

c) $Work = Force \times distance$

150×90

13500 Joules

d) $Power = \dfrac{Work}{time} = \dfrac{13500}{80} = 168.75 \text{ Watts}$

10. A lifeboat has a mass of 600 kg and is pulled alongside a distance of 90 m using a winch using a force of 150 N. It takes 1 minute and 20 seconds to complete this. Effects of friction can be ignored.

Determine EACH of the following:

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(c) the work done;   (2)

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we dont know the starting speed, does it start from rest? We know it has a force of 150N applied, but if there is no friction, then the lifeboat will continue to accelerate for 80 seconds...

$S = 90$
$u =$
$v =$
$a = 0.25$
$t = 80 \text{ sec}$

$v = u$

$S = u + \frac{1}{2}at^2$

$90 = u + 0.5(0.25) \, 80^2$

$90 = u + 800$

$-710 = u$

so we can see that the initial velocity is 710 m/s away from us, we multiply by 3.6 to get Km/hour

$710 \times 3.6 = 2556 \quad kmph$

this question has a typo, the effects of friction cannot be ignored, otherwise the lifeboat is supersonic

lets assume the life boat goes from rest

$S = 90$
$u = 0$
$v =$
$a = 0.25$
$t = 80 \text{ sec}$

$v = u + at$

$0 + 0.25 \times 80$

$v = 20 \, m/s$

$\downarrow \times 3.6$

$72 \, kmph$

but then we get a contradiction on the distance:

$S = \left(\frac{u+v}{2}\right)t$

$\left(\frac{0+20}{2}\right) \, 80$

$10 \times 80 = \underline{\underline{800 \, m}}$

10. A lifeboat has a mass of 600 kg and is pulled alongside a distance of 90 m using a winch using a force of 150 N. It takes 1 minute and 20 seconds to complete this. Effects of friction can be ignored.

Determine EACH of the following:

(a) the acceleration of the lifeboat;   (2)

(b) the average speed;   (2)

(c) the work done;   (2)

(d) the power required.   (2)

friction cannot be ignored, it doesnt say the lifeboat
starts from rest, so lets assume that the lifeboat is
already moving, so the acceleration is zero

a)   accel = 0

b)   speed = $\dfrac{dis}{tim}$ = $\dfrac{90}{80}$ = 1.125 m/s

          $\} \times 3.6$

          4.05 kmph (better!)

c)   Work = F $\times$ d

          150 $\times$ 90

          13500 Joules

d)   P = $\dfrac{work}{time}$ = $\dfrac{13500}{80}$ = 168.75 Watts

Conclusion: typo on the question, effects of
friction CANNOT be ignored
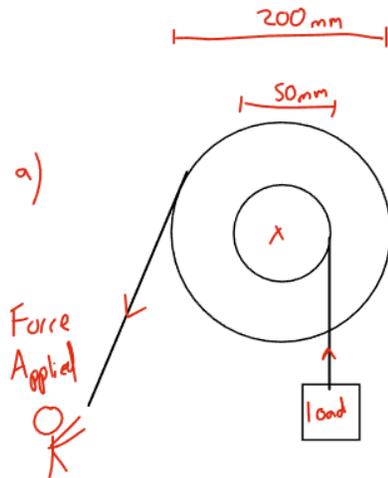
200 mm

50mm

a)

Force
Applied

load

1. 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.   (2)

(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 310 N to just lift
     a mass of 75 kg.   (3)

b) i) $\text{movement Ratio} = \dfrac{\text{Dist 1 move}}{\text{Dist load moves}} = \dfrac{\not\pi\, D}{\not\pi\, d} = \dfrac{200}{50} = \boxed{4}$
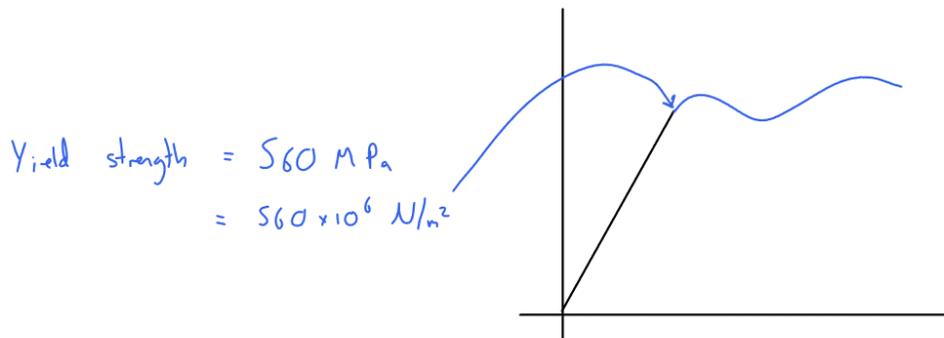
ii) $\text{Force Ratio} = \dfrac{\text{Force Req to lift}}{\text{Force 1 Apply}} = \dfrac{75 \times 9.81}{310} = \dfrac{735.75}{310} = 2.37338$

$Eff = \dfrac{F}{M} = \dfrac{2.37338}{4} \times 100 = \boxed{59.335\,\%}$

12. A hydraulic ram has a working length of 1.4 m. It is to be made of steel with a yield strength of 560 MPa and a Modulus of Elasticity of 210 GPa. To avoid buckling the design requires a factor of safety of 4.5 for a working load 210 kN.

Determine EACH of the following:

(a) the maximum working stress;   (3)

(b) the minimum diameter of the rod;   (4)

(c) the direct strain in the rod.   (3)

1.4m

Yield strength = 560 MPa

$= 560 \times 10^6 \ N/m^2$

a)   Yield   =   Factor   ×   Max working
         Stress   of   Stress
                            safety

$560 \times 10^6 = 4.5 \times Max$

$\dfrac{560 \times 10^6}{4.5} = Max$

$124.444 \times 10^6 \ N/m^2 = Max \ working \ stress$

b) $stress = \dfrac{F}{A}$

$A = \dfrac{F}{stress} = \dfrac{210,000}{124.444 \times 10^6}$

$A = 1.6875 \times 10^{-3} = \pi R^2$

$\sqrt{\dfrac{1.6875 \times 10^{-3}}{\pi}} = R$

$0.023176 \ m = R$

$\boxed{0.0463529 \ m \quad = dia}$

c) $Elas = \dfrac{stress}{strain}$

$strain = \dfrac{stress}{Elas} = \dfrac{124.444 \times 10^6}{210 \times 10^9}$

$= \boxed{5.9259 \times 10^{-4}}$