WINTER – 14 EXAMINATIONS

Subject Code: 17204 **Model Answer** **Total Pages: 38**

Important Instruction to Examiners:-

1) The answers should be examined by key words & not as word to word as given in the model answers scheme.

2) The model answers & answers written by the candidate may vary but the examiner may try to access the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance.

4) While assessing figures, examiners, may give credit for principle components indicated in the figure.

The figures drawn by candidate & model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credit may be given step wise for numerical problems. In some cases, the assumed contact values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding.

7) For programming language papers, credit may be given to any other programme based on equivalent concept.

Important notes to examiners

Examiner should consider following points while assessing the Answers.

1) In Q-2(c) Two equal and unlike parallel forces (couple) are given therefore resultant is zero and position of resultant cannot found out.

2) In Q-3(a) Angle of Forces is written as with five X-axis, but it should be positive x-axis

3) In Q-3(c) Two forces 100N and 300N are given, student can consider any force P and Q. therefore two directions of resultant is calculated.

4) In Q-5(d) The statement of the problem is not correct, therefore the problem is solved by considering (case-I) single body and (case-II) two body together and pull is found out

5) In Q-6(c) Given lamina is symmetrical about both the axis, therefore two solutions are given examiner should consider any one for giving proportionate marks

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Q.NO	SOLUTION	MARKS
1		
a)	**output of Machine.**	
	"It is defined as the amount of workdone by the load, by using simple lifting machine." OR	1M
	"It is the product of Load and Distance moved by the load, by using simple lifting machine."	
	output = W x x where. ∴ W = Load ∴ x = Dist. moved by load	1M
(b)	The force which is applied, so as to overcome the resistance or to lift the load is called as effort.	1M
	S.I. unit → Newton (N) or KiloNewton (KN)	1M
(c)	**Self locking Machine:-** A Machine which is not capable of doing work in reverse direction even on removal of effort, then the machine is called as self-locking or Non-reversible Machine.	1M
	condition for self locking Machine:- ∴ efficiency < 50 %. ∴ η% < 50%	1M

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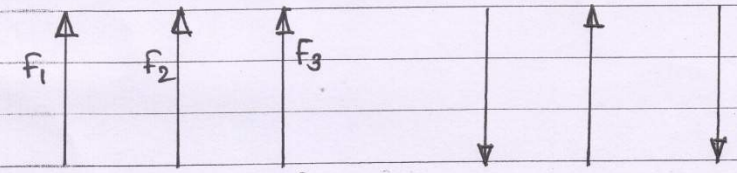
Q.NO	SOLUTION	MARKS
1 (d)	**Rigid body** :- The body which does not undergo any change in its dimension or shape, even after application force is called as rigid body. **OR** A body is said to be rigid, if the relative positions of any two particles in it do not change under the action of the forces.	2M OR 2M
(e)	 like Parallel forces. unlike Parallel forces.	1 M for (each force system)
(f)	**Statics** :- It is the branch of Mechanics which deals with the action and effect of forces acting on rigid body at rest.	1M
	Dynamics:- It is the branch of Mechanics, which deals with action and effect of forces acting on rigid body in motion	1M.
(g)	use of vector diagram in graphic statics.:-	

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Q.NO	SOLUTION	MARKS
1 (g) cont.	The magnitude and direction of Resultant is found out by using vector diagram	2M.
(h)	Graphical conditions of eqns for Parallel forces. (i) Force polygon or vector diagram must be a closed figure. (i.e In Parallel forces starting point and end point of the vector diagram is same only one point) (ii) Funicular Polygon or link Polygon must be closed figure.	1 M (each)
(i)	free body diagram :- when all actions and reactions of surrounding bodies are shown on a separated body independently, then the resulting diagram is called free body diagram. OR when Number of bodies are in contact with each other, then if we separate the body from other bodies then it is called free body. * If all actions and reactions, & self weight of body are shown on a separated body then the diagram is called free body diagram.	2M OR 2M.

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Q.NO	SOLUTION	MARKS
1 (j)	**cone of friction** :- It is an imaginary cone generated by revolving resultant reaction about the normal reaction, when body is in limiting equilibrium condition.	2M
	OR	OR
	when body placed on horizontal surface is in limiting equilibrium by a horizontal force P, then the resultant reaction makes an angle ϕ with Normal reaction.	2M.
	If we gradually change the angle of force P through 360°, then imaginary cone is generated as resultant reaction revolves around Normal reaction. This imaginary cone is called cone of friction	
(k)	**Coefficient of friction** :- The ratio of limiting force of friction and Normal reaction is constant called as coefficient of friction.	2M
(l)	$\therefore$ V.R. $= \frac{D}{d} \times \frac{T_1}{T_2}$ (for single Purchase crab)	1M
	$\therefore$ D = diameter of effort wheel $\therefore$ d = diameter of load drum. $\therefore T_1$ = No of teeth on spur or main gear $\therefore T_2$ = No of teeth on pinion	1M (for meaning of Term)

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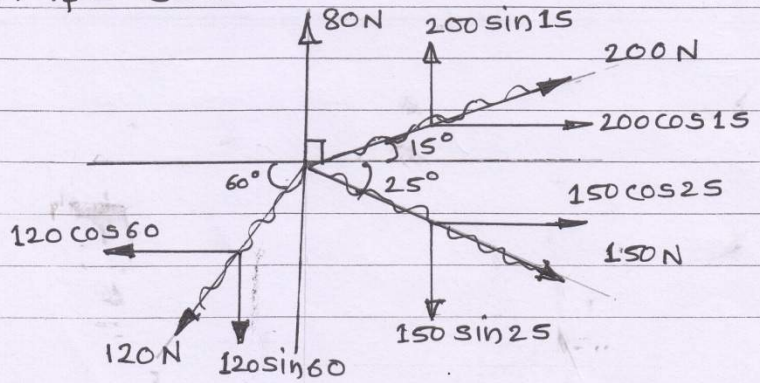
Q .NO	SOLUTION	MARKS
2 (a)	* Given Data * Law of M/C $P = \frac{1}{20} W$ $W = 1 KN = 1000 N$ V.R. = 40. $P = ?$, $\eta\% = ?$ $P_f = ?$	
	(i) Effort required to lift load ($W = 1 KN$). $\therefore P = \frac{1}{20} W$ $\therefore P = \frac{1}{20} \times 1000$ $\therefore P = 50 N$	1M
	(ii) Mechanical Advantage $M.A = \frac{W}{P} = \frac{1000}{50} = 20$	1M
	(iii) Efficiency ($\eta\%$). $\eta = \frac{M.A.}{V.R.} \times 100 = \frac{20}{40} \times 100 = 50\%$	1M
	(iv) Effort Lost in friction (P_f) $\therefore P_f = P - \frac{W}{V.R.}$ $\therefore P_f = 50 - \frac{1000}{40}$ $\therefore P_f = 25 N$	1M.
(b)		$\frac{1}{2}$ M

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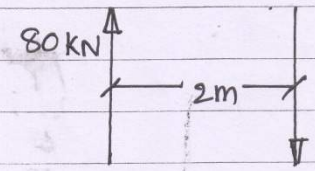
Q .NO	SOLUTION	MARKS
2 (b) cont.d	(i) Resolution and composition of forces	
	$\therefore \Sigma fx = 200\cos 15 + 80\cos 90 - 120\cos 60 + 150\cos 25$	
	$\therefore \Sigma fx = 269.131$ N	1M
	$\therefore \Sigma Fy = 200\sin 15 + 80\sin 90 - 120\sin 60 - 150\sin 25$	
	$\therefore \Sigma Fy = -35.552$ N	1M
	(ii) Magnitude of Resultant (R)	
	$\therefore R = \sqrt{(\Sigma fx)^2 + (\Sigma fy)^2}$	
	$\therefore R = \sqrt{(269.131)^2 + (-35.552)^2}$	
	$\therefore R = 271.469$ N	1M
	(iii) Direction of Resultant (θ)	
	$\therefore \tan\theta = \frac{\Sigma fy}{\Sigma fx}$	
	$\therefore \theta = \tan^{-1}\left(\frac{\Sigma fy}{\Sigma fx}\right)$	
	$\therefore \theta = \tan^{-1}\left(\frac{35.552}{269.131}\right)$	
	$\therefore \theta = 7.525^\circ$	$\frac{1M}{2}$
(c)		



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Q.NO	* Problem is based on couple, examiner consider the same.	MARKS
2 (c) cont.d..	(i) Magnitude of Resultant (R)	
	$\therefore R = 80 - 80$	
	$\therefore R = 0$	2 M
	(ii) Position of Resultant. (x)	
	As the value of unlike Parallel forces is equal. ie Problem based on couple is asked.	
	$\therefore$ As resultant is zero, Position of Resultant cannot be found.	1 M
	(iii) Name the force system.	
	The given force system is unlike Parallel force system.	1 M
(d)	Given data.	
	$\therefore$ Dia of wheel (D) = 20 cm.	
	$\therefore$ dia. of bigger axle (d_1) = 8 cm.	
	$\therefore$ dia of smaller axle (d_2) = 7 cm.	
	$\therefore$ effort (P) = 200 N	
	$\eta\% = 80\%$	
	(i) Velocity Ratio (V.R.) $W = ?$	
	$\therefore V.R. = \frac{2D}{d_1 - d_2}$	1 M

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Q .NO	SOLUTION	MARKS
2 (d)	$\therefore V.R. = \frac{2 \times 20}{8-7} = 40$	1M
Contd....	(ii) efficiency ($\eta\%$)	
	$\therefore \eta = \frac{M.A.}{V.R.} \times 100$	
	$\therefore \eta = \frac{W}{P \times V.R.} \times 100$	1M
	$\therefore 80 = \frac{W}{200 \times 40} \times 100$	
	$\therefore W = 6400\ N$	1M
(e)	* Given data.*	
	$\therefore$ Pitch = p = 4 mm.	
	$\therefore L = 140\ cm = 1400\ mm.$	
	$\therefore W = 80\ KN = 80000\ N$	
	$\therefore P = 500\ N$	
	(i) Mechanical Advantage	
	$\therefore M.A. = \frac{W}{P} = \frac{80000}{500} = 160.$	1M
	(ii) Velocity Ratio (V.R.)	
	$\therefore V.R. = \frac{2\pi L}{pitch} = \frac{2\pi \times 1400}{4} = 2199.115.$	1M
	(iii) Efficiency ($\eta\%$)	
	$\therefore \eta = \frac{M.A.}{V.R.} \times 100$	
	$\therefore \eta = \frac{160}{2199.115} \times 100 = 7.276\%$	1M

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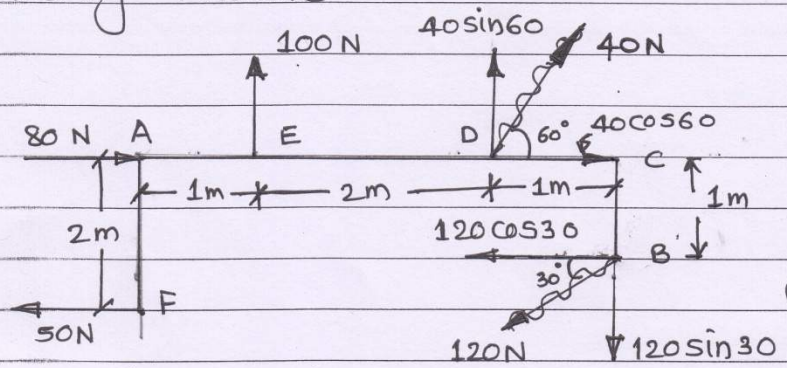
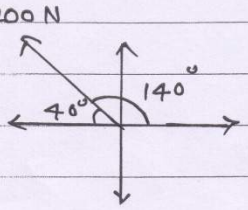
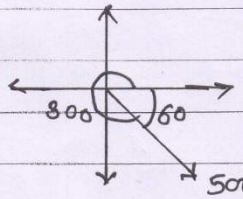
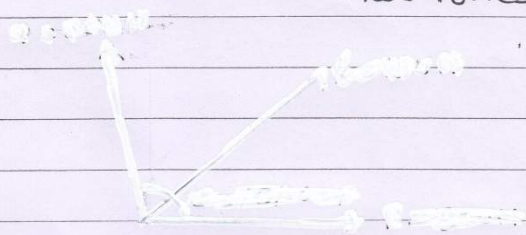
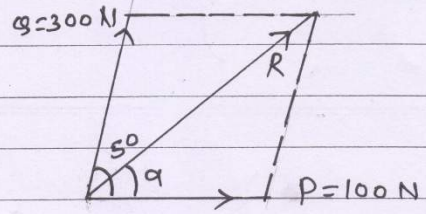
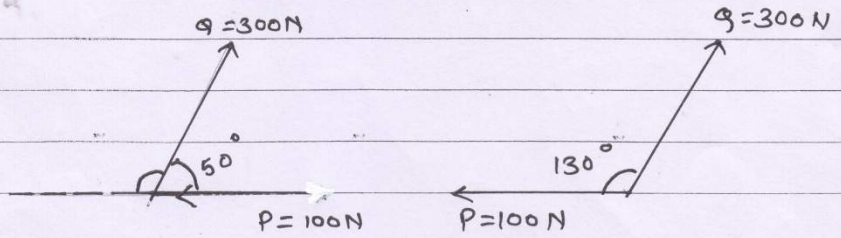
Q .NO	SOLUTION	MARKS
2 (e) cont^{d}	(iv) Type of Machine	
	As $\eta\% < 50\%$.	
	The machine is Non-reversible or self locking machine	1M.
(f)		1M (for sketch)
	(i) Moment induced at 'A'.	
	$\therefore M_A = 50\times2 + 80\times0 - 100\times1 - 40\sin60\times3 + 40\cos60\times0 + 120\cos30\times1 + 120\sin30\times4$	$1\frac{1}{2}$M
	$\therefore M_A = 240$ KN-m.	
	(ii) Moment induced at 'B'.	
	$\therefore M_B = 50\times1 + 80\times1 + 100\times3 + 40\sin60\times1 + 40\cos60\times1$	$1\frac{1}{2}$M
	$\therefore M_B = 484.641$ N-m.	

Q.NO	SOLUTION	MARKS
*	In this Problem, angle with five x-axis is written but it should be with +ve x axis.	
Q.3.	Attempt any four of the following.	
a)	(1) 200 N force at 140° with +ve x-axis	
	 $F_X = -200 \cos 40$ $\boxed{F_X = -153.208\ N}$	1 M
	$F_Y = 200 \sin 40$ $\boxed{F_Y = 128.557\ N}$	1 M
	(ii) 500 N force 300° with +ve x-axis	
	 $F_X = 500 \cos 60$ $\boxed{F_X = 250\ N}$	1M
	$F_Y = -500 \sin 60$ $\boxed{F_Y = -433.01\ N}$	1M
b)	Given, $P = Q = 300\ N$ $R = 150\ N$ By using law of parallelogram of forces, $R^2 = P^2 + Q^2 + 2PQ\cos\theta$	1M
	$(150)^2 = (300)^2 + (300)^2 + 2(300)(300)\cos\theta$	

Q.NO	SOLUTION	MARKS
Q.3 b) cont.....	$22500 = (180\times10^3) + (180\times10^3)\cos\theta$	
	$22500 - (180\times10^3) = (180\times10^3)\cos\theta$	
	$-157500 = (180\times10^3)\cos\theta$	
	$\therefore \cos\theta = -0.875$	1 M
	$\therefore \theta = \cos^{-1}(-0.875)$	
	$\boxed{\theta = 151.044}$ ---Angle bet? two forces	2 M
		
c)	Given, - (1) Both have same sense,	
	$P = 100\,N$, $Q = 300\,N$	
	$\theta = 50^\circ$	
		
	$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$	
	$= \sqrt{(100)^2 + (300)^2 + 2(100)(300)\cos(50)}$	

Q.NO	SOLUTION	MARKS
9.3 c)	$R = 372.246\ N$	1 M
cont.....	Magnitude of Resultant (R) = 372.246 N	
	Let, α be the direction of resultant (R) with the force P = 100 N.	
	$\therefore \alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$	
	$= \tan^{-1}\left(\frac{300\sin 50}{100+300\cos 50}\right)$	
	$= \tan^{-1}(0.784)$	
	$\alpha = 38.12^\circ$ ---- direction of 'R'	1 M
	(ii) forces have different sense,	
		
	$\theta = 180 - 50 = 130^\circ$	
	By using law of parallelogram of forces, we get,	
	$R = \sqrt{P^2+Q^2+2PQ\cos\theta}$	
	$= \sqrt{(100)^2+(300)^2+2(100)(300)\cos 130}$	

Q .NO	SOLUTION	MARKS
Q.3 c)	$= \sqrt{(100\times10^3)+(-38.567\times10^3)}$	
contd.....		
	$\boxed{R = 247.856\,N}$ ---- magnitude of Resultant	1M
	∴ Let, α - be the direction of resultant (R) with the force P = 100 kN	
	$\therefore \alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$	
	$= \tan^{-1}\left(\frac{300\sin130}{100+300\cos130}\right)$	
	$= \tan^{-1}(-2.475)$	
	$\boxed{\alpha = -68^\circ}$ ---- direction of R.	1M
	OR Alternate values of α for Resultant force for both cases. (case II)	
	case (I) If P = 300 N and Q = 100 N Then value of α	
	$\alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$	$\alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$
	$= \tan^{-1}\left(\frac{100\sin50}{300+100\cos50}\right)$	$= \tan^{-1}\left(\frac{100\sin130}{300+100\cos130}\right)$
	$\boxed{\alpha = 11.87^\circ}$	$= \tan^{-1}(0.325)$
		$\boxed{\alpha = 18^\circ}$

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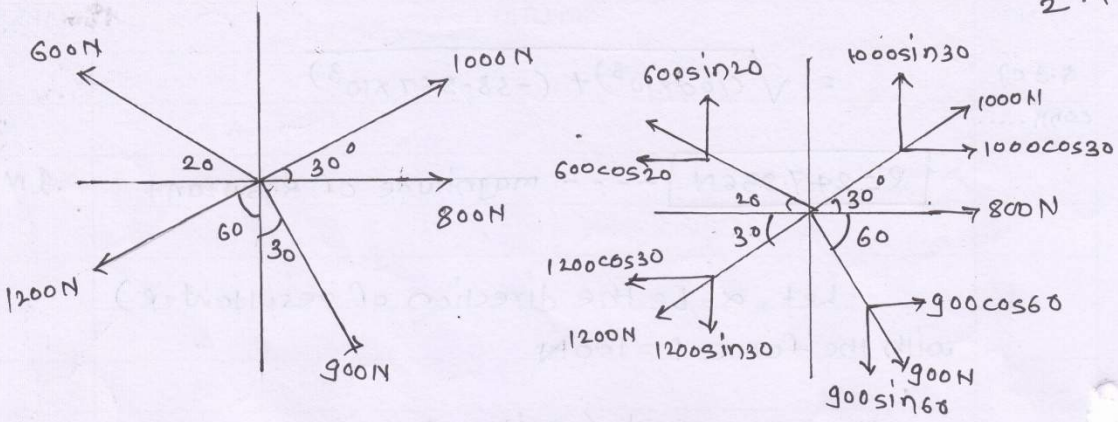
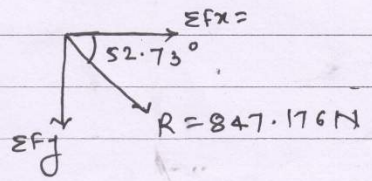
Q3 (d)

$\frac{1}{2}$ M



Q.NO	SOLUTION	MARKS
Q.3d) contd.....	1) Resolving the forces horizontally,	
	$\Sigma Fx = 800 + 1000\cos30 - 600\cos20 - 1200\cos30 + 900\cos60$	
	$= 512.979$ N	1M
	2) Resolving the forces vertically,	
	$\Sigma Fy = 1000\sin30 + 600\sin20 - 1200\sin30 - 900\sin60$	
	$= -674.211$ N	1M
	3) Resultant:	
	$R = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2}$	
	$= \sqrt{(512.979)^2 + (-674.211)^2}$	
	$R = 847.176$ N	1M
	3) direction:	
	$\theta = \tan^{-1}\left(\frac{\Sigma Fy}{\Sigma Fx}\right)$	
	$= \tan^{-1}\left(\frac{-674.211}{512.979}\right) = \tan^{-1}(-1.314)$	$\frac{1}{2}$M
	$\theta = -52.73^\circ$	



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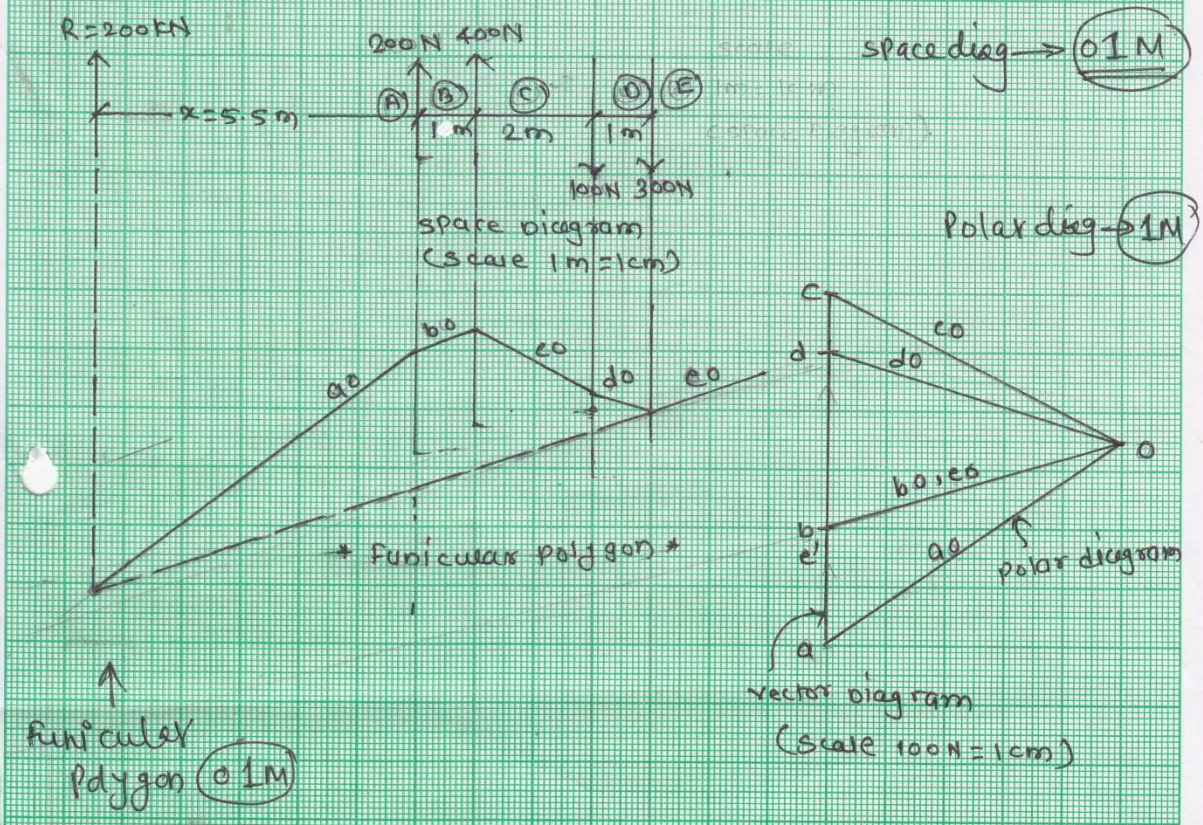
Q.3 e]



space diag → 01 M

Polar diag → 1M

Funicular Polygon 01M

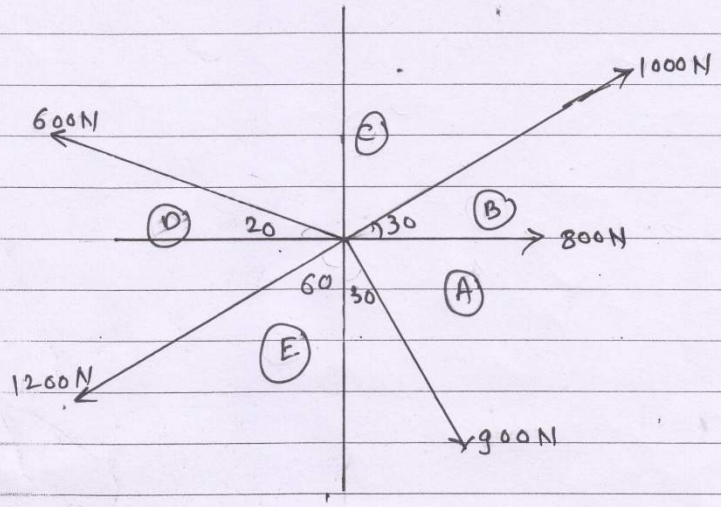
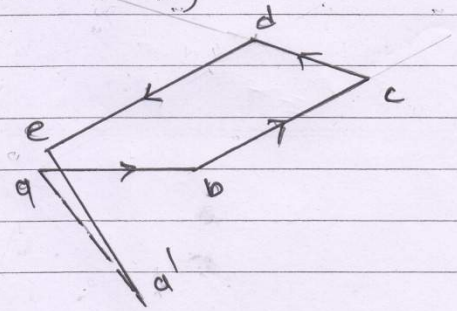
Resultant (R) = l (ae) x scale

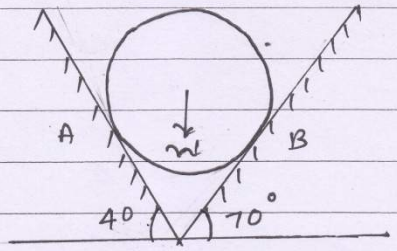
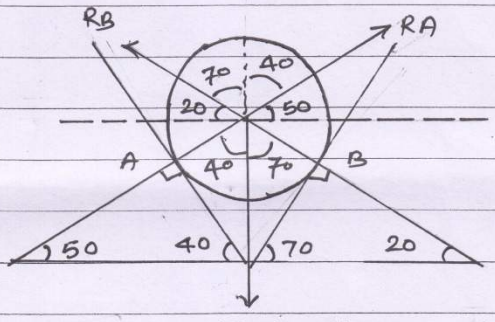
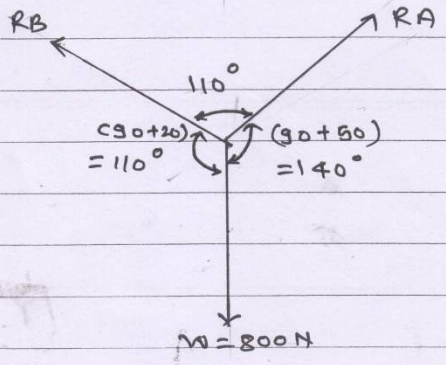
= 2 x 100 → $\frac{1}{2}$ M

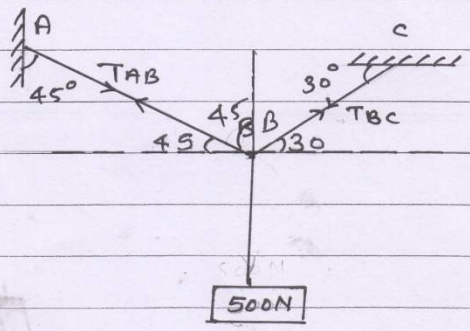
= 200kN

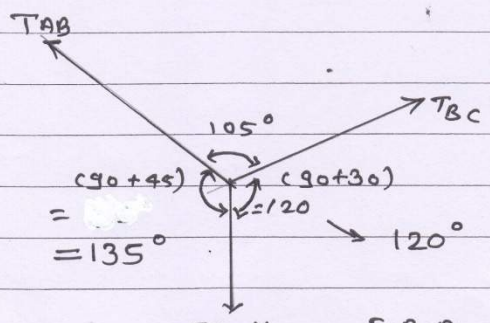
$x = 5.5 \times 1 = 5.5$ m.

Position (x) = 5.5 m → $\frac{1}{2}$ M

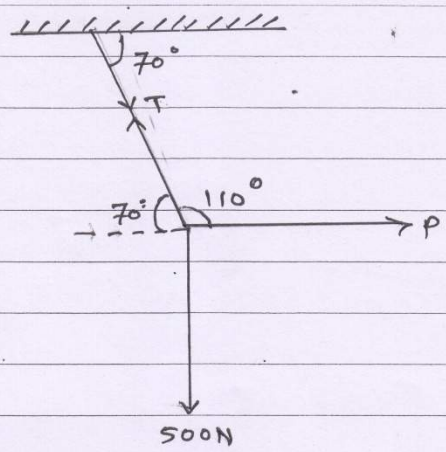
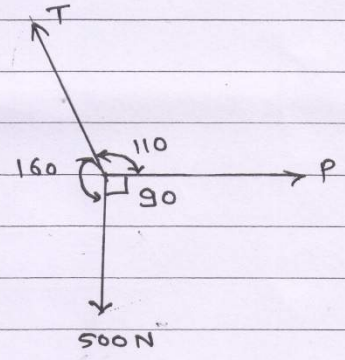
Q.NO	SOLUTION	MARKS
3 f)		
		1M
	space diagram 1cm = 300 N	
	vector diagram (scale 1cm = 300 N)	
		2M
	$R = l(aa') \times scale = 2.824 \times 300$	
	$R = 847.2\,N$	1M

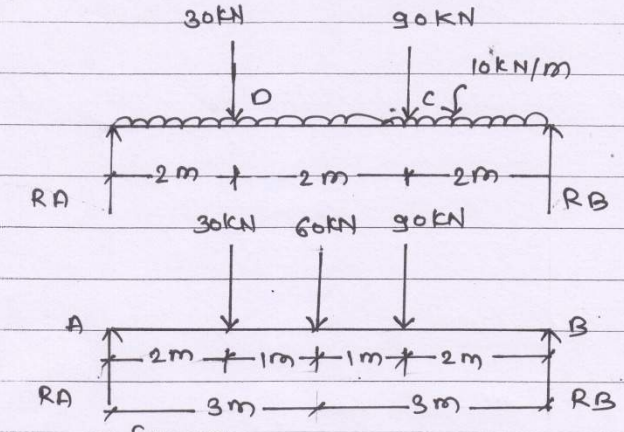
Q .NO	SOLUTION	MARKS
Q.4.	Attempt any four of the following :	
a)		
		
	W = 800 N	
	F.B.D. :-	
		1M

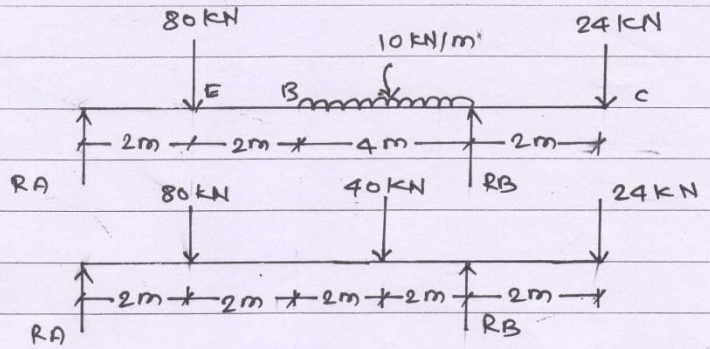
Q NO	SOLUTION	MARKS
Q.4 a) conti.....	Applying Lami's theorem	
	$\frac{RA}{\sin 110} = \frac{RB}{\sin 140} = \frac{800}{\sin 110}$	$\frac{1}{2}$ M
	$\therefore \frac{RA}{\sin 110} = \frac{800}{\sin 110}$	
	$\therefore RA = \frac{800}{\sin 110} \times \sin 110$	
	$RA = 800N$	1 M
	$\frac{RB}{\sin 140} = \frac{800}{\sin 110}$	$\frac{1}{2}$ M
	$RB = \frac{800}{\sin 110} \times \sin 140$	
	$RB = 547.232N$	1 M
Q.4 b]		

Q.NO	SOLUTION	MARKS
Q.4 b) cont.....	 F.B.D.	1M
	Applying Lami's theorem, $\frac{T_{AB}}{\sin 120} = \frac{T_{BC}}{\sin 135} = \frac{500}{\sin 105}$	
	$\frac{T_{AB}}{\sin 120} = \frac{500}{\sin 105}$	
	$T_{AB} = \frac{500 \sin 120}{\sin 105}$	
	$\boxed{T_{AB} = 448.287\ N}$	1M
	$\frac{T_{BC}}{\sin 135} = \frac{500}{\sin 105}$	
	$T_{BC} = \frac{500}{\sin 105} \times \sin 135$	
	$\boxed{T_{BC} = 366.025\ N}$	1M
	The tension developed in part AB is 448.28 N but an axial tensile strength of cable is 400 N hence, it can not maintain the equilibrium of the assembly.	1M

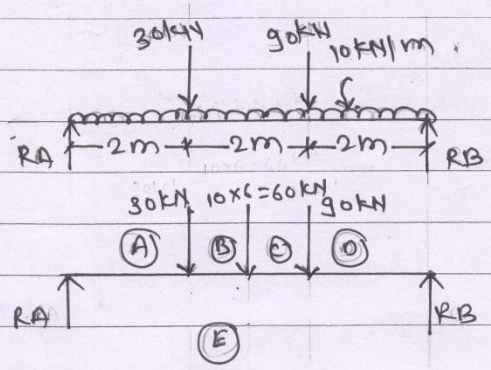
(cc)

Q .NO	SOLUTION	MARKS
4 c)		½ M
	F.B.D. 	1 M / 2
	Applying Lami's theorem, $\frac{T}{\sin 90} = \frac{P}{\sin 160} = \frac{500}{\sin 110}$	1 M
	$T = \frac{500}{\sin 110} \times \sin 90 = 532.088\ N$	1 M
	$P = \frac{500}{\sin 110} \times \sin 160 = 181.985\ N$	1 M

Q .NO	SOLUTION	MARKS
4 d)		
	$\therefore \Sigma fy = 0$ →	$\frac{1}{2}$ M (for condition of eqn.)
	i) $\Sigma F_y = RA - 30 - 60 - 90 + RB = 0$	
	$\Sigma F_y = RA - 180 + RB$	
	Applying the condition of equilibrium, we get,	
	$\Sigma F_y = 0$	
	$\therefore RA + RB = 180$ KN — (1)	1M
	ii) Taking moment about point A, $\therefore \Sigma M_A = 0$. →	$\frac{1}{2}$ M
	$\Sigma MA = (30 \times 2) + (60 \times 3) + (90 \times 4) - (RB \times 6) = 0$	
	Applying condition of equilibrium.,	
	$60 + 180 + 360 = 6RB$	
	$600 = 6RB$	
	$\boxed{RB = 100KN}$	1 M
	substitute RB in eq? (1), we get	
	$RA + 100 = 180$	
	$\therefore \boxed{RA = 80 KN}$	1M

Q .NO	SOLUTION	MARKS
4 e)		
	$\Sigma f_y = 0$	$\frac{1}{2}$ M
	1) $\Sigma F_y = R_A - 80 - 40 + R_B - 24$	
	$\Sigma F_y = R_A - 144 + R_B$	
	Applying condition of equilibrium,	
	$\Sigma F_y = 0$	
	$R_A - 144 + R_B = 0$	
	$\therefore R_A + R_B = 144$ ——— (i)	1M
	ii) Taking moment about point A, $\Sigma M_A = 0$	$\frac{1}{2}$ M
	$\Sigma M_A = (80 \times 2) + (40 \times 6) - (R_B \times 8) + (24 \times 10)$	
	$\Sigma M_A = 160 + 240 - 8R_B + 240$	
	Applying condition of equilibrium,	
	$\Sigma M_A = 0$	
	$640 - 8R_B = 0$	
	$640 = 8R_B$	
	$\boxed{R_B = 80 \text{ KN}}$ ——— Ans	1 M
	substitude 'RB' in equation (i), we get	
	$R_A = 144 - 80$	
	$\boxed{R_A = 64 \text{ KN}}$ ——— Ans	01M

Q.NO	SOLUTION	MARKS
4 A)		

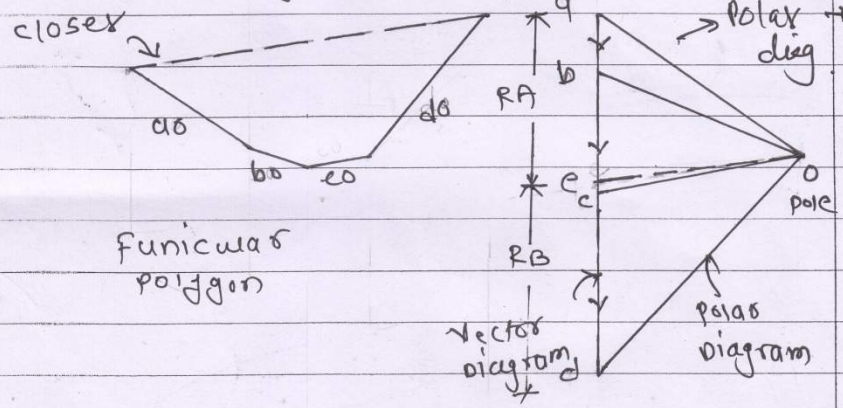


→ Space diag – 1M

funicular polygon → 1M

Polar diag → 1M

Space diagram (scale 1 cm = 1 m)



scale (1cm = 30kN)

RA = l (ea) × scale

= 2.70 × 30

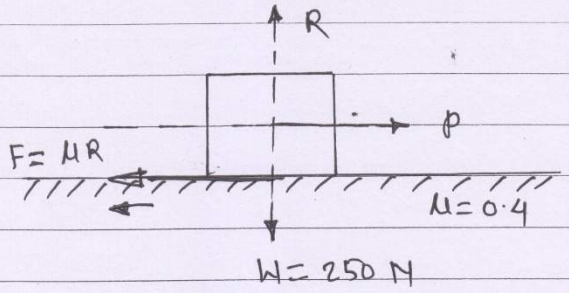
RA = 81 kN = 81 KN → ½ M

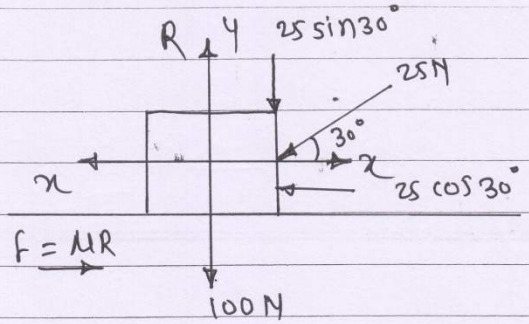
RB = l (de) × scale

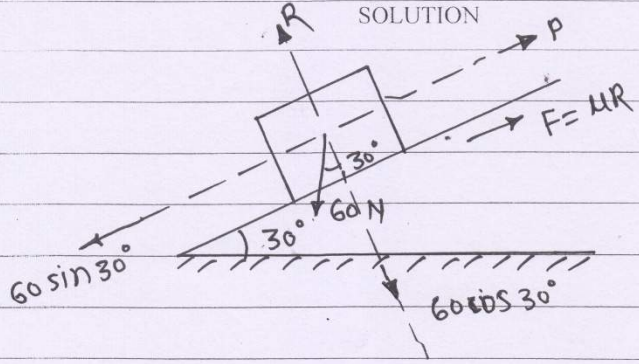
= 3.30 × 30

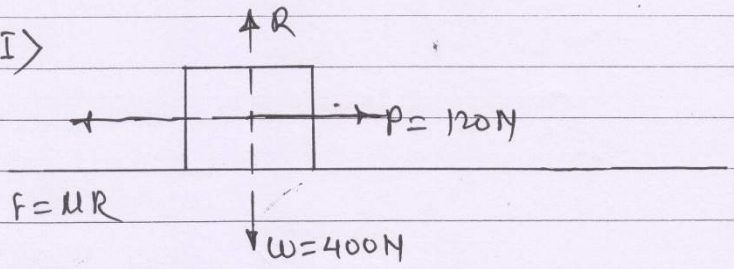
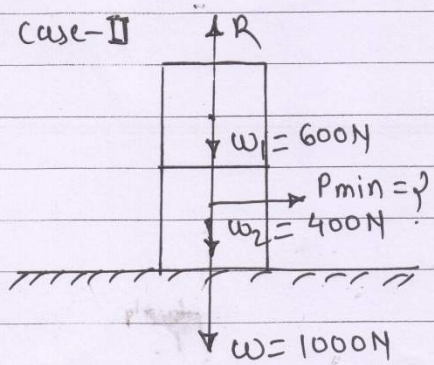
RB = 99 kN = 100 KN → ½ M

1 (g)

Q .NO	SOLUTION	MARKS
Q-5 (a)		
	i> $\Sigma F_y = 0$ Normal reaction $R - 250 = 0$ $\boxed{R = 250\,N}$	1M
	ii> $\Sigma F_x = 0$ force of friction $P - F = 0$ $\therefore P - \mu R = 0$ $P - 0.4 \times 250 = 0$ $\boxed{P = 100\,N}$ $\therefore$ $\boxed{F = 100\,N}$	1M
	iii> Angle of friction $\mu = \tan\phi$ $\therefore \tan^{-1}(\mu) = \phi$ $\therefore \phi = \tan^{-1}(0.4)$ $\boxed{\phi = 21.80^\circ}$	1M
	iv) Resultant reaction $S = \sqrt{R^2 + F^2} = \sqrt{(250)^2 + (100)^2}$ $\boxed{S = 269.258\,N}$	1M

Q.NO	SOLUTION	MARKS
Q-5 (b)		1M
	i> Coeff. of friction & angle of repose $\Sigma F_y = 0$ $R - 100 - 25\sin 30^\circ = 0$ $R - 112.5 = 0$ $\boxed{R = 112.5\ N}$	1M
	$\Sigma F_x = 0$ $-P + F = 0$ $-25\cos 30 + \mu R = 0$ $\mu R = 25\cos 30^\circ$ $\mu = \frac{25\cos 30^\circ}{112.5}$ $\boxed{\mu = 0.192}$	1M
	ii> $\mu = \tan\alpha$ $\alpha = \tan^{-1}(\mu)$ $\alpha = \tan^{-1}(0.192)$ $\boxed{\alpha = 10.86^\circ}$	1M

Q .NO	SOLUTION	MARKS
Q-5 (c)		1 M
	i> $\Sigma F_y = 0$ $R - 60\cos 30° = 0$ $R = 60\cos 30°$ $\boxed{R = 51.96\ N}$	$\frac{1}{2}$ M 1 M
	ii> $\Sigma F_x = 0$ $P + F - 60\sin 30° = 0$ $P + \mu R - 60\sin 30° = 0$ $P + 0.12 \times 51.96 - 60\sin 30° = 0$ $P + 6.2353 - 30 = 0$ $P - 23.76 = 0$ $\boxed{P = 23.76\ N}$ prevent from block sliding.	$\frac{1}{2}$ M 1 M

Q.NO	SOLUTION	MARKS
Q-5(d)	case-I> 	
	i> $\Sigma F_y = 0$ $R - 400 = 0$ $\boxed{R = 400\ N}$	1M
	$\Sigma F_x = 0$ $120 - \mu R = 0$ $120 = \mu R$ $\therefore \mu = \frac{120}{R} = \frac{120}{400} = 0.3$ $\boxed{\mu = 0.3}$	1M
	case-II 	
	$\Sigma F_y = 0$ $R - 1000 = 0$ $\therefore \boxed{R = 1000\ N}$	1M
	$\Sigma F_x = 0$ $P_{min} - \mu R = 0$ $P_{min} = \mu R$ $= 0.3 \times 1000$ $\boxed{P_{min} = 300\ N}$	1M

Q .NO	SOLUTION	MARKS
Q-5 (e)	effort (P) = 100N & W = 1KN = 1000N effort (P) = 150 N & W = 2KN = 2000N	
	i> Law of machine $P = mW + C$ $100 = m \times 1000 + C$ $100 = m \times 1000 + C$ — (1) $150 = m \times 2000 + C$ — (2) Multiplying eqn (1) by 2 $\therefore 1000m + C = 100 \times 2$ $2000m + C = 150$ $\therefore$ substracting eqn (2) from eqn (1) $2000m + 2C = 200$ — (1) $-2000m + C = -150$ — (2) $\boxed{C = 50}$ N put in eqn (2)	1M
	$150 = m \times 2000 + 50$ $150 - 50 = 2000m$ $100 = 2000m$ $\boxed{m = 0.05}$	1M
	ii> Law of machine $P = (0.05W + 50)$ N	1M

Q.NO	SOLUTION	MARKS
	iii) Max. M.A $= \frac{1}{m}$	
	$= \frac{1}{0.05}$.	
	Max. M.A = 20	$\frac{1}{2}$ M
	iv) Max. $\eta = \frac{\text{Max. M.A}}{\text{V.R}} \times 100 = \frac{20}{20} \times 100$	
	Max. η = 100 %.	$\frac{1}{2}$ M
Q-5 (F)	given	
	i) Diameter of effort wheel = 60 cm	
	ii) load drum diameter = 30 cm	
	iii) no. of teeth on worm wheel are = 60	
	iv) P = ?	
	v) W = 6 kN = 6000 N	
	vi) η = 30 %.	
	V.R $= \frac{RT}{nr}$ or $\frac{DT}{nd}$	
	a) V.R $= \frac{RT}{nr}$ Assuming n = 1, for single threaded worm and worm	1 M
	$\therefore$ R $= \frac{60}{2} = 30$ cm	
	T = 60	
	r $= 30/2 = 15$ cm	½ M
	$\therefore$ V.R $= \frac{30 \times 60}{1 \times 15} =$ 120	1 M

Q .NO	SOLUTION	MARKS
	b) $\eta = \frac{M.A}{V.R} \times 100$	
	$30 = \frac{M.A}{120} \times 100$	
	$\frac{30 \times 120}{100} = M.A$	
	$\boxed{M.A = 36}$	1M
	but $M.A = \frac{W}{P}$	
	$36 = \frac{6}{P}$	
	$\therefore P = \frac{6}{36}$	
	$\boxed{P = 0.167\ KN}$ $\boxed{P = 167\ N}$	1M

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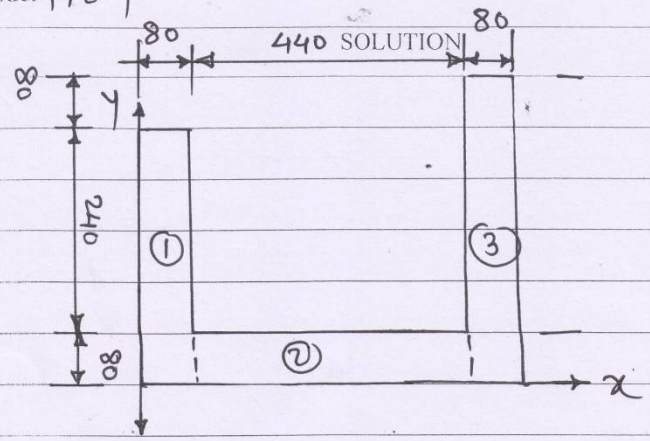
Q .NO		MARKS
Q-6 (a)		

Notes: units are not given in the fig.

i) Area calculation

$A_1 = 320 \times 80 = 25600$

$A_2 = 440 \times 80 = 35200$ 1M

$A_3 = 400 \times 80 = 32000$ 1M

ii)

$\bar{x}_1 = \frac{80}{2} = 40$

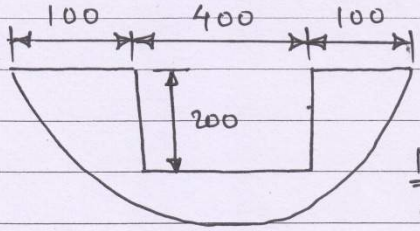
$\bar{x}_2 = 80 + \frac{440}{2} = 300$

$\bar{x}_3 = 80 + 440 + \frac{80}{2} = 560$ 1M

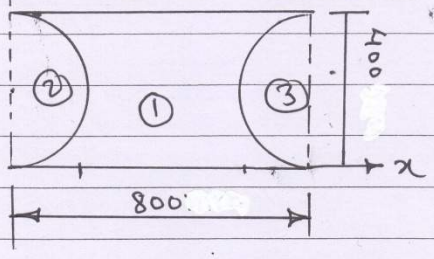
iii) $\bar{x} = \frac{A_1\bar{x}_1 + A_2\bar{x}_2 + A_3\bar{x}_3}{A_1 + A_2 + A_3}$ 1 M

$\bar{x} = \frac{25600 \times 40 + 35200 \times 300 + 32000 \times 560}{25600 + 35200 + 32000}$

$\bar{x} = \frac{29.504 \times 10^6}{92800}$ $\boxed{\bar{x} = 317.93}$ 1M

Q .NO	SOLUTION	MARKS
Q-6 (b)	 Note:- unit is not given in the fig	
	i) A_1 = area of semi circle $= \frac{\pi r^2}{2} = \frac{\pi \times 300^2}{2}$ $= 141.37 \times 10^3$	
	A_2 = area of rectangle $= 200 \times 400 = 80000$	
	Net Area $= A_1 - A_2 = 141.37 \times 10^3 - 80000$	
	$\boxed{A = 61370}$	1M
	ii) Distances of centroid from Top	
	y_1 = C.G of semicircle from top	
	$= \frac{4r}{3\pi} = \frac{4 \times 300}{3\pi} = 127.32$	1M
	y_2 = C.G of rectangle from top $= \frac{200}{2} = 100$	
	Now $\bar{y} = \frac{A_1 y_1 - A_2 y_2}{A_1 - A_2} =$	1M
	$\bar{y} = \frac{141.37 \times 10^3 \times 127.32 - 80000 \times 100}{61370}$	
	$\bar{y} = 162.93$ from Top of fig	1M

Q.NO	SOLUTION	MARKS
6 (c)	Two solutions possible examiner should consider any one	



i> Note :- unit is not given in the problem Student may assume

a) Area calculation

A_1 = Area of rectangle = $800 \times 400 = 320000$

A_2 = Area of semi circle - 1

$A_2 = \frac{\pi}{2} R^2 = \frac{\pi}{2} \times 200^2 = 62.83 \times 10^3$

$A_3 = \pi/2 R^2 = \pi/2 \times 200^2 = 62.83 \times 10^3$ 1M

b) calculate $\bar{x}$

$x_1 = \frac{800}{2} = 400$

$x_2 = \frac{4R}{3\pi} = \frac{4 \times 200}{3 \times \pi} = 84.88$

$x_3 = 800 - \frac{4R}{3\pi} = 715.117$ 1M

$$\bar{x} = \frac{A_1 x_1 - [A_2 x_2 + A_3 x_3]}{A_1 - [A_2 + A_3]}$$

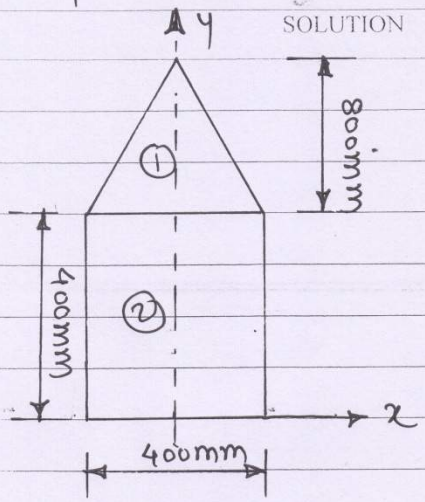
$$\bar{x} = \frac{320000 \times 400 - [62.83 \times 10^3 \times 84.88 + 62.83 \times 10^3 \times 715.117]}{320000 - [62.83 \times 10^3 + 62.83 \times 10^3]}$$

$\boxed{\bar{x} = 400}$ 1M

Q.NO	SOLUTION	MARKS
	c) Calculate $\bar{y}$	
	$y_1 = \frac{400}{2} = 200$	
	$y_2 = r = 200$	
	$y_3 = 200$	
	$\bar{y} = \frac{A_1 y_1 - [A_2 y_2 + A_3 y_3]}{A_1 - [A_2 + A_3]}$	
	$\bar{y} = \frac{320000 \times 200 - [62.83 \times 10^3 \times 200 - 62.83 \times 10^3 \times 200]}{194340}$	
	$\boxed{\bar{y} = 200}$	01 M
	OR	
	The given fig is symmetrical about x-axis & y-axis	
	$\bar{x} = \frac{800}{2} = 400$	
	$\boxed{\bar{x} = 400}$	2 M
	$\bar{y} = \frac{400}{2} = 200$	
	$\boxed{\bar{y} = 200}$	2 M

Q.NO	SOLUTION	MARKS

Q-6(d)



i) $V_1 = \frac{1}{3}\pi r^2 h = \frac{1}{3}\pi \times 200^2 \times 800 = 33.51 \times 10^6 \text{ mm}^3$

$V_2 = 400^3 = 64 \times 10^6 \text{ mm}^3$

$V = V_1 + V_2 = 97.51 \times 10^6 \text{ mm}^3$

$V = 97.51 \times 10^6 \text{ mm}^3$ 1M

ii) Distⁿ of C.G from base

$y_1 = 400 + \frac{800}{4} = 600\text{mm}$

$y_2 = \frac{400}{2} = 200\text{mm}$ 1M

let $\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V}$

$\bar{y} = \frac{33.51 \times 10^6 \times 600 + 64 \times 10^6 \times 200}{97.51 \times 10^6}$ $\bar{y} \rightarrow$ 1 M

$\bar{x} \rightarrow$ 1M

$\bar{y} = \frac{(33.51 \times 600 + 64 \times 200) \times 10^6}{97.51 \times 10^6}$ fig symmetrical & verified

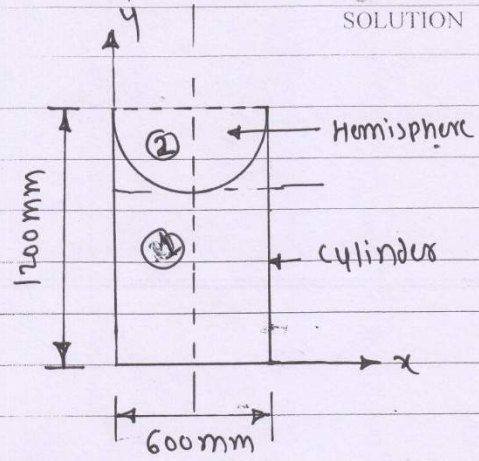
$\bar{y} = 337.462\text{mm}$

iii) $\bar{x} = \frac{400}{2} = 200\text{mm}$

$\bar{x} = 200\text{mm}$

Q.NO	SOLUTION	MARKS

Q-6 (e)



$\frac{1}{2}$ M

i) $V_2 = \frac{2}{3}\pi r^3 = \frac{2}{3} \times \pi \times 300^3 = 56.547 \times 10^6 \text{ mm}^3$

$V_1 = \pi r^2 h = \pi \times 300^2 \times 1200 = 339.292 \times 10^6 \text{ mm}^3$

$V = V_1 - V_2 = 339.292 \times 10^6 - 56.547 \times 10^6$

$V = 282.745 \times 10^6 \text{ mm}^3$ 1 M

ii) Distⁿ of C.G from x_1-axis

$y_1 = \frac{1200}{2} = 600 \text{ mm}$

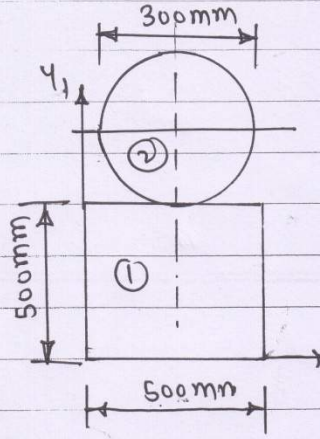
$y_2 = 1200 - \frac{3r}{8} = 1200 - \frac{3 \times 300}{8} = 1087.5 \text{ mm}$ $\frac{1}{2}$ M

iii) $\bar{y} = \frac{V_1 y_1 - V_2 y_2}{V} = \frac{339.292 \times 10^6 \times 600 - 56.547 \times 10^6 \times 1087.5}{282.745 \times 10^6}$ $\frac{1}{2}$ M

$\boxed{\bar{y} = 502.50 \text{ mm}}$ → $\frac{1}{2}$ M

Body is symmetrical about the vertical line

$\bar{x} = \frac{600}{2} = 300 \text{ mm}$ $\boxed{\bar{x} = 300 \text{ mm}}$ 1 M

Q.NO	SOLUTION	MARKS
Q-6 (f)		
	i) V_1 = vol^m of cube $V_1 = 500^3 = 125 \times 10^6\ mm^3$ $V_2 = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi \times 150^3$ $V_2 = 14.136 \times 10^6\ mm^3$	1M
	$V = 139.136 \times 10^6\ mm^3$	
	ii) since the body is symmetrical about vertical line $\bar{x} = \frac{500}{2} = 250\ mm$ $\boxed{\bar{x} = 250mm}$	1M
	iii) Distance of c.g from x_4-axis	
	$y_1 = \frac{500}{2} = 250\ mm$ $y_2 = 500 + 150 = 650\ mm$	1M
	$\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2} = \frac{125 \times 10^6 \times 250 + 14.136 \times 10^6 \times 650}{139.136 \times 10^6}$	
	$\boxed{\bar{y} = 290.639mm}$	1M