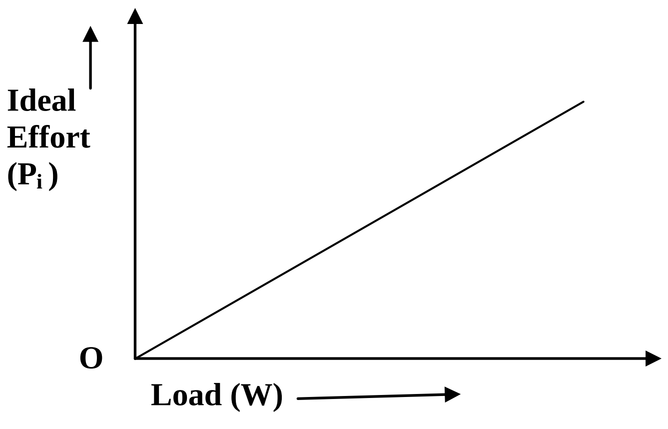
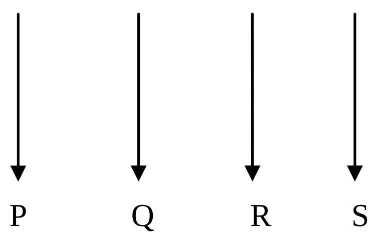
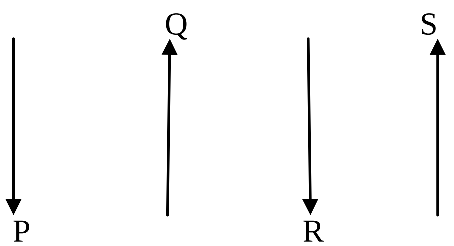
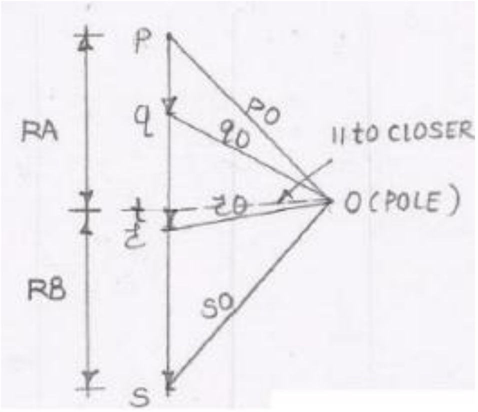
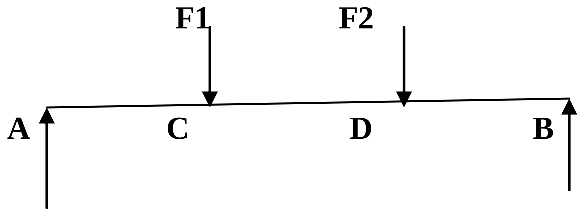
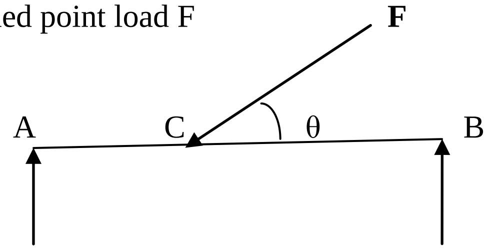
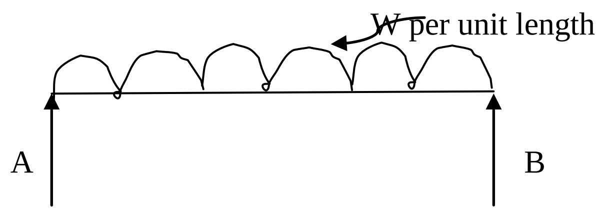
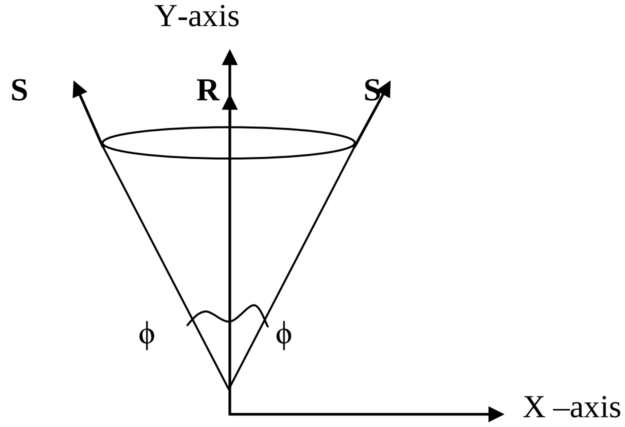
Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and Communication Skills.)
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by the candidate and those in the model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and the model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

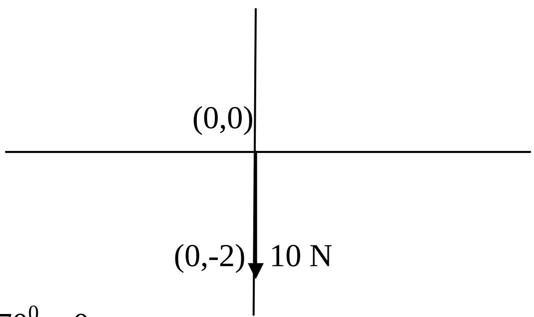
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1		**Attempt any TEN of the following :**		**20**
	a)	**Define effort and effort lost in friction.**		
	Ans	<u>Effort(P):</u> The force applied to lift the heavy loads is known as effort.	1 M	
		<u>Effort lost in friction (P_f):</u> It is the effort by considering the wear and tear effect while use of machine. OR It is the effort obtained by subtracting ideal effort from an effort.	1 M	2 M
	b)	**State any two uses of machines.**		
	Ans	1) To lift heavy loads which is not possible manually. 2) To minimize the human beings efforts.	1M each	2 M
	c)	**Draw nature of graph for load against Ideal effort.**		
	Ans		2 M	2 M

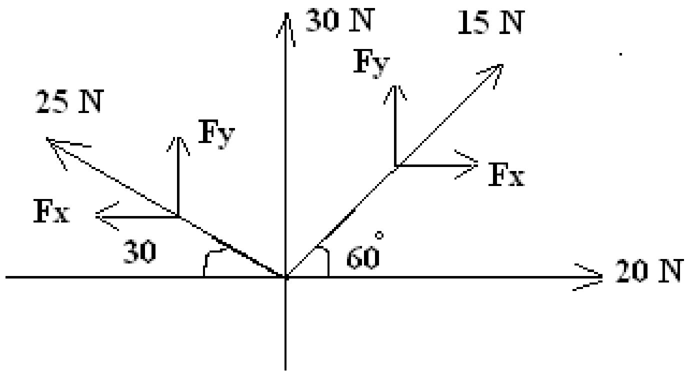
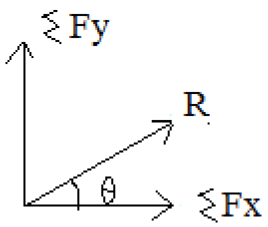
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1	d) **Ans**	**Define rigid body with one example.** Rigid Body: It is defined as the body which do not deform when subjected to system of forces and it is fixed in position. e. g. In fact, no body is perfectly rigid. Every body deforms slightly under the action of forces. Hence, rigid body is a theoretical concept.	1 M 1 M	2 M
	e) **Ans**	**State any two effects of force on a body.** 1) It may change the state of a body. 2) It may accelerate or retard the motion of a body. 3) It may turn or rotate the body on which it acts. 4) It may deform the body on which it acts.	1M each (any two)	2 M
	f) **Ans**	**Define coplanar parallel force system along with neat sketch.** Definition: If lines of action of forces are parallel to each other in the same plane, the system is called as **coplanar parallel force system.** Sketch : Parallel forces may be like or unlike. a) Like parallel forces: acting in same direction  b) Unlike parallel forces: acting in opposite direction 	1 M ½ M ½ M	2 M
	g) **Ans**	**What is polar diagram?** Polar Diagram : In case of non-concurrent or parallel force system the point of application of resultant can be found out by constructing polar diagram. Polar diagram is obtained from the vector diagram. To construct a polar diagram, any point "O" known as pole is chosen near the vector diagram and the points on the vector diagram are joined to it. The lines joined in this way are known as rays.	1 M	

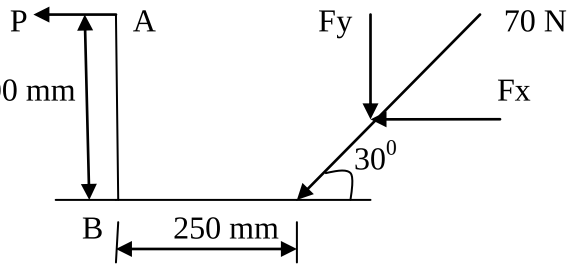
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1		**e.g.**  	1 M	2 M
	h) **Ans**	**State any two types of loading on a beam with sketches.** 1) Point load at point C & D  2) Inclined point load F  3) Uniformly distributed load W (udl)  	1 M each (any two)	2 M
	i) **Ans**	**State analytical conditions for equilibrium for concurrent force system.** 1) $\Sigma Fx = 0$ i. e. Algebric sum of all the forces along X-axis must be equal to zero. 2) $\Sigma Fy = 0$ i. e. Algebric sum of all the forces along Y-axis must be equal to zero.	1 M each	2 M

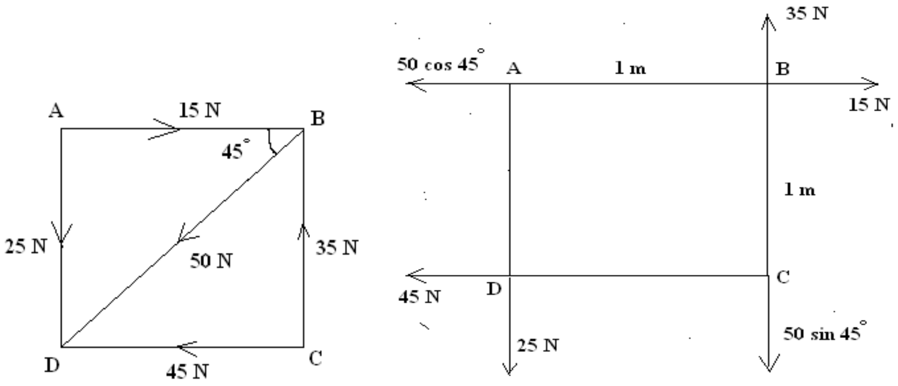
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1	**j) Ans**	**State types of friction.** 1) Static friction: The friction experienced by a body when it is in equilibrium. 2) Dynamic friction: The friction experienced by a body when it is in motion 3) Rolling : The friction experienced by a bodies when one rolls over the another body. 4) Sliding: The friction experienced by a bodies when one slides over the another body	1 M each (any two)	2 M
	k) Ans	**Define cone of friction.** Cone of friction : The resultant reaction S makes an angle ϕ with normal reaction R as shown for given set of axes XY.  If X axis is rotated about Y axis, the resultant reaction S will also rotate. The line of action of action of S will always lie on surface of right circular cone whose vertex angle is equal to 2ϕ. This cone is known as cone of friction.	1M for dia-gram & 1 M For explanation	2 M
	l) Ans	**State velocity ratio for screw jack with meaning of term involved.** Velocity Ratio of Simple Screw jack is given by - **VR = 2πL / p** --------- When handle of length L is provided **OR** **VR = 2πR / p** --------- When effort wheel is provided Where, L = length of handle P = pitch of screw R = radius of an effort wheel.	1 M for for-mula 1 M terms used	2 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2		**Answer any FOUR of the following :**		16 M
	a)	**In a certain machine effort was found to move a distance of 30 m, when load moved through a distance of 1.5 m. If the machine is ideal, find VR & MA of the machine.**		
	Ans	Givens : Distance moved by effort (y)= 30 m, distance moved by load (x) = 1.5 m, & the Machine is Ideal i. e. MA = VR efficiency (η) = 100 % Find: M. A. & V. R. Of the machine Solution: (1) VR = y / x = 30 / 1.5 = 20	2 M	
		<u>VR = 20</u> (2) Mechanical Advantage (M. A) As machine is Ideal, i. e. its M. A. & V. R. both are same and its efficiency (η) = 100 % **<u>M. A. = V. R. = 20</u>**	2 M	4 M
	b)	**For a general pulley block number of cogs on effort wheel is 24, that of on load wheel is 6. Number of teeth on the pinion is 4 & that of on spur is 36. If the maximum effort, which can be applied is 60 N, calculate the maximum load that can be lifted, if efficiency of machine is 80 %.**		
	Ans	Given: Geared pulley block machine No of cogs on effort wheel (N_1) = 24 No of cogs on load wheel (N_4) = 6 No of cogs on pinion (N_2) = 4 No of cogs on spur (N_3) = 36, Max effort(P) = 60 N, (η) = 80 %		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2		Find: Max load lifted by machine(W) Solution: 1)for given machine VR is given by V. R. = N_1 X N_3 / N_2X N_4 = 24 x 36 / 4 x 6 = 36 **VR = 36** 2) Efficiency (η) = MA / VR X 100 80 = MA / 36 x 100 MA = 28.8 But, MA = W/P 28.8 = W/60 **W = 1728 N**	2 M 1 M 1 M	4 M
	c) **Ans**	**In a double purchase crab, the two pinions have 10 teeth each & the two spur wheel has 60 teeth each. The diameter of load drum is 20 cm & that of effort wheel is 60 cm. Find the velocity ratio.** Given: Double purchase crab winch No of teeths on spur (N_1) & (N_3) = 60 No of teeth on pinion (N_2) & (N_4) = 10 Diameter of load drum(D)= 20 cm & effort wheel (d) = 60 cm Find: Velocity Ratio(VR) Solution: For given machine VR is given by V. R. = N_1 X N_3 X D / N2 X N_4 X d = 60x60x60 / 10x10x20 **V. R. = 108**	2 M for for-mula & 2 M for ans-wer	4 M
	d) **Ans**	**Resolve a force of 10 N magnitude passing through co-ordinates (0,0) & (0,-2)** Given: Force 10 N passing through (0,0) & (0,-2) Find: Resolution of force  Fx = 10 cos 270^0 = 0 Fy = 10 sin 270^0 = -10 N	1 M 1½ M 1½ M	4 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2	**e)**	**Determine the resultant of the forces acting on a hook as shown in fig.** 		
	Ans.	Given: Concurrent force system Find: Resultant (R) Solution: Σ Fx = 20 cos 0^0 + 15 cos 60^0 + 30 cos 90^0 + 25 cos 30^0 = 5.849 N (+ve) Σ Fy = 20 sin 0^0 + 15 sin 60^0 + 30 sin 90^0 + 25 sin 30^0 = 55.49 N (+ve) Resultant $(R)^2 = \Sigma Fx^2 + \Sigma Fy^2$ **= $5.849^2 + 55.49^2$** Hence**, R = 55.797 N** Direction & Position of Resultant As Σ Fx = + ve & Σ Fy = + ve, R lies in First Quadrant $\theta = \tan^{-1}\left\|\frac{\sum Fy}{\sum Fx}\right\| = \tan^{-1}\left\|\frac{55.49}{5.849}\right\|$ $\theta = 83.98°$ 	1 M 1 M 1 M 1 M	4 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2	f)	**A crank ABC with system of forces acting on it is shown in Fig. Find force P to maintain equilibrium.**		
	Ans	Given: 70 N force acting at 30^0 inclination as shown Find: P, if equilibrium is maintained		
			2 M	
		Taking moment @ point B & considering equilibrium condition $\sum M_B = 0$ $= Fy \times 250 - Px300 = 70\sin30 \times 250 - 300P$		
		P = 29.17 N	2 M	4 M
3		**Attempt any FOUR of the following :**		16 M
	a)	**Find the angle between two forces of magnitude 120 N each, such that their resultant is 60 N.**		
	Ans.	Givens : P = Q = 120 N R = 60 N To find : θ Solution :		
		Using Law of parallelogram of forces $R^2 = P^2 + Q^2 + 2PQ\cos\theta$	1 M	
		$(60)^2 = (120)^2 + (120)^2 + 2X120X120\cos\theta$ $3600 = 14400 + 14400 + 28800\cos\theta$ $3600 = 28800 + 28800\cos\theta$ $3600 - 28800 = 28800\cos\theta$	1 M	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		$-25200 = 28800\cos\theta$ $\theta = \cos^{-1}(\frac{-25200}{28800})$ $\theta = \cos^{-1}(-0.875)$ $\theta = 151.04$	2 M	4 M
	b) **Ans.**	**A square ABCD of 1 m side is subjected to a force of 15 N, 25 N, 35 N, 45 N & 50 N along AB, AD, CB, CD & BD. Find magnitude & direction w.r.t. A, shown in Figure No. 3**  1) Resolving all forces – Σ Fx = + 15 – 50 cos 45 - 45 = - 65.35 N Σ Fy = + 35 – 25 – 50 sin 45 = -25.35 N	1 M	
		2) Magnitude of Resultant $R = \sqrt{(\sum Fx)^2 + (\sum Fy)^2}$ $R = \sqrt{(-65.35)^2 + (-25.35)^2}$ $R = 70.10N$	1 M	
		3) Direction and position of resultant As Σ Fx is –ve and Σ Fy is -ve , Resultant lies in 3^{rd} quadrant.		

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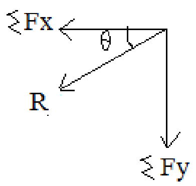
<tr><td>3</td><td></td><td>

$\theta = \tan^{-1}\left|\frac{\sum Fy}{\sum Fx}\right| = \tan^{-1}\left|\frac{25.35}{65.35}\right|$

$\theta = 21.2°$



4) Position of Resultant w.r.to point A
Let x be the perpendicular distance of R from point A.
ΣMF_A = (-35 X 1) + (50 sin 45 X 1) + (45 X 1) = + 45.35 Nm
MR_A = + R. x = 70.10 x

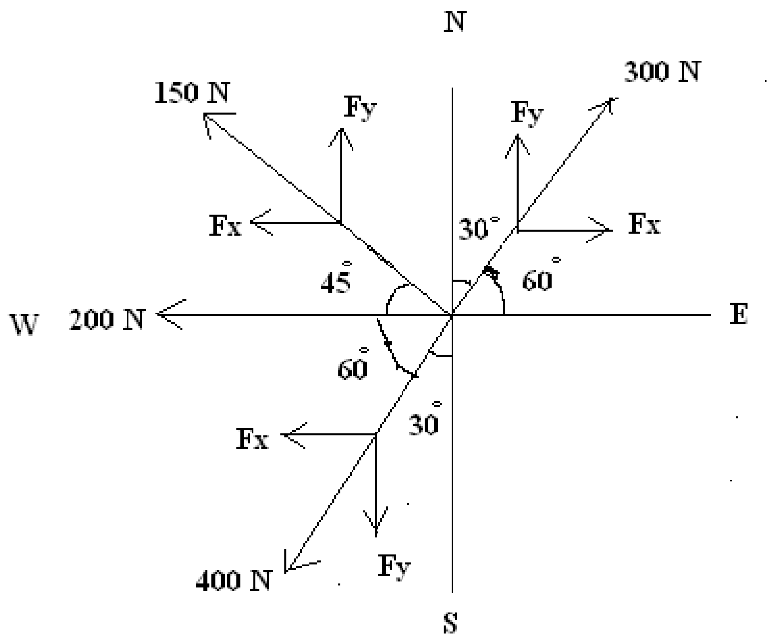
Using Varignon's theorem of moment
$\Sigma MF_A = MR_A$
45.35 = 70.10 x
x = 0.65 m
Hence, perpendicular distance of R from point A = 0.65 m

</td><td>1 M

1 M</td><td>4 M</td></tr>
<tr><td></td><td>c)

Ans.</td><td>

Find the resultant in magnitude & direction if following forces acting away from a point.
(i) 300 N force acting 30 degree East of North
(ii) 150 N force acting 45 degree West of North
(iii) 200 N force towards West
(iv) 400 N force acting 30 degree West of South.



</td><td>1 M</td><td></td></tr>
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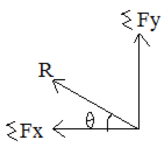
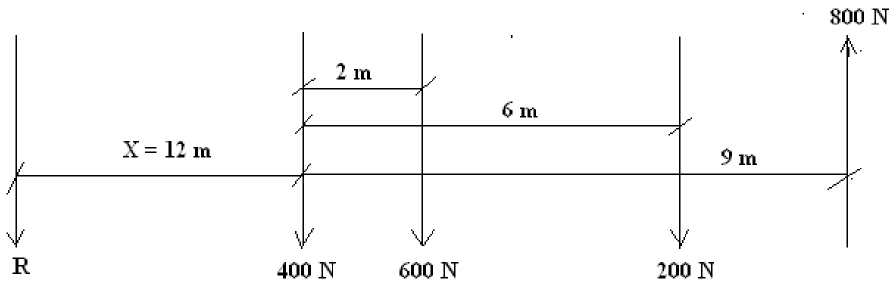
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		1) Resolving all forces –		
		Σ Fx = + 300 cos 60 – 150 cos 45 – 200 – 400 cos 60 = + 150 – 106.066 – 200 - 200 = - 356.066 N	½ M	
		Σ Fy = + 300 sin 60 + 150 sin 45 – 400 sin 60 = + 259.807 + 106.066 – 346.410 = +19.463 N	½ M	
		2) Magnitude of Resultant $R=\sqrt{(\sum Fx)^2+(\sum Fy)^2}$ $R=\sqrt{(-356.066)^2+(19.463)^2}$ $R=356.597N$	1 M	
		3) Direction and position of resultant As Σ Fx is –ve and Σ Fy is +ve , Resultant lies in 2nd quadrant.		
		$\theta=\tan^{-1}\left\lvert\frac{\sum Fy}{\sum Fx}\right\rvert=\tan^{-1}\left\lvert\frac{19.463}{356.597}\right\rvert$ $\theta=3.128°$ 	1 M	4 M
	d)	**Calculate resultant, direction & it's position w.r.t. 400 N force for given force system as shown in figure**		
	Ans.			
		1) Magnitude of Resultant R = - 400 – 600 – 200 + 800 = - 400 N ($\downarrow$) - ve sign indicates Resultant acts vertically downwards.	1 M	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		2) Position of Resultant Considering Varignon's theorem of moment & taking moment of all forces @ about 400 N force. Let, R acts at x distance from 400 N force. $\Sigma M_F = M_R$ (400 X 0) + (600 X 2) + (200 X 6) – (800 X 9) = - R X x - 4800 = - 400 X x x = 12 m Hence, R must be located at 12 m distance from 400 N force, so as to produce anti - clockwise moment.	1 M 2 M	 4 M
	e)	**Explain the following :** **(i) Resolution of a force** **(ii) Composition of force**		
	Ans.	**(i) Resolution of a force -** The way of representing a single force into number of forces without changing the effect of the force on the body is called as resolution of force. **(ii) Composition of force –** The process of finding out the resultant force of a given system of forces is called as composition of forces.	2 M 2 M	 4 M
	f)	**Solve Que. 3 (d) by graphical method.**		
	Ans.			

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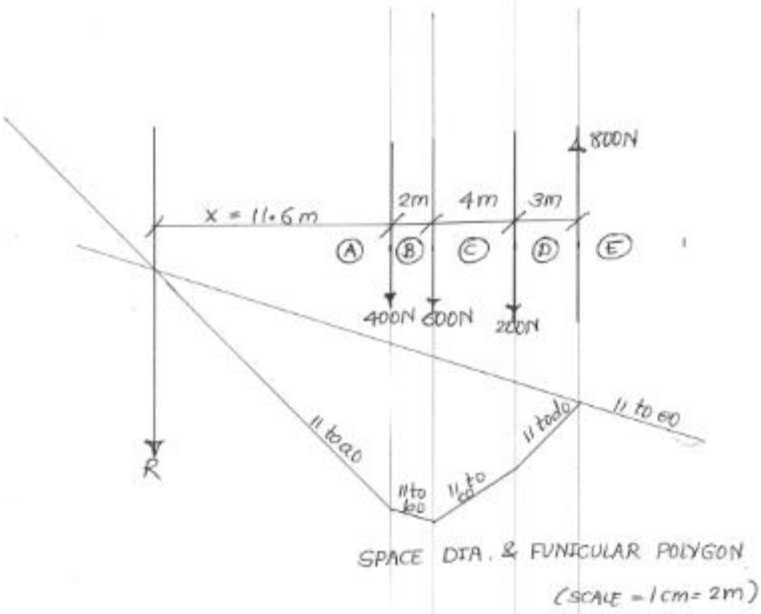
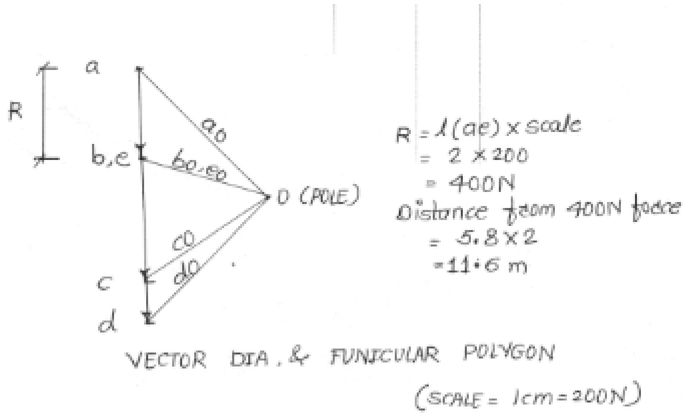
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answers</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>3</td><td></td><td>


</td><td>2 M with labe-lling & position of R</td><td></td></tr>
<tr><td></td><td></td><td>


</td><td>2 M with labe-lling & magni-tude of R</td><td>4 M</td></tr>
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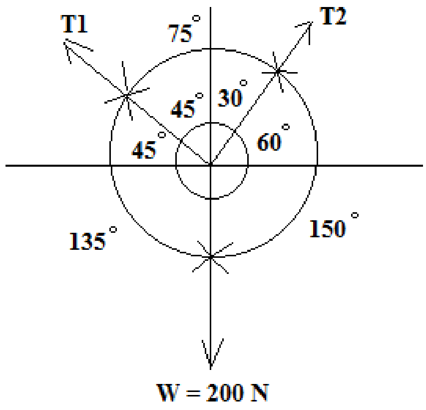
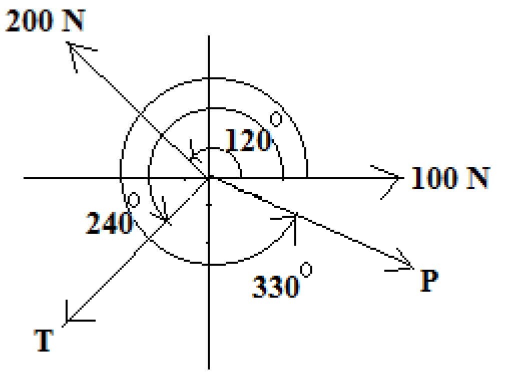
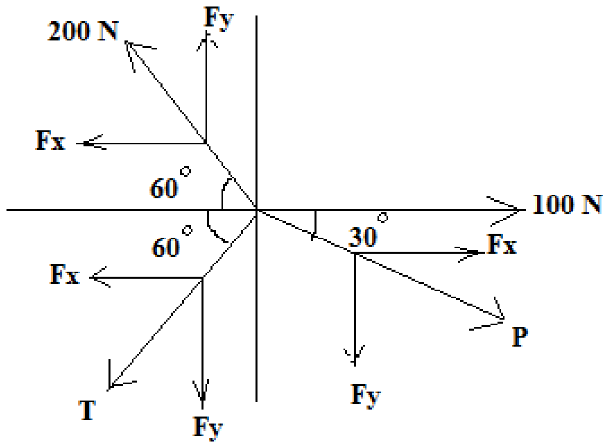
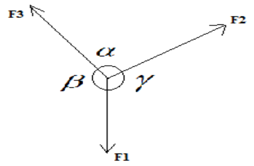
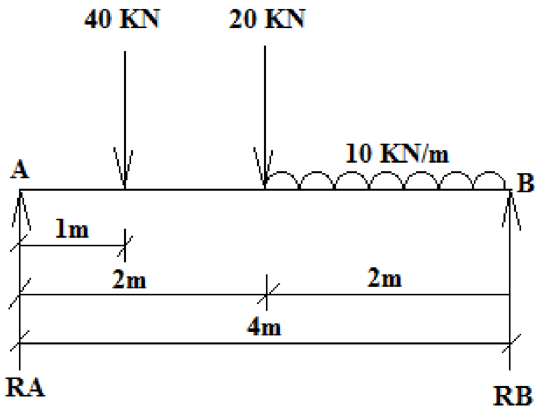
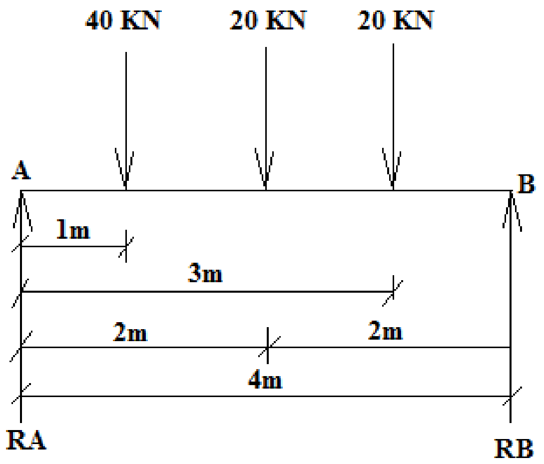
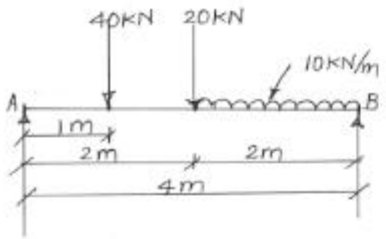
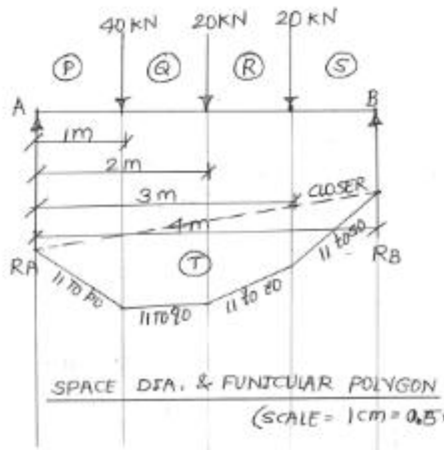
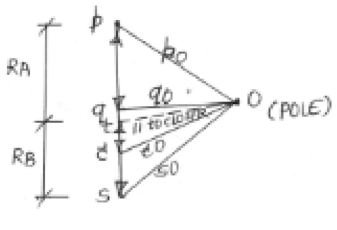
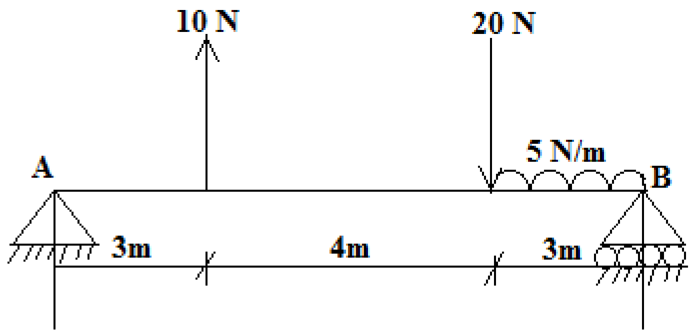
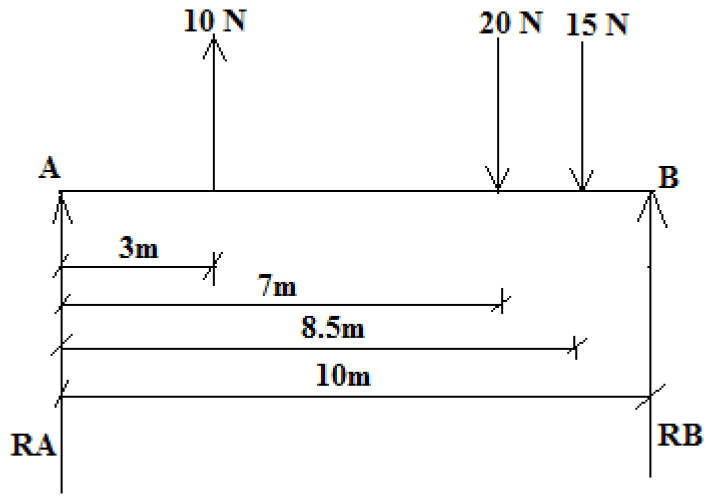
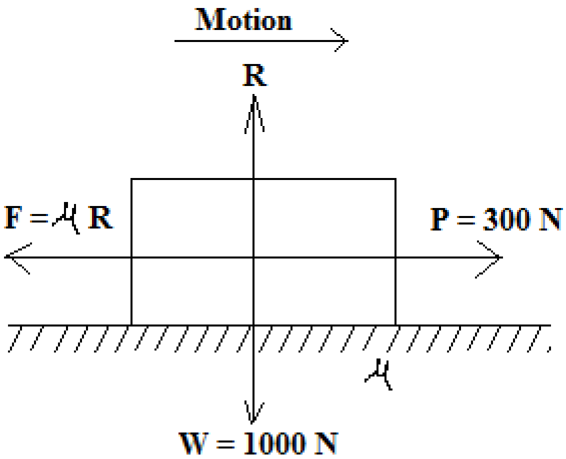
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		**Attempt any Four of the following :**		16
	a)	**Two men carry a weight 200 N by means of ropes fixed to the weight. One rope is inclined at 45 degree & other 30 degree with the vertical. Find tension in each side of rope.**		
	Ans.		1 M	
		Using Lami's theorem, $$\frac{W}{\sin 75°}=\frac{T_1}{\sin 150°}=\frac{T_2}{\sin 135°}$$ $$\underset{(1)}{\frac{200}{\sin 75°}}=\underset{(2)}{\frac{T_1}{\sin 150°}}=\underset{(3)}{\frac{T_2}{\sin 135°}}$$	1 M	
		Using term (1) and (2) $$\frac{200}{\sin 75°}=\frac{T_1}{\sin 150°}$$ $$T_1=200 X \frac{\sin 150°}{\sin 75°}$$ T_1 = 103.527 N	1 M	
		Using term (1) and (3) $$\frac{200}{\sin 75°}=\frac{T_2}{\sin 135°}$$ $$T_2=200 X \frac{\sin 135°}{\sin 75°}$$ T_2 = 146.410 N	1 M	4 M

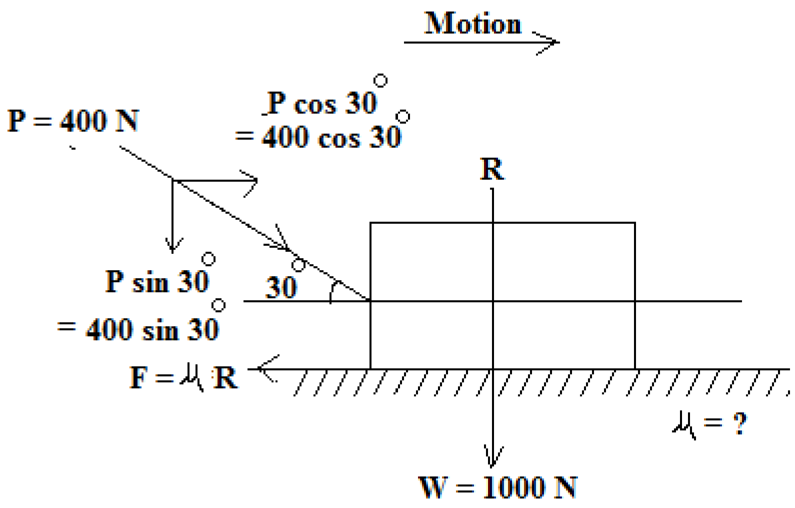
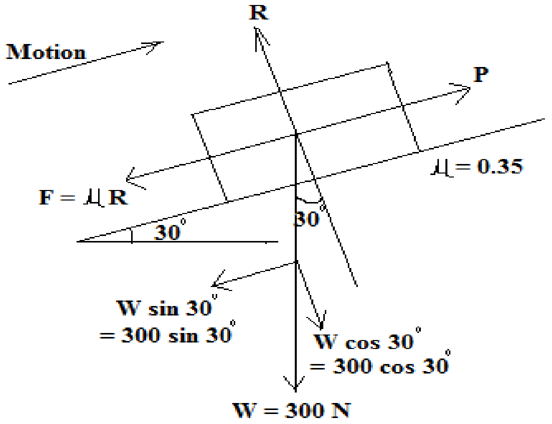
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4	b) Ans.	**If four forces acting at a point (all away from the point) are 100 N, 200 N, T & P at 0°, 120°, 240° & 330°. Determine the value of T & P, if the system is in equilibrium.**  	1 M	
		1) For equilibrium of a body, $\Sigma Fx = 0$ & $\Sigma Fy = 0$ Resolving all forces – $\Sigma Fx = + 100 - 200 \cos 60 - T \cos 60 + P \cos 30 = 0$ $0 = - (0.5) T + (0.866) P$ $0 = (0.5) T - (0.866) P$ --------------------(1)	1 M	
		$\Sigma Fy = + 200 \sin 60 - T \sin 60 - P \sin 30 = 0$ $0 = 173.205 - (0.866) T - (0.5) P$ $173.205 = (0.866) T + (0.5) P$ --------------------(2)	1 M	
		Solving Eqn. (1) & (2) simultaneously, T = 150 N P = 86.605 N	1 M	4 M
	c) Ans.	**State Lami's theorem & give its limitations.** **Lami's theorem** – It states that, if three forces acting at a point on a body keep it at rest, then each force is proportional to the sine of the angle between the other two forces.	1 M	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		As per Lami's theorem, $$\frac{F_1}{sin\alpha} = \frac{F_2}{sin\beta} = \frac{F_3}{\sin\gamma}$$  	1 M	
		Limitations of Lami's theorem – (1) It is applicable only when body is in equilibrium. (2) It is applicable only for concurrent force system. (3) It is applicable only when there are three forces only. (4) It is applicable only when three forces are acting away from the point.	1 M each (any two)	4 M
	d)	**A beam of span 4 m is simply supported at it's end. It carries a concentrated loads of 40 KN & 20 KN at 1 m & 2 m from left hand support respectively. It carries udl of 10 kN/m for 2 m from the right end. Determine the reactions at support.**		
	Ans.	  	1 M	
		1) Equivalent point load and it's position Equivalent point load = Intensity of udl X span of udl = 10 X 2 = 20 KN Position from RA = 2 m + Span of udl / 2 = 2 + (2/2) = 3 m		

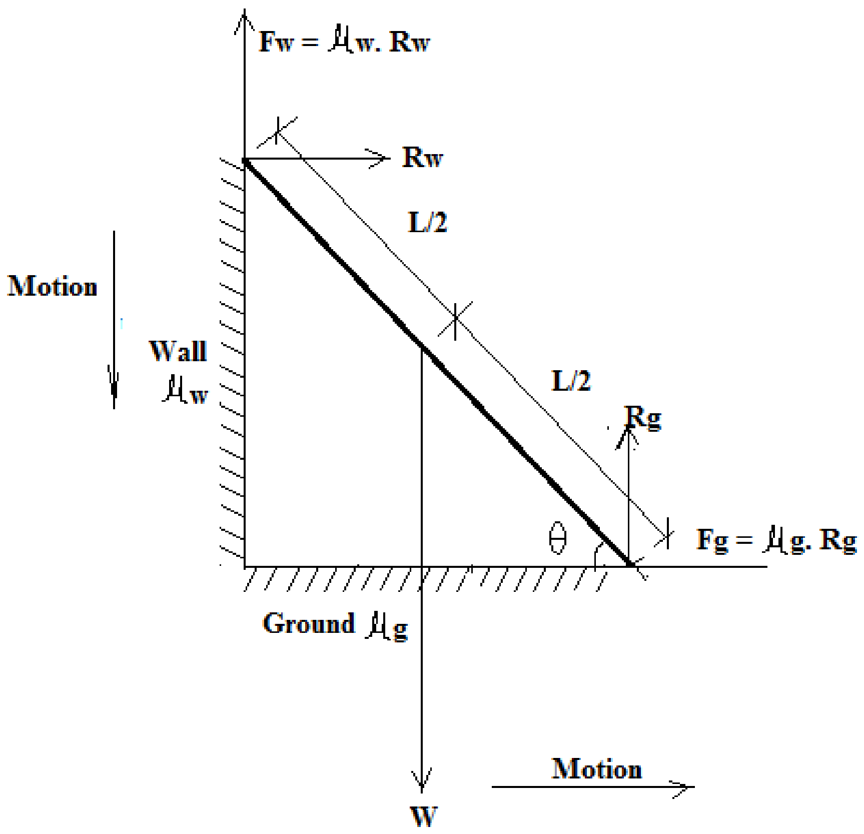
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		2) Applying equilibrium conditions $\Sigma Fy = 0$ ($\uparrow$+ve , $\downarrow$−ve) and $\Sigma M = 0$ ($\circlearrowright$+ve , $\circlearrowleft$−ve) $\Sigma Fy = 0$ RA – 40 – 20 - 20 + RB = 0 RA + RB = 80 KN -------(1) $\Sigma M_A = 0$ Taking moment of all forces @ point A (RA x 0) + (40 X 1) + (20 X 2) + (20 X 3) – (RB X 4) = 0 RB = 35 KN Putting value of RB in eqn. (1) RA + 35 = 80 RA = 45 KN	 1 M 1 M 1 M	 4 M
	e) **Ans.**	**Solve Que. 4 (d) by graphical method.** SPACE DIA. & FUNICULAR POLYGON (SCALE= 1cm=0.5m) RA = l(tp) x scale = 2.3 x 20 = 46 KN RB = l(st) x scale = 1.8 x 20 = 36 KN VECTOR DIA. & POLAR DIA. (SCALE = 1cm = 20KN)	2 M with labe-lling 2 M with labe-lling & magni-tude of of R_A & R_B	 4 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4	**f)**	**Find the support reactions of simply supported beam shown in Figure.** 		
	Ans.		1 M	
		1) Equivalent point load and it's position Equivalent point load = Intensity of udl X span of udl = 5 X 3 = 15 N Position from RA = 7 m + Span of udl / 2 = 7 + (3/2) = 8.5 m 2) Applying equilibrium conditions Σ Fy = 0 (↑+ve , ↓−ve) and Σ M = 0 (↻+ve , ↺−ve) Σ Fy = 0 RA + 10 – 20 - 15 + RB = 0 RA + RB = 25 N -------(1)	1 M	
		$\Sigma M_A = 0$ Taking moment of all forces @ point A (RA x 0) - (10 X 3) + (20 X 7) + (15 X 8.5) – (RB X 10) = 0 RB = 23.75 N Putting value of RB in eqn. (1) RA + 23.75 = 25 RA = 1.25 N	1 M 1 M	4 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		**Attempt any Four of the following :**		16
	a)	**A block of 1000 N is kept on a horizontal surface. A horizontal force of 300 N is required to just move it. Find –** **(i) Normal reaction** **(ii) Frictional resistance** **(iii) Resultant reaction** **(iv) Coefficient of friction**		
	Ans.	 For limiting equilibrium $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ $+ R – W = 0$ $R = W = 1000$ N $R = 1000$ N	1 M	
		$\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$ $+ P – F = 0$ $+300 = F$ $F = 300$ N	1 M	
		But, $F = \mu R$ $300 = \mu\ 1000$ $\mu = 300 / 1000$ $\mu = 0.3$	1 M	
		Resultant reaction $s = \sqrt{F^2 + R^2} = \sqrt{(\mu R)^2 + R^2}$ $S = \sqrt{(300)^2 + (1000)^2}$ $S = 1044.03$ N	1 M	4 M

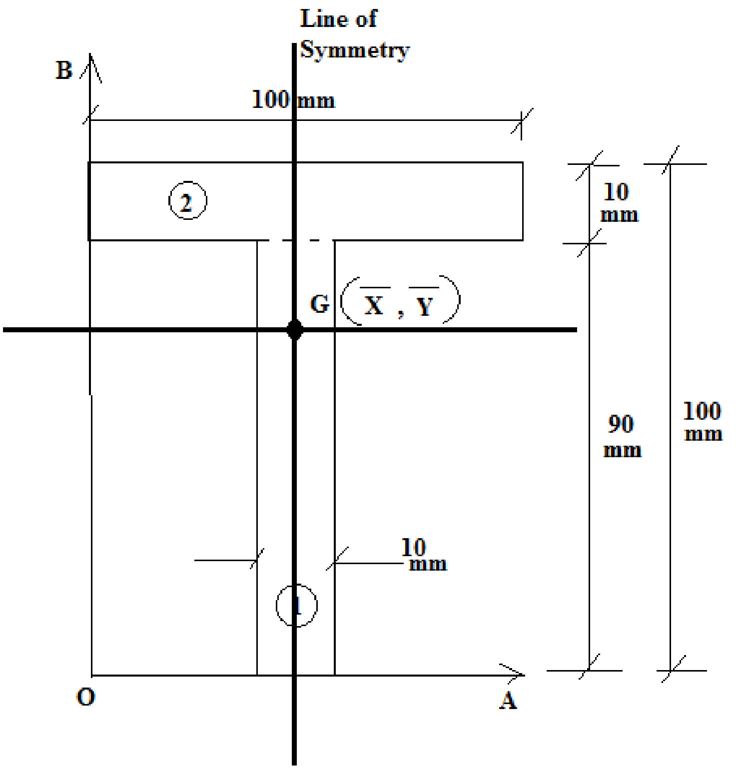
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5	b)	**Find the value of μ if the body is in limiting equilibrium. Refer fig.**		
	Ans.	 		
		For limiting equilibrium $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ $+ R - W - 400 \sin 30 = 0$ $R = 1000 + 200$ $R = 1200$ N	1 M	
		$\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$ $+ 400 \cos 30 - F = 0$ $F = 346.410$ N	1 M	
		But, $F = \mu R$ $346.410 = \mu (1200)$ $\mu = 346.410 / 1200$ $\mu = 0.288$	2 M	4 M
	c)	**A block weighing 300 N is resting on an inclined plane making an angle of 30° with the horizontal. Calculate the pull applied parallel to the plane to move the block up the plane if μ = 0.35.**		
	Ans.	 	2 M	

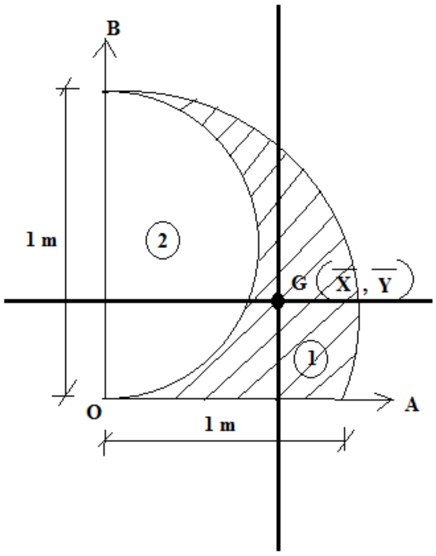
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		Consider inclined plane as x-x axis and perpendicular to it as y-y axis. For limiting equilibrium $\Sigma Fy = 0$ $+ R - W \cos 30 = 0$ $R = 300 \cos 30$ $R = 259.807$ N	1 M	
		$\Sigma Fx = 0$ $+P - F - W \sin 30 = 0$ $+P = (0.35 \times 259.807) + 300 \sin 30$ $P = 240.93$ N	1 M	4 M
	d) **Ans.**	**Draw FBD of a ladder resting against a wall & floor having weight W.**		

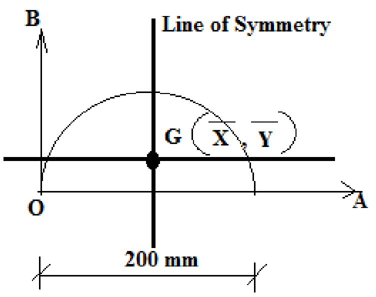


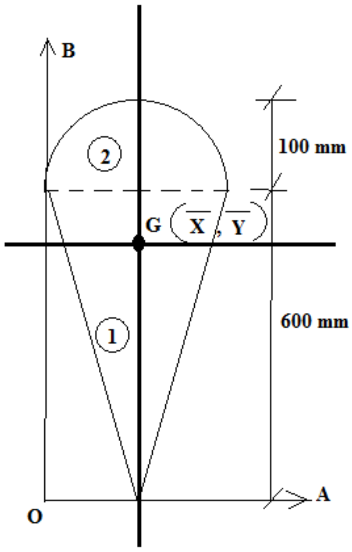
		(Figure above)	2 M Fig. + 1 M forces	
		Where, μg = Coefficient of friction between the ladder & the ground μw = Coefficient of friction between the ladder & the wall Rg = Normal reaction at the ground Rw = Normal reaction at the wall Fg = Frictional force between the ladder & the ground Fw = Frictional force between the ladder & the wall	1 M	4 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5	e)	**Following observations were made in a end of simple lifting machine with VR = 100.**		
		Load – **Effort**: **5 KN** – **150 KN**; **10 KN** – **200 KN**		
		Determine law of machine & Max. efficiency of machine.		
	Ans.	1) Law of machine is given by P = (mW + C) KN		
		Putting values of W & P from above table –		
		150 = m (5) + C ---------- (1)		
		200 = m (10) + C ---------- (2)	1 M	
		Subtracting Eqn. (2) from (1)		
		150 = m (5) + C		
		_200 = _m (10) $\underline{+}$ C		
		-50 = - m (5)		
		Hence, m = 50 / 5 = 10		
		Putting value of m in Eqn (1)	1 M	
		150 = (10 X 5) + C		
		C = 100 KN		
		Law of machine is -	1 M	
		P = (10 W + 100) KN		
		MAmax = 1/m = 1 / 10 = 0.1		
		$\%\eta_{max} = \frac{M.A._{max}}{V.R.} X100$		
		$\%\eta_{max} = \frac{0.1}{100} X100$		
		$\%\eta_{max} = 0.1\%$	1 M	4 M
	f)	**In a differential wheel & axle, the diameter of wheel is 36 cm & that of axles are 9 cm & 6 cm. If the efficiency of the machine is 80 %, find the load lifted with an effort of 100 N.**		
	Ans.	(1) VR of differential axle & wheel is given by -		
		$VR = \frac{2D}{d_1 - d_2} = \frac{2X36}{9-6}$		
		$VR = 24$	2 M	

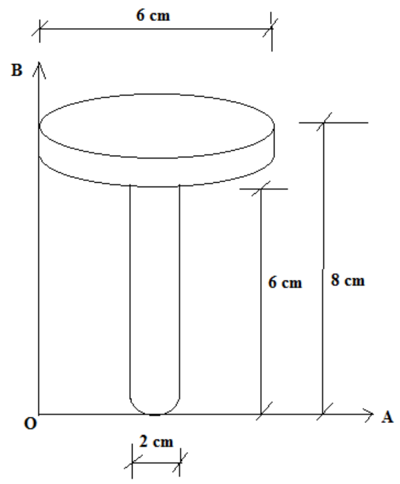
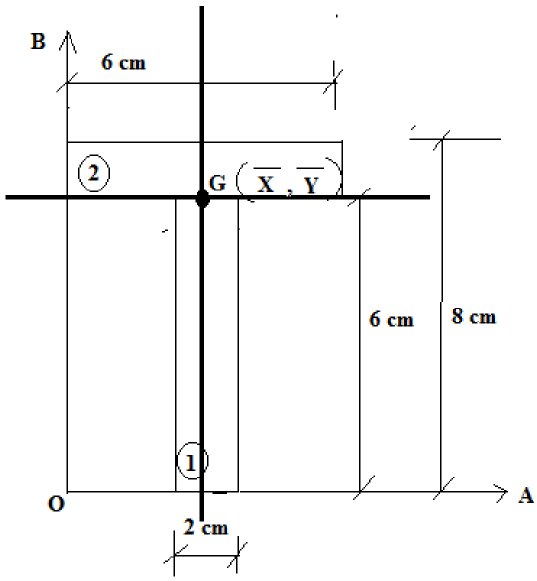
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		$\%\eta = \frac{M.A.}{V.R.} X100$ $80 = \frac{MA}{24} X100$ $MA = \frac{80X24}{100} = 19.2$	1 M	
		$MA = \frac{W}{P}$ $19.2 = \frac{W}{100}$ $W = 19.2X100$ $W = 1920N$	1 M	4 M
6		**Attempt any Four of the following :**		16
	a)	**Locate the centroid of T section 100 X 100 X 10 mm having total depth of 100 mm.**		
	Ans.		1 M	
		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 100 / 2 = 50 mm	1 M	

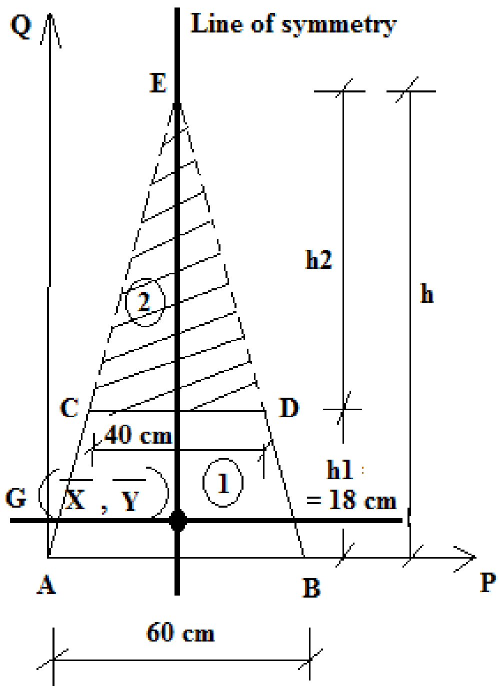
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		2) Area calculation $A_1 = 90 \text{ X } 10 = 900 \text{ mm}^2$ $A_2 = 100 \text{ X } 10 = 1000 \text{ mm}^2$ $A = A_1 + A_2 = 1900 \text{ mm}^2$	1 M	
		3) Location of $\bar{y}$ $y_1 = 90 / 2 = 45$ mm $y_2 = 90 + (10/2) = 95$ mm $\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A}$ $\bar{y} = \frac{(900 X 45) + (1000 X 95)}{1900}$ $\bar{y} = 71.315 mm$	1 M	
		Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (50 mm from OB and 71.315 mm from OA)		4 M
	b) **Ans.**	**Locate the centroid of the shaded area as shown in figure.** 		
		1) Let, Fig. 1 – Quarter circle and Fig. 2 – Semi Circle Area Calculation $A_1 = \frac{\pi r_1^2}{4} = \frac{\pi (1)^2}{4} = 0.7854 m^2$ $A_2 = \frac{\pi r_2^2}{2} = \frac{\pi (0.5)^2}{2} = 0.3927 m^2$ $A = A_1 - A_2 = 0.3927 m^2$	1 M	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		2) $\bar{x}$ calculation $x_1 = \frac{4r_1}{3\pi} = \frac{4X1}{3\pi} = 0.424m$ $x_2 = \frac{4r_2}{3\pi} = \frac{4X0.5}{3\pi} = 0.212m$ $\bar{x} = \frac{A_1x_1 - A_2x_2}{A} = \frac{(0.7854X0.424) - (0.3927X0.212)}{0.3927}$ $\bar{x} = 0.64m$	1½ M	
		3) $\bar{y}$ calculation $y_1 = \frac{4r_1}{3\pi} = \frac{4X1}{3\pi} = 0.424m$ $y_2 = r_2 = 0.5m$ $\bar{y} = \frac{A_1y_1 - A_2y_2}{A} = \frac{(0.7854X0.424) - (0.3927X0.5)}{0.3927}$ $y = 0.35m$	1½ M	
		Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (0.64 m from OB and 0.35 m from OA)		4 M
	c)	**Define centroid. Show on sketch the C. G. of a semicircle of diameter 200 mm.**		
	Ans.	**Centroid :-** It is defined as the point through which the entire area of a plane figure is assumed to act, for all positions of the lamina. e. g. Triangle, Square	2 M	
		C. G. of a semicircle $\bar{x} = r = 100mm$ $\bar{y} = \frac{4r}{3\pi} = \frac{4X100}{3\pi} = 42.44mm$  	2 M	4 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6	d)	**Locate the position of centroid of an ice – cream cone as shown in figure**		
	Ans.			
		NOTE : Considering Centroid		
		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 200 / 2 = 100 mm	1 M	
		2) Area Calculation $A_1 = \frac{1}{2} b h_1 = \frac{1}{2} X\, 200\, X\, 600 = 60000 mm^2$ $A_2 = \frac{\pi r^2}{2} = \frac{\pi (100)^2}{2} = 15707.96 mm^2$ $A = A_1 + A_2 = 75707.96 mm^2$	1 M	
		3) $\overline{y}$ calculation $y_1 = \frac{2}{3} h_1 = \frac{2}{3} X\, 600 = 400 mm$ $y_2 = h_1 + \frac{4r}{3\pi} = 600 + \left(\frac{4 X 100}{3\pi}\right) = 642.44 mm$	1 M	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A}$		
		$\bar{y} = 450.30mm$	1 M	
		Hence, centroid (G) for given ice cream cone lies at G($\overline{x,y}$) = (100 mm from OB and 450.30 mm from OA)		4 M
		<u>OR</u>		
	Ans.	**<u>NOTE : Considering Center of Gravity of ice-cream cone.</u>**		
		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 200 / 2 = 100 mm	1 M	
		2) Volume Calculation		
		$V_1 = (1/3)\pi r_1^{\,2} h_1 = (1/3)\pi(100)^2 X\,600 = 6.28318 X 10^6 mm^3$ $V_2 = (2/3)\pi r_2^{\,3} = (2/3)\pi(100)^3 = 2.094395 X 10^6 mm^3$ $V = V_1 + V_2 = 8.377575 X 10^6 mm^3$	1 M	
		3) $\bar{y}$ calculation		
		$y_1 = h_1 - \frac{h_1}{4} = 600 - \frac{600}{4} = 450mm$ $y_2 = h_1 + \frac{3r_2}{8} = 600 + \left(\frac{3X100}{8}\right) = 637.5mm$	1 M	
		$\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V}$ $\bar{y} = 496.875mm$	1 M	4 M
		Hence, Centre of Gravity (G) for given ice cream cone lies at G($\overline{x,y}$) = (100 mm from OB and 496.875 mm from OA)		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6	**e)**	**Find the $\bar{y}$ of the composite body given in figure.** 		
	Ans.	 1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 6 / 2 = 3 cm 2) Volume Calculation $V_1 = \pi r_1^2 h_1 = \pi (1)^2 X\, 6 = 18.849 cm^3$ $V_2 = \pi r_2^2 h_2 = \pi (3)^2 X\, 2 = 56.548 cm^3$ $V = V_1 + V_2 = 75.397 cm^3$	1 M	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		3) $\bar{y}$ calculation		
		$y_1 = \frac{h_1}{2} = \frac{6}{2} = 3cm$	1 M	
		$y_2 = h_1 + \frac{h_2}{2} = 6 + \frac{2}{2} = 7cm$	1 M	
		$\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V}$		
		$\bar{y} = 6cm$	1 M	4 M
		Hence, centre of gravity (G) for given composite body lies at G($\bar{x}, \bar{y}$) = (3 cm from OB and 6 cm from OA)		
	f)	**The frustum of a cone has top diameter 40 cm & bottom diameter 60 cm with height 18 cm. Calculate y only.**		
	Ans.			
		Let, Full cone as Fig. 1 & cut cone as Fig. 2		
		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 60 / 2 = 30 cm		
		h_1 = 18 cm, h_2 = Height of cut cone		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
		In triangle, ABE & CDE $\frac{h}{60}=\frac{h_2}{40}$ $h=\frac{60}{40}h_2$ $h=1.5h_2$ $h_1+h_2=h$ $h_1+h_2=1.5h_2$ $h_1=1.5h_2-h_2$ $h_1=0.5h_2$ $18=0.5h_2$ $h_2=36cm$ $h=18+36=54cm$	1 M	
		2) Volume Calculation $V_1=(1/3)\pi r_1^2h=(1/3)\pi(30)^2X54=50.86X10^3cm^3$ $V_2=(1/3)\pi r_2^2h_2=(1/3)\pi(20)^2X36=15.07X10^3cm^3$ $V=V_1-V_2=35.82X10^3cm^3$	1 M	
		3) $\overline{y}$ calculation $y_1=\frac{h}{4}=\frac{54}{4}=13.5cm$ $y_2=h_1+\frac{h_2}{4}=18+\left(\frac{36}{4}\right)=27cm$	1 M	
		$\overline{y}=\frac{V_1y_1-V_2y_2}{V}$ $\overline{y}=7.815cm$	1 M	
		Hence, centre of gravity (G) for given frustum of cone lies at G($\overline{x},\overline{y}$) = (30 cm from AQ and 7.815 cm from AP)		4 M