
WINTER – 2015 EXAMINATION

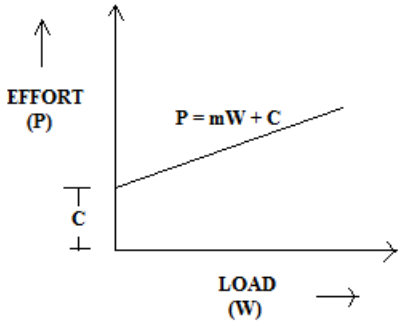
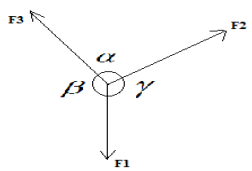
Subject & Code : **Engineering Mechanics (17204)**

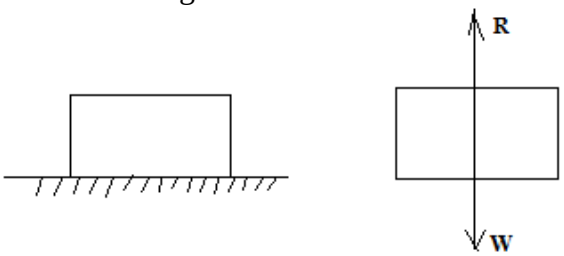
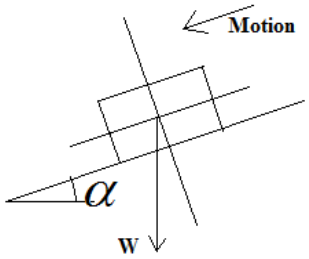
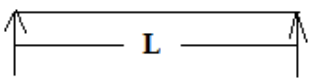
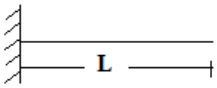
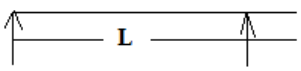
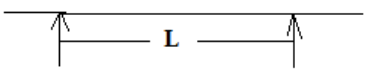
Important Instructions to examiners:

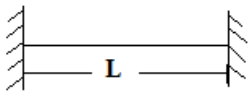
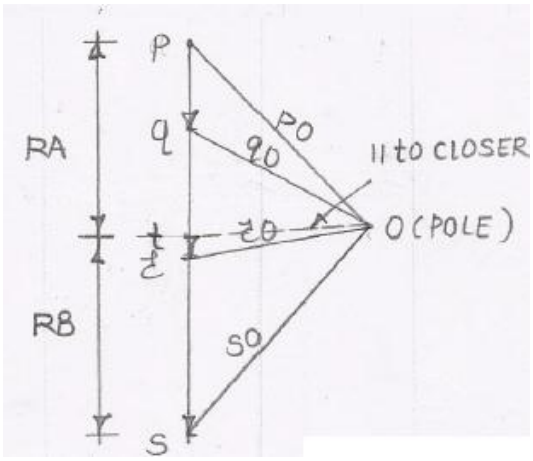
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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.

Model Answer

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1		**Attempt any TEN of the following :**		**20**
	a) Ans.	**What is efficiency of machine?** The efficiency of a machine is the ratio of output to input of a machine and is generally expressed as a percentage. $\%\eta = \frac{Output}{Input} X 100$ **OR** The efficiency of a machine can also be defined as a ratio of Mechanical Advantage (MA) to Velocity Ratio (VR) of a machine and is generally expressed as a percentage. $\%\eta = \frac{M.A.}{V.R.} X 100$	**1 M for define-tion and 1 for form-ula** **2 M**	
	b) Ans.	**Define mechanical advantage along with it's expression.** Mechanical Advantage is the ratio of the load lifted by the machine to the effort applied to lift the load. It is denoted by M.A. $M.A. = \frac{LOAD}{EFFORT} = \frac{W}{P}$	**1 M for define-tion and 1 for form-ula** **2 M**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1	C) **Ans.**	**What is law of machine?** The relation between the load lifted (W) and the effort applied (P) is known as the law of machine. This relationship, when plotted on a graph results in a straight line as shown below. The equation of this straight line is – $P = (mW + c)N$  Where, m = slope of line = constant c = Intercept on y axis = effort required to start the machine	**1 M** **1 M**	**2 M**
	d) **Ans.**	**Enlist four coplanar force system.** Following are the four coplanar force system – 1) Concurrent force system 2) Collinear force system 3) Non-concurrent force system 4) Parallel force system	**½ M for each**	**2 M**
	e) **Ans.**	**State four effects of forces on rigid body.** Following are the effects of forces on rigid 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.	**½ M for each**	**2 M**
	f) **Ans.**	**Define resolution of 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.	**2 M**	**2 M**
	g) **Ans.**	**Define Lami's theorem.** Lami's theorem 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. As per Lami's theorem, $\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$  	**1 M** **1 M**	**2 M**

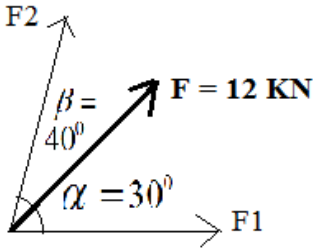
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1	h) **Ans.**	**Define free body diagram with one example.** In statics, for considering the equilibrium of the bodies under any system of forces, each body is separated from it's surrounding. Such body is known as a free body. If all active and reactive forces acting on free body are shown, the diagram is known as free body diagram. e. g. Consider block resting on a horizontal surface.  Block on horizontal surface Free body Diagram Where, W = Self weight of block = active force R = Reaction offered by the surface = reactive force. (Note : Student may take any example of lamp suspended form ceiling or sphere resting in a trough etc., so marks may be given.)	**1 M** **1 M**	**2 M**
	i) **Ans.**	**Define angle of repose with diagram.** Angle of repose is defined as the angle made by the inclined plane with the horizontal plane at which the body placed on an inclined plane is just on the point of moving down the plane, under the action of its own weight.  	**1 M** **1 M**	**2 M**
	j) **Ans.**	**State any two types of beams with diagram of each.** Following are the different types of beams – (1) Simply supported beam  (2) Cantilever beam  (3) Over hanging beam   		

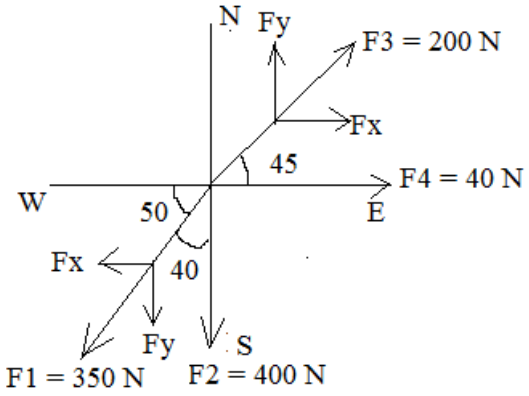
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1		(4) Fixed Beam  (5) Continuous beam  	**1 M each for any two types**	**2 M**
	k) Ans.	**Define polar diagram with one example.** Polar diagram is obtained from the vector diagram. To construct a polar diagram, any point "O" known as pole is chosen 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. e.g.  	**1 M** **1 M**	**2 M**
	l) Ans.	**Define centroid and centre of gravity.** **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 **Centre of Gravity :-** It is defined as the point through which the whole weight of the body is assumed to act, irrespective of the position of a body. e.g. Cone, Cylinder.	**1 M** **1 M**	**2 M**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2		**Attempt any <u>FOUR</u> of the following :**		**16 M**
	a)	**For a certain machine the law is P = (0.08 W + 5) N. Calculate the effort required to lift a load of 5 KN. Also calculate the maximum M.A. and identify the type of machine. V.R. of machine is 20.**		
	Ans.	1) Using Law of machine P = (0.08 W + 5) N. = ((0.08 X 5000) + 5) N ---------- Putting W = 5000 N = 405 N	**1 M**	
		2) Law of machine is given by P = (mW + C) N Hence, comparing given law of machine, we get, m = 0.08 Hence, Max. MA = 1/ m = 1 / 0.08 Max. MA = 12.5	**1 M**	
		3) $\%\eta = \frac{M.A.}{V.R.} X100$ $\%\eta = \frac{\left(\frac{W}{P}\right)}{V.R.} X100 = \frac{\left(\frac{5000}{405}\right)}{20} X100$ = 61.72 % > 50 %	**1 M**	
		4) As efficiency of machine is greater than 50 %, machine is Reversible machine.	**1 M**	**4 M**
	b)	**In a machine an effort of 2 N is lifted a load of 30 N. If the effort lost due to friction is 0.5 N. Find the velocity ratio and efficiency of machine.**		
	Ans.	1) Effort lost in friction is given by – $P_f = P - P_i$ $0.5 = 2 - P_i$ $P_i = 1.5$ N	**1 M**	
		2) Ideal Effort $P_i = W / VR$ 1.5 = 30 / VR		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2		VR = 30 / 1.5 = 20 3) Mechanical Advantage MA = W / P = 30 / 2 = 15 4) $\%\eta = \frac{M.A.}{V.R.} X 100 = \frac{15}{20} X 100$ $VR = \frac{N_1}{N_2} X \frac{N_3}{N_4} = \frac{120}{10} X \frac{20}{12}$ = 75 %	**1 M** **1 M** **1 M**	**4 M**
	c)	**A Weston's differential pulley block is used to lift a load of 8 KN. The diameter of pulleys are 26 cm and 24 cm. Calculate the effort required if the efficiency is 45 %. Also calculate the load lost in friction.**		
	Ans.	1) VR of Weston's differential pulley block is given by - $VR = \frac{2D}{D-d} = \frac{2X26}{26-24}$ VR = 26 2) $\%\eta = \frac{M.A.}{V.R.} X 100$ $45 = \frac{MA}{26} X 100$ $MA = \frac{45X26}{100}$ MA = 11.7 But, $MA = \frac{W}{P}$ $11.7 = \frac{8000}{P}$ $P = \frac{8000}{11.7}$ P = 683.76 N 3) Ideal Load (W_i) = P X VR = 683.76 X 26 =17777.76 N 4) Load lost in friction (W_f) = W_i – W = 17777.76 – 8000 = 9777.76 N	**1 M** **1 M** **1 M** **1 M**	**4 M**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2	**d)**	**A geared pulley block is used to lift a load by an effort of 1000 N with 60 % efficiency. Calculate the load lifted by the effort –** **(i) Cogs on effort wheel = 120,** **(ii) Cogs on load drum = 12,** **(iii) No. of teeth on pinion = 10,** **(iv) No. of teeth on spur = 20**		
	Ans.	1) Let, (i) Cogs on effort wheel (N_1) = 120, (ii) No. of teeth on pinion (N_2) = 10, (iii) No. of teeth on spur (N_3) = 20 (iv) Cogs on load drum (N_4) = 12, VR of geared pulley block is given by – $VR = \frac{N_1}{N_2} X \frac{N_3}{N_4}$ $VR = \frac{120}{10} X \frac{20}{12}$	**1M**	
		VR = 20	**1 M**	
		2) $\%\eta = \frac{M.A.}{V.R.} X 100$ $60 = \frac{MA}{20} X 100$ $MA = \frac{60 X 20}{100}$		
		MA = 12	**1 M**	
		3) $MA = \frac{W}{P}$ $12 = \frac{W}{1000}$ $W = 12 X 1000$		
		W = 12000 N OR 12 KN	**1 M**	**4 M**
	e)	**A screw jack has an effort wheel diameter of 20 cm and pitch is 5 mm. Find velocity ratio. If a load of 1000 N is lifted by an effort of 150 N. Find the efficiency of the machine.**		
	Ans.	1) VR of simple screw jack is given by -		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2				
		$VR = \frac{\pi D}{p}$	**1 M**	
		$VR = \frac{\pi X 200}{5}$		
		VR = 125.66	**1 M**	
		2) $MA = \frac{W}{P} = \frac{1000}{150} = 6.66$	**1 M**	
		3) $\%\eta = \frac{M.A.}{V.R.} X100 = \frac{6.66}{125.66} X100$		
		= 5.31 %	**1 M**	**4 M**
	f)	**A machine has a VR = 50. A load of 3 KN is lifted by an effort of 150 N. Calculate MA, efficiency and effort lost in friction and ideal effort.**		
	Ans.	1) MA = W / P = 3000 / 150 = 20	**1 M**	
		2) $\%\eta = \frac{M.A.}{V.R.} X100 = \frac{20}{50} X100$		
		= 40 %	**1 M**	
		3) Ideal Effort		
		$P_i = \frac{W}{VR} = \frac{3000}{50} = 60N$	**1 M**	
		4) Effort lost in friction		
		$P_f = P - P_i = 150 - 60 = 90N$	**1 M**	**4 M**
3		**Attempt any <u>FOUR</u> of the following :**		**16**
	a)	**Resolve a force of 12 KN into two directions at 30° and 40° on either side of it.**		
	Ans.			

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		Resolving forces as shown in fig.		
		$F_1 = \frac{F \sin\beta}{\sin(\alpha+\beta)}$	**1 M**	
		$F_1 = \frac{12X \sin 40}{\sin(30+40)}$		
		$F_1 = 8.208KN$	**1 M**	
		$F_2 = \frac{F \sin\alpha}{\sin(\alpha+\beta)}$	**1 M**	
		$F_2 = \frac{12X \sin 30}{\sin(30+40)}$		
		$F_2 = 6.39KN$	**1 M**	**4 M**
	b)	**Find the orthogonal components of each of the following forces –** **(i) 350 N acting 40° West of South** **(ii) 400 N acting due South** **(iii) 200 N acting North – East** **(iv) 40 N acting due East**		
	Ans.			

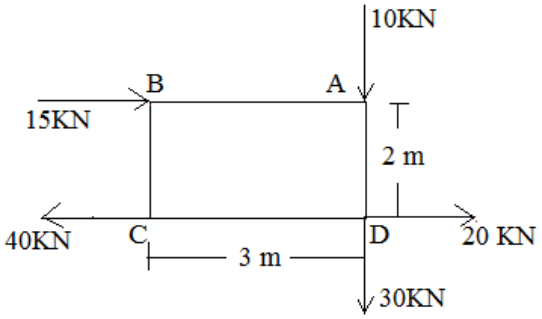
Force (F) in N	θ w.r.to x axis	Orthogonal components	
		$F_x = F \cos\theta$	$F_y = F \sin\theta$
$F_1 = 350$	$\theta_1 = 50°$	= - 350 cos 50 **= - 224.98 N**	= -350 sin 50 **= - 268.12 N**
$F_2 = 400$	$\theta_2 = 270°$	= 400 cos 270 **= 0 N**	= - 400 sin 270 **= - 400 N**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks

Force (F) in N	θ w.r.to x axis	Ortho onal components	
		$F_x = F \cos \theta$	$F_y = F \sin \theta$
$F_3 = 200$	$\theta_3 = 45°$	= 200 cos 45 **= 141.42 N**	= 200 sin 45 **= 141.42 N**
$F_4 = 40$	$\theta_4 = 0°$	= 40 cos 0 **= 40 N**	= 40 sin 0 **= 0 N**

Each Fx & Fy compo -nent ½ M

c) **Calculate the moment about point B for the force system as shown in fig.**



Ans.

Taking moment @ point B –

M_B = (15 X 0) + (10 X 3) – (20 X 2) + (30 X 3) + (40 X 2) **2 M**

= 0 + 30 – 40 + 90 + 80 **1 M**

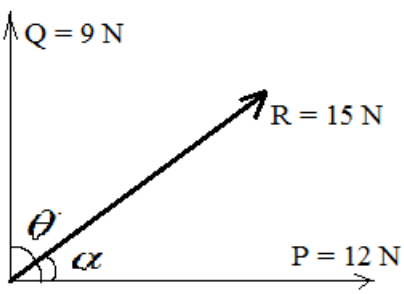
= + 160 N-m (↻) **1 M**

= 160 N-m (Clockwise moment) **4 M**

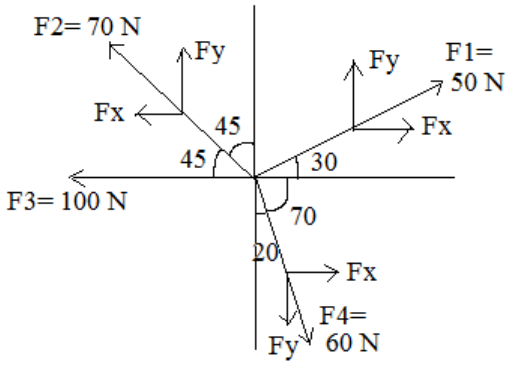
d) **Two forces of 12 N and 9 N are acting at a point such that their resultant is 15 N. Find the angle between them. Also find angle between resultant and one of the force.**

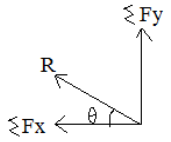
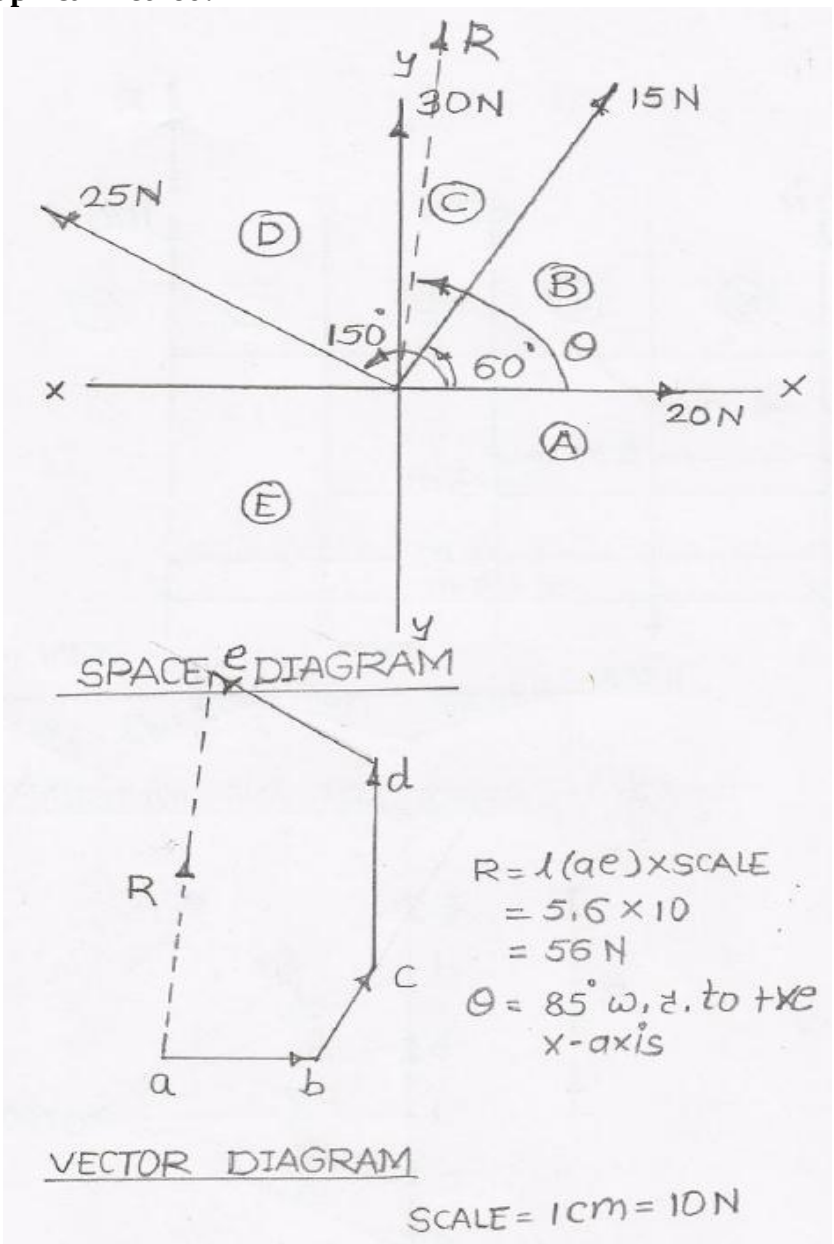
Ans.

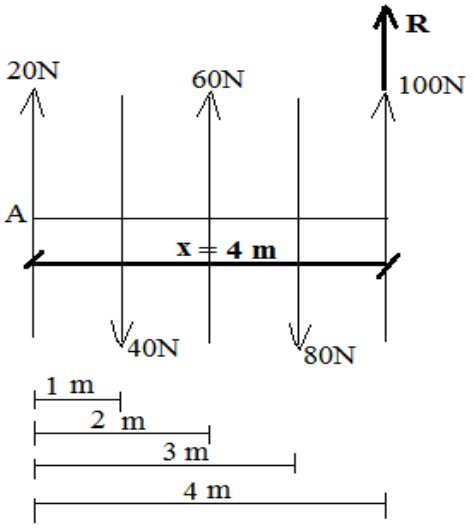
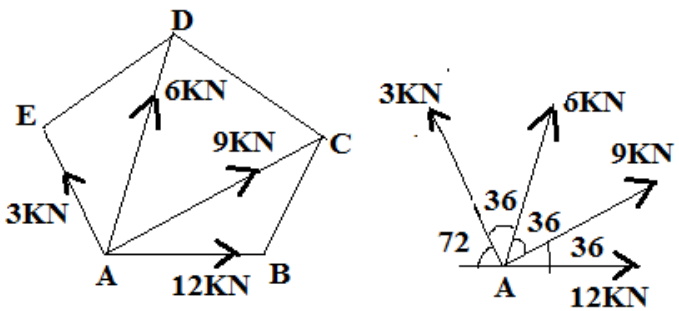
1) Let, P be the 12 N force and Q be the 9 N force.
θ be the angle between P and Q force.
α be the angle between P & R.

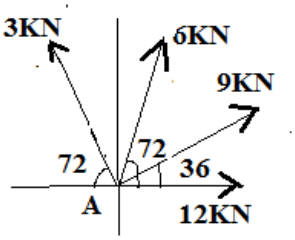
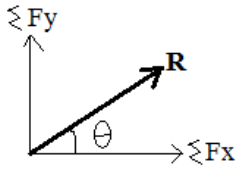


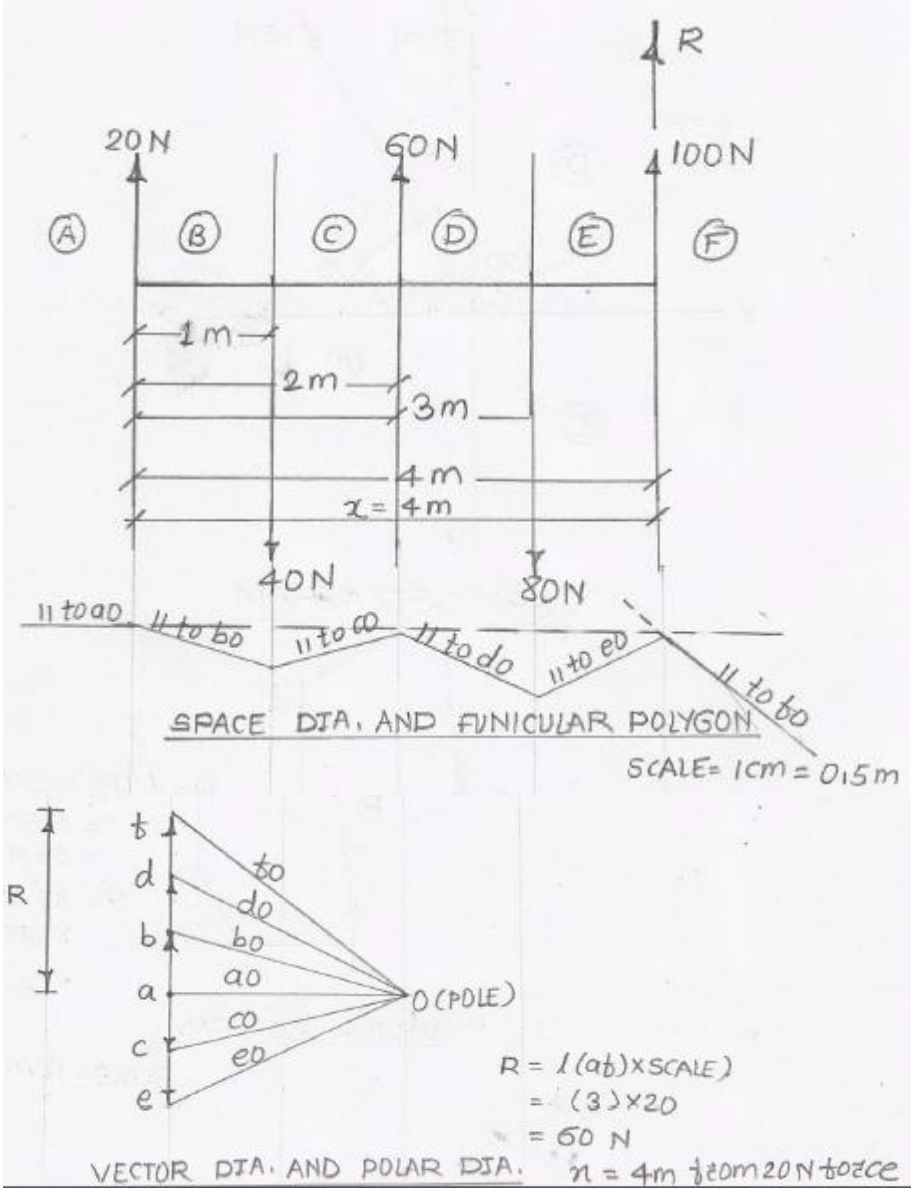
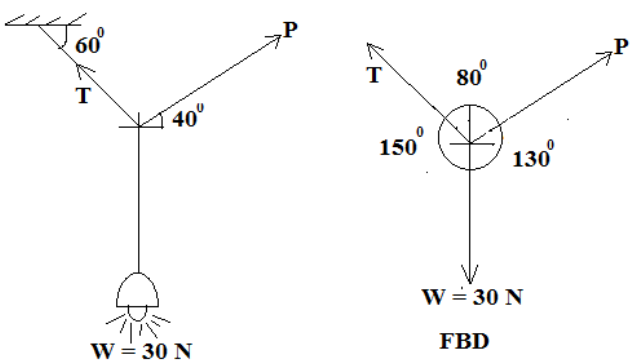
1 M

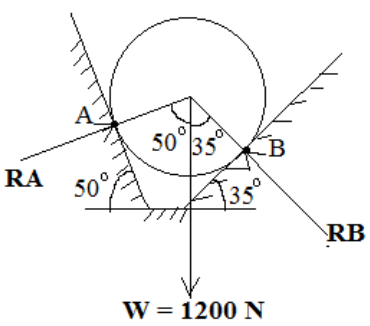
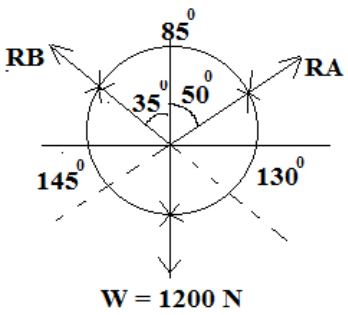
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		2) Using Law of parallelogram of forces $R^2 = P^2 + Q^2 + 2PQ\cos\theta$ $(15)^2 = (12)^2 + (9)^2 + (2 \text{ X } 12 \text{ X } 9 \text{ X } \cos\theta)$ $225 = 144 + 81 + 216 \cos\theta$ $225 = 225 + 216 \cos\theta$ $225 - 225 = 216 \cos\theta$ $0 = 216 \cos\theta$ $0 = \cos\theta$ $\theta = \cos^{-1}(0)$ $\theta = 90°$ Hence, the two forces are perpendicular to each other. 3) Using relation, $\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta} = \frac{9\sin 90}{12 + 9\cos 90}$ $\tan\alpha = 0.75$ $\alpha = \tan^{-1}(0.75)$ $\alpha = 36.87°$ with 12 N force **OR** Angle between Q and R = 90°- 36.87° = 53.13°	**1 M** **1 M** **1 M**	**4 M**
	e)	**Calculate the magnitude and direction of resultant for concurrent force system as shown in Fig.. Use analytical method.**  		
	Ans	1) Resolving all forces – $\Sigma Fx = + (50 \cos 30) - (70 \cos 45) + (100 \cos 180) + (60 \cos 70)$ $= + 43.30 - 49.50 - 100 + 20.52$ $= - 85.68$ N $\Sigma Fy = + (50 \sin 30) + (70 \sin 45) + (100 \sin 180) - (60 \sin 70)$ $= + 25 + 49.50 + 0 - 56.38$ $= + 18.12$ N 2) Magnitude of Resultant $R = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2}$ $R = \sqrt{(-85.68)^2 + (18.12)^2}$ $R = 87.58N$	**1 M** **1 M** **1 M**	

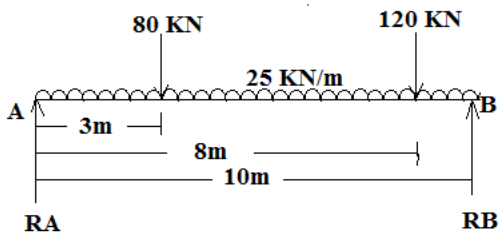
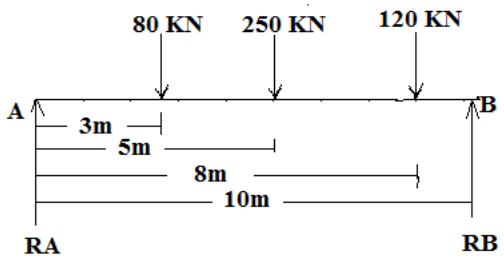
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		3) Direction and position of resultant As Σ Fx is –ve and Σ Fy is +ve , Resultant lies in 2nd quadrant.	**1/2 M**	
		$\theta = \tan^{-1}\left\lvert\frac{\sum Fy}{\sum Fx}\right\rvert = \tan^{-1}\left\lvert\frac{18.12}{85.68}\right\rvert$ $\theta = 11.94°$  	**1/2 M**	**4 M**
	f) **Ans.**	**Four forces of 20 N, 15 N, 30 N and 25 N are acting at 0°, 60°, 90° and 150° from x-axis taken in order. Find the resultant by graphical method.**  	**2 M for each diag-ram with all nota-tions** **4 M**	

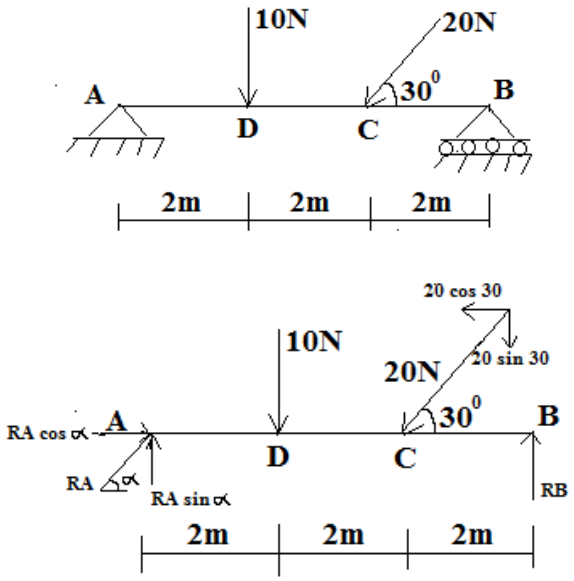
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		**Attempt any FOUR of the following :**		**16**
	a)	**Five parallel forces of 20, 40, 60, 80 and 100 N are acting on beam. Distances of forces from 20 N force are 1m, 2m, 3m and 4m. Forces of 40 N and 80 N are acting vertically downwards. Other pointing upwards. Find resultant in magnitude and direction and locate it's position with respect to 20 N force.**		
	Ans.	1) 	**1 M**	
		Magnitude of Resultant R = + 20 – 40 + 60 – 80 + 100 = + 60 N (↑) + ve sign indicates Resultant acts vertically upwards.	**1 M**	
		2) Position of Resultant Considering Varignon's theorem of moment & taking moment of all forces @ point A i.e. about 20 N force. Let, R acts at x distance from point A. $\Sigma M_{FA} = M_{RA}$ (20 0) + (40 X 1) – (60 X 2) + (80 X 3) – (100 X 4) = - R X x - 240 = - 60 X x x = 4 m	**1 M**	
		Hence, R must be located at 4 m distance from 20 N force, so as to produce anticlockwise moment.	**1 M**	**4 M**
	b)	**Forces of 3, 6, 9 and 12 KN respectively acts on a regular pentagon as shown in figure. Find the resultant in magnitude and direction. Use analytical method only.**		
	Ans.			

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		1) Exterior angle = 360 / No. of angular points = 360 / 5 = 72° Interior angle = 180° – 72° = 108° Angle BAC = Angle CAD = Angle DAE = 108° / 3 = 36°  	**1 M**	
		2) Magnitude of Resultant Resolving all forces – Σ Fx = (12 cos 0) + (9 cos 36) + (6 cos 72) – (3 cos 72) = + 12 + 7.28 + 1.85 – 0.93 = + 20.2 N	**1/2 M**	
		Σ Fy = (12 sin 0) + (9 sin 36) + (6 sin 72) + (3 sin 72) = 0 + 5.29 + 5.71 + 2.85 = + 13. 85 N	**1/2 M**	
		3) Magnitude of resultant $R = \sqrt{(\sum Fx)^2 + (\sum Fy)^2}$ $R = \sqrt{(20.2)^2 + (13.85)^2}$ $R = 24.49N$	**1 M**	
		4) Direction and position of resultant As Σ Fx = +ve and Σ Fy = + ve, R lies in 1st quadrant	**1/2 M**	
		$\theta = \tan^{-1}\left\lvert\frac{\sum Fy}{\sum Fx}\right\rvert = \tan^{-1}\left\lvert\frac{13.85}{20.2}\right\rvert$ $\theta = 34.44°$  	**1/2 M**	**4 M**
	c) Ans.	**Solve Q. 4 (a) graphically**		

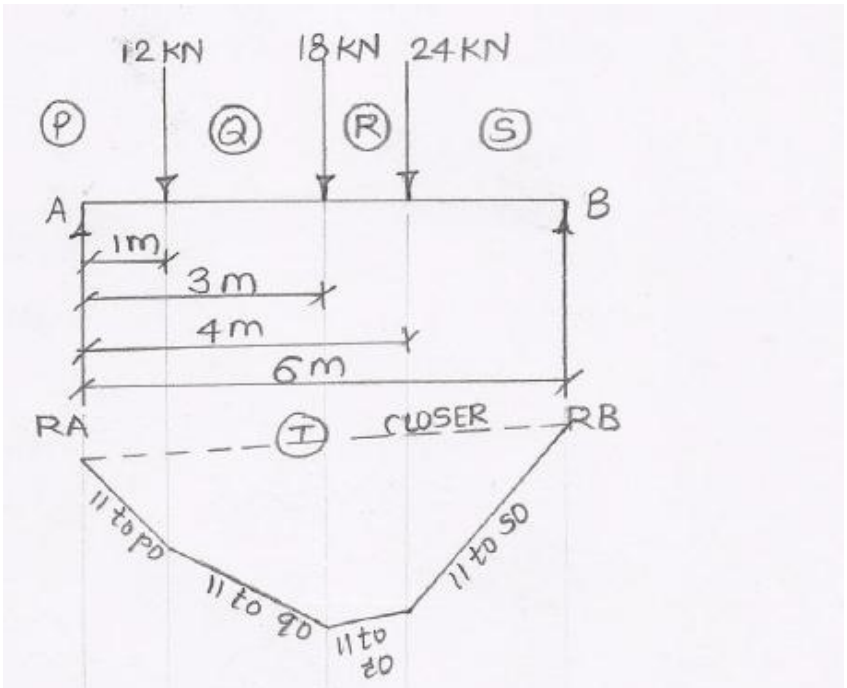
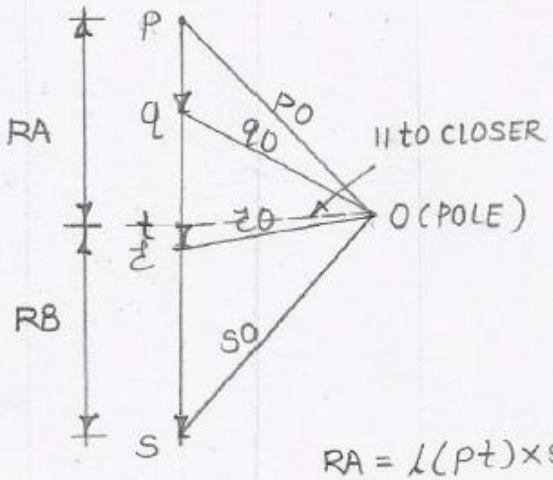
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4			**2 M for each diagram with all notations**	**4 M**
	d)	**An electric bulb of 30 N weight is hanging from ceiling. It's wire is pulled by a force acting at 40° to the horizontal such that the wire makes an angle of 60° with the ceiling. Find the magnitude of force and tension in the wire.**		
	Ans.		**1 M**	

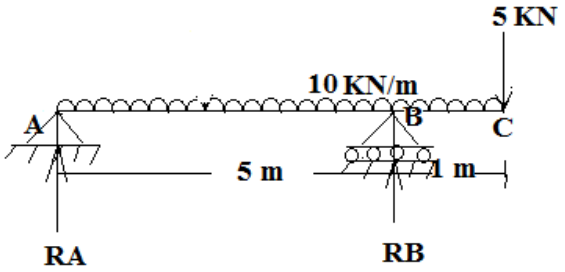
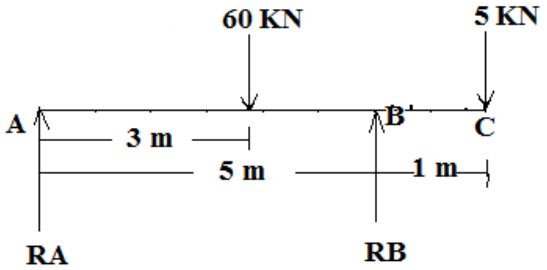
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		Using Lami's theorem, $\frac{W}{\sin 80°} = \frac{T}{\sin 130°} = \frac{P}{\sin 150°}$ $\frac{30}{\sin 80°} = \frac{T}{\sin 130°} = \frac{P}{\sin 150°}$ (1) (2) (3)	**1 M**	
		Using term (1) and (2) $\frac{30}{\sin 80°} = \frac{T}{\sin 130°}$ $T = 30X \frac{\sin 130°}{\sin 80°}$ T = 23.34 N	**1 M**	
		Using term (1) and (3) $\frac{30}{\sin 80°} = \frac{P}{\sin 150°}$ $P = 30X \frac{\sin 150°}{\sin 80°}$ P = 15.23 N	**1 M**	**4 M**
	e)	**A sphere weights 1200 N. It is supported by two planes at 35° and 50° to the horizontal respectively. Calculate the support reactions.**		
	Ans.	  **FBD**	**1 M**	

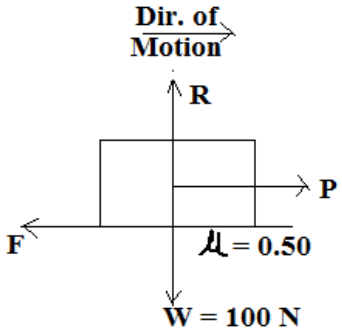
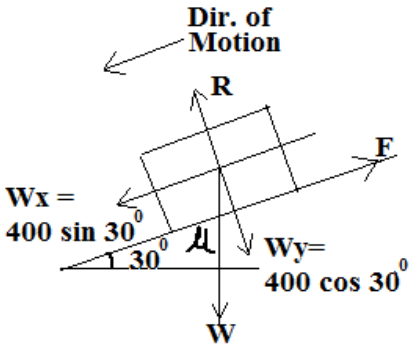
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		Using Lami's theorem, $\frac{W}{\sin 85°} = \frac{RA}{\sin 145°} = \frac{RB}{\sin 130°}$ $\frac{1200}{\sin 85°} = \frac{RA}{\sin 145°} = \frac{RB}{\sin 130°}$ (1) (2) (3)	**1 M**	
		Using term (1) and (2) $\frac{1200}{\sin 85°} = \frac{RA}{\sin 145°}$ $RA = 1200X \frac{\sin 145°}{\sin 85°}$		
		RA = 690.92 N	**1 M**	
		Using term (1) and (3) $\frac{1200}{\sin 85°} = \frac{RB}{\sin 130°}$ $RB = 1200X \frac{\sin 130°}{\sin 85°}$		
		RB = 922.77 N	**1 M**	**4 M**
	f)	**A simply supported beam is of 10 m span. It has a udl of 25 KN/m throughout it's length and point loads of 80 KN and 120 KN at 3m and 8 m from left support. Calculate the reactions at support using analytical method.**		
	Ans.		**1 M**	
				

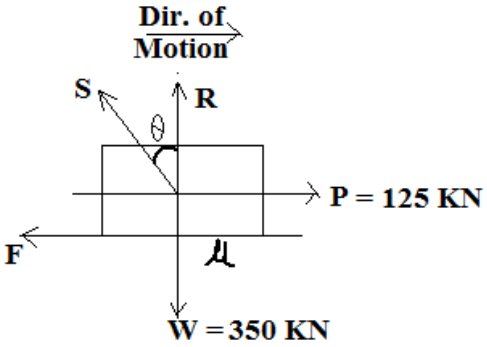
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		1) Equivalent point load and it's position Equivalent point load = Intensity of udl X span of udl = 25 X 10 = 250 KN Position from RA = Span of udl / 2 = 10 / 2 = 5 m 2) Applying equilibrium conditions $\Sigma Fy = 0$ (↑ +ve , ↓ −ve) and $\Sigma M = 0$ (↺ +ve , ↻ −ve) $\Sigma Fy = 0$ RA – 80 – (25 X 10) – 120 + RB = 0 RA + RB = 450 KN -------(1) $\Sigma M_A = 0$ Taking moment of all forces @ point A (RA x 0) + (80 X 3) + (250 X 5) + (120 X 8) – (RB X 10) = 0 2450 = 10 RB RB = 245 KN Putting value of RB in eqn. 1 RA + 245 = 450 RA = 205 KN	**1 M** **1 M** **1 M**	**4 M**
5		**Attempt any <u>FOUR</u> of the following :**		**16**
	a)	**Calculate the reactions of beam at the support as shown in figure using analytical method.**		
	Ans.	 Reaction at roller support is always perpendicular to the support but reaction at hinge support will be inclined due to inclined load. Let, this inclination is α.	**1 M**	

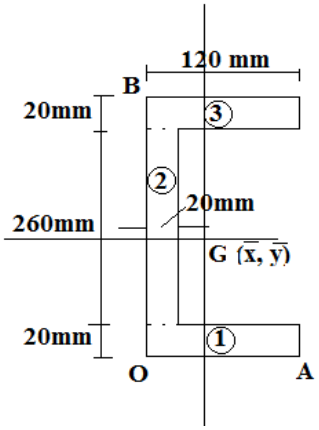
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		Applying equilibrium conditions – $\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$, $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ and $\Sigma M = 0$ $(\circlearrowleft +ve, \circlearrowright -ve)$ $\Sigma Fx = 0$ $RA \cos\alpha - 20 \cos 30 = 0$ $RA \cos\alpha = 17.32$ -------(1) $\Sigma Fy = 0$ $RA \sin\alpha - 10 - 20 \sin 30 + RB = 0$ $RA \sin\alpha + RB = 20$ -------- (2) Taking moment of all forces @ point A $\Sigma M_A = 0$ $+ (10 \times 2) + (20 \sin 30 \times 4) - (RB \times 6) = 0$ $20 + 40 = 6\ RB$ $RB = 10$ N Putting value of RB in eqn. (2) $RA \sin\alpha + 10 = 20$ $RA \sin\alpha = 10$ ------- (3) Divide eqn. (3) by (1) $\frac{RA \sin\alpha}{RA \cos\alpha} = \frac{10}{17.32}$ $\tan\alpha = 0.577$ $\alpha = \tan^{-1}(0.577) = 30°$ Putting value of α in eqn (1) $RA \cos 30 = 17.32$ $RA = 20$ N	**1 M** **1 M** **1 M**	**4 M**
	b)	**A beam of 6 m span simply supported at ends. It carries three loads 12 KN, 18 KN, 24 KN at 1m, 3m, 4m respectively from left hand support. Calculate reactions at the end of the beam graphically.**		

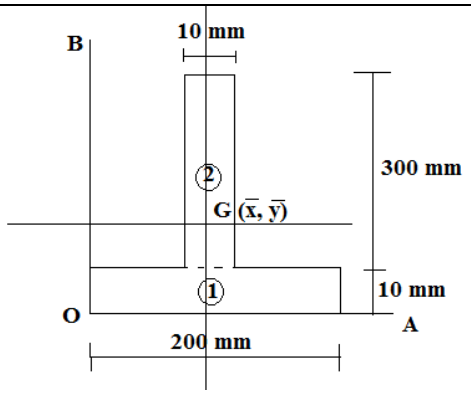
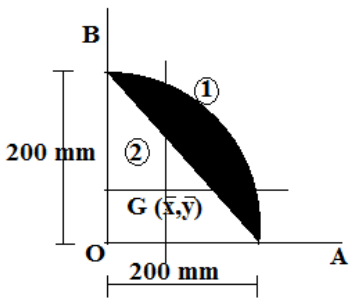
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5	**Ans.**	 SPACE DIA. AND FUNICULAR POLYGON SCALE = 1cm = 1m  RA = l(pt) × SCALE = (2.7 × 10) = 27 KN RB = l(st) × SCALE) = (2.7 × 10) = 27 KN VECTOR DIA. AND POLAR DIA. SCALE = 1cm = 10 KN	**2 M for each diag-ram with all notati ons**	**4 M**

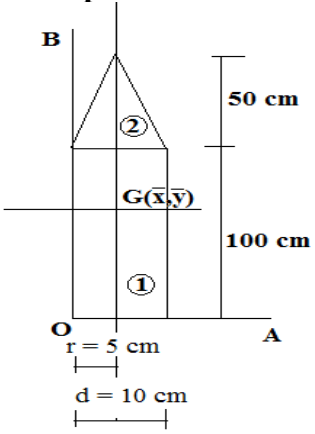
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5	c)	**A beam ABC is hinged at A and placed rollers at B. The distance between two supports AB is 5 m and overhanging BC is 1 m. The beam carries a udl of 10 KN/m over it is entire length along with a point load of 5 KN at C. Calculate support reactions by analytical method.**		
	Ans.			
			**1 M**	
		As all loads are vertical on beam and plane of roller is also not inclined, reaction at support A will act vertically upwards. 1) Equivalent point load and it's position Equivalent point load = Intensity of udl X span of udl = 10 X 6 = 60 KN Position from RA = Span of udl / 2 = 6 / 2 = 3 m 2) Applying equilibrium conditions $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ and $\Sigma M = 0$ $(\circlearrowleft +ve, \circlearrowright -ve)$ $\Sigma Fy = 0$ RA – 60 + RB - 5 = 0 RA + RB = 65 KN -------(1)	**1 M**	
		$\Sigma M_A = 0$ Taking moment of all forces @ point A (RA x 0) + (60 X 3) – (RB X 5) + (5 X 6) = 0 210 = 5 RB RB = 42 KN	**1 M**	
		Putting value of RB in eqn. 1 RA + 42 = 65 RA = 23 KN	**1M**	**4 M**
	d)	**A block weighing 100 N can be just moved by applying a pull of P N being applied horizontal. Find P if coefficient of friction between block and surface is 0.50.**		
	Ans.			

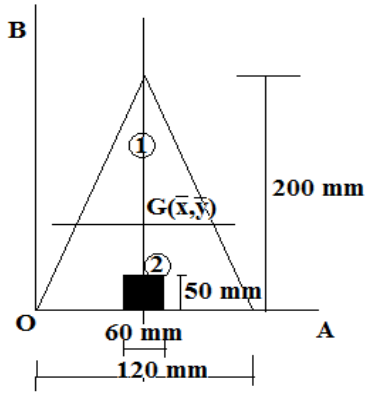
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		 For limiting equilibrium $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ + R – W = 0 R = W = 100 N $\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$ + P – F = 0 + P – μR = 0 +P – (0.50 X 100) = 0 P = 50 N	**1 M** **1 M** **2 M**	**4 M**
	e)	**A body of weight 400 N resting on a inclined plane inclined at an angle of 30° with the horizontal just started to move down the plane. Calculate :** **(i) Coefficient of friction** **(ii) Angle of friction** **(iii) Angle of repose**		
	Ans.	 Consider inclined plane as x-x axis and perpendicular to it as y-y axis. For limiting equilibrium $\Sigma Fy = 0$ + R – Wy = 0 R = Wy = 400 cos 30 R = 346.47 N $\Sigma Fx = 0$ + F – Wx = 0 μR – 400 sin 30 = 0 (μ X 346.47) = 200 μ = 300 / 346.47	**1 M** **1 M**	

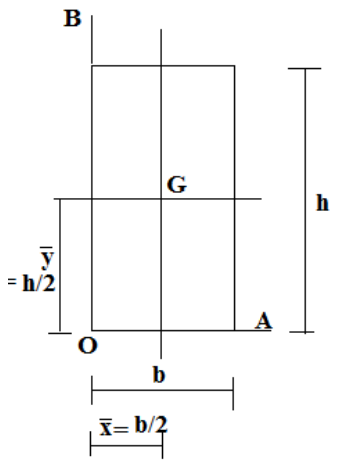
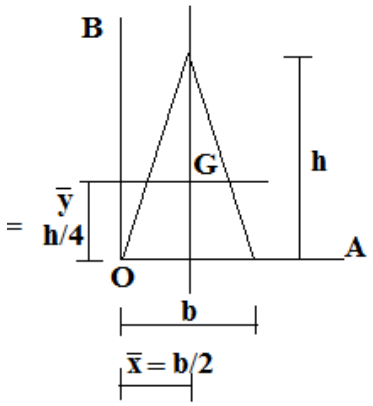
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		$\mu = 0.577$ Using relation between coefficient of friction, angle of friction and angle of repose $\mu = \tan\alpha = \tan\phi$ $0.577 = \tan\alpha = \tan\phi$ $\alpha = \phi = 29.98°$	**1 M** **1 M**	**4 M**
	f)	**A body weighing 350 KN is resting on a horizontal plane and can be just moved by a force of 125 KN applied horizontally. Find coefficient of friction. Also find magnitude and direction of resultant reaction.**		
	Ans.	 1) For limiting equilibrium $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ $+ R - W = 0$ $R = W = 350$ KN	**1 M**
		$\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$ $+ P - F = 0$ $P = F$ $P = \mu R$ $125 = \mu$ X 350 $\mu = 125 / 350$ $\mu = 0.36$	**1 M**
		2) Resultant reaction $s = \sqrt{F^2 + R^2} = \sqrt{(\mu R)^2 + R^2}$ $S = \sqrt{(0.36X350)^2 + (350)^2}$ S = 371.99 N	**1 M**
		3) Direction of resultant reaction $\tan\phi = \frac{F}{R} = \frac{\mu R}{R} = \mu$	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		$\phi = \tan^{-1}\mu = \tan^{-1}(0.36)$ $\phi = 19.80°$	**1 M**	**4 M**
6		**Attempt any <u>FOUR</u> of the following :**		**16**
	a)	**Find the centroid for a channel section as shown in figure.**		
				
	Ans.	1) Figure is symmetric @ x-x axis and hence, $\bar{y}$ = Maximum vertical dimension /2 = 300 / 2 = 150 mm	**1 M**	
		2) Area calculation $A_1 = A_3 = 120 \text{ X } 20 = 2400 \text{ mm}^2$ $A_2 = 260 \text{ X } 20 = 5200 \text{ mm}^2$ $A = A_1 + A_2 + A_3 = 10000 \text{ mm}^2$	**1 M**	
		3) Location of $\bar{x}$ $x_1 = x_3 = 120 / 2 = 60$ mm $x_2 = 20 / 2 = 10$ mm	**1 M**	
		$\bar{x} = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A}$ $\bar{x} = \frac{(2400X60) + (5200X10) + (2400X60)}{10000}$ $\bar{x} = 34mm$	**1 M**	
		Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (34 mm from OB and 150 mm from OA)		**4 M**
	b)	**Find the centroid of an inverted T – Section with flange 200 X 10 mm and a web of 300 X 10 mm.**		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6	**Ans.**	 1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 200 / 2 = 100 mm	**1 M**	**4 M**
		2) Area calculation $A_1 = 200 \times 10 = 2000\ mm^2$ $A_2 = 300 \times 10 = 3000\ mm^2$ $A = A_1 + A_2 = 5000\ mm^2$	**1 M**	
		3) Location of $\bar{y}$ $y_1 = 10 / 2 = 5$ mm $y_2 = 10 + (300/2) = 160$ mm	**1 M**	
		$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A}$ $\bar{y} = \frac{(2000 X 5) + (3000 X 160)}{5000}$ $\bar{y} = 98 mm$	**1 M**	
		Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (100 mm from OB and 98 mm from OA)		
	c)	**Find the centroid of the shaded area of a lamina as shown in figure.** 		
	Ans.	1) Let, Fig. 1 – Quarter circle and Fig. 2 – Triangle		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		Area Calculation $A_1 = \frac{\pi r^2}{4} = \frac{\pi(200)^4}{4} = 31415.93 mm^2$ $A_2 = \frac{1}{2}bh = \frac{1}{2} X\, 200 X\, 200 = 20000 mm^2$ $A = A_1 - A_2 = 11415.93 mm^2$	**1 M**	
		2) $\bar{x}$ calculation $x_1 = \frac{4r}{3\pi} = \frac{4X\,200}{3\pi} = 84.88 mm$ $x_2 = \frac{b}{3} = \frac{200}{3} = 66.67 mm$ $\bar{x} = \frac{A_1 x_1 - A_2 x_2}{A} = \frac{(31415.93 X\, 84.88) - (20000 X\, 66.67)}{11415.93}$ $\bar{x} = 116.78 mm$	**½ M** **1 M**	
		3) $\bar{y}$ calculation $y_1 = \frac{4r}{3\pi} = \frac{4X\,200}{3\pi} = 84.88 mm$ $y_2 = \frac{b}{3} = \frac{200}{3} = 66.67 mm$ $\bar{y} = \frac{A_1 y_1 - A_2 y_2}{A} = \frac{(31415.93 X\, 84.88) - (20000 X\, 66.67)}{11415.93}$ $y = 116.78 mm$	**½ M** **1 M**	
		Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (116.78 mm from OB and 116.78 mm from OA)		**4 M**
	d)	**A right circular cone of 5 cm radius and 50 cm height is placed co-axially on a solid cylinder of 5 cm radius and 100 cm height. Find centre of gravity of the composite solid.**  		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 10 / 2 = 5 cm	**1 M**	
		2) Volume Calculation $V_1 = \pi r^2 h = \pi(5)^2 100 = 7853.98 cm^3$ $V_2 = (1/3)\pi r^2 h = (1/3)\pi(5)^2 X\, 50 = 1308.99 cm^3$ $V = V_1 + V_2 = 9162.97 cm^3$	**1 M**	
		3) $\bar{y}$ calculation $y_1 = 100/2 = 50 cm$ $y_2 = 100 + (50/4) = 112.5 cm$ $\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V} = \frac{(7853.98 X\, 50) + (1308.99 X 112.5)}{9162.97}$ $\bar{y} = 58.92 cm$	**1 M** **1 M**	
		Hence, centre of gravity (G) for given composite body lies at G($\bar{x}, \bar{y}$) = (5 cm from OB and 58.92 cm from OA)		**4 M**
	e)	**A cone has base 120 mm and height 200 mm. In to it a hole of diameter 60 mm is drilled upto a depth of 50 mm. Find centre of gravity of remaining volume of cone.**		
				
	Ans.	Let's assume that hole is drilled co-axially with the cone. 1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 120 / 2 = 60 mm	**1 M**	
		2) Volume Calculation		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		$V_1 = (1/3)\pi r^2 h = (1/3)\pi(60)^2 X\, 200 = 753982.24 mm^3$ $V_2 = \pi r^2 h = \pi(30)^2 50 = 141371.67 mm^3$ $V = V_1 - V_2 = 612610.57 mm^3$	**1 M**	
		3) $\bar{y}$ calculation $y_1 = 200/4 = 50 mm$ $y_2 = 50/2 = 25 mm$	**1 M**	
		$\bar{y} = \frac{V_1 y_1 - V_2 y_2}{V} = \frac{(753982.24 X\, 50) - (141371.67 X\, 25)}{612610.57}$ $\bar{y} = 55.77 mm$	**1 M**	
		Hence, centre of gravity (G) for given composite body lies at G($\bar{x}, \bar{y}$) = (60mm from OB and 55.77 mm from OA)		**4 M**
	f)	**Draw the sketch of solid cylinder and solid cone and show the position of CG on it.**		
	Ans.	1) Solid cylinder  	**1 M for each figure and ½ M for each $\bar{x}, \bar{y}$**	
		2) Solid cone  		**4 M**