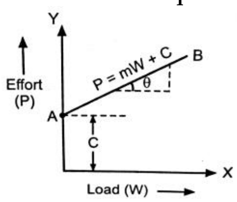
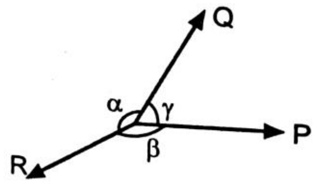
Model Answer: Winter-2018

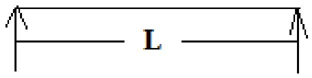
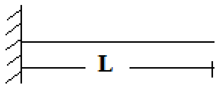
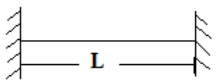
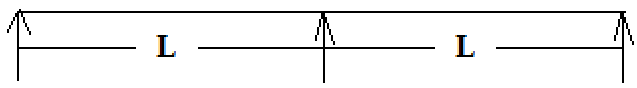
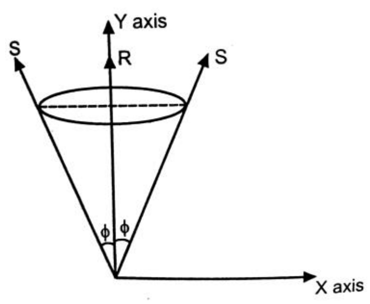
Subject: Engineering Mechanics. **Sub. Code: 17204**

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.

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1		**Attempt any TEN:**		(20)
	(a) Ans.	**Define efficiency of machine.** The ratio of output to input of a machine is known as efficiency. It is expressed in %. **OR** The ratio of Mechanical Advantage (M.A.) to Velocity Ratio (V.R.) of a machine is known as efficiency. It is expressed in %.	2	2
	(b) Ans.	**Define Reversible & Non-reversible machine with it's condition.** **Reversible Machine:** A machine which is capable of doing work in the reverse direction after the effort is removed is called the 'reversible' machine. Condition for Reversible machine : $\%\eta > 50\%$	1	2
		Non-reversible Machine: A machine which is not capable of doing work in the reverse direction after the effort is removed is called the 'non-reversible' or 'self-locking' machine. Condition for Non-reversible machine : $\%\eta < 50\%$	1	
	(c) Ans.	**What is law of machine?** **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 in figure below. The equation of this straight line is P = (mW+C) N  C = Intercept on y axis. i.e. effort required to start the machine. m = Slope of line.	2	2

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	(d) Ans.	**State principle of transmissibility of force.** **Principle of Transmissibility of Force**: It states that if a force acts at a point on a rigid body, it is assumed to act at any other point on the line of action of force within the same body.	2	2
	(e) Ans.	**State statics & dynamics.** **Statics:** It is the branch of applied mechanics which deals with forces and their action on bodies at rest.	1	2
		Dynamics: It is the branch of applied mechanics which deals with forces and their action on bodies in motion.	1	
	(f) Ans.	**Define a force & state it's SI unit.** **Force:** It is an external agency either push or pulls which changes or tends to change the state of rest or of uniform motion of a body, upon which it acts.	1	2
		S. I. Unit of force – N, kN	1	
	(g) Ans.	**Explain space diagram & vector diagram.** **Space diagram**: It is the diagram in which number of forces acting on body is drawn in space to a suitable scale and naming the spaces in order by Bow's notation.	1	2
		Vector diagram: It is the diagram in which the forces are taken to a suitable scale and drawn parallel to their respective lines of action of the forces drawn in space diagram by maintaining the same order as it was maintained in space diagram.	1	
	(h) Ans.	**Define Lami's theorem.** **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 sin of the angle between the other two forces. As per Lami's theorem, $\frac{P}{\sin\alpha}=\frac{Q}{\sin\beta}=\frac{R}{\sin\gamma}$ 	2	2

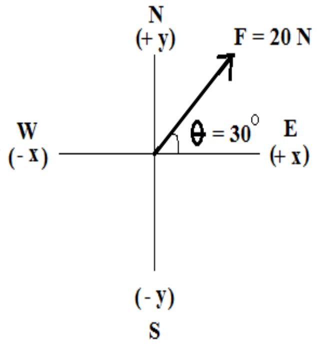
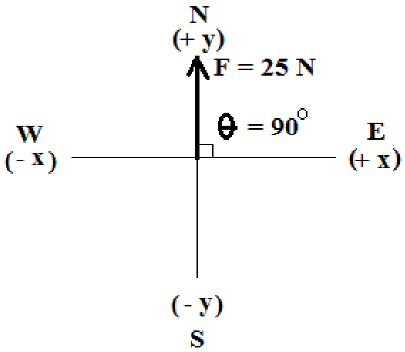
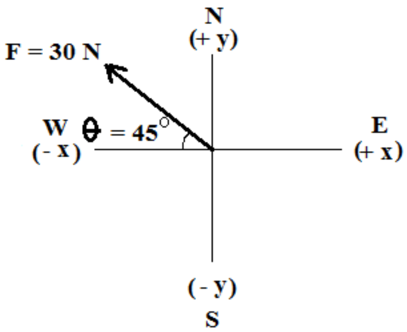
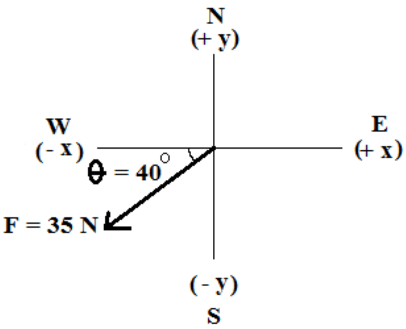
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**(i)** **Ans.**	**State different types of beams with sketch.** **Following are the different types of beams:** (i) Simply supported beam  (ii) Cantilever beam  (iii) Over hanging beam  (iv) Fixed Beam  (v) Continuous beam  	**1 each (any two)**	**2**
	(j) **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 is known as cone of friction.	**2**	**2**

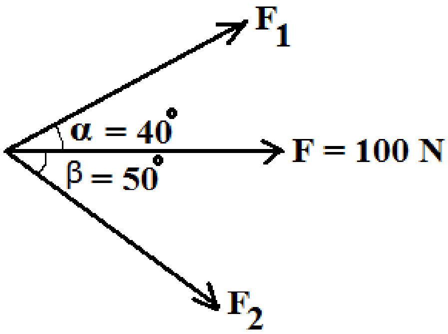
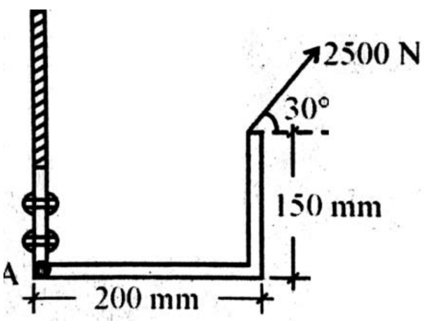
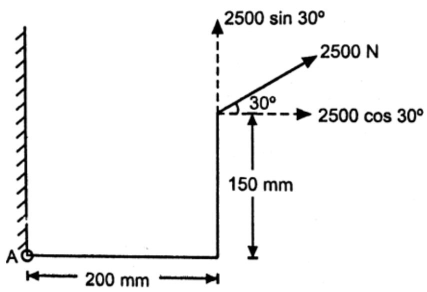
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	(k) Ans.	**State the factors on which frictional resistance depends.** Following are the different factors on which frictional resistance depends: 1. Nature of surface in contact. 2. Magnitude of applied force. 3. Normal reaction between the surfaces of contact.	1 each (any two)	2
	(*l*) Ans.	**State Varignon's theorem of moment.** **Varignon's Theorem:** It states that the algebraic sum of moments of all forces about any point is equal to moment of resultant about the same point. Let, $\sum MF_A$ = Algebraic sum of moments of all forces about point A MR_A = Moment of Resultant about point A Then, $\sum MF_A = MR_A$	2	2
Q.2		**Attempt any FOUR :**		(16)
	(a) Ans.	**In a certain machine a load of 100 N is lifted by an effort of 8 N at an efficiency of 60%. Find effort lost in friction & load lost in friction.** $W=100N, P=8N, \%\eta=60\%$ $P_f=?, W_f=?$ $M.A.=\frac{W}{P}=\frac{100}{8}=12.5$	1	
		$\%\eta=\frac{M.A.}{V.R.}\times 100$ $60=\frac{12.5}{V.R.}\times 100$ $V.R.=20.83$	1	
		$P_f=P-P_i=P-\left(\frac{W}{V.R.}\right)=8-\left(\frac{100}{20.83}\right)$ $\boxed{P_f=3.2\,N}$	1	
		$W_f=W_i-W=(P\times V.R.)-W=(8\times 20.83)-100$ $\boxed{W_f=66.64\,N}$	1	4

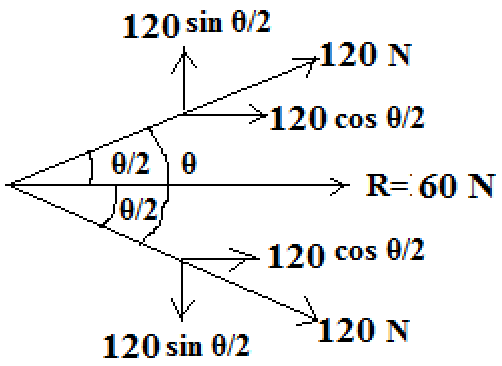
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	(b)	**In a certain lifting machine, the effort has to move through 1 m in order to lift the load through 10 mm. If the efficiency of the machine is 60%, find the load that can be lifted by an effort of 25 N.**		
	Ans.	y = Distance moved by effort = 1 m = 1000 mm x = Distance moved by load = 10 mm % η = 60 %, P = 25 N W = ?		
		$\text{V.R.} = \frac{y}{x} = \frac{1000}{10} = 100$	1	
		$\%\eta = \frac{\text{M.A}}{\text{V.R}} \times 100$	1	
		$60 = \frac{\text{M.A}}{100} \times 100$ M.A.=60	1	
		But, $\text{M.A.} = \frac{W}{P}$ $60 = \frac{W}{25}$ $\boxed{W = 1500\text{ N}}$	1	4
	(c)	**A machine lifts a load of 400 N & 600 N by efforts of 60 N & 80 N respectively. Find law of machine & efficiency at a load of 800 N if VR is 22.**		
	Ans.	$W_1 = 400\text{ N},\ P_1 = 60\text{ N}, W_2 = 600\text{ N},\ P_2 = 80\text{ N},$ $W_3 = 800\text{ N}, \text{V.R.} = 22$ Law of m/c =?, $P_3 = ?$		
		Using Law of m/c, P = mW+C N Putting given values of W & P in above equation		
		$60 = (m \times 400) + C$ ----(i) $80 = (m \times 600) + C$ ----(ii)	1	
		Subtracting eqn. (ii) from (i), $m = 0.1$ Putting value of m in eqn. (i), $C = 20$		
		$\boxed{\text{Law of m/c} = P = [(0.1)W + 20]\text{ N}}$	1	

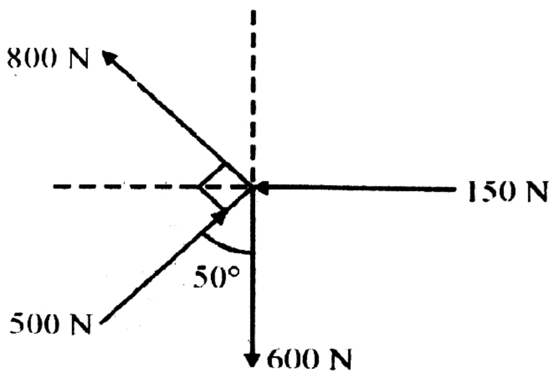
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2		$P=[(0.1)W+20]$ $P_3=[(0.1)W_3+20]=[(0.1\times800)+20]$ $P_3=100\,N$	1	
		$M.A.=\frac{W_3}{P_3}=\frac{800}{100}=8$ $\%\eta=\frac{M.A.}{V.R.}\times100=\frac{8}{22}\times100$ $\boxed{\%\eta=36.36\%}$	1	4
	(d)	**A screw jack of pitch 8 mm has a lever of 250 cm length. If the efficiency of the machine is 30%, find the effort required to lift a load of 1500 N.**		
	Ans.	p = 8 mm, L = 250 cm = 2500 mm, η% = 30 %, W = 1500 N, P = ?		
		$V.R.=\frac{2\pi L}{p}=\frac{2\times\pi\times2500}{8}$ $V.R.=1963.495$	1	
		$MA=\frac{W}{P}=\frac{1500}{P}$		
		$\eta\%=\frac{MA}{VR}\times100\%$	1	
		$30=\left(\frac{\left(\frac{1500}{P}\right)}{1963.495}\right)\times100$	1	
		$\boxed{P=2.546\,N}$	1	4

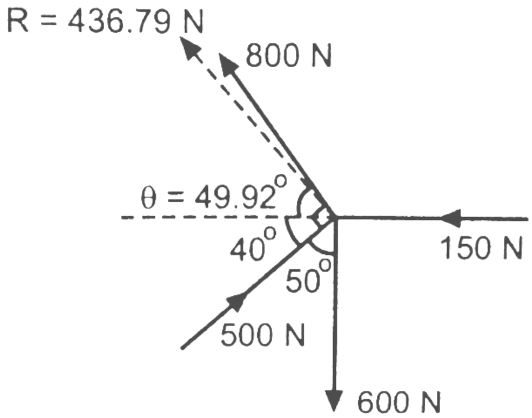
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	(e)	**A single purchase crab has following details – No. of teeth on spur = 125, No. of teeth on pinion = 25, Dia. Of effort wheel = 40 cm & Dia. of load drum = 16 cm. A load of 250 N is lifted by an effort of 32 N. Find efficiency.**		
	Ans.	$N_1=125, N_2=25, D=40\,cm,\ d=16\,cm,\ W=250\,N, P=32\,N,$ $\%\eta=?$		
		$V.R.=\frac{D}{d}\times\frac{N_1}{N_2}=\frac{40}{16}\times\frac{125}{25}=12.5$	1	
		$M.A.=\frac{W}{P}=\frac{250}{32}=7.812$	1	
		$\%\eta=\frac{M.A.}{V.R.}\times100=\frac{7.812}{12.5}\times100$	1	
		$\boxed{\%\eta=62.5\%}$	1	4
	(f)	**In a differential axle & wheel, the dia. of wheel is 40 cm & that of axles are 10 cm & 8 cm. If the efficiency of m/c is 90%, determine the load lifted by an effort of 200 N.**		
	Ans.	$d_1=10\text{ cm},\ d_2=8\text{ cm}, D=40\,cm,\ P=200\,N,\ \%\eta=90\ \%$ $W=?$		
		$V.R.=\frac{2\times D}{d_1-d_2}=\frac{2\times40}{10-8}=40$	1	
		$M.A.=\frac{W}{P}=\frac{W}{200}$	1	
		$\%\eta=\frac{M.A.}{V.R.}\times100$ $90=\frac{\left(\frac{W}{200}\right)}{40}\times100$	1	
		$\boxed{W=7200\,N}$	1	4

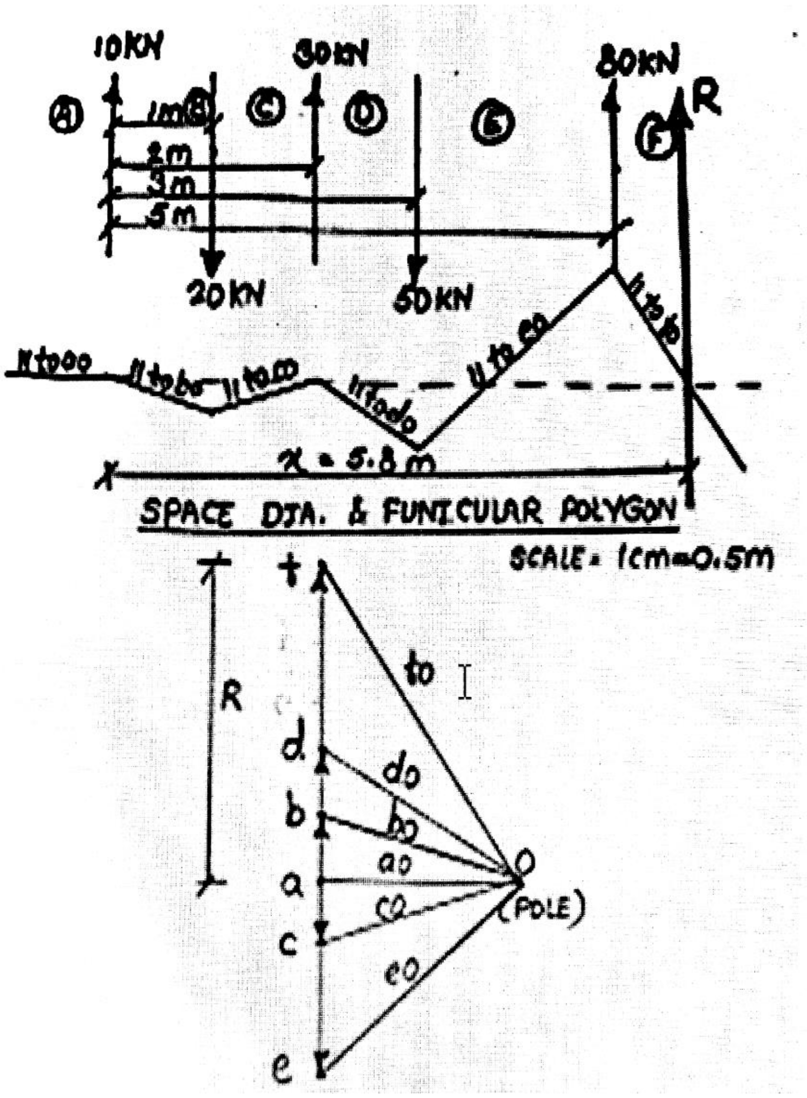
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3		**Attempt any FOUR :**		**(16)**
	(a)	**Resolve each of the following forces into orthogonal components :** **(i) 20 N acting 30° North of East.** **(ii) 25 N acting due North.** **(iii) 30 N acting North-West.** **(iv) 35 N acting 40° South of West.**		
	Ans.	(i)  $F_x = F\times\cos\theta$ $=+20\times\cos 30$ $\boxed{F_x = +17.320\,N}$ $F_y = F\times\sin\theta$ $=+20\times\sin 30$ $\boxed{F_y = +10\,N}$		
		(ii)  $F_x = F\times\cos\theta$ $=+25\times\cos 90$ $\boxed{F_x = 0\ N}$ $F_y = F\times\sin\theta$ $=+25\times\sin 90$ $\boxed{F_y = +25\,N}$	1 each	4
		(iii)  $F_x = F\times\cos\theta$ $= -30\times\cos 45$ $\boxed{F_x = -21.213\,N}$ $F_y = F\times\sin\theta$ $=+30\times\sin 45$ $\boxed{F_y = +21.213\ N}$		
		(iv)  $F_x = F\times\cos\theta$ $= -35\times\cos 40$ $\boxed{F_x = -26.811\,N}$ $F_y = F\times\sin\theta$ $=-35\times\sin 40$ $\boxed{F_y = -22.497\,N}$		

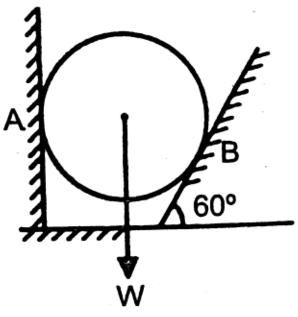
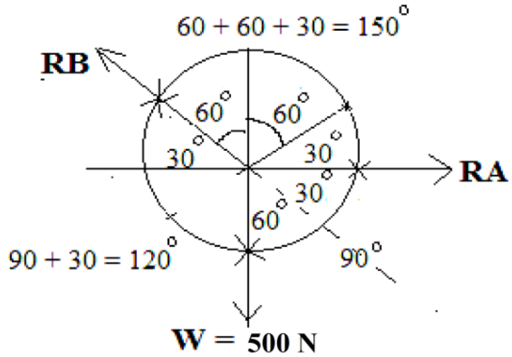
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(b)	**Resolve a force of 100 N into two directions 40° & 50° on either side of it acting on +ve x-axis.**		
	Ans.			
		Using Sine rule:		
		$F_1=\dfrac{F\times\sin\alpha}{\sin(\alpha+\beta)}=\dfrac{100\times\sin50}{\sin(40+50)}$	1	
		$\boxed{F_1=76.6\,N}$	1	
		$F_2=\dfrac{F\times\sin\beta}{\sin(\alpha+\beta)}=\dfrac{100\times\sin40}{\sin(40+50)}$	1	
		$\boxed{F_2=64.28\,N}$	1	4
	(c)	**A force of 2500 N acts on a bracket. Find moment of this force at 'A'. (Fig. 1).**		
	Ans.	 **Fig. 1**  **FBD**	1	
		$M_A=-(2500\times\sin30\times200)+(2500\times\cos30\times150)$	2	
		$\boxed{M_A=74759.53\,N.mm\,(\text{Clockwise})}$	1	4

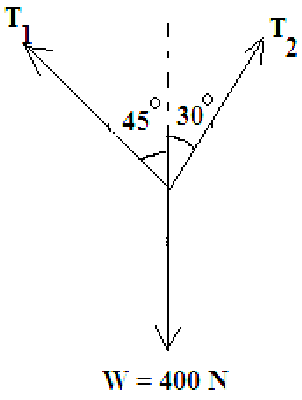
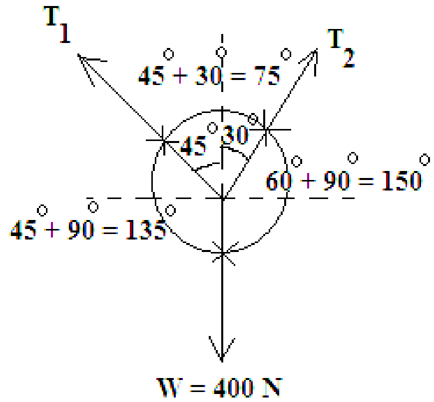
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(d)	**Find the angle between the two forces of magnitude 120 N each, such that their resultant is 60 N.**		
	Ans.	$P = Q = 120\ N, R = 60\ N$		
		$\theta = ?$		
		Using Law of Parallelogram of forces	1	
		$R^2 = P^2 + Q^2 + (2 \times P \times Q \times \cos\theta)$		
		$R^2 = P^2 + P^2 + (2 \times P \times P \times \cos\theta)$		
		$(60)^2 = (120)^2 + (120)^2 + (2 \times 120 \times 120 \times \cos\theta)$	1	
		$3600 = 14400 + 14400 + (28800 \times \cos\theta)$		
		$\cos\theta = -\frac{25200}{28800} = -0.875$	1	
		$\theta = \cos^{-1}(-0.875)$	1	4
		$\boxed{\theta = 151.04°}$		
		OR		
		Using Conditions of Equilibrium:		
				
		1) $\sum F_x = 0 (\rightarrow +ve, \leftarrow -ve)$		
		$= +120\cos\left(\frac{\theta}{2}\right) + 120\cos\left(\frac{\theta}{2}\right)$		
		$= +240\cos\left(\frac{\theta}{2}\right)$	1	
		2) $\sum F_y = 0 (\uparrow +ve, \downarrow -ve)$		
		$= +120\sin\left(\frac{\theta}{2}\right) - 120\sin\left(\frac{\theta}{2}\right)$		
		$= 0$		

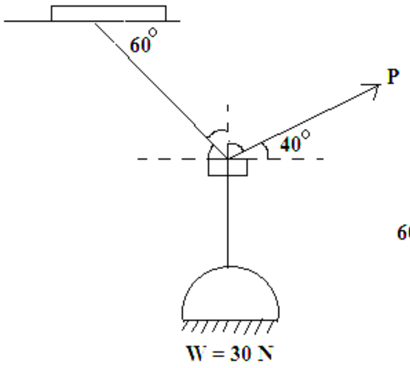
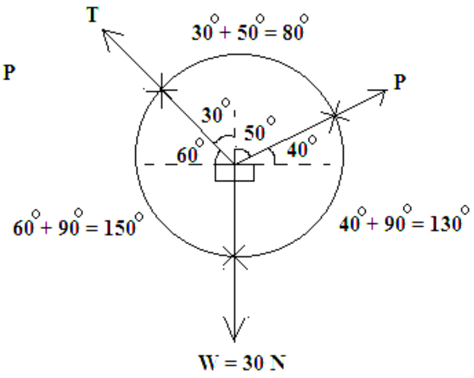
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3		3) $R=\sqrt{\sum F_x{}^2+\sum F_y{}^2}$ $=\sqrt{\left(240\cos\left(\frac{\theta}{2}\right)\right)^2+0}$ $R^2=\left(240\cos\left(\frac{\theta}{2}\right)\right)^2$ $R\ =\left(240\cos\left(\frac{\theta}{2}\right)\right)$ $60\ =\left(240\cos\left(\frac{\theta}{2}\right)\right)$ $\left(\frac{\theta}{2}\right)=\cos^{-1}\left(\frac{60}{240}\right)=75.522$ $\theta=2\times 75.522$ $\boxed{\theta=151.04°}$	1 1 1	4
	(e)	**Find the resultant of all forces shown in Fig. 2. Mark it's position & direction on sketch.** 		
	Ans.	Resolving all forces $\sum F_x = -(150)-(800\times\cos 50°)+(500\times\cos 40°)$ $=-(281.21)\ N$ $\sum F_y = +(800\times\sin 50°)+(500\times\sin 40°)-(600)$ $=+(334.23)\ N$ $R=\sqrt{\left(\sum F_x\right)^2+\left(\sum F_y\right)^2}=\sqrt{(281.21)^2+(334.23)^2}$ $\boxed{R=436.79\ N}$	1 1	

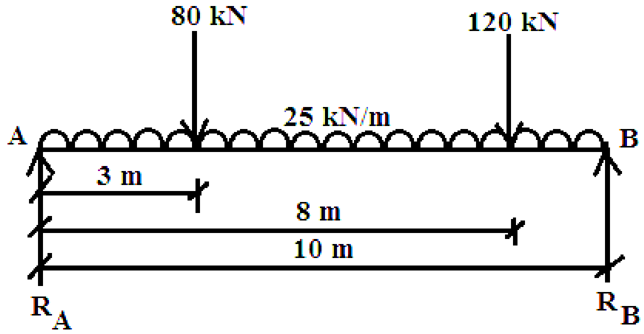
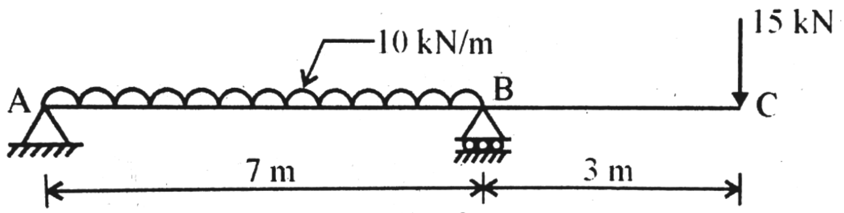
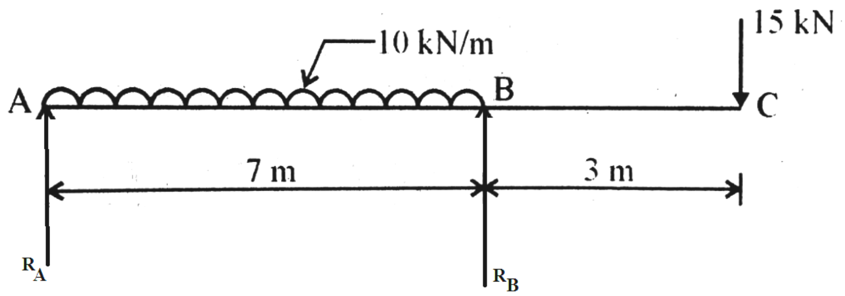
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3		Since, $\sum F_x = -\text{ve}$ *and* $\sum F_y = +\text{ve}$, R lies in $\boxed{2^{nd}\text{ quadrant}}$.	1	
		Let, θ be the angle made by R with horizontal. $\theta = \tan^{-1}\left\lvert\frac{\sum F_y}{\sum F_x}\right\rvert = \tan^{-1}\left\lvert\frac{334.23}{281.21}\right\rvert$ $\boxed{\theta = 49.92° \text{ with negative x axis.}}$	1	4
		 **Fig. Location of Resultant**		
	(f)	**Five parallel forces of 10, 20, 30, 50 & 80 kN are acting on a beam. Distances of forces from 10 kN force are 1 m, 2 m, 3 m & 5 m. Forces 20 & 50 kN are acting downward & other acting upward. Find resultant in magnitude, direction & position w.r. to 10 kN force graphically.**		

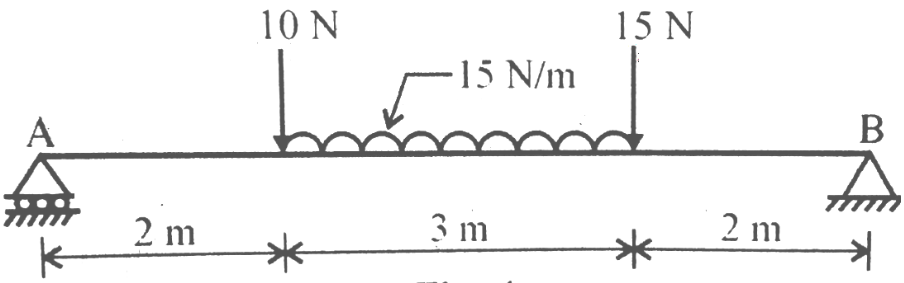
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(f) Ans.	 **Vector diagram and Polar diagram** Scale 1cm = 10kN R = l(af) × Scale = 5×10 = 50kN X = 11.6 × 0.5 = 5.8m	1½ 1½ 1	4

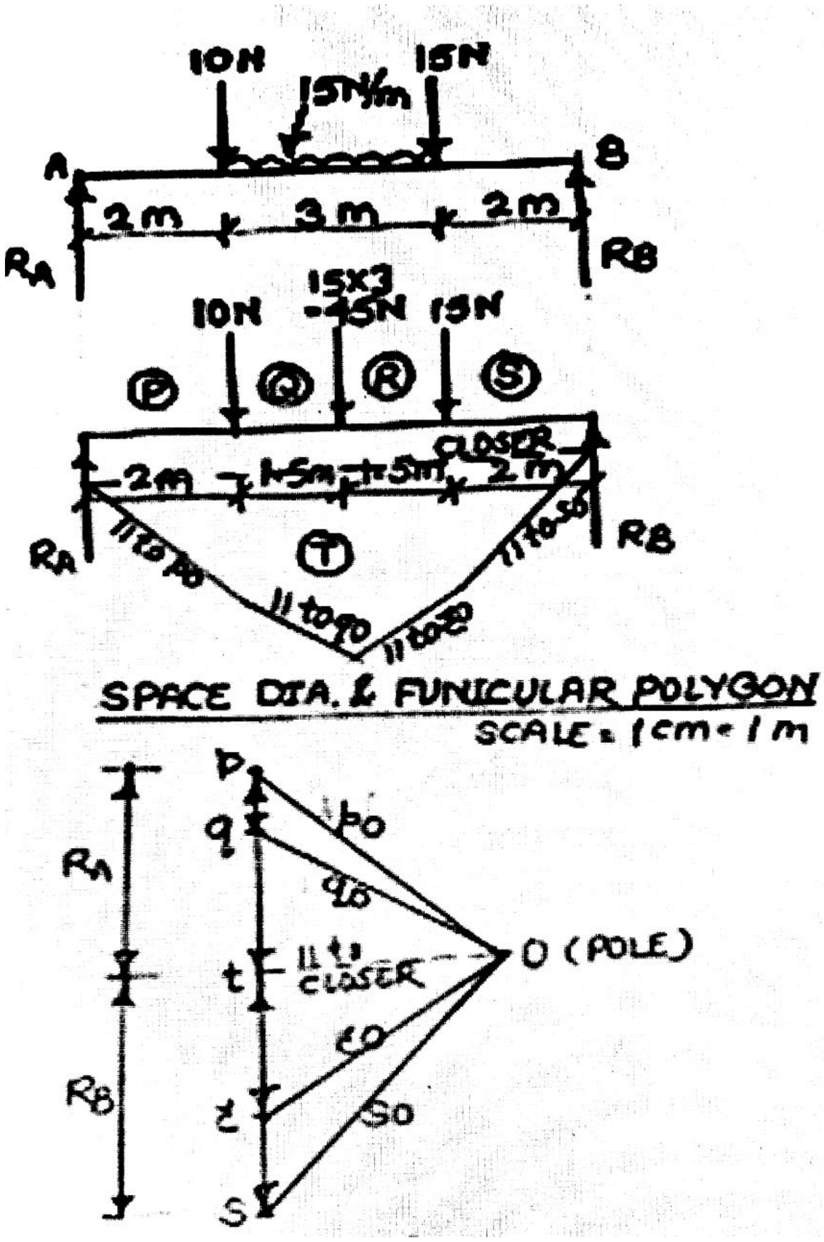
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4		**Attempt any FOUR :**		(16)
	(a)	**A sphere weighing 500 N is supposed by two planes. One plane is vertical & other is inclined at 60° to the horizontal. Calculate the reactions at the planes.**		
	Ans.	 **Problem Figure**  **FBD**	1	
		Using Lami's theorem, $\frac{500}{\sin 150} = \frac{R_A}{\sin 120} = \frac{R_B}{\sin 90}$ (1) (2) (3)	1	
		Using term (1) & (2) $\frac{500}{\sin 150} = \frac{R_A}{\sin 120}$ $R_A = \sin 120 \times \frac{500}{\sin 150}$ $\boxed{R_A = 866.025\,N}$	1	
		Using term (1) & (3) $\frac{500}{\sin 150} = \frac{R_B}{\sin 90}$ $R_B = \sin 90 \times \frac{500}{\sin 150}$ $\boxed{R_B = 1000\,N}$	1	4
		(Note: If the problem solved by using conditions of equilibrium, should be considered.)		

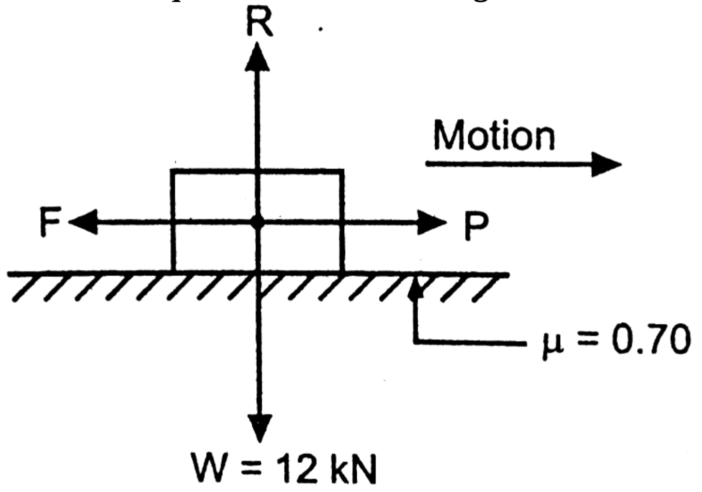
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(b)	**Two men carry a weight 400 N by means of ropes fixed to the weight. One rope is inclined at 45° & other at 30° with vertical. Find tension in each rope.**		
	Ans.	Problem Fig.		
		FBD	1	
		Using Lami's theorem, $\frac{400}{\sin 75} = \frac{T_1}{\sin 150} = \frac{T_2}{\sin 135}$ (1) (2) (3)	1	
		Using term (1) & (2) $\frac{400}{\sin 75} = \frac{T_1}{\sin 150}$ $T_1 = \sin 150 \times \frac{400}{\sin 75}$ $\boxed{T_1 = 207.055\,\text{N}}$	1	
		Using term (1) & (3) $\frac{400}{\sin 75} = \frac{T_2}{\sin 135}$ $T_2 = \sin 135 \times \frac{400}{\sin 75}$ $\boxed{T_2 = 292.820\,\text{N}}$	1	4
		(Note: If the problem solved by using conditions of equilibrium, should be considered.)		

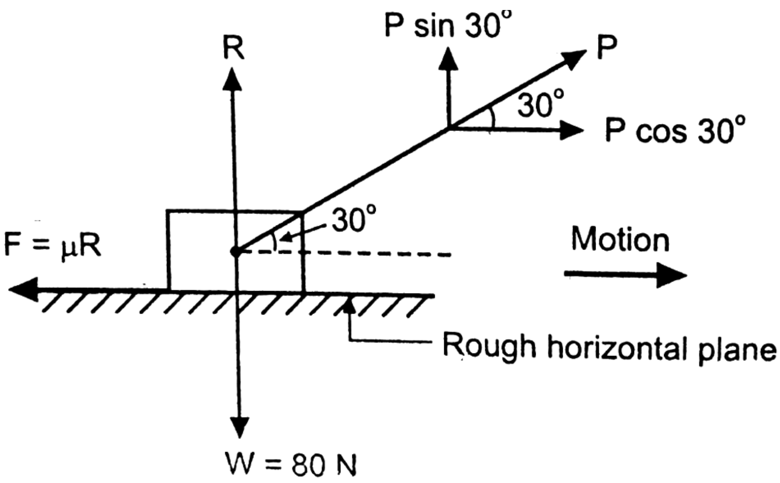
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(c)	**An electric bulb of 30 N weight is hanging from ceiling. It's wire is pulled by a force acting at 40 to the horizontal such that the wire makes an angle of 60° with the ceiling. Find magnitude of force & tension in the wire.**		
	Ans.	Problem Fig.FBD	1	
		Using Lami's theorem, $\frac{30}{\sin 80} = \frac{T}{\sin 130} = \frac{P}{\sin 150}$ (1) (2) (3)	1	
		Using term (1) & (2) $\frac{30}{\sin 80} = \frac{T}{\sin 130}$ $T = \sin 130 \times \frac{30}{\sin 80}$ $\boxed{T = 23.336\,N}$	1	
		Using term (1) & (3) $\frac{30}{\sin 80} = \frac{P}{\sin 150}$ $P = \sin 150 \times \frac{30}{\sin 80}$ $\boxed{P = 15.231\,N}$	1	4
		(Note: If the problem solved by using conditions of equilibrium, should be considered.)		

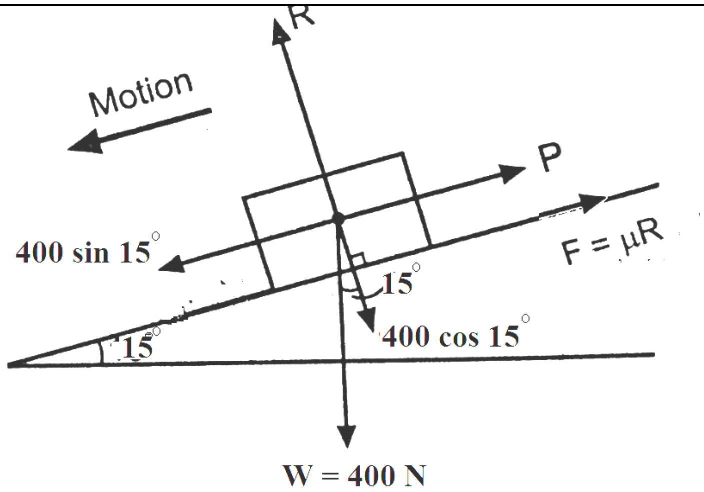
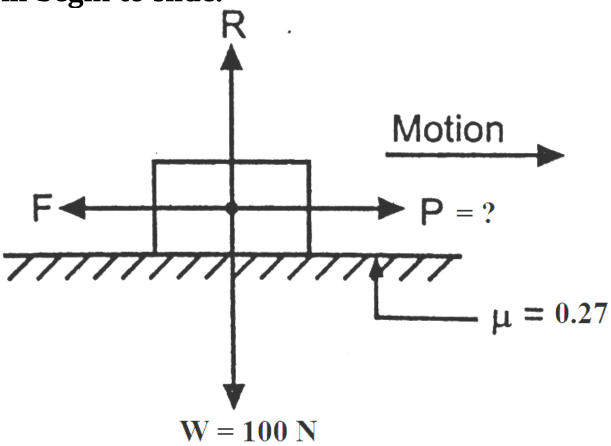
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(d)	**A simply supported beam is of 10 m span. It has a udl of 25 kN/m throughout it's length & point loads of 80 kN & 120 kN at 3 m & 8 m from left support. Calculate support reactions by analytical method.**		
	Ans.		1	
		$\sum F_y = 0$ $+R_A - (25\times10) - 80 - 120 + R_B = 0$ $R_A + R_B = 450$ kN----(1)	1	
		$\sum M_A = 0$ $(R_B\times10) = (25\times10\times5) + (80\times3) + (120\times8) = 0$ $\boxed{R_B = 245\,\text{kN}\ (\uparrow)}$	1	
		Putting value of R_A in equation (1) $R_A + R_B = 450$ $R_A + 245 = 450$ $\boxed{R_A = 205\,\text{kN}\ (\uparrow)}$	1	4
	(e)	**Find support reactions for a beam shown in Fig. 3 by analytical method.**		
	Ans.	 **Fig. 3** 		

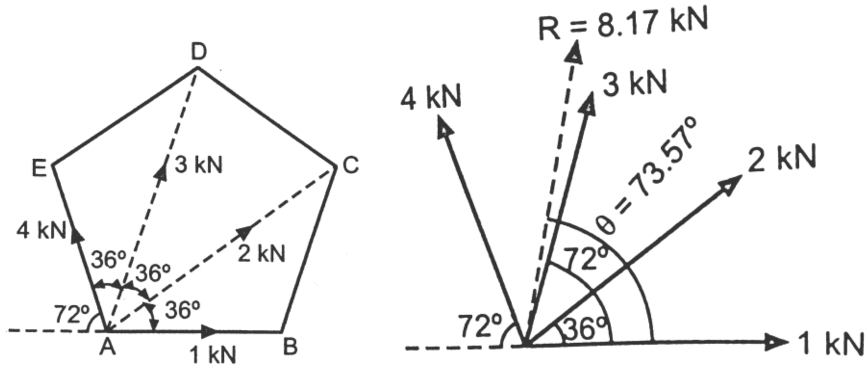
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4		$\sum F_y = 0$ $+R_A - (10\times7) + R_B - 15 = 0$ $R_A + R_B = 85$ N----(1)	1	
		$\sum M_B = 0$ $(R_A\times7) - (10\times7\times3.5) + (15\times3) = 0$ $\boxed{R_A = 28.571\text{N} \ (\uparrow)}$	2	
		Putting value of R_A in equation (1) $R_A + R_B = 85$ $28.571 + R_B = 85$ $\boxed{R_B = 56.429\text{N} \ (\uparrow)}$	1	4
	(f)	**Find support reactions for a beam shown in Fig. 4 by graphical method.**  **Fig. 4**		

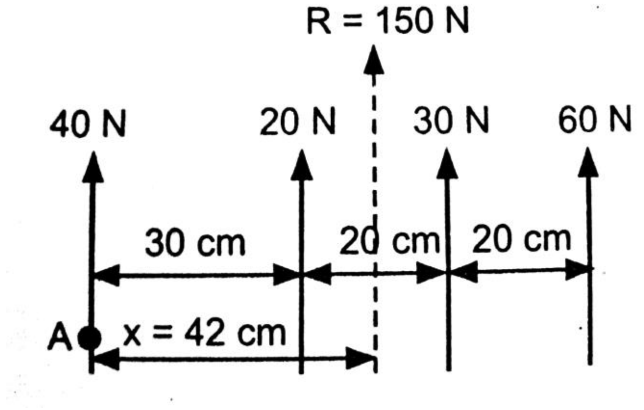
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(f) Ans.		1½ 1½	
		Vector diagram and Polar diagram Scale 1cm = 10N $R_A = l(pt) \times Scale = 3.4 \times 10 = 34N$ $R_B = l(st) \times Scale = 3.6 \times 10 = 36N$	1	4

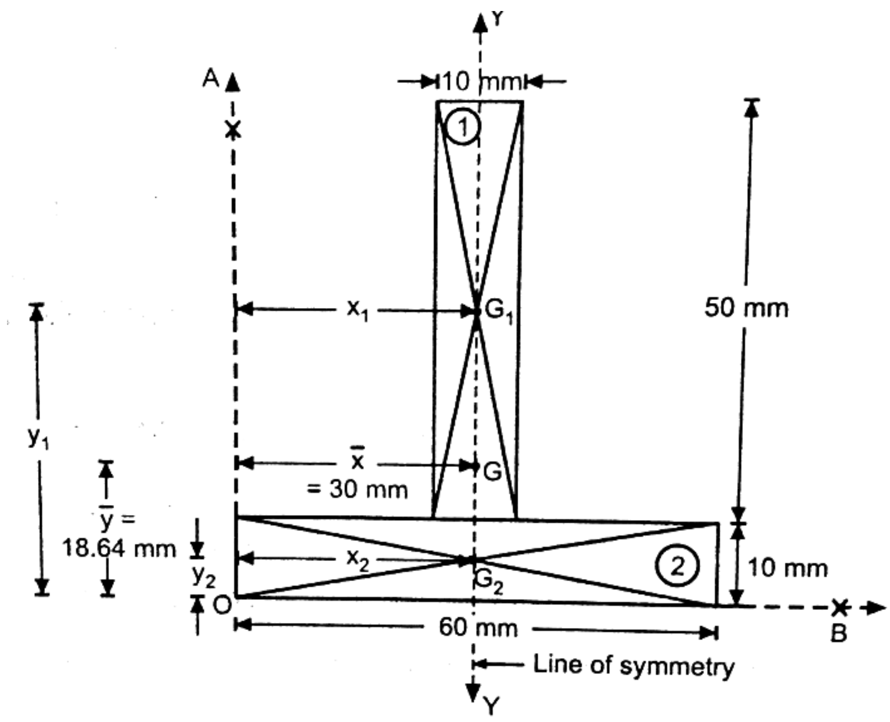
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5		**Attempt any FOUR :**		**(16)**
	(a)	**A body weighing 12 kN is lying on a horizontal plane for which μ = 0.70. Determine normal reaction, limiting force of friction, horizontal force required to move it & angle of friction.**		
	Ans.			
		$\sum F_y = 0 \ (\uparrow +ve, \downarrow -ve)$ $R - W = 0$ $R - 12 = 0$ $\boxed{R = 12\,kN}$	1	
		$\sum F_X = 0 \quad (\rightarrow +ve, \leftarrow -ve)$ $P - F = 0$ $P = F$ $P = \mu \times R = 0.7 \times 12$ $\boxed{P = 8.4\,kN}$	1	
		$P = F$ $\boxed{F = 8.4\,kN}$	1	
		$\mu = \tan\phi$ $\text{Angle of friction} = \phi = \tan^{-1}\mu = \tan^{-1}(0.7)$ $\boxed{\text{Angle of friction} = \phi = 34.99^\circ}$	1	4

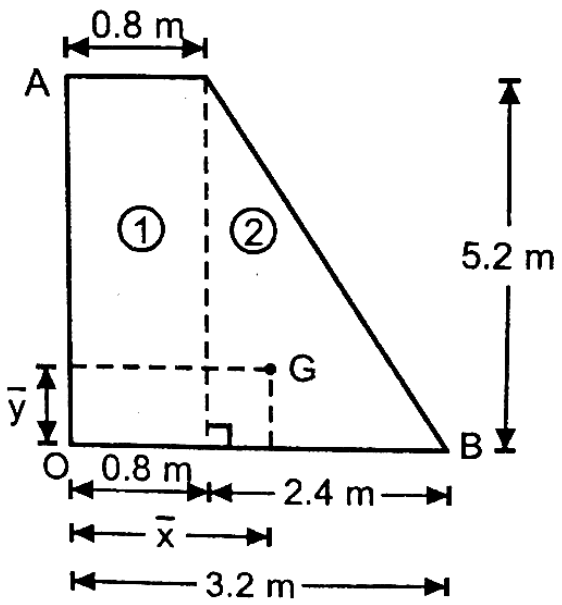
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(b)	**A block of 80 N is placed on a horizontal plane where the coefficient of friction is 0.25. Find the force at 30° upto the horizontal to just move the block.**		
	Ans.			
		$\sum F_X = 0 \quad (\rightarrow +ve, \leftarrow -ve)$ $(P \times \cos 30) - F = 0$ $(P \times \cos 30) - (\mu \times R) = 0$ $(P \times 0.866) - (0.25 \times R) = 0$ $(P \times 0.866) = (0.25 \times R)$ $R = \left(\frac{0.866}{0.25}\right) \times P$ $R = (3.464)P$ -----(1)	1 1	
		$\sum F_y = 0 \quad (\uparrow +ve, \downarrow -ve)$ $R + (P \times \sin 30) - W = 0$ $(3.464 \times P) + (P \times 0.5) - 80 = 0$ $(3.964)P = 80$ $\boxed{P = 20.18\,N}$	1 1	4
	(c)	**A body of weight 400 N is placed on an inclined plane at an angle of 15° with the horizontal. If coefficient of friction is 0.14, find the value of force to be applied parallel to plane just to prevent the body from sliding down.**		

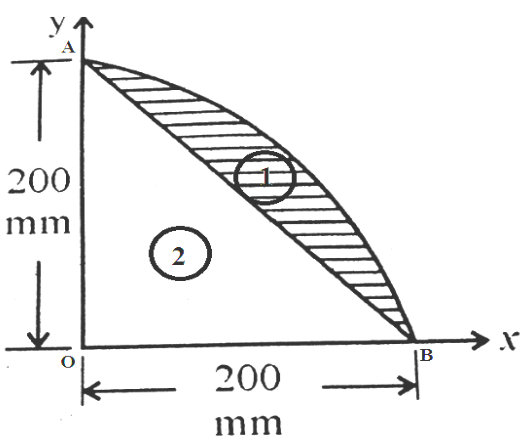
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	**(c) Ans.**			
		Consider inclined plane as x-x axis & perpendicular to it as y-y axis.		
		$\sum F_y = 0$		
		$R - (400\times\cos 15) = 0$	1	
		$R = (400\times\cos 15)$		
		$\boxed{R = 386.37\ N}$	1	
		$\sum F_x = 0$		
		$P + F - (400\times\sin 15) = 0$		
		$P + (\mu\times R) - (400\times\sin 15) = 0$	1	
		$P + (0.14\times 386.37) - (400\times\sin 15) = 0$		
		$\boxed{P = 49.43\,N}$	1	4
	(d)	**Find the horizontal force required to drag a body of weight 100 N along a horizontal plane. If the plane is raised gradually upto 15°, the body will begin to slide.**		
	Ans.			

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5		We know, $\mu = \tan\alpha = \tan 15° = 0.27$		
		$\sum F_y = 0 \; (\uparrow +ve, \downarrow -ve)$	**1**	
		$R - W = 0$ $R - 100 = 0$ $R = 100\,N$	**1**	
		$\sum F_X = 0 \quad (\rightarrow +ve, \leftarrow -ve)$ $P - F = 0$	**1**	
		$P - (\mu \times R) = 0$ $P = (\mu \times R) = (0.27 \times 100)$ $\boxed{P = 27\,N}$	**1**	**4**
	(e)	**Forces of 1, 2, 3 & 4 kN respectively act at one of the angular points of a regular pentagon towards the other four angular points taken in order. Find the resultant in magnitude & direction.**		
	Ans.	 **Fig. Direction of Resultant**		
		$\text{Exterior angle} = \frac{360}{\text{No. of angular points}} = \frac{360}{5} = 72°$ $\text{Interior angle} = 180 - 72 = 108°$ $\angle BAC = \angle CAD = \angle DAE = \frac{108}{3} = 36°$	**1**	
		(Note: If forces are taken in different order and attempted, should be considered.)		

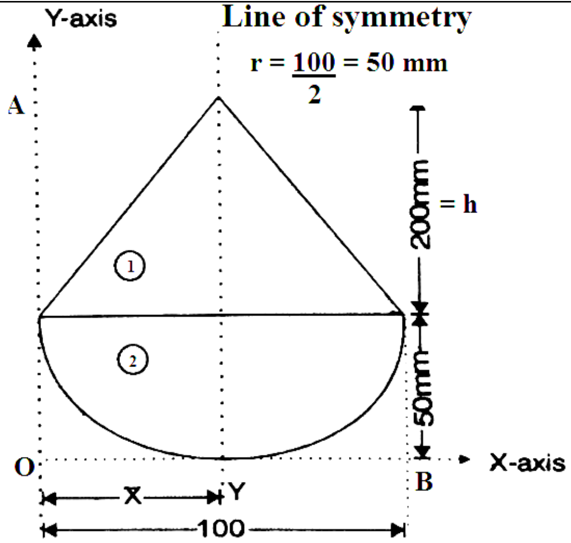
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 5		Resolving all forces $\sum F_x = (1)+(2\times\cos 36°)+(3\times\cos 72°)-(4\times\cos 72°)$ $=+(2.310)\,kN$ $\sum F_y = (2\times\sin 36°)+(3\times\sin 72°)+(4\times\sin 72°)$ $=+(7.833)\,kN$	**1**	
		$R=\sqrt{\left(\sum F_x\right)^2+\left(\sum F_y\right)^2}=\sqrt{(2.310)^2+(7.833)^2}$ $\boxed{R=8.17\,kN}$	**1**	
		Since, $\sum F_x=+ve$ & $\sum F_y=+ve$, R lies in $\boxed{1^{st}\text{ quadrant}}$. Let, θ be the angle made by R with horizontal. $\theta=\tan^{-1}\left\|\frac{\sum F_y}{\sum F_x}\right\|=\tan^{-1}\left\|\frac{7.833}{2.310}\right\|$ $\boxed{\theta=73.57°\text{ with positive x axis.}}$	**1**	**4**
	(f)	**Determine analytically the resultant of the coplanar parallel forces acting vertically upwards –** **(i) 40 N** **(ii) 20 N at 30 cm** **(iii) 30 N at 50 cm &** **(iv) 60 N at 70 cm.** **All distances are measured from the first force towards right.**		
	Ans.		**1**	

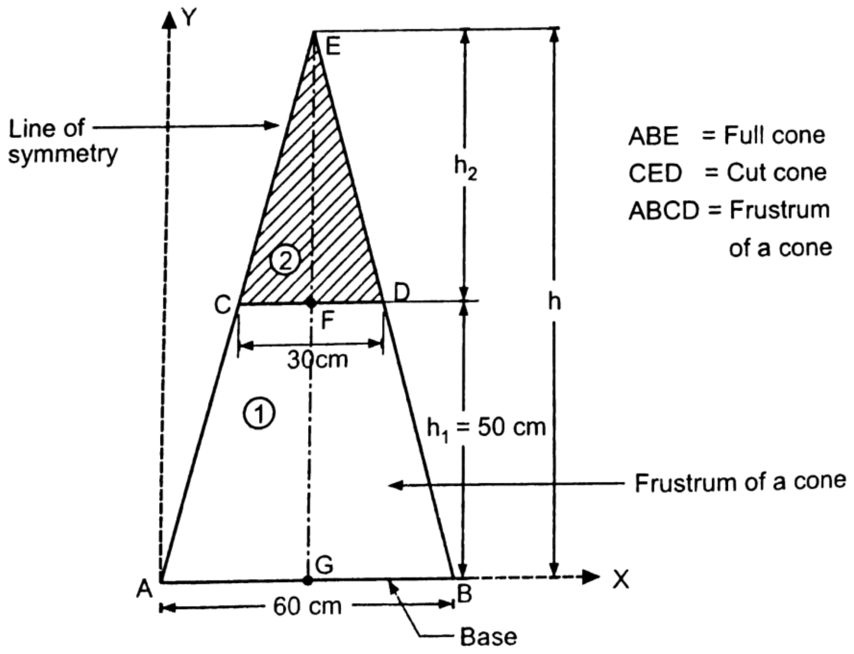
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(f) Ans.	$R = +40+20+30+60$ $\boxed{R = +150\,N(\uparrow)}$ Let, x be the distance of R from 40 N force. Taking moment of all forces about point 'A' & using Varignon's theorem of moment $\sum M_{F_A} = M_{R_A}$ $(40\times0)-(20\times30)-(30\times50)-(60\times70) = -(R\times x)$ $(40\times0)-(20\times30)-(30\times50)-(60\times70) = -(150\times x)$ $-(6300) = -(150\times x)$ $\boxed{x = 42\,cm}$ $\boxed{R = 150\text{ N lies at 42 cm from 40 N force vertically upward.}}$	1 1 1	 4
Q.6		**Attempt any FOUR :**		(16)
	(a)	**Find centroid of an inverted T – section with flange 60 x 10 mm & web 50 x 10 mm.**		
	Ans.		1	

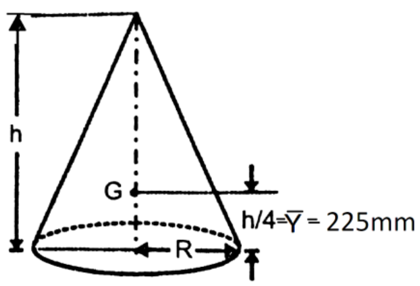
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6		(1) Area calculation $a_1 = 10 \times 50 = 500\,mm^2$ $a_2 = 60 \times 10 = 600\,mm^2$ $a = a_1 + a_2 = 1100\,mm^2$	1	
		(2) $\bar{x}$ calculation As given figure is symmetric @ y axis, $\bar{x} = \frac{60}{2}$ $\boxed{\bar{x} = 30\,mm\,(\text{from OA on line of symmetry})}$	1	
		(3) $\bar{y}$ calculation $y_1 = 10 + \left(\frac{50}{2}\right) = 35\,mm$ $y_2 = \left(\frac{10}{2}\right) = 5\,mm$ $\bar{y} = \frac{(a_1 \times y_1) + (a_2 \times y_2)}{a} = \frac{(500 \times 35) + (600 \times 5)}{1100}$ $\boxed{\bar{y} = 18.64\,mm\,(\text{from OB on line of symmetry})}$	1	4
	(b)	**A retaining wall of height 5.2 m has one side vertical. The top width is 0.8 m & bottom width is 3.2 m, find centroid.**		
	Ans.	 	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	**(b) Ans.**	(1) Area calculation $a_1 = \text{Area of rectangle} = (0.8\times5.2) = 4.16\,m^2$ $a_2 = \text{Area of triangle} = \frac{1}{2}\times2.4\times5.2 = 6.24\,m^2$ $a = a_1 + a_2 = 10.40\,m^2$	**1**	
		(2) $\bar{x}$ calculation $x_1 = \left(\frac{0.8}{2}\right) = 0.4\,m$ $x_2 = 0.8 + \left(\frac{1}{3}\times2.4\right) = 1.6\,m$ $\bar{x} = \frac{(a_1\times x_1)+(a_2\times x_2)}{a} = \frac{(4.16\times0.4)+(6.24\times1.6)}{10.40}$ $\boxed{\bar{x} = 1.1\,m\,(\text{from OA})}$	**1**	
		(3) $\bar{y}$ calculation $y_1 = \left(\frac{5.2}{2}\right) = 2.6\,m$ $y_2 = \left(\frac{1}{3}\times5.2\right) = 1.73\,m$ $\bar{y} = \frac{(a_1\times y_1)+(a_2\times y_2)}{a} = \frac{(4.16\times2.6)+(6.24\times1.73)}{10.40}$ $\boxed{\bar{y} = 2.08\,m\,(\text{from OB})}$	**1**	**4**
	(c)	**Find the centroid of shaded area of a lamina shown in Fig. 5.**  **Fig.5**		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(c) Ans.	Let, Quarter circle = Fig. (1) & Triangle = Fig.(2) (1) Area calculation $a_1 = \frac{\pi \times r^2}{4} = \left(\frac{\pi \times 200^2}{4}\right) = 31415.926\,mm^2$ $a_2 = \frac{1}{2} \times 200 \times 200 = 20000\,mm^2$ $a = a_1 - a_2 = 11415.926\,mm^2$	1	
		(2) $\bar{x}$ calculation $x_1 = \left(\frac{4 \times r}{3 \times \pi}\right) = \left(\frac{4 \times 200}{3 \times \pi}\right) = 84.883\,mm$ $x_2 = \left(\frac{1}{3} \times b\right) = \left(\frac{1}{3} \times 200\right) = 66.667\,mm$ $\bar{x} = \frac{(a_1 \times x_1) - (a_2 \times x_2)}{a} = \frac{(31415.926 \times 84.883) - (20000 \times 66.667)}{11415.926}$ $\boxed{\bar{x} = 116.796\,mm\,(\text{from OA})}$	1½	
		(3) $\bar{y}$ calculation $y_1 = \left(\frac{4 \times r}{3 \times \pi}\right) = \left(\frac{4 \times 200}{3 \times \pi}\right) = 84.883\,mm$ $y_2 = \left(\frac{1}{3} \times b\right) = \left(\frac{1}{3} \times 200\right) = 66.667\,mm$ $\bar{y} = \frac{(a_1 \times y_1) - (a_2 \times y_2)}{a} = \frac{(31415.926 \times 84.883) - (20000 \times 66.667)}{11415.926}$ $\boxed{\bar{y} = 116.796\,mm\,(\text{from OB})}$	1½	4
	(d)	**A right circular cone of base diameter 100 mm & height 200 mm is placed on the base of hemisphere of same diameter. Find C.G.**		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(d) Ans.		1	
		Let, Cone = Fig. (1) & Hemi-sphere = Fig.(2) (1) Volume calculation $V_1=\frac{1}{3}\times\pi\times r^2\times h=\frac{1}{3}\times\pi\times 50^2\times 200=523598.776\,mm^3$ $V_2=\frac{2}{3}\times\pi\times r^3=\frac{2}{3}\times\pi\times 50^3=261799.388\,mm^3$ $V=V_1+V_2=785398.164\,mm^3$	1	
		(2) $\bar{x}$ calculation As fig. is symmetric @ y-y axis, $\bar{x}=\frac{100}{2}$ $\boxed{\bar{x}=50\,mm\,(\text{from OA})}$	1	
		(3) $\bar{y}$ calculation $y_1=r+\left(\frac{h}{4}\right)=50+\left(\frac{200}{4}\right)=100\,mm$ $y_2=r-\left(\frac{3\times r}{8}\right)=50-\left(\frac{3\times 50}{8}\right)=31.25\,mm$ $\bar{y}=\frac{(V_1\times y_1)+(V_2\times y_2)}{V}=\frac{(523598.776\times 100)+(261799.388\times 31.25)}{785398.164}$ $\boxed{\bar{y}=77.083\,mm\,(\text{from OB})}$	1	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	**(e)**	**A frustum of a solid circular cone is of top dia. 30 cm & bottom dia. 60 cm of height 50 cm. Find C.G. of the frustum.**		
	Ans.		**1**	
		Let, Full cone as Fig. 1 and cut cone as Fig. 2 1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 60 / 2 $\boxed{\bar{x} = 30\,\text{cm}\,(\text{from y axis})}$	½	
		h_1 = 50 cm, h_2 = Height of cut cone In triangle, ABE and CDE $\frac{h}{60} = \frac{h_2}{30}$ $h = \frac{60}{30} h_2$ $h = 2h_2$ $h_1 + h_2 = h$ $h_1 + h_2 = 2h_2$ $h_1 = 2h_2 - h_2$ $h_1 = 1h_2$ $50 = 1h_2$ $h_2 = 50\text{cm}$ $h = 50 + 50 = 100\text{cm}$		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6		2) Volume Calculation $V_1=(1/3)\pi r_1^2 h=(1/3)\pi(30)^2 X100=30000\pi cm^3$ $V_2=(1/3)\pi r_2^2 h_2=(1/3)\pi(15)^2 X50=3750\pi cm^3$ $V=V_1-V_2=26250\pi cm^3$	1	
		3) $\bar{y}$ calculation $y_1=\frac{h}{4}=\frac{100}{4}=25cm$ $y_2=h_1+\frac{h_2}{4}=50+\left(\frac{50}{4}\right)=62.5cm$	½	
		$\bar{y}=\frac{V_1y_1-V_2y_2}{V}=\frac{30000\pi\times25-3750\pi\times62.5}{26250\pi}$ $\bar{y}=19.64\text{ cm}(\text{from } x-\text{axis})$	1	4
	(f)	**Define – Centroid & Centroid of Gravity. Locate C.G. of a solid cone of height 900 mm & show it on sketch.**		
	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.	1	
		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	
		C.G. of a solid cone of height 900 mm : $\bar{y}=\left(\frac{h}{4}\right)=\frac{900}{4}=225mm$	1	
			1	4