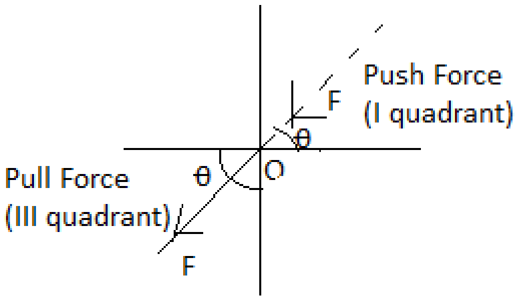
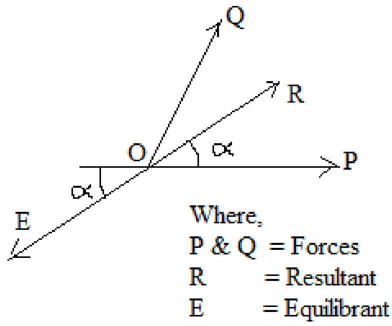
Model Answer: Summer-2019

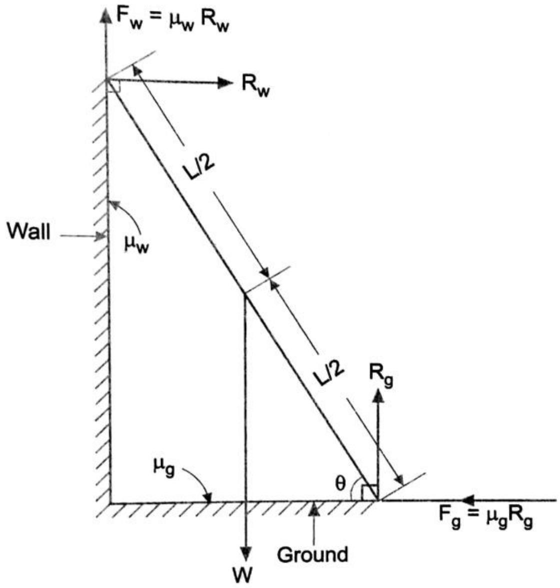
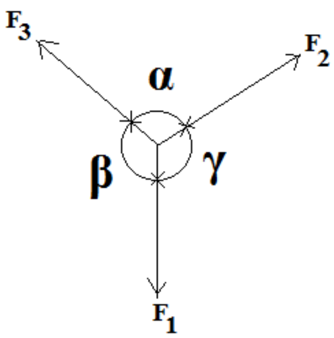
Subject: Engineering Mechanics **Sub. Code: 17204**

Important Instructions to Examiners

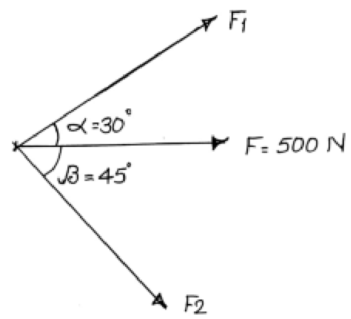
1) The Answer should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

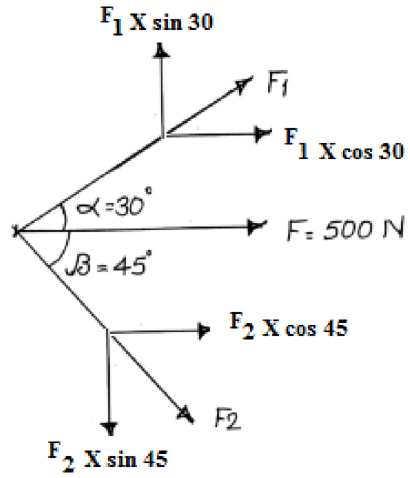
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 1		**Attempt any TEN of the following:**		(20)
	(a)	**Define the ideal machine and ideal effort.**		
	Ans.	**Ideal Machine** is the machine whose efficiency is 100 % and in which friction is zero.	1	2
		Ideal Effort is the ratio of load lifted to velocity ratio.	1	
	(b)	**Define effort lost in friction with formula.**		
	Ans.	**Effort lost in friction** is the difference between actual effort and ideal effort.	1	2
		$P_f = P - P_i = P - \left(\frac{W}{VR}\right)$	1	
	(c)	**State V.R. of differential axle and wheel.**		
	Ans.	V. R. of Differential axle and wheel $\text{V. R.} = \frac{2\times D}{d_1 - d_2}$	1	2
		Where, D = Diameter of Effort Wheel d_1 = Diameter of bigger axle d_2 = Diameter of smaller axle	1	
	(d)	**Define statics and dynamics.**		
	Ans.	**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	

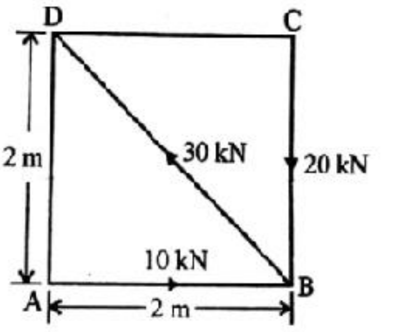
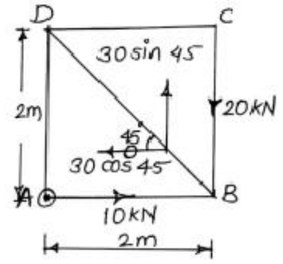
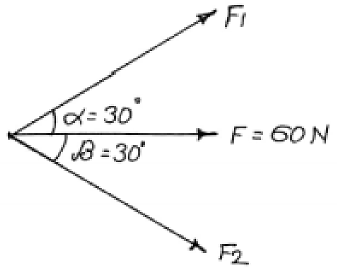
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 1	(e) Ans.	**State the principle of transmissibility of a force.** Principle of transmissibility of force states that, "if a force acts at a point on a rigid body, it is assumed to act at any other point on the line of action of force within the same body". As per this principle force of push nature can be made pull by extending the line of a force in opposite quadrant.  	2	2
	(f) Ans.	**State Varignon's theorem of moments.** Varignon's theorem states, "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
	(g) Ans.	**State the relation between resultant and equilibrant.** **Relation between resultant and equilibrant** - An equilibrant force is always equal in magnitude, opposite in direction and collinear to the resultant.  	2	2
	(h) Ans.	**Define angle of repose.** **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.	2	2

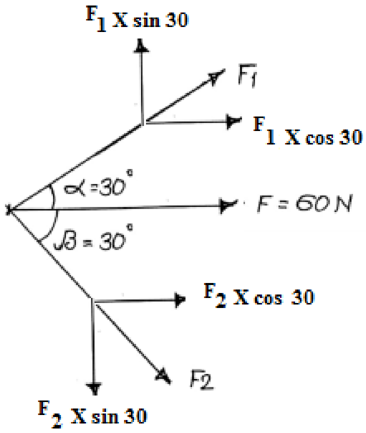
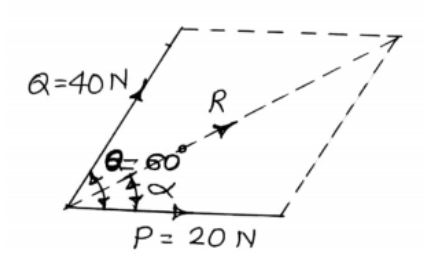
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 1	(i) Ans.	**Draw F.B.D. for a ladder having weight 'W'.** 	2	2
	(j) Ans.	**State Lami's theorem.** Lami's theorem states that, if three forces acting at a point on a body keep it at rest, then each force is proportional to the sin of the angle between the other two forces.  As per Lami's Theorem $\frac{F_1}{\sin\alpha}=\frac{F_2}{\sin\beta}=\frac{F_3}{\sin\gamma}$	2	2
	(k) Ans.	**State the parallelogram law of forces.** **Law of Parallelogram of force** states, "If two forces acting at and away from point be represented in magnitude and direction by the two adjacent sides of parallelogram, then the diagonal of the parallelogram passing through the point of intersection of the two forces, represents the resultant in magnitude and direction".	2	2
	(l) Ans.	**State the graphical conditions of equilibrium.** 1) For coplanar concurrent force system to be in equilibrium, the polygon of forces must be a closed figure. 2) For coplanar non-concurrent force system in equilibrium, in addition to above, the funicular polygon must be a closed figure.	1 1	2

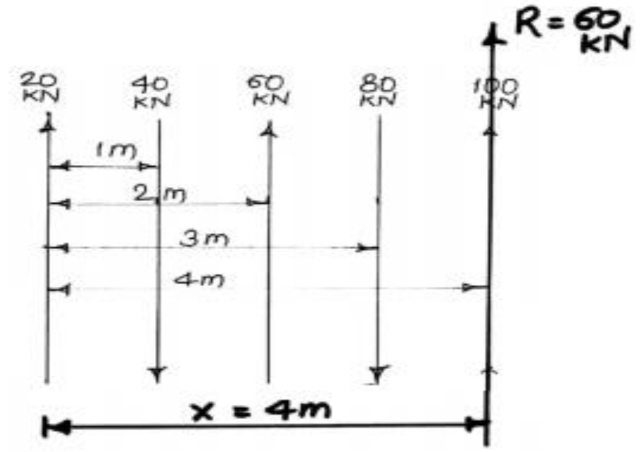
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 2		**Attempt any FOUR of the following:**		**(16)**
	(a)	**A certain machine has an efficiency of 48 %. The velocity ratio of the machine is 200. Find the effort required to lift a load of 2 kN using this machine.**		
	Ans.	$\text{M.A.} = \frac{W}{P} = \frac{2000}{P}$	**1**	
		$\%\eta = \frac{\text{M.A.}}{\text{V.R.}} \times 100$	**1**	**4**
		$48 = \frac{\left(\frac{2000}{P}\right)}{200} \times 100$	**1**	
		$\boxed{P = 20.83\ \text{N}}$	**1**	
	(b)	**An effort of 800 N is required to lift a load of 10 kN. On this machine an effort of 1400 N, lifts a load of 22 kN. Find the law of machine.**		
	Ans.	Using law of machine P = mW + C		
		Putting values of load and effort 800 = m (10000) + C ---- (i) 1400 = m (22000) + C ---- (ii)	**1**	
		Solving simultaneous equations m = 0.05	**1**	**4**
		Putting value of m in eqn (i) 800 = (0.05×10000) + C C = 300 N	**1**	
		Hence, Law of machine $\boxed{P = (0.05)\,W + 300\ \text{N}}$ ---(iii)	**1**	
	(c)	**A screw jack lifts a load of 30 kN by an effort of 400 N applied at the end of lever arm of length 750 mm. If the pitch of screw is 6 mm. Calculate efficiency of the screw jack.**		
	Ans.	$\text{V.R.} = \frac{2 \times \pi \times L}{p}$ $\text{V.R.} = \frac{2 \times \pi \times 750}{6}$ $\text{V.R.} = 785.4$	**1**	
		$\text{M.A.} = \frac{W}{P} = \frac{30000}{400}$ $\text{M.A.} = 75$	**1**	**4**

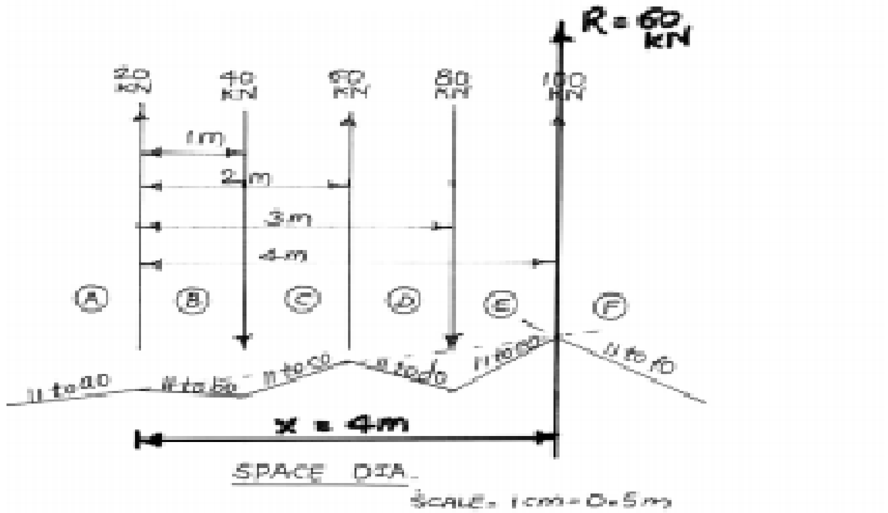
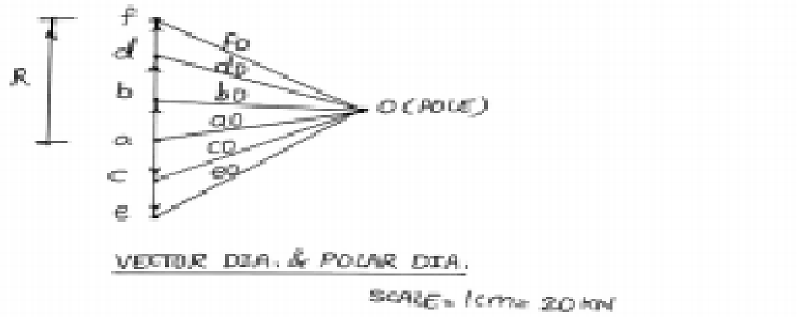
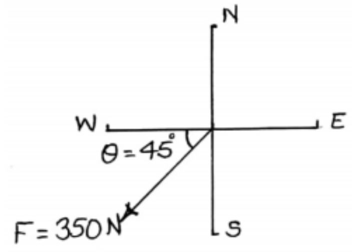
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 2	(c)	$\% \eta = \frac{M.A.}{V.R.} \times 100$ $= \frac{75}{785.4} \times 100$ $\boxed{\% \eta = 9.55\%}$	1 1	
	(d)	**A machine has VR = 25 and law of machine is P = (0.01 W + 5) N. Find M.A., efficiency and effort lost in friction when load is 1000 N, also state whether the machine is reversible or not.**		
	Ans.	1) Mechanical Advantage $P = [(0.01 \times W) + 5] N$ $P = 15 N$ $M.A. = \frac{W}{P} = \frac{1000}{15}$ $\boxed{M.A. = 66.67}$ 2) $\% \eta = \frac{M.A.}{V.R.} \times 100$ $= \frac{66.67}{25} \times 100$ $\boxed{\% \eta = 266.68\%}$ Practically efficiency of machine is always less than 100 % 3) Effort lost in friction at a load of 1000 N $P_i = \frac{W}{V.R.} = \frac{1000}{25}$ $\boxed{P_i = 40 N}$ $P_f = P - P_i = 15 - 40$ $\boxed{P_f = -25 N}$ 4) Machine is reversible as $\% \eta > 50\%$.	½ 1 1 1 ½	4
	(e)	**Resolve a force of 500 N into two directions at 30° and 45° on either side of it.**		
	Ans.			

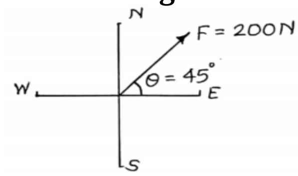
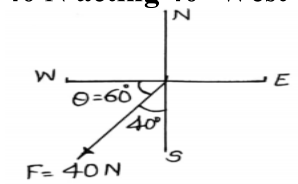
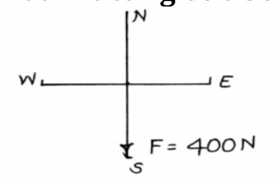
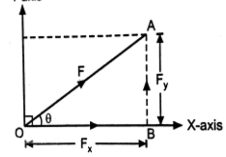
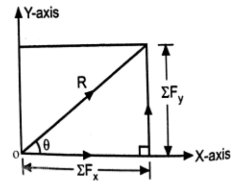
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 2		$F_1 = \dfrac{F \times \sin\beta}{\sin(\alpha+\beta)}$	1	
		$= \dfrac{500 \times \sin 45}{\sin(30+45)}$		
		$\boxed{F_1 = 366.03\ N}$	1	4
		$F_2 = \dfrac{F \times \sin\alpha}{\sin(\alpha+\beta)}$	1	
		$= \dfrac{500 \times \sin 30}{\sin(30+45)}$		
		$\boxed{F_2 = 258.82\ N}$	1	
		OR		
				
		Using conditions of equilibrium for concurrent force system		
		$\sum F_x = 0$		
		$+[F_1 \times (\cos 30)] + [F_2 \times (\cos 45)] = 500$		
		$+[F_1 \times (0.866)] + [F_2 \times (0.707)] = 500$ -----(1)	1	
		$\sum F_y = 0$		
		$+[F_1 \times (\sin 30)] - [F_2 \times (\sin 45)] = 0$	1	4
		$+[F_1 \times (0.5)] - [F_2 \times (0.707)] = 0$ -----(2)		
		Solving equation (1) and (2) simultaneously		
		$\boxed{F_1 = 366.03\ N}$	1	
		$\boxed{F_2 = 258.82\ N}$	1	

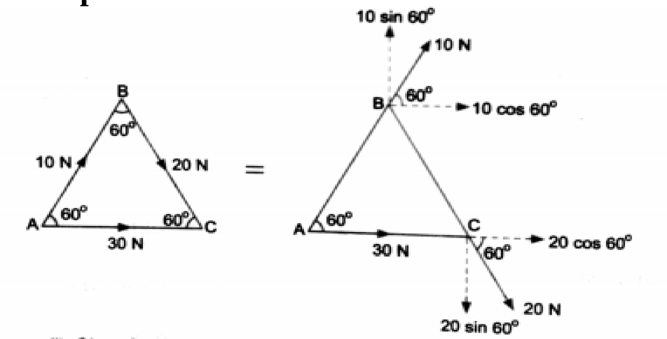
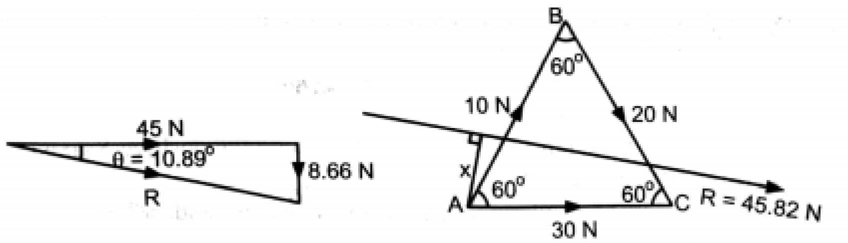
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 2	(f)	**Determine the resultant moment of the forces about point 'A' in fig. 1.**		
	Ans.	Fig. - 1 		
		Taking moment of all forces about point A		
		$M_A = +\left[20 \times 2\right] - \left[(30 \times \sin 45) \times 2\right]$	2	4
		$\boxed{M_A = -2.426 \text{ kN.m}}$	2	
		OR		
		$\boxed{M_A = +2.426 \text{ kN.m (Anti-clockwise)}}$		
Q. 3		**Solve any FOUR:**		(16)
	(a)	**Find the components of 60 N force acting horizontal, in two directions on either side at an angle of 30° each.**		
	Ans.			
		$F_1 = \dfrac{F \times \sin \beta}{\sin(\alpha + \beta)}$	1	
		$= \dfrac{60 \times \sin 30}{\sin(30 + 30)}$		
		$\boxed{F_1 = 34.64 \text{ N}}$	1	4
		$F_2 = \dfrac{F \times \sin \alpha}{\sin(\alpha + \beta)}$	1	
		$= \dfrac{60 \times \sin 30}{\sin(30 + 30)}$		
		$\boxed{F_2 = 34.64 \text{ N}}$	1	

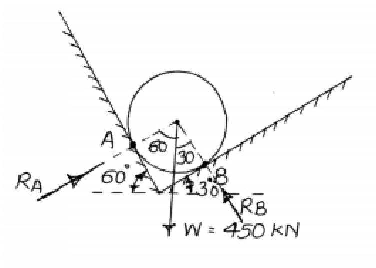
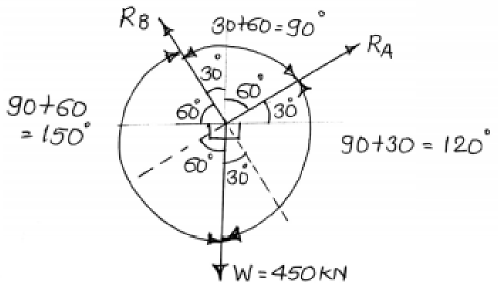
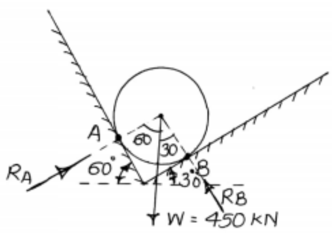
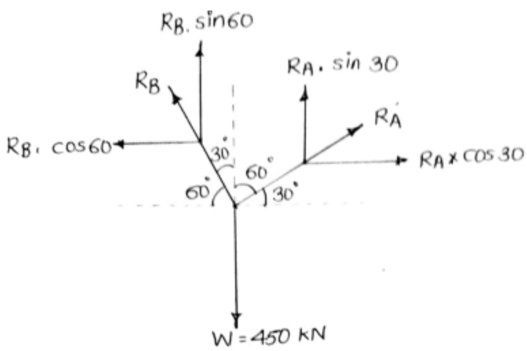
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 3	(a)	**OR**		
				
		Using conditions of equilibrium for concurrent force system		
		$\sum F_x = 0$		
		$+\left[F_1 \times (\cos 30)\right] + \left[F_2 \times (\cos 30)\right] = 60$	1	
		$+\left[F_1 \times (0.866)\right] + \left[F_2 \times (0.866)\right] = 60$ -----(1)		
		$\sum F_y = 0$		
		$+\left[F_1 \times (\sin 30)\right] - \left[F_2 \times (\sin 30)\right] = 0$	1	4
		$+\left[F_1 \times (0.5)\right] - \left[F_2 \times (0.5)\right] = 0$ -----(2)		
		Solving equation (1) and (2) simultaneously		
		$\boxed{F_1 = 34.64 \text{ N}}$	1	
		$\boxed{F_2 = 34.64 \text{ N}}$	1	
	(b)	**Find the resultant force and its directions if two forces 20 N and 40 N is acting along the adjacent sides of a parallelogram making an angle of 60°.**		
	Ans.			
		Let, $P = 20\text{ N},\ Q = 40\text{ N}, \theta = 60°$		
		Using the parallelogram law of forces		
		$R = \sqrt{P^2 + Q^2 + (2 \times P \times Q \times \cos\theta)}$	1	
		$= \sqrt{(20)^2 + (40)^2 + (2 \times 20 \times 40 \times \cos 60)}$		
		$\boxed{R = 52.92 \text{ N}}$	1	

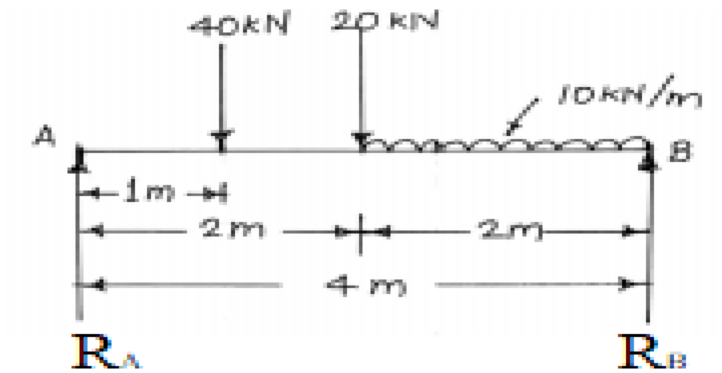
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 3	(b)	Let, α be the inclination of R with P.		
		$\alpha = \tan^{-1}\left[\dfrac{Q\times\sin\theta}{P + (Q\times\cos\theta)}\right]$	1	4
		$= \tan^{-1}\left[\dfrac{40\times\sin 60}{20 + (40\times\cos 60)}\right]$		
		$\boxed{\alpha = 40.90° \text{ with } 20\text{ N force.}}$	1	
	(c)	**Five parallel forces of magnitude 20, 40, 60, 80 and 100 kN are acting on a beam. Distance of forces from 20 kN force are 1 m, 2 m, 3 m and 4 m respectively. Forces of 40 kN and 80 kN are acting vertically downwards. Other pointing upwards. Find the resultant in magnitude and direction and locate its position with respect to 20 kN force.**		
	Ans.		1	
		1) Magnitude of Resultant R = +20 – 40 + 60 – 80 + 100 = + 60 kN $\boxed{\text{R = 60 kN (Acting vertically upward)}}$	1	4
		2) Position of Resultant Considering Varignon’s theorem of moment and taking moment of all forces about 20 kN force. Let, R acts at x distance from 20 kN force. $\Sigma M_F = M_R$ (20 X 0) + (40 X 1) - (60 X 2) + (80 X 3) – (100 X 4) = - R X x (20 X 0) + (40 X 1) - (60 X 2) + (80 X 3) – (100 X 4) = - 60 X x	1	
		$\boxed{x = 4m}$	1	
		Hence, R must be located at 4 m distance from 20 kN force, so as to produce Anti-clockwise moment.		

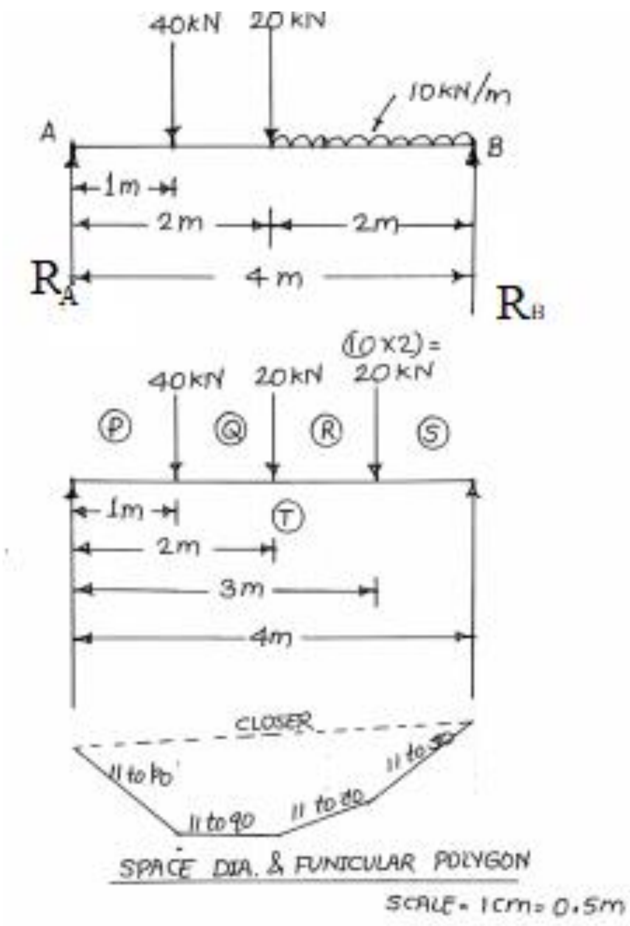
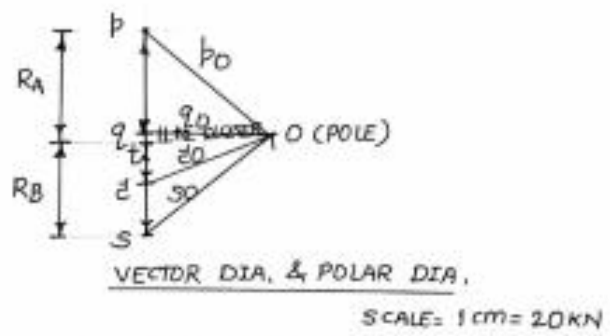
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 3	(d)	**Solve Q. 3 (C) graphically.**		
	Ans.		1 ½	
			1 ½	4
		R=l (af)xscale R=3X20=60kN As point 'f' lies above 'a', R acts vertically upwards. x=4m from 20kN force.	1	
	(e)	**Resolve each of the following forces into orthogonal components:** **(i) 350 N acting South – West away** **(ii) 200 N acting North-East away** **(iii) 40 N acting 40° West of South away** **(iv) 400 N acting due South way.**		
	Ans.	**(i) 350 N acting South – West away** $F_x = -F \times \cos\theta$ $= -350 \times \cos 45$ $\boxed{F_x = -247.49\,N}$ $F_y = -F \times \sin\theta$ $= -350 \times \sin 45$ $\boxed{F_y = -247.49\,N}$	**½ each**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 3	**(e)**	**(ii) 200 N acting North-East away**  $F_x = +F \times \cos\theta$ $= +200 \times \cos 45$ $\boxed{F_x = +141.42\,N}$ $F_y = +F \times \sin\theta$ $= +200 \times \sin 45$ $\boxed{F_y = +141.42\,N}$	**½ each**	
		(iii) 40 N acting 40° West of South away  $F_x = -F \times \cos\theta$ $= -40 \times \cos 60$ $\boxed{F_x = -20\,N}$ $F_y = -F \times \sin\theta$ $= -40 \times \sin 60$ $\boxed{F_y = -34.64\,N}$	**½ each**	**4**
		(iv) 400 N acting due South way  $F_x = F \times \cos\theta$ $= 400 \times \cos 270$ $\boxed{F_x = 0\,N}$ $F_y = F \times \sin\theta$ $= 400 \times \sin 270$ $\boxed{F_y = -400\,N}$	**½ each**	
	(f)	**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 a force.	**1**	
		 $F_x = F\cos\theta$, $F_y = F\sin\theta$	**1**	**4**
		(ii) Composition of force: The process of finding out the resultant force of a given force system is called as composition of forces.	**1**	
		 $R=\sqrt{\sum(F_X)^2+\sum(F_y)^2}$ $\theta=\tan^{-1}(F_y / F_X)$	**1**	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 4		**Attempt any FOUR of the following:**		**(16)**
	(a)	**A triangle ABC of 1 m side is subjected to forces of 10 N, 20 N, 30 N along AB, BC & AC respectively. Find the magnitude, direction and locate the position of it from A.**		
	Ans.			
		1) Resolving all forces		
		$\sum F_x = (10\times\cos 60)+(20\times\cos 60)+30 = 45\,N$	½	
		$\sum F_y = (10\times\sin 60)-(20\times\sin 60) = -8.66\,N$	½	
		2) Magnitude of Resultant		
		$R = \sqrt{\left(\sum F_x\right)^2+\left(\sum F_y\right)^2} = = \sqrt{(45)^2+(8.66)^2}$		
		$\boxed{R = 45.82\ N}$	1	
		$\boxed{\text{As } \sum F_x = +\text{ve and } \sum F_y = -\text{ve, R lies in fourth quadrant}}$		
		3) Direction of resultant		
		$\theta = \tan^{-1}\left\lvert\frac{\sum F_y}{\sum F_x}\right\rvert = = \tan^{-1}\left\lvert\frac{8.66}{45}\right\rvert$		
		$\boxed{\theta = 10.89^\circ \text{ with positive x axis}}$	½	
		4) Position of resultant		
		Let, x be the perpendicular distance of the resultant from point A.		
		Using Varignon's theorem of moment,		4
		$\sum M_{F_A} = M_{R_A}$		
		$(10\times 0)+(30\times 0)+(20\times\cos 60\times 0)+(20\times\sin 60\times 1) = R\times x$		
		$17.32 = 45.82\times x$		
		$\boxed{x = 0.38\ \text{m from point A}}$	1	
		The resultant must be located at a perpendicular distance of 0.38 m from A, on upper side of A so as to produce the clockwise moment about A.		
		(Note: As position of A changes ∑ Fx, ∑ Fy, θ, and quadrant of R will change accordingly. Magnitude of R and distance x will remain same.)		
			½	

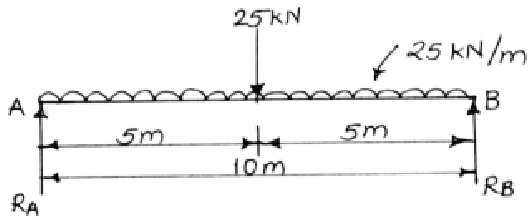
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 4	**(b)**	**A sphere of weight 450 kN rests in a groove of smooth inclined surfaces which are making 60° and 30° inclination with horizontal. Find the reactions at the contact surfaces.**		
	Ans.	FBD	1	
		Using Lami's Theorem, $\frac{450}{\sin 90} = \frac{R_A}{\sin 150} = \frac{R_B}{\sin 120}$ (1) (2) (3)	1	
		Using term (1) and (2) $\frac{450}{\sin 90} = \frac{R_A}{\sin 150}$ $R_A = \frac{450 \times \sin 150}{\sin 90}$ $\boxed{R_A = 225\ \text{N}}$	1	4
		Using term (1) and (3) $\frac{450}{\sin 90} = \frac{R_B}{\sin 120}$ $R_B = \frac{450 \times \sin 120}{\sin 90}$ $\boxed{R_B = 389.71\ \text{N}}$	1	
		OR 	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 4	(b)	Using conditions of equlibrium for concurrent force system and resolving all forces. $\sum F_x=0$ $+(R_A \times \cos 30)-(R_B \times \cos 60)=0$ $+(R_A \times 0.866)-(R_B \times 0.5)=0$----(1)	1	4
		$\sum F_y=0$ $+(R_A \times \sin 30)+(R_B \times \sin 60)-450=0$ $+(R_A \times 0.5)+(R_B \times 0.866)=450$-----(2)	1	
		Solving equation (1) and (2) $\boxed{R_A=225N}$ $\boxed{R_B=389.71N}$	1	
	(c)	**A beam of span 4 m is simply supported at its end. It carries a concentrated load of 40 kN and 20 kN at 1 m and 2 m from left hand support respectively. It carries a udl of 10 kN/m for 2 m from the right end. Determine the reactions at supports.**		
	Ans.	 	1	
		$\sum F_y=0$ $+R_A - 40 - 20 - (10\times 2) + R_B=0$ $R_A+R_B=80$ ----(1)	1	4
		$\sum M_A=0$ $+(40 \times 1)+(20 \times 2)+(10 \times 2 \times [2+1])-(R_B \times 4)=0$ $\boxed{R_B = 35\,kN}$	1	
		Putting value of R_B in equation (1) $R_A+R_B=80$ $R_A+35=80$ $\boxed{R_A=45kN}$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 4	(d)	**Solve Q. 4 (C) by graphical method.**		
	Ans.		1 ½	4
			1 ½	
		$R_A = l(pt) \times Scale = 45kN$ $R_B = l(st) \times Scale = 35kN$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 4	(e)	**A simply supported beam of span 10 m carries a centre load of 25 kN and a u.d.l of 25 kN/m throughout. Find support reaction.**		

Ans.



(1 mark)

$\sum F_y = 0$

$+R_A - 25 - (25\times10) + R_B = 0$

$R_A + R_B = 275$ ----(1)

(1 mark) (Total: 4)

$\sum M_A = 0$

$+(25\times5) + (25\times10\times5) - (R_B\times10) = 0$

$\boxed{R_B = 137.5\,\text{kN}}$

(1 mark)

Putting value of R_B in equation (1)

$R_A + R_B = 275$

$R_A + 137.5 = 275$

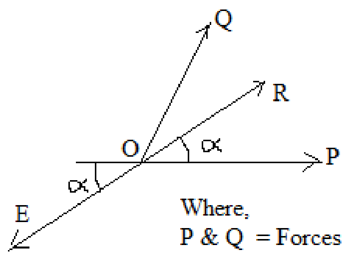
$\boxed{R_A = 137.5\,\text{kN}}$

(1 mark)

(f) **Distinguish between resultant and equilibrant.**

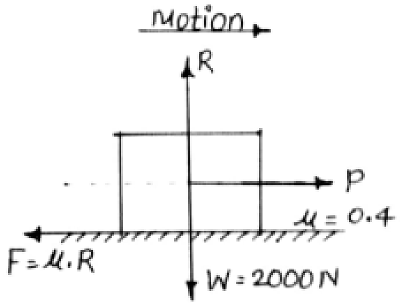
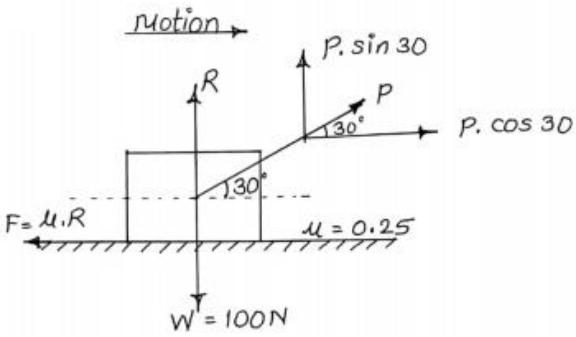
Ans.

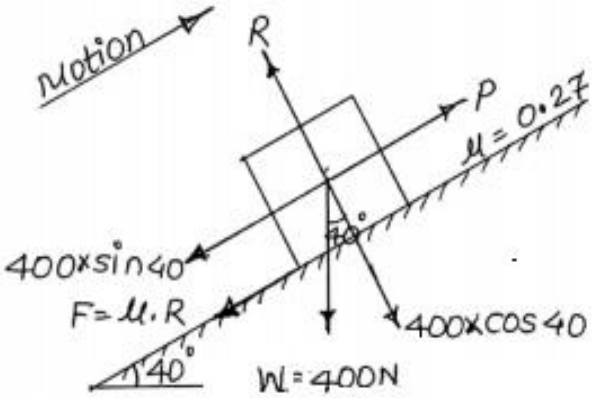
Resultant	Equilibrant
1) Resultant is a single force which can produce the same effect on the body as it is produced by all forces acting together.	1) Equilibrant is a single force which when acts with other forces brings the set of forces and body in equilibrium.
2) It is donated by R.	2) It is denoted by E.
3) It causes displacement of body.	3) It keeps the body at rest.
4) The set of forces which causes the displacement of a body are called as components of a resultant or component forces.	4) The set of forces which keeps the body at rest are called as components of a equilibrant or equilibrant forces.
5)	

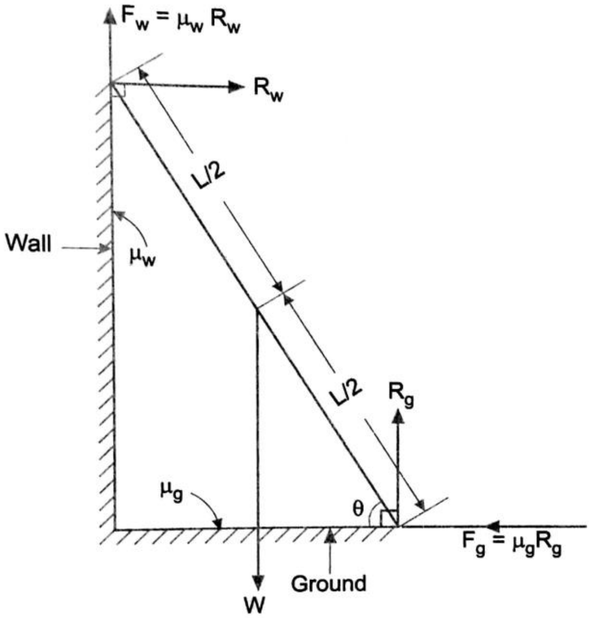


Where,
P & Q = Forces
R = Resultant
E = Equilibrant

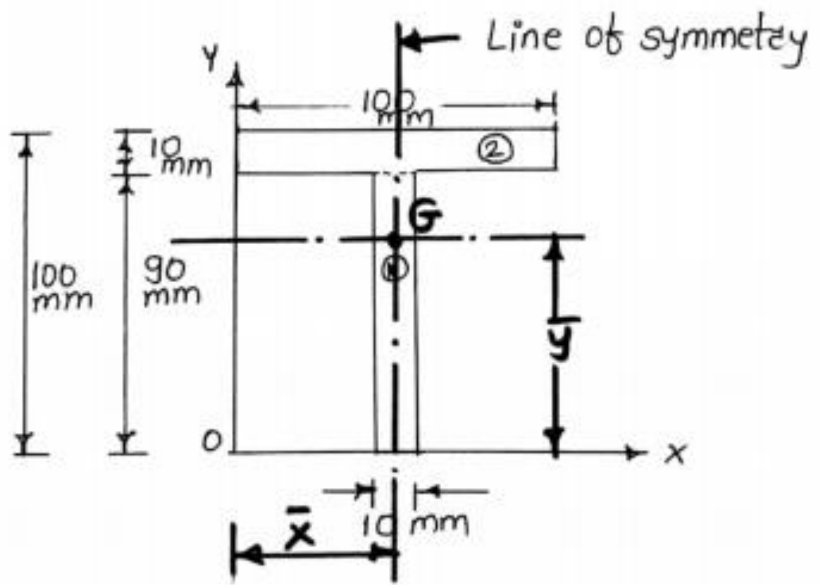
(Marks: 1 each (any four); Total: 4)

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 5		**Attempt any FOUR of the following:**		(16)
	(a)	**A body of weight 2000 N rest on a horizontal plane. If the coefficient of friction is 0.4. Find the horizontal force required to move the body.**		
	Ans.		1	
		For limiting equilibrium $\sum F_y = 0$ $+ R - 2000 = 0$ $R = 2000$ N	1	4
		$\sum F_x = 0$ $P - F = 0$ $P - (\mu \times R) = 0$	1	
		$P - (0.4 \times 2000) = 0$ $\boxed{P = 800\,N}$	1	
	(b)	**A block of 100 N is placed on a horizontal plane where the coefficient of friction is 0.25. Find the force at 30° up the horizontal to just move the block.**		
	Ans.		1	
		For limiting equilibrium $\sum F_x = 0$ $(P \times \cos 30) - F = 0$ $(P \times \cos 30) - (\mu \times R) = 0$	1	
		$(P \times 0.866) - (0.25 \times R) = 0$ $(0.25 \times R) = (P \times 0.866)$ $R = P \times 3.464$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 5	(b)	$\sum F_y=0$ $(P\times\sin 30)+R-100=0$ $(P\times0.5)+(P\times3.464)=100$ $\boxed{P=25.23\text{ N}}$	1	4
	(c)	**A block of 400 N is kept on 40° inclined plane. Find the force, applied parallel to plane, require to just move the block up the plane. Coefficient of friction is 0.27.**		
	Ans.	 	1	
		For limiting equilibrium $\sum F_y=0$ $+R-(400\times\cos 40)=0$ $R=306.42\text{ N}$	1	4
		$\sum F_x=0$ $P-F-(400\times\sin 40)=0$ $P-(\mu\times R)-(400\times\sin 40)=0$	1	
		$P-(0.27\times306.42)-(257.12)=0$ $\boxed{P=339.84\text{N}}$	1	
	(d)	**Draw FBD of a ladder resting against a wall and floor having weight W.**		
	Ans.	Here, μ_g = Coefficient of friction between the ladder and the ground. μ_w = Coefficient of friction between the ladder and the wall. R_g = Normal reaction at the ground. R_w = Normal reaction at the wall. F_g =Force of friction between the lader and the ground. F_w = Force of friction between the lader and the wall.		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 5	(d)	 ***(Note: 2 Marks for sketch, 1 Mark for showing Active forces and 1 Mark for showing Reactive forces.)***	4	4
	(e) Ans.	**State the procedure to draw funicular polygon with resultant of concurrent and parallel force system.** **Procedure to draw funicular polygon with resultant for concurrent force system:** 1) Draw a given concurrent force system by taking given angles accurately using protractor. 2) Use Bow's notation to represent the force system. 3) Give name to the diagram as 'Space diagram'. 4) Space diagram is used to draw 'Vector diagram'. 5) For drawing vector diagram, use suitable scale to represent the given forces. According to the force direction and scale draw parallel lines to each force as per Bow's notation. 6) Join first point and last point. Consider the direction from first point to last point which indicates direction of resultant. 7) Draw line parallel to first and last point from origin in Space diagram which will give position of resultant. 8) Measure angle of resultant from 'x' axis to get its position. **Procedure to draw funicular polygon with resultant for parallel force system:** 1) By taking suitable scale for distances between forces, draw given parallel force system. 2) Use Bow's notation to represent the force system. 3) Give name to the diagram as 'Space diagram and funicular polygon'.	2	

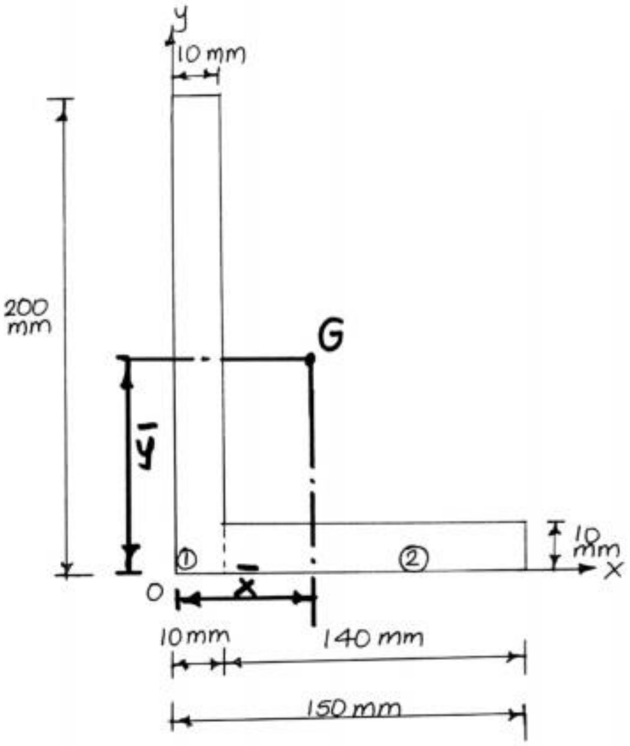
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 5	(e)	4) Space diagram is used to draw 'Vector diagram and polar diagram'. 5) For drawing vector diagram, use suitable scale to represent the given forces. According to the force direction and scale draw parallel lines to each force as per Bow's notation. 6) Take one point as pole and join all lines to this pole. 7) Now draw lines parallel to polar diagram according to space names in corresponding space in 'Space diagram and funicular diagram'. 8) Extend parallel line drawn for first and last point in space diagram. The intersection of these two lines will give position of resultant. 9) In Vector and polar diagram, observe the direction of last point from first point, which will indicate direction of resultant. 10) Measure length from first to last point in vector and polar diagram and multiply it by scale to get magnitude of resultant. 11) In space diagram and funicular polygon, measure the distance of resultant from given force to get position of resultant from given force.	2	4
	(f)	**A certain machine has a velocity ratio 20. If the load of 100 N is lifted by an effort of 25 N. Find the mechanical advantage and efficiency of machine.**		
	Ans.	$\text{M.A.} = \frac{W}{P}$	1	
		$= \frac{100}{25}$ $\boxed{\text{M.A.} = 4}$	1	4
		$\%\eta = \frac{\text{M.A.}}{\text{V.R.}} \times 100$	1	
		$= \frac{4}{20} \times 100$ $\boxed{\%\eta = 20\,\%}$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 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	
		(1) Area calculation $a_1 = 10 \times 90 = 900 mm^2$ $a_2 = 100 \times 10 = 1000 mm^2$ $a = a_1 + a_2 = 1900 mm^2$	½	4
		(2) $\bar{x}$ calculation As given figure is symmetric @ y axis, $\bar{x} = \frac{100}{2}$ $\boxed{\bar{x} = 50 \text{ mm from y axis}}$	½	
		(3) $\bar{y}$ calculation $y_1 = \frac{90}{2} = 45 \text{ mm}$ $y_2 = 90 + \left(\frac{10}{2}\right) = 95 \text{ mm}$	1	
		$\bar{y} = \frac{(a_1 \times y_1) + (a_2 \times y_2)}{a} = \frac{(900 \times 45) + (1000 \times 95)}{1900}$ $\boxed{\bar{y} = 71.32 \text{ mm from x axis.}}$	1	

<table>
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answer</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>Q. 6</td><td>(b)

Ans.</td><td>

Find the position of centroid of an unequal angle section with dimensions 200 mm X 150 mm X 10 mm. Longer leg is vertical.



(1) Area calculation

$a_1 = 200\times10 = 2000\text{ mm}^2$

$a_2 = 140\times 10 = 1400\text{ mm}^2$

$a = a_1 + a_2 = 3400\text{mm}^2$

(2) $\bar{x}$ calculation

$x_1 = \frac{10}{2} = 5\text{ mm}$

$x_2 = 10+\left(\frac{140}{2}\right) = 80\text{ mm}$

$\bar{x} = \frac{(a_1x_1)+(a_2x_2)}{a} = \frac{(2000\times5)+(1400\times80)}{3400}$

$\boxed{\bar{x} = 35.88\text{ mm from y axis}}$

(3) $\bar{y}$ calculation

$y_1 = \frac{200}{2} = 100\text{ mm}$

$y_2 = \frac{10}{2} = 5\text{ mm}$

$\bar{y} = \frac{(a_1y_1)+(a_2y_2)}{a} = \frac{(2000\times100)+(1400\times5)}{3400}$

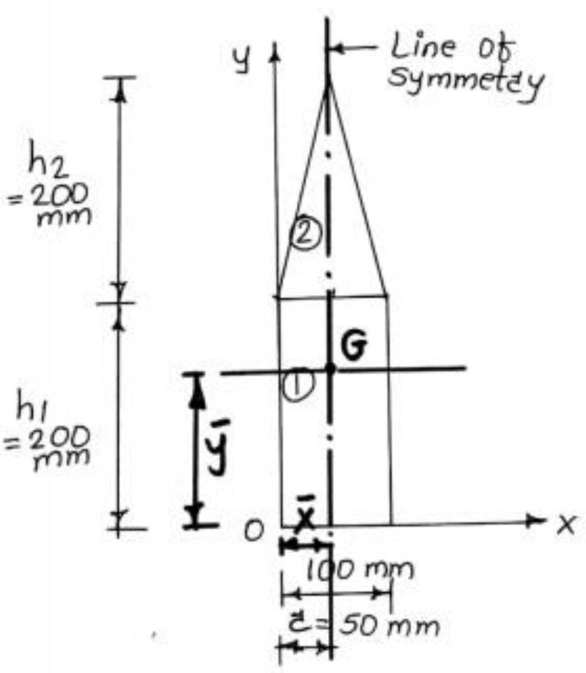
$\boxed{\bar{y} = 60.88\text{ mm from x axis.}}$

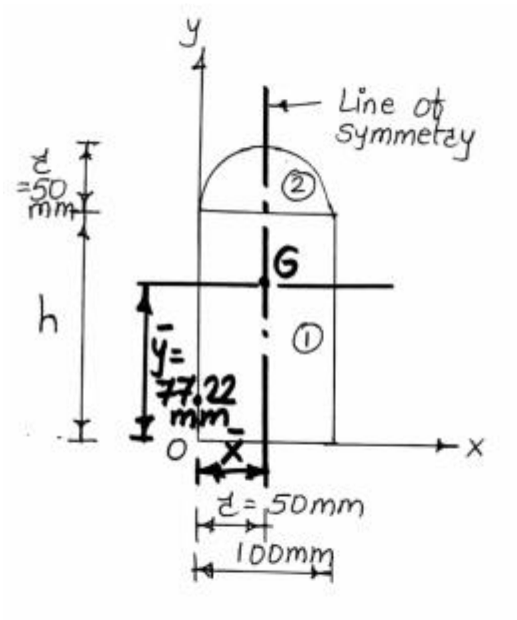
</td><td>1

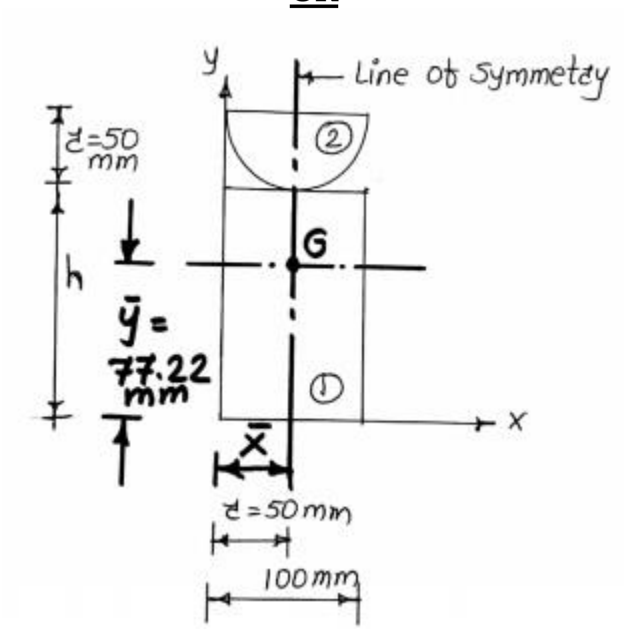
1

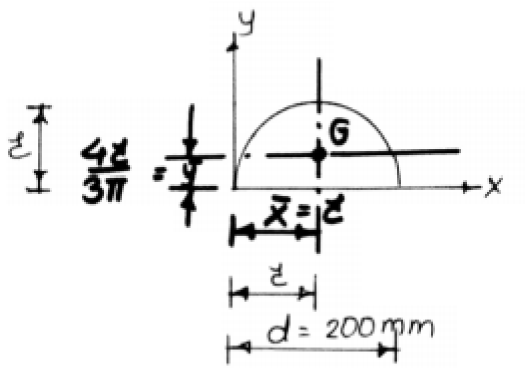
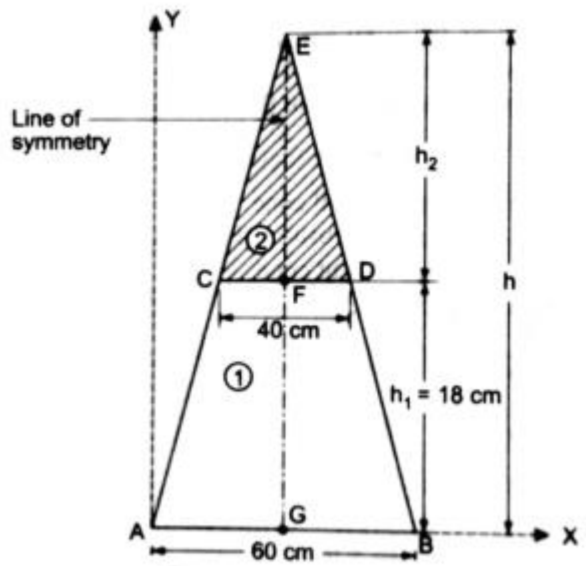
1

1</td><td>4</td></tr>
</table>

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	(c)	**A solid forming a cone of base 100 mm and height 200 mm joins to base with cylinder of base 100 mm and height 200 mm. Compute the position of C.G.**		
	Ans.		1	
		Let, Fig. 1 = Cylinder and Fig. 2 = Cone (1) Volume Calculation $v_1 = \pi \times r^2 \times h_1 = \pi \times 50^2 \times 200$ $= (500000 \times \pi)\ mm^3$ $v_2 = \frac{1}{3} \times \pi \times r^2 \times h_2 = \frac{1}{3} \times \pi \times 50^2 \times 200$ $= (166666.67 \times \pi)\ mm^3$ $V = v_1 + v_2 = (666666.67 \times \pi)\ mm^3$	1	4
		(2) $\bar{x}$ calculation As figure is symmetric about y axis, $\boxed{\bar{x} = r = 50 \text{ mm form y axis}}$		
		(3) $\bar{y}$ calculation $y_1 = \left(\frac{h}{2}\right) = \left(\frac{200}{2}\right) = 100\,mm$ $y_2 = h_1 + \left(\frac{h_2}{4}\right) = 200 + \left(\frac{200}{4}\right) = 250\ mm$	1	
		$\bar{y} = \frac{v_1 y_1 + v_2 y_2}{V} = \frac{[(500000 \times \pi) \times 100] + [(166666.67 \times \pi) \times 250]}{(666666.67 \times \pi)}$ $\boxed{\bar{y} = 137.5 \text{ mm form x axis}}$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	**(d)**	**A hemisphere of diameter 100 mm is placed on the top of cylinder whose diameter is also 100 mm. If the C.G. of the composite solid is 77.22 mm from the bottom of the cylinder. Find the height of the cylinder.**		
	Ans.	 		
		Let, Fig. 1 = Cylinder and Fig. 2 = Hemisphere (1) Volume Calculation $V_1 = \pi \times r^2 \times h = \pi \times 50^2 \times h$ $= (7853.981634 \times h)\ mm^3$ $V_2 = \frac{2}{3} \times \pi \times r^3 = \frac{2}{3} \times \pi \times 50^3$ $= (261799.3878)\ mm^3$ $V = V_1 + V_2 = [(7853.981634 \times h) + (261799.3878)]\ mm^3$	1	
		(2) Calculation of height of cylinder $y_1 = \left(\frac{h}{2}\right) = (0.5 \times h)$ $y_2 = h + \left(\frac{3 \times r}{8}\right) = h + \left(\frac{3 \times 50}{8}\right) = (h + 18.75)$ $\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V} = \frac{[(7853.981634 \times h) \times (0.5 \times h)] + [(261799.3878) \times (h + 18.75)]}{[(7853.981634 \times h) + (261799.3878)]}$ $77.22 \times [(7853.981634 \times h) + (261799.3878)] = [(7853.981634 \times h) \times (0.5 \times h)] + [(261799.3878) \times (h + 18.75)]$	1	4
		$0 = (3926.990817 \times h^2) - (344685.074 \times h) - (15307410.21)$	1	
		Solving quadratic equation, $\boxed{h = 120.20\ mm}$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	(d)	**OR**  		
		Let, Fig. 1 = Cylinder and Fig. 2 = Hemisphere		
		(1) Volume Calculation $V_1 = \pi \times r^2 \times h = \pi \times 50^2 \times h$ $= (7853.981634 \times h)\ mm^3$ $V_2 = \frac{2}{3} \times \pi \times r^3 = \frac{2}{3} \times \pi \times 50^3$ $= (261799.3878)\ mm^3$ $V = V_1 + V_2 = \left[(7853.981634 \times h) + (261799.3878)\right] mm^3$	1	
		(2) Calculation of height of cylinder $y_1 = \left(\frac{h}{2}\right) = (0.5 \times h)$ $y_2 = h + \left\{r - \left(\frac{3 \times r}{8}\right)\right\} = h + \left\{50 - \left(\frac{3 \times 50}{8}\right)\right\} = (h + 31.25)$ $\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V} = \frac{\left[(7853.981634 \times h) \times (0.5 \times h)\right] + \left[(261799.3878) \times (h + 31.25)\right]}{\left[(7853.981634 \times h) + (261799.3878)\right]}$	1	4
		$77.22 \times \left[(7853.981634 \times h) + (261799.3878)\right] =$ $\left[(7853.981634 \times h) \times (0.5 \times h)\right] + \left[(261799.3878) \times (h + 31.25)\right]$	1	
		$0 = (3926.990817 \times h^2) - (344685.074 \times h) - (12034918.15)$ Solving quadratic equation, $\boxed{h = 114.53\ mm}$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	(e)	**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	1	
			1½	4
		$\overline{X} = r$ $\boxed{\overline{X} = 100\,\text{mm}}$	½	
		$\overline{y} = \frac{4 \times r}{3 \times \pi} = \frac{4 \times 100}{3 \times \pi}$ $\boxed{\overline{y} = 42.44\,\text{mm}}$	1	
	(f)	**The frustum of a cone has top diameter 40 cm and bottom diameter 60 cm with height 18 cm. Calculate it's depth.**		
	Ans.		1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	(f)	Let h = height of full cone, h_1 = height of frustum of cone = 18 cm h_2 = height of cut cone As the triangles Δ ABE and Δ CDE are symmetrical, $\frac{h}{60} = \frac{h_2}{40}$	1	4
		$h = \frac{60}{40} \times h_2$ $h = 1.5 \times h_2$ Now, $h_1 + h_2 = h$	1	
		$h_1 + h_2 = (1.5 \times h_2)$ $h_1 = (1.5 - 1) h_2$ $h_1 = (0.5)\ h_2$ $h_2 = \frac{h_1}{0.5} = \frac{18}{0.5}$ $\boxed{h_2 = 36\ \text{cm}}$ $h = h_1 + h_2$ Total depth(h) = 18 + 36 = 54 cm	1	