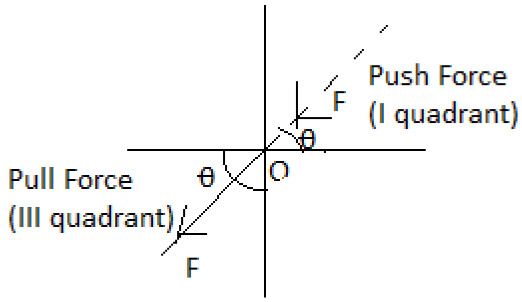
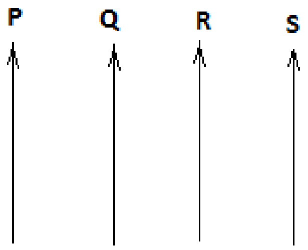
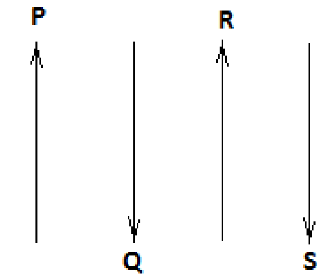
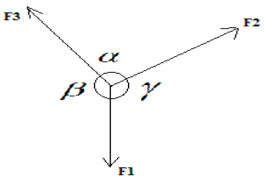
Model Answer: Summer 2018

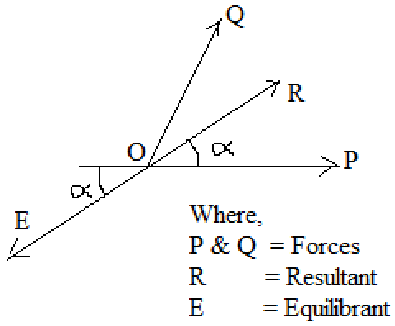
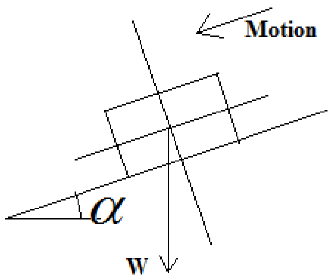
Subject: Engineering Mechanics **Sub. Code: 17204**

Important Instructions to examiners:

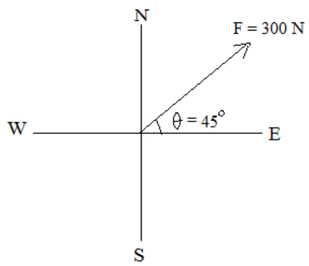
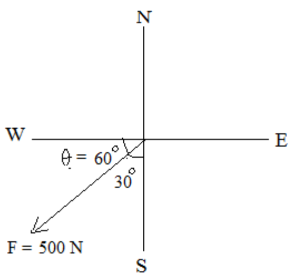
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling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

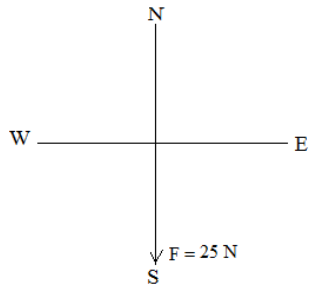
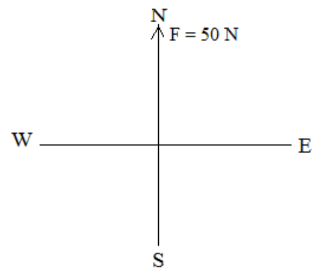
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 1		**Attempt any TEN of the following:**		20
	(a)	**Define Mechanical Advantage (MA) and Velocity Ratio (VR).**		
	Ans.	**Mechanical Advantage:** It is the ratio of the load (W) lifted by the machine to the effort (P) applied to lift the load. It is denoted by M.A. $M.A. = \frac{W}{P}$	1	
		Velocity Ratio: It is the ratio of distance travelled by effort (y) to distance travelled by load (x). $V.R. = \frac{y}{x}$	1	2
	(b)	**Define effort and state its SI units.**		
	Ans.	**Effort:** The force applied to overcome the resistance or to lift the load is known as effort.	1	
		S. I. Unit : N, kN	1	2
	(c)	**Define ideal machine.**		
	Ans.	**Ideal Machine:** It is the machine whose efficiency is 100 % and in which friction is zero.	2	2
	(d)	**Define force and state its SI units.**		
	Ans.	**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	
		S. I. Unit of force – N, kN	1	2

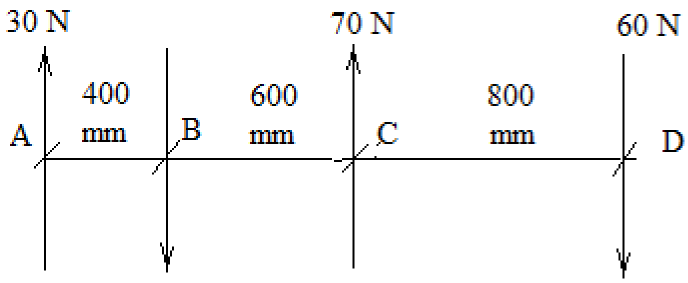
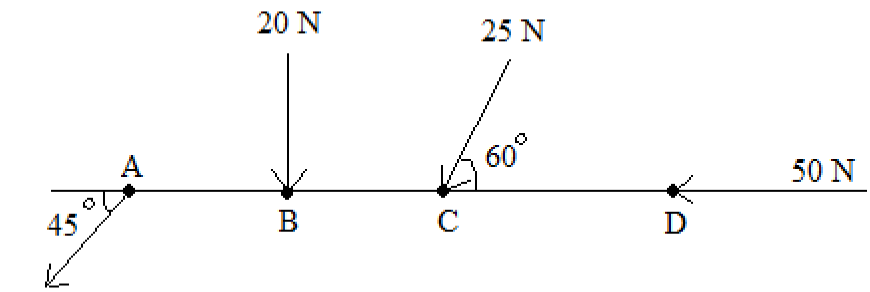
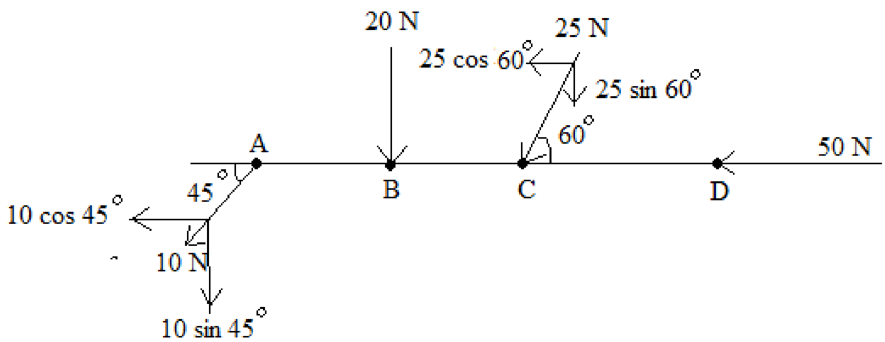
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 1	(e) Ans.	**State principle of transmissibility.** Principle of transmissibility of force states that, "if a force acts at a point on a rigid body, it is assumed to act at any other point on the line of action of force within the same body". As per this principle force of push nature can be made pull by extending the line of a force in opposite quadrant. 	2	2
	(f) Ans.	**Draw diagram of like parallel and unlike parallel force system.**  **Like Parallel Force System**  **Unlike Parallel Force System**	1 each	2
	(g) Ans.	**What is space diagram and vector diagram?** **Space diagram:** It is the diagram in which number of forces acting on body is drawn in space to a suitable scale & naming the spaces in order by Bow's notation. **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 1	 2
	(h) 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, $\frac{F_1}{\sin\alpha}=\frac{F_2}{\sin\beta}=\frac{F_3}{\sin\gamma}$ 	1 1	 2

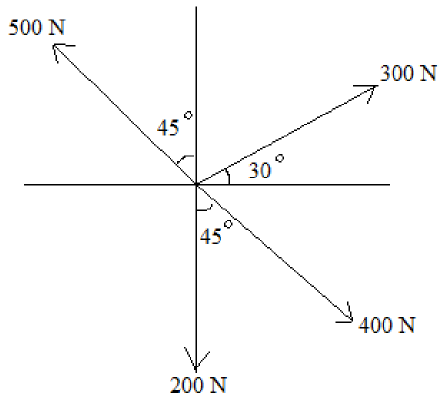
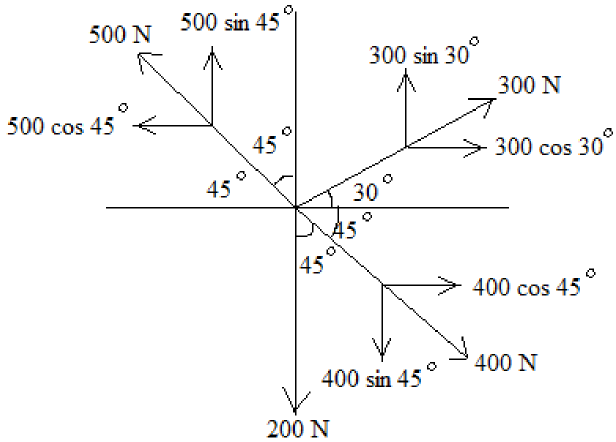
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 1	(i) Ans.	**State relation between resultant and equilibrant.** Equilibrant is always equal in magnitude, opposite in direction and collinear to the resultant.	1	
			1	2
	(j) Ans.	**Define angle of repose.** Angle of repose is defined as the angle 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
				
	(k) Ans.	**State advantages of friction.** 1) One can walk easily on rough surface than smooth surface. 2) Moving vehicle on road can be stopped suddenly by applying brakes. 3) One can hammer nail into wall. 4) One can easily hold pen, pencil and can write on paper.	1 each (any two)	2
	(l) Ans.	**State VR of screw jack and give the meaning of each terms used in it.** $V.R.=\frac{2\pi L}{p}$ OR $V.R.=\frac{2\pi R}{p}$	1	
		Where, V.R.= Velocity Ratio p = Pitch of the screw L = Length of handle R = Radius of effort wheel	1	2

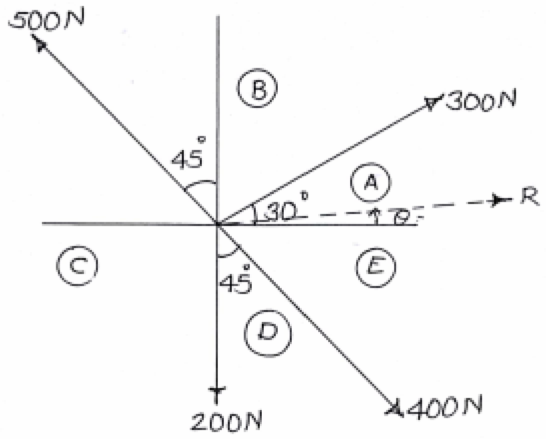
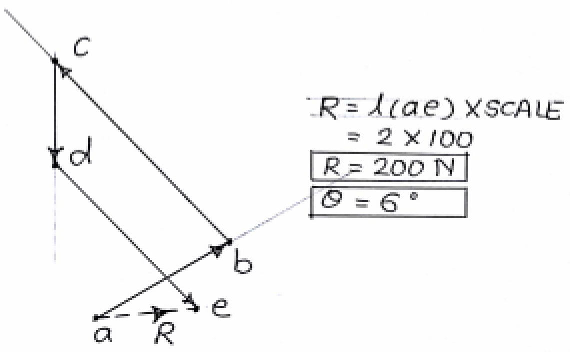
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2		**Attempt any FOUR :**		16
	(a)	**The law of machine is P = 0.02 W + 30 N. It has velocity ratio of 82. Calculate effort and effort lost in friction for a load of 1200 kN.**		
	Ans.	Effort requried to lift 1200 kN=1200000 N load $P = (0.02W+30)N$ $P = ((0.02\times1200000)+30))$ $\boxed{P = 24030\,N}$	2	
		Effort lost in friction $P_f = P - P_i$ $= P - \left(\frac{W}{VR}\right)$ $= 24030 - \left(\frac{1200000}{82}\right)$	1	4
		$\boxed{P_f = 9395.854\,N}$	1	
	(b)	**In a differential axle and wheel, the diameter of wheel is 400 mm and diameter of bigger axle is 100 mm and smaller axle is 80 mm. If an effort of 50 N can lift a load of 1500 N. Find the velocity ratio and efficiency of the machine.**		
	Ans.	VR of differential axle & wheel is given by - $VR = \frac{2\times D}{d_1 - d_2}$	1	
		$= \frac{2\times400}{100-80}$ $\boxed{VR = 40}$	1	4
		$MA = \frac{W}{P} = \frac{1500}{50} = 30$	1	
		$\%\eta = \frac{MA}{VR}\times100$ $= \frac{30}{40}\times100$ $\boxed{\%\eta = 75\%}$	1	

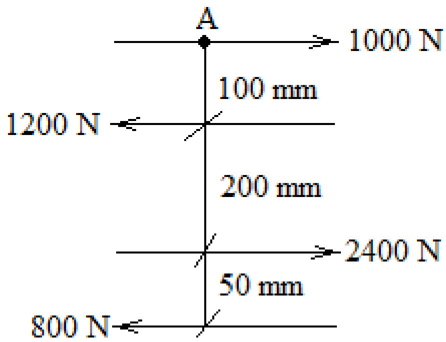
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2	(c)	**A screw jack has pitch of 5 mm and length of lever as 150 mm. An effort required to lift a load of 80 kN is 500 N. Calculate the efficiency and state the type of machine.**		
	Ans.	$V.R.=\frac{2\pi L}{p}=\frac{2\times\pi\times150}{5}$		
		$V.R.=188.495$	1	
		$MA=\frac{W}{P}=\frac{80000}{500}=160$	1	
		$\eta\%=\frac{MA}{VR}\times100\%$		
		$=\left(\frac{160}{188.495}\right)\times100$		4
		$P=84.883\%$		
		$\boxed{\%\eta=84.883\%}$	1	
		Type of machine :		
		As $\%\eta=84.883\%>50\%$, machine is $\boxed{\text{Reversible machine}}$.	1	
	(d)	**Find the orthogonal component of the following forces.** **(1) 300 N acting NE** **(2) 500 N acting 30° West of South** **(3) 25 N due South and** **(4) 50 N due North**		
	Ans.	**1) 300 N acting NE**		
				
		$F_x = F\cos\theta = 300 \times \cos 45 = 212.132$ N $F_y = F\sin\theta = 300 \times \cos 45 = 212.132$ N		
		(2) 500 N acting 30° West of South		
				
		$F_x = F\cos\theta = 500 \times \cos 60 = 250$ N $F_y = F\sin\theta = 500 \times \sin 60 = 433.012$ N	1 each	4

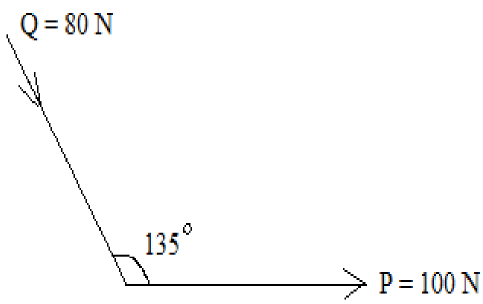
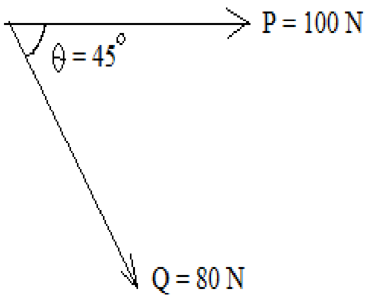
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2		**(3) 25 N due South**  Fx = F cos θ = 25 X cos 270 = 0 N Fy = F sin θ = 25 X sin 270 = - 25 N		
		(4) 50 N due North  Fx = F cos θ = 50 X cos 90 = 0 N Fy = F sin θ = 50 X sin 90 = 50 N		
	(e) Ans.	**Define couple and state any four properties of couple.** **Couple:** Two equal, unlike, parallel, non-collinear forces form a couple.	2	
		Properties of couple : 1) The resultant of the forces of a couple is zero. 2) The moment of a couple is equal to the product of one of the force and arm of couple. 3) Moment of a couple about any point is constant. 4) A couple can be balanced only by another couple of equal and opposite moment. 5) Two or more couples are said to be equal when they have same sense and moment. 6) Any number of coplanar couples can be represented by a single couple, the moment of which is equal to the algebraic sum of the moment of all the couples.	½ each (any four)	4

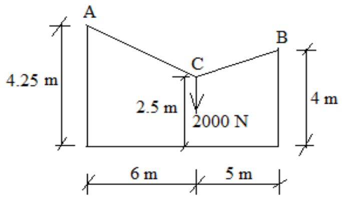
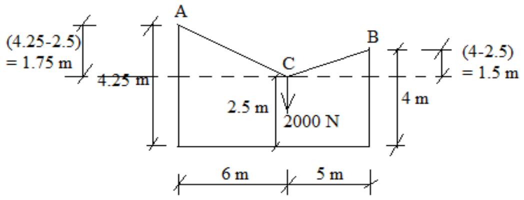
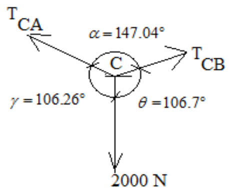
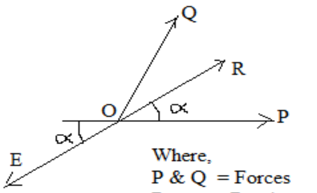
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2	(f)	**Calculate the resultant in magnitude, direction and position with respect to 30 N force for the parallel forces system as shown in fig (I).**		
	Ans.	 Fig. (I) Magnitude of resultant $R = \Sigma F$ $= +30 - 40 + 70 - 60$ $\boxed{R = 0\ N}$	4	4
Q. 3		**Attempt any <u>FOUR</u> :**		16
	(a)	**Four forces act on a bar as shown in fig (II). Determine their resultant in magnitude and direction, if AB = 2m, BC = 2m, CD = 3m.**		
	Ans.	 Fig. (II)  		

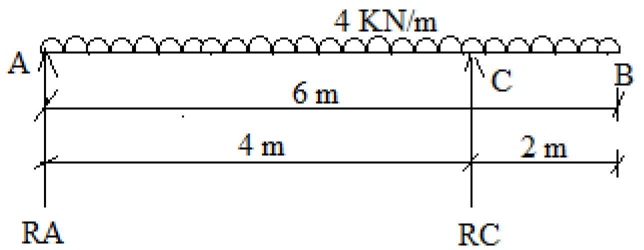
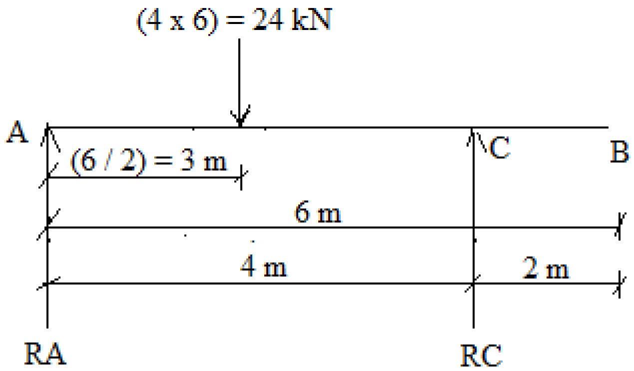
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3		1) Resolving all forces (↑ +ve, ↓ -ve, → +ve, ← -ve)		
		$\sum F_x = -10\cos 45 - 25\cos 60 - 50 = -69.572N$		
		$\sum F_y = -10\sin 45 - 20 - 25\sin 60 = -48.721N$	1	
		2) Magnitude of Resultant		
		$R=\sqrt{(\sum F_x)^2+(\sum F_y)^2}=\sqrt{(69.572)^2+(48.721)^2}$		
		$\boxed{R=84.935N}$	1	4
		3) Since $\sum F_x$ is -ve & $\sum F_y$ is -ve,		
		$\boxed{\text{R lies in III quadrant}}$	1	
		4) Position of Resultant		
		$\theta=\tan^{-1}\left\|\frac{\sum F_y}{\sum F_x}\right\|=\tan^{-1}\left\|\frac{48.721}{69.572}\right\|$		
		$\boxed{\theta=35.00° \text{ with negative 'x' axis}}$	1	
	(b)	**Calculate the resultant of force system as shown in fig (III).**		
	Ans.	 Fig. (III)		
				

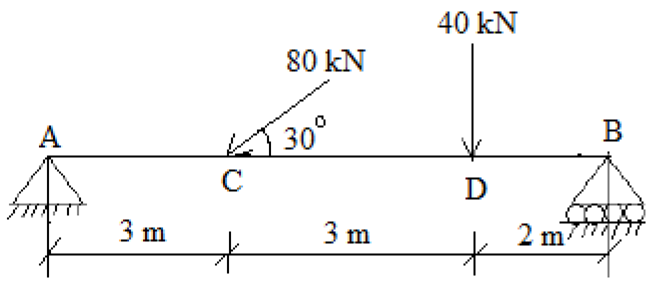
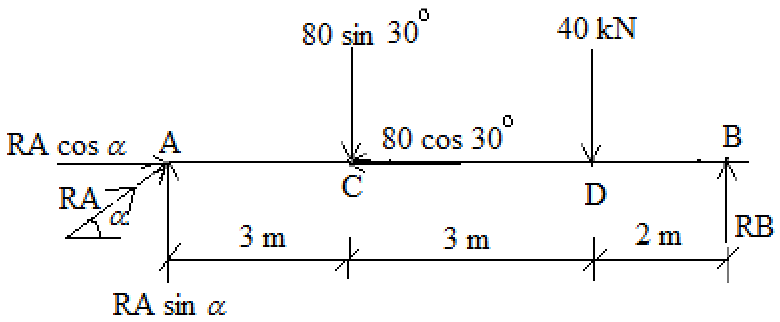
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3		1) Resolving all forces ($\uparrow$ +ve, $\downarrow$ -ve, $\rightarrow$ +ve, $\leftarrow$ -ve) $\sum F_x = +300\cos 30 - 500\cos 45 + 400\cos 45 = +189.096$ N $\sum F_y = +300\sin 30 + 500\sin 45 - 200 - 400\sin 45 = +20.710$ N	1	
		2) Magnitude of Resultant $R=\sqrt{(\sum F_x)^2+(\sum F_y)^2}=\sqrt{(189.096)^2+(20.710)^2}$ $\boxed{R=190.226\text{ N}}$	1	
		3) Since $\sum F_x$ is +ve & $\sum F_y$ is +ve, R lies in I quadrant	1	4
		4) Position of Resultant $\theta=\tan^{-1}\left\lvert\frac{\sum F_y}{\sum F_x}\right\rvert=\tan^{-1}\left\lvert\frac{20.710}{189.096}\right\rvert$ $\boxed{\theta=6.25^\circ \text{ with positive 'x' axis}}$	1	
	(c)	**Solve graphically Q. No. 3 (b).**		
	Ans.	 SPACE DIAGRAM	2	4
		 VECTOR DIAGRAM SCALE = 1cm = 100N	2	

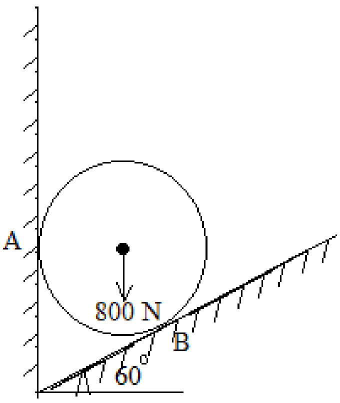
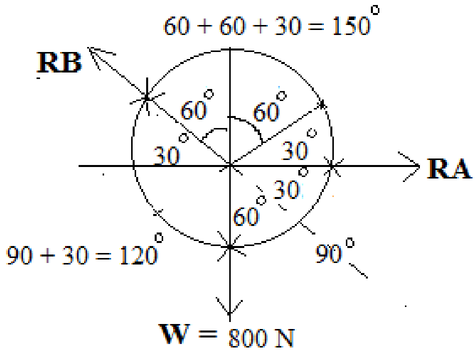
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3	(d)	**Calculate the resultant of force system as shown in fig (IV) w.r.t. A point.**		
	Ans.	 Fig. (IV)		
		Magnitude of resultant ($\rightarrow$ +ve, $\leftarrow$ -ve) $R = \Sigma F$ $= 1000 - 1200 + 2400 - 800$ $\boxed{R = 1400\ N}$	1	
		Direction of resultant Positive sign of R indicates that it acts horizontally rightward. Position of resultant Taking moments of all forces about point A $\Sigma M_{F_A} = (1000\times0)+(1200\times100)-(2400\times300)+(800\times350)$ $= -320000\ N.mm$ $M_{R_A} = -R\times x = -1400\times x$	1	4
		Use Varigon's theorem of moments $\Sigma M_{F_A} = M_{R_A}$	1	
		$-320000 = -1400\times x$ $\boxed{x = 228.571\ mm\ from\ point\ 'A'}$	1	
		R= 1400 N horizontally rightward at a distance of 228.571 mm from point A		
	(e)	**Define space diagram, vector diagram. State the use of vector diagram in graphic statics.**		
	Ans.	**<u>Space diagram:</u>** It is a diagram in which number of forces acting on body is drawn in space to a suitable scale & naming the spaces in order by Bow's notation.	1	
		<u>Vector diagram:</u> It is a diagram in which the forces are taken to a suitable scale & 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	4

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3		Use of vector diagram in graphic statics : i) To calculate magnitude of resultant, direction and sense. ii) To calculate beam reaction.	**1 each**	
	(f)	**Two forces of magnitude 100 N pull and 80 N push are acting at a point making an angle of 135° between them. Find the resultant in magnitude and direction.**		
	Ans.	Problem Fig. Solution Fig.	**1** **1**	**4**
		Using Law of parallelogram of forces $R=\sqrt{P^2+Q^2+2PQ\cos\theta}$ $R=\sqrt{(100)^2+(80)^2+2X100X80\cos45}$ $\boxed{R=166.474N}$	**1**	
		Let, α be the inclination of R with P $\alpha=\tan^{-1}\left[\frac{Q\sin\theta}{P+Q\cos\theta}\right]=\tan^{-1}\left[\frac{80\sin45}{100+80\cos45}\right]$ $\boxed{\alpha=19.864° \text{ with P force}}$	**1**	

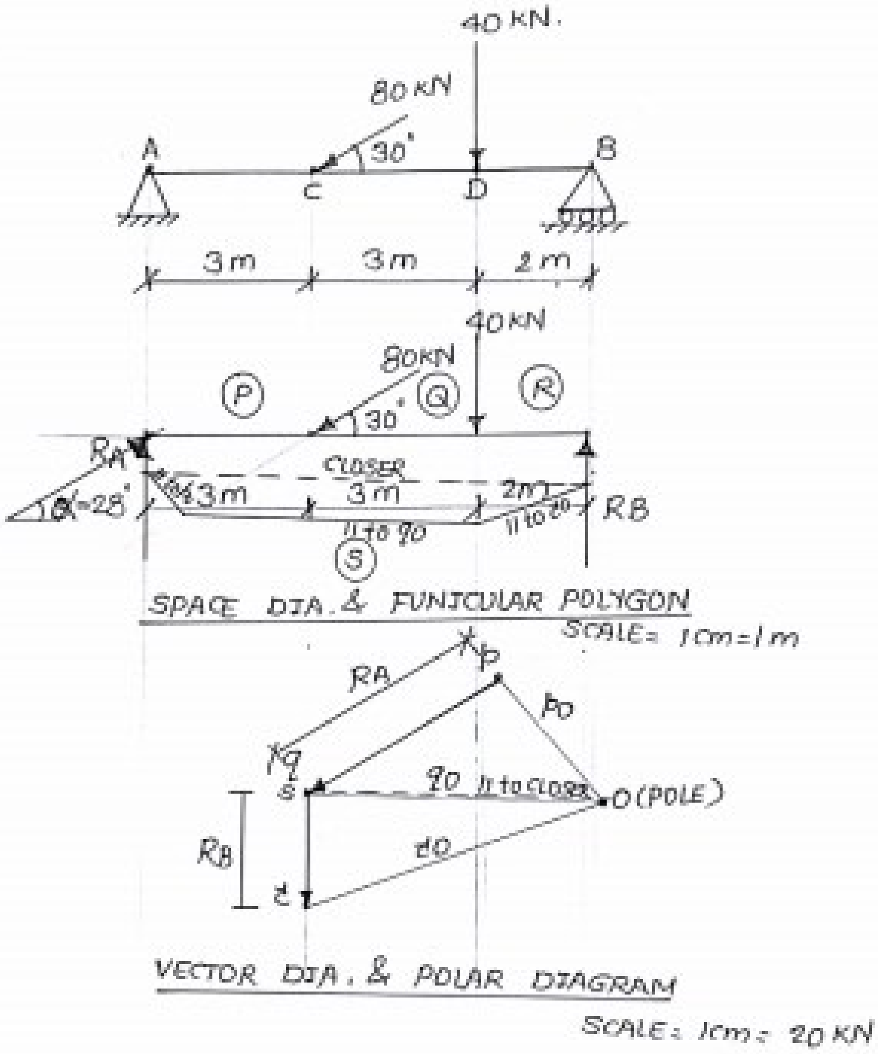
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4		**Attempt any <u>FOUR</u>:**		**16**
	(a)	**Two cables are tied together at C and loaded as shown in fig. (V). Determine the tension in cables AC and BC using Lami's theorem.**		
	Ans.	 Fig. (V)  $\theta = \tan^{-1}\left(\frac{1.5}{5}\right)+90=16.7+90=106.7°$ $\gamma = \tan^{-1}\left(\frac{1.75}{6}\right)+90=16.260+90=106.26°$ $\alpha=360-106.7-106.260=147.04°$	1	
		 FBD		
		Using Lami's theorem, $\frac{2000}{\sin 147.04}=\frac{T_{CA}}{\sin 106.7}=\frac{T_{CB}}{\sin 106.26}$ (1) (2) (3)	1	4
		Using term (1) and (2) $\frac{2000}{\sin 147.04}=\frac{T_{CA}}{\sin 106.7}$ $T_{CA}=\frac{\sin 106.7}{\sin 147.04}X2000$ $\boxed{T_{CA}=3521.06N}$ Using term (1) and (3) $\frac{2000}{\sin 147.04}=\frac{T_{CB}}{\sin 106.26}$ $T_{CB}=\frac{\sin 106.26}{\sin 147.04}X2000$ $\boxed{T_{CB}=3529.07N}$	1 each	
	(b)	**State the relation between resultant and equilibrium. Also state analytical conditions of equilibrium for non-concurrent force system.**		
	Ans.	**Relation between resultant and equilibrant:** Equilibrant is always equal in magnitude, opposite in direction & collinear to the resultant.	1	
		 Where, P & Q = Forces R = Resultant E = Equilibrant		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4		**Analytical conditions of equilibrium for non-concurrent force system** 1) Σ Fx = 0 i. e. Algebric sum of all the forces along X-axis must be equal to zero. 2) Σ Fy = 0 i. e. Algebric sum of all the forces along Y-axis must be equal to zero. 3) Σ M = 0 i. e. Algebric sum of moment of all the forces about any point must be equal to zero.	1 each (any three)	4
	(c)	**A beam AB 6 m long rests on two supports 4 m apart the right hand end is over hanging by 2 m, the beam carries a udl of 4 kN/m over the entire span. Determine the reactions of supports.**		
	Ans.	  	1	
		1) Equivalent point load and it's position Equivalent point load = Intensity of udl X span of udl = 4 X 6 = 24 KN Position from R_A = Span of udl / 2 = 6 / 2 = 3 m 2) Applying equilibrium conditions Σ Fy = 0 (↑+ve , ↓−ve) and Σ M = 0 (↻+ve , ↺−ve) Σ Fy = 0 $R_A - 24 + R_C = 0$ $R_A + R_C = 24$ KN -------(1)	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4		$\Sigma M_A = 0$ Taking moment of all forces @ point A $(R_A \times 0) + (24 \times 3) - (R_C \times 4) = 0$ $72 = 4 R_C$ $R_C = 18$ KN	1	4
		Putting value of R_C in eqn. 1 $R_A + 18 = 24$ $R_A = 6$ KN	1	
	(d) Ans.	**A beam AB is loaded as shown in fig (VI). Calculate the reactions at A and B.**  		
		Applying equilibrium conditions $\Sigma Fx = 0$ (→ +ve , ← −ve) $\Sigma Fy = 0$ (↑ +ve , ↓ −ve) and $\Sigma M = 0$ (↻ +ve , ↺ −ve) $\Sigma Fx = 0$ $R_A \cos \alpha - 80 \cos 30 = 0$ $R_A \cos \alpha = 69.282$ -------- (1)	½	
		$\Sigma M_A = 0$ Taking moment of all forces @ point A $(R_B \times 8) = (80 \sin 30 \times 3) + (40 \times 6)$ $(R_B \times 8) = 360$ $R_B = 45$ kN	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4		$\Sigma F_y = 0$ $R_A \sin\alpha + R_B = 80 \sin 30 + 40$ $R_A \sin\alpha + 45 = 80$ $R_A \sin\alpha = 35$ ---------- (2)	½	
		Divide equation (2) by (1) $\frac{R_A \sin\alpha}{R_A \cos\alpha} = \frac{35}{69.282}$ $\tan\alpha = 0.505$ $\alpha = \tan^{-1}(0.505)$ $\boxed{\alpha = 26.793°}$	1	4
		$R_A \cos\alpha = 69.282$ $R_A \cos 26.793 = 69.282$ $\boxed{R_A = 77.615 kN}$	1	
	(e)	**Calculate the reaction given by the plane at A and B supporting a 800 N sphere as shown in fig (VII).**		
	Ans.	 Fig. (VII)  **FBD**	1	
		Using Lami's theorem, $\frac{800}{\sin 150} = \frac{R_A}{\sin 120} = \frac{R_B}{\sin 90}$ (1) (2) (3)	1	4
		Using term (1) and (2) $\frac{800}{\sin 150} = \frac{R_A}{\sin 120}$ $R_A = \frac{\sin 120}{\sin 150} \times 800$ $\boxed{R_A = 1385.640 N}$ Using term (1) and (3) $\frac{800}{\sin 150} = \frac{R_B}{\sin 90}$ $R_B = \frac{\sin 90}{\sin 150} \times 800$ $\boxed{R_B = 1600 N}$	1 each	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	(f)	**Solve Question No. 4 (d) graphically.**		
	Ans.	See solution below	2 2	4



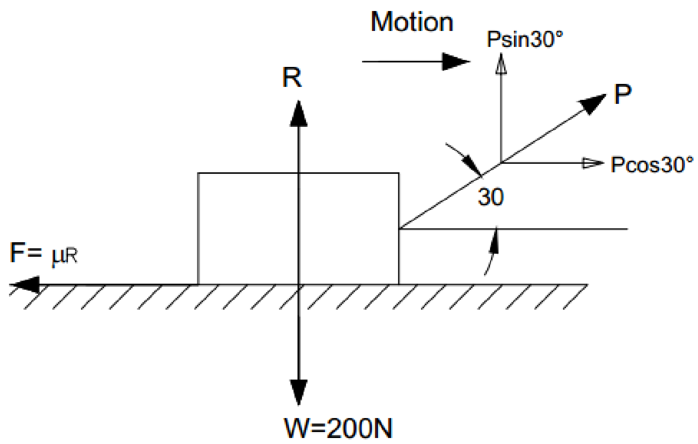
$R_A = l(ps) \times SCALE = 3.9 \times 20$

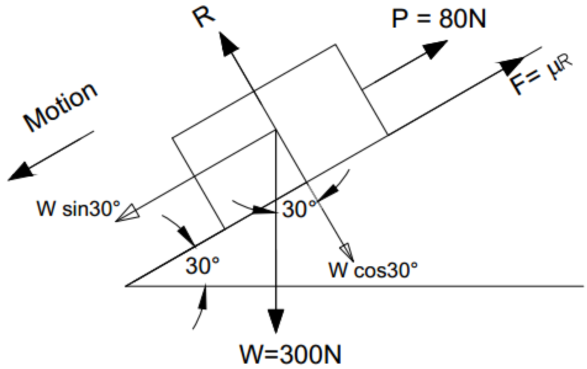
$R_A = 78$ KN

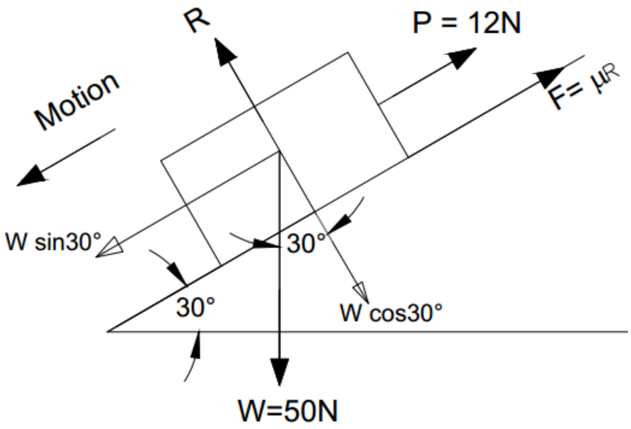
θ of R_A with x-axis = 28°

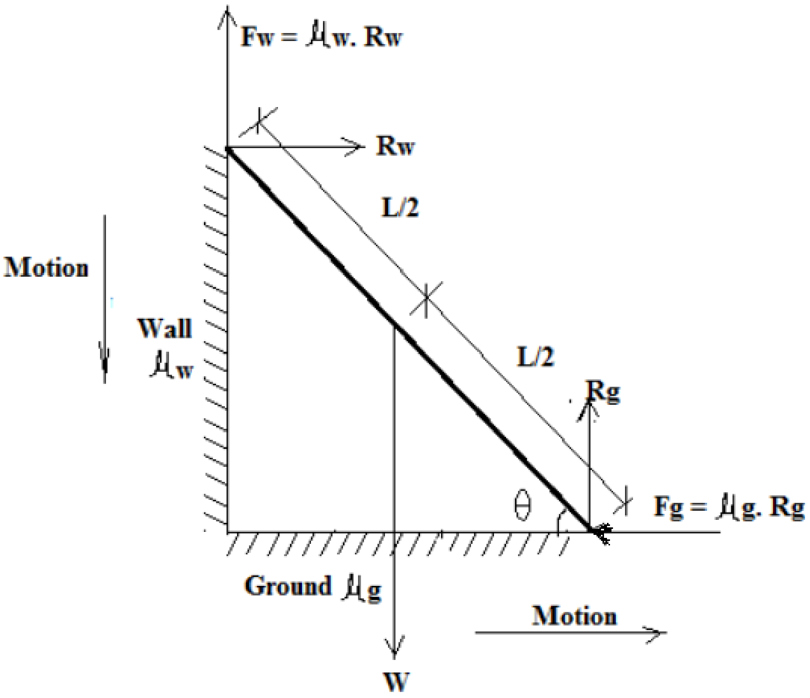
$R_B = l(rs) \times SCALE = 2.2 \times 20$

$R_B = 44$ KN

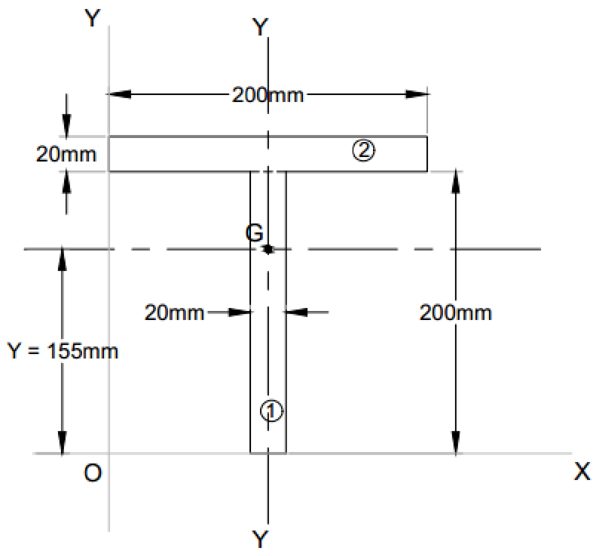
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5		**Attempt any FOUR:**		**16**
	(a)	**A block of weight 200N rest on a rough horizontal surface. Find the magnitude of the force to be applied at an angle of 30° to the horizontal in order to just move the body on the surface. Assume μ = 0.30.**		
	Ans.		1	
		For limiting equilibrium $\Sigma Fx = 0$ $+ P\cos 30° - F = 0$ $+ P\cos 30° - \mu R = 0$ $(0.866)P - (0.30)R = 0$ $(0.866)P = (0.30)R$	1	4
		$R = \left(\dfrac{0.866}{0.30}\right) P$ $R = (2.887)P$	1	
		$\Sigma Fy = 0.$ $+ R + P\sin 30 - W = 0$ $(2.887)P + (0.5)P - 200 = 0$ $3.387P = 200$ $\boxed{P = 59.055\ N}$	1	

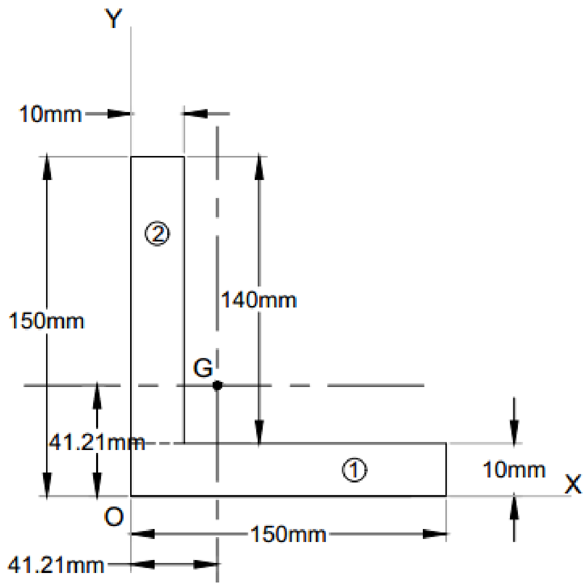
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	(b)	**A body of weight 300 N is resting on inclined plane making an angle of 30°to the horizontal. A pull of 80 N applied parallel and up the plane. Calculate coefficient of friction and force of friction.**		
	Ans.		1	
		For limiting equilibrium		
		$\Sigma Fx = 0$		
		$+ P + F – W \sin30° = 0$		
		$+ 80 + \mu R - 300 \sin30° = 0$		
		$+ \mu R - 70 = 0$		
		$\mu R = 70$ ----------- (i)	½	
		$\Sigma Fy = 0.$		
		$+ R - W \cos30° = 0$		
		$+ R – 300 \cos30° = 0$		
		$+ R – 259.81 = 0$		
		$R = 259.81$ N	½	4
		From equation (i)		
		Coefficient of friction		
		$\mu R = 70$		
		$\mu \times 259.81 = 70$		
		$\boxed{\mu = 0.269}$	1	
		Force of friction		
		$F = \mu R$		
		$F = 0.269 \times 259.81$		
		$\boxed{F = 69.888 \text{ N}}$	1	

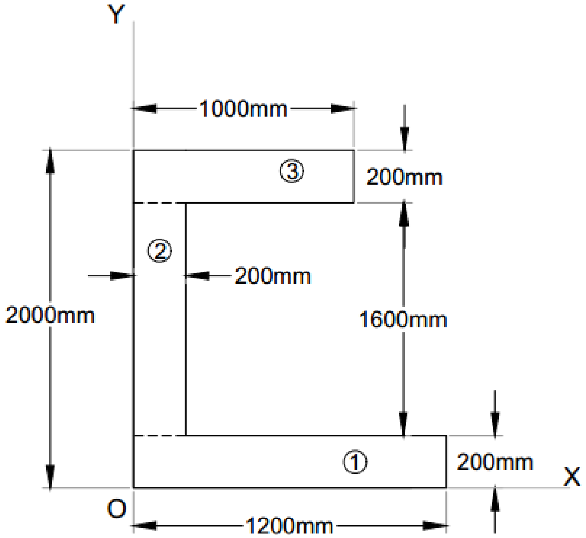
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	(c)	**A block weighing 50 N is resting on 30° rough inclined plane. A force of 12 N parallel to plane is applied to the block up the plane and the block is just on the point of moving down the plane. Find the coefficient of friction.**		
	Ans.		1	
		For limiting equilibrium $\Sigma Fx = 0$ $+P + F - W \sin 30° = 0$ $+12 + \mu R - 50 \sin 30° = 0$ $+\mu R - 13 = 0$ $\mu R = 13$ ----------- (i)	1	4
		$\Sigma Fy = 0.$ $+R - W \cos 30° = 0$ $+R - 50 \cos 30° = 0$ $+R - 43.301 = 0$ $R = 43.301$ N	1	
		From equation (i) Coefficient of friction $\mu R = 13$ $\mu \times 43.301 = 13$ $\boxed{\mu = 0.30}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	(d)	**Draw neat & labeled sketch of ladder friction. Show all forces acting on it.**		
	Ans.		4	4
		(Note : 2 marks for sketch, 1 mark for active and reactive forces, 1 mark for labeling)		
	(e)	**What do you understand by term 'Reversibility' of machine? Explain the difference between a reversible and a self-locking machine.**		
	Ans.	Sometimes a machine is capable of doing some work in the reverse direction, even after the effort is removed. Such a machine is called the reversible machine and the action of such a machine is known as 'reversibility' of the machine.	2	
		A machine which is capable of doing work in the reverse direction after the effort is removed is called the '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.	1	4
		The machine which has efficiency greater than 50%, (η>50%) such a machine is called as 'reversible' machine. Whereas the machine which has efficiency less than 50%, (η<50%) such a machine is called as 'self-locking' or non-reversible machine.	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	(f)	**In a machine. It was found that an effort had to be moved through a distance of 500 mm to move load by 50 mm. Using this machine a load of 10 kN was raised by an effort 1.25kN. determine –** **(i) Velocity ratio** **(ii) Mechanical advantage** **(iii) Efficiency** **(iv) Effort lost in friction**		
	Ans.	(i) Velocity Ratio $VR = \frac{y}{x} = \frac{500}{50}$ $\boxed{VR = 10}$	1	
		(ii) Mechanical advantage $MA = \frac{W}{P} = \frac{10}{1.25}$ $\boxed{MA = 8}$	1	
		(iii) Efficiency $\%\eta = \frac{MA}{VR} \times 100$ $= \frac{8}{10} \times 100$ $\boxed{\%\eta = 80\%}$	1	4
		(iv) Effort lost in friction $P_f = P - P_i$ $= P - \left(\frac{W}{VR}\right)$ $= 1.25 - \left(\frac{10}{10}\right)$ $= 0.25$ kN $\boxed{P_f = 250 \text{ N}}$	1	

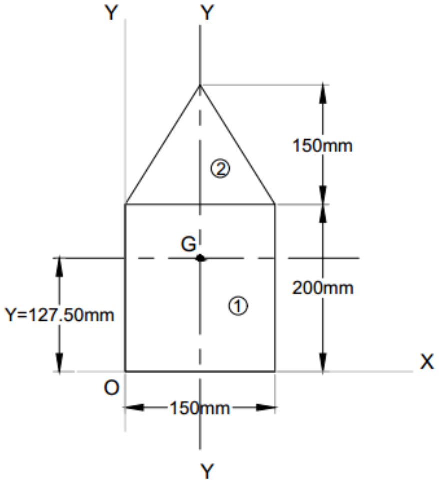
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6		**Attempt any FOUR :**		16
	(a)	**Determine centroid of T section with respect to bottom having flange 200 mm x 20 mm and web 20 mm x 200 mm.**		
	Ans.			
		As the given composite section is symmetric about Y-Y axis $\therefore\ \overline{X} = x_1 = x_2 = \frac{\text{Total breadth}}{2} = \frac{200}{2} = 100\text{mm}$		
		Fig. 1 - $A_1 = b \times d = 20 \times 200 = 4000\ mm^2$ $y_1 = \frac{d}{2} = \frac{200}{2} = 100\text{mm}$	1	
		Fig. 2 - $A_2 = b \times d = 200 \times 20 = 4000\ mm^2$ $y_2 = 200 + \frac{d}{2} = 200 + \frac{20}{2} = 210\text{mm}$	1	4
		$\overline{Y} = \frac{A_1y_1 + A_2y_2}{A_1 + A_2} = \frac{(4000\times100)+(4000\times210)}{4000+4000}$	1	
		$\boxed{\overline{Y} = 155\text{ mm from bottom}}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	(b)	**Locate the centroid of angle section ISA 150 x 150 x 10 mm.**		
	Ans.		1	
		Fig. 1 - $A_1 = b \times d = 150 \times 10 = 1500\ mm^2$ $x_1 = b/2 = 150/2 = 75\ mm$ $y_1 = d/2 = 10/2 = 5\ mm$	1	
		Fig. 2 - $A_2 = b \times d = 10 \times 140 = 1400\ mm^2$ $x_2 = b/2 = 10/2 = 5\ mm$ $y_2 = 10 + d/2 = 10 + 140/2 = 80\ mm$	1	4
		$\overline{X} = \frac{A_1x_1 + A_2x_2}{A_1 + A_2} = \frac{(1500\times75)+(1400\times5)}{1500+1400}$ $\boxed{\overline{X} = 41.21\ mm\ from\ left}$	½	
		$\overline{Y} = \frac{A_1y_1 + A_2y_2}{A_1 + A_2} = \frac{(1500\times5)+(1400\times80)}{1500+1400}$ $\boxed{\overline{Y} = 41.21\ mm\ from\ bottom}$	½	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	(c)	**Calculate the $\overline{X}$ for the channel section as shown in fig.**		
	Ans.			
		Fig. 1 - $A_1 = b \times d = 1200 \times 200 = 240000\ mm^2$ $x_1 = b/2 = 1200/2 = 600$ mm	1	
		Fig. 2 - $A_2 = b \times d = 200 \times 1600 = 320000\ mm^2$ $x_2 = b/2 = 200/2 = 100$ mm	1	4
		Fig. 3 - $A_3 = b \times d = 1000 \times 200 = 200000\ mm^2$ $x_3 = b/2 = 1000/2 = 500$ mm	1	
		$\overline{X} = \frac{A_1x_1 + A_2x_2 + A_3x_3}{A_1 + A_2 + A_3}$ $= \frac{(240000 \times 600) + (320000 \times 100) + (200000 \times 500)}{240000 + 320000 + 200000}$ $\boxed{\overline{X} = 363.16 \text{ mm from bottom}}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	(d)	**A solid cone having base diameter 150 mm and height 150 mm is placed on top of cylinder of dia. 150 mm and height 200 mm such that axis are co-linear. Locate C.G. w.r.t. bottom.**		

Ans.



Marks: 1

As the given combination of solids is symmetric about Y-Y axis

$\therefore\ \overline{X} = x_1 = x_2 = \dfrac{150}{2} = 75\,\text{mm}$

Fig. 1 -

$V_1 = \pi r^2 h$

$= \pi(75)^2 \times 200$

$= 3.534 \times 10^6\ \text{mm}^3$

$y_1 = h/2 = 200/2 = 100\ \text{mm}$

Marks: 1 | **Total Marks: 4**

Fig. 2 -

$V_2 = \dfrac{1}{3}\pi r^2 h$

$= \dfrac{1}{3}\pi(75)^2 \times 150$

$= 883.57 \times 10^3\ \text{mm}^3$

$y_2 = 200 + h/4$

$= 200 + 150/4$

$= 237.5\ \text{mm}$

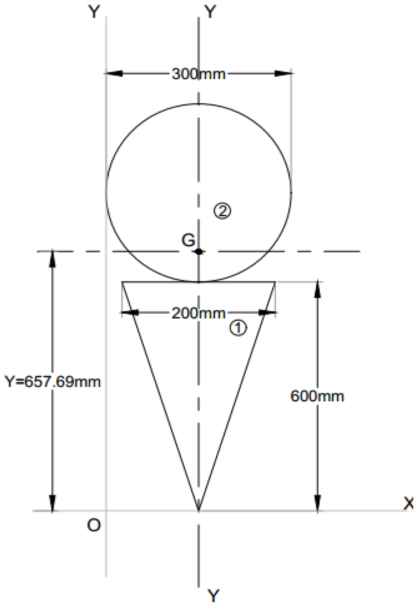
Marks: 1

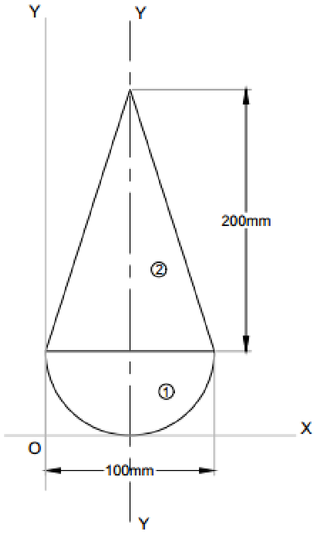
$$\overline{Y} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2}$$

$$= \frac{(3.534 \times 10^6 \times 100) + (883.57 \times 10^3 \times 237.5)}{(3.534 \times 10^6 + 883.57 \times 10^3)}$$

$\boxed{\overline{Y} = 127.50\ \text{mm from bottom}}$

Marks: 1

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	(e)	**On a solid inverted cone 200 mm diameter and 600 mm height a sphere of 300 mm diameter is placed co-axially, locate C.G. w.r.t. apex of cone.**		
	Ans.		1	
		As the given combination of solids is symmetric about Y-Y axis $\therefore\ \overline{X} = x_1 = x_2 = \frac{300}{2} = 150\,\text{mm}$ Fig. 1 - $V_1 = \frac{1}{3}\pi r^2 h$ $= \frac{1}{3}\pi(100)^2 \times 600$ $= 6.283 \times 10^6\ \text{mm}^3$ $y_1 = h - \frac{h}{4} = 600 - \frac{600}{4} = 450\text{mm}$	1	4
		Fig. 2 - $V_2 = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(150)^3 = 14.137\times10^6\ \text{mm}^3$ $y_2 = 600 + r = 600 + 150 = 750\text{mm}$	1	
		$\overline{Y} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2}$ $= \frac{(6.283\times10^6\times450)+(14.137\times10^6\times750)}{(6.283\times10^6+14.137\times10^6)}$ $\overline{Y} = 657.69\ \text{mm from bottom}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	(f)	**A right circular cone of base dia. 100 mm and height 200 mm is placed on the hemisphere of the same diameter. Calculate its C.G.**		
	Ans.		1	
		As the given combination of solids is symmetric about Y-Y axis $\therefore\ \overline{X} = x_1 = x_2 = \frac{100}{2} = 50\text{mm}$	1	
		Fig. 1 - $V_1 = \frac{2}{3}\pi r^3$ $= \frac{2}{3}\pi(50)^3$ $= 261.80 \times 10^3\ \text{mm}^3$ $y_1 = r - \frac{3r}{8} = 50 - \frac{3\times 50}{8} = 31.25\ \text{mm}$	½	4
		Fig. 2 - $V_2 = \frac{1}{3}\pi r^2 h = \frac{1}{3}\pi(50)^2 \times 200 = 523.60\times 10^3\ \text{mm}^3$ $y_2 = r + \frac{h}{4} = 50 + \frac{200}{4} = 100\text{mm}$	½	
		$\overline{Y} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2}$ $= \frac{(261.80\times 10^3 \times 31.25) + (523.60\times 10^3 \times 100)}{(261.80\times 10^3 + 523.60\times 10^3)}$ $\boxed{\overline{Y} = 77.083\ \text{mm from bottom}}$	1	