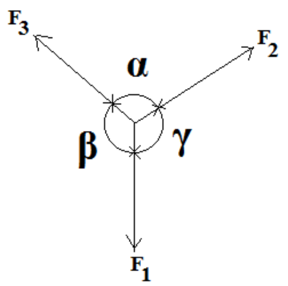
Model Answer: Summer - 2019

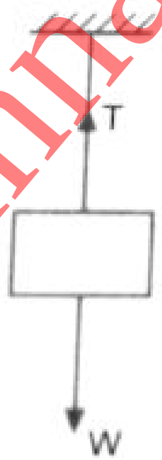
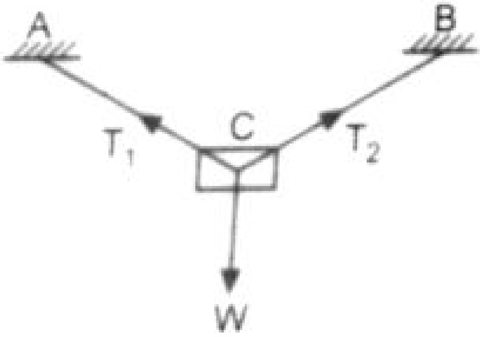
Subject: Applied Mechanics | **Sub. Code: 22203**

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 FIVE of the following:**		(10)
	a)	**Define Statics and Dynamics.**		
	Ans.	**Statics** is the branch of applied mechanics which deals with forces and their action on bodies at rest.	1	
		Dynamics is the branch of applied mechanics which deals with forces and their action on bodies in motion.	1	2
	b)	**State ideal machine and write it's any two characteristics.**		
	Ans.	**Ideal Machine** is the machine whose efficiency is 100 % and in which friction is zero.	1	
		Following are the characteristics of an ideal machine: (1) Efficiency of the machine is 100 %. (2) Output = Input (3) Machine is free from frictional losses. (4) Mechanical Advantage = Velocity Ratio	½ each (any two)	2
	c)	**State law of parallelogram of forces.**		
	Ans.	**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

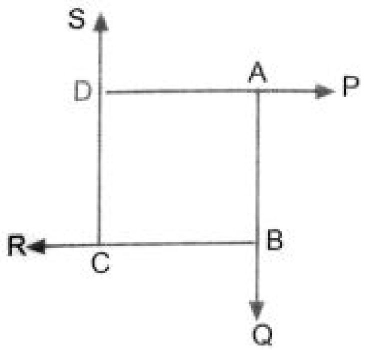
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 1	d) Ans.	**State Lami's theorem.** Lami's theorem states that, if three forces acting at a point on a body keep it at rest, then each force is proportional to the sin of the angle between the other two forces.	1	
		 As per Lami's Theorem $\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$	1	2
	e) Ans.	**Define coefficient of friction.** **Coefficient of friction** is the ratio of limiting friction (F) to the normal reaction (R) at the surface of contact. $F \ \alpha \ R$ $F = \mu R$ $\mu = \frac{F}{R}$	2	2
	f) Ans.	**Define centroid and centre of gravity.** **Centroid:** It is defined as the point through which the entire area of a plane figure is assumed to act, for all positions of the lamina. e. g. Triangle, Square.	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	2
	g) Ans.	**Write analytical conditions of equilibrium for concurrent force system.** 1) $\Sigma Fx = 0$ i. e. Algebric sum of all the forces along X-axis must be equal to zero.	1	
		2) $\Sigma Fy = 0$ i. e. Algebric sum of all the forces along Y-axis must be equal to zero.	1	2
	h) Ans.	**Define force and state its S.I 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	
		S. I. Unit of force – Newton (N)	1	2

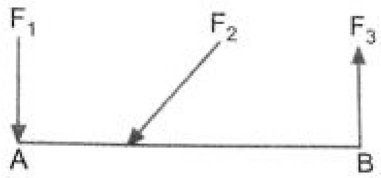
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2		**Attempt any THREE of the following:**		(12)
	a)	**Write classification of force system and explain any one in detail.**		
	Ans.	**Classification of force system:** It is classified mainly into two types. **(1) Coplanar force system** (a) Collinear force system (b) Concurrent force system (c) Non-concurrent force system (d) Parallel force system (i) Like parallel (ii) Unlike parallel	1	
		(2) Non-coplanar force system (a) Concurrent force system (b) Parallel force system (c) Non-concurrent, non-parallel or General force system	1	
		• **Coplanar Collinear force system:** The force system in which forces lies on the same plane and act along the same line of action are known as Coplanar Collinear force system.	1	
			1	4
		OR • **Coplanar Concurrent force system:** The force system in which forces lies on the same plane and meet at a point are known as Coplanar Concurrent force system. 		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2	a)			

<u>**OR**</u>

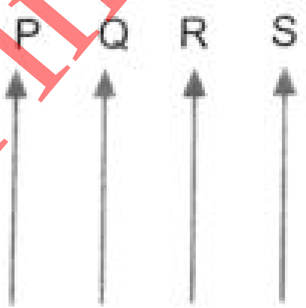
- **Coplanar Non-concurrent force system:** The force system in which forces lies on the same plane but meet at different points are known as Coplanar Concurrent force system.



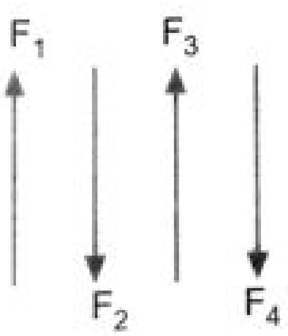


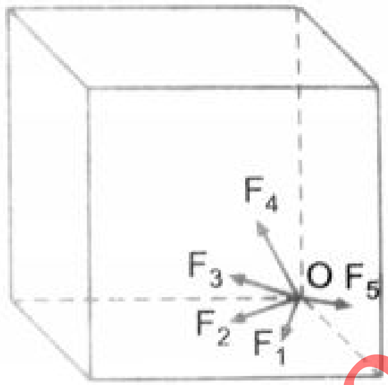
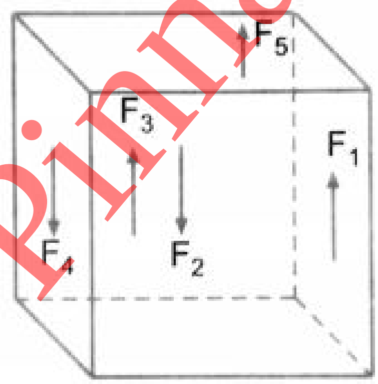
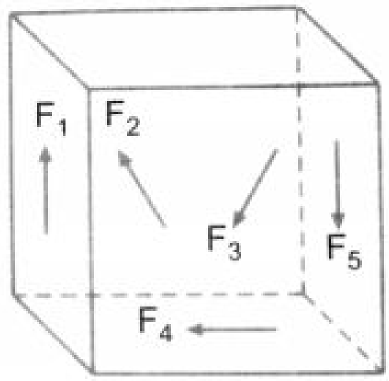
<u>**OR**</u>

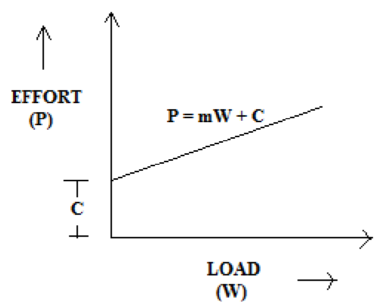
- **Coplanar parallel force system:**
  (i) Like parallel force system: The force system in which forces lies on the same plane and are parallel to each other acting in same direction are known as Coplanar Like parallel force system.

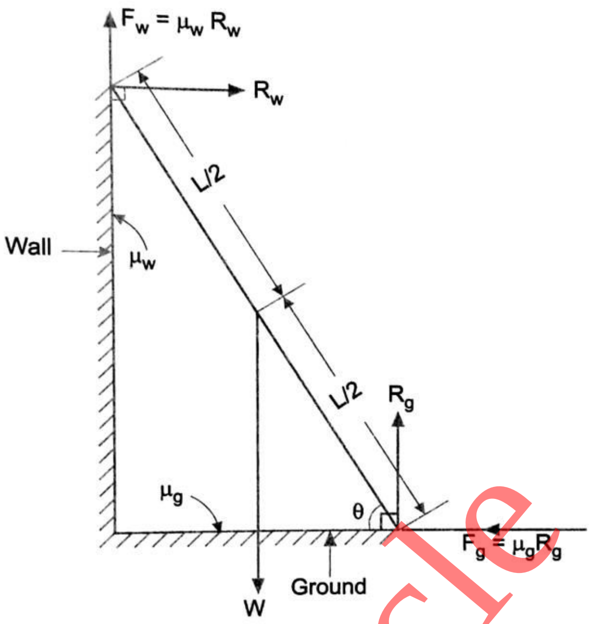
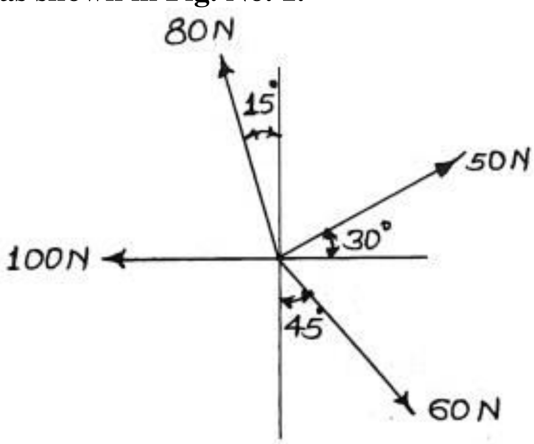


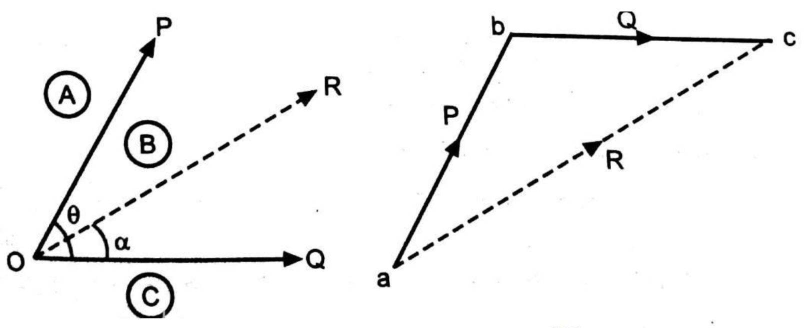
(ii) Unlike parallel force system: The force system in which forces lies on the same plane and are parallel to each other but acting in opposite direction are known as Coplanar Unlike parallel force system.



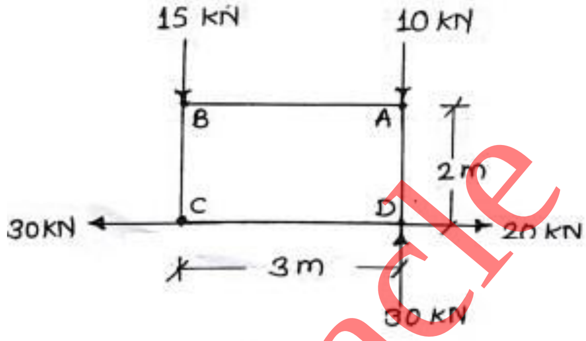
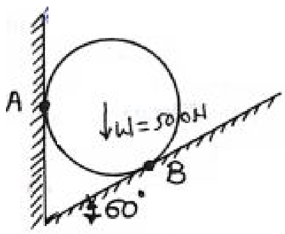
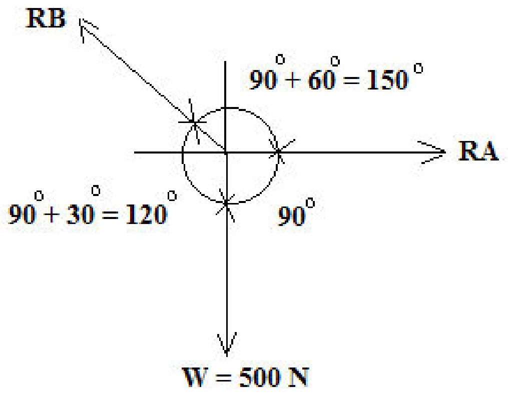
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2	a)	**OR** • **Non-coplanar concurrent force system:** The force system in which forces lies in different planes but meet at a point are known as Non-coplanar Concurrent force system.  **OR** • **Non-coplanar parallel force system:** The force system in which forces lies in different planes but are parallel to each other are known as Non-coplanar parallel force system.  • **General force system:** The force system in which forces act in different planes and they do not possess one single point of concurrency are known as General force system.  *(Note : Classification of force system – 2 Marks, any one force system details – 1 Mark and sketch – 1 Mark)*		

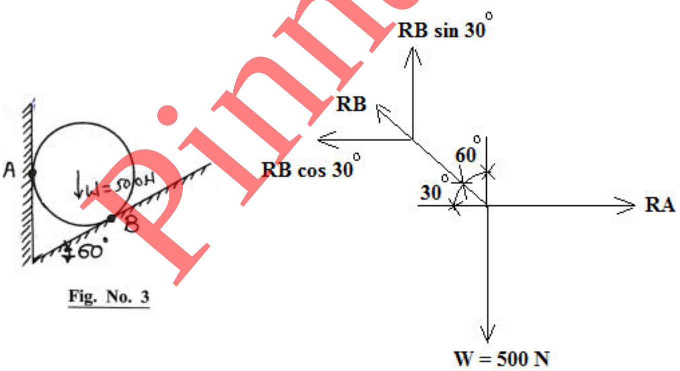
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2	b)	**Calculate effort lost in friction and load lost in friction, if machine lifts a load of 100 N by an effort of 8 N at an efficiency of 60 %.**		
	Ans.	$\text{M.A.} = \frac{W}{P} = \frac{100}{8} = 12.5$	1	
		$\%\,\eta = \frac{\text{M.A.}}{\text{V.R.}} \times 100$ $60 = \frac{12.5}{\text{V.R.}} \times 100$ $\text{V.R.} = 20.83$	1	
		$\text{Effort lost in friction } (P_f) = P - P_i$ $(p_f) = P - \left(\frac{W}{\text{V.R.}}\right) = 8 - \left(\frac{100}{20.83}\right) = 3.2\text{N}$ $\boxed{(P_f) = 3.2\text{ N}}$	1	
		$\text{Load lost in friction } (W_f) = W_i - W$ $(W_f) = (P \times \text{V.R.}) - W = (8 \times 20.83) - 100 = 66.64\text{N}$ $\boxed{(W_f) = 66.64\text{ N}}$	1	4
	c) Ans.	**Explain law of machine. State it's use.** **Law of machine:** The relation between the load lifted (W) and the effort applied (P) is known as the law of machine. This relationship, when plotted on a graph results in a straight line as shown below. The equation of this straight line is,	1	
		$P = (mW + C)\,N$	1	
			1	
		Where, m = Slope of line = constant c = Intercept on y axis = effort required to start the machine. **Use of law of machine:** With the help of law of machine one can find effort required to lift any given load and vice versa.	1	4

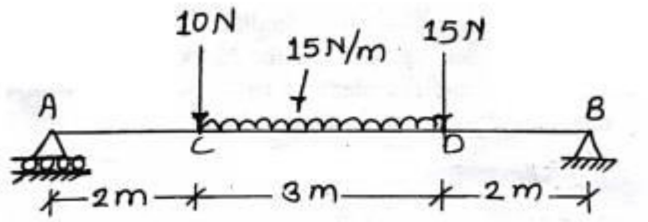
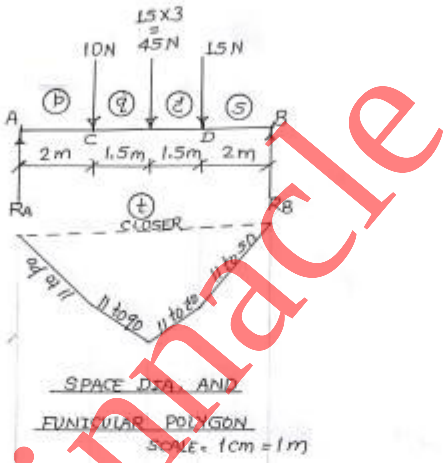
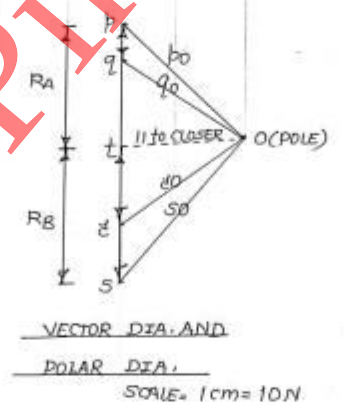
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2	d) Ans.	**Draw FBD of ladder in friction.**  Where, μ_g = Coefficient of friction between the ladder and the ground. μ_w = Coefficient of friction between the ladder and the wall. R_g = Normal reaction at the ground. R_w = Normal reaction at the wall. F_g =Force of friction between the lader and the ground. F_w = Force of friction between the lader and the wall. *(Note: 2 Marks for sketch, 1 Mark for showing Active forces and 1 Mark for showing Reactive forces.)*	4	4
Q. 3		**Attempt any <u>THREE</u> of the following:**		(12)
	a)	**Calculate the magnitude and direction of resultant for concurrent force system as shown in Fig. No. 1.**  **Fig. No. 1**		

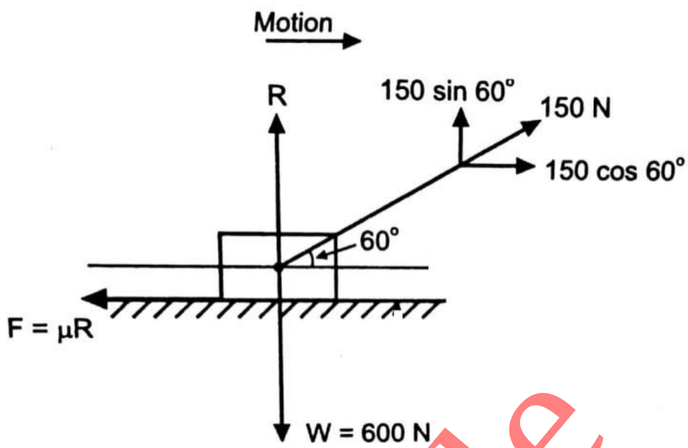
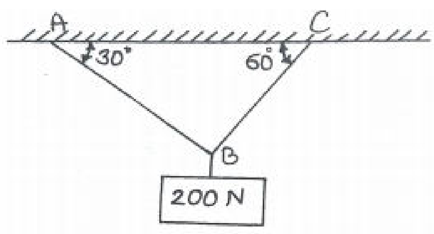
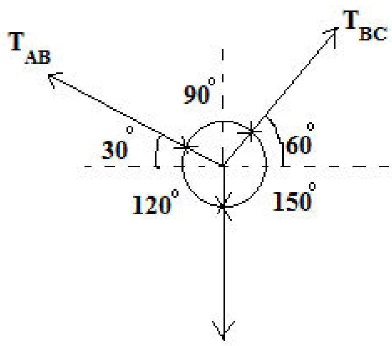
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3	a) Ans.	1) Resolving all forces		
		$\sum Fx = +(50\times\cos 30°) - (80\times\cos 75°) - (100) + (60\times\cos 45°)$ $= -34.98\,N$	½	
		$\sum Fy = +(50\times\sin 30°) + (80\times\sin 75°) - (60\times\sin 45°)$ $= +59.85\,N$	½	
		2) Magnitude of Resultant $R = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2} = \sqrt{(34.98)^2 + (59.85)^2}$ $\boxed{R = 69.32\,N}$	1	
		3) Since $\sum$ Fx is –ve & $\sum$ Fy is +ve, R lies in Second quadrant	1	
		4) Position of Resultant $\theta = \tan^{-1}\left\lvert\frac{\sum Fy}{\sum Fx}\right\rvert = \tan^{-1}\left\lvert\frac{34.98}{59.85}\right\rvert$ $\boxed{\theta = 59.69° \text{ with horizontal}}$	1	4
	b) Ans.	**State triangle law of forces with sketch and state it's use.** **Triangle law of forces:** It states that, " if forces acting simultaneously on a particle be represented in magnitude and direction by two sides of a triangle taken in order, then their resultant may be represented in magnitude and direction by the third side of the triangle taken in opposite order."	2	
		e.g. – Let, P and Q are forces acting at point O. Using Bow's notation, P = AB and Q = BC. Using suitable scale draw line 'ab' parallel to AB 	1	

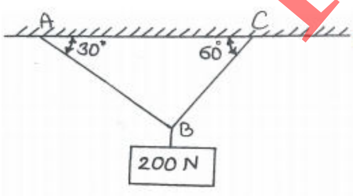
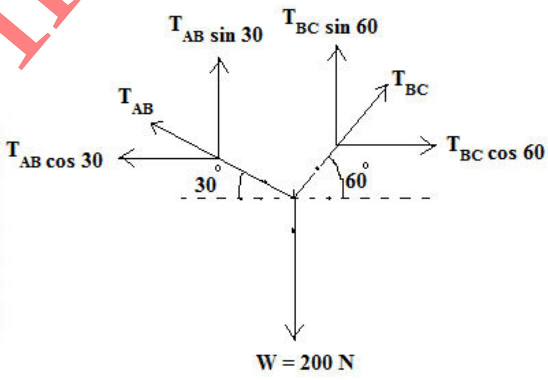
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3	b)	to show force P. Through point b, draw line 'bc' parallel to BC to show force Q. Join the point 'a' and 'c'. The line joining a and c represents resultant in magnitude and direction. To locate the position of the resultant in the space diagram, through point O, draw a line parallel to 'ac'. Measure an angle 'α' i.e. angle made by the resultant with the force Q.		
		Use: Triangle law of forces is used to find the resultant of the two concurrent forces graphically.	1	4
	c)	**Calculate load lifted by differential axle and wheel, if the diameter of wheel is 36 cm and that of axles are 9 cm and 6 cm. The efficiency of the machine is 80 % and an effort is of 100 N.**		
	Ans.	1) VR of differential axle & wheel is given by -		
		$VR = \frac{2 \times D}{d_1 - d_2} = \frac{2 \times 36}{9-6}$	1	
		$VR = 24$		
		$M.A. = \frac{W}{P} = \frac{W}{100}$	1	
		$\%\eta = \frac{M.A.}{V.R.} \times 100 = \frac{M.A.}{24} \times 100$	1	
		$80\% = \frac{(W/100)}{24} \times 100$		
		$\boxed{W = 1920\,N = 1.92\,kN}$	1	4
	d)	**Calculate effort required to lift a load of 3 kN. In a machine a load of 1 kN is lifted by an effort of 56 N and 2 kN is lifted by an effort of 96 N.**		
	Ans.	Using law of machine		
		P = mW + C		
		Putting values of load and effort		
		56 = m (1000) + C ---- (i)	1	
		96 = m (2000) + C ---- (ii)		
		Solving simultaneous equations		
		m = 0.04	½	
		Putting value of m in eqn (i)		
		$56 = (0.04 \times 1000) + C$		
		C = 16 N	½	
		Hence, Law of machine		
		$\boxed{P = (0.04)\,W + 16\,N} --- (iii)$	1	

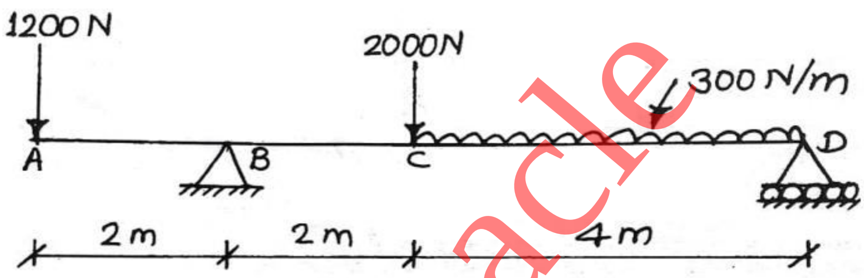
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3	d)	Using, eqn. (iii) $P = (0.04)\,W + 16\ N$ $P = (0.04 \times 3000) + 16$ $\boxed{P = 136\ N}$	1	4
Q. 4		**Attempt any THREE of the following:**		(12)
	a)	**Calculate moment of all forces about point 'A' for the force system as shown in Fig. No. 2.**  **Fig. No. 2**		
	Ans.	Taking moment of all forces about point A $M_A = (10\times0) + (30\times0) - (15\times3) + (30\times2) - (20\times2)$ $M_A = 0 + 0 - 45 + 60 - 40$ $M_A = -25 kN\text{-}m$ $M_A = 25\ kN\text{-}m$ (Anti - clockwise)	2 1 1	4
	c)	**Calculate the reactions offered by planes. Refer Fig. No. 3. A sphere weighs 500N is supported by two planes, one plane is vertical and other is inclined at 60° to the horizontal.**		
	Ans.	 **Fig. No. 3**  FBD	1 (FBD)	

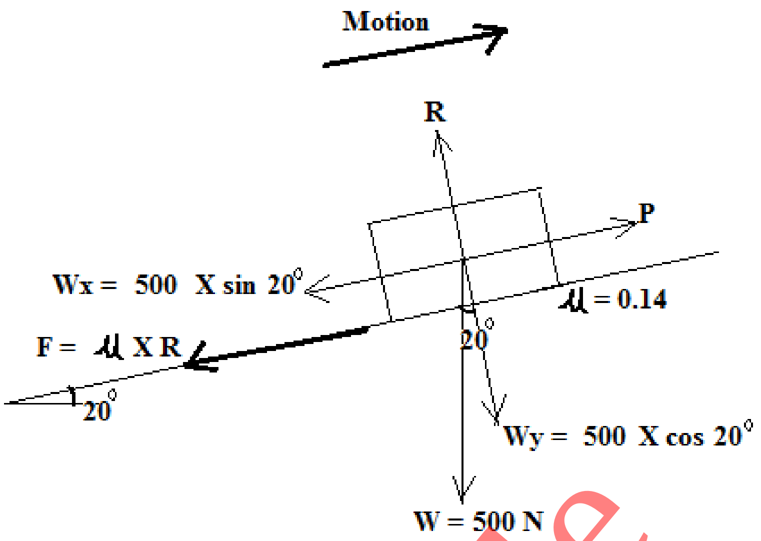
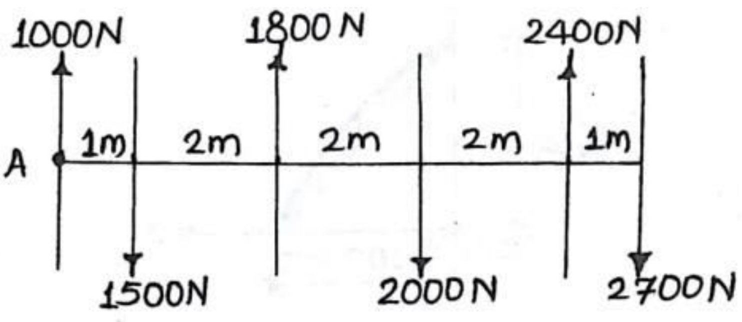
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	b)	Using Lami's Theorem,		
		$\frac{500}{\sin 150} = \frac{R_A}{\sin 120} = \frac{R_B}{\sin 90}$ (1) (2) (3)	1	
		Using term (1) and (2) $\frac{500}{\sin 150} = \frac{R_A}{\sin 120}$ $R_A = \frac{500 \times \sin 120}{\sin 150}$	1	
		$\boxed{R_A = 866\,N}$		
		Using term (1) and (3) $\frac{500}{\sin 150} = \frac{R_B}{\sin\,90}$ $R_B = \frac{500 \times \sin 90}{\sin 150}$	1	4
		$\boxed{R_B = 1000\,N}$		
		OR		
		 Fig. No. 3	1	
		Using conditions of equlibrium for concurrent force system and resolving all forces -		
		$\sum F_x = 0$ $+R_A - R_B \times \cos\,30 = 0$	½	
		$+R_A - R_B \times (0.866) = 0$----(1)		
		$\sum F_y = 0$ $+R_B \times \sin 30 - 500 = 0$	½	
		$+R_B \times (0.5) = 500$		
		$\boxed{R_B = 1000\,N}$	1	
		Using equation (1) $+R_A - (1000 \times 0.866) = 0$		
		$\boxed{R_A = 866\,N}$	1	4

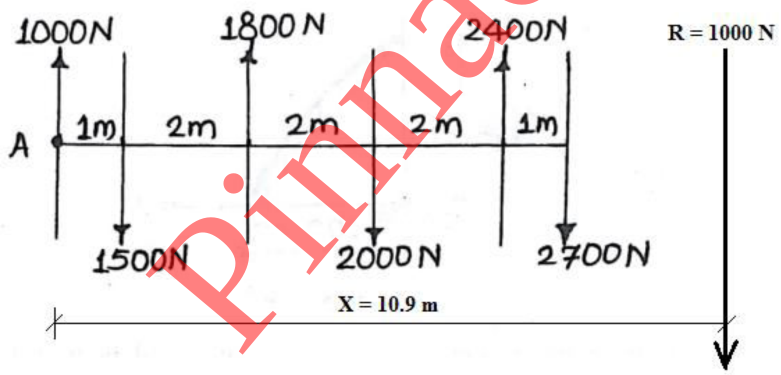
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	c)	**Calculate graphically the reactions of a beam loaded as shown in Fig. No. 4.**  **Fig. No. 4**		
	Ans.	 	1 ½	
		 	1 ½	
		$R_A = l(tp) \times SCALE = 3.4 \times 10$ $\boxed{R_A = 34\,N}$ $R_B = l(st) \times SCALE = 3.6 \times 10$ $\boxed{R_B = 36\,N}$	1	4
		(Note: Variation of ± 1 N in magnitude of reaction should be considered.)		

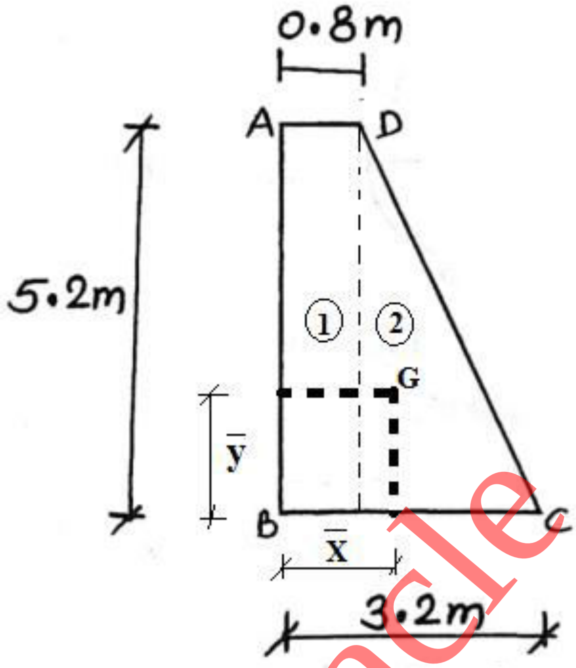
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	d)	**Calculate coefficient of friction if a block weighing 600 N resting on a rough horizontal plane can be moved by a force of 150 N applied at an angle of 60° with the horizontal.**		
	Ans.		1	
		For limiting equilibrium $\Sigma Fy = 0 \quad (\uparrow +ve, \downarrow -ve)$ $+R + (150 \times \sin 60) - 600 = 0$ $R = 470.09$ N	1	
		$\Sigma Fx = 0 \quad (\rightarrow +ve, \leftarrow -ve)$ $+(150 \times \cos 60) - F = 0$ $75 = \mu \times R$ $75 = \mu \times 470.09$	1	
		$\mu = \dfrac{75}{470.09}$ $\boxed{\mu = 0.16}$	1	4
	e)	**Calculate tension in the strings AB and BC if a weight of 200 N is attached by two strings as shown in Fig. No, 5.**		
	Ans.	Fig. No. 5 FBD	1 (FBD)	

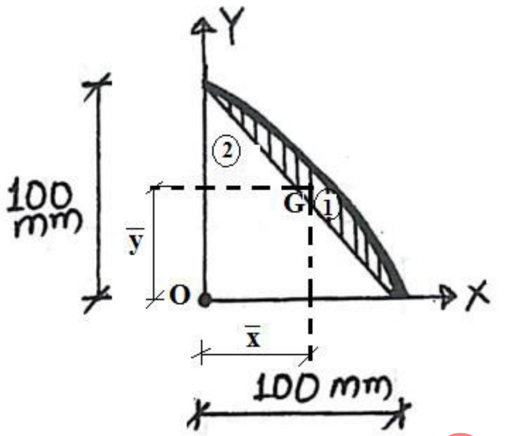
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	e)	Using Lami's Theorem, $\frac{200}{\sin 90} = \frac{T_{AB}}{\sin 150} = \frac{T_{BC}}{\sin 120}$ (1) (2) (3)	1	
		Using term (1) and (2) $\frac{200}{\sin 90} = \frac{T_{AB}}{\sin 150}$ $T_{AB} = \frac{200 \times \sin 150}{\sin 90}$ $\boxed{T_{AB} = 100 \text{ N}}$	1	
		Using term (1) and (3) $\frac{200}{\sin 90} = \frac{T_{BC}}{\sin 120}$ $T_{AB} = \frac{200 \times \sin 120}{\sin 90}$ $\boxed{T_{AB} = 173.20 \text{ N}}$	1	4
		OR  Fig. No. 5  	1	
		Using conditions of equlibrium for concurrent force system and resolving all forces - $\sum F_x = 0$ $+(T_{BC} \text{ x } \cos 60) - (T_{AB} \text{ x } \cos 30) = 0$ $+(T_{BC} \times 0.5) - (T_{AB} \times 0.866) = 0$ ----(1)	1	
		$\sum F_y = 0$ $+(T_{BC} \times \sin 60) + (T_{AB} \times \sin 30) - 200 = 0$ $+(T_{BC} \times 0.866) + (T_{AB} \times 0.5) - 200 = 0$ ----(2)	1	

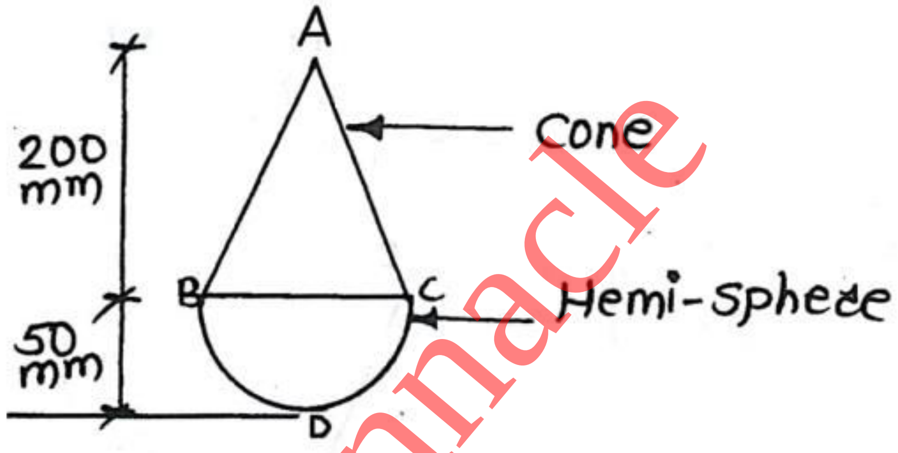
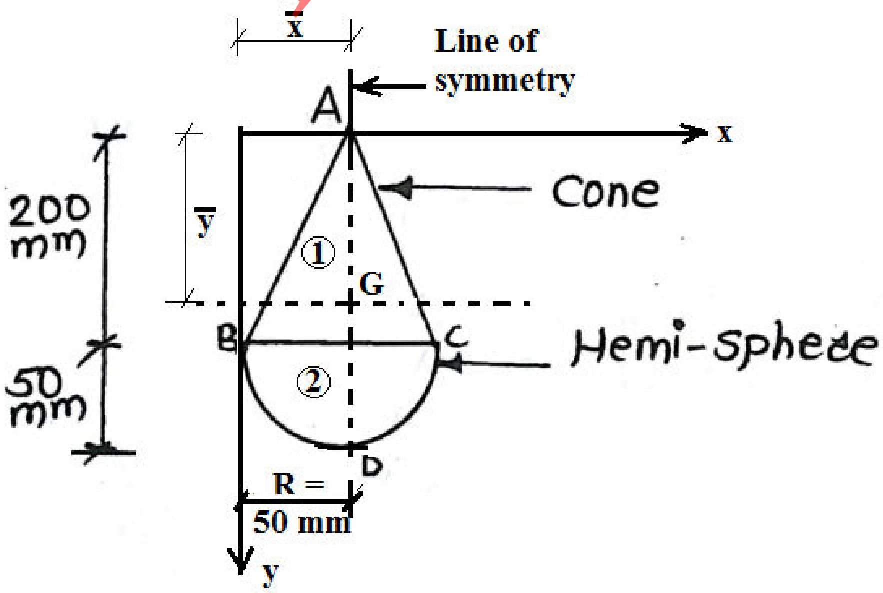
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	e)	Solving equation (1) and (2) simultaneously, $\boxed{T_{AB} = 100\,N}$ $\boxed{T_{BC} = 173.20\,N}$	1	4
Q. 5		**Attempt any TWO of the following:**		(12)
	a)	**Calculate the reactions using analytical method for a beam shown in Fig. No. 6.**  **Fig. No. 6**		
	Ans.	$\sum F_y = 0$ $-1200 + R_B - 2000 - (300 \times 4) + R_D = 0$ $R_B + R_D = 4400$ ----(1)	1 1	
		$\sum M_B = 0$ $-(1200 \times 2) + (2000 \times 2) + (300 \times 4 \times [2+2]) - (R_D \times 6) = 0$ $\boxed{R_D = 1066.66\ N}$	1 1	
		Putting value of R_D in equation (1) $R_B + R_D = 4400$ $R_B + 1066.66 = 4400$ $\boxed{R_B = 3333.34\,N}$	1 1	6
	b)	**Calculate the force 'P' applied parallel to the plane, just to move the block up the plane, if the block weighing 500 N is placed on an inclined plane at an angle of 20° with the horizontal. Coefficient of friction is 0.14.**		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	b) Ans.		1	
		Consider inclined plane as x-x axis and perpendicular to it as y-y axis.		
		For limiting equilibrium		
		$\Sigma Fy = 0$ $+ R - (500 \times \cos 20^\circ) = 0$ $R = 469.85$ N	 1 1	
		$\Sigma Fx = 0$ $+P - F - (500 \times \sin 20^\circ) = 0$ $+P - (\mu \times R) - 171 = 0$ $+P - (0.14 \times 469.85) - 171 = 0$ $+P - 65.78 - 171 = 0$	 1 1 	
		$\boxed{P = 236.78 \text{ N}}$	1	6
	c)	**Find the resultant in magnitude and locate it on the sketch with respect to point 'A' for the force system shown in Fig. No. 7.**		
				
		Fig. No. 7		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	c) Ans.	1) Magnitude of Resultant R = +1000 – 1500 + 1800 – 2000 + 2400 – 2700 = – 1000 N	1	
		$\boxed{R = 1000 \text{ N } (\downarrow)}$	1	
		– ve sign indicates Resultant acts vertically downward.		
		2) Position of Resultant Considering Varignon's theorem of moment and taking moment of all forces @ about 1000 N force. Let, R acts at ***x*** distance from 1000 N force.		
		$\Sigma M_F = M_R$	1	
		$(1000\times0)+(1500\times1)-(1800\times3)+(2000\times5)-(2400\times7)+(2700\times8)=Rx$		
		$10900=1000\times x$	1	
		$x=10.9$ m		
		Hence, R must be located at 10.9 m distance from 1000 N force, so as to produce clockwise moment.	1	
			1	6
Q. 6		**Attempt any TWO of the following:**		(12)
	a)	**Calculate the position of centroid from bottom left corner 'B' for a retaining wall as shown in Fig. No. 8.**		
	Ans.	(1) Area calculation a_1 = Area of rectangle $= 0.8 \times 5.2 = 4.16 \text{ m}^2$		
		a_2 = Area of triangle $= \frac{1}{2} \times 2.4 \times 5.2 = 6.24 \text{ m}^2$	½	
		$a = a_1 + a_2 = 10.4 \text{ m}^2$	½	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	a)	Fig. No. 8	1	
		(2) $\bar{x}$ calculation $x_1 = \frac{0.8}{2} = 0.4\,m$ $x_2 = 0.8 + \left(\frac{1}{3} \times 2.4\right) = 1.6\,m$	1	
		$\bar{x} = \frac{(a_1 \times x_1) + (a_2 \times x_2)}{a} = \frac{(4.16 \times 0.4) + (6.24 \times 1.6)}{10.4} = 1.1m$ $\boxed{\bar{x} = 1.1\,m \text{ from AB}}$	1	
		(3) $\bar{y}$ calculation $y_1 = \frac{5.2}{2} = 2.6\,m$ $y_2 = \left(\frac{1}{3} \times 5.2\right) = 1.73\,m$	1	
		$\bar{y} = \frac{(a_1 \times y_1) + (a_2 \times y_2)}{a} = \frac{(4.16 \times 2.6) + (6.24 \times 1.73)}{10.4} = 2.08m$ $\boxed{\bar{y} = 2.08 \text{ m from BC}}$	1	6

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	b)	**Locate the centroid of shaded area as shown in Fig. No. 9 with respect to origin.**		
	Ans.	 **Fig. No. 9**	1	
		1) Let, Fig. 1 – Quarter circle and Fig. 2 – Triangle		
		Area Calculation		
		$a_1 = \frac{\pi \times r^2}{4} = \frac{\pi \times (100)^4}{4} = 7853.98\ mm^2$ $a_2 = \frac{1}{2} \times b \times h = \frac{1}{2} \times 100 \times 100 = 5000\ mm^2$ $a = a_1 - a_2 = 2853.98\ mm^2$	1	
		2) $\bar{x}$ calculation		
		$x_1 = \frac{4 \times r}{3 \times \pi} = \frac{4 \times 100}{3 \times \pi} = 42.44\,mm$ $x_2 = \frac{b}{3} = \frac{100}{3} = 33.33\,mm$	1	
		$\bar{x} = \frac{a_1 x_1 - a_2 x_2}{a} = \frac{(7853.98 \times 42.44) - (5000 \times 33.33)}{2853.98} = 58.39mm$ $\boxed{\bar{x} = 58.39\,mm \text{ from y axis}}$	1	
		3) $\bar{y}$ calculation		
		$y_1 = \frac{4 \times r}{3 \times \pi} = \frac{4 \times 100}{3 \times \pi} = 42.44\,mm$ $y_2 = \frac{b}{3} = \frac{100}{3} = 33.33\,mm$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	b)	$\bar{y} = \frac{a_1y_1 - a_2y_2}{a} = \frac{(7853.98 \times 42.441) - (5000 \times 33.33)}{2853.98} = 58.39mm$ $\boxed{\bar{y} = 58.39\,mm \text{ from x axis}}$ Hence, centroid (G) for given section lies at G $(\bar{x}, \bar{y})$ = (58.39 mm from y axis and 58.39 mm from x axis)	1	6
	c)	**Locate centre of gravity of a composite solid body from tip 'A' of the cone as shown in Fig. No. 10.**  **Fig. No. 10**		
	Ans.		1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	c)	Let, Fig. 1 = Cone and Fig. 2 = Hemisphere (1) Volume Calculation $V_1 = \frac{1}{3} \times \pi \times R^2 \times h$ $= \frac{1}{3} \times \pi \times 50^2 \times 200$ $= (166666.67 \times \pi)\ mm^3$ $V_2 = \frac{2}{3} \times \pi \times R^3$ $= \frac{2}{3} \times \pi \times 50^3$ $= (83333.33 \times \pi)\ mm^3$ $V = V_1 + V_2$ $= (166666.67 \times \pi) + (83333.33 \times \pi)$ $= (250000 \times \pi)\ mm^3$	1	
		(2) $\bar{x}$ calculation As figure is symmetric about y axis, $\boxed{\bar{x} = R = 50 \text{ mm form y axis}}$	1	
		(3) $\bar{y}$ calculation $y_1 = \left(h - \frac{h}{4}\right) = \left(200 - \frac{200}{4}\right) = 150\ mm$	1	
		$y_2 = h + \left(\frac{3 \times R}{8}\right) = 200 + \left(\frac{3 \times 50}{8}\right) = 218.75\ mm$	1	
		$\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V} = \frac{[(166666.67 \times \pi) \times 150] + [(83333.33 \times \pi) \times 218.75]}{(250000 \times \pi)}$ $\boxed{\bar{y} = 172.92 \text{ mm form x axis}}$	1	6