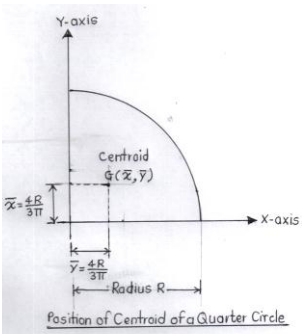
Model Answer: Winter - 2022

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 candidate and 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 model answer.
6) In case of some questions credit may be given by judgement 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.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 1		**Attempt any FIVE of the following:**		**(10)**
	a)	**Define force system and state its classification.**		
	Ans.	**Force System:** When two or more forces are acting on a body, then the formed arrangement is known as Force System.	**1**	
		Classification of Force System: 1. Coplanar force system: a. Co-planner collinear force system. b. Co-planner concurrent force system. c. Co-planner non-concurrent force system. d. Co-planner parallel force system. 2. Non-coplanar force system: a. Non-co-planner collinear force system. b. Non-co-planner concurrent force system. c. Non-co-planner non-concurrent force system. d. Non-co-planner parallel force system.	**1**	**2**
	b)	**State the meaning of reversible machine and state condition for reversibility.**		
	Ans.	**Reversible machine:** When the machine moves in reverse direction after removal of applied effort, then the machine is said to be reversible machine.	**1**	**2**
		Condition for reversibility: When the machine has efficiency more than 50 %, machine is said to be reversible.	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 1	c) Ans.	**State Polygon Law of forces.** **Polygon Law of forces:** If any number of coplanar concurrent forces can be represented in magnitude and direction by the sides of a polygon taken in order; then their resultant will be represented by the closing side of the polygon taken in opposite order.	2	2
	d) Ans.	**State analytical conditions of equilibrium for coplanar non-concurrent force system.** 1. $\Sigma Fx = 0$ i. e. Algebraic sum of all the forces along X-axis must be equal to zero. 2. $\Sigma Fy = 0$ i. e. Algebraic sum of all the forces along Y-axis must be equal to zero. 3. $\Sigma M_A = 0$ i. e. Algebraic sum of moments all the forces about any point (say point A)must be equal to zero.	2	2
	e) Ans.	**State relation between co-efficient of friction (μ) and angle of friction (ϕ).** Relation between co-efficient of friction (μ) and angle of friction (ϕ): $\mu = \tan \phi$	2	2
	f) Ans.	**Show the position of centroid of a quarter circle of radius 'R' with a neat sketch.**  Position of Centroid of a Quarter Circle	2	2
	g) Ans.	**Calculate reaction and reactive moment for a cantilever beam loaded as shown in Fig. No. 1.** Find:R_A = ?; M_A =? Solution:Reaction at point A $\sum Fy = 0$- ↑ +ve; ↓ -ve $R_A = -(4\times2) = -8$ kN Reactive moment at point A $\sum M_A = 0$ $\sum M_A = -(4\times2\times\frac{2}{2}) = -8$ kN.m	1 1	2

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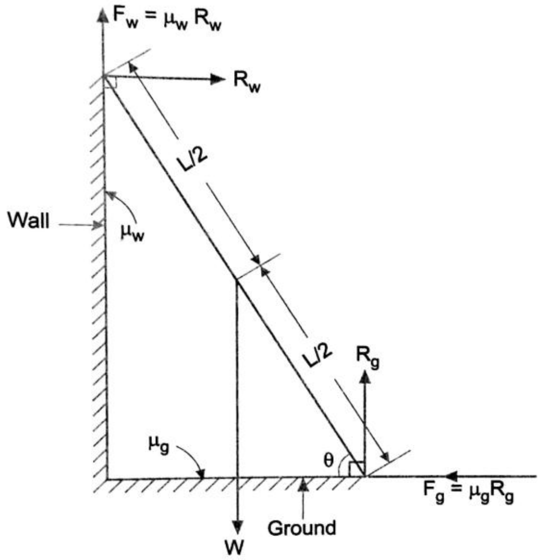
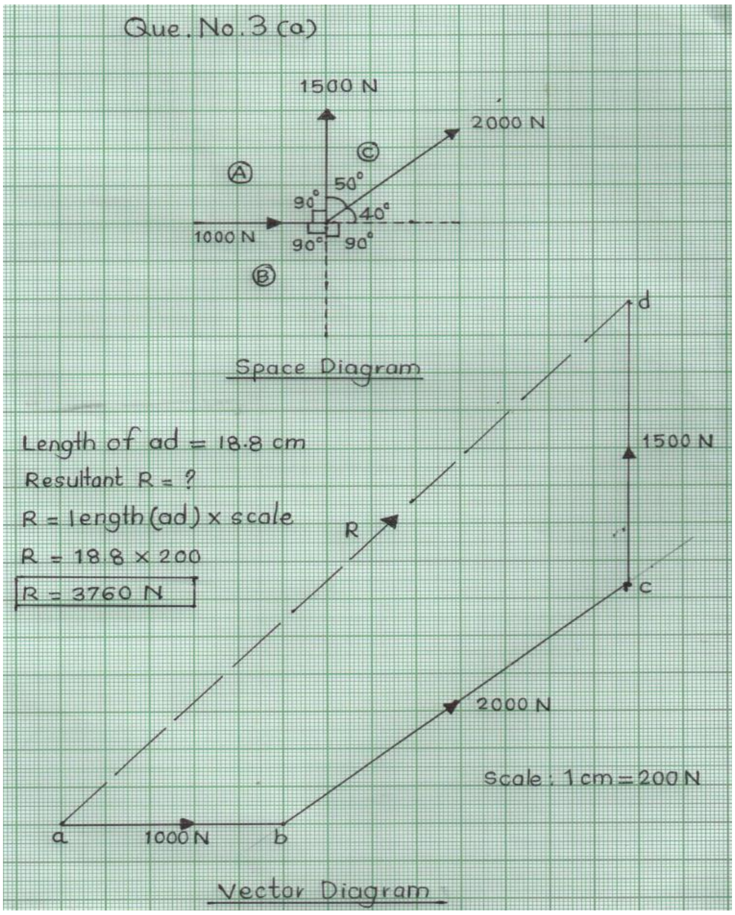
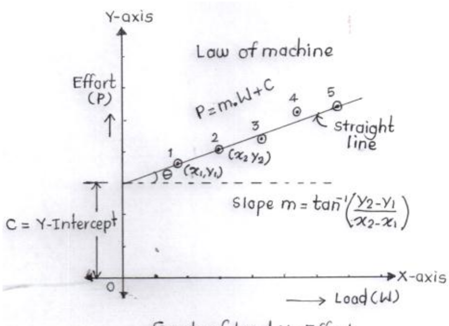
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2		**Attempt any <u>THREE</u> of the following:**		**(12)**
	a)	**Define scalar and vector quantities with two examples of each.**		
	Ans.	**Scalar quantity:** The physical quantity which has only magnitude, but no direction, is called as scalar quantity.	**1**	
		Examples: Mass, area, volume, density, time, speed, work, power	**1**	**4**
		Vector quantity: The physical quantity which has both magnitude and direction is called as vector quantity.	**1**	
		Examples: Force, weight, moment, velocity, acceleration.	**1**	
	b)	**A screw jack lifts a load of 41.25 kN with an effort of 550 N, applied at the end of handle of 60 cm. If the pitch of screw is 15 mm, calculate velocity ratio, mechanical advantage and efficiency of machine.**		
	Ans.	Given: Simple Screw Jack W = 41.25 kN = 41250 N P = 550 N L = 60 cm = 600 mm P = 15 mm Find: MA, VR, = ? Solution:		
		V. R. $= \dfrac{2\pi L}{p} = \dfrac{2 \times \pi \times 600}{15} = 251.32$	**2**	**4**
		M. A. $= \dfrac{W}{P} = \dfrac{41250}{250} = 75$	**1**	
		$\eta = \dfrac{\text{M A}}{\text{V R}} \times 100 = \dfrac{75}{251.32} = 29.84\%$	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 2	c)	**For differential wheel and axle, the diameter of wheel is 36 cm and the diameters of axles are 9 cm and 6 cm. If the efficiency of machine is 80%, effort applied is 120 N, then find the load lifted by it.**		12
	Ans.	Given: Differntial Axle and Wheel		
		$D = 36$ cm; $d_1 = 9$ cm; $d_2 = 6$ cm; $\eta = 80$ %; $P = 120$ N		
		Find: W = ?		
		Solution: $VR = \dfrac{2D}{d_1 - d_2} = \dfrac{2 \times 36}{9 - 6} = 24$	1	
		$\eta = \dfrac{MA}{VR} \times 100$	1	
		$\eta = \dfrac{(W/P)}{VR} \times 100$		4
		$80 = \dfrac{(W/120)}{24} \times 100$		
		$80 = \dfrac{W}{120 \times 24} \times 100$	1	
		$W = \dfrac{80 \times 120 \times 24}{100}$	1	
		$\boxed{W = 2304\ N}$		
	d)	**Draw FBD for a ladder of length 'L', self-weight 'W', resting on rough horizontal floor and leaning against rough vertical wall. Angle between ladder and horizontal floor=θ Co-efficient of friction at floor = μ_f Co-efficient of friction at floor = μ_w**		
	Ans.	**FBD for a ladder:**  	4	4

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3		**Attempt any THREE of the following:**		(12)
	a)	**Find the resultant force in magnitude and direction for the force system shown in Fig. No. 2. Use analytical method.**		
	Ans.	Find: R=?; θ=?		
		Solution:		
		$\sum Fx = 0$		
		$\sum Fx = +1000 + 2000\cos 40^0 = 2532.08$	1	
		$\sum Fy = 0$		
		$\sum Fy = +1500 + 200\sin 40^0 = 2785.57$	1	
		$R = \sqrt{(\sum Fx)^2 + (\sum Fy)^2} = \sqrt{(2532.08)^2 + (2785.57)^2}$		4
		$\boxed{R=3764.41N}$	1	
		$\theta = \tan^{-1}\left[\frac{\sum Fy}{\sum Fx}\right] = \tan^{-1}\left[\frac{2785.57}{2532.08}\right]$		
		$\boxed{\theta = 47.72^0}$	1	
	b)	**Find graphically the resultant force in magnitude and direction for the force system shown in Fig. No. 2.**		
	Ans.		4	4

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 3	c) Ans.	**State law of machines and explain it with the help of sketch.** **Law of machine:** The graphical representation of load lifted (W) by machine to the effort applied (P) to machine, given by P = m.W + C; is said to be law of that particular machine.	1	
		 Graph of Load Vs. Effort	1	
		Explanation: The observations of load lifted to various efforts applied are plotted on graph of Load (W) vs. Effort (P) as shown above. All the points marked are joined with straight line. The line intersects Y-axis at certain point, which is considered as Y-intercept i.e. C. The angle made by straight line with horizontal is taken as Θ. The slope of straight line m is calculated using formula m=$\tan^{-1}$((y_2-y_1)/(x_2-x_1)). Thus law of machine P = m. W + C can be determined from graph. This means that particular machine follows the law for effort calculation for actual load to be lifted.	2	4
	d) Ans.	**A certain machine lifts loads of 400 N and 600 N by an efforts of 60 N and 80 N respectively. Determine law of machine. Also calculate efficiency of 1 kN load if VR is 24.** Given: $W_1 = 400\text{ N},\ P_1 = 60\text{ N}, W_2 = 600\text{ N},\ P_2 = 80\text{ N}; W_3 = 1000\text{ N}, \text{V.R.} = 24$ Find: Law of machine =?, $P_3 = ?$ Solution: Using Law of machine, P = mW+C N Putting given values of W & P in above equation $60 = (m \times 400) + C$ ----(i) $80 = (m \times 600) + C$ ----(ii)	1	
		Subtracting eqn.(ii) from (i), $m = 0.1$	1	
		Putting value of m in eqn.(i), $C = 20$ $\boxed{\therefore \text{Law of machine } P = [(0.1)W + 20]\text{ N}}$	1	4
		For $W_3 = 1000$ N; $P = [(0.1 \times 1000 + 20] = 120$ N $\eta = \frac{MA}{VR} \times 100 = \frac{(W/P)}{VR} \times 100 = \frac{(1000/120)}{24} \times 100$ $\boxed{\eta = 34.72\ \%}$	1	

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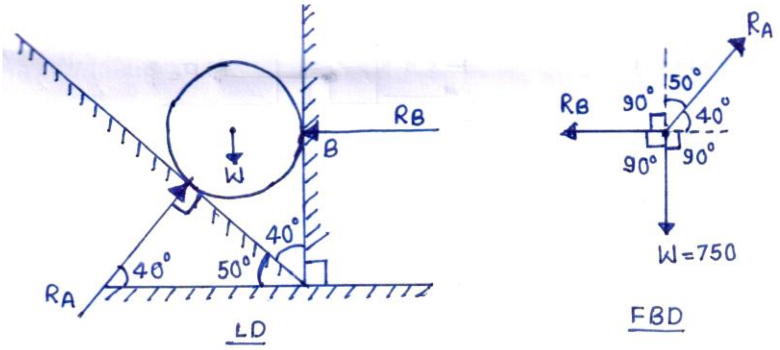
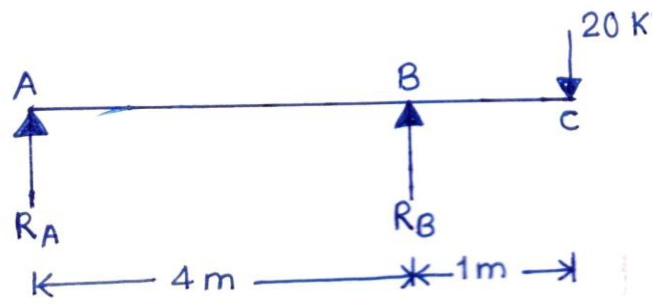
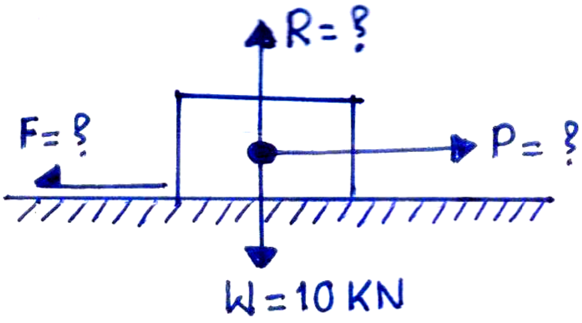
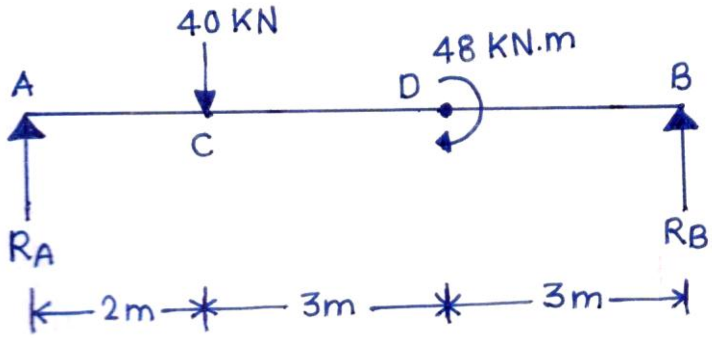
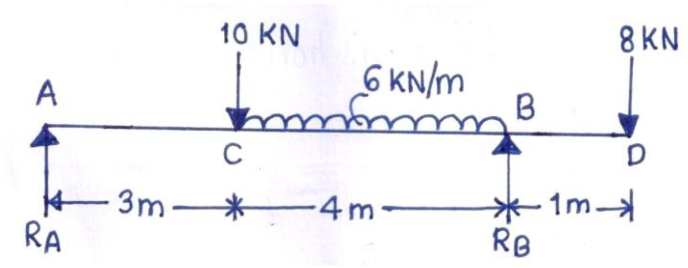
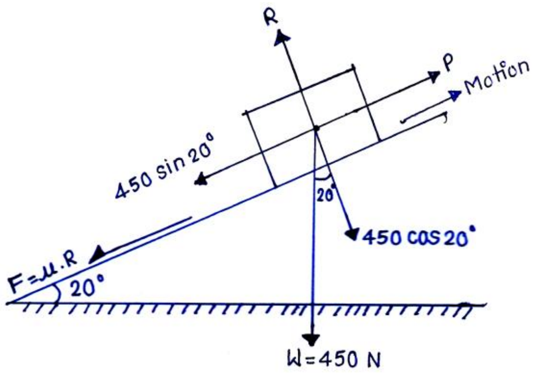
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4		**Attempt any THREE of the following:**		
	a)	**Two forces 40 N and 30 N are acting at and away from the point and making an angle of 35^0 with each other. Calculate magnitude and direction of their resultant.**		
	Ans.	Given: $P = 40\ N,\ Q = 30\ N, R = 60\ N,\ \theta = 35°$		
		Find: R=?; α=?,		
		Solution: Using Law of Parallelogram of forces		
		$R^2 = P^2 + Q^2 + (2\times P\times Q\times \cos\theta)$	1	
		$R^2 = 40^2 + 30^2 + (2\times 40\times 30\times \cos 35°)$		
		$R^2 = 4465.964$		
		$\boxed{R = 66.82\ N}$	1	4
		$\alpha = \tan^{-1}\left[\dfrac{Q\ .\ \sin\theta}{P+Q\ .\ \cos\theta}\right] = \tan^{-1}\left[\dfrac{30\ \times \sin 35°}{40+30\ \times \cos 35°}\right]$	1	
		$\boxed{\alpha = 14.92°}$	1	
	b)	**A sphere of weight 750 N is placed between two surface as shown in Fig. No. 3. Calculate contact reactions offered by the surfaces.**		
	Ans.	 	1	
		Find: $R_A = ?; R_B = ?$		
		Solution: Using Lami's Theorem,		
		$\dfrac{750}{\sin 140^0} = \dfrac{R_A}{\sin 90^0} = \dfrac{R_B}{\sin 130^0}$ (1) (2) (3)	1	4
		Using term 1 and 2		
		$R_A = \dfrac{750}{\sin 140^0}\times \sin 90^0$		
		$\boxed{R_A = 1166.79 N}$	1	
		$R_B = \dfrac{750}{\sin 140^0}\times \sin 130^0$		
		$\boxed{R_B = 893.82 N}$	1	

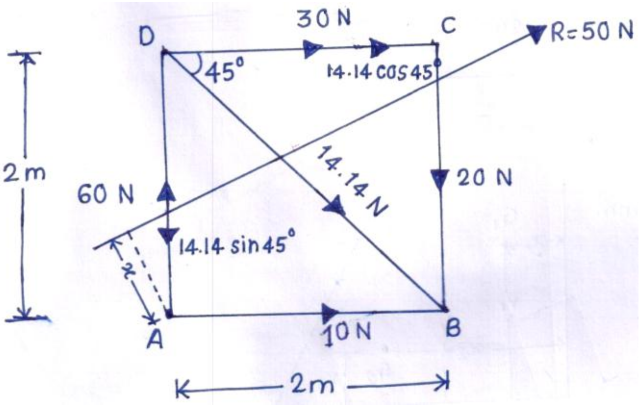
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	c)	**Determine the support reactions of a beam loaded as shown in Fig. No. 4.**		
	Ans.			
		Find: R_A =?; R_B =?		
		Solution:		
		$\sum F_y = 0$		
		$+R_A + R_B - 20 = 0$		
		$R_A + R_B = 20$ kN----(1)	1	
		$\sum M_B = 0$	1	
		$+(20 \times 5) - (R_B \times 4) = 0$		
		$+100 = +4R_B$		4
		$\therefore R_B = \frac{100}{4}$		
		$\boxed{R_B = 25\,\text{kN}\ (\uparrow)}$	1	
		Putting value of R_B in equation (1)		
		$R_A + R_B = 20$		
		$R_A + 25 = 20$		
		$R_A = 20 - 25$		
		$R_A = -5$ kN (-ve sign indicates R_A is acting downwards)	1	
		$\boxed{R_A = 5\,\text{kN}\ (\downarrow)}$		

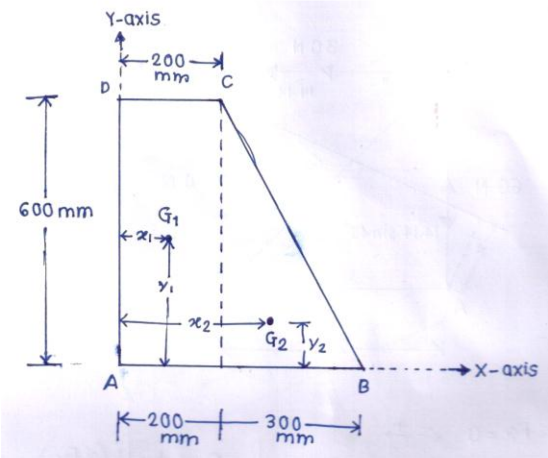
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	d)	**A body weighing 10 kN is placed in rough horizontal plane for which μ=0.60. Calculate normal reaction, limiting force of friction, horizontal force required just to move it and angle of friction.**		
	Ans.		1	
		Given: W=10 kN, μ = 0.60 Find: R=?; F=?; P=? Solution: $\sum F_y = 0 \ (\uparrow +\text{ve}, \downarrow -\text{ve})$ $+R - W = 0$ $+R - 10 = 0$ $\boxed{R = 10\,kN}$	1	4
		$F = \mu \times R$ $F = 0.6 \times 10$ $\boxed{F = 6\ kN}$	1	
		$\sum F_X = 0 \quad (\rightarrow +\text{ve}, \ \leftarrow -\text{ve})$ $+P - F = 0$ $P = F$ $\boxed{P = 6\,kN}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 4	e) Ans.	**Calculate analytically the support reactions of the beam loaded as shown in Fig. No.5.**  Find: R_A =?; R_B =? Solution: $\sum F_y = 0$ $+R_A + R_B - 40 = 0$ $R_A + R_B = 40$ kN----(1) $\sum M_B = 0$ $+(40 \times 2) + 48 - (R_B \times 8) = 0$ $+128 = +8R_B$ $\therefore R_B = \frac{128}{8}$ $\boxed{R_B = 16\,kN\ (\uparrow)}$ Putting value of R_B in equation (1) $R_A + R_B = 20$ $R_A + 16 = 40$ $R_A = 40 - 16$ $\boxed{R_A = 24\,kN\ (\uparrow)}$	 1 1 1 1	 4

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5		**Attempt any TWO of the following:**		**(12)**
	a)	**Determine analytically the reactions of the beam loaded as shown in Fig. No. 6. Also show the direction of reaction at hinged end.**		
	Ans.	 Find: R_A =?; R_B =? Solution: $\sum F_y = 0 \uparrow +ve \ \downarrow -ve$ $+R_A + R_B - 10 - 8 - (6 \times 4) = 0$ $+R_A + R_B - 42 = 0$ $R_A + R_B = 42$ kN----(1)	2	
		$\sum M_A = 0$ $+(10 \times 3) + (8 \times 8) + (6 \times 4 \times 5) - (R_B \times 7) = 0$ $+214 = +7R_B$ $\therefore R_B = \frac{214}{7}$ $\boxed{R_B = 30.57\,kN\ (\uparrow)}$	2	6
		Putting value of R_B in equation (1) $R_A + R_B = 20$ $R_A + 30.57 = 42$ $R_A = 42 - 30.57$ $\boxed{R_A = 11.43\,kN\ (\uparrow)}$	2	

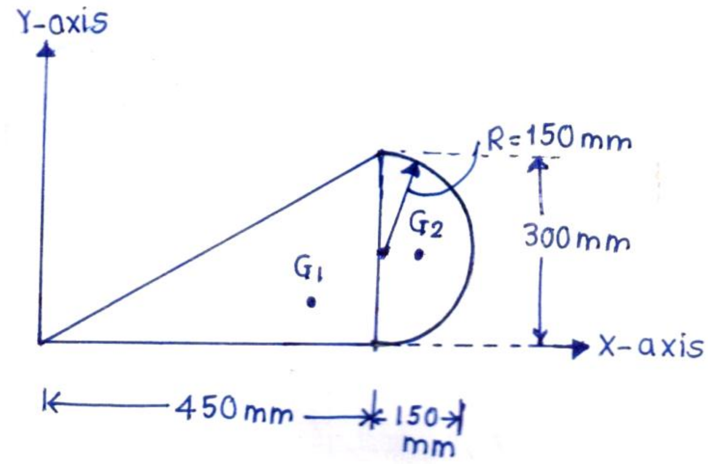
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	b) Ans.	**A block of weight 450 N is placed on rough inclined plane making inclination of 20^0 with horizontal. If μ=0.24, calculate the value of force to be applied parallel to the plane. Just to move the block up the plane.**		
			1	
		Find: Force required to move up the plane, P=?		
		Solution: By considering inclined plane as horizontal plane, Apply $\sum Fy = 0, \uparrow +ve, \downarrow -ve$ $+R - 450 \cos 20^0 = 0$ $+R - 422.86 = 0$ $\boxed{R = 422.86 \text{ N}}$	2	6
		Apply $\sum Fx = 0, \rightarrow +ve, \leftarrow -ve$ $+P - F - 450 \sin 20^0 = 0$	1	
		$+P - \mu R - 450 \sin 20^0 = 0$ $+P - 0.24 \times 422.86 - 450 \sin 20^0 = 0$	1	
		$+P - 255.33 = 0$ $\boxed{P = 255.33 \text{N}}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 5	c)	**Calculate magnitude, direction and position of the resultant w.r.t. 'A' of the forces shown in Fig. No. 7.**		
	Ans.	 Find: R=?, θ=?, x from point A=? Solution: Assume missing horizontal force = 10 N $\sum Fx = 0 \leftarrow$ -ve $\rightarrow +ve$ $\sum Fx = +10+30+14.14\cos 45^0$ $\sum Fx = 49.99 \approx +50N$	1	
		$\sum Fy = 0 \uparrow +ve \downarrow$ -ve $\sum Fy = +60-20+14.14\sin 45^0$ $\sum Fy = +30$ N	1	
		$R = \sqrt{(\sum Fx)^2+(\sum Fy)^2} = \sqrt{50^2+30^2}$ $\boxed{\text{R=58.309 N acting in First Quadrant}}$	1	6
		$\theta = \tan^{-1}\left[\frac{\sum Fy}{\sum Fx}\right] = \tan^{-1}\left[\frac{30}{50}\right]$ $\boxed{\theta = 30.96^0}$	1	
		To find position of R from point A, apply Varignon's Theorem at point A $\sum M_A = 0$ $+(30\times 2)+(20\times 2)+(14.14\cos 45^0\times 2) = 58.309\times x$ $+119.99 = 58.309\times x$	1	
		$\therefore x = \frac{119.99}{58.309} = 2.057$ $\boxed{x = 2.057 \text{ m from point A}}$	1	
		Note: If student assumes different value of force and tried to attempt, then give appropriate marks.		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6		**Attempt any TWO of the following:**		(12)
	a)	**Calculate centroidal position of the lamina of negligible uniform thickness shown in Fig. No. 8.**		
	Ans.		1	
		Find: G $(\bar{x}, \bar{y}) = ?$ Solution: . Calculation of areas: $A_1 = L \times B = 600 \times 200 = 120000\ mm^2$ $A_2 = \frac{1}{2} \times b \times h = \frac{1}{2} \times 300 \times 600 = 90000\ mm^2$	1	
		Calculation of horizontal distances of centroids from Y-axis: $x_1 = \frac{B}{2} = \frac{200}{2} = 100\ mm$ $x_2 = 200 + \frac{b}{3} = 200 + \frac{300}{3} = 300\ mm$	1	6
		Calculation of vertical distances of centroids from X-axis: $y_1 = \frac{L}{2} = \frac{600}{2} = 300\ mm$ $y_2 = \frac{h}{3} = \frac{600}{3} = 200\ mm$	1	
		Calculation of $\bar{x}$: $\bar{x} = \frac{(A_1 \times x_1) + (A_2 \times x_2)}{A_1 + A_2} = \frac{(120000 \times 100) + (90000 \times 300)}{120000 + 90000}$ $\boxed{\bar{x} = 185.71\ mm}$	1	
		Calculation of $\bar{y}$: $\bar{y} = \frac{(A_1 \times y_1) + (A_2 \times y_2)}{A_1 + A_2} = \frac{(120000 \times 300) + (90000 \times 200)}{120000 + 90000}$ $\boxed{\bar{y} = 257.14\ mm}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	b)	**Locate the centroid of the composite area shown in Fig. No. 9.**		

Ans.



1

Find: $G(\bar{x}, \bar{y}) = ?$

Solution: .

Calculation of areas :

$$A_1 = \frac{1}{2} \times b \times h = \frac{1}{2} \times 450 \times 300 = 67500\,\text{mm}^2$$

$$A_2 = \frac{\pi R^2}{2} = \frac{\pi \times 150^2}{2} = 35342.91\,\text{mm}^2$$

1

Calculation of horizontal distances of centroids from Y-axis :

$$x_1 = \frac{2.b}{3} = \frac{2 \times 450}{2} = 300\,\text{mm}$$

$$x_2 = 450 + \frac{4.R}{3.\pi} = 450 + \frac{4 \times 150}{3.\pi} = 513.66\,\text{mm}$$

1

Calculation of vertical distances of centroids from X-axis :

$$y_1 = \frac{h}{3} = \frac{300}{3} = 100\,\text{mm}$$

$$y_2 = \frac{D}{2} = \frac{300}{2} = 150\,\text{mm}$$

1

Calculation of $\bar{x}$:

$$\bar{x} = \frac{(A_1 \times x_1) + (A_2 \times x_2)}{A_1 + A_2} = \frac{(67500 \times 300) + (35342.91 \times 513.66)}{67500 + 35342.91}$$

$$\boxed{\bar{x} = 373.42\text{ mm}}$$

1

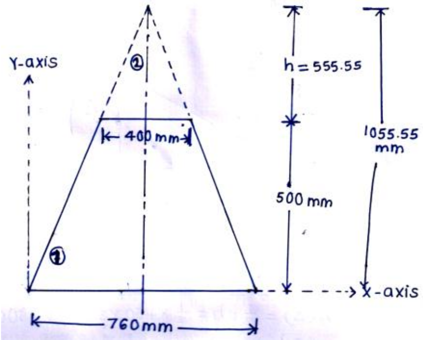
Calculation of $\bar{y}$:

$$\bar{y} = \frac{(A_1 \times y_1) + (A_2 \times y_2)}{A_1 + A_2} = \frac{(67500 \times 100) + (35342.91 \times 150)}{67500 + 35342.91}$$

$$\boxed{\bar{y} = 117.18\text{ mm}}$$

1

Total Marks: 6

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q. 6	c)	**Calculate position of center of gravity of the frustum of cone as shown in Fig. No. 10.**		
	Ans.		1	
		Find: G $(\bar{x}, \bar{y}) = ?$ Solution: Assuming frustum cut from right circular cone as shown. To find h; from similar triangles, $\frac{760}{h+500} = \frac{400}{h}$ $\therefore$ on solving we get, h=555.55 mm $\therefore$ H=h+500=555.55+500=1055.55 mm	1	
		Calculation of $\bar{x}$: As given section is symmetrical @ Y-Y axis, $\bar{x} = \text{Base diameter} = \frac{760}{2} = 380\text{mm}$ $\boxed{\bar{x} = 380\,\text{mm from Y-Yaxis}}$	1	6
		To find $\bar{y}$: Calculation of volume: $V_1 = \frac{1}{3} \times \pi \times R^2 \times H = \frac{1}{3} \times \pi \times 380^2 \times 1055.55 = 159.615 \times 10^6\ \text{mm}^3$ $V_2 = \frac{1}{3} \times \pi \times r^2 \times h = \frac{1}{3} \times \pi \times 200^2 \times 555.55 = 23.270 \times 10^6\ \text{mm}^3$	1	
		Calculation of vertical distances of centroids from X-axis: $y_1 = \frac{h}{4} = \frac{1055.55}{4} = 263.88\,\text{mm}$ $y_2 = 500 + \left(\frac{h}{4}\right) = 500 + \left(\frac{555.55}{4}\right) = 638.88\,\text{mm}$	1	
		Calculation of $\bar{y}$: $\bar{y} = \frac{(V_1 \times y_1) - (V_2 \times y_2)}{V_1 - V_2} = \frac{(159.615 \times 10^6 \times 263.88) - (23.270 \times 10^6 \times 638.88)}{(159.615 \times 10^6) - (23.270 \times 10^6)}$ $\boxed{\bar{y} = 199.87\,\text{mm from X-axis}}$	1	