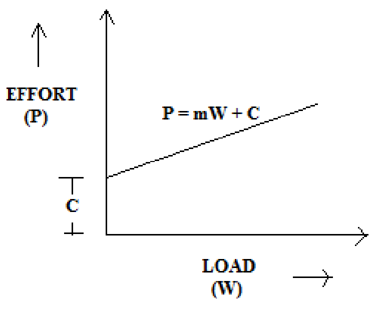
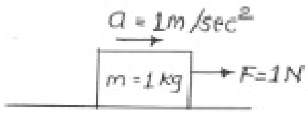
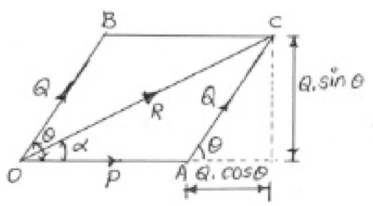
Model Answer: Summer 2017

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		**Answer any TEN of the following :**		**20**
	a) Ans.	**Explain the term 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 – $P = (mW + c)N$	**1**	
		 	**1**	
		Where, m = slope of line = constant c = Intercept on y axis = effort required to start the machine		**2**
	b) Ans.	**How will you find whether machine is reversible or not?** By calculating the efficiency of machine, we can decide whether the machine is reversible or not. If %η < 50% machine is non-reversible i.e. self-locking machine. If %η > 50% machine is reversible.	**2**	**2**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**c) Ans.**	**State VR of Simple axle & wheel.** VR of Simple axle & Wheel = D/d Whether, D = Diameter of Effort Wheel d = Diameter of load drum	**2**	**2**
	d) Ans.	**Differentiate between statics & dynamics.** Statics is the branch of applied mechanics which deals with forces & their action on bodies at rest. Dynamics is the branch of applied mechanics which deals with forces & their action on bodies in motion.	**1** **1**	**2**
	e) Ans.	**What is Unit Newton force?** Unit Newton force is that force which when acts on a body of mass 1 Kg produces an acceleration of 1 m/sec^2 in it.  	**2**	**2**
	f) Ans.	**State parallelogram law of forces. Derive the equations for magnitude & direction of resultant force.** Parallelogram of forces states, "If two forces acting at & away from point be represented in magnitude & 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 & direction.  Let's consider two concurrent forces P & Q acting at & away from O as shown in Fig.. Let these two forces be represented in magnitude & direction by two adjacent sides OA & OB of the parallelogram OACB. Thus the line joining O & C represents the resultant R in magnitude & direction, according to law. Draw CD perpendicular to meet OA produced. Draw AC parallel to OB & OB = AC = Q	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1		OA = P & OC = R AD = Q cos Θ & CD = Q sin Θ In right angled triangle ODC, $OC^2 = OD^2 + DC^2 = (OA + AD)^2 + DC^2$ $= (P+Q\cos\Theta)^2 + (Q\sin\Theta)^2$ $= P^2 + Q^2\cos^2\Theta + 2PQ\cos\Theta + Q^2\sin^2\Theta$ $= P^2 + Q^2(\cos^2\Theta + \sin^2\Theta) + 2PQ\cos\Theta$ $R^2 = P^2 + Q^2 + 2PQ\cos\Theta$----- $(\cos^2\Theta + \sin^2\Theta = 1)$		
		$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$ ------- Magnitude of R	½	
		Let, Θ = Angle between the two forces P & Q. If P, Q & Θ are known, the magnitude of R can be found out. Let R make an angle α with the direction of P. In right angle triangle ODC, $\tan\alpha = \frac{CD}{OD} = \frac{CD}{OA+AD} = \frac{Q\sin\theta}{P+Q\cos\theta}$		2
		$\alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P+Q\cos\theta}\right)$ --------- Direction of R	½	
	g) **Ans.**	**State Varignon's theorem.** 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".	1	2
		Let, $\sum MF_A$ = Algebraic sum of moments of all forces about point A MR_A = Moment of Resultant about point A Then, $\sum MF_A = MR_A$	1	
	h) **Ans.**	**What are the limitations of Lami's theorem?** 1) This theorem is applicable only for three forces. 2) This theorem is applicable when forces are concurrent. 3) This theorem is applicable only when body is in equilibrium. 4) This theorem is not applicable for non-concurrent force system.	**1M each (any two)**	**2**

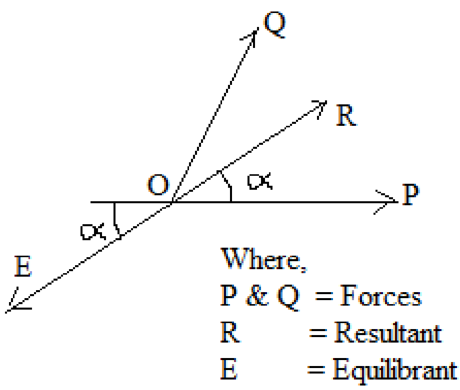
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1	**i)** **Ans.**	**Differentiate between resultant & equilibrant.** (see table below)	**1M each (any two)**	**2**

Q.1 i) Differentiate between resultant & 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 & 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)



1M each (any two) — Total Marks: **2**

j) **What are the two advantages of friction?**

Ans.

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.

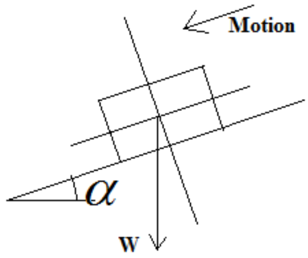
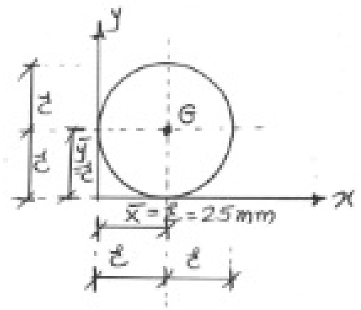
4) One can easily hold pen, pencil & can write on paper.

1 M each (any two) — Total Marks: **2**

k) **Define angle of repose.**

Ans. 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.

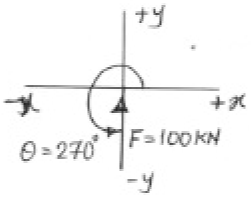
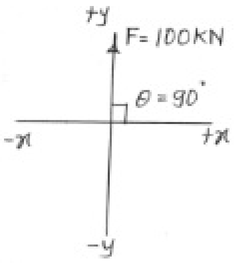
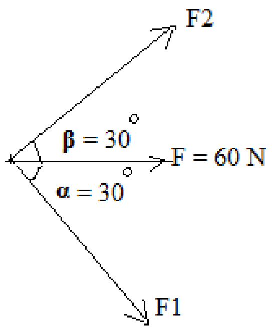
Marks: **1**

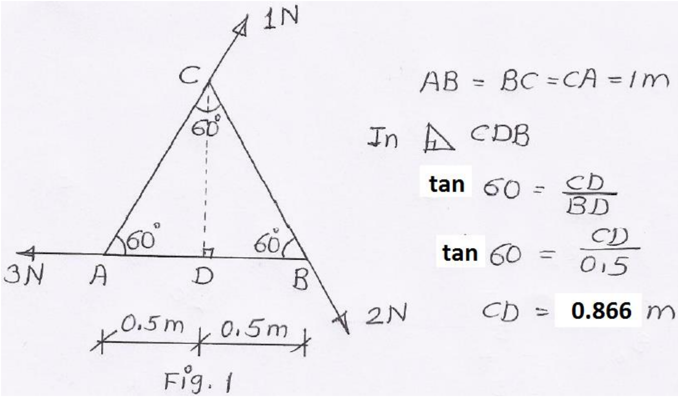
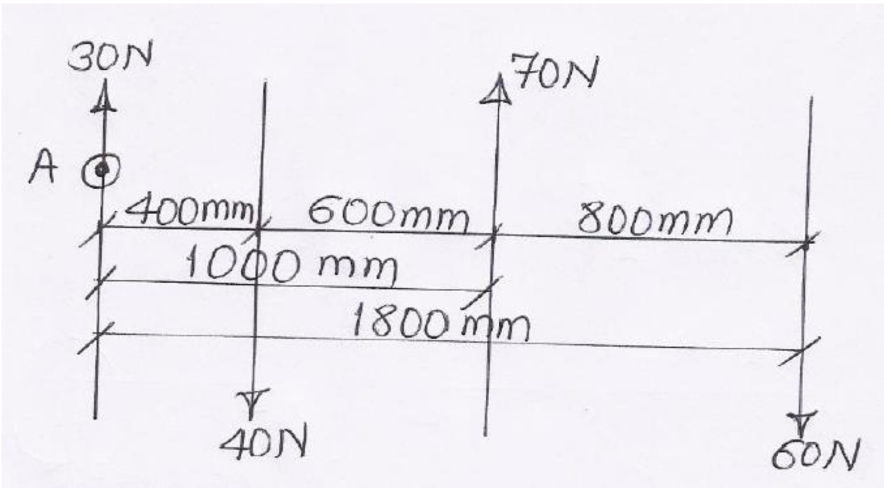
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.1			**1**	**2**
	l) **Ans.**	**What is relation between coefficient of friction & angle of repose?** Relation between coefficient of friction & angle of repose is given by $\mu = \tan\alpha$ Where, μ = Coefficient of friction & α = Angle of repose.	**2**	**2**
	m) **Ans.**	**Calculate & show the centroid of circle of 50 mm diameter.**  $\overline{x} = \overline{y} = \frac{d}{2} = \frac{50}{2} = 25mm$	**1** **1**	**2**
	n) **Ans.**	**Differentiate between centroid & 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 **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** **1**	**2**

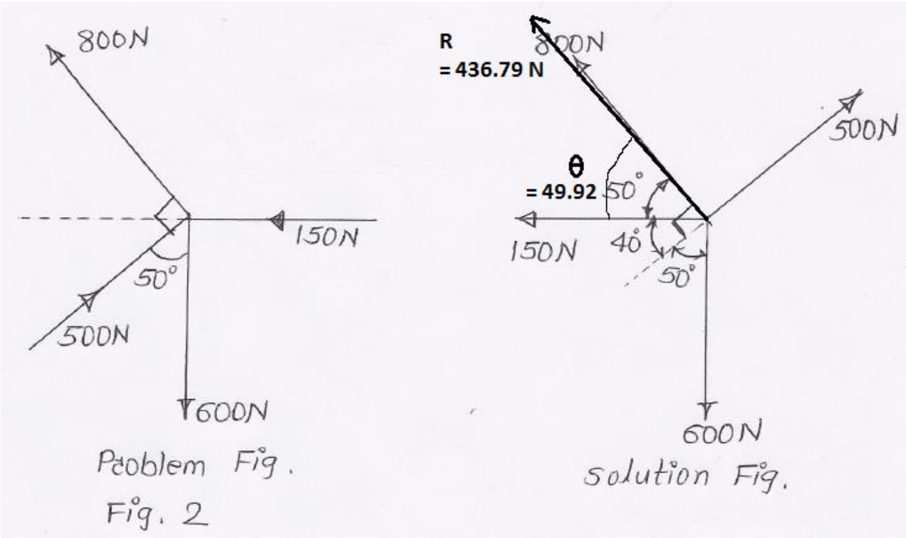
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2		**Answer any FOUR of the following :**		16
	a)	**The velocity ratio of a certain machine is 50. Determine the effort required to lift a load of 1500 N if the efficiency of the machine is 40%.**		
	Ans.	$\%\eta = \frac{MA}{VR} X100$ $40 = \frac{MA}{50} X100$ $MA = 20$	2	4
		$But, MA = \frac{W}{P}$ $20 = \frac{1500}{P}$ $P = 75N$	2	
	b)	**Certain machine has a law of machine P = 0.025 W + 20 N, with VR = 60. Calculate its efficiency at a load of 1 KN.**		
	Ans.	1) Using Law of machine P = (0.025 W + 20) N. = ((0.025 X 1000) + 20) N ------------- Putting W = 1000 N = 45 N	2	4
		2) $MA = \frac{W}{P} = \frac{1000}{45} = 22.222$ $\%\eta = \frac{MA}{VR} X100 = \frac{22.222}{60} X100$ $\%\eta = 37.036\%$	2	
	c)	**In a lifting machine, a load of 10 KN is raised by effort of 300 N. If the efficiency is 75%. Calculate MA & VR, if the machine lifts a load by effort of 550 N. Find the law of machine.**		
	Ans.	$MA = \frac{W}{P} = \frac{10000}{300} = 33.33$ $\%\eta = \frac{MA}{VR} X100$ $VR = 44.44$	1	

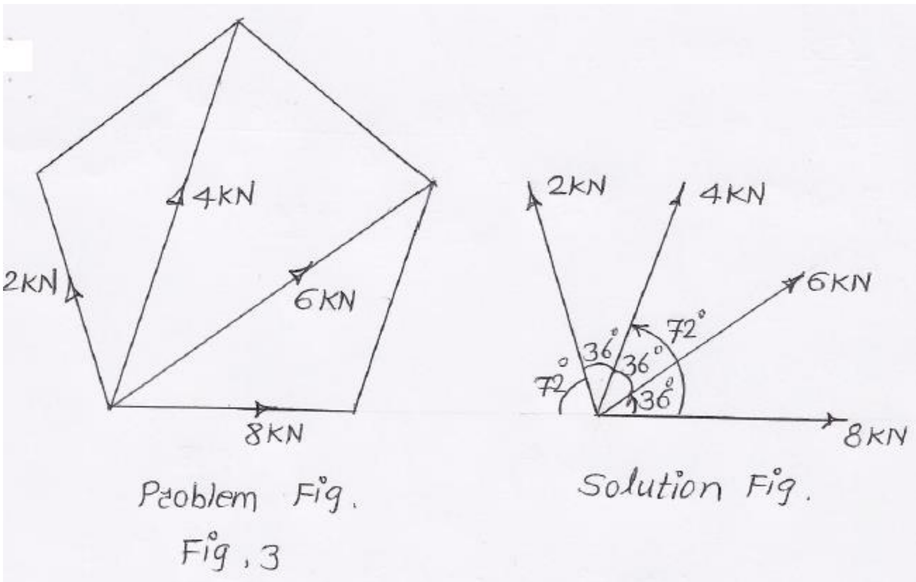
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2		Law of machine is –		
		$P = mW + C$		
		$300 = m(10000) + c -----(1)$	1	
		$550 = m(20000) + c -----(2)$		
		Subtracting equation (1) from (2)		
		m = 0.025	1	4
		Putting value of m in equation (1),		
		300 = (0.025 X 10000) + C		
		C = 50 N		
		Hence, law of machine is, P = (0.025)W + 50 N	1	
	d)	**In a differential axle & wheel, the dia. of wheel is 400 mm & that of axle is 100 mm & 80 mm, if an effort of 50 N can lift a load of 1500 N, find VR & efficiency of the machine.**		
	Ans.	(1) VR of differential axle & wheel is given by -		
		$VR = \frac{2D}{d_1 - d_2} = \frac{2X400}{100-80}$		
		$VR = 40$	2	
		$M.A. = \frac{1500}{50} = 30$		4
		$\%\eta = \frac{M.A.}{V.R.} X100 = \frac{30}{40} X100$		
		$\%\eta = 75\%$	2	
	e)	**A screw jack has effort wheel dia of 200 mm & pitch is 5 mm. Find VR, if load of 1000 N is lifted by an effort of 250 N. Find the efficiency of a machine.**		
	Ans.	1) VR of simple screw jack is given by –		
		$VR = \frac{\pi D}{p}$		
		$VR = \frac{\pi X 200}{5}$		
		VR = 125.66	2	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2		2) $MA = \frac{W}{P} = \frac{1000}{250} = 4$	**1**	
		3) $\%\eta = \frac{M.A.}{V.R.} X100 = \frac{4.0}{125.66} X100$ $\%\eta = 3.183\%$	**1**	**4**
	f)	**In a Westion's pulley block, the radius of the smaller wheel is ¾ than that of a larger wheel. What load is lifted by the pulley block with an effort of 100 N at an efficiency of 50 %.**		
	Ans.	Let, r = Radius of smaller wheel R = Radius of larger wheel d = Diameter of smaller wheel D = Diameter of bigger wheel		
		$r = \frac{3}{4}R$ $\frac{d}{2} = \frac{3}{4} X \frac{D}{2}$ $d = \frac{3}{4}D$ $VR = \frac{2D}{D-d} = \frac{2D}{D - \frac{3}{4}D} = \frac{2}{1-\frac{3}{4}} = 8$	**2**	
		$\%\eta = \frac{MA}{VR} X100$ $50 = \frac{MA}{8} X100$ $MA = 4$ $But, MA = \frac{W}{P}$ $4 = \frac{W}{100}$ $W = 400N$	**2**	**4**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3		**Answer any FOUR of the following :**		**16**
	a)	**Find the components of the force 100 KN (push) acting at 270° with x axis.**		
	Ans.	 		
		$Fx = F\cos\theta = 100 X \cos 90$ $Fx = 0N$	**2**	**4**
		$Fy = F\sin\theta = 100 X \sin 90$ $Fy = 100N$	**2**	
	b)	**What are the components of 60 N force acting horizontal in two directions on either side, at an angle of 30° each?**		
	Ans.			
		$F_1 = \dfrac{F\sin\alpha}{\sin(\alpha+\beta)} = \dfrac{60\sin 30}{\sin(30+30)} = 34.64N$	**2**	**4**
		$F_2 = \dfrac{F\sin\beta}{\sin(\alpha+\beta)} = \dfrac{60\sin 30}{\sin(30+30)} = 34.64N$	**2**	
	c)	**Find the algebraic sum of moment of all forces shown in Fig. 1 about the point C.**		

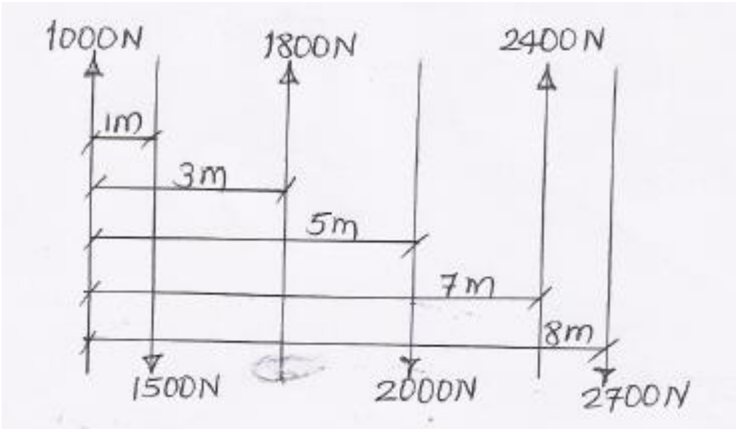
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3	**Ans.**		**2**	**4**
		Mc = (1 X 0) + (2 X 0) + (3 X 0.866) Mc = 2.598 Nm (Clockwise)	**2**	
	d)	**Four forces of 30 N (upward), 40 N (downward), 70 N (upward) & 60 N (downward) are acting in a series. Distances between the forces are 400 mm, 600 mm, 800 mm respectively. Find the moment of a couple.**		
	Ans.		**2**	**4**
		Taking moment of all forces about 30 N force i.e. about point A M = (30 X 0) + (40 X 400) – (70 X 1000) + (60 X 1800) M = 54000 Nm (Clockwise)	**2**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3	**e)**	**Find the angle between two equal forces P, if the resultant is also equal to P.**		
	Ans.	Using Law of parallelogram of forces		
		$R^2 = P^2 + Q^2 + 2PQ\cos\theta$		
		$P^2 = P^2 + P^2 + 2PP\cos\theta$	**2**	
		$P^2 = P^2 + P^2 + 2P^2\cos\theta$		
		$P^2 = P^2(1+1+2\cos\theta)$		**4**
		$1 = 2(1+\cos\theta)$		
		$\frac{1}{2} = (1+\cos\theta)$		
		$0.5 - 1 = \cos\theta$		
		$\cos^{-1}(-0.5) = \theta$	**2**	
		$\theta = 120°$		
	f)	**Find the resultant of all the forces as shown in Fig. 2. Mark its position & direction on a sketch.**		
	Ans.			
		1) Resolving all forces		
		$\sum Fx = -150 - 800\cos 50 + 500\cos 40 = -281.21N$		
		$\sum Fy = 800\sin 50 + 500\sin 40 - 600 = +334.23N$		
		2) Magnitude of Resultant	**1**	
		$R = \sqrt{(\sum Fx)^2 + (\sum Fy)^2} = \sqrt{(-281.21)^2 + (334.23)^2}$		
		$R = 436.79N$	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.3		3) Since ∑Fx is –ve & ∑Fy is +ve, R lies in Second quadrant	**1**	
		4) Position of Resultant $\theta = \tan^{-1}\left\|\frac{\sum Fy}{\sum Fx}\right\| = \tan^{-1}\left\|\frac{334.23}{281.21}\right\|$ $\theta = 49.92°$	**1**	**4**
Q.4		**Answer any FOUR of the following :**		**16**
	a)	**Find the resultant & magnitude & direction of the forces acting on a regular pentagon shown in Fig. 3**		
				
	Ans.	1) Resolving all forces $\sum Fx = 8 + 6\cos 36 + 4\cos 72 - 2\cos 72 = +13.47kN$ $\sum Fy = 6\sin 36 + 4\sin 72 + 2\sin 72 = +9.23kN$	**1**	
		2) Magnitude of Resultant $R = \sqrt{(\sum Fx)^2 + (\sum Fy)^2} = \sqrt{(13.47)^2 + (9.23)^2}$ $R = 16.33kN$	**1**	**4**
		3) Since ∑Fx is +ve & ∑Fy is +ve, R lies in First quadrant	**1**	
		4) Position of Resultant $\theta = \tan^{-1}\left\|\frac{\sum Fy}{\sum Fx}\right\| = \tan^{-1}\left\|\frac{9.23}{13.47}\right\|$ $\theta = 34.42°$	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	b)	**Six parallel forces of magnitude 1000 N, 1500 N, 1800 N, 2000 N, 2400 N, 2700 N are acting at 1, 3, 5, 7, 8 m from the first force. Forces 1st, 3rd, & 5th are acting upwards while other acting vertically downwards. Find the resultant force analytically.**		

Ans.



1) Magnitude of Resultant

R = +1000 – 1500 + 1800 – 2000 + 2400 – 2700 = -1000 N **2**

= 1000 N (↓)

- ve sign indicates Resultant acts vertically downwards.

2) Position of Resultant

Considering Varignon's theorem of moment & taking moment of all forces @ about 1000 N force.

Let, R acts at x distance from 1000 N force. **4**

$$\Sigma M_F = M_R$$

$$(1000 \times 0) + (1500 \times 1) - (1800 \times 3) + (2000 \times 5) - (2400 \times 7) + (2700 \times 8) = R \times x$$

$$10900 = 1000 \times x$$

$$x = 10.9 \text{ m}$$ **2**

Hence, R must be located at 10.9 m distance from 1000 N force, so as to produce clockwise moment.

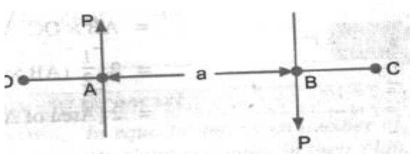
c) Write any four properties of a couple.

Ans.

1) The resultant of the forces of a couple is zero.

2) T he moment of a couple is equal to the product of one of the force & arm of couple.

3) Moment of a couple about any point is constant.



Moment of a couple $= P \times a$

Moment of a couple about 'C'

$= P \times AC - P \times BC$

$= P(AB + BC) - P \times BC$

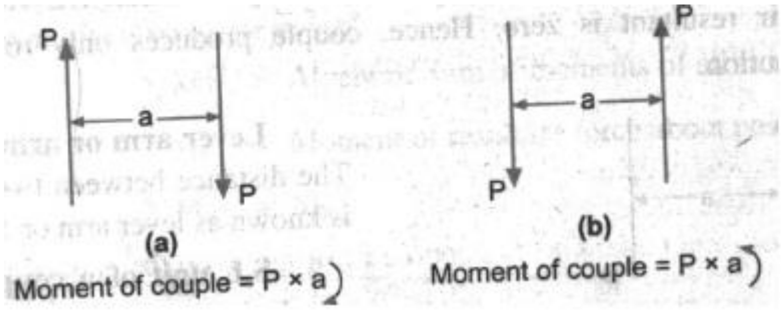
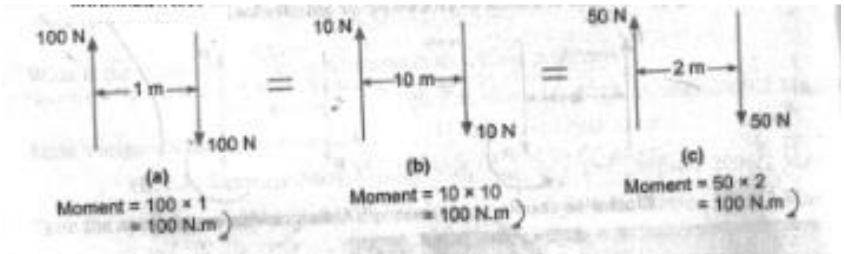
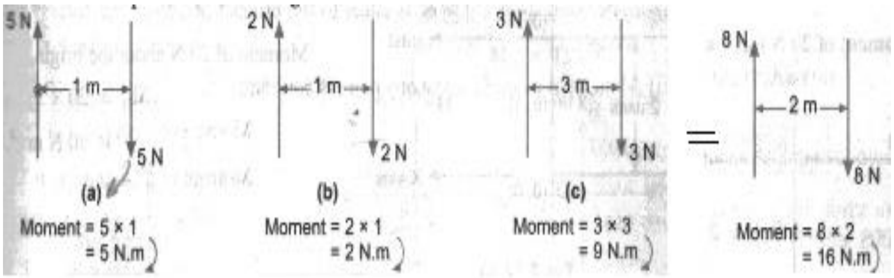
$= P(AB) + P(BC) - P(BC$

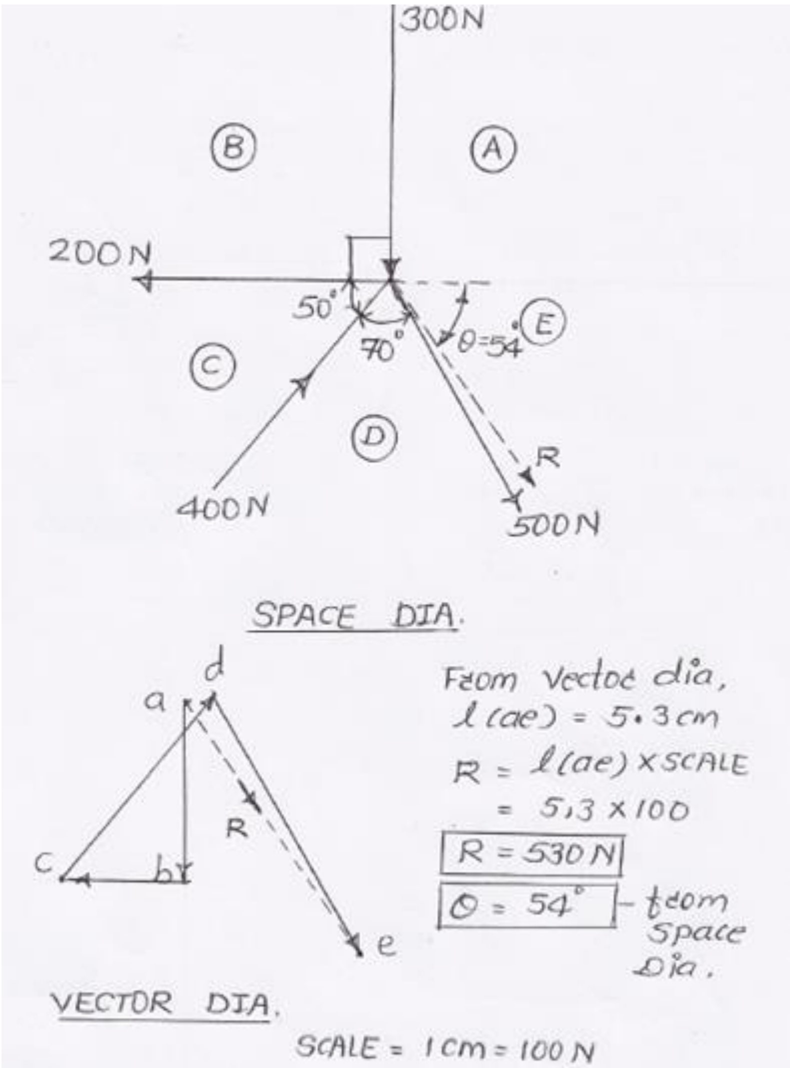
$= P(AB) = P \times a$

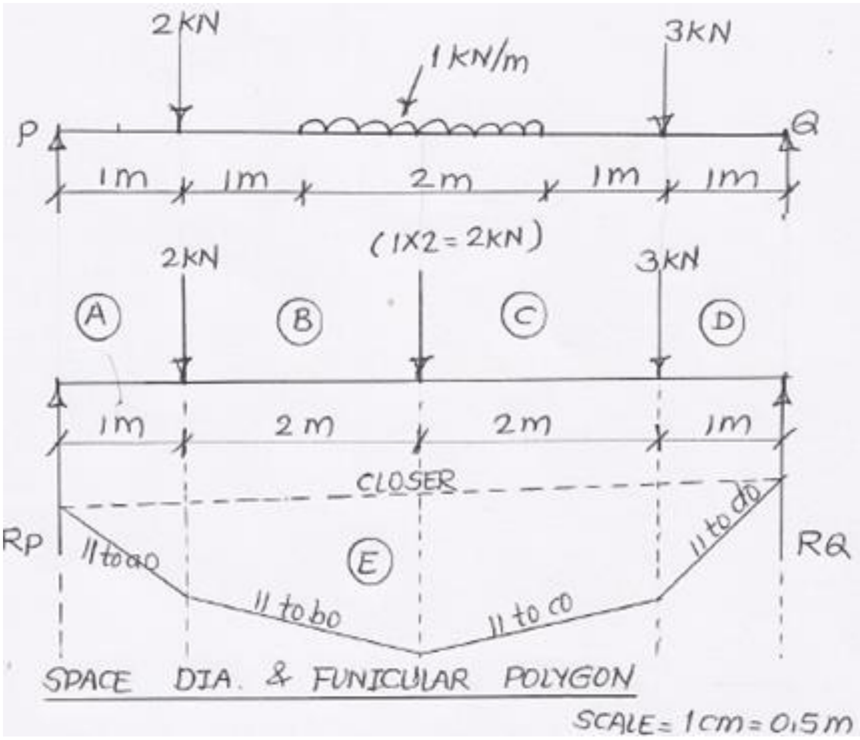
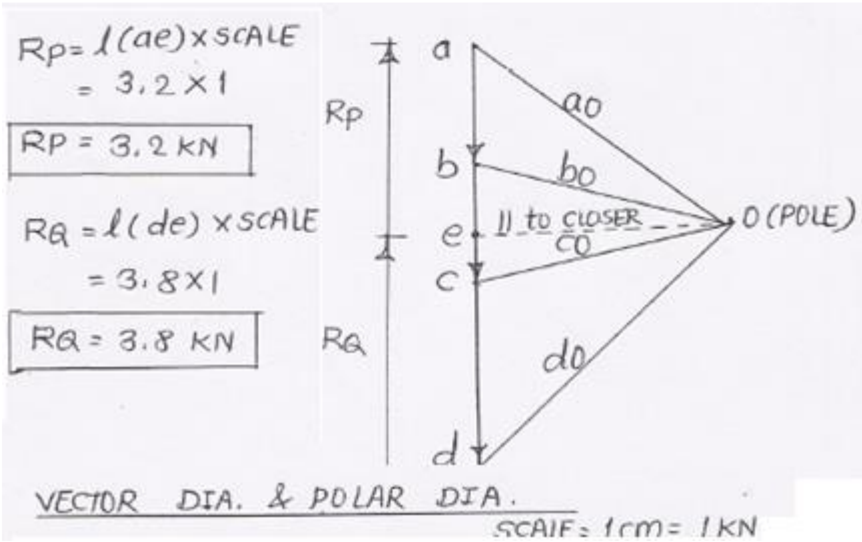
Moment of a couple about 'D' $= -P \times AD + P \times BD = -P \times AD + P \times (AD + AB$

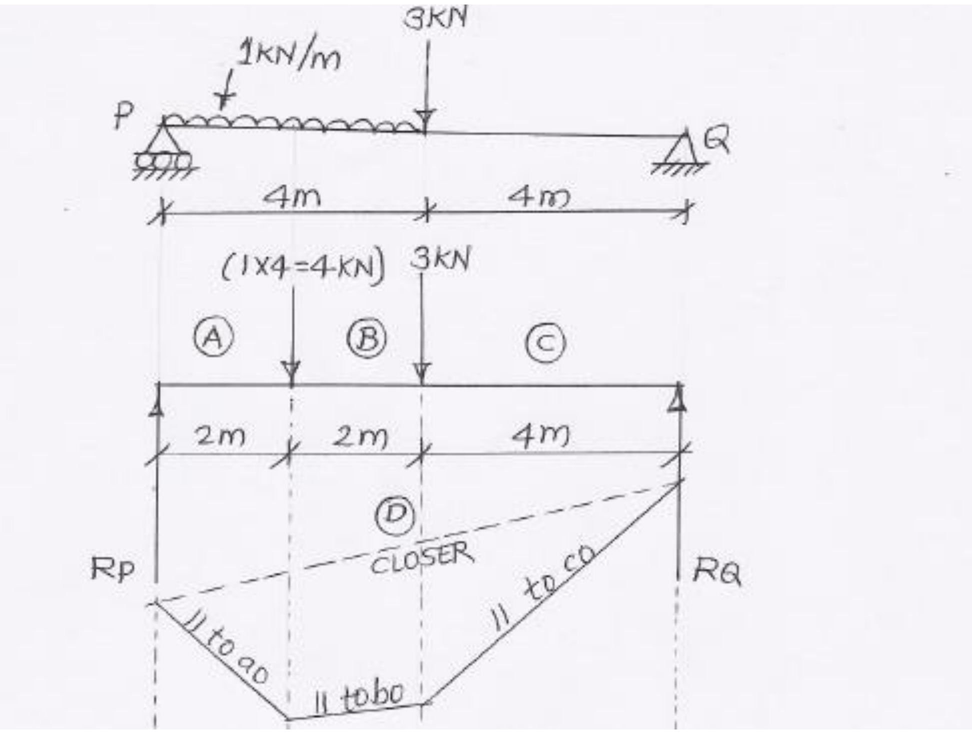
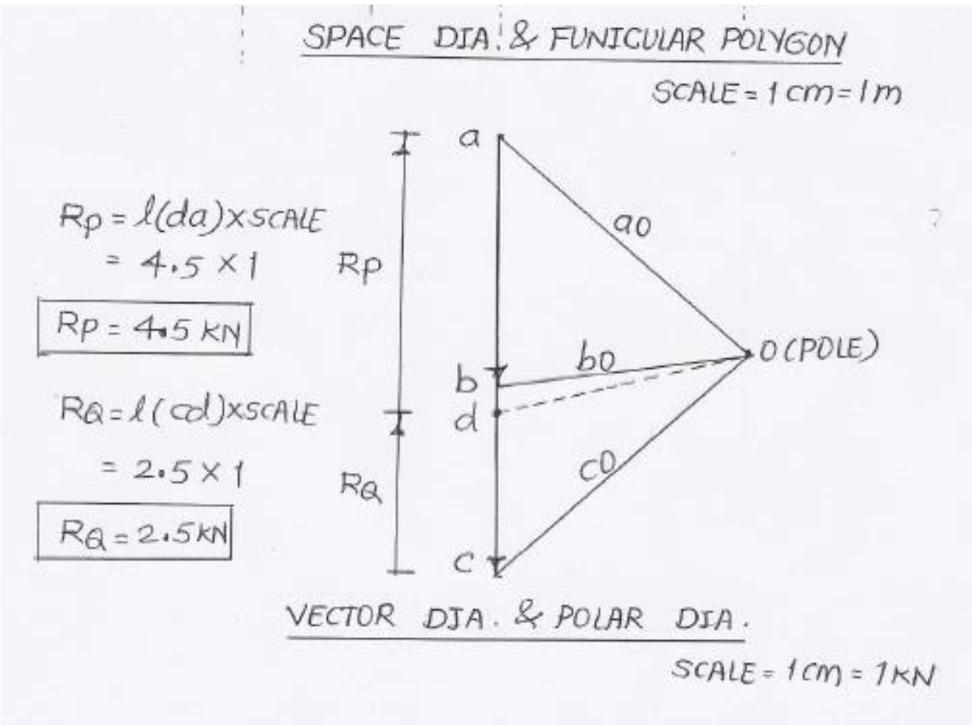
$= -P(AD) + P(AD) + P(AB)$

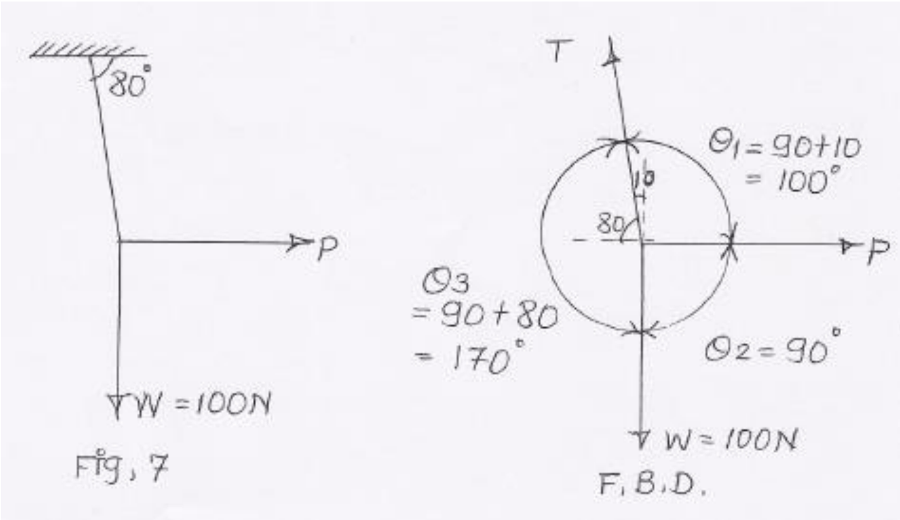
$= P(AB) = P \times a$

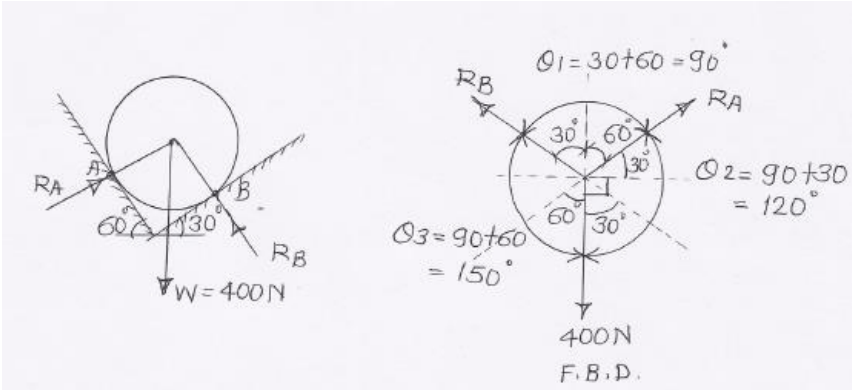
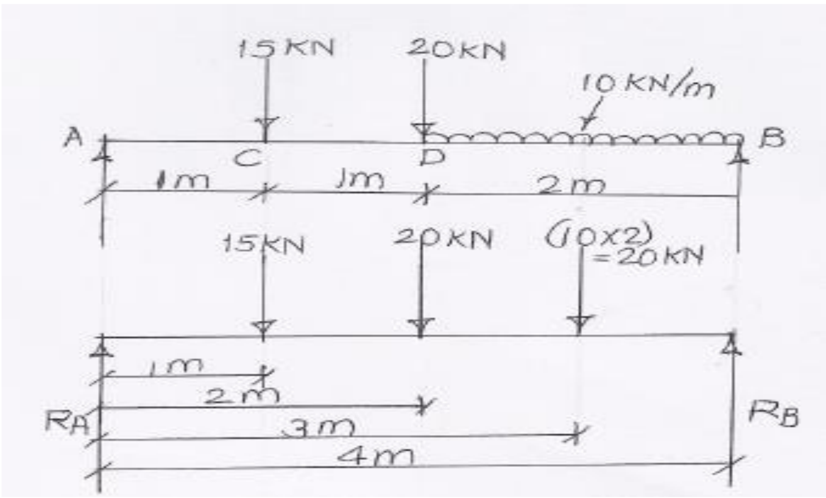
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4		4) A couple can be balanced only by another couple of equal & opposite moment.  5) Two or more couples are said to be equal when they have same sense & moment.  6) Any number of coplanar couples can be represented by a single couple, the moment of which is equal to the algebraic sum of the moment of all the couples. 	**1 M each (any four)**	**4**

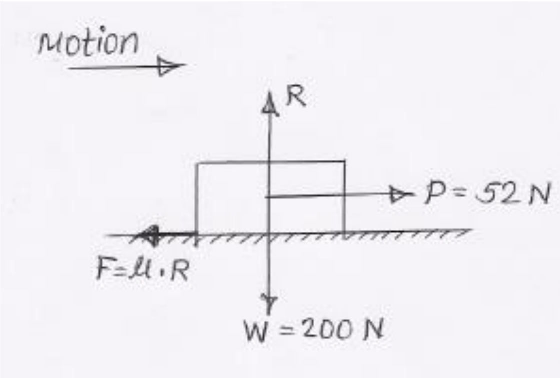
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	d)	**Find graphically the resultant of a concurrent force system. See Fig. 4** 	2 2	4

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	**e)** **Ans.**	**Find support reactions of the beam graphically. See Fig. 5**   	2 2	4

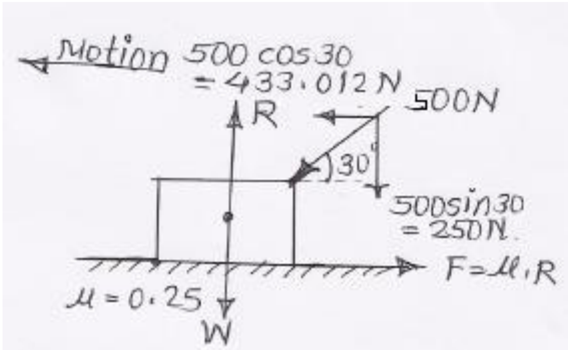
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	**f)**	**Calculate reactions at roller support & hinge support by graphical method of Fig. 6.**		
	Ans.		2	4
			2	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5		**Answer any FOUR of the following :**		**16**
	a)	**A horizontal force P as shown in Fig. 7 keeps the weight of 100 N in equilibrium. Find the magnitude P & tension in the string T.**		
	Ans.			
		Using Lami's theorem,		
		$\frac{W}{\sin 100°} = \frac{T}{\sin 90°} = \frac{P}{\sin 170°}$		
		$\frac{100}{\sin 100°} = \frac{T}{\sin 90°} = \frac{P}{\sin 170°}$		
		Using term (1) and (2)		
		$\frac{100}{\sin 100°} = \frac{T}{\sin 90°}$		
		$T = 100 X \frac{\sin 90°}{\sin 100°}$		
		T = 101.54 N	2	
		Using term (1) and (3)		
		$\frac{100}{\sin 90°} = \frac{P}{\sin 170°}$		4
		$P = 100 X \frac{\sin 170°}{\sin 100°}$		
		P = 17.63 N	2	

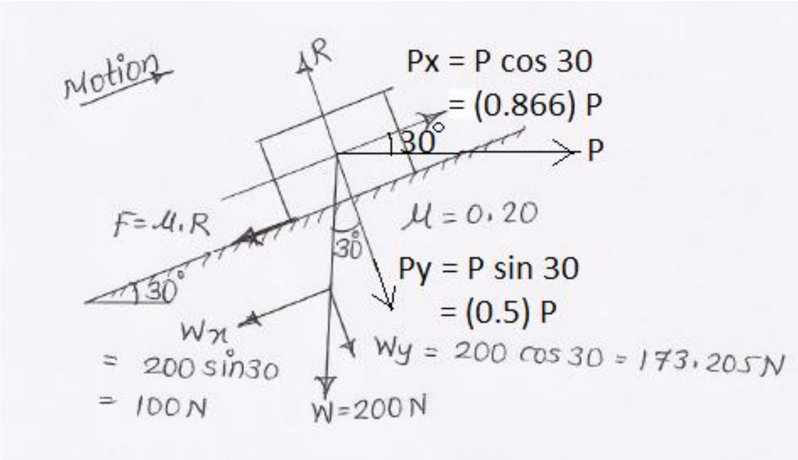
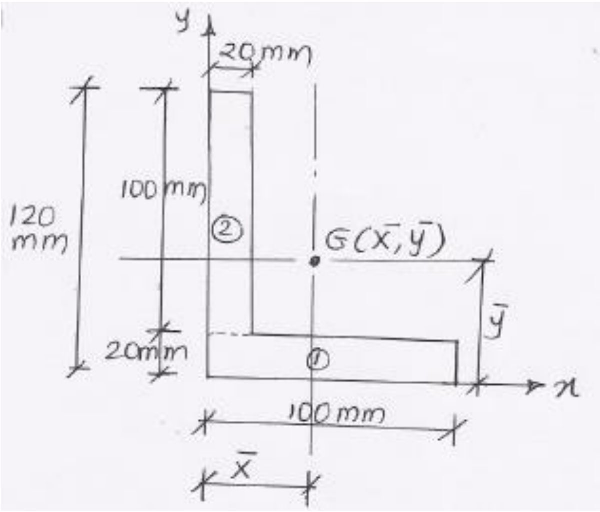
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5	**b)**	**A sphere of weight 400 N rests in a groove of smooth inclined surfaces which are making 60° & 30° inclination to the horizontal. Find the reactions at the contact surfaces.**		
	Ans.	 Using Lami's theorem, $\frac{400}{\sin 90} = \frac{R_A}{\sin 150} = \frac{R_B}{\sin 120}$ (1) (2) (3) Using term (1) and (2) $\frac{400}{\sin 90} = \frac{R_A}{\sin 150}$ $R_A = \frac{\sin 150}{\sin 90} X 400$ $R_A = 200N$ Using term (1) and (3) $\frac{400}{\sin 90} = \frac{R_B}{\sin 120}$ $R_B = \frac{\sin 120}{\sin 90} X 400$ $R_B = 346.40N$	**2 M each (RA & RB)**	**4**
	c)	**A beam of span 4 m is simply supported at its ends. It carries concentrated load of 15 KN & 20 KN at 1m & 2m from left hand support respectively. It carries UDL of 10 KN/m from the right end. Determine reactions at the support.**		
	Ans.		**1**	

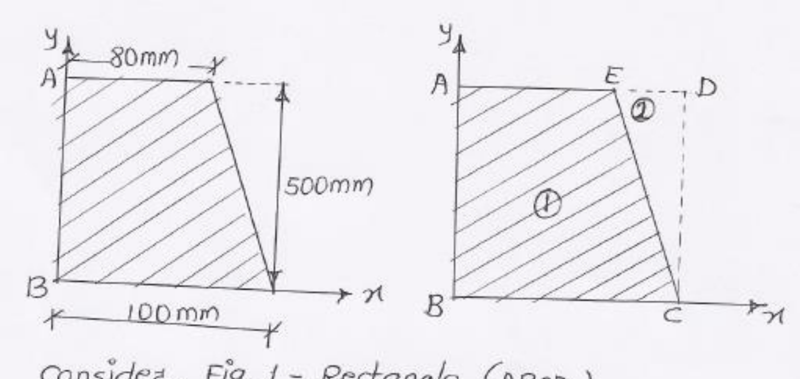
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5		1) Equivalent point load and it's position Equivalent point load = Intensity of udl X span of udl = 10 X 2 = 20 KN Position from equivalent point load from RA = 1 m + 1 m+ Span of udl / 2 = 2 + (2/2) = 3 m 2) Applying equilibrium conditions Σ Fy = 0 (↑+ve , ↓−ve) and Σ M = 0 (↻+ve , ↺−ve) Σ Fy = 0 RA – 15 – 20 - 20 + RB = 0 RA + RB = 55 KN -------(1)	**1**	**4**
		$\Sigma M_A = 0$ Taking moment of all forces @ point A (RA x 0) + (15 X 1) + (20 X 2) + (20 X 3) – (RB X 4) = 0 RB = 28.75 KN	**1**	
		Putting value of RB in eqn. (1) RA + 28.75 = 55 RA = 26.25 KN	**1**	
	d)	**A parcel weighing 200 N is just on the point of moving horizontally by a force of 52 N. What is coefficient of friction?**		
	Ans.			
		For limiting equilibrium Σ Fy = 0 (↑+ve , ↓−ve) + R – W = 0 R = W = 200 N R = 200 N	**2**	
		Σ Fx = 0 (→+ve , ←−ve) + P – F = 0 $52 = \mu R$ $52 = \mu X\, 200$		

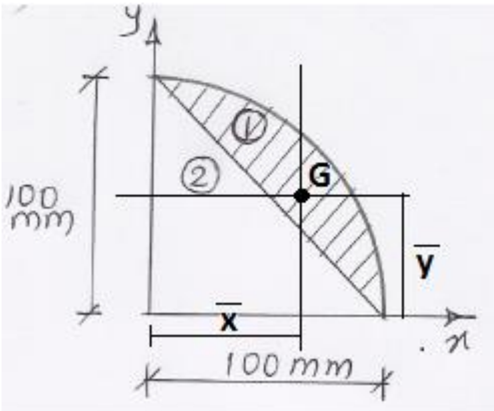
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5		$\mu = \frac{52}{200}$ $\mu = 0.26$	**2**	**4**
	e)	**Find the value of W if the body is in limiting equilibrium. See Fig. 8.**		
	Ans.			

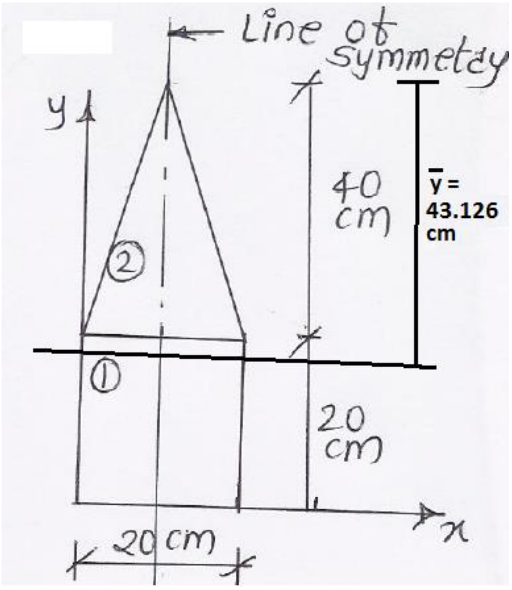


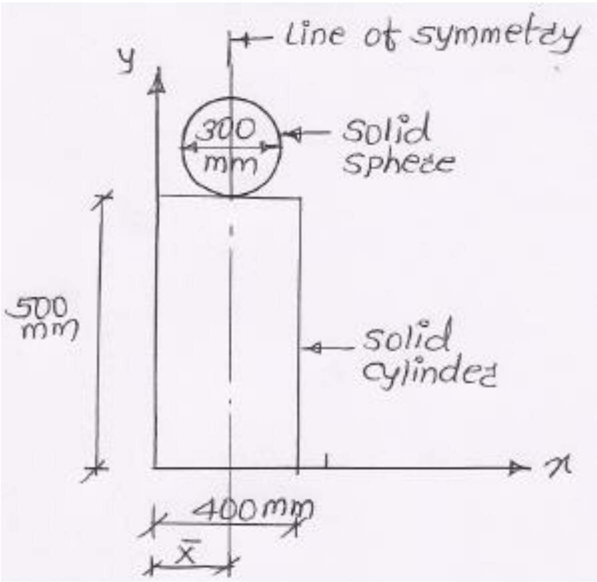
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
		For limiting equilibrium $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ $+ R - W - 250 = 0$ $R = W + 250$ ------ (1)	**1**	
		$\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$ $+F - 433.012 = 0$ $F = 433.012$ N But, $F = \mu R$ $433.012 = 0.25 \times R$ $R = 433.012 / 0.25$ $R = 1732.048$	**1**	**4**
		Putting value of R in equation (1) $1732.048 = W + 250$ $W = 1482.048$ N	**2**	
	f)	**A 200 N block is at rest on a 30° incline. The coefficient of friction between block & the incline is 0.20. Compute the value of a horizontal force P that causes motion to impend up the incline.**		
	Ans.	Consider inclined plane as x-x axis and perpendicular to it as y-y axis. For limiting equilibrium $\Sigma Fy = 0$ $+ R - 173.205 - (0.5) P = 0$ $R = 173.205 + (0.5) P$ ----- (1)	**2**	

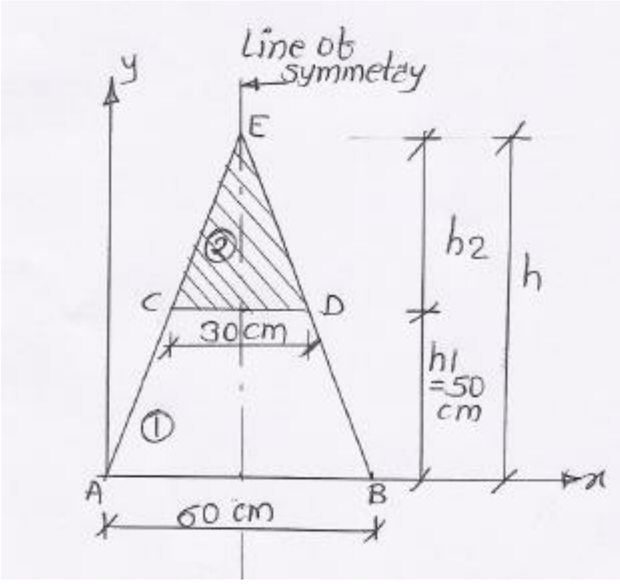
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.5				
		Σ Fx = 0 + (0.866) P - F – 100 = 0 + (0.866) P = (0.20 X (173.205+ 0.5 P) + 100 ---Putting value of R P = 175.77 N	**2**	**4**
Q.6		**Answer any FOUR of the following :**		
	a)	**A L section consists of two legs 100 mm X 20 mm each with 120 mm as overall depth.**		
	Ans.		**1**	
		1) Area calculation A_1 = 100 X 20 = 2000 mm^2 A_2 = 100 X 20 = 2000 mm^2 A = A_1 + A_2 = 4000 mm^2	**1**	
		2) Position of $\bar{x}$ X_1 = 100 / 2 = 50 mm X_2 = 20 / 2 = 10 mm		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6		$\bar{x} = \frac{A_1x_1 + A_2x_2}{A}$ $\bar{x} = \frac{(2000 X 50) + (2000 X 10)}{4000}$ $\bar{x} = 30mm$	**1**	
		3) Position of $\bar{y}$ y_1 = 20 / 2 = 10 mm y_2 = 20 + (100/2) = 70 mm $\bar{y} = \frac{A_1y_1 + A_2y_2}{A}$ $\bar{y} = \frac{(2000 X 10) + (2000 X 70)}{4000}$ $\bar{y} = 40mm$	**1**	**4**
	b) **Ans.**	**Find the centroidal position of shaded area with respect to AB. See Fig. 9**  		
		1) Area calculation A_1 = 100 X 500 = 50000 mm^2 A_2 = ½ X 20 X 500 = 5000 mm^2 A = A_1 - A_2 = 45000 mm^2	**1**	
		2) Position of $\bar{x}$ X_1 = 100 / 2 = 50 mm X_2 = 80 + (2/3) X 20 = 93.333 mm	**1**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6		$\bar{x} = \frac{A_1 x_1 - A_2 x_2}{A}$ $\bar{x} = \frac{(50000 X 50) - (5000 X 93.333)}{45000}$ $\bar{x} = 45.185 mm$	2	4
		Hence, Centroidal position of shaded area with respect to AB = 45.185 mm		
	c)	**Locate centroid of shaded area. See Fig. 10** 		
	Ans.	1) Let, Fig. 1 – Quarter circle and Fig. 2 – Triangle Area Calculation $A_1 = \frac{\pi r^2}{4} = \frac{\pi (100)^4}{4} = 7853.981 mm^2$ $A_2 = \frac{1}{2} bh = \frac{1}{2} X 100 X 100 = 5000 mm^2$ $A = A_1 - A_2 = 2853.981 mm^2$	1	
		2) $\bar{x}$ calculation $x_1 = \frac{4r}{3\pi} = \frac{4 X 100}{3\pi} = 42.441 mm$ $x_2 = \frac{b}{3} = \frac{100}{3} = 33.333 mm$ $\bar{x} = \frac{A_1 x_1 - A_2 x_2}{A} = \frac{(7853.981 X 42.441) - (5000 X 33.333)}{2853.981}$ $\bar{x} = 58.397 mm$	1½	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6		3) $\overline{y}$ calculation $y_1 = \frac{4r}{3\pi} = \frac{4X100}{3\pi} = 42.441mm$ $y_2 = \frac{b}{3} = \frac{100}{3} = 33.333mm$ $\overline{y} = \frac{A_1y_1 - A_2y_2}{A} = \frac{(7853.981X42.441)-(5000X33.333)}{2853.981}$ $\overline{y} = 58.397mm$ Hence, centroid (G) for given section lies at G($\overline{x,y}$) = (58.397 mm from y axis & 58.397 mm from x axis)	**1½**	**4**
	d)	**A solid cone of height 40 cm is placed on a cube of side 20 cm as shown in Fig. 11. Locate the position of CG with respect to tip of the cone.**		
	Ans.			
		1) Volume Calculation $V_1 = 20X20X20 = 8000cm^3$ $V_2 = (1/3)\pi r^2 h = (1/3)\pi(10)^2 X 40 = 4188.79cm^3$ $V = V_1 + V_2 = 12188.79cm^3$	**1**	
		3) $\overline{y}$ calculation $y_1 = 40 + \frac{20}{2} = 50cm$	**1**	
		$y_2 = h_2 - \frac{h_2}{4} = 40 - \frac{40}{4} = 30cm$		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6		$\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V}$ $\bar{y} = 43.126 cm$	**2**	**4**
	e) **Ans.**	**Find the centre of gravity of composite solid w.r.t. x & y axis. See Fig. 12.** 		
		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 400 / 2 = 200 mm	**1**	
		2) Volume Calculation $V_1 = \pi r_1^2 h_1 = \pi (200)^2 X 500 = 62831853 mm^3$ $V_2 = (4/3)\pi r_2^3 = (4/3)\pi (150)^3 = 14137167 mm^3$ $V = V_1 + V_2 = 76.96902 X 10^6 mm^3$	**1**	**4**
		3) $\bar{y}$ calculation $y_1 = \frac{500}{2} = 250 mm$ $y_2 = 500 + 150 = 650 mm$	**1**	
		$\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V}$ $\bar{y} = 323.47 mm$	**1**	

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

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.6		2) Volume Calculation		
		$V_1 = (1/3)\pi r_1^2 h = (1/3)\pi (30)^2 X 100 = 30000\pi cm^3$	**1**	
		$V_2 = (1/3)\pi r_2^2 h_2 = (1/3)\pi (15)^2 X 50 = 3750\pi cm^3$		
		$V = V_1 - V_2 = 26250\pi cm^3$		
		3) $\overline{y}$ calculation		**4**
		$y_1 = \frac{h}{4} = \frac{100}{4} = 25cm$		
		$y_2 = h_1 + \frac{h_2}{4} = 50 + \left(\frac{50}{4}\right) = 62.5cm$		
		$\overline{y} = \frac{V_1 y_1 - V_2 y_2}{V}$		
		$\overline{y} = 19.64cm$	**1**	