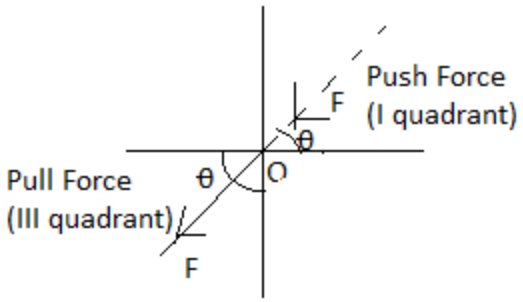
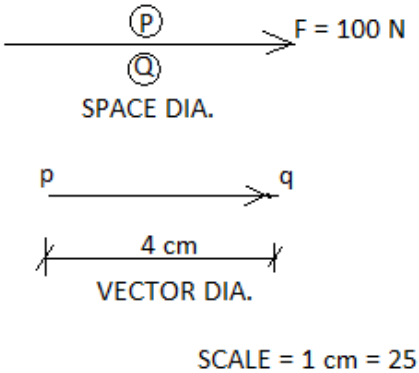
Model Solution : Winter 2016

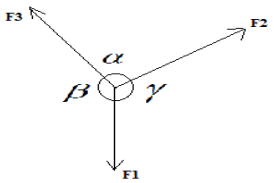
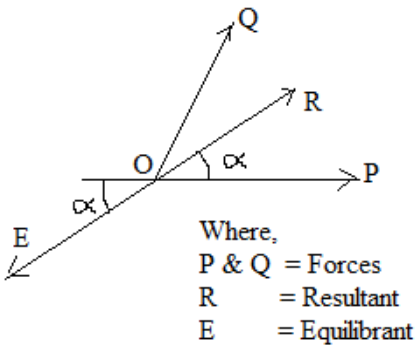
Subject : Engineering Mechanics **Subject Code : 17204**

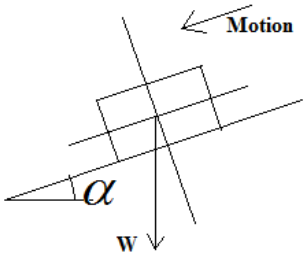
Important Instructions to examiners:

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
1		**Attempt any TEN of the following :**		**20 M**
	a)	**Define velocity ratio & mechanical advantage in a simple machine.**		
	Ans	Mechanical Advantage 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 M**	
		Velocity Ratio is the ratio of distance travelled by effort (y) to distance travelled by load (x). $V.R. = \frac{y}{x}$	**1 M**	**2 M**
	b)	**Define ideal machine & ideal effort.**		
	Ans	Ideal Machine is the machine whose efficiency is 100 % & in which friction is zero.	**1 M**	
		Ideal Effort is the ratio of actual load & VR of machine. It is denoted by (Pi). $Pi = \frac{W}{VR}$	**1 M**	**2 M**
	c)	**Define effort lost in friction with formula.**		
	Ans	Effort lost in friction (P_f): It is the effort by considering the wear and tear effect while use of machine. OR It is the effort obtained by subtracting ideal effort from an effort.	**1 M**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1		$Pf = P - Pi$ *OR* $Pf = P - \left(\frac{W}{VR}\right)$ Where, P = Actual effort & Pi = Ideal Effort	**1 M**	**2 M**
	d) Ans	**State principle of transmissibility of force.** Principle of transmissibility of force states that, "if a force acts at a point on a rigid body, it is assumed to act at any other point on the line of action of force within the same body". As per this principle force of push nature can be made pull by extending the line of a force in opposite quadrant.  	**1 M** **1 M**	**2 M**
	e) Ans	**What is Bow's notation? Explain with a sketch.** Consider a force of 100 N is acting on a body. In this method, capital letters P & Q are marked on both side of line of action of force. A force of 100 N is now read as PQ as shown below in space diagram. To represent a force of 100 N graphically, pq is drawn parallel to PQ as shown in vector diagram.  SCALE = 1 cm = 25 N	**1 M** **1 M**	**2 M**
	f) Ans	**Define 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 M** **1 M**	**2 M**

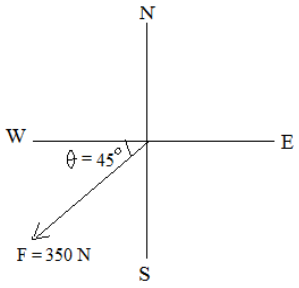
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1	g) Ans	**What is space diagram & vector diagram?** Space diagram is the diagram in which number of forces acting on body is drawn in space to a suitable scale & naming the spaces in order by Bow's notation. Vector diagram is the diagram in which the 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 M 1 M	2 M
	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 sine 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 M 1 M	2 M
	i) Ans	**What is relation between resultant & equilibrant?** Equilibrant is always equal in magnitude, opposite in direction & collinear to the resultant.  	1 M 1 M	2 M
	j) Ans	**Define coefficient of friction & angle of repose.** Coefficient of friction is the ratio of limiting friction (F) to the normal reaction (R) at the surface of contact. $F \alpha R$ $F = \mu R$ $\mu = \frac{F}{R}$ 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.	1 M 1 M	2 M

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1				
	k) Ans	**List any four laws of friction.** (1) Frictional force always acts opposite to the direction of motion & tangential to plane of contact. (2) In limiting equilibrium, liming friction (F) bears a constant ratio to normal reaction (R). (3) Coefficient of friction depends only upon nature of surface in contact & it is independent of surface area in contact. (4) Static friction is more than dynamic friction. (5) Friction is self-adjusting force & increases with increase in applied force up to limiting friction.	**1/2 M Each (any four)**	**2 M**
	l) Ans	**State the formula of velocity ratio of differential axle & wheel with their meaning.** Velocity Ratio of Differential axle & wheel is given by - $VR = \frac{2D}{d_1 - d_2}$ Where, D = Diameter of effort wheel d_1 = Diameter of bigger axle d_2 = Diameter of smaller axle	**1 M** **1 M**	**2 M**
2		**Attempt any <u>FOUR</u> of the following :**		**16 M**
	a)	**In a machine, an effort of 2 N lifted a load of 30 N. If the effort lost due to friction at this load is 0.5 N, find the VR & efficiency of the machine.**		
	Ans.	1) Effort lost in friction is given by – $P_f = P - P_i$ $0.5 = 2 - P_i$ $P_i = 1.5$ N 2) Ideal Effort $P_i = W / VR$ $1.5 = 30 / VR$	**1 M**	

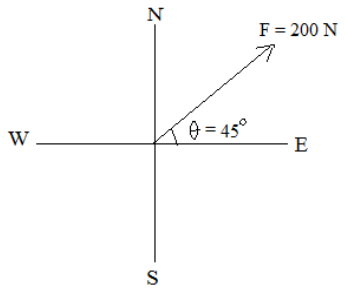
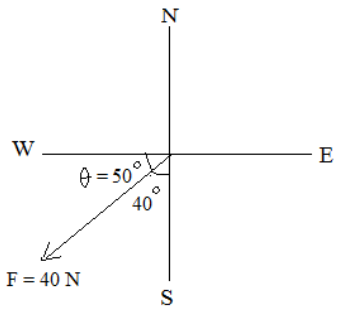
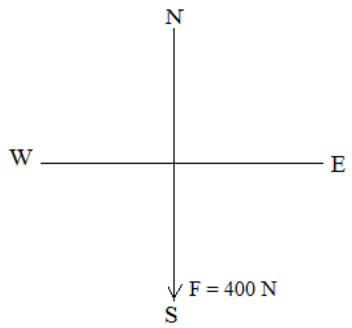
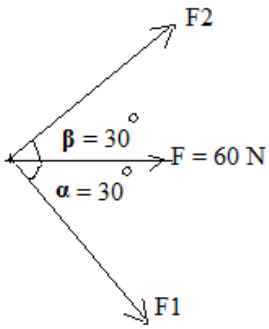
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2		VR = 30 / 1.5 = 20	**1 M**	
		3) Mechanical Advantage MA = W / P = 30 / 2 = 15 $\%\eta = \frac{MA}{VR} X100 = \frac{15}{20} X100$	**2 M**	**4 M**
		= 75 %		
	b)	**A Weston's differential pulley block has 16 & 15 cogs. An effort of 600 N lifts a load of 15 KN. Find VR, MA & efficiency.**		
	Ans.	VR of Weston's differential pulley block is given by - $VR = \frac{2T_1}{T_1 - T_2} = \frac{2X16}{16-15}$	**2 M**	
		VR = 32		
		$M.A. = \frac{W}{P} = \frac{15000}{600}$ $M.A. = 25$	**1 M**	
		$\%\eta = \frac{MA}{VR} X100 = \frac{25}{32} X100$ $\%\eta = 78.125\%$	**1 M**	**4 M**
	c)	**A screw jack has an effort wheel diameter of 300 mm & pitch is 6 mm. If a load of 1200 N is lifted by an effort of 200 N, find VR, MA & efficiency.**		
	Ans.	VR of simple screw jack is given by –		
		$VR = \frac{\pi D}{p} = \frac{\pi X 300}{6}$ $VR = 157.079$	**2 M**	
		$MA = \frac{W}{P} = \frac{1200}{200}$ $MA = 6$	**1 M**	
		$\%\eta = \frac{MA}{VR} X100 = \frac{6}{157.079} X100$ $\%\eta = 3.82\%$	**1 M**	**4 M**

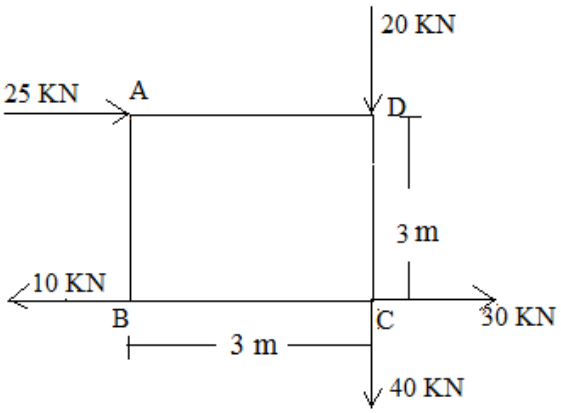
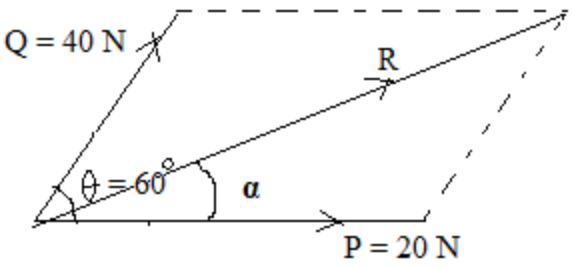
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2	d)	**A machine has VR = 25 & law of machine is P = (0.01 W + 5) N. Find MA, efficiency & effort lost in friction when load is 1000 N. Also state whether the machine is reversible or not.**		
	Ans.	$P = (0.01W + 5)N = ((0.01X1000) + 5)$ $P = 15N$ $MA = \frac{W}{P} = \frac{1000}{15} = 66.667$ $\%\eta = \frac{MA}{VR} X100 = \frac{66.667}{25} X100$ $\%\eta = 266.667\%$ $P_i = \frac{W}{VR} = \frac{1000}{25} = 40$ $P_f = P - P_i = 15 - 40 = -25N$ Since, %η = 266.67 % > 50 %, machine is reversible.	**1 M** **1 M** **1 M** **1 M**	**4 M**
	e)	**In a differential axle & wheel, the diameter of wheel is 36 cm & that of axles are 9 cm & 6 cm. If the efficiency of machine is 80%, determine the load lifted by an effort of 100 N.**		
	Ans.	(1) VR of differential axle & wheel is given by - $VR = \frac{2D}{d_1 - d_2} = \frac{2X36}{9-6}$ $VR = 24$ $\%\eta = \frac{M.A.}{V.R.} X100$ $80 = \frac{MA}{24} X100$ $MA = \frac{80X24}{100} = 19.2$ $MA = \frac{W}{P}$ $19.2 = \frac{W}{100}$ $W = 19.2X100$ $W = 1920N$	**2 M** **2 M**	**4 M**
	f)	**A load of 1 KN is lifted by an effort of 56 N & 2 KN is lifted by an effort of 96 N. Find effort required to lift a load of 3 KN.**		

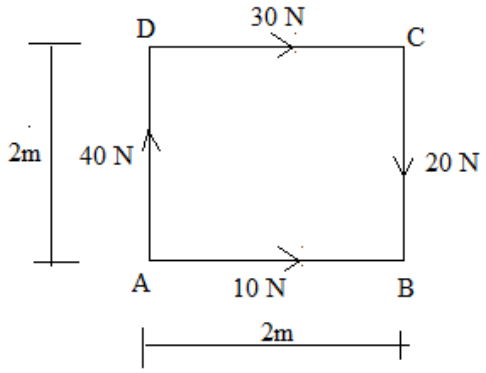
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2	**Ans.**	Using Law of machine –		
		$P = (mW + c)N$		
		Putting values of W & P		
		$56 = m(1000) + c$ – – – – – (1)	**1 M**	
		$96 = m(2000) + c$ – – – – – (2)		
		Subtracting eqn (2) from eqn (1)		
		$-40 = -m(1000)$		
		$m = \frac{40}{1000} = 0.04$		
		Putting value of m in eqn (1)		
		$56 = (0.04)1000 + c$		
		$c = 16N$	**1 M**	
		Hence, Law of machine is –		
		$P = (0.04W + 16)N$ – – – – – (3)	**1 M**	
		Putting W= 3000 N in eqn (3)		
		$P = ((0.04X3000) + 16))$	**1 M**	
		$P = 136N$		**4 M**
3		**Attempt any <u>FOUR</u> of the following :**		**16 M**
	a)	**Resolve each of the following forces into orthogonal components -** **i) 350 N acting South-West away.** **ii) 200 N acting North-East away.** **iii) 40 N acting 40° West of South away.** **iv) 400 N acting due south away.**		
	Ans.	**i) 350 N acting South-West away.**		

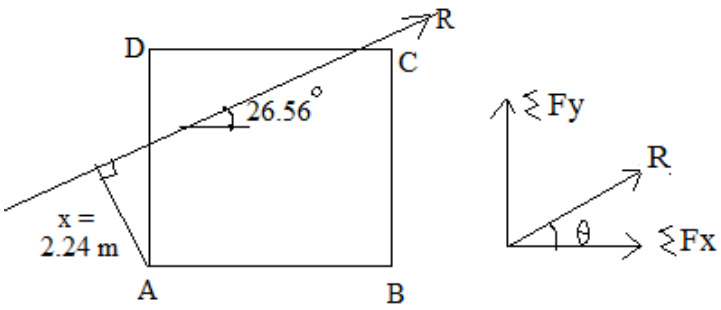
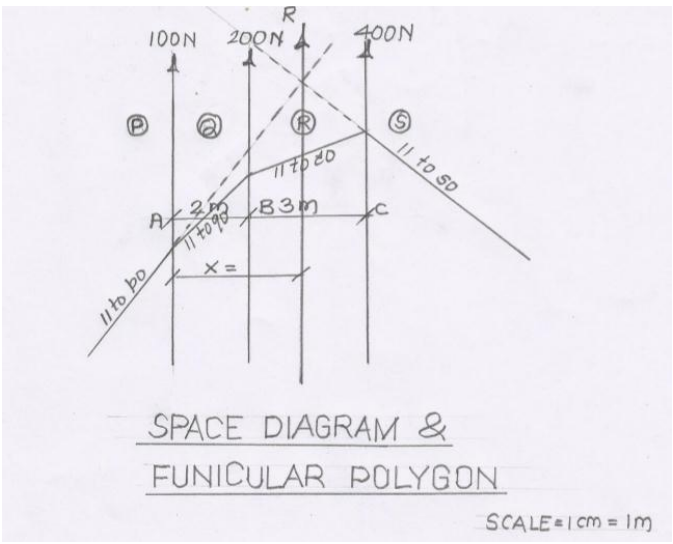
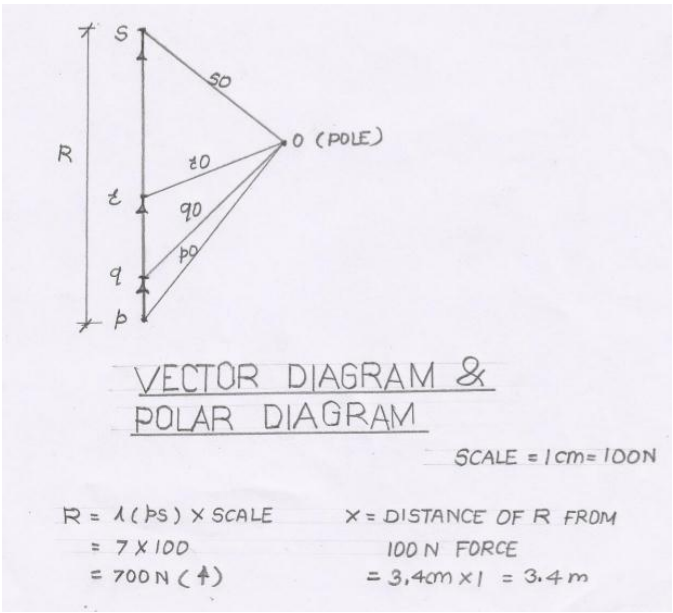


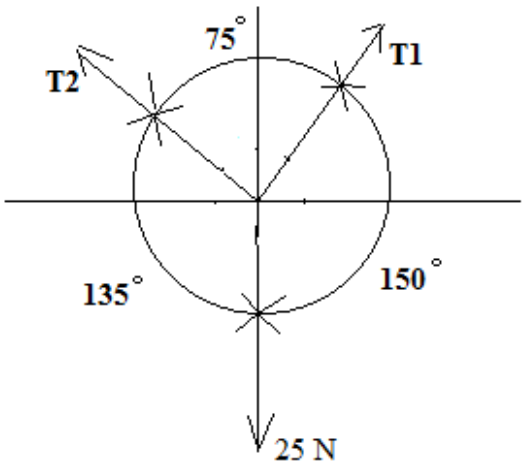
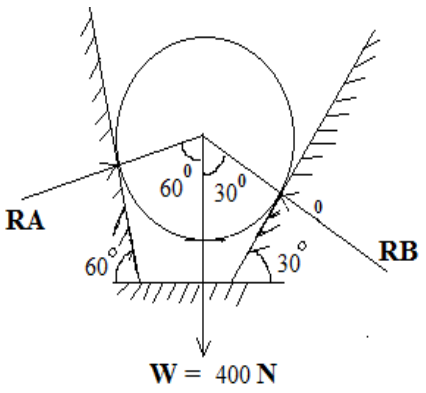
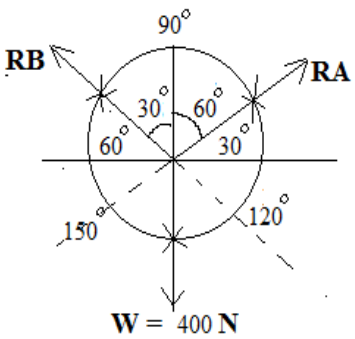
Fx	Fy
= - F cos θ	= - F sin θ
= -350 X cos 45	= -350 X sin 45
= - 247.487 N	= - 247.487 N

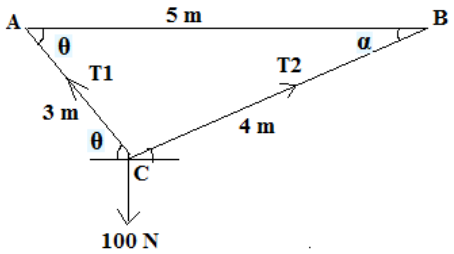
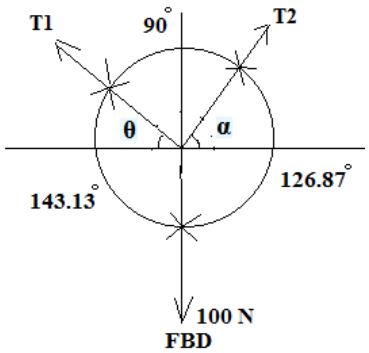
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		**ii) 200 N acting North-East away.**  Fx = F cos θ = 200 X cos 45 = 141.421 N Fy = F sin θ = 200 X sin 45 = 141.421 N **iii) 40 N acting 40° West of South away.**  Fx = -F cos θ = - 40 X cos 50 = - 25.711 N Fy = - F sin θ = - 40 X sin 50 = - 30.642 N **iv) 400 N acting due south away.**  Fx = F cos θ = 400 X cos 270 = 0 N Fy = F sin θ = 400 X sin 270 = - 400 N	**1/2 M Each Fx & Fy**	**4 M**
	b)	**What are the components of 60 N force acting horizontal, in two directions on either side at an angle of 30° each?**		
	Ans.	 		

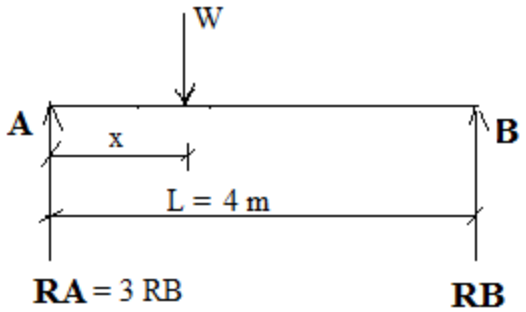
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		$F_1 = \frac{F \sin\alpha}{\sin(\alpha+\beta)} = \frac{60 \sin 30}{\sin(30+30)} = 34.64N$	**2 M**	**4 M**
		$F_2 = \frac{F \sin\beta}{\sin(\alpha+\beta)} = \frac{60 \sin 30}{\sin(30+30)} = 34.64N$	**2 M**	
	c)	**Find the moment about point B as shown in Figure No. 1**		
	Ans.			
		Taking moment @ point B – M_B = (25 X 3) + (20 X 3) + (40 X 3) + (10 X 0) - (30 X 0) = + 255 KN-m (↻) = 255 KN-m (Clockwise moment)	**2 M** **2 M**	**4 M**
	d)	**Find the resultant force & it's direction if two forces 20 N & 40 N is acting along the adjacent sides of a parallelogram making an angle of 60°.**		
	Ans.			
		Using Law of parallelogram of forces $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$ $R = \sqrt{(20)^2 + (40)^2 + 2X\,20X\,40\cos 60}$ $R = 52.915N$	**2 M**	

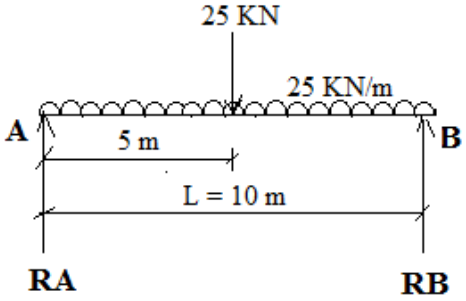
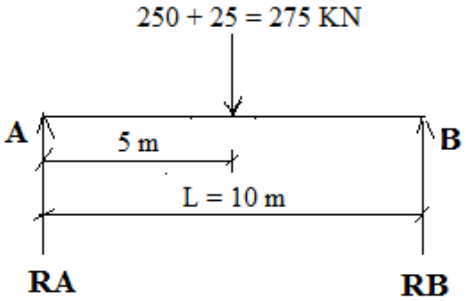
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		Let, α be th inclination of R with P $\alpha = \tan^{-1}\left[\frac{Q\sin\theta}{P+Q\cos\theta}\right] = \tan^{-1}\left[\frac{40\sin 60}{20+40\cos 60}\right]$ $\alpha = 40.893°$	**2 M**	**4 M**
	e)	**ABCD is a square of 2 m side. Along sides AB, CB, DC & AD the forces of 10, 20, 30 & 40 N are acting respectively. Find resultant of forces from A.**		
	Ans.	**NOTE: According to position of ABCD, answer may vary.**  	**1 M**	
		1) Resolving all forces – Σ Fx = + 10 + 30 = + 40 N Σ Fy = + 40 – 20 = + 20 N 2) Magnitude of Resultant $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \sqrt{(40^2) + (20^2)}$ $R = 44.721N$	**1 M**	
		3) Direction and position of resultant As Σ Fx is +ve and Σ Fy is +ve , Resultant lies in 1rd quadrant. $\theta = \tan^{-1}\left\lvert\frac{\Sigma F_y}{\Sigma F_x}\right\rvert = \tan^{-1}\left\lvert\frac{20}{40}\right\rvert = 26.565°$	**1 M**	
		4) Position of Resultant w.r.to point A Let x be the perpendicular distance of R from point A. ΣMF_A = (20 X 2) + (30 X 2) = + 100 Nm MR_A = + R. x = + 44.721 x Using Varignon's theorem of moment $\Sigma MF_A = MR_A$ + 100 = + 44.721 x = 2.24	**1 M**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3		Hence, perpendicular distance of R from point A = 2.24 m so as to produce clockwise moment about point A. 		**4 M**
	f)	**Three parallel forces of magnitude 100 N, 200 N & 400 N are acting vertically upward at A, B & C such that AB = 2m & BC = 3m. Find the resultant force graphically.**		
	Ans.		**2 M**	
			**2 M**	**4 M**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		**Attempt any FOUR of the following :**		**16 M**
	a)	**Find the tensions in the string as shown in Figure No. 2**		
				
	Ans.	Using Lami's theorem, $\frac{25}{\sin 75} = \frac{T_1}{\sin 135} = \frac{T_2}{\sin 150}$ (1) (2) (3)		
		Using term (1) and (2) $\frac{25}{\sin 75} = \frac{T_1}{\sin 135}$ $T_1 = \frac{\sin 135}{\sin 75} X\, 25$ $T_1 = 18.301N$	**2 M each T_1 & T_2**	**4 M**
		Using term (1) and (3) $\frac{25}{\sin 75} = \frac{T_2}{\sin 150}$ $T_2 = \frac{\sin 150}{\sin 75} X\, 25$ $T_2 = 12.940N$		
	b)	**A sphere of weight 400 N rests in a groove of smooth inclined surfaces which are making 60° & 30° inclination with horizontal. Find the reactions at the contact surfaces.**		
	Ans.			
				
		FBD		

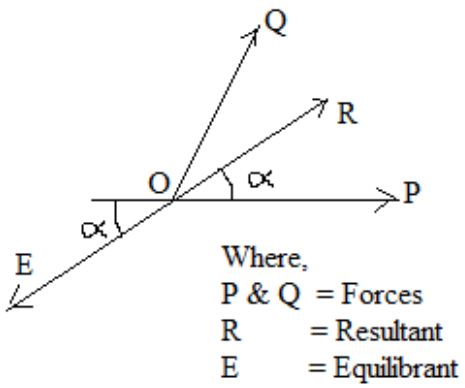
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		Using Lami's theorem, $\frac{400}{\sin 90} = \frac{R_A}{\sin 150} = \frac{R_B}{\sin 120}$ (1) (2) (3)		
		Using term (1) and (2) $\frac{400}{\sin 90} = \frac{R_A}{\sin 150}$ $R_A = \frac{\sin 150}{\sin 90} X 400$ $R_A = 200N$	**2 M each R_A & R_B**	**4 M**
		Using term (1) and (3) $\frac{400}{\sin 90} = \frac{R_B}{\sin 120}$ $R_B = \frac{\sin 120}{\sin 90} X 400$ $R_B = 346.40N$		
	c)	**A body of weight 100 N is suspended by two strings of 4 m & 3 m lengths attached at the same horizontal level 5 m apart. Find the tensions in the strings.**		
	Ans.	 		
		In Δ ACB, $AC^2 + BC^2 = AB^2$ $(3)^2 + (4)^2 = (5)^2$ $\angle ACB = 90^\circ$		
		In right angle Δ ACB, $\sin\theta = \frac{BC}{AB} = \frac{4}{5}$ $\theta = \sin^{-1}\left(\frac{4}{5}\right) = 53.13°$ $\theta + \alpha + 90^\circ = 180^\circ$ $53.13^\circ + \alpha + 90^\circ = 180^\circ$ $\alpha = 36.87^\circ$		
		Using Lami's theorem, $\frac{100}{\sin 90} = \frac{T_1}{\sin 126.87} = \frac{T_2}{\sin 143.13}$ (1) (2) (3)		

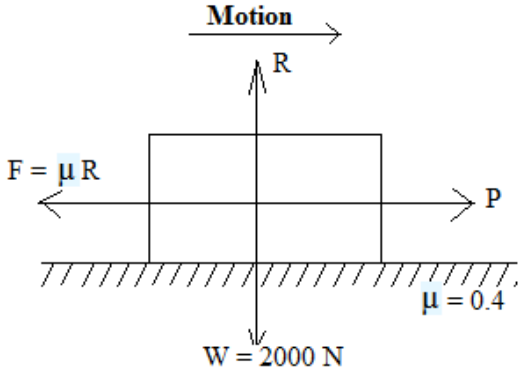
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4		Using term (1) and (2) $\frac{100}{\sin 90} = \frac{T_1}{\sin 126.87}$ $T_1 = \frac{\sin 126.87}{\sin 90} X 100$ $T_1 = 80N$ Using term (1) and (3) $\frac{100}{\sin 90} = \frac{T_2}{\sin 143.13}$ $T_2 = \frac{\sin 143.13}{\sin 90} X 100$ $T_2 = 60N$	**2 M each T_1 & T_2**	**4 M**
	d) **Ans.**	**A simply supported beam has a span of 4 m. Find the position of a concentrated load on it such that the left hand reaction is three times the right hand reaction.**  Let, RA = Left hand reaction RB = Right hand reaction x = Position of W from RA	**1 M**	
		Applying equilibrium conditions $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ and $\Sigma M = 0$ $(\circlearrowleft +ve, \circlearrowright -ve)$ $\Sigma Fy = 0$ RA – W + RB = 0 3 RB – W + RB = 0 4 RB = W	**1 M**	
		$\Sigma MA = 0$ (RA X 0) + (W X x) – (RB X L) = 0 (4 RB X x) = RB X 4 x = 1 m	**2 M**	**4 M**

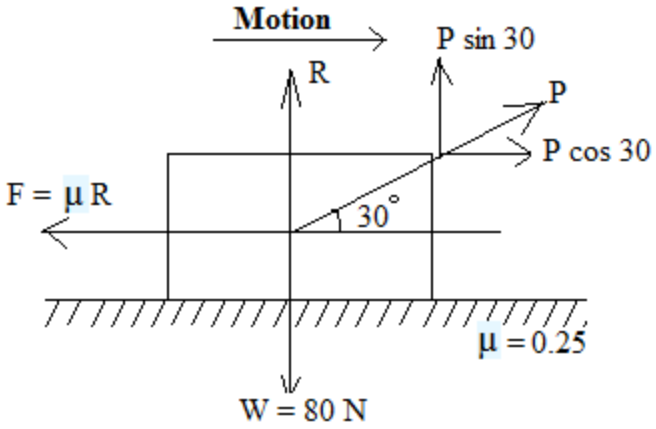
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4	**e)**	**A simply supported beam of span 10 m carries a centre load of 25 KN & a udl of 25 KN/m throughout. Find support reaction.**		
	Ans.		**1 M**	
				
		1) Equivalent point load and it's position Equivalent point load = Intensity of udl X span of udl = 25 X 10 = 250 KN Position from RA = Span of udl / 2 = 10 / 2 = 5 m 2) Applying equilibrium conditions $\Sigma Fy = 0$ ($\uparrow$ +ve, $\downarrow$ −ve) and $\Sigma M = 0$ ($\circlearrowleft$ +ve, $\circlearrowright$ −ve)		
		$\Sigma Fy = 0$ RA – 275 + RB = 0 RA + RB = 275 KN -------(1)	**1 M**	
		$\Sigma M_A = 0$ Taking moment of all forces @ point A (RA x 0) + (275 X 5) – (RB X 10) = 0 1375 = 10 RB RB = 137.5 KN	**1 M**	
		Putting value of RB in eqn. 1 RA + 137.5 = 275 RA = 137.5 KN	**1 M**	**4 M**

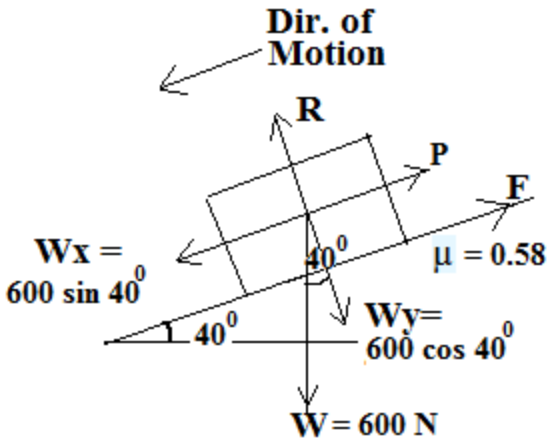
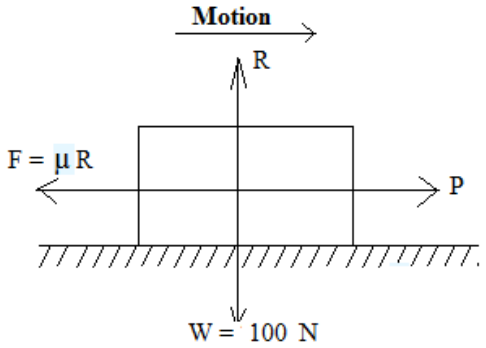
<table>
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answers</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>4</td><td>f)

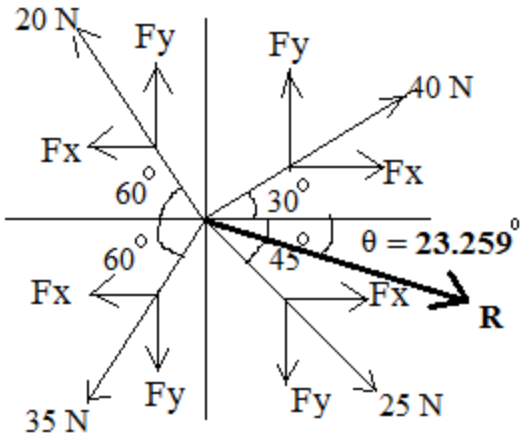
Ans.</td><td>Distinguish between resultant & equilibrant.

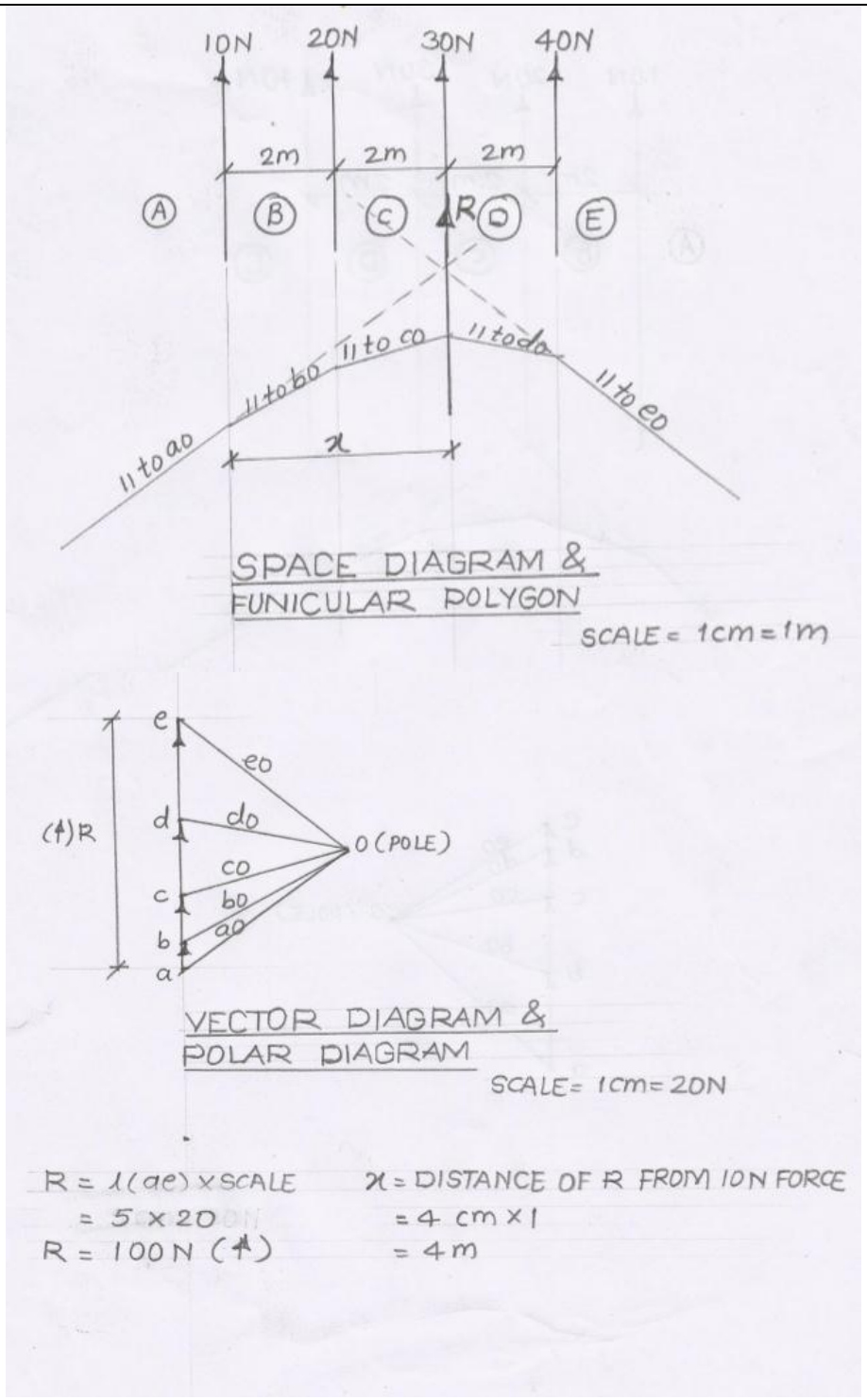
<table>
<tr><th>Resultant</th><th>Equilibrant</th></tr>
<tr><td>1) Resultant is a single force which can produce the same effect on the body as it is produced by all forces acting together.</td><td>1) Equilibrant is a single force which when acts with other forces brings the set of forces & body in equilibrium.</td></tr>
<tr><td>2) It is donated by R.</td><td>2) It is denoted by E.</td></tr>
<tr><td>3) It causes displacement of body.</td><td>3) It keeps the body at rest.</td></tr>
<tr><td>4) The set of forces which causes the displacement of a body are called as components of a resultant or component forces.</td><td>4) The set of forces which keeps the body at rest are called as components of a equilibrant or equilibrant forces.</td></tr>
<tr><td colspan="2">5)
 
</td></tr>
</table>
</td><td>1 M each (any four)</td><td>4 M</td></tr>
<tr><td>5</td><td></td><td>Attempt any <u>FOUR</u> of the following :</td><td></td><td>16</td></tr>
<tr><td></td><td>a)

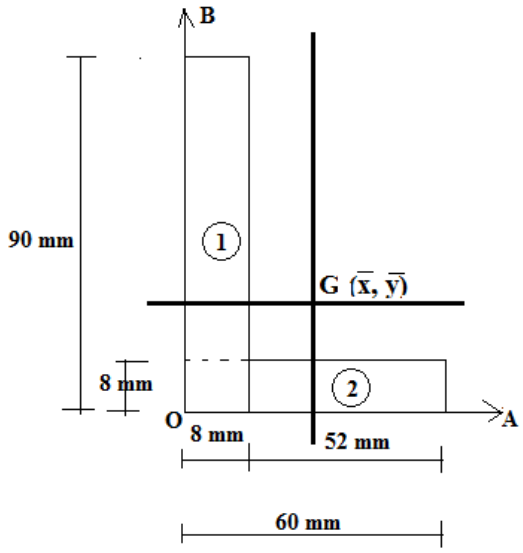
Ans.</td><td>A body of weight 2000 N rests on a horizontal plane. If the coefficient of friction is 0.4. Find the horizontal force required to move the body.
 
</td><td>1 M</td><td></td></tr>
</table>

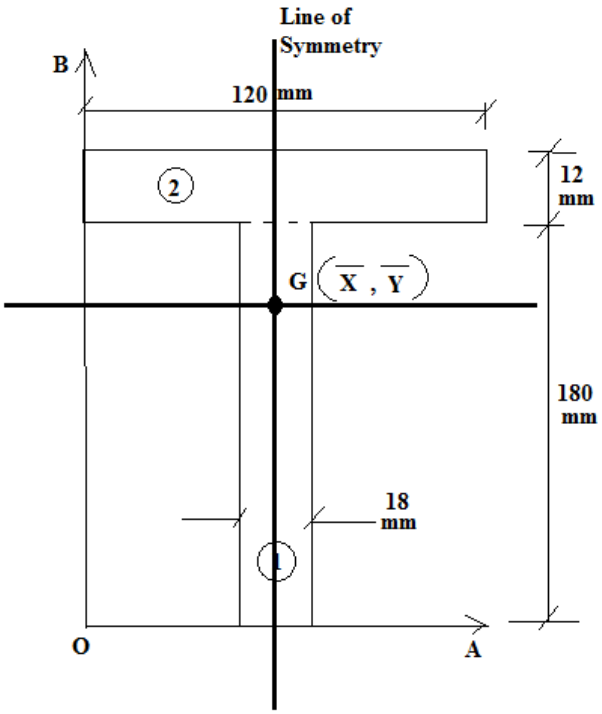
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5		For limiting equilibrium $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ $+ R - W = 0$ $R = W = 2000$ N $R = 2000$ N $\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$ $+ P - F = 0$ $+ P = F$ $P = \mu R$ ------ Since $F = \mu R$ $P = 0.4 \times 2000$ $P = 800$ N	**1 ½ M each for R & P**	**4 M**
	b)	**A block of 80 N is placed on a horizontal plane where the coefficient of friction is 0.25. Find the force at 30° up the horizontal to just move the block.**		
	Ans.		**1 M**	
		For limiting equilibrium $\Sigma Fx = 0$ $(\rightarrow +ve, \leftarrow -ve)$ $+ P \cos 30 - F = 0$ $+ P \cos 30 - \mu R = 0$ $(0.866) P - (0.25) R = 0$ $(0.866) P = (0.25) R$ $R = (0.866 / 0.25) P$ $R = (3.464) P$ $\Sigma Fy = 0$ $(\uparrow +ve, \downarrow -ve)$ $+ R + P \sin 30 - W = 0$ $(3.464) P + (0.5) P - 80 = 0$ $(3.464 + 0.5) P = 80$ $(3.964) P = 80$ $P = 20.18$ N	**1 ½ M each for R & P**	**4 M**
	c)	**A body of weight 600 N is resting on a rough inclined plane of 40°. If the μ = 0.58, what force is required to prevent the body from falling down the plane.**		

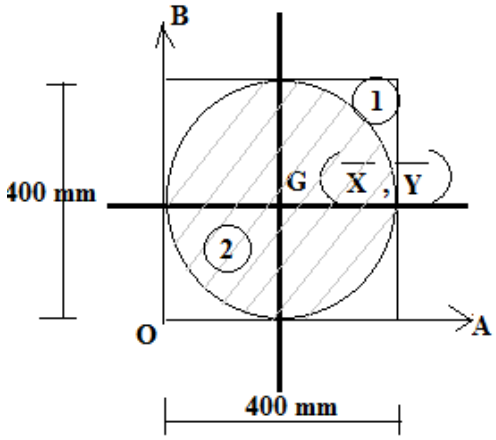
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5			**1 M**	
		Consider inclined plane as x-x axis and perpendicular to it as y-y axis.		
		For limiting equilibrium Σ Fy = 0 + R – Wy = 0 R = Wy = 600 cos 40 R = 459.62 N F = μR = 0.58 X 459.62 = 266.57 N Σ Fx = 0 + P + F – Wx = 0 + P + 266.57 – 600 sin 40 = 0 P = 119.1 N	**1 ½ M each for R & P**	**4 M**
	d)	**Find the horizontal force required to drag a body of weight 100 N along a horizontal plane. If the plane is raised gradually upto 15°, the body will begin to slide.**		
	Ans.		**1 M**	
		We know, μ = tan α = tan 15° = 0.27	**1 M**	
		For limiting equilibrium Σ Fy = 0 (↑ +ve , ↓ −ve) + R – W = 0 R = W = 100 N R = 100 N Σ Fx = 0 (→ +ve , ← −ve) + P – F = 0 + P = F P = μR ------ Since F = μR P = 0.27 X 100 P = 27 N	**1 M each for R & P**	**4 M**

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5	e)	**Calculate the magnitude & direction of resultant force of the force system as shown in Figure No. 3. Use analytical method.**		
				
	Ans.	Resolving all forces horizontally $(\rightarrow +\text{ve}, \leftarrow -\text{ve})$ & vertically $(\uparrow +\text{ve}, \downarrow -\text{ve})$,		
		$\Sigma Fx = +(40\cos 30) - (20\cos 60) - (35\cos 60) + (25\cos 45)$ $= +24.819$ N	**1 M**	
		$\Sigma Fy = +(40\sin 30) + (20\sin 60) - (35\sin 60) - (25\sin 45)$ $= -10.668$ N		
		Magnitude of resultant $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \sqrt{(24.819^2) + (-10.668^2)}$	**1 M**	
		$R = 27.015N$		
		3) Direction and position of resultant As ΣFx is +ve and ΣFy is -ve , Resultant lies in 4th quadrant. $\theta = \tan^{-1}\left\lvert\frac{\Sigma F_y}{\Sigma F_x}\right\rvert = \tan^{-1}\left\lvert\frac{10.668}{24.819}\right\rvert = 23.259°$	**2 M**	**4 M**
	f)	**Find the magnitude, direction & position of resultant force of four parallel like forces as shown in Figure No. 4. Use graphical method.**		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5	**Ans.**		**2 M** **2 M**	**4 M**

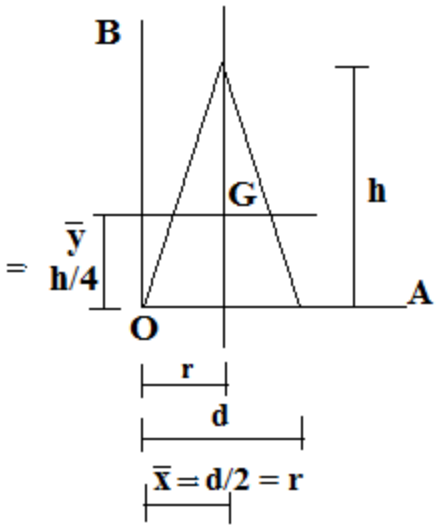
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		**Attempt any <u>FOUR</u> of the following :**		**16 M**
	a) Ans,	**Find the centroid of L section 90 X 60 X 8 mm.**		
			**1 M**	
		1) Area calculation $A_1 = 90 \text{ X } 8 = 720 \text{ mm}^2$ $A_2 = 52 \text{ X } 8 = 416 \text{ mm}^2$ $A = A_1 + A_2 = 1136 \text{ mm}^2$	**1 M**	
		2) Location of $\bar{x}$ $x_1 = 8 / 2 = 4$ mm $x_2 = 8 + (52/2) = 34$ mm $\bar{x} = \frac{A_1 x_1 + A_2 x_2}{A}$ $\bar{x} = 14.98 mm$	**1 M**	
		3) Location of $\bar{y}$ $y_1 = 90 / 2 = 45$ mm $y_2 = 8 / 2 = 4$ mm $\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A}$ $\bar{y} = 29.98 mm$	**1 M**	**4 M**
		Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (14.98 mm from OB and 29.98 mm from OA)		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6	b)	**Find centroid of T section with flange 120 X 12 mm & vertical web 180 X 18 mm.**		
	Ans.		**1 M**	
		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 120 / 2 = 60 mm	**1 M**	
		2) Area calculation A_1 = 180 X 18 = 3240 mm^2 A_2 = 120 X 12 = 1440 mm^2 A = A_1 + A_2 = 4680 mm^2	**1 M**	
		3) Location of $\bar{y}$ y_1 = 180 / 2 = 90 mm y_2 = 180 + (12/2) = 186 mm $\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A}$ $\bar{y} = 119.54 mm$	**1 M**	**4 M**
		Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (60 mm from OB and 119.54 mm from OA)		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6	c)	**A square of 400 mm side from which a circle of 400 mm diameter is cutoff from the center. Find centroid of the remaining area.**		
	Ans.		1M	
		1) Area calculation $A_1 = 400 \times 400 = 160000\ mm^2$ $A_2 = (\pi / 4) \times (400)^2 = 125663.706\ mm^2$ $A = A_1 - A_2 = 34336.293\ mm^2$	1 M	
		2) Location of $\bar{x}$ $x_1 = 400 / 2 = 200$ mm $x_2 = 400 / 2 = 200$ mm $\bar{x} = \frac{A_1 x_1 - A_2 x_2}{A}$ $\bar{x} = 200mm$	1 M	
		3) Location of $\bar{y}$ $y_1 = 400 / 2 = 200$ mm $y_2 = 400 / 2 = 200$ mm $\bar{y} = \frac{A_1 y_1 - A_2 y_2}{A}$ $\bar{y} = 200mm$ Hence, centroid (G) for given section lies at G($\bar{x}, \bar{y}$) = (200 mm from OB and 200 mm from OA)	1 M	4 M
	d)	**Locate center of gravity of a right circular cone & sphere. State formula for the volume.**		

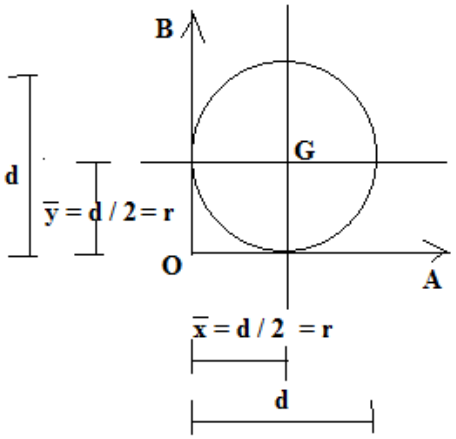
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6	Ans.	**NOTE : 1 Mark for Fig. with position of CG & 1 Mark for Volume**	**2 M each fig.**	**4 M**

(1) Right circular cone



Volume of Right circular cone $= (1/3)\ \pi r^2 h$

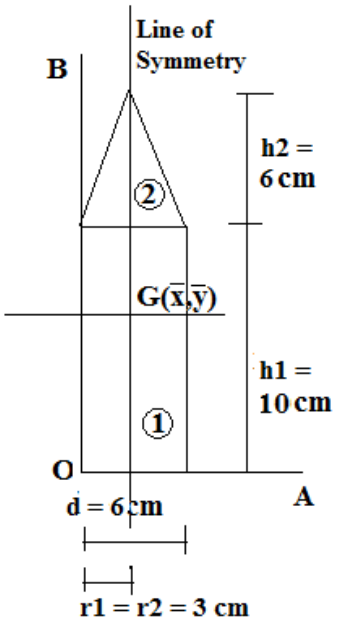
(2) Sphere

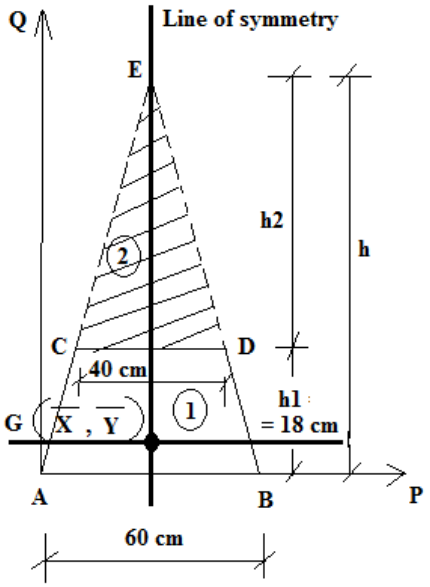


Volume of sphere $= (4/3)\ \pi r^3$

e) A solid cone having base diameter 6 cm & height 6 cm is kept coaxially on a solid cylinder having same diameter & height 10 cm. Find center of gravity of combination.

Ans. **1 M**



Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		1) Figure is symmetric @ y-y axis and hence, $\bar{x}$ = Maximum horizontal dimension /2 = 6 / 2 = 3 cm	**1 M**	**4 M**
		2) Volume Calculation $V_1 = \pi r^2 h = \pi(3)^2 10 = 282.743 cm^3$ $V_2 = (1/3)\pi r^2 h = (1/3)\pi(3)^2 X\, 6 = 56.548 cm^3$ $V = V_1 + V_2 = 339.291 cm^3$	**1 M**	
		3) $\bar{y}$ calculation $y_1 = 10/2 = 5 cm$ $y_2 = 10 + (6/4) = 11.5 cm$ $\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V}$ $\bar{y} = 6.08 cm$	**1 M**	
		Hence, centre of gravity (G) for given composite body lies at G($\bar{x}, \bar{y}$) = (3 cm from OB and 6.08 cm from OA)		
	f) **Ans.**	**A frustum of a cone has top diameter 40 cm & bottom diameter 60 cm with height 18 cm. Find center of gravity.**  	**1 M**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6		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 h_1 = 18 cm, h_2 = Height of cut cone In triangle, ABE & CDE $\frac{h}{60} = \frac{h_2}{40}$ $h = \frac{60}{40} h_2$ $h = 1.5h_2$ $h_1 + h_2 = h$ $h_1 + h_2 = 1.5h_2$ $h_1 = 1.5h_2 - h_2$ $h_1 = 0.5h_2$ $18 = 0.5h_2$ $h_2 = 36cm$ $h = 18 + 36 = 54cm$ 2) Volume Calculation $V_1 = (1/3)\pi r_1^2 h = (1/3)\pi(30)^2 X\,54 = 50.86X10^3 cm^3$ $V_2 = (1/3)\pi r_2^2 h_2 = (1/3)\pi(20)^2 X\,36 = 15.07X10^3 cm^3$ $V = V_1 - V_2 = 35.82X10^3 cm^3$ 3) $\bar{y}$ calculation $y_1 = \frac{h}{4} = \frac{54}{4} = 13.5cm$ $y_2 = h_1 + \frac{h_2}{4} = 18 + \left(\frac{36}{4}\right) = 27cm$ $\bar{y} = \frac{V_1 y_1 - V_2 y_2}{V}$ $\bar{y} = 7.815cm$ Hence, centre of gravity (G) for given frustum of cone lies at G($\bar{x}, \bar{y}$) = (30 cm from AQ and 7.815 cm from AP)	**1 M** **1 M** **1 M**	**4 M**