MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)

SUMMER – 15 EXAMINATIONS

Subject Code: 17204 **Model Answer-Engineering Mechanics**

Important Instruction to Examiners:-

1) The answers should be examined by key words & not as word to word as given in the model answers scheme.

2) The model answers & answers written by the candidate may vary but the examiner may try to access the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more importance.

4) While assessing figures, examiners, may give credit for principle components indicated in the figure.

5) The figures drawn by candidate & model answer may vary. The examiner may give credit for any equivalent figure drawn.

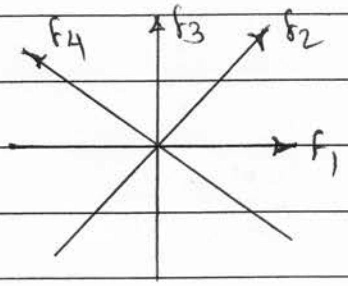
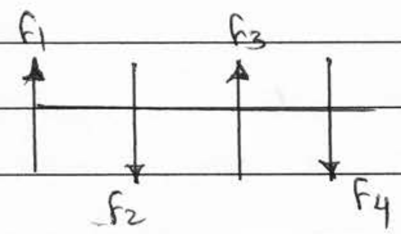
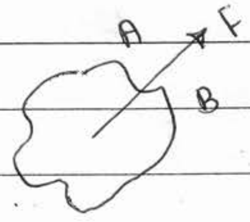
5) Credit may be given step wise for numerical problems. In some cases, the assumed contact values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding.

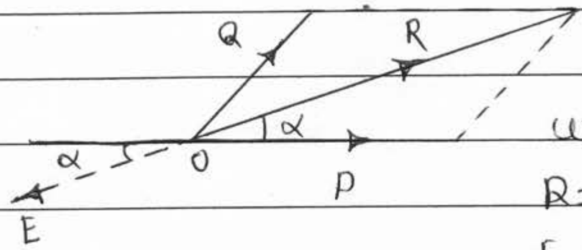
7) For programming language papers, credit may be given to any other programme based on equivalent concept.

Important notes to examiner

Q .NO	SOLUTION	MARKS
Q-1 (a)	i) Mechanical Advantage (M.A)	
	The ratio of load lifted to the corresponding effort applied for a machine called Mechanical advantage.	01 M
	ii) Velocity ratio (V.R)	
	The ratio of distance travelled by effort to corresponding distance travelled by load known as velocity ratio	01 M
b)	characteristics of an ideal machine.	02 M (1 M each write any two)
	i) A machine whose efficiency exactly equal to 100 %.	
	ii) Input should be equal to output	
	iii) velocity ratio should be equal to mechanical advantage	
c)	i) Input –	
	The work done by the effort is known as input to the machine. Since work done by a force is defined as product of force & distance moved in direction of force	01 M
	ii) output – it is defined as useful work got out of machine i.e. work done by load.	01 M

Q .NO	SOLUTION		MARKS
d)	Concurrent force system	Non-concurrent force system	
	i) This system in which all forces act at the same point known as concurrent forces	i) the system in which forces act's at a different point known as non-concurrent forces	01 M
	ii) 	ii) 	01 M (fig)
e)	i) Bow's notation – Bow's notation is used designate a force. As per this notation, each force is designated or named by two spaces one on each side of the line of action of a force. this space are genrally named by capital letters as A, B, C . . . . serially		01 M
	ii) Explaination – A force say 'F' acting onrigid body divided space above or below it into two part's, say 'A' & B hence the force 'F' is named as AB 		01 M

Q .NO	SOLUTION	MARKS
f)	characteristic of a force	
	i) Magnitude – :	02M
	The quantity of force is known as it's magnitude	(1M
	ii) sense or nature – :	for each
	The arrow head marked according to the application of force indicate the sense or nature of force.	write any Two)
	iii) Direction – :	
	The line of action along and towards which the force act's is called as direction of force.	
	iv) point of application – :	
	The point at which the force act's is known as the point of application of the force.	
g)	use of funicular polygon	
	Funicular polygon is necessary to locate position of the resultant of non-concurrent forces.	02 M

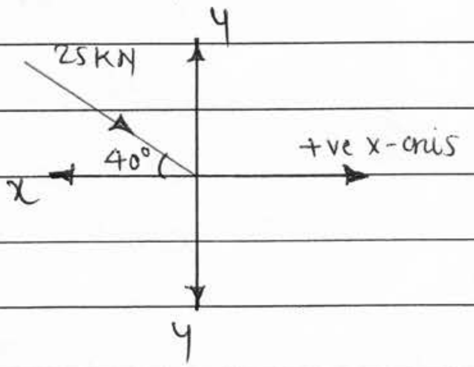
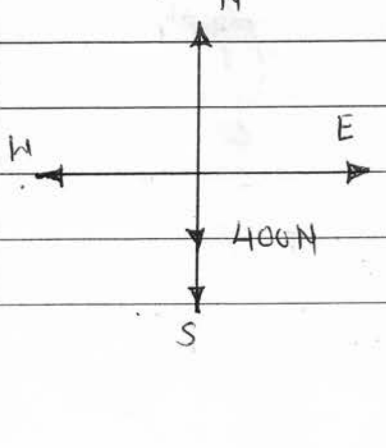
Q .NO	SOLUTION		MARKS
h)	Resultant different from equilibrant		
	 where R= Resultant E - Equillibrant		01M for fig
	Resultant (R)	Equilibrant (E)	
	i) Resultant is defined as a single force which produces the same effect on body that has produced by number of forces acting on it.	i) Equillibrant is defined as a single force which keeps the body in equilibrium when number of forces acting on it.	01M (01M for any ONE point)
	ii) Resultant causes the displacement in body	ii) As Equillibrant keeps the body in equilibrium condition there is no displacement.	
	iii) Resultant has the magnitude and direction	iii) Equillibrant force has the same magnitude as that resultant & opposite direction to that of resultant.	

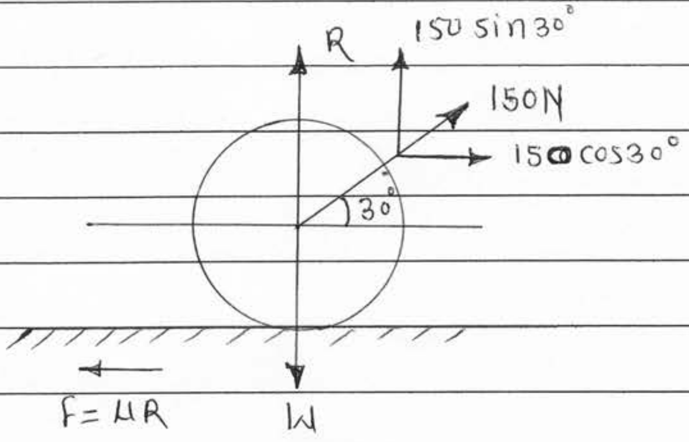
Q .NO	SOLUTION	MARKS
i)	i) Statement of Lami's theorem	
	if three coplanar forces acting on body at a point	
	kept in equilibrium, then each force proportional	
	to sine of angle between the other two forces	01 M
	ii) limitation of lamis theorem	
	- Not applicable for non-concurrent forces	01 M
	- Not applicable for less than three concurrent forces	(01/2 M each
	- Not applicable for more than three concurrent forces	write any TWO)
	- Not applicable for forces if body is not in equilibrium.	
	- the forces must be pull forces.	
J	Laws of friction for static condition	
	i) The direction of frictional force is opposite to that of motion	02 M
	ii) frictional force act's at the common surface of contact	(01 M each
	iii) The limiting value of frictional force is proportional to normal reaction	write any TWO)
	iv) limiting friction is independent of area of contact.	
	v) friction is depend on material and roughness at surface of contact.	
	vi) static friction is always more than dynamic friction	

Q .NO	SOLUTION	MARKS
K)	Define limiting friction	
	it is the maximum value of frictional force. which is held along the surface contact between two bodies when the body is just on point of motion over other known as limitting friction.	02 M
l)	velocity ratio worm and worm wheel	
	i) $VR = \frac{RT}{r}$ where as R = Radius of effort wheel T = number of teeth on warm wheel r = radius of load drum	01 M (for formula) & 1 M meaning of Term's
	or	OR
	ii) if wheel handle is used	
	$V.R = \frac{LT}{r}$ where L = Length of handle T = number of teeth on warm wheel r = radius of load drum	01 M for formula 01 M for meaning of Term's

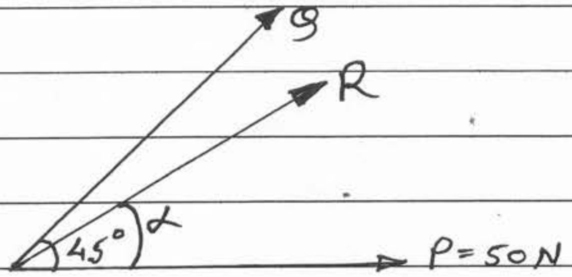
Q .NO	SOLUTION	MARKS
Q-2		
(a)	Data: $P = (0.09W + 6)$ N $W = 6$ KN	
	$V.R = 20$	
	i) effort required to lift 6 KN load	
	$P = (0.09W + 6)$ N --- $W = 6$ KN $= 6000$ N	
	$\therefore P = 0.09 \times 6000 + 6$	
	$P = 546$ N	01M
	ii) Maximum $M.A = \frac{1}{m} = \frac{1}{0.09} = 11.11$	01M
	iii) Type of machine:	
	To know the type of machine, it is necessary to calculate maximum efficiency	
	$\eta_{max} = \frac{1}{m \times V.R} \times 100 = \frac{1}{0.09 \times 20} \times 100 = 55.55\% > 50\%$	01M
	since the maximum efficiency is more than 50% the machine is reversible.	01M

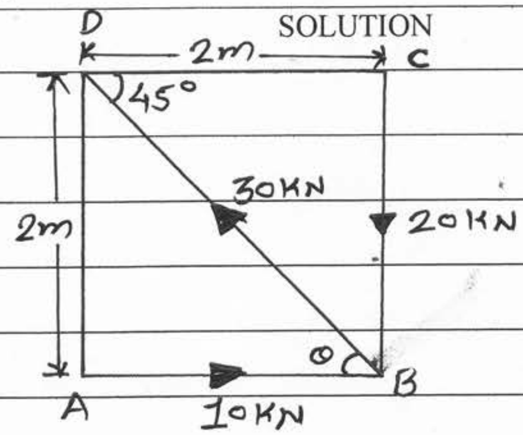
Q .NO	SOLUTION	MARKS
b)	given data:	
	$W = 1400N$ $D = 40cm$	
	$P = 40N$ $d_1 = 10cm$ $d_2 = 8cm$	
	i) $M.A = \frac{W}{P} = \frac{1400}{40} = 35$	01M
	ii) $V.R = \frac{2D}{d_1 - d_2} = \frac{2 \times 40}{10-8} = 40$	01M
	iii) $Efficiency = \frac{MA}{V.R} \times 100$	
	$\eta\% = \frac{35}{40} \times 100 = 87.5\%$	
	$\boxed{\eta\% = 87.5\%}$	01M
	iv) $P_f = P - \frac{W}{V.R}$	
	$P_f = 40 - \frac{1400}{40}$	
	$\boxed{P_f = 5N}$	01M
c)	given data	
	$D = 250mm$ $W = 3KN = 3000N$	
	$d = 100mm$ $\eta\% = 80\%$	
	i) $V.R = \frac{2D}{D-d} = \frac{2 \times 250}{250-100} = 3.33$	01M

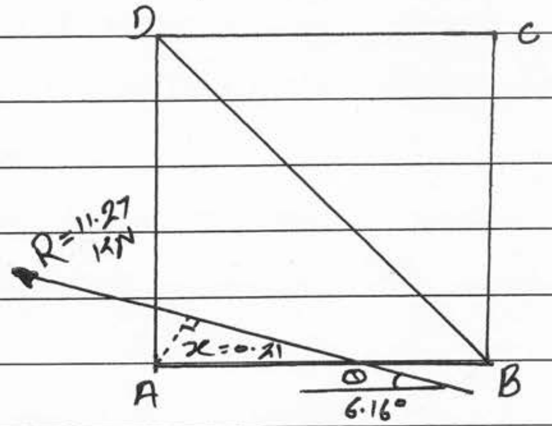
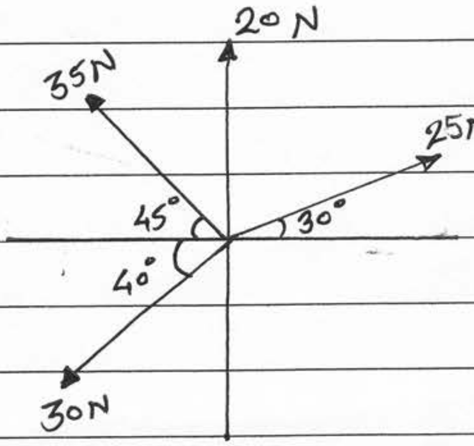
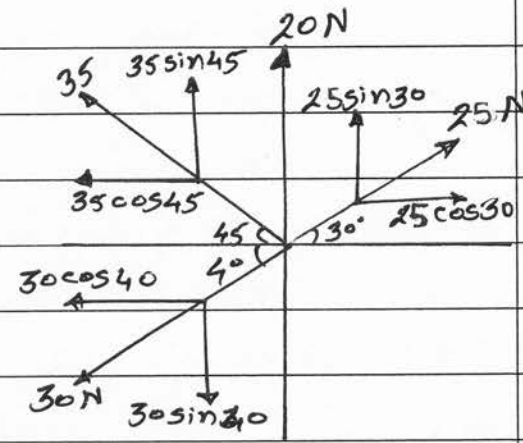
Q .NO	SOLUTION	MARKS
	ii) To find effort 'P'	
	$\eta\% = \frac{M.A}{V.R} \times 100$	01 M
	$\eta\% = \frac{W/P}{V.R} \times 100$	
	$80 = \frac{\frac{3000}{P}}{3.33} \times 100$	
	$80 = \frac{3000}{3.33\ P} \times 100$	
	$P = \frac{3000 \times 100}{3.33 \times 80}$ $\therefore \boxed{P = 1126.12\ N}$	02 M
d)	case-I)	
		
	i) $\Sigma fx = 25 \cos 40 = 19.15\ KN$	01 M
	ii) $\Sigma fy = 25 \sin 40 = -16.06\ KN$	01 M
	Case-II)	
		
	i) $\Sigma fx = 0$	01 M
	ii) $\Sigma fy = -400\ N$	01 M

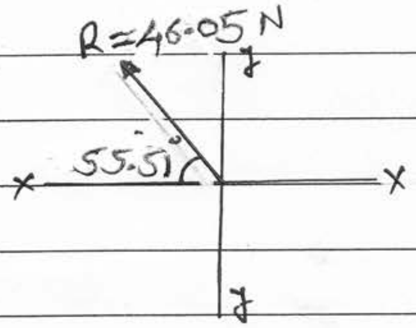
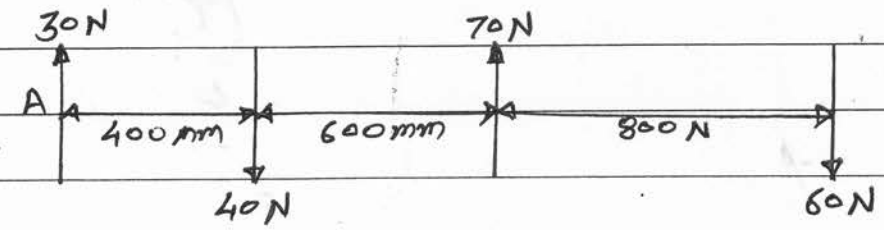
Q .NO	SOLUTION	MARKS
Q-2 (e)		
	i) $\Sigma Fx = 0$	
	$150\cos 30° - F = 0$	01 M
	$150 \cos 30° = F$ but $F = \mu R$	
	$\boxed{129.90 N = F}$ $\therefore R = \frac{F}{\mu} = \frac{129.90}{0.3}$	
	$\Sigma Fy = 0$ $\boxed{R = 433 N}$	01 M
	$R - W + 150\sin 30° = 0$	
	$R + 75 - W = 0$	
	$R + 75 = W$ — (1)	01 M
	put $R = 433$ in eq^n (1)	
	$433 + 75 = W$	
	$\boxed{W = 508 N}$	01 M

Q .NO	SOLUTION	MARKS
Q-2		
f)	properties of couple with examples	
	a)	
	i) The resultant of the forces of a couple is zero.	($\frac{1}{2}$M for each point write any Four)
	ii) The moment of a couple is equal to the product of one of the forces and arm of a couple i.e. $M = P \times a$	
	iii) Moment of a couple about any point is constant	
	iv) A couple can be balanced only by another couple of equal and apposite moment	
	v) Two or more couples are said to be equal when they have same sense and moment.	
	vi) Any number of coplanar couples can be represented by a single couple, the moment of which is equal to the algebric sum of the moments of all the couples.	
	b) examples of couple	($\frac{1}{2}$M for each example write any Four)
	i) Tap handle being rotated by a person.	
	ii) Key of a lock	
	iii) opening or closing the cap of a pen	
	iv) Moving the stearing of a car etc.	
	v) Rotation of screw cap	
	vi) winding of a watch.	
	vii) capstan being rotated by two men.	

Q .NO	SOLUTION	MARKS
Q 3 a)		
	Let, $P = 50\,N$, $Q = ?$, $\theta = 45°$, $R = 200\,N$	
	$\therefore R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$	1
	$200 = \sqrt{50^2 + Q^2 + 2 \times 50 \times Q \cos 45}$	
	$40000 = 2500 + Q^2 + 70.71\,Q$	
	$\therefore Q^2 + 70.71\,Q - 37500 = 0$	1
	solve for Q	
	$\therefore Q = 161.495\,N$	
	Magnitude of force $Q = 161.495\,N$	1
	Let α be the direction of Resultant R with force $P = 50\,N$	
	$\alpha = \tan^{-1}\left(\dfrac{Q\sin\theta}{P + Q\cos\theta}\right) =$	
	$= \tan^{-1}\left(\dfrac{161.495\cdot(\sin 45)}{50 + 161.495\cos 45}\right)$	
	$\alpha = 34.81°$ w.r.to 50 N force	1
	Resultant makes an angle of 34.81° with 50 N force.	

Q .NO	SOLUTION	MARKS
Q3 b)		
	$\theta = \tan^{-1}\left(\frac{AD}{AB}\right)$	
	$\theta = \tan^{-1}\left(\frac{2}{2}\right)$	
	$\theta = 45°$	
	1) Resolving forces horizontally	
	$\Sigma F_x = 10 - 30\cos 45 = -11.21$ KN	1/2
	2) Resolving forces vertically.	
	$\Sigma F_y = -20 + 30\sin 45 = 1.21$ KN	1/2
	3) Magnitude of Resultant	
	$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$	
	$= \sqrt{(-11.21)^2 + (1.21)^2}$	
	$R = 11.27$ KN ... since ΣF_x is $-ve$, ΣF_y is $+ve$	1
	R lies in second quadrant	
	4) Direction of Resultant	
	$\tan\theta = \frac{\Sigma F_y}{\Sigma F_x} = \left(\frac{1.21}{11.21}\right) = 0.1079$	
	$\therefore \theta = \tan^{-1}(0.1079) = 6.16°$ with horizontal	1
	5) Position of Resultant w.r. to. A	
	Taking moment about point A.	
	$\Sigma M_A = (10\times 0) + (20\times 2) - (30\sin 45\times 2)$	
	$\Sigma M_A = -2.426$ KN·m ...(Anticlockwise)	

Q .NO	SOLUTION	MARKS
Q3 b) Cont....	Applying Varignon's theorem	
	$\Sigma M_A = R \times x$	
	$2.426 = 11.27 \cdot x$	
	$\therefore x = 0.215\ m$	1M
	Position of Resultant lie at a perpendicular distance of 0.215m w.r.to point A.	
		
Q3 c)	 	
	1) Resolving force System horizontally	
	$\Sigma F_x = 25\cos 30 - 35\cos 45 - 30\cos 40°$	
	$\Sigma F_x = -26.079\ N$	
	$\boxed{\Sigma F_x = -26.079\ N}$	01M

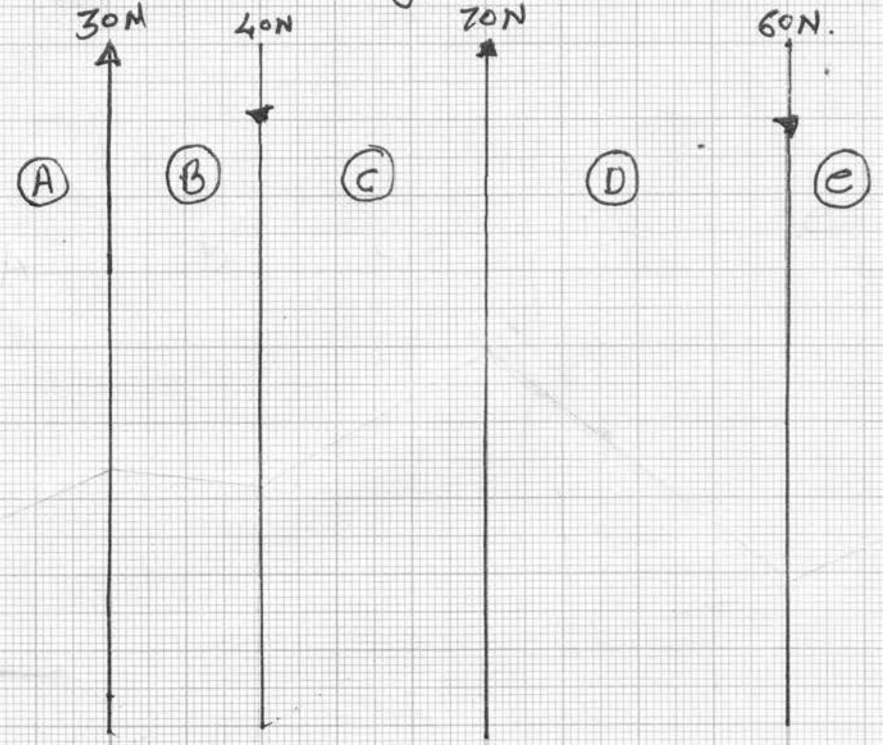
Q .NO	SOLUTION	MARKS
Q3 c) Cont...	2) Resolving force system vertically.	
	$\Sigma F_y = 25 \sin 30 + 20 + 35 \sin 45 - 30 \sin 40$	
	$\Sigma F_y = 37.96\ N$	1
	3) Resultant $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$	
	$R = \sqrt{(-26.079)^2 + (37.96)^2}$	
	$R = 46.05\ N$	1
	4) Angle of Inclination of Resultant	
	$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$	
	$= \tan^{-1}\left(\frac{37.96}{26.079}\right)$	
	$\boxed{\theta = 55.51^\circ}$	1
	since ΣF_x is negative & ΣF_y is positive Resultant lie in the second quadrant	
		
Q3d)		

Q .NO	SOLUTION	MARKS
Q3d Cont....	i) Magnitude of Resultant (R)	
	$R = \Sigma F_y$	
	$= 30 - 40 + 70 - 60$	
	$R = 0$ N.	2M
	* NOTE	
	As the magnitude of Resultant is zero the force system is in equilibrium.	2M
	Hence there is No position & direction of Resultant force.	
Q3e)	i) Resolution of a force	
	The way of representing a single force into number of forces without changing the effect of the force on the body is called as Resolution of a force.	02
	Suppose a single force F is to be resolved into number of forces F_1, F_2, F_3, F_4 ..... etc. then these number of forces are called as Components of a single force F.	
	ii) Composition of a force system	
	The process of finding out the resultant force of a given system of forces is called as Composition of forces.	02
	The single force F is called resultant force of forces F_1, F_2, F_3, F_4, ... etc.	

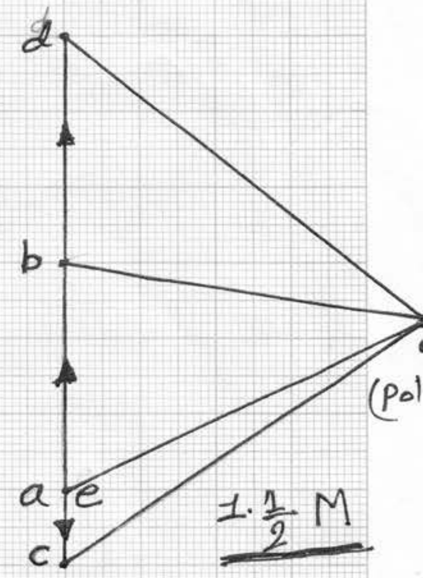
Q NO	SOLUTION	MARKS

Q3 f)

space diagram (scale 1cm = 200mm)



$1\cdot\frac{1}{2}$ M for space diagram.



$1\cdot\frac{1}{2}$ M

Vector diagram & polar diagram

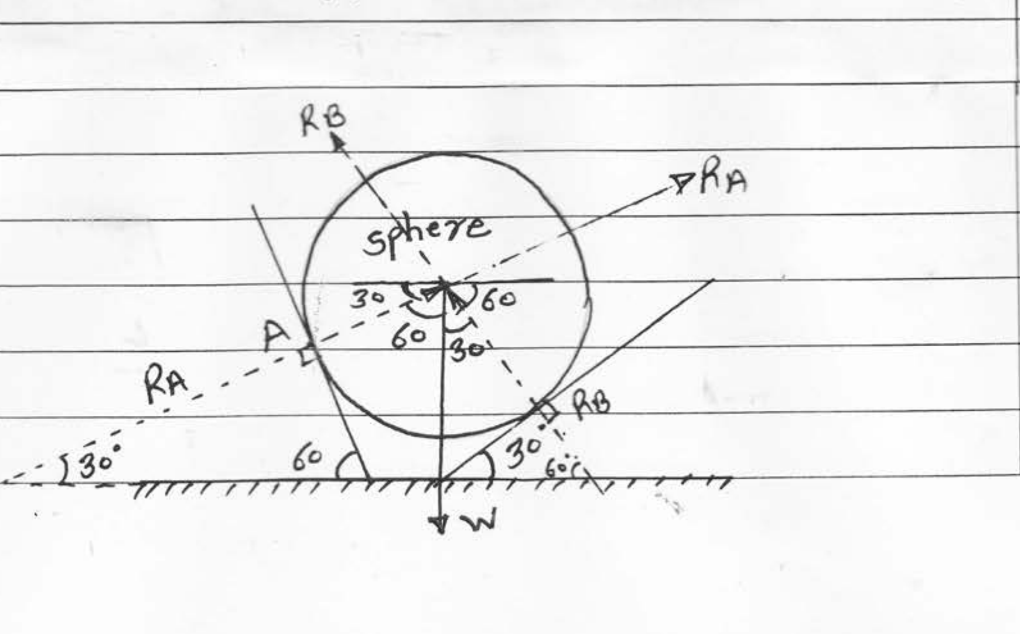
(Scale 1cm = 10 N)

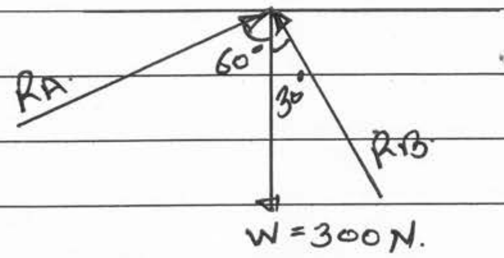
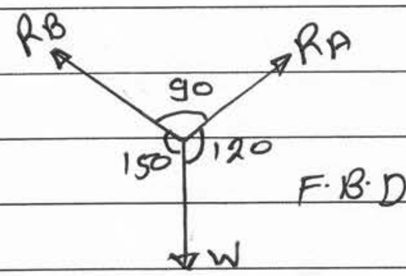
i) Magnitude of Resultant = length ae × scale
= 0 × 10

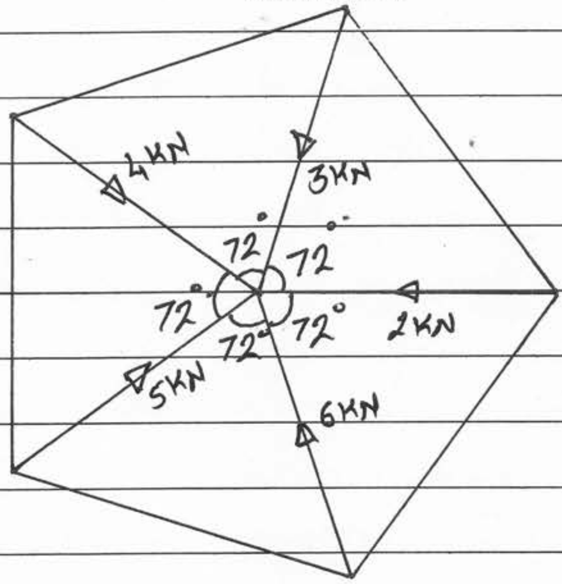
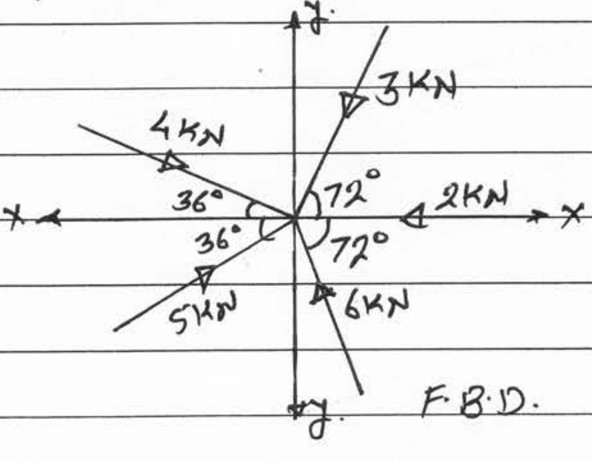
R. = 0 N.

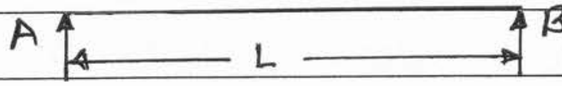
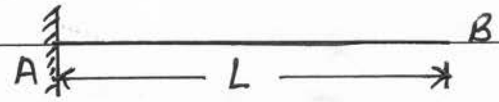
NOTE:-

As the magnitude of Resultant is Zero the force system is in equilibrium. Hence there is No position & direction of resultant force. 1M

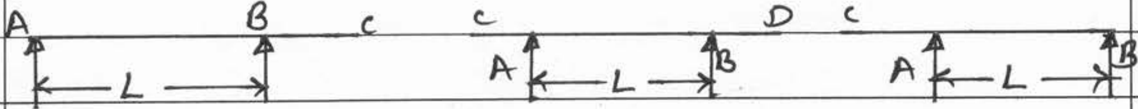
Q .NO	SOLUTION	MARKS
Q4 a)	i) Graphical Condition of equilibrium for Concurrent system. The resultant of coplaner Concurrent forces is found by joining the beiginning of the first force to the end of the last force in the force polygon. If the system of forces is in equilibrium, the resultant must be zero. Thus for the system to be in equilibrium the polygon of forces must be a closed figure.	02
	ii) Graphical Condition of equilibrium for parallel force system.	
	a) The system of forces to be in equilibrium the force polygon must be a closed figure.	1M
	b) The system of forces to be in equilibrium the funicular polygone must be a closed figure.	1M
Q4 b)		

Q .NO	SOLUTION	MARKS
Q4b Cont…		1
	F.B.D	
	Applying Lamis Theorem	
	$\frac{R_A}{\sin 30} = \frac{R_B}{\sin 60} = \frac{W}{\sin(60+30)}$	1
	$\therefore R_A = \frac{W \cdot \sin 30}{\sin 90} = 150\ N.$	1
	$\therefore R_B = \frac{W \sin 60}{\sin 90} = 259.80\ N$	1
	OR	
Q4b	 F.B.D	1
	Apply lamis Theorem	
	$\frac{R_A}{\sin 150} = \frac{R_B}{\sin 120} = \frac{W}{\sin 90}$	1
	$\therefore R_A = \frac{W \sin 150}{\sin 90} = 150\ N$	1
	$\therefore R_B = \frac{W \sin 120}{\sin 90} = 259.80\ N$	1

Q .NO	SOLUTION	MARKS
Q4c)		
	For regular pentagon the angles between each pair of forces $= \frac{360}{5} = 72°$	
		
	1) Resolving all the forces horizontally	
	$\Sigma Fx = -2 - 3\cos72 - 6\cos72 + 4\cos36 + 5\cos36$	
	$\Sigma Fx = 2.5$ KN	1
	2) Resolving all the forces vertically	
	$\Sigma Fy = -3\sin72 + 6\sin72 - 4\sin36 + 5\sin36$	
	$\Sigma Fy = 3.44$ KN	1

Q.NO	SOLUTION	MARKS
Q4 c) Cont...	3) Magnitude of Resultant	
	$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$	
	$R = \sqrt{(2.5)^2 + (3.44)^2}$	
	$R = 4.25$ KN	1
	Since ΣF_x & ΣF_y are positive, R is pull in the first quadrant. So Equilibrant E is pull in the third quadrant.	
	$E = R = 4.25$ KN.	1
Q4 d)	i) Simply supported beam A beam which is freely supported on the walls or columns at its both the ends is called as a simply supported beam.  	
	ii) Cantilever beam A beam fixed at one end and free at other is called as a Cantilever beam.  	1
	iii) Overhanging beam If the end portion of the beam extends beyond the supports it is called as an overhanging beam. A beam may be overhanging on one side or both sides.	

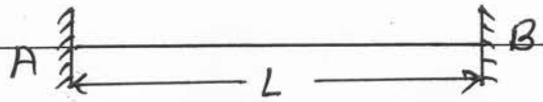
Q .NO	SOLUTION	MARKS
Q4 d) Cont...		



overhung on right side — overhung on both sides — overhung on Left side — 1

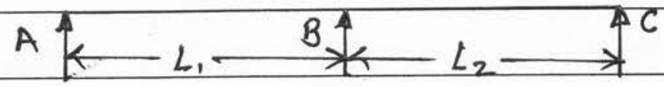
iv) Fixed beam

A beam whose both the ends are rigidly fixed in walls is called a fixed beam, Constrained beam, built-in beam or an encastre beam. — 1



v) Continuous beam

A beam which is supported on more than two supports is called a Continuous beam.



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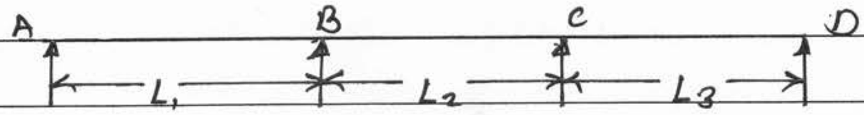
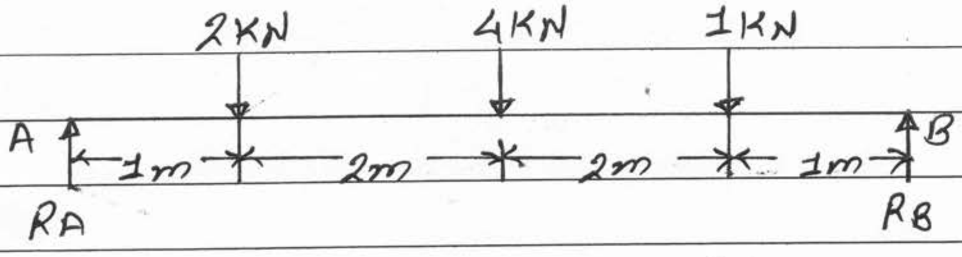
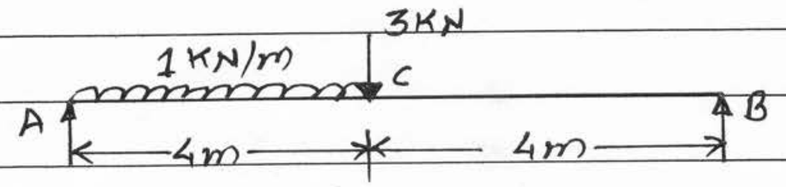
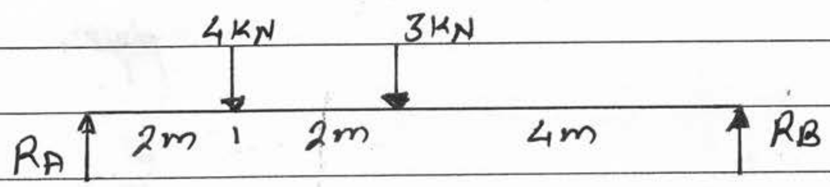
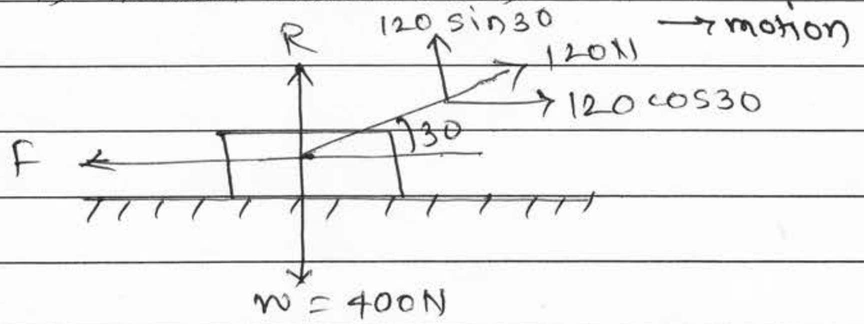
Two span Continuous beam.



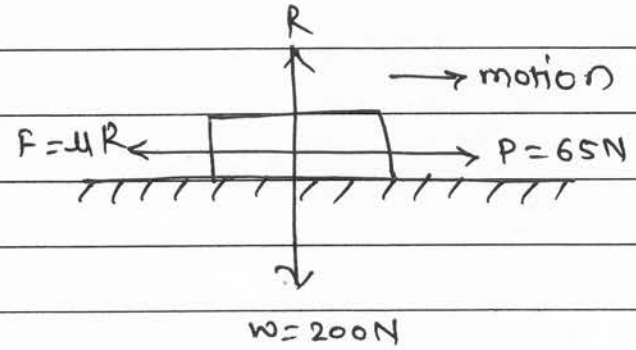
Three span Continuous beam.

Q .NO	SOLUTION	MARKS
Q4 e)		
	1) Applying Condition of equilibrium	
	$\Sigma F_y = 0$	
	$R_A - 2 - 4 - 1 + R_B = 0$	
	$R_A + R_B = 7$ KN. ------(i)	1M
	$\Sigma M@A = 0$	
	$(2\times1) + (4\times3) + (1\times5) - R_B\times6 = 0$	1M
	$2 + 12 + 5 = 6R_B$	
	$\therefore R_B = 3.17$ KN	1M
	from eq^n (i)	
	$R_A + R_B = 7$	
	$\therefore R_A = 7 - 3.17 = 3.83$ KN	1M
	Ans. $\boxed{R_A = 3.83 \text{ KN} \quad R_B = 3.17 \text{ KN}}$	
Q4 f		
		

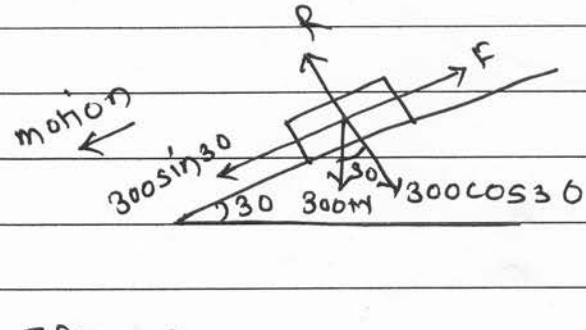
Q .NO	SOLUTION	MARKS
Q4 f Cont...	i) Applying Condition of equilibrium	
	$\Sigma F_y = 0$	
	$R_A - (1\times4) + R_B - 3 = 0$	
	$R_A + R_B = 7$ KN ------- (i)	1M
	$\Sigma M@A = 0$	
	$\left(1\times4\times\frac{4}{2}\right) + (3\times4) - 8R_B = 0$	1M
	$8 + 12 = 8R_B$	
	$\therefore R_B = 2.5$ KN.	1M
	From eq^n (i)	
	$R_A + R_B = 7$	
	$\therefore R_A = 7 - 2.5$	
	$R_A = 4.5$ KN.	1M
	Ans- $R_A = 4.5$ KN, $R_B = 2.5$ KN	

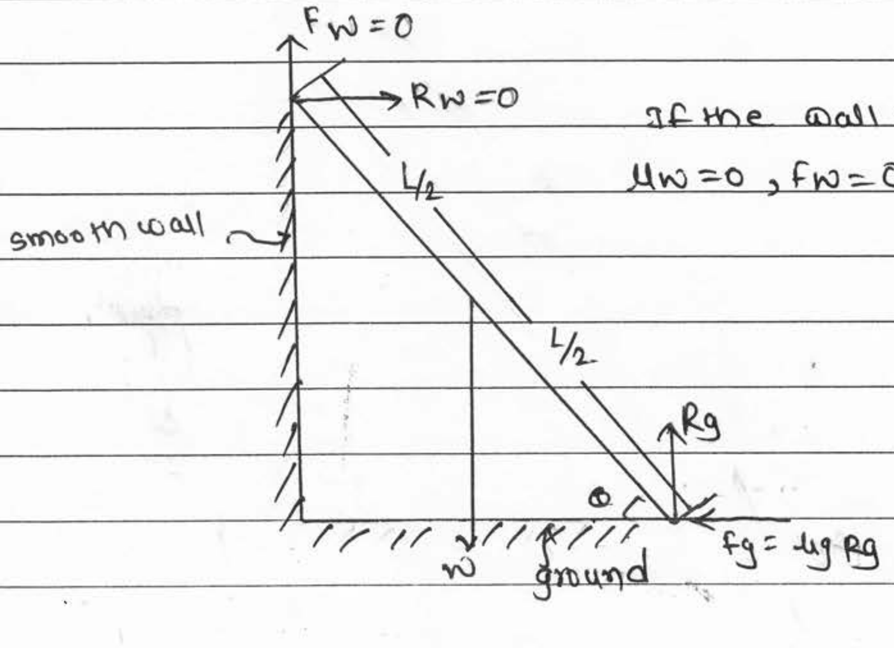
Q .NO	SOLUTION	MARKS
Q. 5	Answer any four of the following	
a)	Given data:-	
	$W = 400N$,	
	$P = 120 N$, $\theta = 30^\circ$	
	Find: i) coefficient of friction (μ)	
	ii) Normal reaction (R)	
		01
	I] Resolve the forces horizontally, we get	
	$\Sigma Fx = 120\cos 30 - F$	
	$\Sigma Fx = 103.92 - \mu R$ ($\because F = \mu R$)	
	As the body in limiting equilibrium, $\Sigma Fx = 0$	
	$\therefore 103.92 - \mu R = 0$	
	$103.92 = \mu R$	
	$\mu = \frac{103.92}{R} \longrightarrow (1)$	01
	II] Resolving the forces vertically, we get	
	$\Sigma Fy = R - W + 120\sin 30$	
	$\Sigma Fy = R - 400 + 60$	
	$\Sigma Fy = 0$	
	$R - 340 = 0$	
	$\boxed{R = 340 N}$	01
	Put the value of 'R' in eq^n (1), we get	

Q.NO	SOLUTION	MARKS
Q.5 a. continue----	$\mu = \frac{103.92}{366}$	01
	$\boxed{\mu = 0.305}$	
b)	Given data:-	
	$w = 200N$, $P = 65N$	
	find:- i) μ, ii) S, iii) ϕ	



	I) $\Sigma Fx = 0$	
	$P - F = 0$	
	$65 - \mu R = 0$ $\quad (\because F = \mu R)$	
	$65 = \mu R$	
	$\mu = \frac{65}{R} \longrightarrow (1)$	
	II) $\Sigma Fy = 0$	
	$R - w = 0$	
	$\boxed{R = 200N}$	01
	put the value of 'R' in eq^n (1), we get	
	$\mu = \frac{65}{200}$	
	$\boxed{\mu = 0.325}$	01

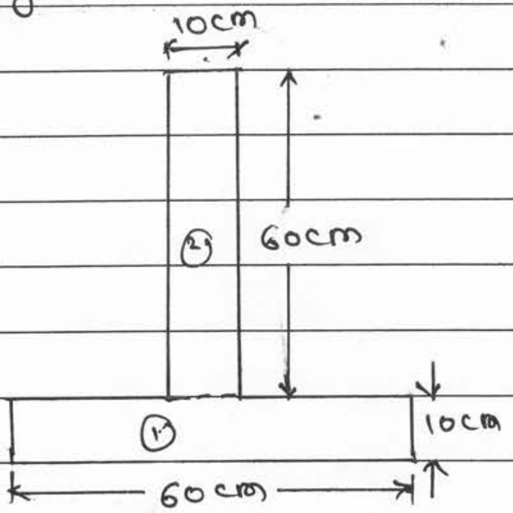
Q .NO	SOLUTION	MARKS
Q.5b continue--	III) calculate magnitude of resultant reaction	
	$S = R\sqrt{1+\mu^2}$	
	$S = 200\sqrt{1+(0.325)^2}$	
	$\boxed{S = 210.297N}$ ---→ Resultant	01
	IV) Direction:	
	$\tan\phi = \mu$	
	$\phi = \tan^{-1}(\mu)$	
	$= \tan^{-1}(0.325)$	
	$\boxed{\phi = 18^\circ}$ ---→ Direction	01
C]	Given:	
	$W = 300N$,	
	Find: I) μ, II) ϕ, III) α	
		
	I] $\Sigma Fx = 0$	
	$F - 300\sin 30$	
	$F = 150N$	
	$\mu R = 150N$ $(\because F = \mu R)$	
	$\mu = 150/R$ ⟶ (1)	

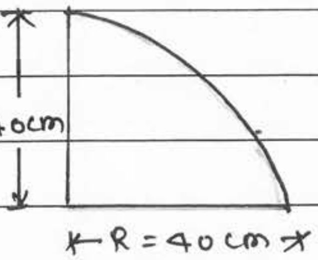
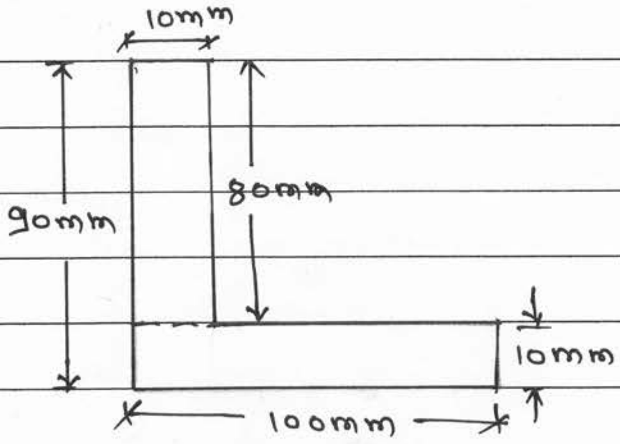
Q .NO	SOLUTION	MARKS
Q.5 C cont....	II) $\Sigma F_y = 0$	
	$R - 300\cos 30 = 0$	
	$\boxed{R = 259.807\,N}$	01
	put 'R' in eqn (1)	
	$\therefore \mu = \frac{150}{259.807}$	
	$\boxed{\mu = 0.577}$	01
	III) $\tan\phi = \mu$	
	$\phi = \tan^{-1}(\mu)$	
	$= \tan^{-1}(0.577)$	01
	$\boxed{\phi = 29.98 \text{ say } 30^\circ}$	
	IV) Angle of friction = Angle of repose	
	$\phi = \alpha$	
	$\boxed{\alpha = 30^\circ}$	01
d]	 If the wall is smooth $\mu_w = 0$, $F_w = 0$	04

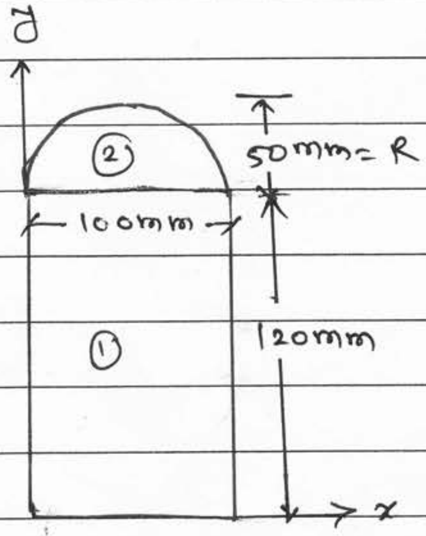
Q .NO	SOLUTION	MARKS
e]	Given:	
	V.R. = 20,	
	$w_1 = 100\,N$, $P_1 = 10\,N$.	
	$w_2 = 200\,N$, $P_2 = 14\,N$	
	Find:- I) Law of machine,	
	II) Effort lost in friction at a load of 300N.	
	I] The eq^n is given by	
	$P = mw + C$	
	$\therefore P_1 = mw_1 + C$	
	$10 = m(100) + C \longrightarrow (I)$	
	$P_2 = mw_2 + C$	
	$14 = 200m + C \longrightarrow (II)$	
	solve eq^n (I) & (II) simultanously	
	$10 = 100m + C$	
	$\overset{+}{-}\, 14 = 200m + C$	
	$-4 = -100m$	
	$\therefore \boxed{m = 0.04}$	1/2
	put m in eq^n (I), we get.	
	$10 = 0.04(100) + C$	
	$10 = 4 + C$	
	$\therefore C = 10 - 4$	
	$\boxed{C = 6}$	1/2
	$\therefore \boxed{P = 0.04w + 6} \longrightarrow$ Law of machine.	01

Q .NO	SOLUTION	MARKS
Q.5e cont....	ii] $w = 300\,N$	
	$\therefore P = 0.04(300) + 6$	
	$\boxed{P = 18N}$	01
	III] Effort lost in friction:	
	$P_f = P - P_i$	
	but, $P_i = \frac{w}{VR} = \frac{300}{20} = 15$	
	$\therefore P_f = 18 - 15$	
	$\boxed{P_f = 3N}$	01
f]	Given:-	
	$P = 50N, \quad \eta = 70\%$	
	$N_1 = 60, \quad N_2 = 10$	
	$N_3 = 90, \quad N_4 = 15$	
	Find:- $w = ?$	
	I) $V.R. = \frac{N_1}{N_2} \times \frac{N_3}{N_4}$	01
	$= \frac{60}{10} \times \frac{90}{15}$	
	$\boxed{V.R. = 36}$	01
	II) $M.A. = \frac{w}{P} \longrightarrow (1)$	
	$\eta = \frac{MA}{VR} \times 100$	01
	$70 = \frac{MA}{36} \times 100$	

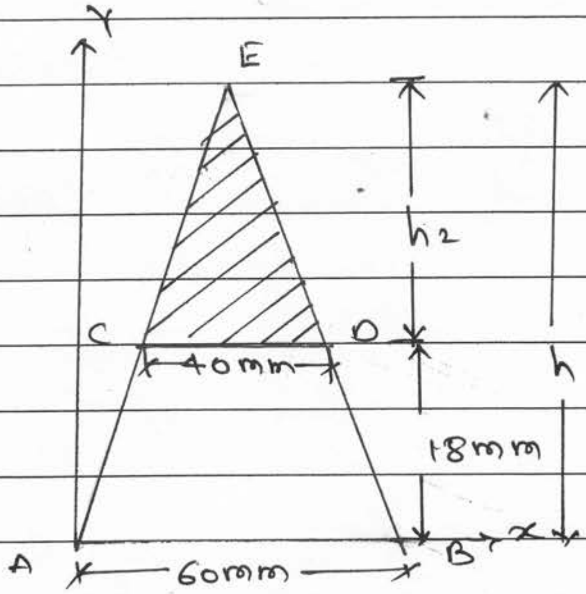
Q .NO	SOLUTION	MARKS
Q.5 f	$M.A. = 25.2$	
cont...	but. $M.A. = \frac{W}{P}$	
	$25.2 = \frac{W}{50}$	
	$\boxed{W = 1260\ N}$	01

Q .NO	SOLUTION	MARKS
Q. 6	Attempt any four of the following	
a)		
	I)	
	$a_1 = 60 \times 10 = 600\ cm^2$	
	$a_2 = 60 \times 10 = 600\ cm^2$	01
	II) Due to symmetry about Y-Y axis	
	$\bar{x} = \frac{60}{2} = 30\ cm$	
	$\boxed{\bar{x} = 30\ cm}$	1/2
	III) $y_1 = \frac{10}{2} = 5\ cm$	1/2
	$y_2 = 10 + \frac{60}{2} = 40\ cm$	
	$\bar{Y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$	01
	$= \frac{(600 \times 5) + (600 \times 40)}{(600 + 600)}$	
	$\boxed{\bar{Y} = 22.5\ cm}$	01

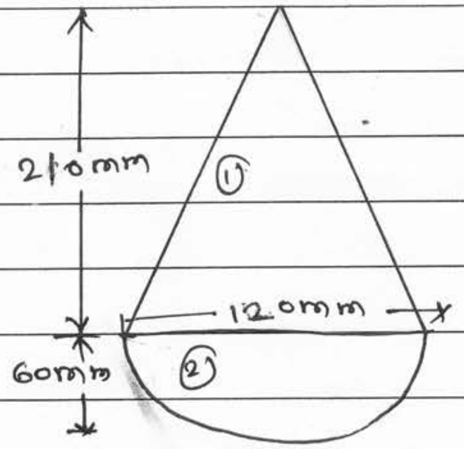
Q .NO	SOLUTION	MARKS
b]		
	$A = \frac{\pi R^2}{4} = \frac{\pi (40)^2}{4}$	
	$\boxed{A = 1256.637\, cm^2}$	
	$\bar{x} = \bar{y} = \frac{4R}{3\pi}$	02
	$= \frac{4(40)}{3\pi}$	01
	$\boxed{\bar{x} = \bar{y} = 16.976\, cm}$	01
c]		
	I) $a_1 = 80 \times 10 = 800\, mm^2$ $a_2 = 100 \times 10 = 1000\, mm^2$	
	II) $x_1 = \frac{10}{2} = 5\, mm$ $\boxed{x_1 = 5\, mm}$	01
	$x_2 = \frac{100}{2} = 50\, mm$ $\boxed{x_2 = 50\, mm}$	

Q .NO	SOLUTION	MARKS
Q.6 C cont...	$y_1 = 10 + \frac{80}{2} = 10 + 40 = 50mm$	
	$y_2 = \frac{10}{2} = 5mm$	01
	$\bar{x}_1 = \frac{a_1 x_1 + a_2 x_2}{a_1 + a_2}$	
	$= \frac{(800 \times 5) + (1000 \times 50)}{(800 + 1000)}$	01
	$\boxed{\bar{x} = 30}$ mm	
	$\bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$	
	$= \frac{(800 \times 50) + (1000 \times 5)}{(800 \times 1000)}$	
	$\boxed{\bar{y} = 25\ mm}$	01
d]		
	I]	
	$V_1 = \pi R^2 h$	01
	$= \pi (50)^2 (120)$	

Q .NO	SOLUTION	MARKS
Q.6 d cont....	$\boxed{V_1 = 942.477 \times 10^3\ mm^3}$	
	$V_2 = \frac{2}{3}\pi R^3$	01
	$= \frac{2}{3}\pi (50)^3$	
	$\boxed{V_2 = 261.799 \times 10^3\ mm^3}$	
	II) Due to symmetry about Y-Y axis	
	$\bar{x} = \frac{100}{2}$	
	$\boxed{\bar{x} = 50\,mm}$	01
	III) $y_1 = \frac{120}{2} = 60\,mm$	
	$y_2 = 120 + \frac{3R}{8}$	
	$= 120 + \frac{3(50)}{8}$	01/2
	$\boxed{y_2 = 138.75\,mm}$	
	$\bar{y} = \frac{V_1\bar{y}_1 + V_2\bar{y}_2}{V_1+V_2} = \frac{942.477\times10^3 \times 60 + 261.799\times10^3 \times 138.75}{(942.477\times10^3)+(261.799\times10^3)}$	
	$\boxed{\bar{y} = 77.12\,mm}$	01/2

Q .NO	SOLUTION	MARKS
e]		1/2
	I) Fig. is symmetrical about Y-Y axis	
	$\bar{x} = \frac{60}{2} =$	
	$\boxed{\bar{x} = 30 mm}$	1/2
	h- height of full cone,	
	h_1 = height of frustum, = 18 mm	
	h_2 = height of cut cone	
	As the triangles Δle ABE & Δ CDE are symmetrical	
	$\frac{h}{60} = \frac{h_2}{40}$	
	$h = \frac{60}{40} \times h_2$	
	$h = 1.5h_2$	
	Now, $h_1 + h_2 = h$ i.e. $h_1 + h_2 = 1.5h_2$	
	$\therefore h_1 = 1.5h_2 - h_2 = 0.5h_2$	
	$h_2 = \frac{h_1}{0.5} = \frac{18}{0.5}$	
	$\boxed{h_2 = 36 mm}$	1/2

Q .NO	SOLUTION	MARKS
Q. 6e cont.	II) $R_1 = 30mm$, $h = 54mm$	
	$V_1 = \frac{1}{3}\pi R_1^2 h$	
	$= \frac{1}{3}\pi (30)^2 (54)$	
	$\boxed{V_1 = 50.86 \times 10^3 \ mm^3}$	1/2
	$V_2 = \frac{1}{3}\pi R_2^2 h_2$	
	$= \frac{1}{3}\pi (20)^2 (36)$	
	$\boxed{V_2 = 15.07 \times 10^3 \ mm^3}$	
	∴ Volume of frustum of cone	
	$V = V_1 - V_2$	
	$= (50.86 \times 10^3) - (15.07 \times 10^3)$	
	$= 35.82 \times 10^3 \ mm^3$	01
	III) $y_1 = \frac{54}{4} = 13.5 mm$	
	$y_2 = 18 + \frac{36}{4} = 27 mm$	
	$\bar{Y} = \frac{V_1 y_1 - V_2 y_2}{V_1 - V_2}$	
	$= \frac{(50.86 \times 10^3)(13.5) - (15.07 \times 10^3 \times 27)}{(35.82 \times 10^3)}$	
	$\boxed{\bar{Y} = 7.815 mm}$	01

Q .NO	SOLUTION	MARKS
f]		1/2
	I) The fig. is symmetrical about Y-Y axis $\bar{x} = \frac{120}{2}$	
	$\boxed{\bar{x} = 60\ mm}$	1/2
	II) $V_1 = \frac{1}{3}\pi R^2 h$ $= \frac{1}{3}\pi(60)^2(210)$	
	$\boxed{V_1 = 791.68 \times 10^3\ mm^3}$	1/2
	$V_2 = \frac{2}{3}\pi R^3$ $= \frac{2}{3}\pi(60)^3$	
	$\boxed{V_2 = 452.389 \times 10^3\ mm^3}$	
	$y_1 = 60 + \frac{h}{4}$ $= 60 + \frac{210}{4}$	1/2
	$y_1 = 112.5\ mm$	

Q .NO	SOLUTION	MARKS
Q.6f cont....	$y_2 = R - \frac{3R}{8}$	
	$= 60 - \frac{3(60)}{8}$	1/2
	$y_2 = 37.5\ mm$	
	$\therefore \bar{Y} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2}$	1/2
	$= \frac{(791.68 \times 10^3 \times 112.5) + (452.38 \times 10^3 \times 37.5)}{(791.68 \times 10^3) + (452.38 \times 10^3)}$	
	$\boxed{\bar{Y} = 85.227\ mm}$	01