WINTER – 13 EXAMINATIONS

Subject Code: 12015 **Model Answer** **Page No: ____/N**

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.

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 for Examiner:-

Q. 2a) In this problem If students consider both forces acting away from the point OR If they consider 50N force acting towards point and 80N acting away from the point to calculate magnitude and direction of resultant. Examiner should consider either of the two solutions for giving proportionate marks.

Q. 2c) For Analytical solution

Five forces are mentioned in question paper, student can assume sixth force OR They can solve by taking five forces. Examiner should consider the same and the proportionate marks must be given.

Q. 2f) For graphical solution

Five forces are mentioned in question paper, student can assume sixth force OR they can solve by taking five forces. Examiner should consider the same and the proportionate marks must be given.

Q.NO	SOLUTION	MARKS
1 a)	Define.	
	i) Dynamics: It is that branch of Applied Mechanics which deals with action of forces on bodies in motion.	(1)
	ii) Kinematics: It is that branch of dynamics which deals with action of forces on bodies in motion without any consideration of the mass of the body and forces causing motion.	(1)
b)	Principle of transmissibility of forces: 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 the force within the body.	(2)
c)	Varignon's principle of moment: The algebraic sum of moments of all forces about any point is equal to moment of their resultant about the same point.	(2)
d)	Conditions of equilibrium for non-concurrent forces are.	
	i) $\Sigma fx = 0$ i.e Algebraic sum of components of all forces along x-axis must be equal to zero.	$(\frac{1}{2})$
	ii) $\Sigma fy = 0$ i.e Algebraic sum of components of all forces along Y-axis must be equal to zero.	$(\frac{1}{2})$
	iii) $\Sigma M = 0$ i.e Algebraic sum of moments of all forces about any point in their plane must be equal to zero.	(1)

Q.NO	SOLUTION	MARKS

1 e).

Resultant	Equilibrant
i) It is a single force which can produce the same effect as it is produced by number of forces acting together.	i). It is a single force which when acts along with the other forces keeps the body in equilibrium condition.
ii) It produces the motion.	ii) It stops the motion.

(2)

f). Lami's theorem: 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. (2)

g). In case of static friction body is already in rest condition and to start the motion of body some additional force is required as compared to dynamic friction, hence static friction is greater than dynamic friction. (2)

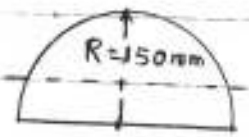
h).

Coefficient of friction (μ) = tan (angle of repose).

$\mu = \tan 30$

$\therefore \mu = 0.577$ (2)

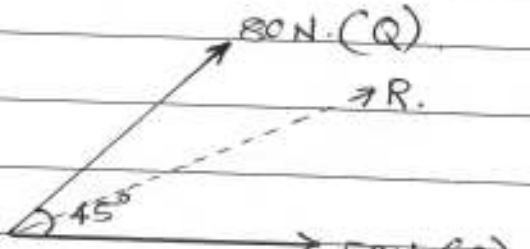
i).



$\bar{y} = \frac{3R}{8} = \frac{3 \times 150}{8} = 56.25$ mm. (2)

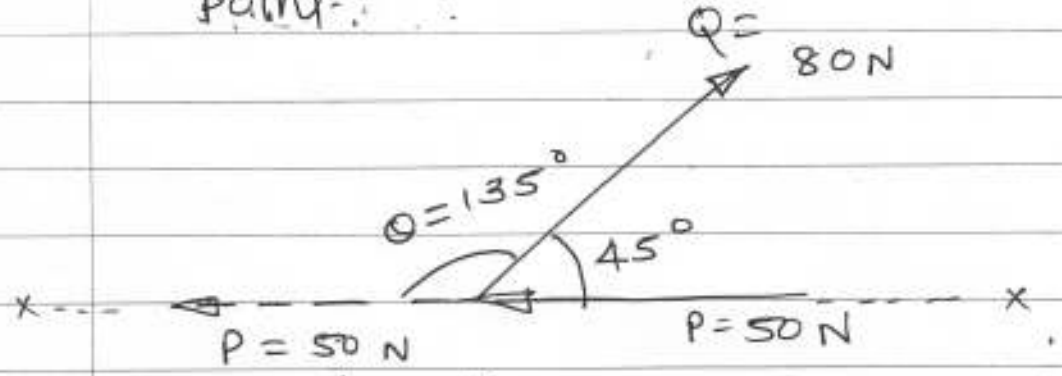
ii) i) Centroid: The point through which the entire area of a plane figure is assumed to act, for all positions of the lamina is called centroid. (1)

ii) Centre of gravity: The point

Q.NO	SOLUTION	MARKS
1. j)	ii) Centre of gravity: The point through which the whole volume of solid body is assumed to act for all positions of the body is called as Centre of gravity.	(1)
k)	i) Mechanical Advantage: It is the ratio of load lifted to the effort applied in a simple lifting machine. $M.A = \frac{\text{load}}{\text{Effort}} = \frac{W}{P}$	(1)
	ii). Velocity ratio: It is the ratio of distance travelled by effort to the distance travelled by load. $V.R = \frac{Sp}{Sw}$	(1)
l).	$\%\ \text{Efficiency} = \frac{\text{Out put}}{\text{In put}} \times 100$	(1)
	$= \frac{90}{150} \times 100$	
	$\%\ \eta = 60\%$	(1)
2 a).		
	$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$	
	$R = \sqrt{(50)^2 + (80)^2 + 2\times50\times80\times\cos 45}$	(1)
	$R = 120.65\ N.$	(1)
	$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta} = \frac{80\sin 45}{50 + 80\cos 45} = 0.531$ hence $\alpha = 27.97°$	(1)
	3/35	(1)

Q.NO	SOLUTION	MARKS

Q 2(a) OR considering 50 N force acting towards point and 80 N acting away from the point.



extending force 50 N, $\therefore \theta = 135°$

Magnitude of Resultant (R)

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$ 1M

$$R = \sqrt{(50)^2 + (80)^2 + 2 \times 50 \times 80 \times \cos 135}$$

$R = 56.948$ N. 1M

Direction of Resultant. (α)

$$\tan\alpha = \frac{Q\sin\theta}{P + Q\cos\theta}$$ 1M

$$= \frac{80\sin 135}{50 + 80\cos 135}$$

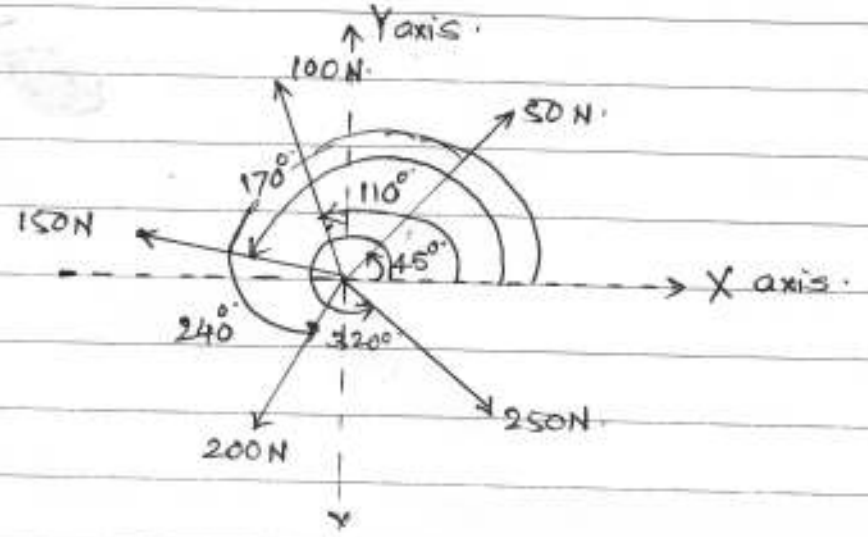
$$= -8.61$$

$\alpha = 83.37°$ w.r.t -ve x axis 1M

Note :- Examiner should consider any one solution of Q 2(a) for giving marks.

Q.NO	SOLUTION	MARKS

2 b).



$$\Sigma fx = +(50\cos 45^\circ) - (100\cos 70^\circ) - (150\cos 10^\circ) - (200\cos 60^\circ) + (250\cos 40^\circ).$$

$$= -55.06\ N \quad (1)$$

$$\Sigma fy = +(50\sin 45^\circ) + (100\sin 70^\circ) + (150\sin 10^\circ) - (200\sin 60^\circ) - (250\sin 40^\circ).$$

$$= -178.53\ N. \quad (1)$$

$$R = \sqrt{(\Sigma fx)^2 + (\Sigma fy)^2}$$

$$= \sqrt{(-55.06)^2 + (-178.53)^2}$$

$$= 186.83\ N. \quad (1)$$

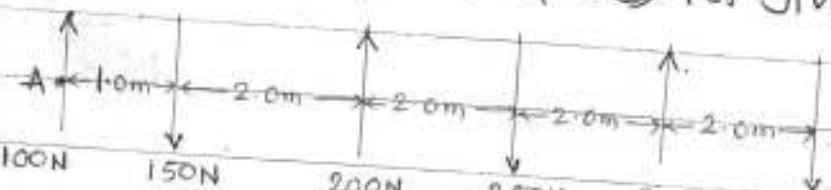
$$\theta = \tan^{-1}\left(\frac{\Sigma fy}{\Sigma fx}\right).$$

$$= \tan^{-1}\left(\frac{-178.53}{-55.06}\right).$$

$$= 72.86^\circ \quad (1)$$

Q NO | Note:- Examiner should consider any one solution of Q 2(c) for giving marks. | MARKS

2 c).



(1)

$\Sigma f_y = 100 - 150 + 200 - 250 + 300 - 350$ N.

$= -150$ N.

$R = -\Sigma f_y = -150$ N (↓). (1)

To find position of resultant R:

Using Varignon's theorem of moment: $\Sigma M_{fA} = M_{RA}$.

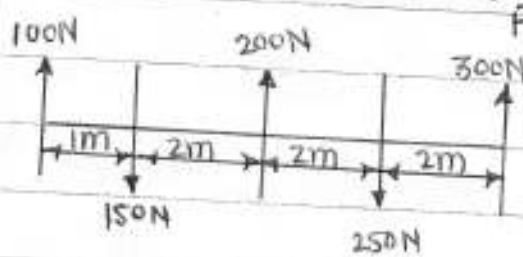
$(150 \times 1) - (200 \times 3) + (250 \times 5) - (300 \times 7) + (350 \times 9) = R \times x$ (1)

$150 - 600 + 1250 - 2100 + 3150 = 150 \times x$.

$x = 12.33$ m from A. (1)

(Note: In the given question magnitude of sixth force is not given. Solution is obtained by assuming it as 350N. but student can assume any value and solve the problem. Answer can be checked on pro the assumed value) and marks can be given to respective value of resultant).

OR → OR → (student may consider 5 forces) for calculation.



$\Sigma f_y = 0$ (1M) for fig

$\Sigma f_y = 100 - 150 + 200 - 250 + 300$

$R = 200$N (↑) (1)

To find position of Resultant using varignon's theorem of moment $\therefore \Sigma M_{fA} = M_{RA}$ (1)

$-300 \times 7 + 250 \times 5 - 200 \times 3 + 150 \times 1 + 100 \times 0 = 200 \times x$

$-2100 + 1250 - 600 + 150 + 0 = 200 \times x$

$\boxed{x = 6.5\text{m}}$ from 'A' point. (1)

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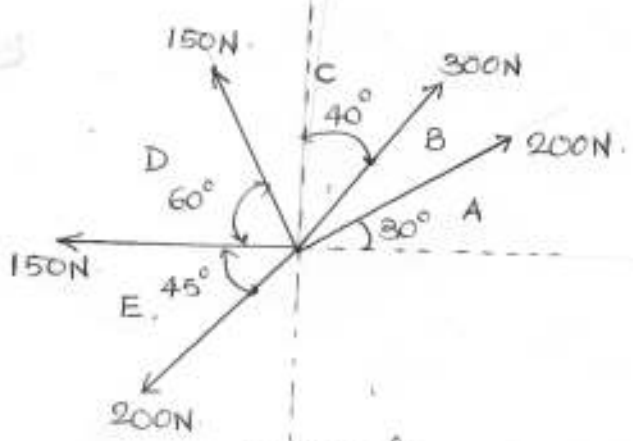
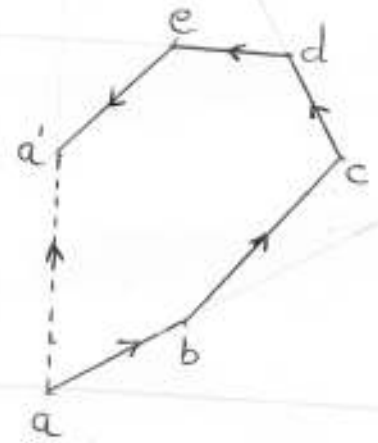
Model Answer.

Q2 d).



space diagram. (2)



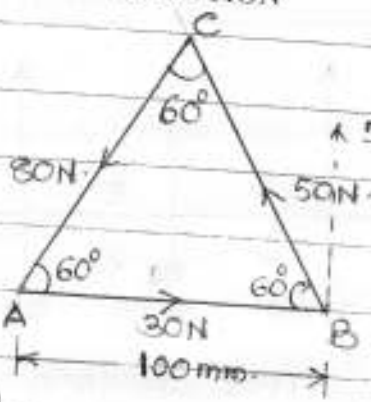
Vector diagram. (scale 1 cm : 100N). (2).

$R = a a' = 3.2 \text{ cm} = 320 \text{ N}$.

$\alpha = 90°$.

Q.NO	SOLUTION	MARKS

2. e).



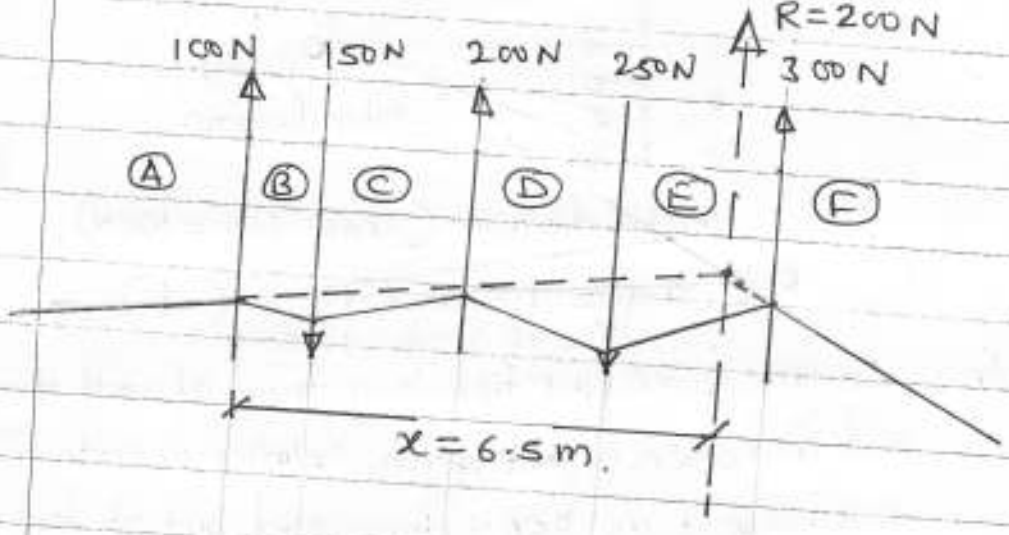
1

Taking moment @ A.

$\Sigma M_A = (30 \times 0) - (50\sin 60 \times 100) - (80 \times 0)$

$= -4330.13$ N mm. 2

Q2 (F) 1

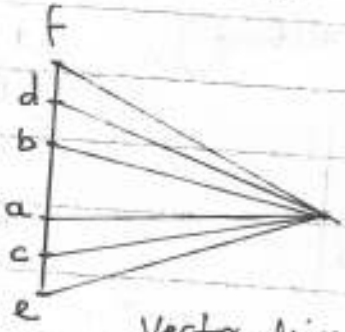


2M

Magnitude $R = l(af) \times 100$

$R = 2 \times 100 = 200$N (↑)

$\therefore x = 6.5$m.



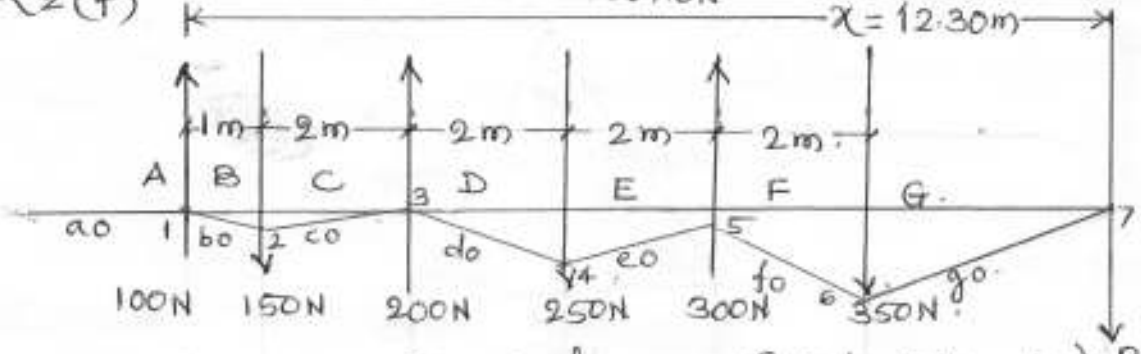
2M

Vector diagram

Scale 1cm = 100N.

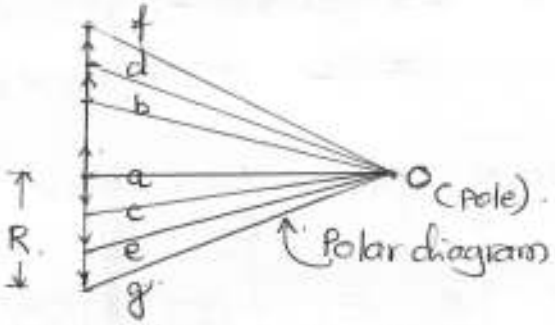
Note:- Student can solve problem by taking 5 forces or they can assume sixth force. Examiner shall give mark for any one solution.

Q2(f) SOLUTION. MARKS. $\frac{8}{35}$



(2)

Space diagram. (scale 1 cm = 1 m). R = 150N.
and funicular Polygon 1-2-3-4-5-6-7



(2).

Vector diagram (scale 1 cm = 100N).

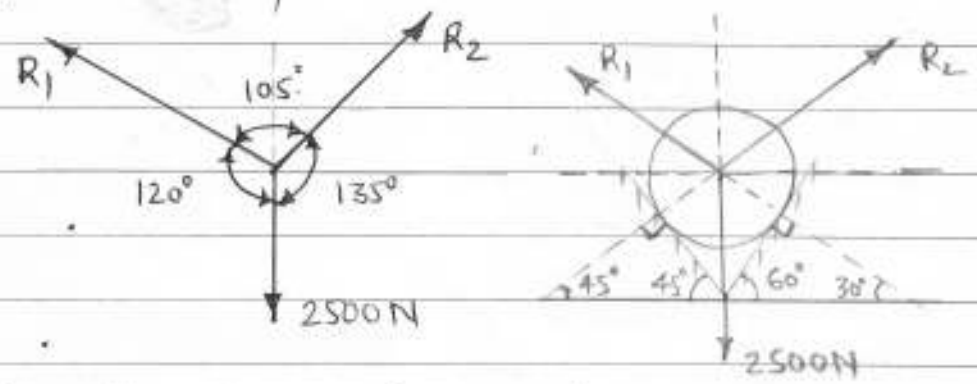
R = ag = 1.5 cm = 150N (↓).
X = 12.30 cm = 12.30 m.

(Note: In the given question, magnitude of sixth force and direction is not given. Solution is obtained by assuming it as 350N downward, but student can assume any magnitude & direction and solve the problem. Answer can be checked as per the assumed value and marks can be given to respective value of resultant).

Q.NO	SOLUTION	MARKS

Q-3

(a) i) Free body diagram



01

ii) Applying sine rule

$$\frac{2500}{\sin 105^\circ} = \frac{R_1}{\sin 120^\circ} = \frac{R_2}{\sin 135^\circ}$$

01

iii) $$\frac{2500}{\sin 105^\circ} = \frac{R_1}{\sin 120^\circ}$$

$$R_1 = \frac{2500 \times \sin 120^\circ}{\sin 105^\circ}$$

$$\boxed{R_1 = 2241.43 \text{ N}}$$

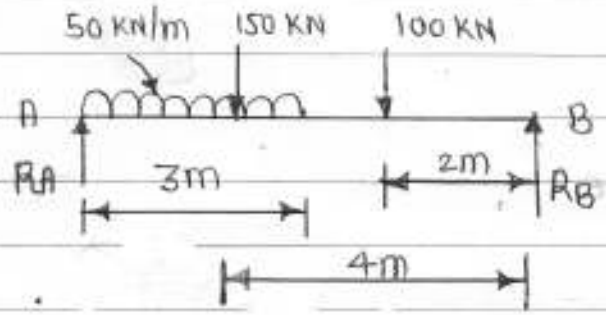
01

iv) $$\frac{2500}{\sin 105^\circ} = \frac{R_2}{\sin 135^\circ}$$

$$R_2 = \frac{2500 \times \sin 135^\circ}{\sin 105^\circ}$$

$$\boxed{R_2 = 1830.12 \text{ N}}$$

01

Q.NO	SOLUTION	MARKS
Q-3 (b)		1
	ii) Applying condition of equilibrium $\Sigma F_y = 0$ $R_A - 50 \times 3 - 150 - 100 + R_B = 0$ $R_A + R_B - 150 - 150 - 100 = 0$ $R_A + R_B - 400 = 0$ $\therefore R_A + R_B = 400$ ——— (A)	1
	iii) $\Sigma M_A = 0$ $-R_B \times 6 + 100 \times 4 + 150 \times 2 + 50 \times 3 \times \frac{3}{2} = 0$ $-6R_B + 400 + 300 + 225 = 0$ $-6R_B + 925 = 0$ $\therefore$ $R_B = 154.17$ KN	1
	put R_B value in eq^n (A) $R_A + R_B = 400$ $R_A + 154.17 = 400$ $\therefore$ $R_A = 245.83$ KN	1

Q-3

(c) given data :-

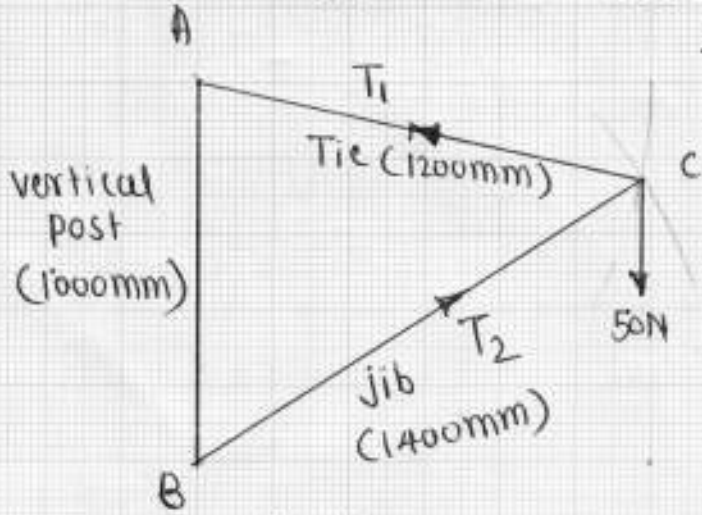
i) Length of vertical post = 1000mm

ii) Length of tie = 1200mm

iii) Length of jib = 1400 mm

As load is 50N and length of vertical post is 5 cm ∴ scale is 5 cm : 50 N

∴ 1 cm = 10 N



Scale (1 cm = 200mm)

Scale (1cm = 10 N)

$T_1 = 6$ cm

$\therefore$ $T_1 = 60$ N

$T_2 = 7$ cm

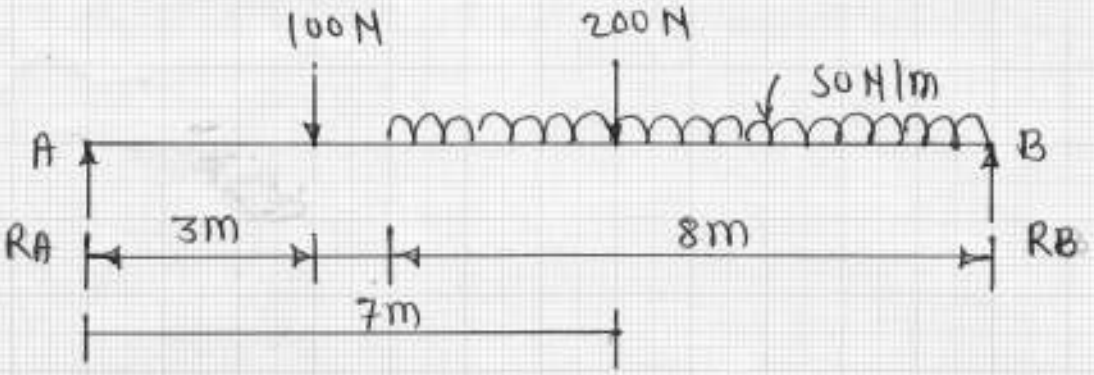
$T_2 = 70$ N

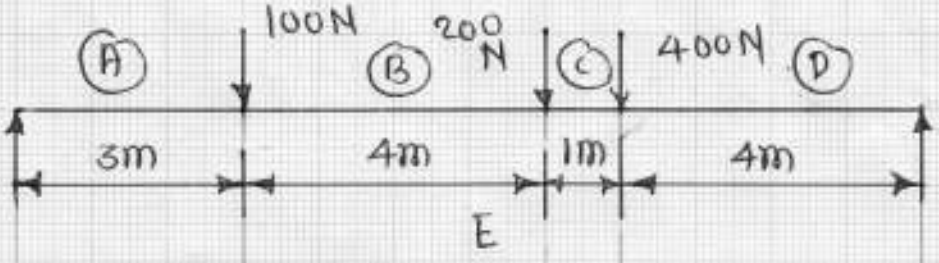
2- Diagram

1

1

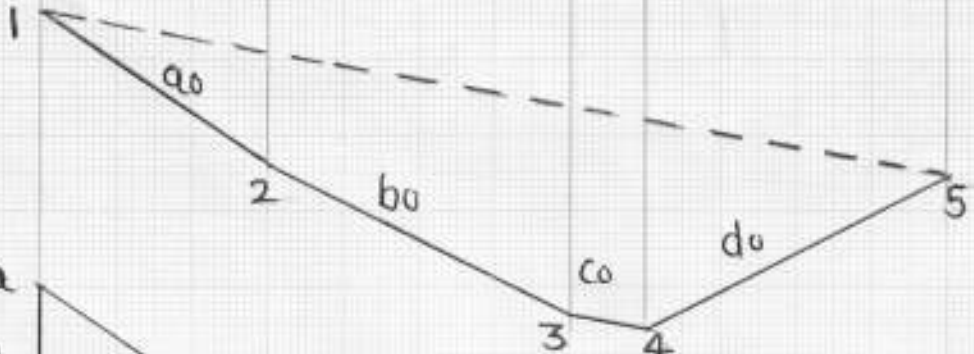
Q-3
(d)



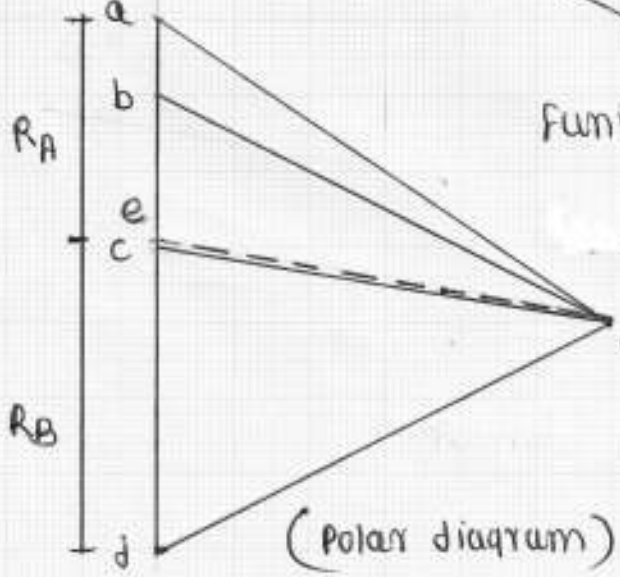


01

Space diagram
(1cm : 1m)



01



Funicular diagram with

Polar diagram

R_A (ae) = 2.9 cm = 290 N

R_B (ed) = 4.1 cm = 410 N

02

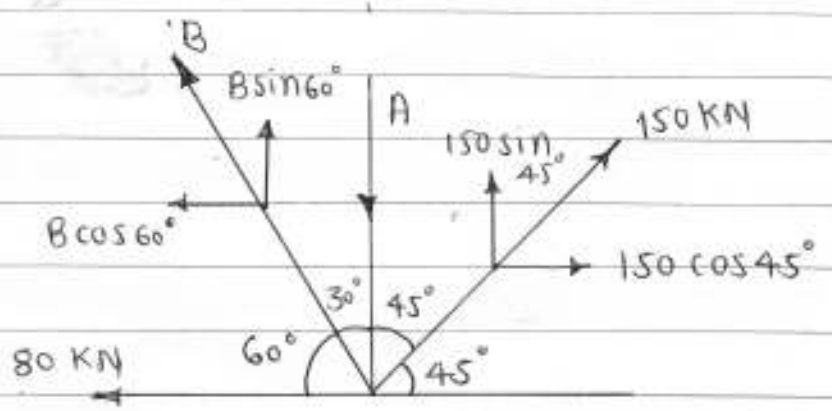
Vector diagram (Scale: 1cm = 100N)

12/35

Q.NO	SOLUTION	MARKS

Q-3

(e) i)



01

- As resultant is zero hence $\Sigma Fx = 0$ & $\Sigma Fy = 0$

ii) $\Sigma Fx = 0$

$150\cos45^\circ - B\cos60^\circ - 80 = 0$ — 1/2

$106.066 - 0.5B - 80 = 0$

$26.066 - 0.5B = 0$

$26.066 = 0.5B$

$\boxed{B = 52.13 \text{ KN}}$ — 01

iii) $\Sigma Fy = 0$

$150\sin45^\circ - A + B\sin60^\circ = 0$ — 1/2

$106.066 - A + 0.866B = 0$

$106.066 - A + 0.866 \times 52.13 = 0$

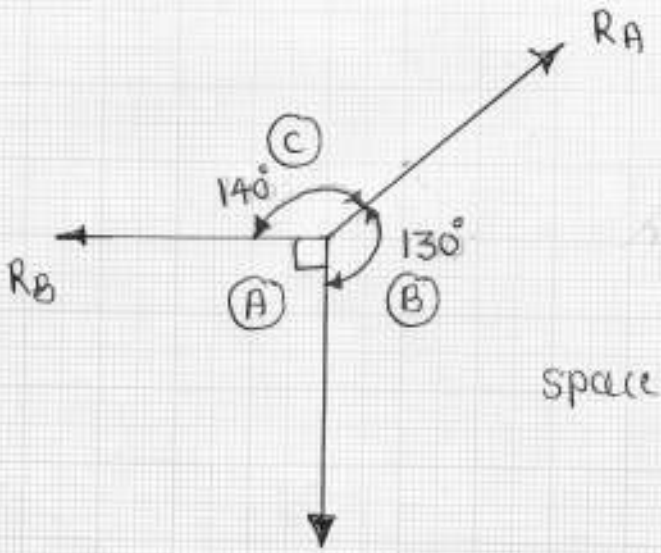
$106.066 - A + 45.146 = 0$

$-A = -151.21$

$\boxed{A = 151.21 \text{ KN}}$ — 01

Q-3
(F)

i) Free body diagram

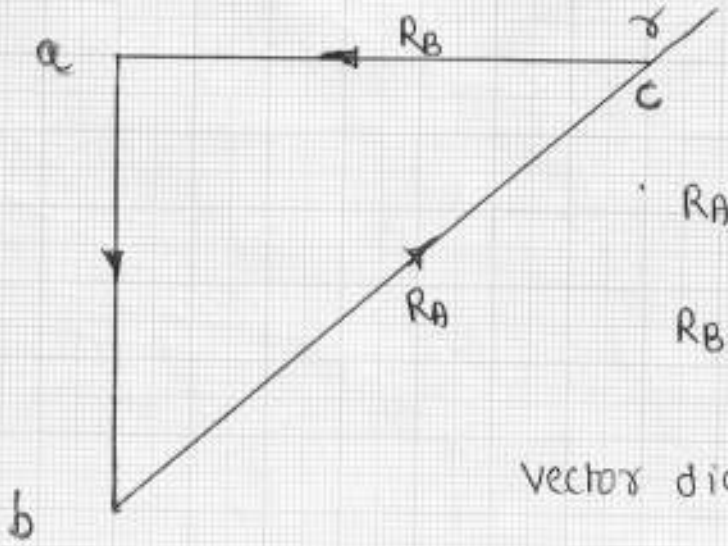


02

Space diagram

Scale : 1cm = 25KN

ii)



R_A = 9.2 cm = 230 KN

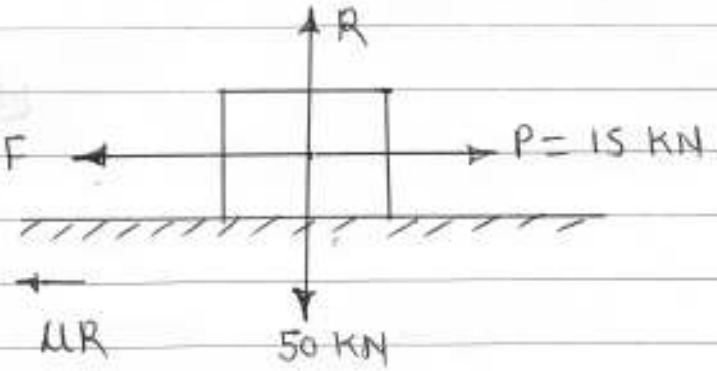
R_B = 7.0 cm = 175 KN

Vector diagram

02

Q.NO	SOLUTION	MARKS

Q-4 (a)



i) $\Sigma F_y = 0$

$R - 50 = 0$

$\boxed{R = 50 \text{ KN}}$ — 1

ii) $\Sigma F_x = 0$

$P - F = 0$

$P - \mu R = 0$

$15 - \mu \times 50 = 0$

$15 = \mu \times 50$

$\mu = \frac{15}{50}$

$\boxed{\mu = 0.3}$ — 1

iii) $F = \mu R$

$F = 0.3 \times 50$

$\boxed{F = 15 \text{ KN}}$ — 1

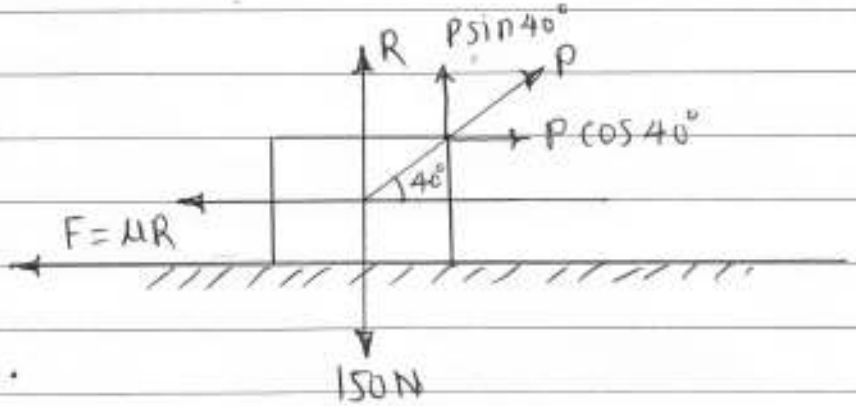
iv) $S = \sqrt{F^2 + R^2} = \sqrt{15^2 + 50^2} = 52.20 \text{ KN}$

— 1

Q.NO	SOLUTION	MARKS

Q- 4

(b)



01

given— i) weight of block = 150 N

ii) $\mu = 0.25$

iii) angle of applied force with horizontal = 40°

for limiting equilibrium

$\Sigma fx = 0$

$P\cos 40^\circ - f = 0$

$P \times 0.7660 - 0.25R = 0$

$0.25R = 0.7660P$

$\boxed{R = 3.064P}$ 01

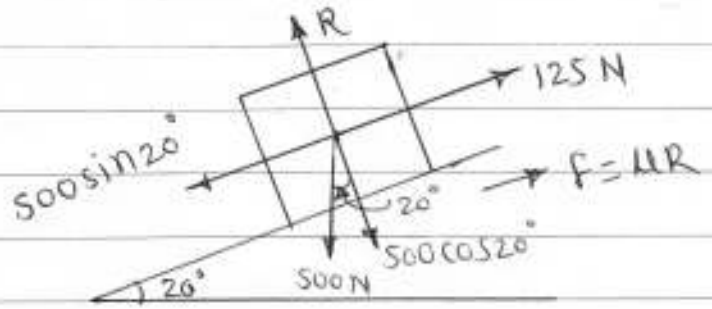
$\Sigma fy = 0$

$R + P\sin 40^\circ - W = 0$

$3.064P + 0.6427P - 150 = 0$

$3.7067P = 150$

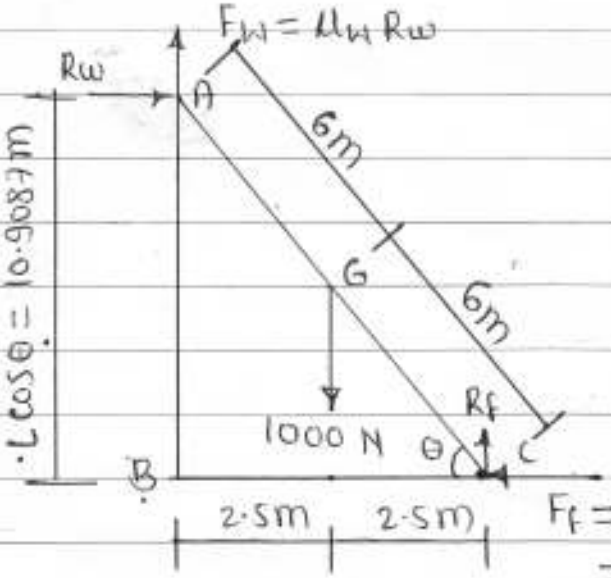
$\therefore P = \frac{150}{3.7067}$ $\therefore \boxed{P = 40.47\ N}$ 02

Q.NO	SOLUTION	MARKS
Q-4 (c)		01
	i) $\Sigma f_y = 0$	
	$R - 500 \cos 20^\circ = 0$	
	$\boxed{R = 469.85\ N}$	01
	ii) $\Sigma f_x = 0$	
	$125 + \mu R - 500 \sin 20^\circ = 0$	01
	$125 + \mu \times 469.85 - 171.010 = 0$	
	$-46.01 + \mu \times 469.85 = 0$	
	$-46.01 = -\mu \times 469.85$	
	$\mu \times 469.85 = 46.01$	
	$\mu = \frac{46.01}{469.85}$	
	$\mu = 0.0979 \simeq \boxed{\mu = 0.1}$	01

Q.NO	SOLUTION	MARKS

Q-4

(d) i)



$F_f = \mu_f R_f$

$= 0.25 R_F$ — 01

ii) $\cos\theta = \frac{5}{12}$

$\theta = \cos^{-1}\left(\frac{5}{12}\right)$ $\boxed{\theta = 65.37^\circ}$ — 01½

iii) $AB = L\sin\theta$

$AB = 12\sin 65.37^\circ$

$AB = 10.9087\,m$

$\boxed{AB = 10.9087\,m}$ — 01½

iv) $\Sigma F_x = 0$

$R_W - F_f = 0$

$\boxed{R_W = F_f}$

Q .NO	SOLUTION	MARKS
	$\Sigma f_y = 0$	
	$F_w + R_f - W = 0$ $0 + R_f - 1000 = 0$	
	$\therefore$ $\boxed{R_f = 1000\ N}$	01
	· Taking moments of all forces about A	
	$\Sigma M_A = 0$	
	$F_f \times L\cos\theta - R_f \times 5 + 1000 \times 2.5 + R_w \times 0 = 0$ $F_f \times 10.9087 - 1000 \times 5 + 2500 = 0$ $F_f \times 10.9087 - 5000 + 2500 = 0$ $10.9087\ F_f - 2500 = 0$	
	$F_f = \frac{2500}{10.9087}$	
	$\boxed{F_f = 229.17\ N}$	
	v> $F_f <$ limiting friction ($\mu_f R_f$) $229.17\ N < 0.25 \times 1000$ $229.17\ N < 250\ N$ ___ OK	
	$\therefore$ ladder will stand in position.	01

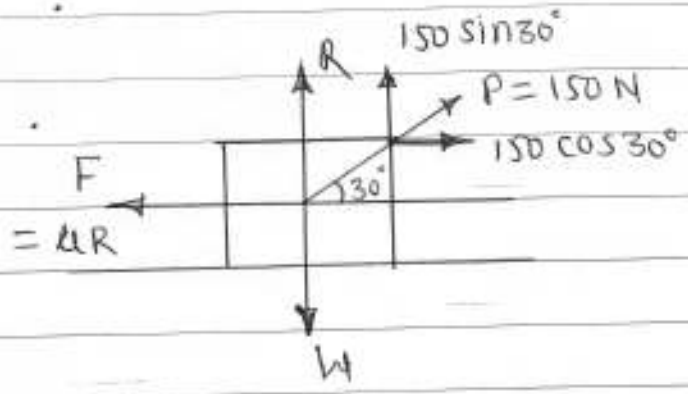
Q.NO	SOLUTION	MARKS
Q-4		
(e)	i) Maximum pull at which the man will slip (force in rope)	
	for equilibrium	
	$R = W = 650\ N$	
	$\therefore P = \mu_1 R_1 = \mu_1 W$	
	$P = 0.4 \times 650$	
	$\boxed{P = 260\ N}$	02
	ii) Let W_{max} be the greatest load which can be moved with this pull	
	for equilibrium	
	$R_2 = W_{max}$	
	& $P = F_2$	
	$\therefore 260 = F_2$	
	$\therefore 260 = \mu_2 R_2$	
	$260 = 0.3 \times R_2$	
	$\therefore R_2 = \frac{260}{0.3} = 866.67\ N$	
	but $R_2 = W_{max}$	
	$\therefore \boxed{W_{max} = 866.67\ N}$	02

Q.NO	SOLUTION	MARKS

Q-4

(f) Case–I>

When a pull of 150 N. is applied at 30°



1/2

i> $\Sigma F_y = 0$

$R + 150 \sin 30° - W = 0$

$R + 75 - W = 0$

$R = W - 75$ ——— (1)

ii> $\Sigma F_x = 0$

$50 \cos 30° - F = 0$

$50 \cos 30° - \mu R = 0$

$-\mu R + 129.90 = 0$

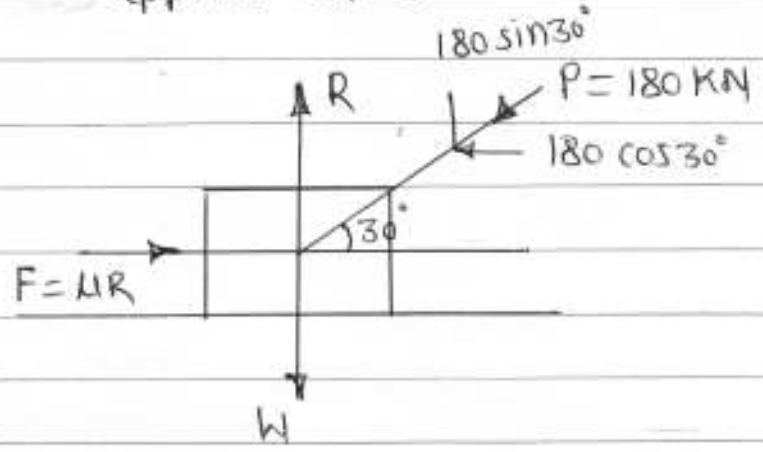
$\mu R = 129.90$

$\boxed{\mu = \frac{129.90}{R}}$ ——— (2) put R value in eqn (2)

$\boxed{\mu = \frac{129.90}{W - 75}}$ ——— (3) 01

Q.NO	SOLUTION	MARKS

Case-II) when a push of 180 KN is applied at 30°



1/2

i) $\Sigma F_y = 0$

$R - 180 \sin 30^\circ - W = 0$

$R = 180 \sin 30^\circ + W$

$R = 90 + W$ ——— (4)

$\Sigma F_x = 0$

$F - 180 \cos 30^\circ = 0$

$F = 180 \cos 30^\circ$

$F = 155.88$ KN

$\mu R = 155.88$

$\mu = \frac{155.88}{R}$ ——— (5)

put R value in eqn (5)

$$\boxed{\mu = \frac{155.88}{90 + W}} \quad \text{——— (6)}$$

01

Q.NO	SOLUTION	MARKS

Equating eqn (3) & (4)

$$\frac{129.90}{W-75} = \frac{155.88}{90+W}$$

$$129.90(90+W) = 155.88(W-75)$$

$$11691 + 129.90W = 155.88W - 11691$$

$$11691 + 11691 = 155.88W - 129.90W$$

$$23382 = 25.98W$$

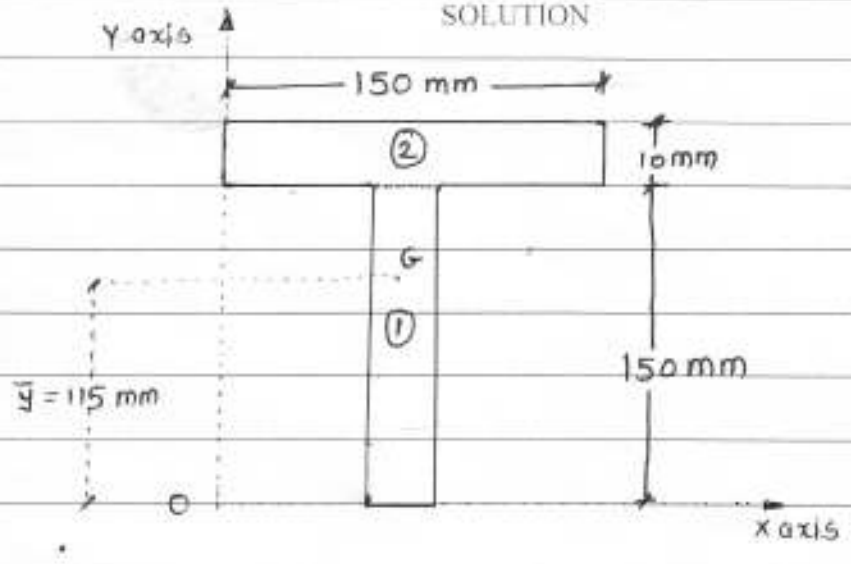
$$\boxed{W = 900\ KN}$$ 1/2

put W value in eqn (3)

$$\mu = \frac{129.90}{900-75}$$

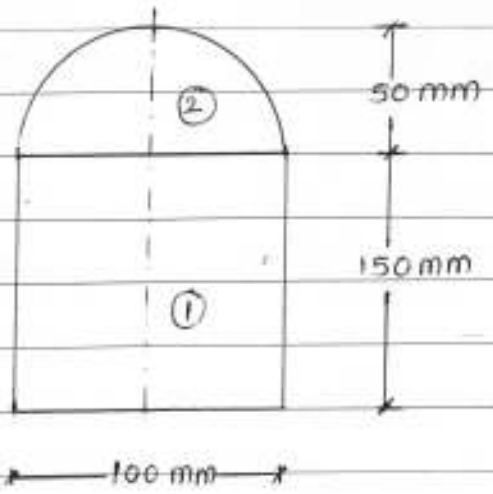
$$\mu = \frac{129.90}{825}$$

$$\boxed{\mu = 0.157}$$ 1/2

Q.NO	SOLUTION	MARKS
Q. 5 a)		
	Divide the 'T' s/c into two rectangles say ① & ②	
	$A_1 = 10 \times 150 = 1500\ mm^2$	01/2
	$A_2 = 150 \times 10 = 1500\ mm^2$	01/2
	The given section is symmetrical about Y axis.	
	$\therefore$ C.G will be on the axis.	
	$\therefore \bar{x} = \frac{150}{2} \quad \therefore \boxed{\bar{x} = 75\ mm}$	01
	$y_1 = \frac{150}{2} = 75\ mm$	1/2
	$y_2 = 150 + \frac{10}{2}$	
	$= 150 + 5$	
	$y_2 = 155\ mm$	1/2
	$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2}$	
	$= \frac{(1500 \times 75) + (1500 \times 155)}{1500 + 1500}$	
	$\boxed{\bar{y} = 115\ mm}$	01

Q.NO	SOLUTION	MARKS

(Q.5 b).



Divide the composite solid into two volumes ① & ②

$$V_1 = \pi r^2 h = \pi \times 50^2 \times 150$$

$$= 1.178 \times 10^6 \text{ mm}^3 \quad 1/2$$

$$V_2 = \frac{2}{3}\pi r^3 = \frac{2}{3} \times \pi \times 50^3$$

$$= 0.2617 \times 10^6 \text{ mm}^3 \quad 1/2$$

As the composite solid is symmentrical about vertical axis, c.g lies on it.

$$\therefore \bar{x} = \frac{100}{2} = 50 \text{ mm} \quad \text{(from left)} \quad 01$$

Distances of c.g from the base:

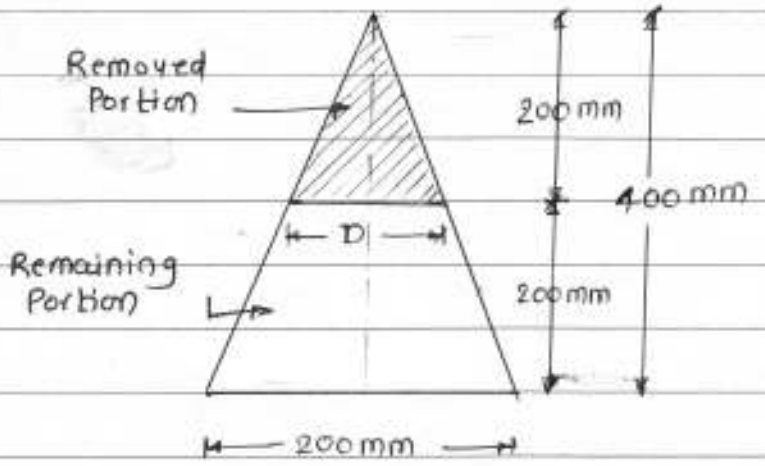
$$y_1 = \frac{h}{2} = \frac{150}{2} = 75 \text{ mm} \quad 1/2$$

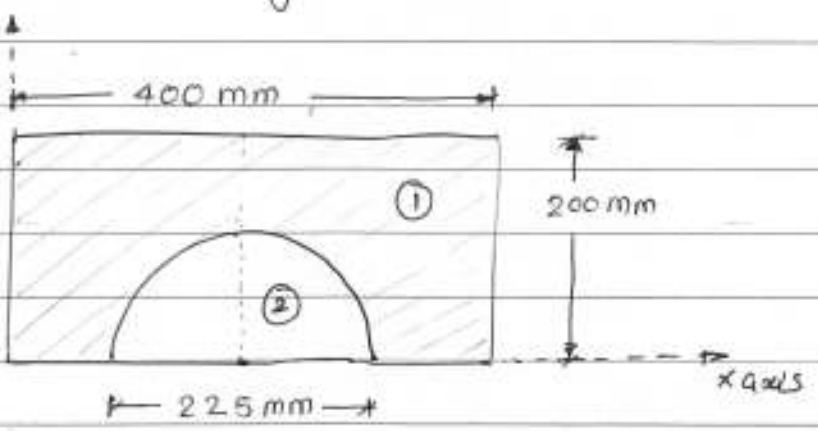
$$y_2 = 150 + \frac{3r}{8} = 150 + \frac{3 \times 50}{8}$$

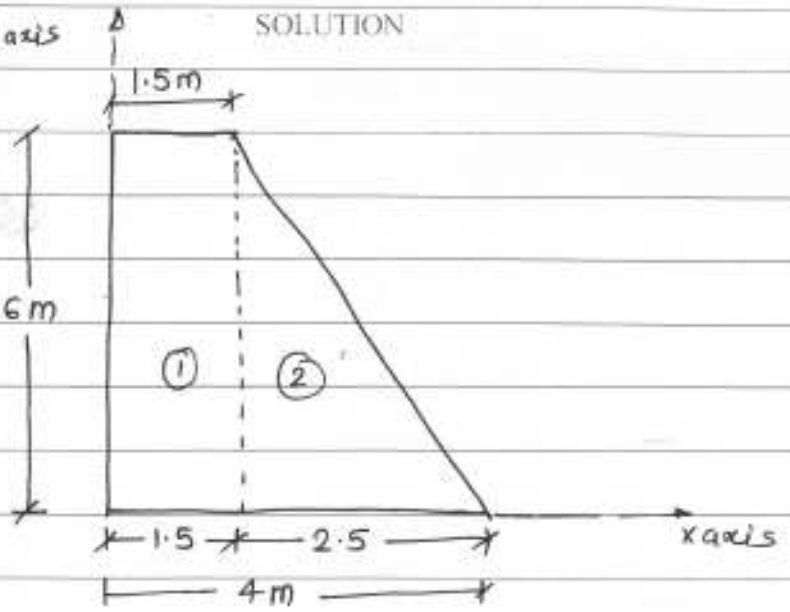
$$= 168.75 \text{ mm} \quad 1/2$$

$$\therefore \bar{y} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2} = \frac{(1.178 \times 10^6 \times 75) + (0.2617 \times 10^6 \times 168.75)}{(1.178 \times 10^6) + (0.2617 \times 10^6)}$$

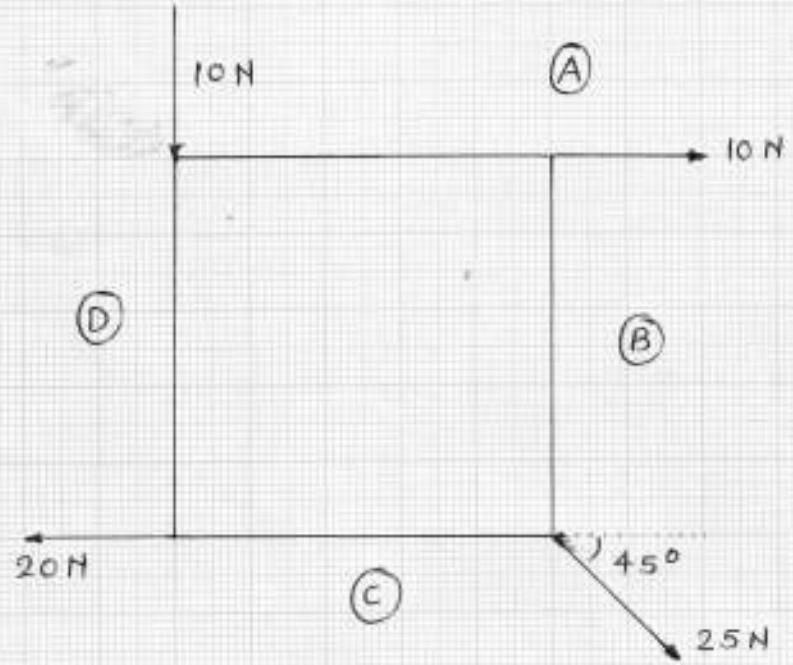
$$\boxed{\bar{y} = 92.04 \text{ mm}} \quad 01$$

Q.NO	SOLUTION	MARKS
Q.5 c).		
	Let, V_1 = Volume of bigger cone	
	V_2 = Volume of smaller cone	
	D = Diameter of smaller cone	
	From similar triangles,	
	$\frac{400}{200} = \frac{200}{D}$	
	$\therefore D = \frac{200 \times 200}{400}$	
	$\boxed{D = 100 \text{ mm}}$	01
	$V_1 = \frac{1}{3}\pi \cdot r^2 \cdot h = \frac{1}{3} \times \pi \times 100^2 \times 400$	
	$= 4.188 \times 10^6 \text{ mm}^3$	1/2
	$V_2 = \frac{1}{3}\pi \cdot r^2 \cdot h = \frac{1}{3} \times \pi \times 50^2 \times 200$	
	$= 0.523 \times 10^6 \text{ mm}^3$	1/2
	Distances of c.g from base.	
	$y_1 = \frac{400}{4} = 100 \text{ mm}$	1/2
	$y_2 = 200 + \frac{200}{4} = 250 \text{ mm}$	1/2
	$\therefore \bar{y} = \frac{V_1 y_1 - V_2 y_2}{V_1 - V_2}$	
	$= \frac{(4.188 \times 10^6 \times 100) - (0.523 \times 10^6 \times 250)}{4.188 \times 10^6 - 0.523 \times 10^6} = 78.59 \text{ mm}$	01

Q.NO	SOLUTION	MARKS
	∴ The C.g lies at 185.72 mm from the base on the line of symmetry.	
Q.5 d)		
	Divide the composite fig. into two portion say ① & ②	
	Area of rectangle, $A_1 = 400 \times 200$	
	$= 80 \times 10^3 \text{ mm}^2$	1/2
	Area of semicircle, $A_2 = \frac{\pi r^2}{2} = \frac{\pi \times (112.5)^2}{2}$	
	$= 19.88 \times 10^3 \text{ mm}^2$	1/2
	The given figure is symmetrical about Y axis	
	∴ C.G will be on the axis of symmetry	
	∴ $\bar{x} = \frac{400}{2}$ $\boxed{\therefore \bar{x} = 200 \text{ mm}}$	01
	$y_1 = \frac{200}{2} = 100 \text{ mm}$	1/2
	$y_2 = \frac{4r}{3\pi} = \frac{4 \times 112.5}{3\pi} = 47.74 \text{ mm}$	1/2
	$\bar{y} = \frac{A_1 y_1 - A_2 y_2}{A_1 - A_2}$	
	$= \frac{(80 \times 10^3 \times 100) - (19.88 \times 10^3 \times 47.74)}{(80 \times 10^3) - (19.88 \times 10^3)}$	
	$\boxed{\bar{y} = 117.28 \text{ mm}}$	01

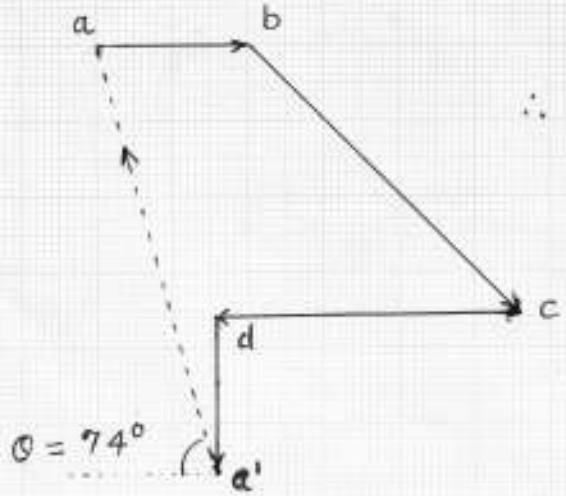
Q.NO	SOLUTION	MARKS
Q.5 e)		
	Divide the composite fig. into two parts say ① & ②	
	$A_1 = 1.5 \times 6 = 9\ m^2$	
	$A_2 = \frac{1}{2} \times 2.5 \times 6 = 7.5\ m^2$	
	Distances of centroid from Yaxis:	
	$x_1 = \frac{1.5}{2} = 0.75\ m$	1/2
	$x_2 = 1.5 + \frac{1}{3} \times 2.5 = 2.33\ m$	1/2
	Distances of centroid from Xaxis	
	$y_1 = \frac{6}{2} = 3m$	1/2
	$y_2 = \frac{1}{3} \times 6 = 2m$	1/2
	$\bar{x} = \frac{A_1 x_1 + A_2 x_2}{A_1 + A_2} = \frac{(9 \times 0.75) + (7.5 \times 2.33)}{9 + 7.5}$	
	$\boxed{\bar{x} = 1.468\ m}$	01
	$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = \frac{(9 \times 3) + (7.5 \times 2)}{9 + 7.5}$	
	$\boxed{\bar{y} = 2.545\ m}$	01

Q. 5 f)



01 Mark

SPACE DIAGRAM



Length of a'a = 5.8 cm

∴ Equilibrant force E,

E = l(a'a) × scale

= 5.8 × 5

E = 29 N & 01 Ma

θ = 74°

VECTOR DIAGRAM
(Scale : 1 cm = 5 N)

02 Marks

Q.NO	SOLUTION	MARKS
Q6. a)	Data - V.R = 100	
	W = 500 N	
	$\eta\% = 55\%$	
	To Find - P	
	Solution - $MA = \frac{W}{P} = \frac{500}{P}$	01
	$\eta\% = \frac{MA}{VR} \times 100$	01
	$55 = \frac{(500/P)}{100} \times 100$	
	$\therefore \frac{500}{P} = \frac{55 \times 100}{100}$	
	$\therefore \frac{500}{P} = 55$	
	$\therefore P = \frac{500}{55}$	
	$\therefore \boxed{P = 9.090 \text{ N}}$	02
6. b)	Data - Initial frictional resistance = 15 N	
	VR = 25	
	W = 5 KN = 5000 N	
	Frictional resistance increases at the rate of 5N / 500N load.	
	To Find - i) P when W = 5 KN	
	ii) $\eta\%$ when W = 5 KN	
	Solution - Effort lost in friction = Total frictional resistance	

Q.NO	SOLUTION	MARKS
	For 500 N Load frictional resistance is 5 N.	
	∴ For 5000 N Load frictional resistance,	
	$= \frac{5000 \times 5}{500}$	
	$= 50\ N$	01
	∴ Total frictional resistance for 5000 N Load	
	= initial resistance + frictional resistance at the rate of 5N/500N	
	$= 15 + 50$	
	$= 65\ N$	01
	∴ Effort lost in friction, $P_f = 65\ N$	
	i) Effort required to lift a load of 5 KN or 5000 N,	
	$P_f = P - P_i$	
	∴ $P_f = P - \frac{W}{VR}$ ∵ $P_i = \frac{W}{VR}$	
	∴ $65 = P - \left(\frac{5000}{25}\right)$	
	∴ $65 = P - 200$	
	∴ $P = 65 + 200$	
	∴ $\boxed{P = 265\ N}$	01
	ii) Efficiency when W = 5 KN or 5000 N	
	$MA = \frac{W}{P} = \frac{5000}{265}$	
	∴ $MA = 18.86$	
	∴ $\eta\% = \frac{MA}{VR} \times 100$	
	$= \frac{18.86}{25} \times 100$	
	$\boxed{\eta\% = 75.44\%}$	01

Q.NO	SOLUTION	MARKS
6.c)	Data –	
	$P_1 = 150\ N$, $W_1 = 1200\ N$	
	$P_2 = 200\ N$, $W_2 = 2000\ N$	
	To Find – i) Law of Machine	
	ii) P when $W = 5\ kN = 5000\ N$	
	Solution –	
	$P = mW + C$ (Law of Machine)	
	Substituting the given values of P and W in above equation, we get	
	$150 = m \cdot 1200 + C$ ... (i)	1/2
	$200 = m \cdot 2000 + C$ .... (ii)	1/2
	Subtracting eqn (i) from eqn (ii), we get	
	$200 = m \cdot 2000 + C$	
	$-\ 150 = m \cdot 1200 + C$	
	$50 = m \cdot 800 + 0$	
	$\therefore\ m = 50/800$	
	$\boxed{m = 0.0625}$	1/2
	Substituting the value of 'm' in eqn (i), we get	
	$150 = (0.0625 \times 1200) + C$	
	$\therefore\ C = 150 - 75$	
	$\boxed{C = 75N}$	1/2
	i) Law of machine is,	
	$\boxed{P = 0.0625\ W + 75N}$	01
	ii) Effort when $W = 5\ kN = 5000\ N$,	
	$P = (0.0625 \times 5000) + 75$	
	$\boxed{P = 387.5\ N}$	01

Q.NO	SOLUTION	MARKS
Q.6 d)	Data – D = 40 cm	
	d_1 = 10 cm	
	d_2 = 8 cm	
	$\eta\%$ = 75 %	
	P = 150 N	
	To Find – W in kN	
	Solution – Velocity Ratio of Machine is,	
	$VR = \frac{2D}{d_1 - d_2}$	
	$= \frac{2 \times 40}{10-8} = \frac{80}{2}$	
	$\boxed{VR = 40}$	02
	Now, efficiency $\eta\% = \frac{MA}{VR} \times 100$	
	But $MA = \frac{W}{P} = \frac{W}{150}$	
	$\therefore 75 = \frac{(W/150)}{40} \times 100$	
	$\therefore \frac{W}{150} = \frac{75 \times 40}{100}$	
	$\therefore \frac{W}{150} = 30$	
	$\therefore \boxed{W = 4500 \text{ N}}$	
	$\therefore \boxed{W = 4.5 \text{ kN}}$	02
Q.6.e)	Data – P = 1500 N	
	$\eta\%$ = 75 %	
	No. of cogs on Effort wheel = N_1 = 100	
	No. of cogs on Load wheel = N_4 = 10	
	No. of teeth on the pinion = N_2 = 20	
	No. of teeth on the spur = N_3 = 40	
	To Find – W.	

Q.NO	SOLUTION	MARKS
	Solution – V.R. of geared pulley block is given by,	
	$V.R = \frac{N_1}{N_2} \times \frac{N_3}{N_4}$	01
	$= \frac{100}{20} \times \frac{40}{10}$	
	$\therefore \boxed{VR = 20}$	01
	To Find the load lifted,	
	$MA = \frac{W}{P} = \frac{W}{1500}$	
	$\eta\% = \frac{MA}{VR} \times 100$	
	$\therefore 75 = \frac{(W/1500)}{20} \times 100$	
	$\therefore \frac{W}{1500} = \frac{75 \times 20}{100}$	
	$\therefore W = 15 \times 1500$	
	$\boxed{W = 22500\ N}$	02
Q.6. f)	Data – $P = 80\ N$	
	$W = 350\ N$	
	To Find – i) P_f ii) W_f iii) $\eta\%$	
	solution –	
	Velocity Ratio of Three sleave Pulley Block	
	$\boxed{VR = 6}$	01
	i) Effort lost in friction = P_f,	

Q.NO	SOLUTION	MARKS
	$P_f = P - P_i$	
	$= P - \frac{W}{VR}$	
	$= 80 - \left(\frac{350}{6}\right)$	
	$\therefore \boxed{P_f = 21.66\ N}$	01
	ii) Load lost in friction = W_f.	
	$W_f = W_i - W$	
	$= (P \times VR) - W$	
	$= (80 \times 6) - 350$	
	$\therefore \boxed{W_f = 130\ N}$	01
	iii) Efficiency $\eta\%$.	
	$\eta\% = \frac{MA}{VR} \times 100$	
	$= \frac{W/P}{VR} \times 100$	
	$= \frac{350/80}{6} \times 100$	
	$\therefore \boxed{\eta\% = 72.91\ \%}$	01