POSTAL BOOK PACKAGE 2024

CONTENTS

MECHANICAL ENGINEERING

Objective Practice Sets

Engineering Mechanics

1 CHAPTER FBD, Equilibrium, Plane Trusses and Virtual Work

MCQ and NAT Questions

Q.1 Varignon's theorem is applicable only when the forces are:
(a) coplanar (b) concurrent
(c) non-concurrent (d) parallel

Q.2 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

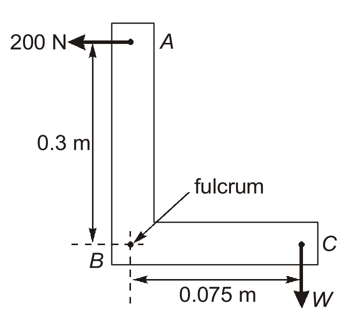
List-I
A. Lami's theorem
B. Varignon's theorem
C. Newton's first law of motion
D. Polygon law of forces

List-II
1. Determination of the position of resultant of parallel forces.
2. Definitions of the general condition of equilibrium.
3. Determination of resultant of non-parallel forces.
4. Estimation of the three forces on a body in equilibrium.

Codes:

	A	B	C	D
(a)	4	1	2	3
(b)	1	4	3	2
(c)	1	4	2	3
(d)	4	1	3	2

Q.3 A horizontal force of 200 N is applied at A to lift the weight *W* at *C* as shown in the figure. The value of weight *W*, will be



(a) 200 N (b) 400 N
(c) 600 N (d) 800 N

Q.4 If two forces P and Q act at an angle θ the resultant of these two forces would make an angle α with P such that

(a) $\tan\alpha = \dfrac{Q\sin\theta}{P-Q\sin\theta}$

(b) $\tan\alpha = \dfrac{P\sin\theta}{P+Q\sin\theta}$

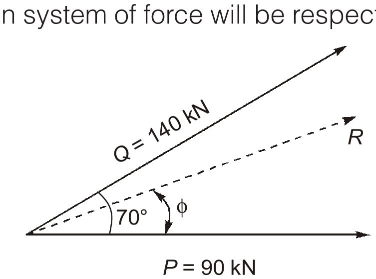
(c) $\tan\alpha = \dfrac{Q\sin\theta}{P+Q\cos\theta}$

(d) $\tan\alpha = \dfrac{P\sin\theta}{Q-P\cos\theta}$

Q.5 The sum of the magnitudes of two forces acting at a point is 18 and the magnitude of their resultant is 12. If the resultant is 90° with the forces of smaller magnitude, the magnitude of forces are
(a) 10 and 8 (b) 9 and 9
(c) 5 and 13 (d) 6 and 12

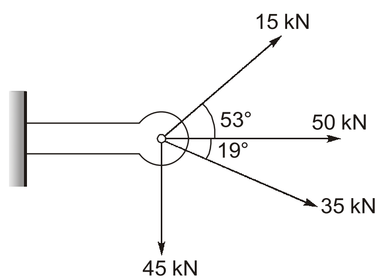
Q.6 If the magnitude of maximum and minimum resultant forces of the two forces acting on a particle are 40 kN and 10 kN respectively, then the two forces would be
(a) 25 kN and 15 kN
(b) 20 kN and 20 kN
(c) 20 kN and 10 kN
(d) 20 kN and 5 kN

Q.7 The resultant R and angle of resultant ϕ for the given system of force will be respectively:



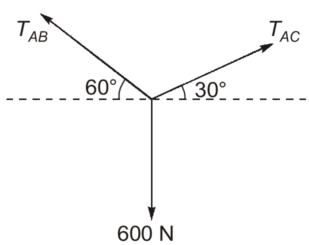
(a) 190.58 kN; 43° 39′ (b) 138.13 kN, 72°14′
(c) 166.43 kN; 47°51′ (d) 190.58 kN, 72°14′

Q.8 In the above figure, four cable exerts tension as indicated on the eyebolt. It is intended to replace these cables by a single cable. The tension on the single cable and angle at which it will be oriented w.r.t. the 50 kN (Assume coplanar force system).



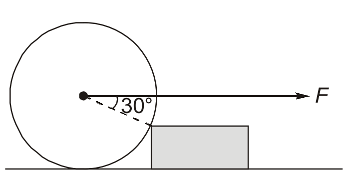
(a) 102.27 kN, 64.36° (clockwise)
(b) 102.27 kN, 25.74° (clockwise)
(c) 100.5 kN, 25.74° (clockwise)
(d) 100.5 kN, 64.26° (clockwise)

Q.9 If a point *A* is in equilibrium under the action of the applied forces, the value of tensions T_{AB} and T_{AC} are respectively



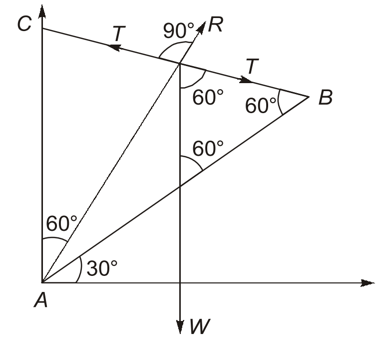
(a) 520 N and 300 N (b) 300 N and 520 N
(c) 450 N and 150 N (d) 150 N and 450 N

Q.10 A roller of weight *W* is rolled over the wooden block as shown in figure below. The pull *F* required to just cause the said motion is:

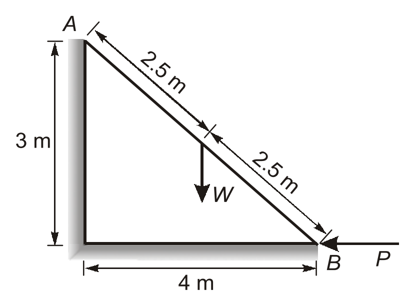


(a) $\frac{W}{2}$ (b) W
(c) $\sqrt{3}W$ (d) $2W$

Q.11 A uniform beam *AB* as shown in figure below is pinned at *A* and is held by a cable *BC* in the position shown. If the tension in the cable is 20 kgf, then the reaction of the pin at A on the beam will be ________ kgf.

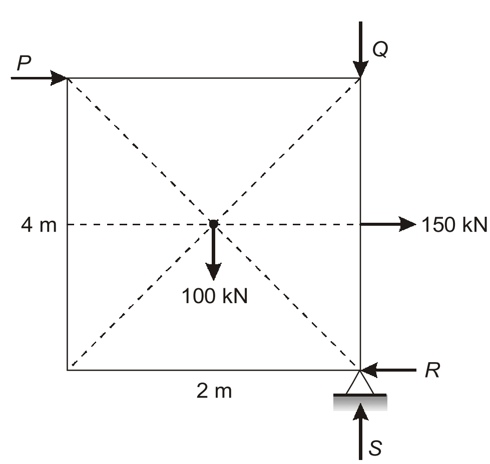


Q.12 A ladder *AB* of length 5 m and weight (W) = 600 N is resting against a wall. Assuming frictionless contact at the floor (B), and the wall (A), the magnitude of force P(in Newton) required to maintain equilibrium of ladder is ________.



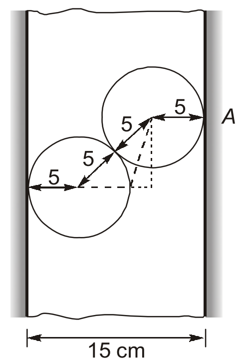
Q.13 Weight of 120 kN is being supported by a tripod whose each leg of length of 13 m. If the vertical height of the point of attachment of the load is 12 m, the force on the tripod leg would be
(a) 37.67 kN (b) 40 kN
(c) 43.3 kN (d) 46.6 kN

Q.14 A rectangular plate is held in equilibrium by then application of forces as shown in figure. What is the magnitude of the force *P*?



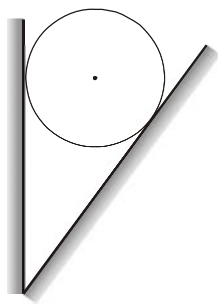
(a) 35 kN (b) 50 kN
(c) 100 kN (d) 200 kN

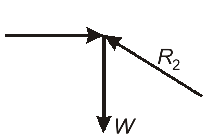
Q.15 In the figure shown, consider the two identical spheres with radius 5 cm, weight 100 N each and the distance between the two walls as 15 cm. What is the reaction force at point A?

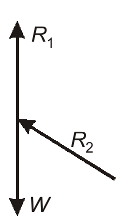


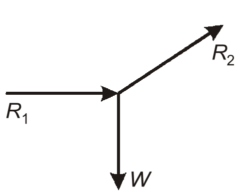
(a) 173.2 N (b) 57.7 N
(c) 100 N (d) 0 N

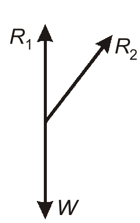
Q.16 A ball of weight W is supported on smooth planes as shown in figure. The correct FBD will be given by:



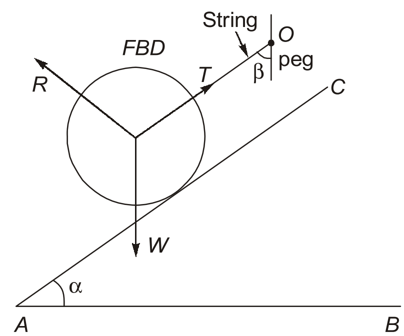
(a)


(b)


(c)


(d)


Q.17 In the system shown in figure forces W, T and R are related as:



(a) $\dfrac{W}{\sin(180+(\alpha+\beta))} = \dfrac{T}{\sin(90^\circ-\alpha)} = \dfrac{R}{\sin(90^\circ-\beta)}$

(b) $\dfrac{W}{\sin(\alpha+\beta)} = \dfrac{T}{\sin\alpha} = \dfrac{R}{\sin\beta}$

(c) $\dfrac{W}{\sin(90^\circ-(\alpha-\beta))} = \dfrac{T}{\sin\alpha} = \dfrac{R}{\sin\beta}$

(d) $\dfrac{W}{\sin(\alpha+\beta)} = \dfrac{T}{\sin\alpha} = \dfrac{R}{\sin\beta}$

Q.18 Three forces acting at a point 'O' are

$P_1 = (3\hat{i}+6\hat{j})N$

$P_2 = (-1.5\hat{i}+4.5\hat{j})N$

$P_3 = (-10.5\hat{i}+1.5\hat{j})N$

If a fourth force P_4 is added such that the point 'O' is in equilibrium, then force P_4 will be

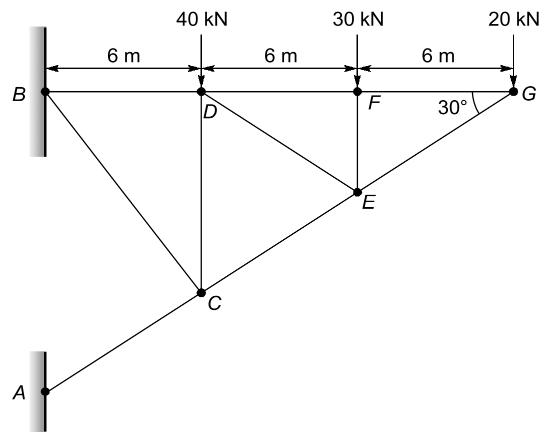
(a) $(-15\hat{i}+15\hat{j})N$ (b) $(-9\hat{i}+12\hat{j})N$

(c) $(-9\hat{i}+12\hat{j})N$ (d) $(-15\hat{i}+15\hat{j})N$

Q.19 Two non-collinear equal parallel forces acting in opposite direction will have
(a) no resultant force and moment
(b) a moment but no resultant force
(c) a resultant force but no moment
(d) a moment and a resultant force

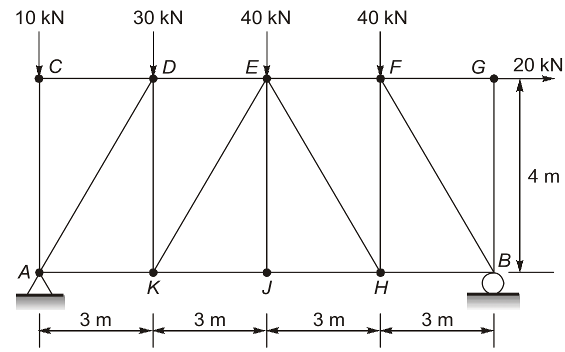
Q.20 The vector product of two non-zero vectors is zero if and only if the vectors are
(a) perpendicular (b) concurrent
(c) parallel or collinear (d) co-planar

Q.21 Four coplanar forces acting at a point 'O' as shown in figure. The equilibrium of the force system acting at O is given by



(a) Force in member EG is 40 kN (Compressive).
(b) Force in member GF is 34.64 kN (Tensile).
(c) Force in member DF is 34.6 kN (Tensile).
(d) Force in member EF is 30 kN (Compressive).

Q.59 A truss is loaded as shown in figure. All members are pin jointed.



(a) Force in member AC is 10 kN (Compressive).
(b) Force in member CD is 0.
(c) Force in member BG is 0.
(d) Force in member JE is 0.

■■■■

Answers FBD, Equilibrium, Plane Trusses and Virtual Work

1. (b)	2. (a)	3. (d)	4. (c)	5. (c)	6. (a)	7. (a)	8. (b)	9. (a)	10. (c)
11. 346.4	12. 400	13. (c)	14. (b)	15. (b)	16. (a)	17. (b)	18. (b)	19. (b)	20. (c)
21. (a)	22. (b)	23. 57.74	24. (a)	25. 100	26. (c)	27. (b)	28. (a)	29. 50	30. 20
31. (d)	32. (d)	33. 1.5	34. (d)	35. (a)	36. (b)	37. (b)	38. (c)	39. (d)	40. 84.3
41. (b)	42. (c)	43. (a)	44. (c)	45. 70.71	46. (d)	47. (a)	48. 0	49. 5	50. 20
51. (a)	52. (c)	53. (c)	54. (d)	55. 10.606		56. (a, b)		57. (a, b, d)	
58. (a, b, c, d)		59. (a, b, c, d)							

Explanations FBD, Equilibrium, Plane Trusses and Virtual Work

2. (a)

Lami's theorem: In statics, lami's theorem is an equation relating the magnitudes of three coplanar, concurrent and non-collinear forces which keeps an object in static equilibrium, with the angles directly opposite to the corresponding forces,

$$\frac{A}{\sin\alpha} = \frac{B}{\sin\beta} = \frac{C}{\sin\gamma}$$

Where,

A, *B*, *C* are the magnitude of three coplanar, concurrent and non-collinear forces which keeps the object in static equilibrium, and α, β and γ are the angles directly opposite to the forces *A*, *B* and *C* respectively.

Polygon Law's of forces: If a number of forces acting simultaneously on a particle be represented in magnitude and direction by the sides of a polygon taken in order, their resultant may be represented in magnitude and direction by the closing side of the polygon taken in opposite order.

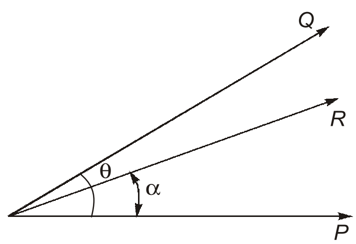
Newton's first Law of Motion: When viewed in an inertial reference frame, an object either remains at rest or moves with constant velocity, unless acted upon by an external force.

Varignon's Theorem: The moment about any point of the resultant of several concurrent forces is equal to the sum of the moments of the particular forces about the same point.

3. (d)
Taking moment about fulcrum B,
$200 \times 0.3 = W \times 0.075$

$$W = \frac{200 \times 0.3}{0.075} = 800 \text{ N}$$

4. (c)



$$R \sin\alpha = Q\sin\theta$$
$$R \cos\alpha = Q\cos\theta + P$$
$$\Rightarrow \quad \tan\alpha = \frac{Q\sin\theta}{Q\cos\theta + P}$$

5. (c)
Let P be the smaller force,
$P + Q = 18$ ...(1)
$R = (P^2 + Q^2 + 2PQ\cos\theta)^{1/2} = 12$ ...(2)
Also,

$$\frac{Q\sin\theta}{P + Q\cos\theta} = \tan\alpha = \tan 90° = \infty$$

$\Rightarrow$ $P + Q\cos\theta = 0$ ...(3)
Subtracting eq. (3) eq. (1)
$P + Q\cos\theta - P - Q = 0 - 18$
$Q(1 - \cos\theta) = 18$ ...(4)
Now, operating square of eq. (2- eq. (1)
$18^2 - (12)^2 = 2PQ(1 - \cos\theta)$
$180 = 2PQ(1 - \cos\theta)$ ...(5)
Operate eq. (4) subtract eq. (5)

$$\frac{Q(1-\cos\theta)}{2PQ(1-\cos\theta)} = \frac{18}{180}$$
$$2P = 10$$
$$P = 5$$

From eq. (1); Q = 18 – 5 = 13
So, magnitude of forces are 5 and 13.

6. (a)
Resultant of two forces,

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

R will be maximum when, $\cos\theta = 1$

$$R_{max} = \sqrt{P^2 + Q^2 + 2PQ} = \sqrt{(P+Q)^2} = P + Q$$

R will be minimum when, $\cos\theta = -1$

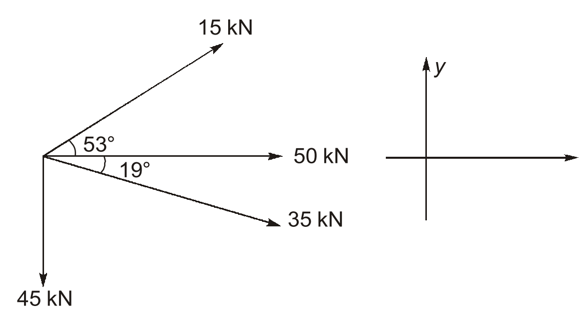
$$R_{min} = \sqrt{P^2 + Q^2 - 2PQ} = \sqrt{(P-Q)^2} = P - Q$$

$P + Q = 40$
$P - Q = 10$
$2P = 50$
$P = 25$ kN; $Q = 15$ kN

7. (a)

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$
$$= \sqrt{(90)^2 + (140)^2 + 2 \times 140 \times 90 \times (\cos 70°)}$$
$$= 190.58 \text{ kN}$$
$$\tan\phi = \frac{Q\sin\theta}{P + Q\cos\theta}$$
$$= \frac{140\sin 70°}{90 + 140\cos 70°} = 0.594$$
$$\phi = 43°39'$$

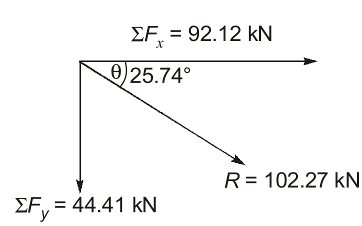
8. (b)
Figure can be idealized as:



$\Sigma F_x = 50 + 15\cos 53° + 35\cos 19° = 92.12$ kN
$\Sigma F_y = 15\sin 53° - 45 - 35\sin 19° = -44.41$ kN
Resultant,

$$F_R = \sqrt{(92.12)^2 + (-44.41)^2} = 102.26 \text{ kN}$$

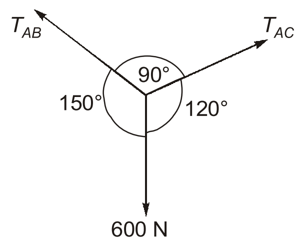
$$\tan\theta = \left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$



$$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right) = \tan^{-1}\left(\frac{44.41}{92.12}\right) = 25.74°$$

9. (a)

Method : 1

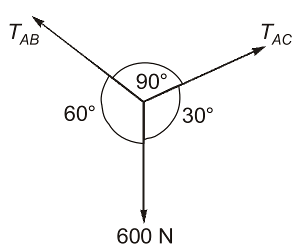


$$\frac{T_{AB}}{\sin 120°} = \frac{T_{AC}}{\sin 150°} = \frac{600}{\sin 90°}$$

$$T_{AB} = 600 \sin 120° = 519.61$$
$$= 520 \text{ N}$$
$$T_{AC} = 600 \sin 150° = 300 \text{ N}$$

Method : 2

In equilibrium:



$$\Sigma F_x = 0$$
$$T_{AC}\cos 30° - T_{AB}\cos 60° = 0$$

$$T_{AC} = T_{AB}\frac{\cos 60°}{\cos 30°} = \frac{T_{AB}}{\sqrt{3}} \quad \text{...(i)}$$

Vertical forces $\Sigma F_y = 0$

$$T_{AC}\sin 30° + T_{AB}\sin 60° - 600 = 0$$

$$T_{AC} + \sqrt{3}\cdot T_{AB} = (600 \times 2)$$

$$T_{AC} + \sqrt{3}\cdot T_{AB} = 1200 \quad \text{...(ii)}$$

From eq. (i) and eq. (ii)

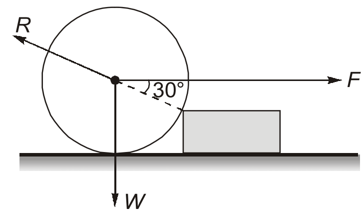
$$\frac{T_{AB}}{\sqrt{3}} + \sqrt{3}\cdot T_{AB} = 1200$$

$$4T_{AB} = 1200\sqrt{3}$$

$$T_{AB} = 300\sqrt{3} = 519.61 \text{ N}$$
$$\simeq 520 \text{ N}$$

and $$T_{AC} = \frac{T_{AB}}{\sqrt{3}} = \frac{300\sqrt{3}}{\sqrt{3}} = 300 \text{ N}$$

10. (c)



$$R\cos 60° = W$$

$$R \times \frac{1}{2} = W$$

$$R = 2W$$

Also, $F = R\cos 30° = 2W \times \frac{\sqrt{3}}{2} = \sqrt{3}\ W$

11. 346.4(345 to 347)

From Lami's theorem:

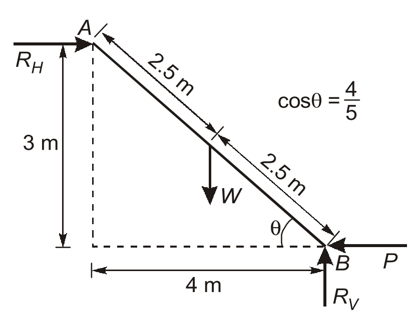
$$\frac{W}{\sin 90°} = \frac{T}{\sin(90°+60°)} = \frac{R}{\sin(90°+30°)}$$

$$W = \frac{200 \times 2}{1} = \frac{R \times 2}{\sqrt{3}}$$

$$R = 200\sqrt{3} \text{ kgf} = 346.4 \text{ kg(f)}$$

12. 400 (399 to 401)

FBD diagram of the ladder:



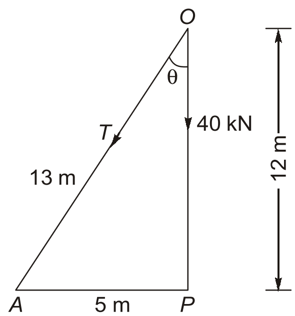
Taking moment about B

$$R_H \times 3 = W \times 2.5 \cos\theta$$

$$R_H = \frac{600 \times 2.5 \times \frac{4}{5}}{3} = 400 \text{ N}$$

$$\Sigma F_H = 0$$
$$R_H = P = 400 \text{ N}$$

13. (c)



The weight $W = 120$ kN would be equally shared by all the three legs.
Since the vertical height $OP = 12$ m
Length of leg $OA = 13$ m

$$\therefore \quad AP = \sqrt{(13)^2 - (12)^2} = 5\text{m}$$

If the force on tripod leg is T, then

$$T\cos\theta + 40 = 0$$

$$T = \frac{-40}{\cos\theta} = \frac{-40}{\left(\frac{12}{13}\right)}$$

$$\Rightarrow \quad T = 43.3 \text{ kN} \qquad \text{(Comp.)}$$

14. (b)
Since, the rectangular plate is held in equilibrium,

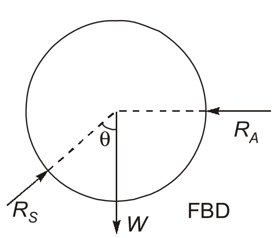
$$\Sigma M_{\text{Hinge}} = 0$$

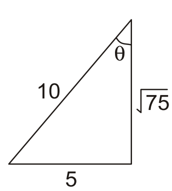
$$P \times 4 + 150 \times 2 = 100 \times 1$$

$$P = \frac{(100-300)}{4} = -50 \text{ kN}$$

Magnitude of force, $P = 50$ kN

15. (b)





$$\cos\theta = \frac{\sqrt{75}}{10}$$

$$\sin\theta = \frac{5}{10}$$

$$\Sigma F_y = 0$$

$$W = R_s\cos\theta$$

$$R_s = \frac{W}{\cos\theta} = \frac{100\times 10}{\sqrt{75}} = \frac{1000}{\sqrt{75}}$$

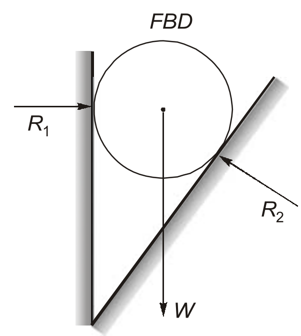
$$\Sigma F_x = 0$$

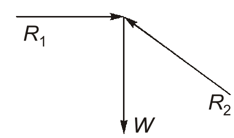
$$R_s\sin\theta = R_A$$

$$R_A = \frac{100}{\sqrt{75}} \times \frac{5}{10} = \frac{500}{\sqrt{75}}$$

$$= 57.735 \text{ N}$$

16. (a)





17. (b)
From geometry it is clear that the angle between R and T is $(\alpha + \beta)$
Angle between R and W is $(180° - \alpha)$
Angle between T and W is $(180° - \beta)$
Using Lami's theorem

$$\frac{W}{\sin(\alpha+\beta)} = \frac{T}{\sin(180°-\alpha)} = \frac{R}{\sin(180°-\beta)}$$

18. (b)
For equilibrium

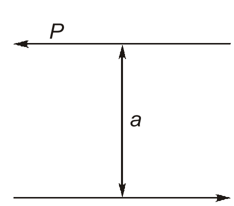
$$P_1 + P_2 + P_3 + P_4 = 0$$

$$P_4 = -(P_1 + P_2 + P_3)$$

$$= -\left(3\hat{i} + 6\hat{i} - 1.5\hat{j} + 4.5\hat{j} - 10.5\hat{i} + 1.5\hat{j}\right)$$

$$= -\left(-9\hat{i} + 12\hat{j}\right) = \left(9\hat{i} - 12\hat{j}\right)N$$

19. (b)
Since equal forces are in opposite direction, so, resultant force will be zero.



moment = (Pa)