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1994-2010

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Civil Engineering

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Preface

B. Singh (Ex. IES)

Engineering Services is one of the dream job destination for every engineer be it UPSC Engineering Services or State Engineering Services. With the increase in competition, increase in levels of practice is much desirable. Moreover, it is observed that year on year UPSC Engineering Service paper standard and pattern is moving close to Civil Services Prelims Paper (when Engineering Optional paper was included). Not only this it is well noticed that previous years' questions of Civil Services Engineering Optional paper are modified and are sometimes asked in Engineering Services exam. This clearly portrays practice of these questions has become very important to get an upper edge in UPSC Engineering Services and other State Engineering Services examination. To facilitate aspirants with practice of every possible question, MADE EASY has come up with all new book of Civil Services Prelims previous years' solved papers (of Engineering Optional) which will surely act as add on practice set for aspirants.

This book is the 3rd edition and has papers of 17 years (1994-2010) with complete explanation of almost every question, written in coherent manner. Due emphasis is made to make aspirants understand the concept and logic behind every question. To make practice easy, the book is segregated in topicwise content so that aspirants can learn topic and practice the questions and thereby prepare thoroughly for the exam.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand upto the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

Best Wishes

B.Singh (Ex. IES)
CMD, MADE EASY Group

Previous CSE Prelims Solved Papers: 1994-2010

UPSC Civil Services Preliminary Examination

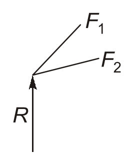
Civil Engineering

CONTENTS

1 Engineering Mechanics

System of Forces

1. In the system of coplanar concurrent forces shown in the given figure,



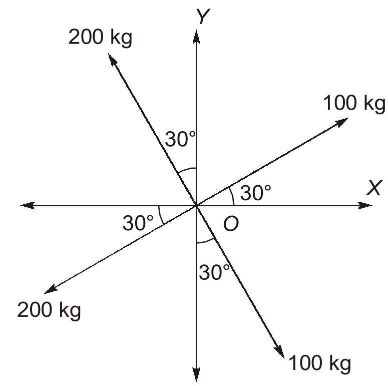
If 'R' is the known force, then to find the unknown force F_1, all the forces are to be resolved in the direction
(a) of the force F_1
(b) of the force F_2
(c) of the force R
(d) normal to the line of action of F_2
[CSE-Pre : 1994]

2. If n_1 and n_2 are the measures of a given physical quantity when the units used are u_1 and u_2 respectively, then
(a) $n_1\sqrt{u_1} = n_2\sqrt{u_2}$ (b) $\sqrt{n_1}\,u_1 = \sqrt{n_2}\,u_2$
(c) $n_1u_1 = n_2u_2$ (d) $n_1n_2 = u_1u_2$
[CSE-Pre : 1994]

3. In a system of coplanar forces, when the force polygon closes but funicular polygon does not close, the forces are
(a) equivalent to a couple
(b) equivalent to a resultant whose magnitude, direction and line of action can be determined.
(c) in equilibrium
(d) equivalent to a couple and a resultant force.
[CSE-Pre : 1994]

4. Two ships A and B leave a port at the same time, the ship A moving north at 30 km/h and ship B moving eastward at 40 km/h. The speed of B relative to A is
(a) 70 km/h (b) 35 km/h
(c) 10 km/h (d) 50 km/h
[CSE-Pre : 1994]

5. Four coplanar forces are acting at a point 'O' as shown in the figure. The equilibrant of the force system acting at 'O' is given by



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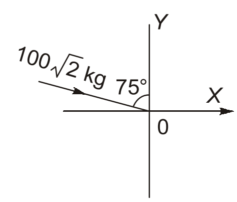

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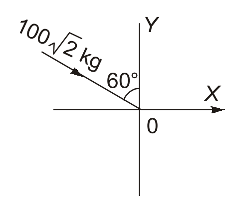

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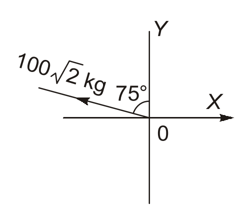

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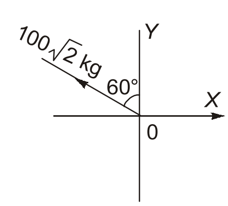


[CSE-Pre : 1994]

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

List-I

I. Catenary
II. Truss analysis
III. Centre of gravity
IV. Cable under udl

List II

A. Equilibrium of concurrent forces
B. Parabola
C. Hyperbolic functions
D. Parallel forces

Codes:

(a) I-C, II-A, III-D, IV-B
(b) I-D, II-C, III-A, IV-B
(c) I-C, II-A, III-B, IV-D
(d) I-A, II-C, III-D, IV-B **[CSE-Pre : 1995]**

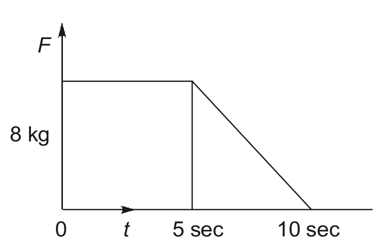
7. Match **List-I** with **List-II** and select the correct answer using the codes given below the list:

List-I (Physical quantity)		**List-II** (Dimensional formula)
I. Specific gravity	A.	$[M^0L^2T^{-1}]$
II. Coefficient of viscosity	B.	$[M^0L^0T^0]$
III. Kinematic viscosity	C.	$[ML^{-1}T^{-1}]$
IV. Stress	D.	$[ML^{-1}T^{-2}]$

(a) I-B, II-C, III-D, IV-A
(b) I-D, II-A, III-B, IV-C
(c) I-A, II-D, III-C, IV-B
(d) I-B, II-C, III-A, IV-D

[CSE-Pre : 1995]

8. A particle of weight 10 kg moving along a straight line is acted on by a force F varying as shown in the given figure. If the initial velocity is 2 m/sec., its velocity at the end of the period during which the force acts is (assuming g = 10 m/sec^2)



(a) 6 m/sec (b) 60 m/sec
(c) 62 m/sec (d) 82 m/sec

[CSE-Pre : 1995]

9. A particle of mass M is attached to a light horizontal wire which is stretched tightly between two fixed ends with a tension T. If a and b are the distances of the particle from the two ends, then the period of a small transverse oscillation of the particle is given by

(a) $2\pi\left(\dfrac{Mab}{T(a+b)}\right)^{1/2}$

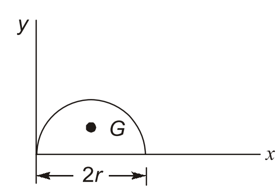
(b) $2\pi\left(\dfrac{Tab}{M(a+b)}\right)^{1/2}$

(c) $2\pi\left(\dfrac{M(a+b)}{Tab}\right)^{1/2}$

(d) $\dfrac{2\pi T}{M}\left(\dfrac{ab}{a+b}\right)^{1/2}$

[CSE-Pre : 1995]

10. The distance of the centroid of a semi circle of radius r from its base is



Semi-circle

(a) $\dfrac{4r}{3\pi}$ (b) $\dfrac{3\pi}{4r}$

(c) $\dfrac{4\pi}{3r}$ (d) $\dfrac{3r}{4\pi}$

[CSE-Pre : 1996]

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

List I

1. Co-planar forces
2. Concurrent forces
3. Non-Concurrent co-planar forces
4. Collinear forces

List-II

A. Lines of action of all forces lie in the same plane but do not pass through a common point.
B. Lines of action of all forces do not lie in the same plane but do pass through a common point.

C. Lines of action of all forces lie in the same plane.
D. Lines of action of all forces do not lie in the same plane
E. Vectors lie along the same line.
(a) 1–E, 2–D, 3–A, 4–C
(b) 1–D, 2–C, 3–B, 4–A
(c) 1–D, 2–E, 3–B, 4–A
(d) 1–C, 2–D, 3–A, 4–E

[CSE-Pre : 1996]

12. The quantities given in **List-I** and **List-II** correspond to a projectile on plane horizontal ground with an initial velocity 'u' and an angle of projection α with the horizontal. Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	List-II
A. Maximum height	1. $\frac{u}{g}\sin\alpha$
B. Maximum range	2. $\frac{2u}{g}\sin\alpha$
C. Time taken to reach the max. ht.	3. $\frac{u^2\sin^2\alpha}{g}$
D. Time of flight	4. $\frac{u^2\sin 2\alpha}{g}$
	5. $\frac{u^2\sin^2\alpha}{2g}$

	A	B	C	D
(a)	4	3	2	1
(b)	3	4	1	2
(c)	5	3	2	1
(d)	5	4	1	2

[CSE-Pre : 1997]

13. The equilibrium of two equal forces P acting at 60° between them is possible if a force of $P\sqrt{3}$ is applied at an angle of
(a) 30°
(b) 120°
(c) 150°
(d) 210°

[CSE-Pre : 1998]

14. Given that for a particle the initial velocity is 'u' the angle of projection to the horizontal is α and x and y are the coordinates of a point on the trajectory, match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I
A. Maximum height
B. Time of flight
C. Range
D. Trajectory

List-II
1. $[2u\sin\alpha]/g$
2. $[u^2\sin\alpha]/g$
3. $y = x\tan\alpha - \frac{1}{2}g\left[\frac{x^2}{u^2}\right](1+\tan^2\alpha)$
4. $[u^2\sin^2\alpha]/2g$

Codes:

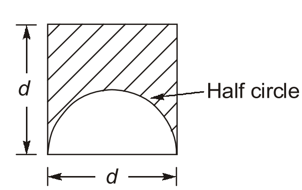
	A	B	C	D
(a)	1	4	3	2
(b)	4	2	3	1
(c)	4	1	2	3
(d)	4	1	3	2

[CSE-Pre : 1998]

15. Two forces each equal of P act on a body. One force acts in north-east direction and the other in north-west direction. Their effect may be neutralized by a third force acting in south direction with its magnitude equal to
(a) $P\sqrt{2}$
(b) $\sqrt{2P}$
(c) $\frac{P}{\sqrt{2}}$
(d) $2P$

[CSE-Pre : 1999]

16. The centroid of the hatched portion from the base shown in the given figure is



(a) $\frac{d}{2}$
(b) $\frac{4d}{6\pi}$
(c) $\frac{10d}{3(8-\pi)}$
(d) $\frac{3(8-\pi)d}{10}$

[CSE-Pre : 1999]

17. One ship A, sailing east with a speed of 20 km/h passes a certain point O at noon, a second ship B, sailing north at the same speed of 20 km/h passes the same point O at 2 p.m. The shortest distance in km between them would be

(a) $\frac{20}{\sqrt{2}}$ (b) $\sqrt{20}$

(c) $20\sqrt{2}$ (d) $\frac{40}{\sqrt{2}}$

[CSE-Pre : 1999]

18. **Assertion (A) :** Centroid of an area will lie in the axis of symmetry, if it exists.

Reason (R): Distance of centroid from any axis is given by moment of area divided by total area.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[CSE-Pre : 1999]

19. Two non-collinear equal parallel forces acting in opposite directions will have

(a) no resultant force and no moment
(b) a moment but no resultant force
(c) a resultant force but no moment
(d) a moment and a resultant force

[CSE-Pre : 2000]

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

[CSE-Pre : 2000]

21. A projectile is shot straight up with a velocity of 40 m/s. After how many seconds, will it return if drag is neglected and g = 10 m/s^2?

(a) 4 s (b) 6 s
(c) 8 s (d) 10 s

[CSE-Pre : 2001]

22. **Assertion (A) :** The position of the directrix of the path of a projectile depends upon the initial speed.

Reason (R): It also depends upon the angle of projection.

(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true (u_1, u_2)

[CSE-Pre : 2002]

23.

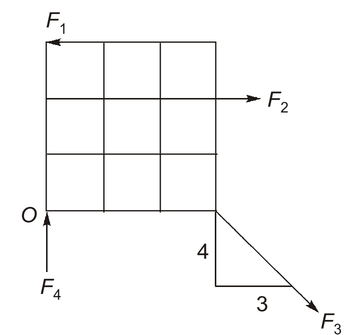


Figure shows the forces acting on a body. Each square is 3 cm × 3 cm. If F_1 = 30N, F_2 = 15N, F_3 = 25N and F_4 = 20N, the resultant force and the moment about point O, respectively, are

(a) 0 N, 0 N cm (b) 90 N, 80 N cm
(c) 60 N, 60 N cm (d) 30 N, 30 N cm

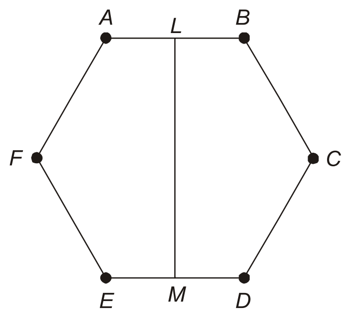
[CSE-Pre : 2003]

24. When two forces A and B are mutually at right angles, their resultant is 10 kN. When they are inclined at 60º, the resultant is $5\sqrt{6}$ kN. The individual magnitudes of the forces are:

(a) 4 kN and 6 kN
(b) $\sqrt{50}$ kN and $\sqrt{50}$ kN
(c) 5 kN and $\sqrt{75}$ kN
(c) 6 kN and 8 kN

[CSE-Pre : 2004]

25. Six identical uniform rods AB, BC, CD, DE, EF and FA each weighing w are freely joined at their extremities so that they form a regular hexagon. The rod AB is fixed in a horizontal position and the middle points L and M of AB and DE are connected by a weightless rod. The force induced in the connecting rod LM is



(a) 6 w (b) 4 w
(c) 3 w (d) 2.5 w

[CSE-Pre : 2004]

26. A projectile is fired horizontally with a velocity of 6 m/s from a point of height h m above and 12 m away from an object. What is the value of *h* required so that projectile hits the object?

(a) 4.9 m (b) 9.8 m
(c) 6 m (d) 19.6 m

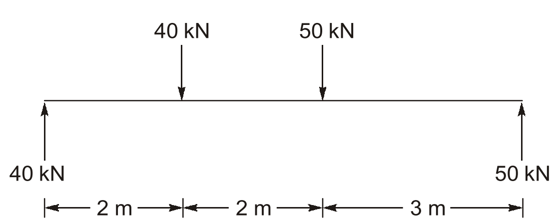
[CSE-Pre : 2005]

27. If the magnitude of the resultant of two forces *F* and 2*F* acting at a point *O* is 50 *N*, and the included angle between *F* and 2*F* is 90°, then what is the magnitude of *F*?

(a) $F = 10$ N (b) $F = 50\sqrt{2}N$
(c) $F = 25\sqrt{2}N$ (d) $F = 10\sqrt{5}N$

[CSE-Pre : 2006]

28. What is the magnitude of the resultant of the parallel force system as shown in the figure given below ?



(a) 70 kNm clockwise
(b) zero
(c) 70 kNm couple anticlockwise
(d) 90 kN vertical force and a moment of 70 kNm clockwise.

[CSE-Pre : 2007]

29. What is the magnitude of the resultant of forces

$\vec{A} = 2\hat{i} + 5\hat{j}, \vec{B} = 6\hat{i} - 7\hat{k}, \vec{C} = 2\hat{i} - 6\hat{j} + 10\hat{k}$

(a) 10.0 units (b) 10.5 units
(c) 8.9 units (d) 9.5 units

[CSE-Pre : 2008]

30. Two unlike parallel forces of 10 kN and 5 kN are 45 cm apart. If the direction of 5 kN force is reversed, then their resultant shifts through what distance?

(a) 90 cm (b) 60 cm
(c) 45 cm (d) 30 cm

[CSE-Pre : 2008]

31. Given that $F = (\alpha t^{-1} + \beta t^2)$ where *F* denotes force and *t* time; how is β described dimensionally?

(a) MLT^{-3} (b) MLT^{-2}
(c) LT^{-4} (d) MLT^{-4}

[CSE-Pre : 2009]

32. What is the unit vector of the resultant of the following two forces?

$$\bar{F}_1 = 2\hat{i} + 3\hat{j} + 4\hat{k}$$

$$\bar{F}_2 = 4\hat{i} + 3\hat{j} + 2\hat{k}$$

(a) $6\hat{i} + 6\hat{j} + 6\hat{k}$ (b) $\frac{i}{\sqrt{3}} + \frac{\hat{j}}{\sqrt{3}} + \frac{k}{\sqrt{3}}$
(c) $-2\hat{i} + 2\hat{k}$ (d) $2\hat{i} - 2\hat{k}$

[CSE-Pre : 2009]

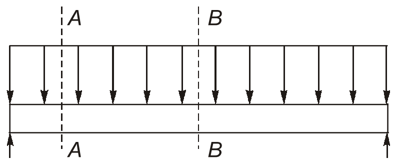
33. If two forces each of 10 kN act an angle θ, then what is the resultant force?

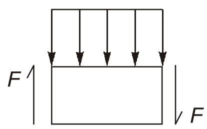
(a) 20 cosθ (b) $20\cos\frac{\theta}{2}$
(c) 20 cos2θ (d) $20\sin\frac{\theta}{2}$

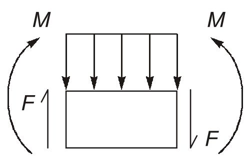
[CSE-Pre : 2010]

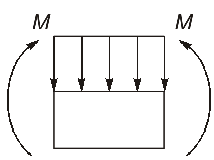
Free Body Diagrams and Equilibrium Equations

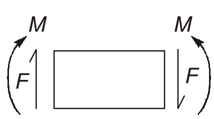
34. Which one of the following figures correctly represents the free body diagram for the portion of the loaded beam (shown in the figure) between sections *AA* and *BB*?



(a) 

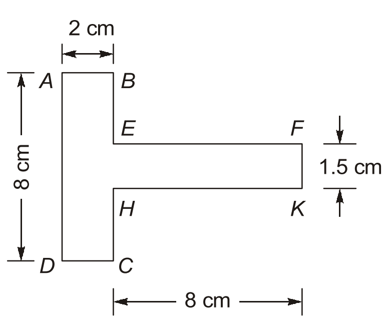
(b) 

(c) 

(d) 

[CSE-Pre : 1994]

35. The distance of the centre of gravity of a thin uniform lamina, shown in the given figure, computed from *AD* along the horizontal axis is



(a) 3.14 cm (b) 4.00 cm
(c) 5.3 cm (d) 6.0 cm

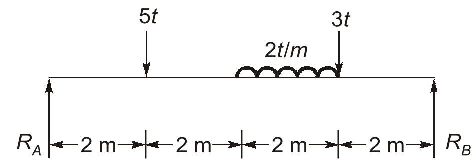
[CSE-Pre : 1994]

36. A metal block weighing 20 kgf rests on a horizontal surface, whose coefficient of friction is 0.22. The horizontal force necessary to just move the block is

(a) 0.22 kgf (b) 2.20 kgf
(c) 4.40 kgf (d) 8.80 kgf

[CSE-Pre : 1994]

37. The ratio of reactions R_A and R_B of the simply supported beam shown in the given figure is



(a) $\frac{1}{2}$ (b) $\frac{2}{3}$
(c) $\frac{3}{2}$ (d) 1

[CSE-Pre : 1994]

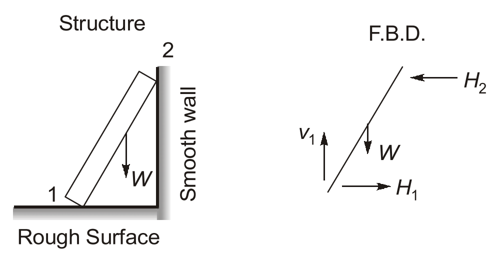
38. Pendulum *A* has length 'l' and pendulum *B* has length '$4l$'. The periodic time of pendulum *A* and *B* will be in the ratio of

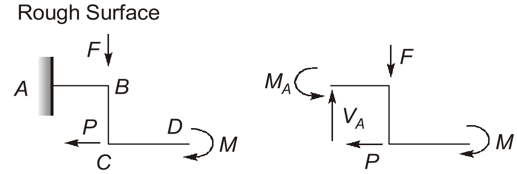
(a) 1 : 0.5 (b) 1 : 1
(c) 1 : 2 (d) 1 : 4

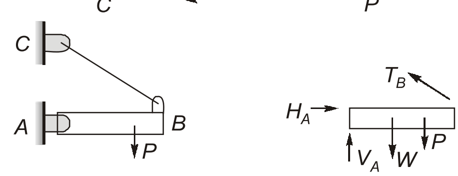
[CSE-Pre : 1994]

39. Which of the following structures and the corresponding free body diagrams are correctly matched?

Structure F.B.D.

I. 

II. 

III. 

Select the correct answer using the codes:

(a) I, II, and III (b) I and II
(c) II and III (d) I and III

[CSE-Pre : 1995]

40. Two particles of masses 21 gm and 28 gm are connected by a light inextensible string which passes over a fixed smooth pulley. The tension in the string in the ensuing motion will be

(a) 7 gm. wt. (b) 10 gm. wt.
(c) 12 gm. wt. (d) 24 gm. wt.

[CSE-Pre : 1996]

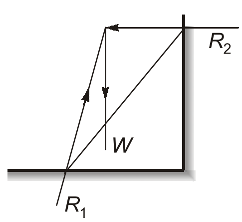
41. **Assertion (A):** If a rigid body is in equilibrium then the vector sum of the forces acting on the body is zero.

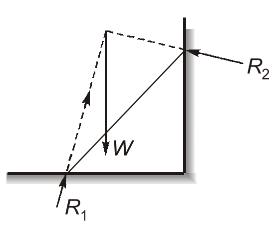
Reason (R): Vanishing of the resultant of the forces acting on a rigid body is a sufficient condition for the body to be in equilibrium.

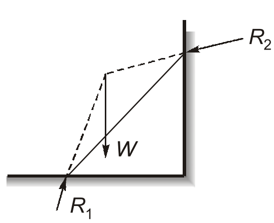
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

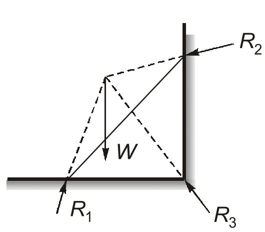
[CSE-Pre : 1996]

42. A ladder is placed on the floor leaning against a wall. Neither the floor nor the wall is smooth. If W is the weight of the ladder and R_1, R_2 and R_3 are the reactions, then the free-body diagram will be as in

(a)


(b)


(c)


(d)


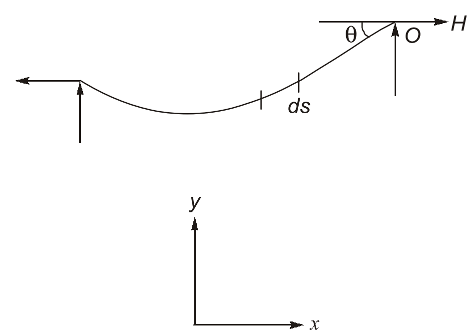
[CSE-Pre : 1997]

43. A square framework formed of uniform heavy rods of equal weight joined together is hung by one corner. A weight W is suspended from each of the three lower corners and the shape of the square is preserved with the help of a light rod along the horizontal diagonal. The thrust of the light rod is

(a) 2 W (b) 3 W
(c) 4 W (d) 6 W

[CSE-Pre : 1997]

44. Which one of the following is the correct differential equation of the shape of the cable (similar to electrical cables) of unit weight 'q', with small slopes, as shown in the given figure?



(a) $\frac{d^2y}{dx^2} = \frac{q}{H}\frac{ds}{dx}$ (b) $\frac{d^2y}{dx^2} = \frac{q}{H}$

(c) $\frac{d^2y}{dx^2} = \frac{q}{H}\sin\theta$ (d) $\frac{d^2y}{dx^2} = \frac{q}{H}\cos\theta$

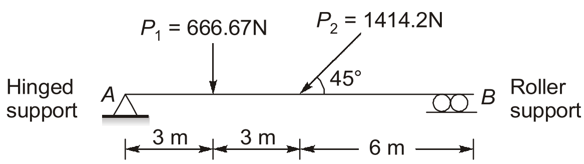
[CSE-Pre : 1997]

45. The effort 'P' to be applied horizontally to pull a weight 'W' on a plane inclined at an angle α with the horizontal is given by (tan ϕ is the coefficient of friction)

(a) $P = W\tan(\alpha + \phi)$
(b) $P = W\tan(\alpha - \phi)$
(c) $P = \frac{W\sin(\alpha + \phi)}{\cos(\alpha - \phi)}$
(d) $P = \frac{W\sin(\alpha - \phi)}{\cos(\alpha + \phi)}$

[CSE-Pre : 1997]

46. A beam AB is hinged at 'A' and is supported on rollers at 'B'. It carries two loads P_1 and P_2 as shown in the figure:



The reactions at 'A' and 'B' will be respectively

(a) 1000.0 N and 666.67 N

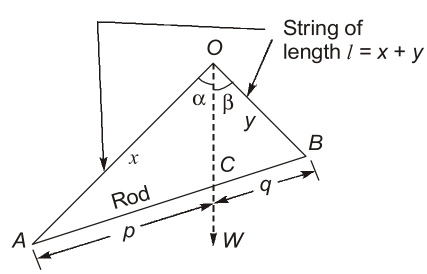
(b) 1000.0 N and 1000.0 N

(c) 1414.2 N and 666.67 N

(d) 1414.2 N and 1000.0 N

[CSE-Pre : 1998]

47. A rod AB of weight W is in equilibrium. Its centre of gravity divides into two portions of lengths p and q. A string of length l is tied to its ends and string is slung over a small smooth peg such that $OA = x$, $OB = y$ and $x + y = l$ as shown in figure. The line of action CO of W making angles α and β would be such that



(a) $\alpha > \beta$

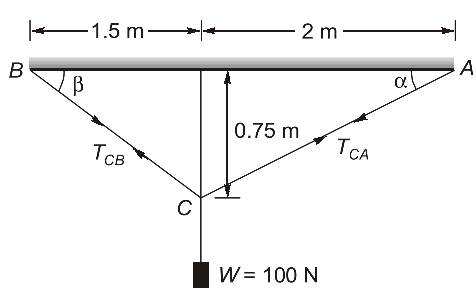
(b) $\alpha < \beta$

(c) $\alpha = \beta$

(d) the rod will not be in equilibrium as the peg is smooth

[CSE-Pre : 1999]

48. A lamp of weight W 100 N is supported by two cables CA and CB as shown in the figure. The equation for analysing the cable system is given by



(a) $T_{CA}\dfrac{2}{\sqrt{4.563}} + T_{CB}\dfrac{1.5}{\sqrt{2.813}} = 0$

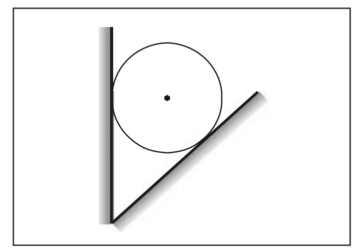
(b) $T_{CA}\sin\alpha + T_{CB}\sin\beta + 100 = 0$

(c) $T_{CB}(3.5)\sin\alpha = 100(1.5)$

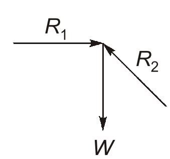
(d) $T_{CA}(3.5)\sin\alpha = 100(1.5)$

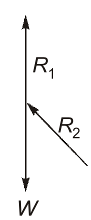
[CSE-Pre : 1999]

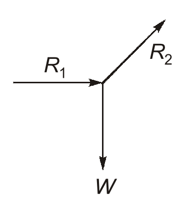
49. A ball of weight 'W' is supported on smooth planes as shown in the given figure.

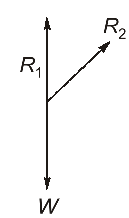


The free body diagram will be

(a)


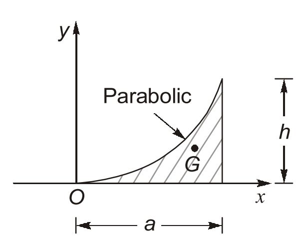
(b)


(c)


(d)


[CSE-Pre : 2000]

50. The co-ordinates of the centroid of the hatched section shown in the given figure will be

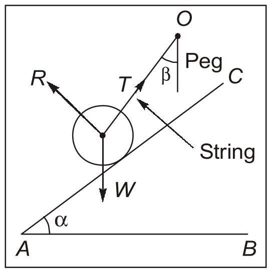


(a) $\dfrac{3a}{4}$ and $\dfrac{3h}{10}$ (b) $\dfrac{3a}{10}$ and $\dfrac{h}{3}$

(c) $\dfrac{3a}{5}$ and $\dfrac{3h}{8}$ (d) $\dfrac{3a}{8}$ and $\dfrac{3h}{5}$

[CSE-Pre : 2000]

51. In the system shown in the given, forces W, T and R are related as



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

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

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

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

[CSE-Pre : 2000]

52. Three forces acting at a point 'O' are $P_1 = (3i + 6j)N$, $P_2 = (-1.5i + 4.5j)N$ and $P_3 = (-10.5i + 1.5j)N$.
If a fourth force P_4 is added such that the point 'O' is in equilibrium, then force P_4 will be

(a) $(15i - 15j)N$ (b) $(9i - 12j)N$
(c) $(-9i - 12j)N$ (d) $(15i + 15j)N$

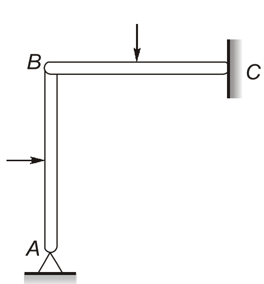
[CSE-Pre : 2001]

53. Two blocks of masses m_1 and m_2 ($m_1 > m_2$) are connected by an inextensible string passing over a smooth pulley and move vertically. If the acceleration of m_1 is $\dfrac{g}{5}$ downwards, then the ratio of $m_1 : m_2$ is

(a) 3 : 1 (b) 5 : 3
(c) 5 : 1 (d) 3 : 2

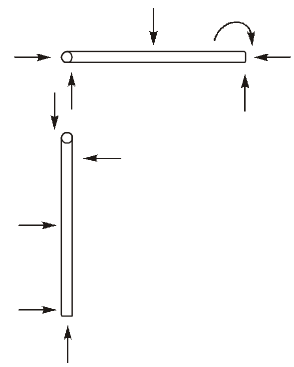
[CSE-Pre : 2001]

54.

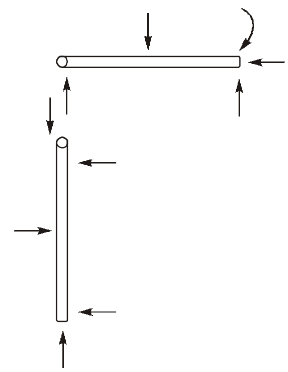


Select the correct free body diagram for the structure shown in the figure given above. The structure is hinged at A and B while C is fixed.

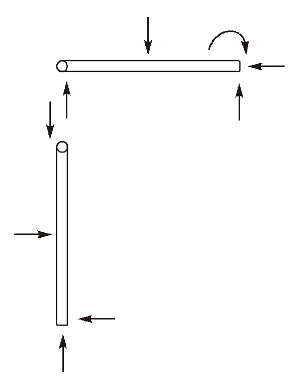
(a)



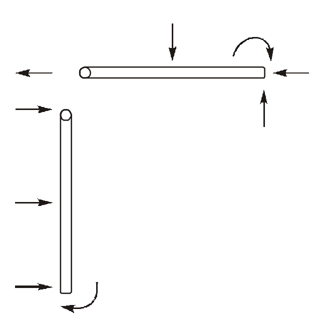
(b)



(c)



(d)



[CSE-Pre : 2002]

55. Two men, one stronger than the other have to lift a load of 1200 N which is suspended from a light rod of length 3 m. The load is suspended between the two persons positioned at the two ends of the

Answers Engineering Mechanics

1.	(d)	2.	(c)	3.	(a)	4.	(d)	5.	(a)	6.	(a)	7.	(c)	8.	(c)
9.	(a)	10.	(a)	11.	(d)	12.	(d)	13.	(a)	14.	(c)	15.	(a)	16.	(c)
17.	(c)	18.	(a)	19.	(b)	20.	(c)	21.	(c)	22.	(b)	23.	(a)	24.	(b)
25.	(c)	26.	(d)	27.	(d)	28.	(c)	29.	(b)	30.	(d)	31.	(d)	32.	(b)
33.	(b)	34.	(b)	35.	(a)	36.	(c)	37.	(d)	38.	(c)	39.	(d)	40.	(d)
41.	(c)	42.	(b)	43.	(a)	44.	(a)	45.	(a)	46.	(c)	47.	(c)	48.	(d)
49.	(a)	50.	(a)	51.	(b)	52.	(b)	53.	(d)	54.	(a)	55.	(b)	56.	(c)
57.	(b)	58.	(b)	59.	(c)	60.	(c)	61.	(b)	62.	(d)	63.	(a)	64.	(c)
65.	(c)	66.	(a)	67.	(b)	68.	(a)	69.	(b)	70.	(a)	71.	(d)	72.	(c)
73.	(c)	74.	(b)	75.	(d)	76.	(a)	77.	(c)	78.	(c)	79.	(c)	80.	(a)
81.	(d)	82.	(c)	83.	(*)	84.	(b)	85.	(b)	86.	(d)	87.	(a)	88.	(d)
89.	(b)	90.	(b)	91.	(c)	92.	(a)	93.	(d)	94.	(b)	95.	(b)	96.	(a)
97.	(b)	98.	(d)	99.	(b)	100.	(a)	101.	(c)	102.	(c)	103.	(c)	104.	(a)
105.	(c)	106.	(a)	107.	(b)	108.	(a)	109.	(a)	110.	(b)	111.	(d)	112.	(b)
113.	(d)	114.	(c)	115.	(d)	116.	(c)	117.	(a)	118.	(b)	119.	(d)	120.	(d)
121.	(a)	122.	(b)	123.	(a)	124.	(d)	125.	(d)	126.	(c)	127.	(a)	128.	(c)
129.	(c)	130.	(d)	131.	(b)	132.	(b)	133.	(a)	134.	(d)	135.	(d)	136.	(c)
137.	(d)	138.	(d)	139.	(b)	140.	(a)	141.	(d)	142.	(a)	143.	(c)	144.	(d)
145.	(c)	146.	(c)	147.	(d)	148.	(d)	149.	(c)	150.	(b)	151.	(d)	152.	(b)
153.	(c)	154.	(c)	155.	(d)	156.	(a)	157.	(c)	158.	(c)	159.	(d)	160.	(d)
161.	(b)	162.	(c)	163.	(b)	164.	(c)	165.	(b)	166.	(a)	167.	(a)	168.	(a)
169.	(a)	170.	(b)	171.	(a)	172.	(a)	173.	(c)	174.	(a)	175.	(c)		

Explanations Engineering Mechanics

1. (d)

When we resolve all the forces in the direction normal to F_2, the force F_2 vanishes and only the components of F_1 and R remain. So unknown force F_1 can be found by one equation.

2. (c)

$$n_1u_1 = n_2u_2$$

Let us take

$n_1 = 100$

$n_2 = 1$

$u_1 = \text{cm}$

$u_2 = \text{m}$

$\therefore$ 100 cm = 1 m

Putting m = 100 cm

$\therefore$ 100 cm = 100 cm

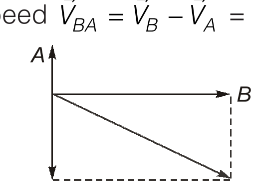
3. (a)

Closing of force polygon means that there is no resultant force.

Closing of funicular polygon means that there is no resultant moment. Since funicular polygon does not close so there is an equivalent couple.

4. (d)

Relative speed $\vec{V}_{BA} = \vec{V}_B - \vec{V}_A = 40\hat{e} - 30\hat{n}$

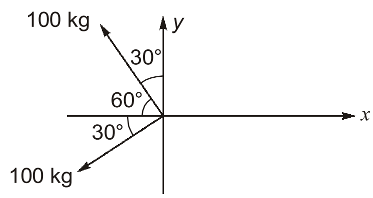


Where $\hat{e}$ and $\hat{n}$ are unit vectors in east and north directions respectively.

$$\therefore \quad |\vec{V}_{BA}| = \sqrt{40^2 + 30^2} = 50 \text{ km/h.}$$

5. (a)

There is a net force of 100 kg in third quadrant making angle 30° with horizontal. There is another net force in second quadrant making angle 30° with vertical.



The angle between these forces is 90° so there resultant will be at 45° from any of the forces. The resultant will be $100\sqrt{2}$ kg making an angle 75° with *y*-direction.

The figure (c) represents the resultant force. The figure (a) represent equilibrant (opposite to the resultant).

6. (a)

Catenary is a hyperbolic curve formed by a wire, rop or chain hanging freely from two points that are not in the same vertical line.

Truss analysis is done by analysing the equilibrium of concurrent forces by method of joints or method of sections or any other suitable method.

Cable under udl forms a parabolic shape.

7. (c)

$$\text{Specific Gravity} = \frac{\text{Density of a liquid}}{\text{Density of std. liquid (water)}}$$

= unit less

∴ S.G. = $[M^0L^0T^0]$

Unit of coefficient of viscosity

$$= \frac{N_s}{m^2} = \frac{[MLT^{-2}][T]}{[L^2]}$$

$= [ML^{-1}T^{-1}]$

Unit of kinematic viscosity = m^2/s

$$= \frac{[L^2]}{[T]} = [M^0L^2T^{-1}]$$

8. (c)

$$\text{Acceleration } a = \frac{F}{m} = \frac{8\times 10}{10} = 8 \text{ m/s}^2$$

Change in velocity = area of the acceleration versus time curve

$$= 8\times 5 + \frac{8\times 5}{2} = 60 \text{ m/s}$$

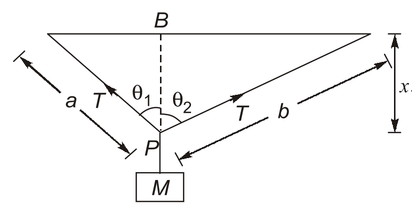
Velocity at the end of period when during which the force acts is = 2 + 60 = 62 m/s

9. (a)

For equilibrium at point *P*

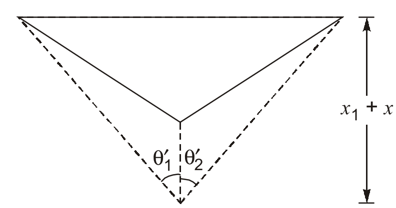
$T\cos\theta_1 + T\cos\theta_2 = mg$ ...(1)

Now, when particle is displaced in transverse direction we need to find the restoring force acting on the particle.



Let the acceleration be *A*.

Let the particle be displaced by *x* distance.



$T(\cos\theta_1' + \cos\theta_2') - Mg = MA$ ...(2)

$$\cos\theta_1' = \frac{x_1 + x}{a}$$

$$\cos\theta_2' = \frac{x_1 + x}{b}$$

$$\cos\theta_1 = \frac{x_1}{a}$$

$$\cos\theta_2 = \frac{x_1}{b}$$

Subtracting eq. (1) from (2)

$$T[x]\left[\frac{1}{a}+\frac{1}{b}\right] = MA$$

$$MA = x\left[\frac{T(a+b)}{ab\cdot M}\right]$$

Comparing with $A = x\omega^2$

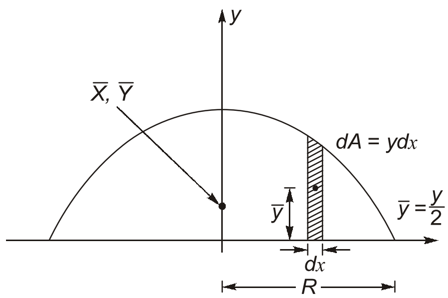
$$\omega^2 = \frac{(a+b)T}{abM}$$

$$\text{Time Period} = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{abM}{(a+b)T}}$$

10. (a)

$$\bar{X} = \frac{\int \bar{x}dA}{A} = 0 \text{ from symmetry}$$

$$\bar{Y} = \frac{\int \bar{y}dA}{A} = \frac{\int \frac{y}{2}(ydx)}{\frac{1}{2}\pi R^2} = \frac{\int_{-R}^{+R} y^2 dx}{\pi R^2}$$



$$x^2 + y^2 = R^2 \text{ (equation of circle)}$$

$$y^2 = R^2 - x^2$$

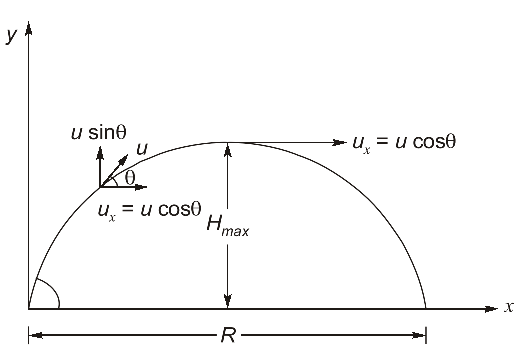
$$\bar{Y} = \frac{\int_{-R}^{R} (R^2 - x^2)dx}{\pi R^2}$$

$$= \frac{2\times\left(R_x^2 - \frac{x^3}{3}\right)_0^R}{\pi R^2} = \frac{4R}{3\pi}$$

11. (d)

1. *Co-planar forces :* Lines of action of all forces lie in the same plane.
2. *Concurrent forces :* Lines of action of all forces do not lie in the same plane.
3. *Non-concurrent co-planar forces :* Lines of action of all forces lie in the same plane but do not pass through a common point.
4. *Collinear forces :* Vectors lie along the same line.

12. (d)



- $v = u_0 + at$
  Considering upward motion, $v = 0$ at top point.
  $u_0 = u \sin\theta$ [vertical component]

$\therefore \quad 0 = u \sin\theta - gt$

$\therefore \quad t = \frac{u\sin\theta}{g}$

= time taken to reach top point

$\therefore$ Total time of flight

$$= 2t = \left(\frac{2u\sin\theta}{g}\right)$$

- Distance = Speed × Time

$$R = u\cos\theta \times \frac{2u\sin\theta}{g}$$

Horizontal Range,

$$R = \frac{u^2 \sin 2\theta}{g}$$

- from, $v^2 - u^2 = 2as$
  Considering upward motion, $v = 0$ at top point
  $u = u \sin\theta$
  $-u^2 \sin^2\theta = -2gs$

$$\therefore \quad s = \left(\frac{u^2 \sin^2\theta}{2g}\right)$$

13. (a)

Resultant of the forces (R)

$$= \sqrt{P^2 + P^2 + 2P \times P\cos 60^\circ} = P\sqrt{3}$$

Angle of resultant

$$\tan\alpha = \frac{P\sin 60^\circ}{P + P\cos 60^\circ} = \frac{1}{\sqrt{3}}$$

$\therefore \quad \alpha = 30^\circ$

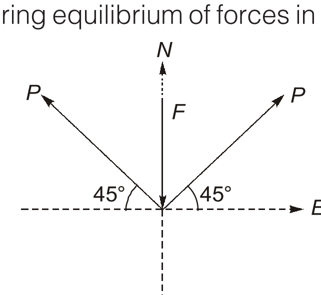
14. (c)

Trajectory of parabola motion is given by

$$y = x\tan\alpha - \frac{gx^2}{2u^2}(1 + \tan^2\alpha)$$

15. (a)

Considering equilibrium of forces in N-S direction



$$\left(\frac{P}{\sqrt{2}}\right) + \left(\frac{P}{\sqrt{2}}\right) - F = 0$$

$$F = \frac{2P}{\sqrt{2}} = \sqrt{2}P$$

16. (c)

Shape	Area	Centroid from base
Square	$A_1 = d^2$	$y_1 = d/2$
Half circle	$A_2 = \pi d^2/8$	$y_2 = 2d/3\pi$

The centroid of hatched position from base.

$$\bar{y} = \frac{A_1 y_1 - A_2 y_2}{A_1 - A_2}$$

$$= \frac{d^2 \cdot \frac{d}{2} - \frac{\pi d^2}{8} \cdot \frac{2d}{3\pi}}{d^2 - \frac{\pi d^2}{8}} = \frac{10d}{3(8-\pi)}$$

17. (c)

Let the shortest distance between ships will occur at time thereafter the ship A passes point O.

The distance of ship A from O = $20\ t$

The distance of ship B from O = $20\ (2 - t)$

The distance between ships

$$D = \sqrt{(20t)^2 + \{20(2-t)\}^2}$$

For shortest distance

$$\frac{dD}{dt} = 0 \quad \text{or} \quad \frac{d(D^2)}{dt} = 0$$

$$2 \times 20t - 20(2-t) \times 2 = 0$$

$$t = 1 \text{ hrs}$$

Shortest distance = $20\sqrt{2}$ km

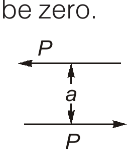
18. (a)

Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.

19. (b)

Since the equal forces are in opposite directions so resultant force will be zero.

The moment = Pa.



(Two non-collinear equal parallel forces acting in opposite directions)

20. (c)

$$|\vec{A} \times \vec{B}| = AB \sin\theta$$

When $\theta = 0$, $|\vec{A} \times \vec{B}| = 0$ because $\sin\theta = 0$

When two non-zero vectors are parallel or collinear, their vector product is zero.

21. (c)

$$\alpha = 90°$$

The projectile will have zero velocity at highest point.

Total time taken $T = \frac{2u\sin\alpha}{g} = \frac{2 \times 40}{10} = 8s$

22. (b)

For parabola $y = ax^2$ the equation of directrix is $x = -a$.

Thus the position of directrix will depend upon the angle of projection, and initial speed both.

The path of a projectile is parabolic

$$y = x \tan\alpha = -\frac{gx^2}{2u^2\cos^2\alpha}$$

23. (a)

Conditions of equilibrium are:

$$\sum F_x = 0 \qquad \sum F_y = 0 \qquad \sum M = 0$$

Let resultant force in x-direction is R_x and in y-direction it is R_y

$$F_2 - F_1 + \frac{3}{5}F_3 + R_x = 0$$

$$R_x = 30 - 15 - \frac{3}{5} \times 25 = 0$$

$$F_4 - \frac{4}{5}F_3 + R_y = 0$$

$$R_y = \frac{4}{5} \times 25 - 20 = 0$$

Thus resultant force is zero newton.

Taking moment about σ. (Clockwise moment taken positive)

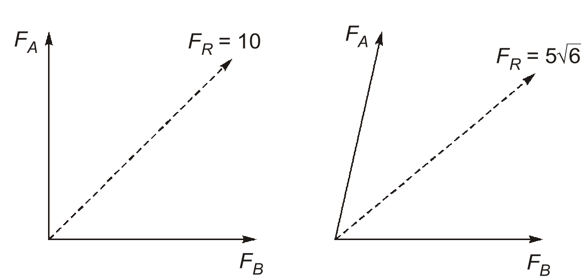
$$-F_1 \times 9 + F_2 \times 6 + \frac{4}{5}F_3 \times 9 + M_0 = 0$$

$$M_0 = 30 \times 9 - 15 \times 6 - \frac{4}{5} \times 25 \times 9 = 0 \text{ N-cm}$$

24. (b)

When forces are at right angles.

$$A^2 + B^2 = (10)^2 = 100 \quad \text{...(i)}$$



When they are at 60° indication

$$A^2 + B^2 + AB = (5\sqrt{6})^2 = 150 \quad ...(ii)$$

$$\therefore \quad AB = 50$$

$$A^2 + B^2 - 2AB = 100 - 100 = 0$$

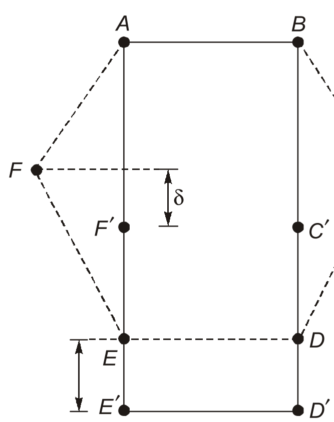
$$(A - B)^2 = 0 \quad \text{or} \quad A = B$$

$$\therefore \quad A = \sqrt{100/2} = \sqrt{50} \text{ kN.}$$

25. (c)

The mass of each bar on periphery will be acting at its centre. The rod *AB* is fixed. Introducing a cut in bar *LM*. The frame will achieve the position shown in the figure.

Suppose *F* and *C* move vertically by δ so *E* and *D* will move 2δ. The mid points of rod *AF* and *BC* will move vertically by δ/2. The mid points of rods *FE* and *CD* will move vertically by 3δ/2. The mid point of rod *ED* will move by 2δ. Using virtual work method.

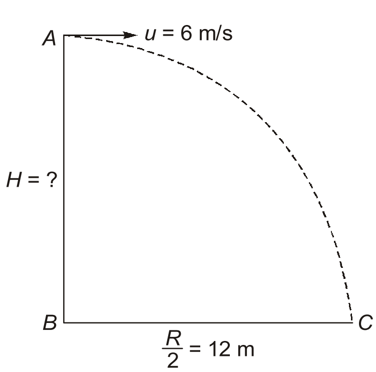


$$P_{LM} \cdot 2\delta = w\frac{\delta}{2} + w\frac{\delta}{2} + w\frac{3\delta}{2} + w\frac{3\delta}{2} + w \cdot 2\delta$$

$$= w\delta + 3w\delta + 2w\delta + 6w\delta$$

$$P_{LM} = 3w$$

26. (d)



Time taken to hit object at *C*

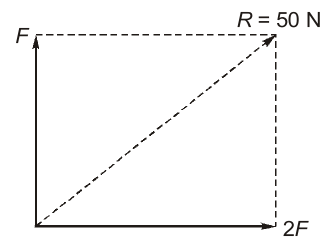
$$= \frac{12 \text{ m}}{6 \text{ m/s}} = 2\text{s}$$

Vertical velocity, $u_y = 0$, $a = +g$, $t = 2$ sec

$$s = u_y t + \frac{1}{2}at^2$$

$$H = 0 + \frac{1}{2} \times 9.81 \times 2^2 = 19.62 \text{ m}$$

27. (d)



Given, $R = 50$ N

$$R = \sqrt{F^2 + (2F)^2 + 2 \times F \times 2F\cos 90°}$$

$$= \sqrt{5}\, F$$

$$\therefore \quad F = \frac{50}{\sqrt{5}} = 10\sqrt{5}\text{N}$$

28. (c)

The resultant force will be zero.

Taking moment about left point with clockwise moment positive

$$M = 40 \times 2 + 50 \times 4 - 50 \times 7$$

$$= 80 + 200 - 350 = -70 \text{ kNm}$$

29. (b)

$$\vec{A} = 2\hat{i} + 5\hat{j}\,,\ \vec{B} = 6\hat{i} - 7\hat{k}\,,\ \vec{C} = 2\hat{i} - 6\hat{j} + 10\hat{k}$$

x component = 2 + 6 + 2 = 10

y component = 5 – 6 = –1

z component = –7 + 10 = 3

$$\text{Resultant} = \sqrt{10^2 + (-1)^2 + 3^2} = \sqrt{110}$$

$$= 10.488 \text{ units}$$

30. (d)

The resultant of two like parallel forces is the sum of the two forces and acts at a point between the line in such a way that the resultant divides the distance in the ratio inversely proportional to the magnitude of the forces.

31. (d)

$$\text{Force} = \frac{kgm}{s^2} = MLT^{-2}$$

dimension of force = dimension of βt^2

i.e., $MLT^{-2} = [\beta][T^2] \Rightarrow [\beta] = MLT^{-4}$

32. (b)

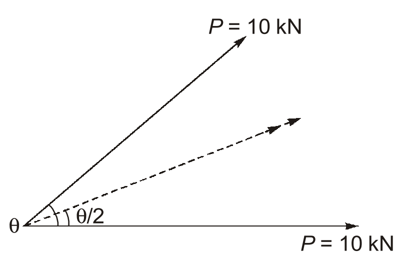
Resultant of $\vec{F_1}$ and $\vec{F_2} = 6\hat{i} + 6\hat{j} + 6\hat{k}$

$$\text{Magnitude} = \sqrt{6^2 + 6^2 + 6^2} = 6\sqrt{3}$$

$$\therefore \text{Unit vector} = \frac{6\hat{i} + 6\hat{j} + 6\hat{k}}{6\sqrt{3}}$$

$$= \frac{\hat{i}}{\sqrt{3}} + \frac{\hat{j}}{\sqrt{3}} + \frac{\hat{k}}{\sqrt{3}}$$

33. (b)

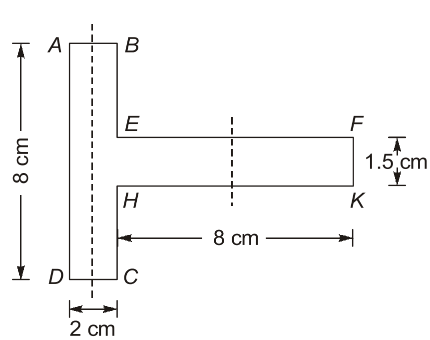


$$\text{Resultant} = 2P\cos\frac{\theta}{2} = 2 \times 10\cos\frac{\theta}{2} = 20\cos\frac{\theta}{2}$$

34. (b)

The FBD should show the applied load, shear force developed and bending moment developed.

35. (a)



Rectangle *ABCD*

Area $A_1 = 2 \times 8 = 16 \text{ cm}^2$

Centroid $y_1 = 1$ cm from *AD*

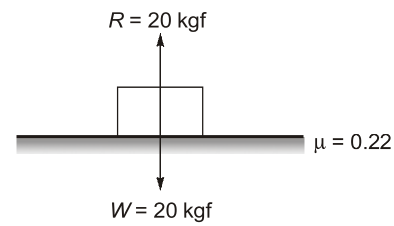
Rectangle *EFHK*

Area $A_2 = 8 \times 1.5 = 12 \text{ cm}^2$

Centroid $y_2 = 2 + 4 = 6$ cm from *AD*

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A_1 + A_2} = 3.14 \text{ cm}$$

36. (c)



The reaction on the block (R) = 20 kg f

The horizontal force needed to move the block

$$= \mu R = 0.22 \times 20$$

$$= 4.4 \text{ kg f}$$

37. (d)

$$R_A + R_B = 5 + 2 \times 2 + 3 = 12t$$

Taking moment about *A*

$$R_B = \frac{5 \times 2 + 2 \times 2 \times 5 + 3 \times 6}{8} = 6t$$

$$\therefore \quad R_A = 6t$$

$$\frac{R_A}{R_B} = 1$$

38. (c)

$$\text{The periodic time } T = 2\pi\sqrt{\frac{l}{g}}$$

$$\therefore \quad \frac{T_A}{T_B} = \sqrt{\frac{l_A}{l_B}} = \frac{1}{2}$$

39. (d)

Horizontal reaction at fixed support is missing.

40. (d)

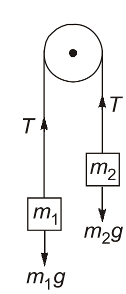
$$m_1 g - T = m_1 a \quad \text{...(1)}$$

$$T - m_2 g = m_2 a \quad \text{...(2)}$$

Adding (1) and (2)

$$m_1 g - m_2 g = m_1 a + m_2 a$$

$$\frac{(m_1 - m_2)g}{m_1 + m_2} = a$$



Placing values of a in eqn. (1)

$$m_1 g - T = m_1 a$$

$$m_1 g - T = \frac{m_1(m_1 - m_2)g}{m_1 + m_2}$$

$$T = \left[m_1 - \frac{m_1(m_1 - m_2)}{m_1 + m_2}\right]g$$

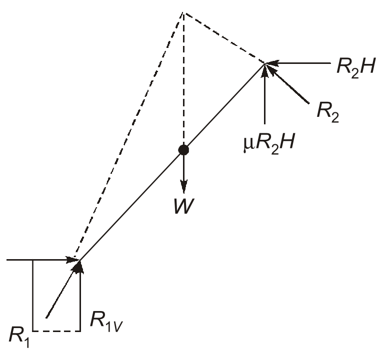
$$T = \left(\frac{2m_1 m_2}{m_1 + m_2}\right)g$$

$$T = \frac{2m_1 m_2}{m_1 + m_2}g = \frac{2 \times 21 \times 28}{21 + 28}g = 24 \text{ gm wt}$$

41. (c)

The force equilibrium and moment equilibrium are necessary conditions for equilibrium i.e., if the system is in equilibrium then these equation must be satisfied.

42. (b)



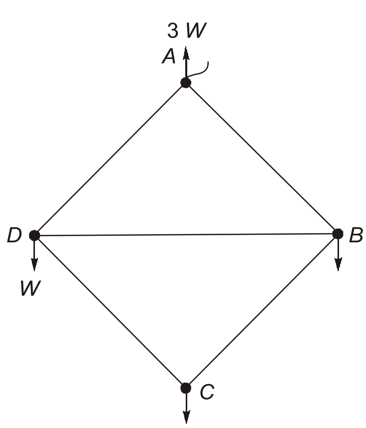
The free body diagram of the ladder with all components of forces is shown in the figure.

43. (a)

The reaction at hinge A will be 3 W.

Tension in rod CD and BC will be $\frac{W}{\sqrt{2}}$. Tension in or AB and AD will be $\frac{3W}{\sqrt{2}}$.

Now consider equilibrium at joint D.



thrust in BD = 2 W

44. (a)

The shape, which a string (cable or rope) takes up under its own weight (without any external load) is called cantenary. It is a cosh function.

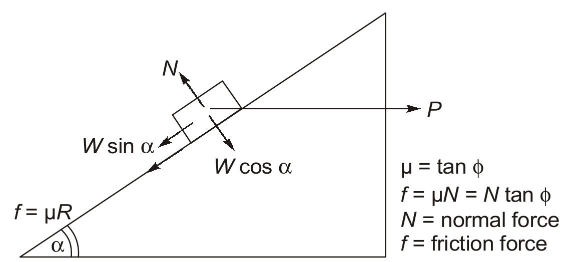
The equation of cable under uniformly loaded string.

$$\frac{d^2y}{dx^2} = \frac{q}{H}$$

For cantenary the equation is

$$\frac{d^2y}{dx^2} = \frac{q}{H}\frac{ds}{dx}$$

45. (a)



$$N = W\cos\alpha + P\sin\alpha$$

$$f = N\tan\phi$$

$$P\cos\alpha = W\sin\alpha + f$$

$$P\cos\alpha - W\sin\alpha = f = \tan\phi\,(W\cos\alpha + P\sin\alpha)$$

$$P = \frac{W[\sin\alpha + \cos\alpha\tan\phi]}{[\cos\alpha - \sin\alpha\tan\phi]},$$

taking cos α common

$$P = \frac{W[\tan\alpha + \tan\phi]}{[1 - \tan\alpha\tan\phi]} = W\tan(\alpha + \phi)$$

46. (c)

Vertical reaction at B.

$$V_B = \frac{666.67 \times 3}{12} + 1414.2\sin 45° \times \frac{6}{12}$$

= 666.67 N.

Vertical reaction at A

V_A = 666.67 + 1414.2 sin 45° – 666.67 = 1000 N

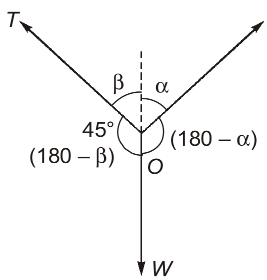
Horizontal reaction at A

H_A = 1414.2 cos 45° = 1000 n

Reaction at A = $\sqrt{V_A^2 + H_A^2}$ = 1414.2 N

47. (c)

The rod will be in equilibrium under tension (T) at ends A and B. All the forces on rod passes trough point O.



Using Lami's Theorem

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

$$\therefore \frac{T}{\sin\alpha} = \frac{T}{\sin\beta} = \frac{W}{\sin(\alpha+\beta)}$$

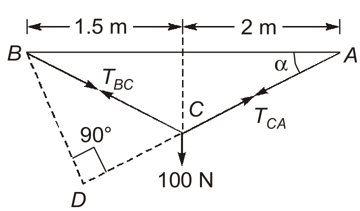
For the above equation

$$\alpha = \beta$$

The length p and q as well as x and y are such that the angle are equal to each other.

48. (d)

Taking moment about point B

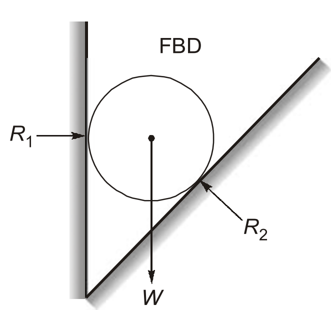


$$BD \cdot T_{CA} = 100 \times 1.5$$

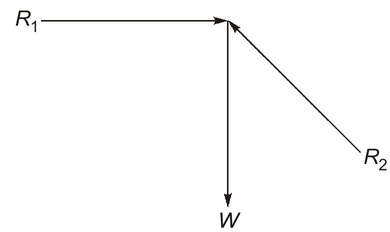
$$BD = 3.5 \sin\alpha$$

$\therefore$ TCA (3.5) sin α = 100 (1.5) is the equation for analysing the equilibrium.

49. (a)



FBD of the above scenario is



50. (a)

Equation of parabola $y = cx^2$ where $c = (h/a^2)$

y–coordinate of centroid

$$\bar{y} = \frac{\int \frac{y}{2}\cdot dA}{\int dA} = \frac{\int_0^a y^2 dx}{2\int_0^a y dx}$$

$$= \frac{ca^5/5}{2a^3/3} = \frac{3}{10}a^2 c = \frac{3}{10}h$$

x-coordinate

$$\bar{x} = \frac{\int xdA}{dA} = \frac{\int_0^a xydx}{\int_0^a ydx} = \frac{a^4/4}{a^3/3} = \frac{3}{4}a$$

51. (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

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

$$\therefore \frac{W}{\sin(\alpha+\beta)} = \frac{T}{\sin\alpha} = \frac{R}{\sin\beta}$$

52. (b)

For equilibrium

$P_1 + P_2 + P_3 + P_4 = 0$

$$\therefore \quad P_4 = -(P_1 + P_2 + P_3)$$

$$= (9i - 12j)N$$

53. (d)

$$\frac{m_1}{m_2} = \frac{1 + a/g}{1 - a/g} = \frac{3}{2} \qquad (\therefore a = g/5)$$