Statics, Earth's Atmosphere and Astrophysics

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1 The necessary condition for the static equilibrium of a rigid body is that

a) the resultant external force acting on it must be zero

b) the resultant torque acting on it must be zero about any point

c) both (a) and (b)

d) neither (a) nor (b)

Solution: A rigid body in static equilibrium (i.e at rest) has no linear or angular velocity. Hence, both the conditions must be fulfilled.

Ans: [C] **both (a) and (b)**

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2.A number of forces acting on a body are in equilibrium. Then the body

a) must be at rest

b) must move with uniform velocity

c) may be either at rest or may move with uniform velocity

d) must move with constant acceleration

Solution: $\sum F = 0$ this implies, $a = 0$, this implies, V = constant

Thus, the body can be at rest or in uniform motion

Ans: (C) may be either at rest or may move with uniform velocity

Q.3 The equilibrant of a 5N force towards east is a

a) 5N force towards west

b) 5N force towards east

c) 10N force towards north

d) $5\sqrt{2}$ N force along north – east

Solution: The equilibrant of a single force is equal in magnitude but opposite in direction to the given force. Hence, it is a 5 N force towards west.

Ans: (a) 5N force towards west

4) The maximum and minimum values of the resultant of two forces P and Q are 13 N and 7 N respectively. Then, the values of P and Q are

a) 10 N and 3 N

b) 7 N and 6 N

c) 8 N and 5 N

d) 9 N and 4 N

Solution: The maximum value of resultant of two forces is P + Q = 13 N and minimum value is P – Q = 7 N. On solving for P and Q, we get P = 10 N and Q = 3 N

Ans: (a) 10 N and 3 N

5)Two identical forces are acting on a body. The magnitude of each force is equal to the magnitude of their resultant. The angle between the two forces is

a) 60^0 b) 120^0

c) 90^0 d) 0^0

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Solution: We know that,

$$R^2 = P^2 + Q^2 + 2\,PQ\cos\theta$$

But, $P = Q = R$

$$\therefore \quad P^2 = 2P^2 + 2P^2\cos\theta$$

This implies, $\cos\theta = -\frac{1}{2}$

$$\therefore \ \theta = 120^0$$

Ans: (b) $\theta = 120^0$

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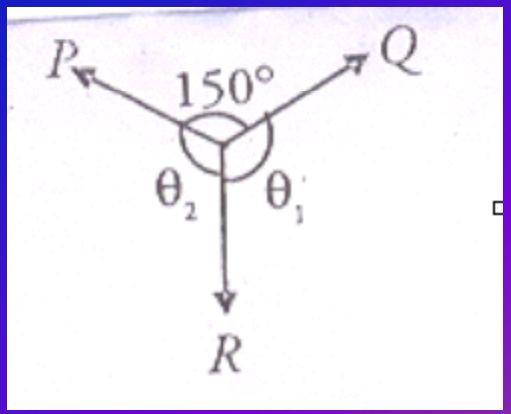
6) P,Q and R are three coplanar forces acting at a point and are in equilibrium. Given P = 1.9318 Kg – Wt, $\sin\theta_1 = 0.9659$, the value of R is (in Kg – Wt)

a) ½ b) 1 c) 2 d) 0.9659



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Solution: According to Lami's theorem,

$$P / \sin\theta_1 = R / \sin 150$$

$$R = (P / \sin\theta_1) \sin 150$$

$$R = (P / \sin\theta_1) \sin[90 + 60]$$

$$R = (P \cos 60) / \sin\theta_1$$

$$R = (1.9318 \times 0.5000) / 0.9659$$

$$R = 1$$

Ans: (b) 1

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7) If three concurrent forces acting at a point are in equilibrium, then

a) each force is proportional to the angle between the other two

b) each force is proportional to sine of the angle between the other two

c) each force is inversely proportional to the sine of the angle between the other two

b) each force is inversely proportional to the angle between the other two

Solution: According to Lami's theorem, when three concurrent forces are in equilibrium, each force is proportional to the sine of the angle between the other two.

Ans: (b) each force is proportional to sine of the angle between the other two

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8) Two concurrent equal forces of magnitude 5 N each act at an angle of 120^0. The magnitude of their resultant is

a) 15 N b) $5\sqrt{3}$ N

c) 5 N d) 10 N

Solution: Two forces of equal magnitude having angle of 120^0 with each other have resultant of magnitude equal to either of the forces.

Ans: (C) 5N

9) Moment of a force is also known as

a) momentum b) linear momentum

c) angular momentum d) torque

Solution: Moment of a force is also known as torque

Ans: (d) torque

10) The SI unit of Moment of a force is

a) N / m

b) $N\ m^2$

c) $N\ m^{-2}$

d) N – m

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Solution: We know that,

Moment of a force = F x d

= N – m

Ans: (d) N – m

11) The dimensional formula of Moment of force is

a) $[MLT^{-2}]$ b) $[ML^{2}T^{-2}]$

c) $[ML^{-2}T^{-2}]$ d) $[ML^{2}T^{2}]$

Solution: Moment of a force = F x d

$= [MLT^{-2}] [L]$

$= [ML^{2}T^{-2}]$

Ans:(b) $[ML^{2}T^{-2}]$

12) If the line of action of force passing through the axis of rotation, what is the moment of force?

a) 1 b) zero

c) no effect d) both (a) and (b)

Solution: We know that,

Moment of a force = F x d

Here d = 0

$\therefore$ Moment of a force = F x 0

Moment of a force = 0

Ans: (b) Zero

13) If a body rotates clockwise direction, the moment of force is

a) Positive

b) Negative

c) may positive or negative

d) Neither positive nor negative

Solution: If a body rotates clockwise direction, the moment of force is negative.

Ans: (b) negative

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14) Moment of a force does not depends on

a) Magnitude of the force

b) direction of the force

c) Point of application of the force

d) axis of rotation

Solution: Moment of a force depends on magnitude of a force, direction of force and point of application of the force but not on the axis of rotation.

Ans: (d) axis of rotation

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15) A gate of 2 m wide requires a force of 2 Kg – Wt to be applied at one end to open it. The force that must be applied at a point 0.5 m distant from the hinges for opening the gate is

a) 0.5 Kg – Wt b) 2 Kg – Wt

c) 4.5 Kg – Wt d) 8 Kg – Wt

Solution: According to law of moments,

The moments must be equal,

$$F_1 \times X_1 = F_2 \times X_2$$

$$F_2 = (F_1 \times X_1) / X_2$$

$$= (2 \times 2) / 0.5$$

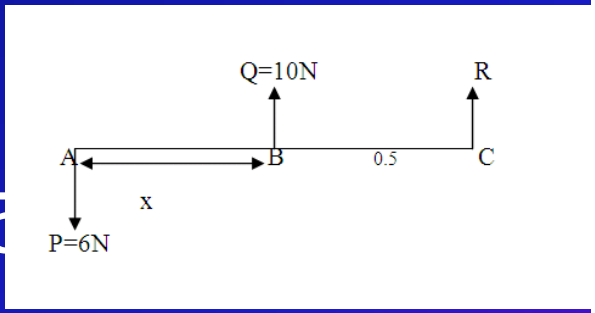
$$= 8 \text{ kg – wt}$$

Ans: (d) 8 kg – wt

16) Two unlike parallel forces 6 N and 10 N act on a rigid body at points A and B. If their resultant acts at a distance of 0.5 m from the greater force, the separation between A and B is

a) 1 m
b) ¼ m
c) 2/3 m
d) 1/3 m

Solution: Resultant of two unlike parallel forces is outside the forces as shown in the figure. It acts at C



$$P\,(AC) = Q(\,BC)$$

$$6\,(\,x + 0.5\,) = 10(0.5$$

$$6x + 3 = 5$$

$$X = 1/3 \quad \text{i.e } AB = 1/3 \text{ m}$$

Such that, taking moments about C

Ans: (d) 1/3 m

17) A man and a boy carry a light pole of length 5 m at either end. A load of 100 kg is hung from the pole in such a way that the boy bears ¼ th of the total load. The position of the load from the end of the pole being carried by the boy is

a) 1.25 m b) 3.75 m

c) 4.5 m d) 2.5 m

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Solution: Load carried by the boy

F_B = ¼ X total load

=1/4 X 100 = 25 kg

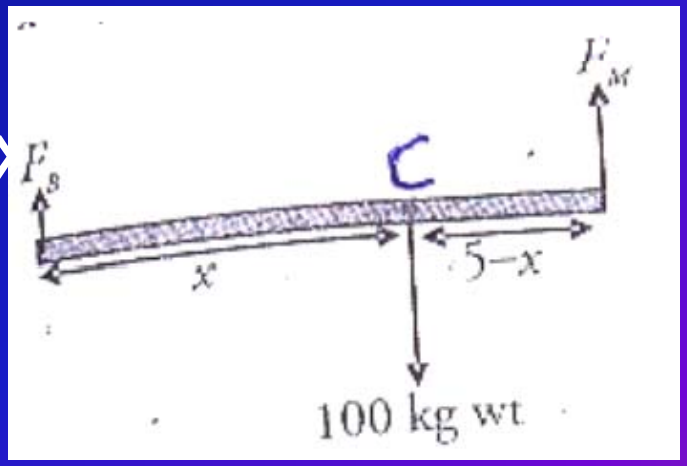
taking moments about C,

we get

25 x = 75 (5 - x

x = 3.75 m

Ans: (b) 3.75 m



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18) The force of 10 N acting on a body at a distance 2 m from the axis of rotation, the torque produced is

a) 10 N – m b) 2 N – m

c) 20 N – m d) 0.2 N – m

Solution: We know that,

Moment of a force = F x d

= 10 x 2

= 20 N – m

Ans: (c) 20 N – m

19) A torque applied to the rigid body always tends to produce

a) linear acceleration

b) rotational inertia

c) rotational equilibrium

d) angular acceleration

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Solution: A net torque applied to a rigid body causes rotation of the body. Therefore the angular acceleration is produced in the body.

Ans: (d) angular acceleration

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20) The rotatory effect produced by a force acting on a rigid body which is free to rotate about an axis is called

a) pure rotation
b) momentum of force
c) moment of momentum
d) moment of force

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Solution: It is called the moment of the applied force about the axis of rotation.

Ans: (d) moment of force

21)A gate of 6 m wide requires a force of 5.2 Kg – Wt to be applied at one end to open it. The force to be applied at a 1.5 m distance from the hinges to open it is

a) 20.8 Kg – Wt b) 10.4Kg – Wt

c) 15.3 Kg – Wt d) 6 Kg – Wt

Solution: Moment of the force about an axis must be equal

$$6 \times 5.2 = 1.5 \times F$$

$$\therefore \quad F = 20.8 \text{ kg- wt.}$$

Ans: (a) 20.8 kg- wt

22) The resultant of two forces is

a) always a constant

b) always unique

c) a non zero force

d) none of these

Solution: The resultant of two given forces is always unique. i.e, it has a fixed magnitude and direction.

Ans: (b) always unique

23) Two equal forces act at a point. The square of their resultant is equal to three times the product of the forces. The angle between the forces is

a) 30^0 b) 45^0

c) 60^0 d) 90^0

Solution: We know that,

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

$$R^2 = P^2 + P^2 + 2P^2\cos\theta$$

since P = Q Given, $R^2 = 3P^2$

$$\therefore \quad 3P^2 = 2P^2 + 2P^2\cos\theta$$

$$P^2 = 2P^2\cos\theta$$

$$\tfrac{1}{2} = \cos\theta \quad \text{or} \quad \cos\theta = \tfrac{1}{2}$$

$$\therefore \theta = 60^0$$

Ans: (c) 60^0

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24) The resultant of two forces 3P and 2P is R. If the first force is doubled then, the resultant is also doubled. The angle between the two forces is

a) 120^0 b) 60^0

c) 180^0 d) 90^0

Solution: We know that,

$R^2 = P^2 + Q^2 + 2\,PQ\cos\theta$

$R^2 = 9P^2 + 4P^2 + 2 \times 6P^2\cos\theta$

$R^2 = 9P^2 + 4P^2 + 12P^2\cos\theta$ --------(1)

$R^2 = 13P^2 + 12P^2\cos\theta$

First force is doubled means,

$P = 2(3P) = 6P$, $R = 2R$

$R^2 = P^2 + Q^2 + 2\,PQ\cos\theta$

$R^2 = 36\,P^2 + 4P^2 + 24P^2\cos\theta$ -------(2)

(2) / (1) gives

$4 = (40 + 24 \cos\theta) / (13 + 12\cos\theta)$

$52 + 48 \cos\theta = 40 + 24 \cos\theta$

$12 = -24 \cos\theta$

$\therefore \quad \cos\theta = -\frac{1}{2}$

$\therefore \quad \theta = 120^0$

Ans: (a) 120^0

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25)The resultant of two forces, one doubled the other in magnitude, is perpendicular to the smaller of the two forces.
The angle between the two forces is

a) 90^0 b) 150^0

c) 120^0 d) 60^0

Solution: We know that,

$\tan \alpha = (Q \sin \theta) / (P + Q \cos \theta)$

Given, $Q = 2P$, $\alpha = 90^0$

$\tan 90^0 = (2P \sin \theta) / (P + 2P \cos \theta)$

$P + 2P \cos \theta = (2P \sin \theta) / \tan 90^0$

$P + 2P \cos \theta = 0$

$\cos \theta = -\frac{1}{2}$

$\therefore \theta = 120^0$

Ans: (c) 120^0

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26)The resultant of a set of concurrent forces acting on a rigid body can be found out using

a) parallelogram law of forces
b) triangle law of forces
c) Lami's theorem
d) All these

Solution

Ans: (d) All these

27) A couple acting on a body causes

a) rotational motion only

b) translational motion only

c) both translational and rotational motion

d) vibrational motion

Solution: A couple acting on a body causes only rotational motion of the body.

Ans: (a) rotational motion

28) Two unequal forces F_1 and F_2 acting at an angle of 120^0 have their resultant perpendicular to the smaller of the two forces. If the greater force has the magnitude 10 N, the magnitude of their resultant is

a) $10\sqrt{2}$ N b) $5\sqrt{3}$ N

c) $10\sqrt{5}$ N d) 5 N

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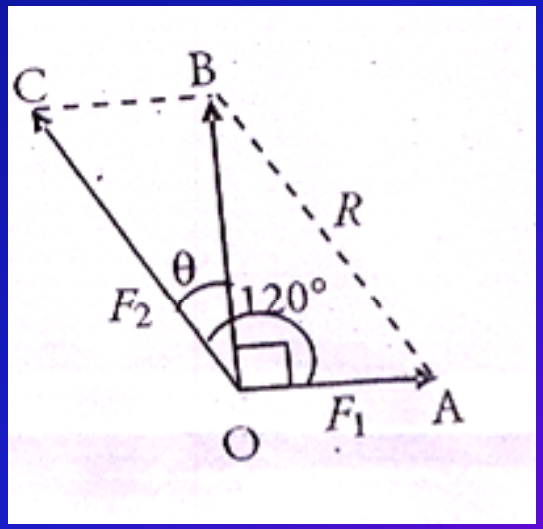
Solution: Let $F_1 \rightarrow$ be the smaller of the two forces.



From the figure, $\theta = 30^0$

From the right angled triangle OBC,

$\cos \theta = OB / OC$

$\cos \theta = R / F_2$

$\therefore \quad R = F_2 \cos \theta$

$= (10 \times \sqrt{3}) / 2 = 5 \sqrt{3}$ N

Ans: (b) $5 \sqrt{3}$ N

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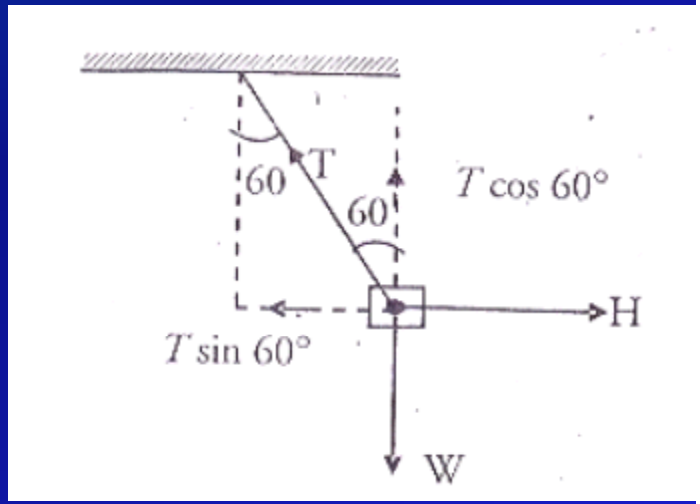
29) A block of mass 20 kg is suspended using an inextensible rope from a rigid support. The block is pulled aside by a horizontal force H such that the rope makes an angle 60^0 with the vertical. The horizontal force acting on the block is

a) 10 Kg – Wt

b) $20\sqrt{3}$ Kg – Wt

c) $20/\sqrt{3}$ Kg – Wt

d) $10/\sqrt{3}$ Kg – Wt



Solution: Given W = 20 kg

At equilibrium,

$T\cos 60 = W$ ----(1)

$T\sin 60 = H$ ----(2)

(2) /(1) gives, $\tan 60 = H / W$

$H = W \tan 60$

$H = 20\sqrt{3}$ kg – wt

Ans: (b) $20\sqrt{3}$ kg – wt

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30) Of the following sets of concurrent forces, the one which may be in equilibrium is

a) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 1$ N

b) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 9$ N

c) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 6$ N

d) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 15$ N

Solution: If three concurrent forces are to be in equilibrium, the sum of the two smallest magnitudes must be greater than the magnitude of third force.

Ans: (C) $F_1 = 3$ N, $F_2 = 5$ N, $F_3 = 6$ N

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31) Earth's atmosphere extends to about ---------- from the surface of the earth.

a) 56 km b) 560 km

c) 5600 km d) 56000 km

Solution:

Ans: b

32) Atmospheric pressure

a) decreases with elevate

b) increases with elevation

c) first increases and then decreases with elevation

d) does not depend on elevation

- **Solution:**

- **Ans: a**