# Laws of Motion

**2011**

1. **A fighter aircraft is looping in a vertical plane. The minimum velocity at the highest point is (Given r = radius of the loop)**

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

2. **In non-inertial frame, the second law of motion is written as**

   a) F = ma b) $F = ma + F_p$ c) $F = ma - F_p$ d) F = 2ma

**2010**

3. **A man of mass 60kg is riding in a lift. The weight of the man, when the lift is accelerating upwards and downwards at $2ms^{-2}$, are respectively (taking $g = 10ms^{-2}$)**

   a) 720N and 480N b) 480N and 720N c) 600N and 600N d) None of these

4. **The x and y-coordinates of a particle at any time t are given by $x = 7t + 4t^2$ and y = 5y, where x and y are in metre and t is second. The acceleration of the particle at t = 5s is**

   a) Zero b) $8ms^{-2}$ c) $20ms^{-2}$ d) $40ms^{-2}$

5. **A ball of mass 0.5kg is moving with a velocity v of $2ms^{-1}$. It is subjected to a force of x Newton in 2s. Because of this force, the ball moves with a velocity of $3ms^{-1}$. The value of x is**

   a) 5N b) 8.25N c) 0.25N d) 1N

6. **A force $F_1$ and 500N is required to push a car of mass 1000kg slowly at constant speed on a leveled road. If a force $F_2$ of 1000N is applied, the acceleration of the car will be**

   a) Zero b) $1.5ms^{-2}$ c) $1ms^{-2}$ d) $0.5ms^{-2}$

**2009**

7. **A monkey of mass m kg slides down a light rope attached to a fixed spring balance, with an acceleration a. The reading of this balance is w kg (g = acceleration due to gravity)**

a) $m = \frac{wg}{g-a}$ b) $m = w\left(1+\frac{a}{g}\right)$

c) The force of friction exerted by the rope on the monkey is m (g –a) Newton

d) The tension in the rope is wg Newton

8. **A ball hits a vertical wall horizontally at 10 m/s and bounces back at 10m/s, then**

a) There is no acceleration because 10 m/s -10m/s = 0

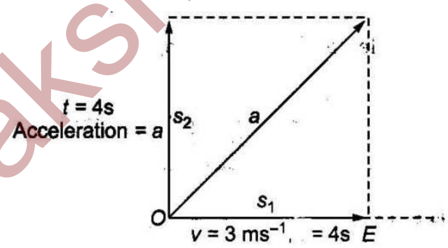
b) There may be an acceleration because its initial direction is horizontal

c) There is an acceleration because there is a momentum change

d) Even though there is no change in momentum there is a change in direction. Hence, it has acceleration

**2008**

9. **A body of mass 2kg has an initial velocity of $3ms^{-1}$ along OE and it is subjected to a force of 4N in a direction perpendicular to OE. The distance of body from O after 4s will be**




a) 12m b) 20m c) 8m d) 48m

10. **An object of mass 10kg moves at a constant speed of $10ms^{-1}$. A constant force, which acts for 4s on the object, gives it a speed $2ms^{-1}$ in opposite direction. The force acting on the object is**

a) -3N b) -30N c) 3N d) 30N

**2007**

**11. A 60kg man stands on a spring scale in the lift. At some instant he finds, scale reading has changed from 60kg to 50kg for a while and then comes back to the original mark. What should we conclude?**

a) The lift was in constant motion upwards

b) The lift while in motion downwards

c) The lift while in constant motion upwards, is suddenly stopped

d) The lift while in constant motion downwards, is suddenly stopped

**12. A man weighs 80kg. He stands on a weighing scale in a lift which is moving upwards with a uniform acceleration of** $5ms^{-2}$ **. What would be the reading on the scale (** $g = 10ms^{-2}$ **)**

a) 800N b) 1200N c) Zero d) 400N

**13. When a car moves on a road with uniform speed of** $30kmh^{-1}$ **, then resultant force on the car is**

a) The driving force drives the car in the direction of propagation of car

b) The resistive force acts opposite to the direction of propagation of car

c) Zero

d) None of the above

**2005**

**14. A person is standing in an elevator. In which situation he finds his weight less**

a) When the elevator moves upward with constant acceleration

b) When the elevator moves downward with constant acceleration

c) When the elevator moves upward with uniform velocity

d) When the elevator moves downward with uniform velocity

**2004**

**15. A ball of mass 150g moving with acceleration** $20ms^{-2}$ **is hit by a force, which acts on it for 0.1s. The impulsive force is**

a) 0.5N-s b) 0.1N-s c) 0.3N-s d) 1.2N-s

# Conservation of Linear Momentum and Impulse

**2008**

**16. A particle of mass m is projected with velocity v making an angle of $45^0$ with the horizontal. When the horizontal. When to particle lands on the level ground the magnitude of the change in its momentum will be**

a) 2mv  b) $mv/\sqrt{2}$  c) $mv\sqrt{2}$  d) Zero

**17. Sand is being dropped on a conveyor belt at the rate of $Mkgs^{-1}$. The force necessary to keept the belt moving with a constant velocity of $vms^{-1}$ will be**

a) Mv Newton  b) 2Mv Newton  c) $\frac{Mv}{2}$ Newton  d) Zero

**18. A machine gun is mounted on a 200kg vehicle on a horizontal smooth road (friction negligible). The gun fires 10 bullets with a velocity of $500ms^{-1}$. If the mass of each bullet be 10g, what is the acceleration produced in the vehicle?**

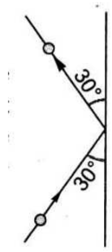
a) $25cms^{-2}$  b) $30cms^{-2}$  c) $50cms^{-2}$  d) $20cms^{-2}$

**2006**

**19. A disc of mass 100g is kept floating horizontally in air by firing bullets, each of mass 5g with the same velocity at the same rate of 10 bullets per second. The bullets rebound with the same speed in opposite direction, the velocity of each bullet at the time of impact is**

a) $196cms^{-1}$  b) $9.8cms^{-1}$  c) $98cms^{-1}$  d) $980cms^{-1}$

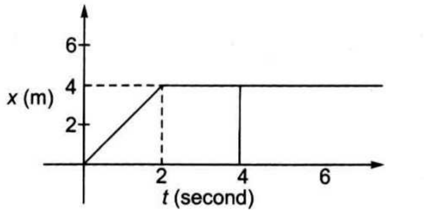
**20. A 0.5kg ball moving with a speed of $12ms^{-1}$ strikes a hard wall at an angle of $30^0$ with the wall. It is reflected with the same speed and at the same angle. If the ball is in contact with the wall for 0.25s, the average force acting on the wall is**




a) 48N  b) 24N  c) 12N  d) 96N

**2005**

**21. In the figure given the position-time graph of a particle of mass 0.1kg is shown. The impulse at t = 2s is**




a) $0.2 kg - ms^{-1}$ b) $-0.2 kg - ms^{-1}$

c) $0.1 kg - ms^{-1}$ d) $-0.4 kg - ms^{-1}$

**22. A rocket of mass 1000kg is to be projected vertically upwards. The gases are exhausted vertically downwards with velocity $100 ms^{-1}$ with respect to the rocket. What is the minimum rate of burning of fuel, so as to just lift the rocket upwards against the gravitational attraction (take $g = 10 ms^{-2}$)**

a) $50 kgs^{-1}$ b) $100 kgs^{-1}$ c) $200 kgs^{-1}$ d) $400 kgs^{-1}$

**23. A force of 10N acts on a body of mass 20kg for 10s. The change in its momentum is**

a) $50 kg - ms^{-1}$ b) $100 kg - ms^{-1}$

c) $300 kg - ms^{-1}$ d) $1000 kg - ms^{-1}$

**2004**

**24. A boat of mass 40kg is at rest. A dog of mass 4kg moves in the boat with a velocity of $10 ms^{-1}$. What is the velocity of boat?**

a) $4 ms^{-1}$ b) $2 ms^{-1}$

c) $8 ms^{-1}$ d) $1 ms^{-1}$

**25. A nucleus of mass under A, originally at rest, emits an $\alpha$-particle with speed v. The daughter nucleus recoils with a speed**

a) $\frac{2v}{A+4}$ b) $\frac{4v}{A+4}$

c) $\frac{4v}{A-4}$ d) $\frac{2v}{A-4}$

**26. What is the momentum of a 10000kg truck whose velocity is $2 ms^{-1}$**

a) $2\times10^{5} kg - ms^{-1}$ b) $1\times10^{5} kg - ms^{-1}$

c) $4kg - ms^{-1}$ d) None of these

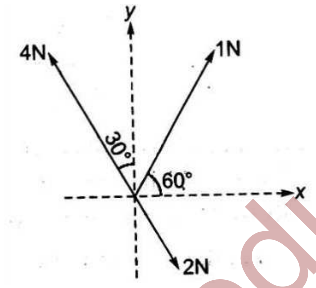
**27. Masses of two substances are 1g and 9g respectively. If their kinetic energies are same, then the ratio of their momentum will be**

a) 1:9 b) 9:1 c) 3:1 d) 1:3

# Equilibrium of Forces

**2008**

**28. Three forces acting on a body are shown in the figure. To have the resultant force only along the y-direction, the magnitude of the minimum additional force needed is**



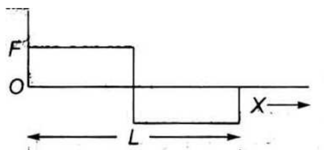

a) 0.5N b) 1.5N c) $\frac{\sqrt{3}}{4}N$ d) $\sqrt{3}N$

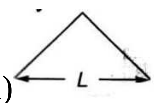
**29. The square of resultant of two equal forces is three times their product. Angle between the forces is**

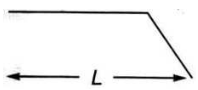
a) $\pi$ b) $\frac{\pi}{2}$ c) $\frac{\pi}{4}$ d) $\frac{\pi}{3}$

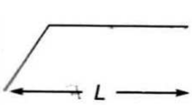
**2006**

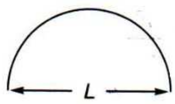
**30. A person used force (F), shown in figure to move a load with constant velocity on given surface. Identify the correct surface profile.**



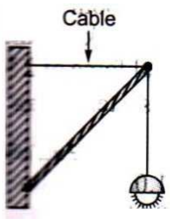

a) 

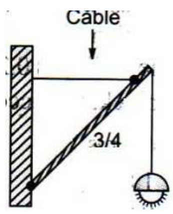
b) 

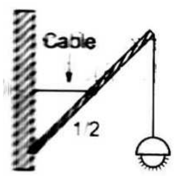
c) 

d) 


**31. If a street light of mass M is suspend from the end of a uniform rod of length L in different possible pattern as shown in figure, then**

**A)** 

**B)** 

**C)** 


a) Pattern A is more sturdy b) Pattern B is more sturdy
c) Pattern C is more sturdy d) All will have same sturdiness

**32. A weight w is suspended from, the mid-point of a rope, whose ends are at the same level. In order to make the rope perfectly horizontal, the force applied to each of its ends must be**

a) Less than w b) Equal to w c) Equal to 2w d) Infinitely large

**2004**

**33. Two equal forces (P each) act at a point inclined to each other at an angle of $120^0$. The magnitude of their resultant is**

a) P/2 b) P/4 c) P d) 2P

## Key

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1) **c** | 2) **c** | 3) **a** | 4) **b** | 5) **c** | 6) **d** | 7) **c** | 8) **c** | 9) **b** | 10) **b** |
| 11) **c** | 12) **b** | 13) **c** | 14) **b** | 15) **d** | 16) **c** | 17) **a** | 18) **a** | 19) **d** | 20) **b** |
| 21) **a** | 22) **b** | 23) **b** | 24) **d** | 25) **c** | 26) **a** | 27) **d** | 28) **a** | 29) **d** | 30) **a** |
| 31) **a** | 32) **d** | 33) **c** | | | | | | | |

## Hints

1. $mg = \frac{mv^2}{r}$

   $v^2 = gr$

   $v = \sqrt{gr}$

2. In non-inertial frame, $F = ma - F_p$

   Here $F_p$ is pseudo force and a is the acceleration of the body relative to non-inertial frame

3. Weight w = m (g+a) = 60(10+2) = 60x12 = 720 N

4. Acceleration $a = \sqrt{a_x^2 + a_y^2}$

   $$= \left[\left(\frac{d^2x}{dt^2}\right)^2 + \left(\frac{d^2y}{dt^2}\right)^2\right]^{\frac{1}{2}} = \frac{d^2x}{dt^2} = 8ms^{-2}$$

5. $F\Delta t = m\Delta v$

   F = x Newton, $\Delta t = 2s$, $v_1 = 2ms^{-1}$, $v_2 = 3ms^{-1}$, m = 0.5kg

   $\Rightarrow x = \frac{0.5}{2} = 0.25N$

6. Acceleration $= \frac{Net\ \ force}{Mass} = \frac{1000 - 500}{1000} = 0.5ms^{-2}$

7. The reading of the spring balance = tension in the rope = force of friction between the rope and monkey

   = m (g) – m (a)

   = m (g- a) Newton

8. Change in momentum = 2mv

   Also since we know that force = rate of change of momentum so, force will act on the ball. So there is acceleration.

9. The acceleration of the body perpendicular to OE is

   $a = \frac{F}{m} = \frac{4}{2} = 2ms^{-2}$

   Displacement along OE

   $s_1 = vt = 3 \times 4 = 12m$

   Displacement perpendicular to OE

$s_2 = \frac{1}{2}at^2 = \frac{1}{2}\times 2\times(4)^2 = 16m$

The resultant displacement

$s = \sqrt{s_1^2 + s_2^2} = \sqrt{144+256} = 20m$

10. $a = \frac{v-u}{t}$

$\therefore a = \frac{-2-10}{4} = -3ms^{-2}$

But,F = ma = 10 x (-3) = -30N

11. Apparent weight = m ( g + a )

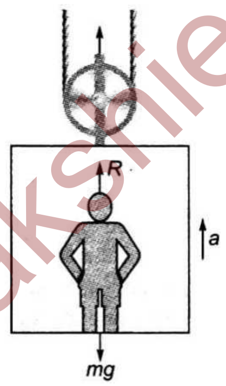
If lift suddenly stops during upward motion then apparent weight = m (g - a)

As it is given that scale reading initially was 60 kg and due to sudden jerk reading decreases and finally comes back to the original mark i.e 60 kg.

So, we can conclude that lift was moving upwards with constant speed and suddenly stops.

12. Mass of man M = 80 kg

Acceleration of lift, a = $5ms^{-2}$




When lift is moving upwards, the reading of weighting scale will be equal to R.

The equation of motion gives

R – mg = ma

Or R = mg + ma = m (g + a) = 80 (10 +5) = 1200 N

13. Concept

14. $w' = m(g-a)$

i.e, the person finds his weight less.

15. F= ma

$m = 150g = 150\times10^{-3}kg, a = 20ms^{-2}$

$\therefore F = 0.15\times20 = 3N$

$\text{Im } pulse = F\Delta t = 3\times0.1 = 0.3Ns$

**Topic – 2: Conversation of Linear Momentum and Impulse**

16. Change in momentum, $\Delta p = p_f - p_i = m(v_f - v_i)$

$$= m\left[\left(v\cos45^0 i - v\sin45^0 j\right) - \left(v\cos45^0 i + v\sin45^0 j\right)\right]$$

$$= m\left[\left(\frac{v}{\sqrt{2}}i - \frac{v}{\sqrt{2}}j\right) - \left(\frac{v}{\sqrt{2}}i + \frac{v}{\sqrt{2}}j\right)\right] = -\sqrt{2}mvj$$

$$\therefore |\Delta p| = \sqrt{2}mv$$

17. Force required, $F = \dfrac{d(mv)}{dt}$

$$= v\left(\frac{dm}{dt}\right) - vM$$

As velocity v is constant, hence

F = Mv Newton

18. Momentum carried by each bullet = mv =0.010x 500 $kg - ms^{-1} = 5kg - ms^{-1}$

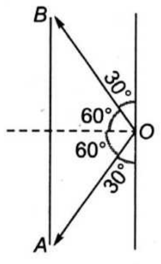
Now, force = change in momentum in 1 s = 5x10 = 50 N

Acceleration = $\dfrac{50}{200}ms^{-2} = 25cms^{-2}$

19. From law of conversation of momentum., $2m'vn = mg$

$$\therefore v = \frac{mg}{2m'n} = \frac{100\times980}{2\times5\times10} = 980\,cms^{-1}$$

20. $\Delta p = OB\sin30^0 - \left(-OA\sin30^0\right)$




$= mv\sin 30^0 - \left(-mv\sin 30^0\right) = 2mv\sin 30^0$

$\therefore F \times t = 2mv\sin 30^0$

Or $F = \dfrac{2mv\sin 30^0}{t}$

But, m=0.5 kg, v = $12ms^{-1}$ ,t = 0.25 s, $\theta = 30^0$

$F = \dfrac{2\times 0.5\times 12\times \sin 30^0}{0.25} = 24\,N$

21. I = change in momentum

$= \Delta p = m\Delta v = m\dfrac{\Delta x}{\Delta t}$

But, $m = 0.1kg, \dfrac{\Delta x}{\Delta t} = \dfrac{4.0}{2} ms^{-1}$

$\therefore I = 0.1\times \dfrac{4}{2} = 0.2kg - ms^{-1}$

22. The velocity of exhaust gases with respect to rocket $= 100ms^{-1}$

The minimum force on the rocket to lift it

$F_{\min} = mg = 1000\times 10 = 10000N$

Minimum rate of burning of fuel $\dfrac{dm}{dt} = \dfrac{F_{\min}}{v} = \dfrac{10000}{100} = 100kgs^{-1}$

23. The change in momentum of the body $\Delta p = F\times \Delta t = 10\times 10 = 100kg - ms^{-1}$

24. By law of conservation of linear momentum, $m_1v_1 = m_2v_2$

But, $m_1 = 40kg$ , $m_2 = 4kg$ , $v_2 = 10ms^{-1}$

$\therefore 40\times v_1 = 4\times 10 \Rightarrow v_1 = \dfrac{4\times 10}{40} = 1ms^{-1}$

25. $X^A \rightarrow Y^{A-4} + \alpha^4$

According to the law of conservation of momentum

Or $0 = m_y v_y + m_\alpha v_\alpha$

Or $0=(A-4)v_y+4v$

Or $v_y=-\frac{4v}{A-4}$

Negative sign corresponds the recoil speed of daughter nucleus

26. Momentum of truck $p=mv=100000\times2=2\times10^5 kg-ms^{-1}$

27. By the following relation $p=\sqrt{2mK}$

Given, $m_1=1g$ , $m_2=9g$ , $K_1=K_2=K$

$\therefore\frac{p_1}{p_2}=\frac{\sqrt{2\times1\times K}}{\sqrt{2\times9\times K}}=\frac{1}{3}$

**Topic 3: Equilibrium of Forces**

28. Minimum additional force needed

$F=-(F_{\text{resultant}})_x$

$F_{\text{resultant}}=[(4-2)(\cos30j-\sin30i)+(\cos60i+\sin60j)]$

$=\left[2\left(\frac{\sqrt{3}}{2}j+\frac{1}{2}i\right)+\left(\frac{1}{2}i+\frac{\sqrt{3}}{2}j\right)\right]=-\frac{i}{2}+\frac{3\sqrt{3}}{2}j$

$\therefore F=-\left(-\frac{i}{2}\right)=\frac{1}{2}i$

$|F|=0.5N$

29. P = Q and $R^2=3PQ=3P^2$

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

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

Or $3P^2-2P^2=2P^2\cos\theta$

Or $1=2\cos\theta$

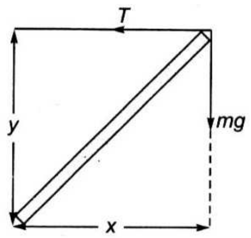
$\therefore\cos\theta=\frac{1}{2}$, thus, $\cos\theta=\cos60^0$

$\therefore\cos\theta=\frac{1}{2}$, thus $\cos\theta=\cos60^0$ or $\theta=60^0=\frac{\pi}{3}$

30. Concept

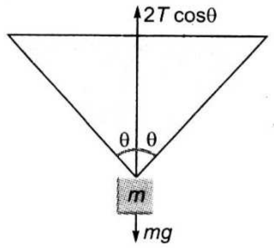
31. For equilibrium of street light,

$mg\times x=T\times y$




Or $T = \frac{mgx}{y}$

For T to be minimum, y should be maximum




Hence, pattern A is sturdier

32. For equilibrium of body

$mg = 2T\cos\theta$

$\therefore T = \frac{mg}{2\cos\theta}$

For the string to be horizontal

$\theta \to 90^0$

$\therefore T = \frac{mg}{2\cos 90^0} \Rightarrow T \to \infty$

33. The resultant force of two equal forces

$= \sqrt{P^2 + P^2 + 2P.P\cos 120^0} = \sqrt{2P^2 - P^2} = \sqrt{P^2} = P$