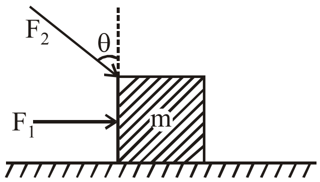
4

Laws of Motion

Diagram Based Questions :

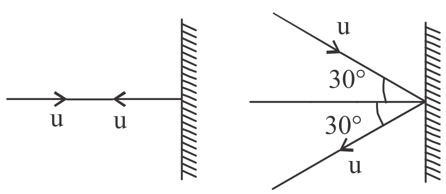
1. A block of mass m on a rough horizontal surface is acted upon by two forces as shown in figure. For equilibrium of block the coefficient of friction between block and surface is



(a) $\frac{F_1 + F_2 \sin\theta}{mg + F_2 \cos\theta}$ (b) $\frac{F_1 \cos\theta + F_2}{mg - F_2 \sin\theta}$

(c) $\frac{F_1 + F_2 \cos\theta}{mg + F_2 \sin\theta}$ (d) $\frac{F_1 \sin\theta - F_2}{mg - F_2 \cos\theta}$

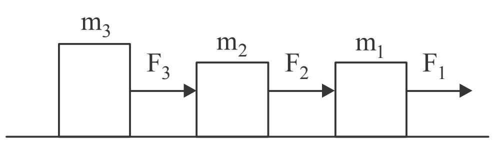
2. What is the direction of force on the wall due to the ball in two cases shown in the figures?



(a) (b)

(a) In (a) force is normal to the wall and in (b) force is inclined at 30° to the normal.
(b) In (a) force is normal to the wall and in (b) force is inclined at 60° to the normal.
(c) In (a) the force is along the wall and in (b) force is normal to the wall.
(d) In (a) and (b) both the force is normal to the wall.

3. For the system shown in figure, the correct expression is



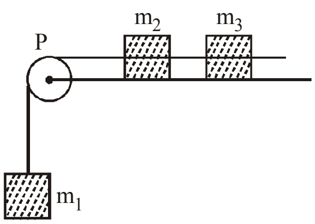
(a) $F_3 = F_1 + F_2$

(b) $F_3 = \frac{m_3 F}{F_1 + F_2 + F_3}$

(c) $F_3 = \frac{m_3 F}{m_1 + m_2 + m_3}$

(d) $F_3 = \frac{m_3 F}{m_1 + m_2}$

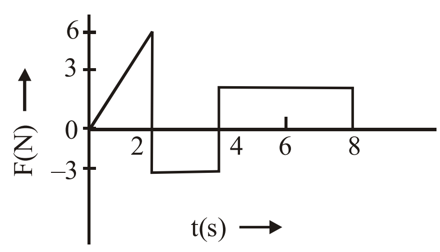
4. A system consists of three masses m_1, m_2 and m_3 connected by a string passing over a pulley P. The mass m_1 hangs freely and m_2 and m_3 are on a rough horizontal table (the coefficient of friction = μ). The pulley is frictionless and of negligible mass. The downward acceleration of mass m_1 is :
(Assume $m_1 = m_2 = m_3 = m$)



(a) $\frac{g(1 - g\mu)}{g}$ (b) $\frac{2g\mu}{3}$

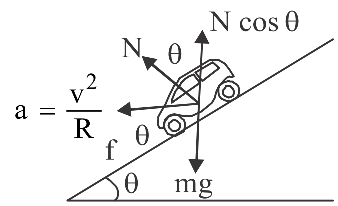
(c) $\frac{g(1 - 2\mu)}{3}$ (d) $\frac{g(1 - 2\mu)}{2}$

5. The force 'F' acting on a particle of mass 'm' is indicated by the force-time graph shown below. The change in momentum of the particle over the time interval from zero to 8 s is :



(a) 24 Ns (b) 20 Ns
(c) 12 Ns (d) 6 Ns

6. The motion of a car on a banked road is shown in the figure. The centripetal force equation will be given by



(a) $N\sin\theta + f\cos\theta = \frac{mv^2}{R}$

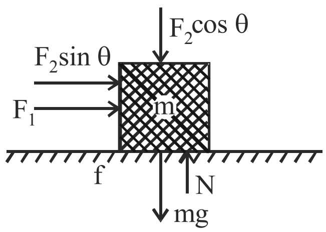
(b) $f = \frac{mv^2}{R}$

(c) $N\cos\theta + f = \frac{mv^2}{R}$

(d) $N\sin\theta + f = \frac{mv^2}{R}$

Solution

1. **(a)** Here, on resolving force F_2 and applying the concept of equilibrium



$N = mg + F_2\cos\theta$, and $f = \mu N$

$\therefore\ f = \mu[mg + F_2\cos\theta]$ … (i)

Also $f = F_1 + F_2\sin\theta$ … (ii)

From (i) and (ii)

$\mu[mg + F_2\cos\theta] = F_1 + F_2\sin\theta$

$\Rightarrow \mu = \frac{F_1 + F_2\sin\theta}{mg + F_2\cos\theta}$

2. **(d)** Case **(a)**

$(P_x)_i = mu$

$P_y(\text{initial}) = 0$

$(P_x)_f = f = -mu$

$P_y(\text{final}) = 0$

Impulse = $\Delta P = -2mu$ (along x –axis)

Impulse = 0 along y–axis

parallaly in case **(b)**

$(P_x)_i = mu\cos 30°$

$(P_y)_i = -mu\sin 30°$

$(P_x)_f = f = -mu\cos 30°$

$(P_y)_f = -mu\sin 30°$

$\therefore$ Impulse = $-2mu\cos 30°$(along x-axis)

Impulse = 0 (along y–axis)

Force and impulse are in the same direction the force on wall due to the ball is normal to the wall along positive x–direction in both **(a)** & **(b)** case.

3. **(c)** Common acceleration of system is

$a = \frac{F}{m_1 + m_2 + m_3}$

$\therefore$ Force on m_3 is $F_3 = m_3 \times a$

$= \frac{m_3 F}{m_1 + m_2 + m_3}$

4. **(c)** Acceleration

$= \frac{\text{Net force in the direction of motion}}{\text{Total mass of system}}$

$= \frac{m_1 g - \mu(m_2 + m_3)g}{m_1 + m_2 + m_3} = \frac{g}{3}(1 - 2\mu)$

($\because\ m_1 = m_2 = m_3 = m$ given)

5. **(c)** Change in momentum,

$\Delta p = \int F\,dt$

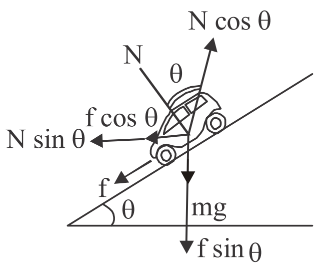
= Area of F-t graph

= ar of Δ – ar of ▭ + ar of ▭

$= \frac{1}{2} \times 2 \times 6 - 3 \times 2 + 4 \times 3$

= 12 N-s

6. **(a)**



Clearly form the figure, $N\sin\theta$ and $f\cos\theta$ contribute to the centripetal force.

$\therefore N\sin\theta + f\cos\theta = \frac{mv^2}{R}$