Solution

LAWS OF MOTION WS 1

Class 11 - Physics

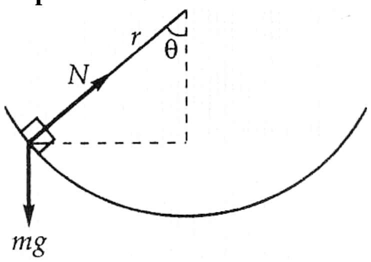
1.
   (b) 15 m/s
   Explanation: Net forward force = 1000 - 500 = 500 N
   $a = \frac{F}{m} = \frac{500}{1000} = \frac{1}{2}$ ms^{-2}
   v = u + at $= 10 + \frac{1}{2} \times 10$ = 15 ms^{-1}
2. **(a)** a vector equal in magnitude to the product of mass and instantaneous velocity and direction being that of instantaneous velocity
   Explanation: $\vec{p} = m\vec{v}$
3.
   (c) Three equations, one for each component of the vectors
   Explanation: $F_x = ma_x$, $F_y = ma_y$, $F_z = ma_z$
4.
   (d) generally $\mu_s > \mu_k$
   Explanation: generally $\mu_s > \mu_k$
5.
   (d) 40 s
   Explanation: $\vec{u} = (30\hat{i} + 40\hat{j})$m/s
   $\therefore u_y$ = 40 m/s
   $\vec{F} = (-6\hat{i} - 5\hat{j})$N
   $\therefore F_y$ = -5N
   $a_y = \frac{F_y}{m} = \frac{-5}{5}$ = -1 m/s^2
   v_y = 0
   But $v_y = u_y + a_y t$
   $\therefore$ 0 = 40 - 1 $\times$ or t = 40 s
6.
   (d) 1 : 1
   Explanation: $\omega = \frac{2\pi}{T}$
   For both cars, period of revolution T is same, so their angular speed ω is also same.
7. **(a)** as the force applied is internal to the system
   Explanation: The force applied by the student into himself is an internal force. According to Newton's laws, only an external force can change the state of motion of an object.
8. **(a)** $\frac{mL}{(M+m)}$
   Explanation: If the boy walks with speed v on the plank and the plank moves in opposite direction with speed V, then by conservation of momentum,
   mv - (M + m)V = 0 $\Rightarrow \frac{V}{v} = \frac{m}{M+m}$
   As distance covered $\propto$ speed, so
   $\frac{L'}{L} = \frac{V}{v} = \frac{m}{(M+m)}$
   $\Rightarrow L' = \frac{mL}{(M+m)}$
9.
   (d) $\frac{mv}{2}$ eastward and is exerted by the car engine
   Explanation: Car start from rest mean initial velocity u = 0, also $\vec{v} = v\hat{\imath}$ and t = 2 s mass is given as m
   As we know $\vec{v} = \vec{u} + \vec{a}t$ or $\vec{v}\hat{\imath}$ = 0 + $\vec{a} \times 2$ so $\vec{a} = \frac{\vec{v}}{2}$

Now force exerted on the car i.e. $\vec{F} = m\vec{a} = m\frac{\vec{v}}{2}$ here this force is due to engine of car so whatever this force is actually internal force in another words due to friction force the car moves in eastward direction.

10.

(d) $\omega = \sqrt{\frac{g}{r}\cos\theta}$

Explanation:



Resolving the forces along horizontal and vertical directions,

$N\sin\theta = m\omega^2 r\sin\theta$

$\Rightarrow \quad N = m\omega^2 r$

and N cos θ = mg

On dividing, we get

$\frac{1}{\cos\theta} = \frac{\omega^2 r}{g}$ or $\omega = \sqrt{\frac{g}{r\cos\theta}}$.

11.

(c) $\frac{4}{5}$

Explanation: From the equation of motion, we know that when a body is dropped

s = $ut + \frac{1}{2}gt^2$

h = $\frac{1}{2}gt^2$

So $\frac{\mathrm{t}_1}{\mathrm{t}_2} = \sqrt{\frac{\mathrm{h}_1}{1_2}} = \sqrt{\frac{16}{25}} = \frac{4}{5}$

12.

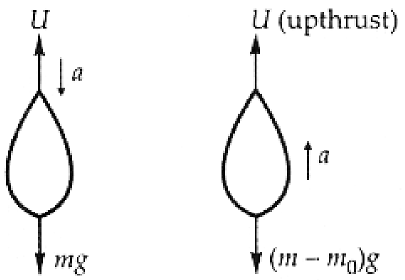
(c) car will cover less distance before stopping

Explanation: Being lighter than a truck, the car has less kinetic energy. On applying brakes with the same force, the car will cover less distance before coming to rest.

13.

(d) $\frac{2ma}{g+a}$

Explanation:



When the balloon descends down with acceleration a,

mg - U = ma

When the balloon moves up with acceleration a,

U - (m - m_0)g = (m - m_0)a

On adding the two equations,

$\Rightarrow$ mg - mg + m_0g = ma + ma - m_0a

$\Rightarrow m_0 = \frac{2ma}{g+a}$

14.

(b) move along tangent

Explanation: When the string breaks, the centripetal force becomes zero. The stone moves along the tangent to the circular path i.e., in the direction of velocity.

15.

(b) $-(0.9\hat{\mathbf{i}} + 1.2\hat{\mathbf{j}})$

Explanation: We know that change in momentum =final momentum - initial momentum 0 $\Delta\vec{p} = m_1\vec{v} - m_2\vec{u}$

now we have given mass 150 g i.e. $m_1 = m_2 = m = 0.15$ kg also $\vec{v} = -(3\hat{\imath} + 4\hat{\jmath})\text{ms}^{-1}$ and $\vec{u} = (3\hat{\imath} + 4\hat{\jmath})ms^{-1}$ so

$\Delta\vec{p} = m(\hat{v} - \hat{u}) = 0.15[-(3\hat{\imath} + 4\hat{\jmath}) - (3\hat{\imath} + 4\hat{\jmath})]$

= 0.15[-3$\hat{\imath}$ - 4$\hat{\jmath}$ -3$\hat{\imath}$ - 4$\hat{\jmath}$]

= 0.15[-6$\hat{\imath}$ - 8$\hat{\jmath}$]

= -0.9$\hat{\imath}$ -1.2$\hat{\jmath}$

So $\Delta\vec{p}$ = -[0.9$\hat{\imath}$ + 1.2$\hat{\jmath}$]

16.

(c) 1

Explanation: Uniform speed does not affect the weight of a man.

Required ratio $= \frac{60 \text{ kgwt}}{60 \text{ kgwt}} = 1$

17.

(d) 187.5 kgs^{-1}

Explanation: Initial acceleration,

$a = \frac{u}{m_0}\frac{dm}{dt} - g$

$20 = \frac{800}{5000} \times \frac{dm}{dt} - 10$

$\frac{dm}{dt} = \frac{30\times50}{8}$

= 187.5 kg s^{-1}

18.

(d) g

Explanation: For ball on the table,

$\frac{mv^2}{l} = T$

For the hanging ball,

mg = T

$\therefore \frac{mv^2}{l} = mg$

or $a_c = \frac{v^2}{l} = g$

19.

(d) related to acceleration **a** at that point and the same instant.

Explanation: According to Newton's second law of motion, the acceleration of a point mass as produced by a net force is directly proportional to the magnitude of the net force at that point in the same direction as the net force at that instant

F = ma

20.

(d) 0.1 m/s^2

Explanation: $\frac{1}{2}mv^2 = E \Rightarrow \frac{1}{2}\left(\frac{10}{1000}\right)v^2 = 8 \times 10^{-4}$

$\Rightarrow v^2 = 16 \times 10^{-2} \Rightarrow v = 4 \times 10^{-4} = 0.4$ m/s

Now, $v^2 = u^2 + 2a_t s (s = 4\pi R)$

$\Rightarrow \frac{16}{100} = 0^2 + 2a_t\left(4 \times \frac{22}{7} \times \frac{6.4}{100}\right)$

$\Rightarrow a_t = \frac{16}{100} \times \frac{7 \times 100}{8 \times 22 \times 6.4}$ = 4 = 0.1 m/s^2

21.

(d) remain standing

Explanation: If downward force on the earth stops. so upward self adjusting force also stop. In vertical direction. there is no force. Due to inertia person resists any change to its state of rest. Person will remain standing.

22.

(b) 75 N

Explanation: $f = \mu R = \mu mg$

= 03 × 250 = 75 N

23.

(b) the reading of spring balance will increase

Explanation: The reading of the spring balance will increase (F = ma + mg). The reading of the physical balance is not affected because the fictitious force acts equally on both the pans.

24.

(b) more than actual weight

Explanation: The apparent weight of the body is more than actual weight till the lift stops and then the weight becomes equal to mg.

25.

(c) bob will go down in a parabolic path

Explanation: At the mean position, the bob has a horizontal velocity. So when the string is cut, it will fall along a parabolic path under the effect of gravity.

26.

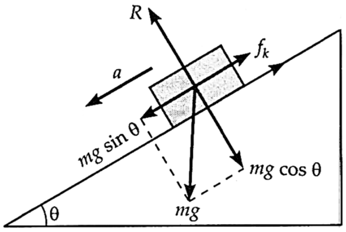
(d) zero

Explanation:

According to Newton's second law,

ma = f_k - mg sin θ = μ_r R - mg sin θ

= $\mu_k \cdot$ mg cos θ - mg sin θ



$\therefore a = g\left(\mu_k \cos\theta - \sin\theta\right)$

$= g\left(\frac{1}{\sqrt{3}} \cos 30^\circ - \sin 30^\circ\right)$

$= g\left(\frac{1}{\sqrt{3}} \cdot \frac{\sqrt{3}}{2} - \frac{1}{2}\right) = 0$

27.

(b) 500 m/s

Explanation: mv = MV

$v = \frac{MV}{m} = \frac{1 \times 5}{0.01}$ = 500 ms^{-1}

28.

(c) 21.6 km/h

Explanation: $v_{\max} = \sqrt{\mu r g} = \sqrt{0.2 \times 18 \times 10} = \sqrt{36}$ = 6 m/s

= 21.6 km/h

29.

(b) 60000 N

Explanation: $F = u\frac{dm}{dt}$ = 60 kms^{-1} × 1 kgs^{-1}

= 60000 kg ms^{-2} = 60000 N

30.

(b) 1.5 kg

Explanation: By conservation of momentum

MV = mv

$M = \frac{mv}{V} = \frac{0.05 \times 30}{1}$ = 1.5 kg

31. **(a)** $\sqrt{3}:2$

Explanation: Centripetal force, $F=\frac{mv^2}{r}$

$v=\sqrt{\frac{Fr}{m}}$

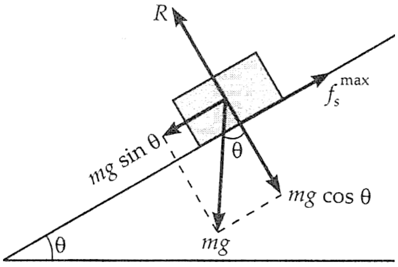
For same F and m, $v\propto\sqrt{r}$

$\therefore\frac{v_1}{v_2}=\sqrt{\frac{r_1}{r_2}}=\sqrt{\frac{6}{8}}=\frac{\sqrt{3}}{2}$

32.

(d) $\theta=\tan^{-1}\mu$

Explanation:



For equilibrium of the body,

mg $\sin\theta=f_s^{\max}$

mg cos θ = R

$\therefore\frac{mg\sin\theta}{mg\cos\theta}=\frac{f_s^{\max}}{R}$

or $\tan\theta=\mu$

or $\theta=\tan^{-1}(\mu)$

33.

(b) 45°

Explanation: $\tan\theta=\frac{v^2}{Rg}=\frac{20\times20}{40\times10}=1$

$\Rightarrow\theta=45^{\circ}$

34.

(d) 4.2 kg ms^{-1}

Explanation: Let $\overrightarrow{v_1}$ and $\overrightarrow{v_2}$ be the velocities of the ball before and after deflection, which is equal to 54 km h^{-1} = 15ms^{-1} as the speed of the ball does not change after a deflection.

$v=\sqrt{v_1^2+v_2^2+2v_1v_2\cos45^{\circ}}$

$=\sqrt{15^2+15^2+2\times15\times15\times(\frac{1}{\sqrt{2}}}$

= 27.72 ms^{-1}

Impulse imparted to the ball = Mass $\times$ change in velocity of the ball

0.15 $\times$ 27.72 = 4.2kgms^{-1}

35. **(a)** $18\hat{i}+6\hat{j}$

Explanation: $\vec{a}=\frac{\vec{F}}{m}=\frac{1}{3}\left(6t^2\hat{i}+4t\hat{j}\right)=\frac{d\vec{v}}{dt}$

$d\vec{v}=\frac{1}{3}\left(6t^2\hat{i}+4tj\right)dt$

Velocity at t = 3s will be

$\vec{v}=\int d\vec{v}=\frac{1}{3}\int_0^3\left(6t^2\hat{i}+4t\hat{j}\right)dt$

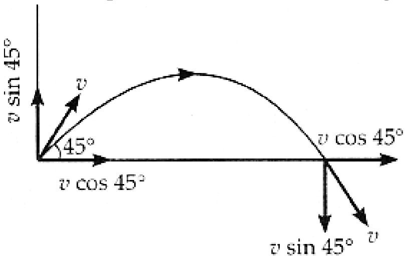
$=\frac{1}{3}\left|2t^3\hat{i}+2t^2\hat{j}\right|_0^3=\frac{2}{3}\left(3^3\hat{i}+3^2\hat{j}\right)$

$=(18\hat{i}+6\hat{j})\mathrm{ms}^{-1}$

36. **(a)** $\sqrt{2}mv$

Explanation:

When the particle lands on the level ground, its momentum along the horizontal direction does not change.



But vertical component of velocity gets reversed.

Change in momentum in vertical direction

= mv sin 45° - (-mv sin45°)

$= 2mv \times \frac{1}{\sqrt{2}} = \sqrt{2}mv$

37.

(c) 1 N

Explanation: $v^2 - u^2 = 2as$

$0^2 - 2^2 = 2a \times 0.05$

$a = -\frac{2}{0.05}$ = 40 ms^{-2}

Average resistance = ma

$= \frac{25}{1000} \times 40$ = 1 N

38.

(c) an object moving in straight line with constant velocity

Explanation: No force is required for an object moving in a straight line with constant velocity or for nonaccelerated motion.

39.

(b) zero

Explanation: m_A = 10 kg and m_B = 40 kg

In this case, $f_L = 0.5 \times 40 \times 10$ = 200N

But F = 40 N

Hence, $F < f_L$

Hence, m_B cannot move with respect to m_A.

40.

(c) $\sqrt{10}\ \text{ms}^{-1}$

Explanation: $\sqrt{10}\ \text{ms}^{-1}$

41.

(d) $2m_0$

Explanation: $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{m_0}{\sqrt{1-\frac{3}{4}c^2 \cdot \frac{1}{c^2}}} = 2m_0$

42. **(a)** 400 N

Explanation: When monkey climbs with the uniform speed, the acceleration is zero and we have:

$T = mg = 40 \times 10$ = 400N

43. **(a)** linear momentum

Explanation: A rocket works on the principle of conservation of linear momentum.

44.

(c) $\frac{3}{4}\tan\theta$

Explanation: When there is no friction, a = y sin θ

When there is friction, a' = g(sin θ - μ cos θ)

If the length of the inclined plane is d, then

$d = \frac{1}{2}at^2 = \frac{1}{2}a'(2t)^2$

or a = 4a'

or $g \sin\theta = 4g(\sin\theta - \mu\cos\theta)$
$\sin\theta = 4\sin\theta - 4\mu\cos\theta$
$4\mu\cos\theta = 3\sin\theta$
$\mu = \frac{3}{4}\tan\theta$

45.

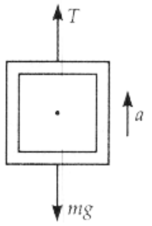
(c) to start a stationary object and to stop a moving object

Explanation: Force is required to start a stationary object and to stop a moving object due to inertia.

46.

(c) 11000 N

Explanation:



T - m g = ma
T = m(g + a)
= (940 + 60) $\times$ (10 + 1)
= 11000 N

47.

(b) the integral of force over a short period

Explanation: A resultant force causes acceleration and a change in the velocity of the body for as long as it acts. The change in momentum is equal to the product of the average force and duration. Conversely, a small force applied for a long time produces the same change in momentum, the same impulse, as a larger force applied for a short time interval.

Impulse J is

J = $F_{average}(t_2 - t_1)$

The impulse is the integral of the resultant force (F) with respect to time

$J = \int_{t_1}^{t_2} F.dt$

48.

(d) the pilot of an aeroplane which is taking off

Explanation: An inertial frame is a non-accelerated frame.

49. **(a)** 1000 N

Explanation: v = 36 km $h^{-1} = 36 \times \frac{5}{18}\ ms^{-1}$ = 10 ms^{-1}

$F = \frac{mv^2}{r} = \frac{500 \times 10 \times 10}{50}$ = 1000 N

50.

(b) 0.06

Explanation: $a = \frac{v-u}{t} = \frac{0-6}{10} = -\frac{3}{5}$ m/s^2

$\mu = \frac{a}{g} = \frac{3}{5 \times 10}$ = 0.06

51. **(a)** Velocity of light

Explanation: Velocity of light is same in all inertial frames.

52. **(a)** $5\sqrt{2}, \frac{\pi}{4}$

Explanation: $R = \sqrt{5^2 + 5^2} = 5\sqrt{2}$

$\tan\phi = \frac{5\sin 90^\circ}{5 + 5\cos 90^\circ} = \frac{5}{5}$ = 1

$\therefore \phi = \frac{\pi}{4}$

53.

(c) 136 N

Explanation: We have given in question x(t) = pt + qt^2 + rt^3 so to find the force we will differentiate above position equation two times i.e. $\vec{F} = m\vec{a} = m\frac{d^2x}{dt^2}$

We have x(t) = pt + qt^2 + rt^3 where p = 3 ms^{-1}, q = 4 ms^{-2}, r = 5 ms^{-3}

So x(t) = 3t + $4t^2$ + $5t^3$

Now first derivative of above equation

$\frac{dx(t)}{dt}$ = 3(1) + 4(2t) + 5($3t^2$) = 3 + 8t + $15t^2$

$\frac{d^2x(t)}{dt^2}$ = 0 + 8 + 30t

$\left[\frac{d^2x(t)}{dt^2}\right]$ t = 2 = 8 + 30 $\times$ 2 = 68 ms^{-2}

Hence $\vec{F} = m\frac{d^2x}{dt^2}$ = 2 $\times$ 68 = 136 N

54. **(a)** 40.8

Explanation: Retardation, a = μ g = 0.5 $\times$ 9.8 ms^{-2}

u = 72 km h^{-1} = 20 ms^{-1}

v^2 - u^2 = 2 as

0 - $(20)^2$ = -2 $\times$ 0.5 $\times$ 9.8s

$s = \frac{20\times20}{2\times0.5\times9.8}$ = 40.8 m

55.

(c) $10\sqrt{2}$ m/sec

Explanation: Two parts having same masses move in perpendicular directions. So, the resultant is the third one having mass 3 times of the two masses.

So, the resultant is = $\sqrt{(30)^2 + (30)^2}$ = $\sqrt{1800}$ = $30\sqrt{2}$

Since, the bigger part is thrice in mass of the other two parts.

So, $\Rightarrow$ $30\sqrt{23}$ = $10\sqrt{2}$ ms^{-1}

The velocity of bigger part is $10\sqrt{2}$ ms^{-1}

56.

(d) 2 mv

Explanation: Impulse = Change in momentum

= mv - (-mv) = 2mv

57.

(d) $\frac{-\beta v^2}{M}$

Explanation: Thrust, $F = -v\frac{dM}{dt} = -v \cdot \beta v = -\beta v^2$

Acceleration, $a = \frac{F}{M} = -\frac{\beta v^2}{M}$

58.

(c) -50 km

Explanation: a = $\frac{F}{m} = \frac{8}{0.4}$ = $20ms^{-2}$ towards the south

position at t = 30 sec

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

$s_1 = (10 \times 30) - \frac{1}{2} \times 20 \times 30 \times 30$ = -8700 m

velocity at t = 30 sec

v = u + at

v = 10 - (20 $\times$ 30) = −590m/sec

for motion between 30 sec to 100 sec (for 70 sec)

s_2 = (−590 $\times$ 70) + 0 = −41300m

total distance

s = s_1 + s_2 = -(8700 + 41300) = -50000m = -50Km

59.

(c) Both at rest and moving with uniform velocity

Explanation: In equilibrium, net force is zero, there force, acceleration is zero, hence particle is either at rest or in motion with uniform velocity.

60.

(d) 2.25×10^3 N

Explanation: Here, u = $15ms^{-1}$, v = 0, t = 1 s, A = $10^{-2}m^{-2}$

m = mass of water gushed out per second

$= \frac{\text{Volumexdensity}}{\text{Time}}$

$= \frac{\text{Area} \times \text{distance} \times \text{density}}{\text{Time}}$

=Area $\times$ velocity $\times$ density

= Auρ

= $10^{-2} \times 15 \times 1000$ = 150kg

Force exerted by the wall on water,

F = ma = $m\frac{v-u}{t} = 150 \times \frac{0-15}{1}$ = -2250 N

So the force exerted on the wall by the impact of water,

F_1 = -F = 2250 N

61.

(c) zero

Explanation: Apparent weight of the body in the lift = m (g - g) = 0

Consequently, normal reaction and hence force of friction are both zero.

62.

(c) Newton

Explanation: In the International System of Units (SI) the newton is the unit for force. It is equal to the amount of net force required to accelerate a mass of one kilogram at a rate of 1 m/sec^2 in direction of the applied force. It is named after Isaac Newton in recognition of his work on classical mechanics, specifically Newton's second law of motion.

63.

(b) 30 ms^{-1}

Explanation: For a banked road, the safe speed limit is $v = \sqrt{rg\tan\theta} = \sqrt{90 \times 10 \times \tan 45^\circ} = \sqrt{900}$ = 30 ms^{-1}

64.

(c) 16 m

Explanation: As the box is in an accelerated frame, it experiences a backward force,

F = ma

Motion of the box is opposed by friction,

$f = \mu R = \mu mg$

Net backward force on the box,

F' = F - f = ma - μmg

= m (a - μg)

= 20(2 - 0.15 $\times$ 10)N = 10N

Backward acceleration of the box,

$a' = \frac{F'}{m} = \frac{10}{20}$ = 0.5 ms^{-2}

If the box takes time t to fall off the truck, then

s = ut + $\frac{1}{2}a't^2$

4 = 0 + $\frac{1}{2} \times 0.5 \times t^2$

$\Rightarrow t^2 = 16$

$\Rightarrow$ t = 4s

Distance covered by the truck accelerating at 2 ms^{-2} during this time,

$x = \frac{1}{2}at^2 = \frac{1}{2} \times 2 \times 16$ = 16 m

65.

(b) radius

Explanation: $a = \frac{v^2}{r}$ i.e. $a \propto \frac{1}{r}$

66.

(c) $Mg - \frac{Mv^2}{r}$

Explanation: $F = Mg - \frac{Mv^2}{r}$

67.

(d) 15.24 km

Explanation: Here, we have

θ = 15^o, g = $9.8ms^{-2}$, v = $720kmh^{-1}$ = $200ms^{-1}$

Now we have, $\tan\theta = \frac{v^2}{rg}$

$\therefore r = \frac{200\times200}{9.8\times tan15^o}$

radius of loop is ,r = 15.24km

68.

(c) momentum

Explanation: [Impulse] = [Change in momentum]

= $[MLT^{-1}]$

69.

(c) 24 N

Explanation: 24 N

70. **(a)** 1929 N

Explanation: For car : $f_1 = \mu m_1 g = 0.001 \times 400 \times 10 = 4$ N

$4500 - T - 4 = 400 \times a$

For coach : $f_2 = 0.001 \times 300 \times 10 = 3$ N

$T - 3 = 300 \times a$

$\therefore$ 4500 - 7 = 700a

or $a = \frac{4493}{700}$ ms^{-2}

Hence T = 300a + 3

$= 300 \times \frac{4493}{700} + 3$

= 1929 N

71.

(b) 2 N

Explanation: P + Q = 7 N and P - Q = 3 N

$\therefore$ P = 5 N, Q = 2 N

Thus smaller force is equal to 2 N.

72.

(b) 6.0 m

Explanation: The man and the boy move in opposite directions.

Momentum of man = - Momentum of boy

$60 \times 0.4 = -30 \times v$

$\therefore$ Velocity of the boy,

v = $-0.8 ms^{-1}$

Relative velocity = 0.4 + 0.8 = 1.2 ms^{-1}

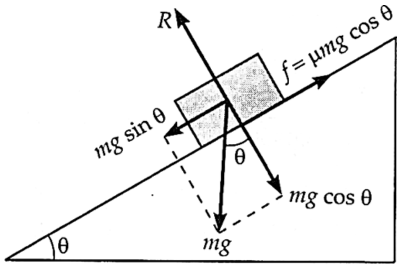
Distance between man and boy after 5 s

$= 1.2 \times 5 = 6.0$ m

73.

(d) mg $\cos\theta\sqrt{1+\mu^2}$

Explanation:



The contact force between the block and the inclined plane,

$F = \sqrt{R^2 + f^2} = \sqrt{(mg\cos\theta)^2 + (\mu mg\cos\theta)^2}$

$= mg\cos\theta\sqrt{1+\mu^2}$

74.

(c) 6.6 N

Explanation: Let, m = 0.25 kg, r = 1.5m and f = 40 rv/min = 40 rev /60 s = 2/3 rps

$\omega = 2\pi f = 2\pi \times \frac{2}{3} = \frac{4\pi}{3}\, rad\, s^{-1}$

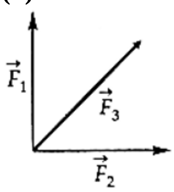
Tension in the string = Centripetal force

so, $T = mr\omega^2 = 0.25 \times 1.5 \times (\frac{4\pi}{3})^2$

6.6 N

75.

(b)



Explanation: $\vec{F}_1$ and $\vec{F}_2$ can add up in same order to give $\vec{F}_3$ in opposite order.