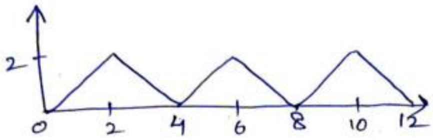
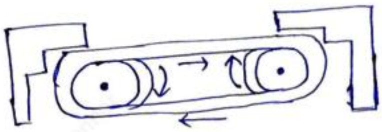
SRIGAYATRI EDUCATIONAL INSTITUTIONS
INDIA

LAWS OF MOTION UT-04 QB
PHYSICS
PART -1 (NUMERICAL TYPE UESTIONS)

1. **Figure shows the position – time (x - t) graph of one dimensional motion of a body of mass 500g consecutive impulses received by the body ?**



2. **Fig shows a man standing stationary with respect to a horizontal conveyor but that is acceleration with $2m/s^2$. What is the net force on the man? If the coefficient of static friction between the man's shoes and the belt is 0.4 up to what acceleration of the belt can the man continue to be stationary relative to the belt ?(Mass of the man = 50 kg)**



3. **A constant retarding force of 100N is applied to a body of mass 40 kg moving initially with a speed of 30 m/s. How long does the body take to stop ?.....**

4. **A body of mass 10 Kg is acted upon by two perpendicular forces 4N and 3N. Give the magnitude & direction of the acceleration of the body…**

5. **A rocket with a lift-off mass 40,000kg is blasted upwards with an initial acceleration of 15.0 m/s^2. Calculate the initial thrust (force) of the blast.**

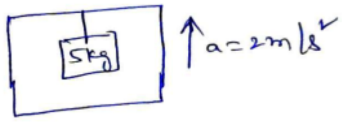
6. **A bullet of mass 0.02 Kg moving with a speed of 80 m/s enters a heavy wooden block and is stopped after a distance of 50 cm. What is the average resistive force exerted by the lock on the bullet?**

7. **The motion of a particle of mass m is described by $y = ut + \frac{1}{2}gt^2$. Find the force acting on the particle ….**

8. **An aircraft executes a horizontal loop at a speed of 720 km/h with its wings banked at 15^0. What is the radius of the loop?**

9. **A stream of water flowing horizontally with a speed of 15 m/s gushes out of a tube of cross sectional area 10^{-2} m^2 & hit vertical wall near by. What is the force exerted on the wall by the impact of water assuming it does not rebound?**

10. **A 5 Kg block is hanging in a lift accelerating upward with acceleration $2m/s^2$. The tension (in N) in the string is ……**
Assuming that string is ideal and g = 10 m/s^2



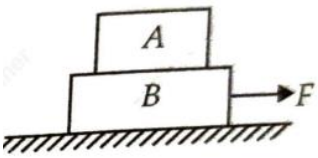
11. A monkey of mass 40 kg climbs ona massless rope which can stand a maximum tension of 500 N. In which of the following cases will the rope break? (Take.g=10 ms^{-2})

1) The monkey climbs up with an acceleration of 5 ms^{-2}
2) The monkey climbs down with an acceleration of 5 ms^{-2}
3) The monkey climbs up with a uniform speed of 5 ms^{-2}
4) The monkey falls down the rope freely under gravity.

12. A circular racetrack of radius 300 m is banked at an angle of 15^0. The coefficient of friction between the wheels of a race car and the road is 0.2. The optimum speed of take race car to avoid wear and tear on its tyres is (Take tan 15^0=0.27, g=10 ms^{-2})

1) $10\sqrt{3}\text{ms}^{-1}$ 2) $9\sqrt{10}\text{ms}^{-1}$ 3) $\sqrt{10}\text{ms}^{-1}$ 4) $2\sqrt{10}\text{ms}^{-1}$

13. In figure, the coefficient of friction between the floor and the block B is 0.1. The coefficient the block B is the friction between the blocks of B and A is 0.2. The mass force A is m/2 and of B is m. what is the maximum horizontal force F which can be applied to the block B so that two blocks move together?



1) 0.15 mg 2) 0.05 mg 3) 0.1 mg 4) 0.45 mg

14. A block of mass m rests on a rough inclined plane. The coefficient of friction between the surface and the block is μ. At what angle of inclination θ of the plane to the horizontal will the block just start to slide down the plane?

1) $\theta = \tan^{-1}\mu$ 2) $\theta = \cos^{-1}\mu$ 3) $\theta = \sin^{-1}\mu$ 4) $\theta = \sec^{-1}\mu$

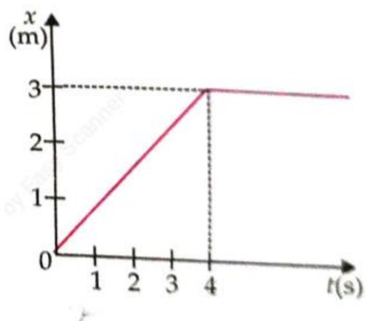
15. A constant retarding force of 50 N is applied to a body of mass 10 kg moving initially with a speed of 10 m s^{-1}. The body comes to rest after

1) 2 s 2) 4 s 3) 6 s 4) 8 s

16. If the force on a rocket, moving with a velocity of 300 ms^{-1} is 210 N, then the rate of combustion of the fuel is

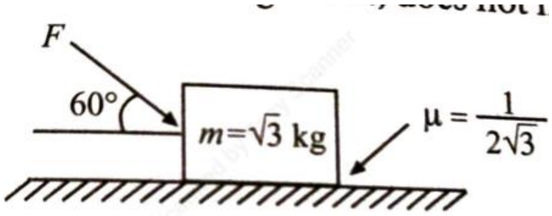
1) 0.07kgs^{-1} 2) 1.4kgs^{-1} 3) 0.7kgs^{-1} 4) 10.7kgs^{-1}

17. The position-time graph of a body of mass 2 kg is as shown in figure. What is the impulse on the body at t=4 s ?



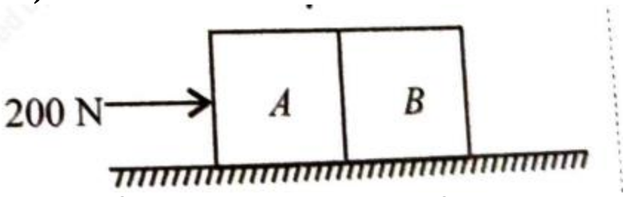
1) $\frac{2}{3}\text{kgms}^{-1}$ 2) $-\frac{2}{3}\text{kgms}^{-1}$ 3) $\frac{3}{2}\text{kgms}^{-1}$ 4) $-\frac{3}{2}\text{kgms}^{-1}$

18. **The maximum value of the force F such that the block shown in the arrangement, does not move is**



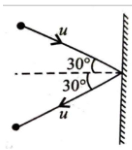
1) 10 N 2) 15 N 3) 20 N 4) 5 N

19. **Two blocks A and B of masses 10 kg and 15 kg are placed in contact with each other rest on a rough horizontal surface as shown in the figure. The coefficient of friction between the blocks and surface is 0.2. A horizontal force of 200 N is applied to block A. The acceleration of the system is (Take g=10 ms^{-2})**



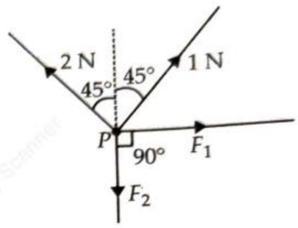
1) 4ms^{-2} 2) 6ms^{-2} 3) 8ms^{-2} 4) 10ms^{-2}

20. **A ball of mass m strikes a rigid wall with speed u at an angle of 30^0 and get reflected with the same speed and at the same angle as shown in the figure. If the ball is in contact with the wall for time t then the force acting on the wall is**



1) $\frac{mu\sin 30^\circ}{t}$ 2) $\frac{2mu\sin 30^\circ}{t}$ 3) $\frac{mu\cos 30^\circ}{t}$ 4) $\frac{2mu\cos 30^\circ}{t}$

21. **There are four forces acting at a point P produced by strings as shown in figure, which is at rest. The forces F_1 and F_2 are**

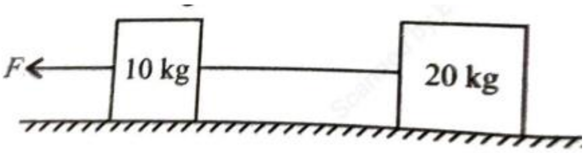


1) $\frac{1}{\sqrt{2}}$N, $\frac{3}{\sqrt{2}}$N 2) $\frac{3}{\sqrt{2}}$N, $\frac{1}{\sqrt{2}}$N 3) $\frac{1}{\sqrt{2}}$N, $\frac{1}{\sqrt{2}}$N 4) $\frac{3}{\sqrt{2}}$N, $\frac{3}{\sqrt{2}}$N

22. **A block of mass M is held against a rough vertical wall by pressing it with a finger. If the coefficient of friction between the block and the wall is μ and the acceleration due to gravity is g, what is the minimum force required to be applied by the finger to hold the block against the wall?**

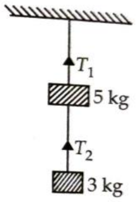
1) μMg 2) Mg 3) $\frac{Mg}{\mu}$ 4) $2\mu Mg$

23. **Two blocks of masses 10 kg and 20 kg are connected by massless string and placed on a smooth horizontal surface as shown in the figure. If a force F=600 N is applied to 10 kg block, then the tension in the string is**



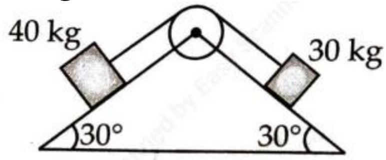
1) 100 N 2) 200 N 3) 300N 4) 400 N

24. Two masses of 5 kg and 3 kg are suspended with the help of massless inextensible strings as shown in figure. The whole system is going upwards with an acceleration of 2 m s^{-2} . The tensions T_1 and T_2 are respectively



1) 96 N, 36 N 2) 36 N, 96 N 3) 96 N, 96 N 4) 36 N, 36 N

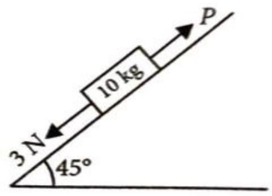
25. Two blocks of masses 40 kg and 30 kg are connected by a weightless string passing over a frictionless pulley as shown in the figure.



The acceleration of the system would be

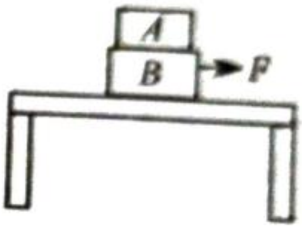
1) $0.7ms^{-2}$ 2) $0.8ms^{-2}$ 3) $0.6ms^{-2}$ 4) $0.5ms^{-2}$

26. A block of mass 10 kg is kept on a rough inclined plane as shown in the figure. A force of 3 N is applied on the block. The coefficient of static friction between the plane and the block is 0.6. What should be the minimum value of downward? (Take g=10 ms^{-2})



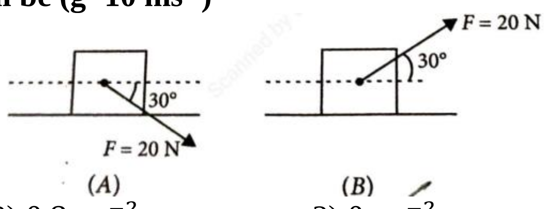
1) 25 N 2) 23 N 3) 18 N 4) 32 N

27. Two blocks A and B of masses m_A=1 kg and m_B=3 kg are kept on the table as shown in figure. The coefficient of friction between A and B is 0.2 and between B and the surface of the table is also 0, force F that can be applied on B horizontally, so that the block A does not slide over the block B is [Take g=10 m / s^2]



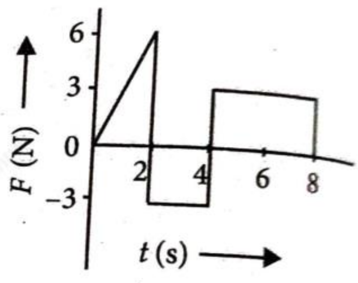
1) 16 N 2) 8 N 3) 12 N 4) 40 N

28. A block of mass 5 kg is (i) pushed in case (A) and (ii) pulled in case (B), by a force F=20 N, making an angle of 30^0 with the horizontal, as shown in the figures. The coefficient of friction between the block and floor μ = 0.2. The difference between the accelerations of the block, in case (B) and case (A) will be (g=10 ms^{-2})



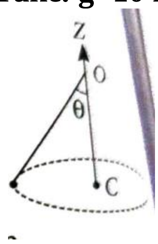
1) $0.4ms^{-2}$ 2) $0.8ms^{-2}$ 3) $0ms^{-2}$ 4) $3.2ms^{-2}$

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



1) 24 Ns 2) 20 Ns 3) 12 Ns 4) 6 Ns

30. A conical pendulum of length 1 m makes an angle θ=45^{0}w.r.t. Z -axis and moves in a circle in the XY plane. The radius of the circle is 0.4m and its center is vertically below O. The speed of the pendulum, in its circular path, will be (Take. g=10 ms^{-2})



1) 0.4 m/s 2) 2 m/s 3) 0.2 m/s 4) 4 m/s

KEY

PHYSICS

1) **2s**	2) **4**	3) **12**	4) **0.5**	5) **10^6**	6) **128**	7) **Mg**	8) **14815**	9) **2250**	10) **60**
11) **1**	12) **2**	13) **4**	14) **1**	15) **1**	16) **3**	17) **4**	18) **3**	19) **2**	20) **4**
21) **1**	22) **3**	23) **4**	24) **1**	25) **1**	26) **4**	27) **1**	28) **2**	29) **3**	30) **2**

SOLUTION

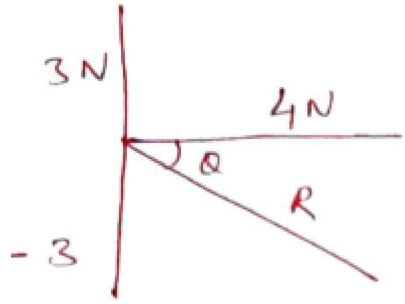
1. Figure shows that slope of x-t graph changes from positive to negative at t = 2s, and it changes from negative to positive at t = 4s and so on. Thus direction of velocity is reversed after every two seconds. Hence, the body must be receiving consecutive impulses after every two seconds

2. $M = 50kg$
$a = 2m/s^2$
$\mu = 0.4$
$F_{net} = ma = 50\times 2 = 100N$
$F_{net} = f_s$
$\cancel{m}a' = \mu \cancel{m}\,g$
$a' = 0.4\times 10 = 4m/s$

3. $F = -100N$
$m = 40Kg$
$u = 30m/s$
$v = 0$
$-100 = 4\times a$
$a = \dfrac{-100}{40}$
$v = u + at$

$t = \frac{-u}{a} = \frac{-30 \times 4}{-10} = 12s$

4.



$R = \sqrt{4^2 + (-3)^2} = \sqrt{16+9} = \sqrt{25} = 5N$

θ is the angle made by R with the force 4 N

$\theta = Tan^{-1}\left(\frac{-3}{4}\right)$ (C.W.D) w. r to force of 4N

$F = ma$

$a = \frac{F}{m} = \frac{5}{10} = \frac{1}{2} = 0.5m/s^2$

5. $m = 40,000kg$

$a = 15.0m/s^2$

$g = 10m/s^2$

$F = m(g+a) = 40000 \times (10+15) = 40000 + 25$

$= 10^6$

6. $a = \frac{-u^2}{2s} = \frac{-80 \times 80}{2 \times 0.5} = \frac{-6400}{1} = -6400m/s^2$

(retarding $F_{net} = ma = 0.02 \times 6400 = 128N$

7. $y = ut + \frac{1}{2}at^2$

$v = \frac{dy}{dt} = u + gt$

$a = \frac{dv}{dt} = g$

$F = ma = mg$

8. $V = 720km/h = 720 \times \frac{5}{18} = 200m/s$

$Tan\theta = \frac{v^2}{rg}$

$r = \frac{v^2}{\tan\theta g} = 14815m$

9. $v = 15m/s$

$A = 10^{-2}m^2$

$V = AV = 15 \times \grave{}0^{-2}m^3/s$

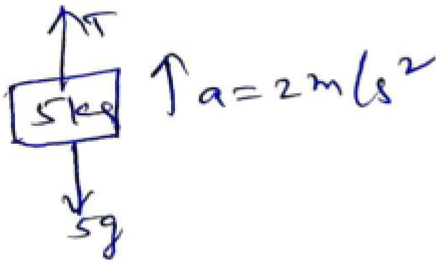
$\rho = 10^3 kg/m^3$

Mass of water flowing out through the pipe per second

$F = \frac{\Delta p}{\Delta t} = \frac{mv}{t}$

$= \rho \times v = 150 kg/s \qquad = 150 \times 15 = 2250 N$

10.



$T - 5g = 5a$

$T = 5g + 5a = 60N$

11. Here mass of monkey, $m = 40$kg

Maximum tension the rope can stand, T=500N

Tension in the rope will be equal to apparent weight of the monkey (R).

The rope will break when R exceeds T

(a) When the monkey climbs up with an acceleration a = 5ms^{-2}

R=m(g+a)=40(10+5)=600 N $\quad\quad\quad \therefore$ R>T

Hence, the rope will break.

b) When the monkey climbs down with an acceleration a = 5ms^{-2}

R=m(g-a)=40(10-5)=200 N $\quad\quad\quad \therefore$R < T

Hence, the rope will not break

(c) When the monkey climbs up with a uniform speed v=5ms^{-1}, its acceleration a=0

$\therefore$ R = mg = 40 × 10 = 400 N $\quad\quad\quad \therefore$R<T

Hence, the rope will not break.

(d) When the monkey falls down the rope freely under gravity

a=g $\quad\quad\quad \therefore$ R=m(g-a)=m(g-g)= zero

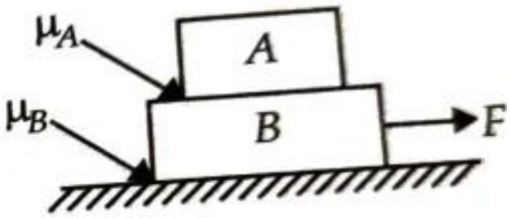
Hence the rope will not break.

12. Here, $R = 300\text{m}, \theta = 15°, g = 10\text{ms}^{-2}, \mu = 0.2$

The optimum speed of the car to avoid wear and tear is given by

$v = \sqrt{\text{Rg}\tan\theta} = \sqrt{300 \times 10 \times \tan 15°} = \sqrt{810} = 9\sqrt{10}\text{ms}^{-1}$

13. Here, $m_A = \frac{m}{2}, m_B = m$



$\mu_A = 0.2, \mu_B = 0.1$

Let both the blocks moving with common acceleration a.

Then,

$a = \frac{\mu_A m_A g}{m_A} = \mu_A g = 0.2g$

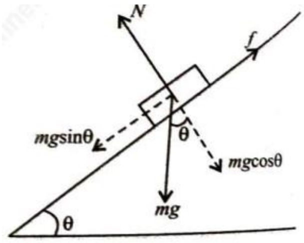
and $F - \mu_B(m_B + m_A)g = (m_B + m_A)a$

$F = (m_R + m_A)a + \mu_B(m_B + m_A)g$

$= \left(m + \frac{m}{2}\right)(0.2g) + (0.1)\left(m + \frac{m}{2}\right)g$

$= \left(\frac{3}{2}m\right)(0.2g) + \left(\frac{3}{2}m\right)(0.1g) = \frac{0.9}{2}mg = 0.45mg$

14. The various forces acting on the block are as shown in the figure.



From figure.
$mg \sin\theta = f \ldots.(i)$
$mg \cos\theta = N \ldots.(ii)$

Divide (i) by (ii), we get
$\tan\theta = \frac{f}{N} = \frac{\mu N}{N}$ or $\theta = \tan^{-1}(\mu)$

15. Here, $F = -50\text{N}$(- ve sign for retardation)

$m = 10\text{kg}, u = 10\text{ms}^{-1}, v = 0$

As $F = ma \therefore a = \frac{F}{m} = \frac{-50\text{N}}{10\text{kg}} = -5\text{ms}^{-2}$

Using $v = u + at \therefore t = \frac{v-u}{a} = \frac{0-10\text{ms}^{-1}}{-5\text{ms}^{-2}} = 2\text{s}$

16. Force $= \frac{d}{dt}$(momentum)

$= \frac{d}{dt}(mv) = v\left(\frac{dm}{dt}\right) \Rightarrow 210 = 300\left(\frac{dm}{dt}\right)$

rate of combustion, $\frac{dm}{dt}=\frac{210}{300}=0.7\text{kgs}^{-1}$

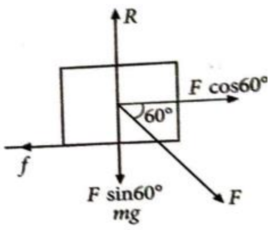
17. At $t=4\text{s}$, the body has constant velocity

$u=\frac{3}{4}\text{ms}^{-1}$

After $t=4\text{s}$, the body is at rest $i.e.,v=0$

$\therefore$ Impulse $=m(v-u)=2\text{kg}\left(0-\frac{3}{4}\text{ms}^{-1}\right)=-\frac{3}{2}\text{kgms}^{-1}$

18.



Let F be the maximum value of force applied when

the block of $m=\sqrt{3}\text{kg}$ does not move on the rough surface.

$R=$ normal reaction

or $R=F\sin 60^{\circ}+mg$

$f=$ force of friction

$\mu R=F\cos 60^{\circ}$

и ($F\sin 60^{\circ}+mg)=F\cos 60^{\circ}$

or $\mu F\sin 60^{\circ}+\mu mg=F\cos 60^{\circ}$

or $F=\frac{\mu\text{mg}}{\cos 60^{\circ}-\mu\sin 60^{\circ}}$

$=\frac{\frac{1}{2\sqrt{3}}\times\sqrt{3}\times 10}{\frac{1}{2}-\left(\frac{1}{2\sqrt{3}}\times\frac{\sqrt{3}}{2}\right)}=\frac{5}{\frac{1}{2}-\frac{1}{4}}=5\times 4=20\text{N}$

Maximum value of force $=20\text{N}$.

19. Here, Mass of block $A,m_A=10\text{kg}$

Mass of block $B,m_B=15\text{kg}$

Coefficient of friction between the blocks and the surface $\mu=0.2$

Applied force $=200\text{N}$

Force of friction on $A = \mu N_A = \mu m_A g = 0.2 \times 10 \times 10 = 20\text{N}$

Force of friction on $B = \mu N_B = \mu m_B g = 0.2 \times 15 \times 10 = 30\text{N}$

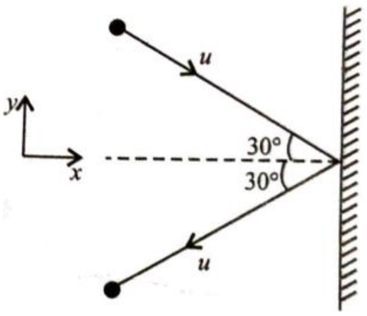
Taking two blocks forming one system, therefore net force acting on the blocks is

$F = 200 - 20 - 30 = 150\text{N}$

Let a be common acceleration of the system.

$\therefore a = \frac{F}{m_A + m_B} = \frac{150\text{N}}{(10+15)\text{kg}} = 6\text{ms}^{-2}$

20.



Initial momentum of the ball is

$\vec{p}_i = mu\cos 30° i - mu\sin 30° j$

Final momentum of the ball is

$\vec{p}_f = -mu\cos 30° \hat{\imath} - mu\sin 30 \hat{\jmath}$

$\therefore$ Change in momentum,

$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = -2mu\cos 30° \hat{\imath}$

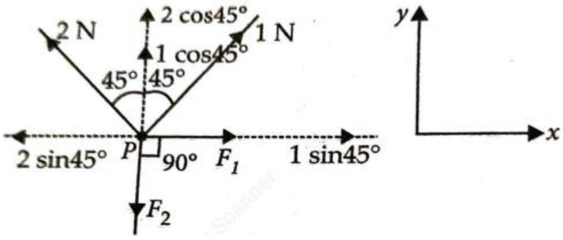
Impulse = Change in momentum

$= -2mu\cos 30° \hat{\imath}$

As impulse and force are in the same direction, therefore, force on the ball due to the wall is normal to the wall along the negative x -axis. Using Newton's 3^{rd} law of motion the force on the wall due to the ball is normal to the wall along the positive x-direction

$$\therefore F = \frac{2mu\cos 30°}{t}$$

21.



Applying equilibrium conditions, $\Sigma F_x = 0$

$\Rightarrow F_1 + 1\sin 45° - 2\sin 45° = 0$

or $F_1 = 2\sin 45° - 1\sin 45° = \frac{2}{\sqrt{2}} - \frac{1}{\sqrt{2}} = \frac{2-1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$N

and $\Sigma F_y = 0 \Rightarrow 1\cos 45° + 2\cos 45° - F_2 = 0$

$F_2 = \frac{2}{\sqrt{2}} + \frac{1}{\sqrt{2}} = \frac{2+1}{\sqrt{2}} = \frac{3}{\sqrt{2}}$N

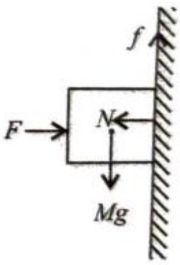
22. Let F be the force applied by the finger on the block

Nis normal reaction of the wall on the block. Mg is weight

of block acting vertically downwards. f is the force of friction

between the wall and the block which acts upwards as shown

in the figure



The block will not fall, if

$f = Mg$

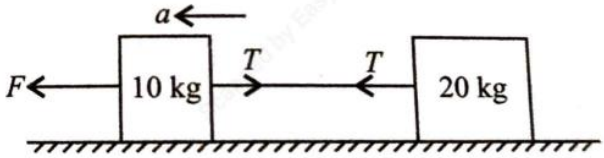
$\mu N = Mg (\because f = \mu N)$

$\mu F = Mg (\because N = F) = F = \frac{Mg}{\mu}$

23. Here, $m_1 = 10$kg, $m_2 = 20$kg, $F = 600$N

Let T be tension or the string and a be common acceleration of the system.

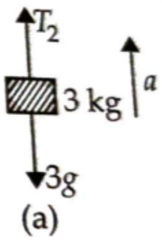
$a = \frac{F}{m_1 + m_2} = \frac{600\text{N}}{10\text{kg}+20\text{kg}} = \frac{600}{30}\text{ms}^{-2} = 20\text{ms}^{-2}$



When a force F is applied on 10kg block, then the tension in the string is

$T = m_2 a = (20\text{kg})(20\text{ms}^{-2}) = 400\text{N}$

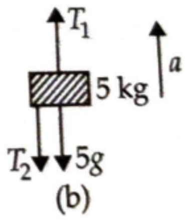
24. The free body diagram of 3kg block is as shown in the Fig. (a).



The equation of motion of 3kg block is $T_2 - 3g = 3a$

$T_2 = 3(a+g) = 3(2+10) = 36\text{N}$ ... (i)

The free body diagram of 5kg is as shown in the Fig. (b).



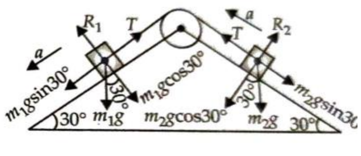
The equation of motion of 5kg block is

$T_1 - T_2 - 5g = 5a$

$T_1 = 5(a+g) + T_2$

$= (2+10) + 36 = 96\text{N}$ (Using (i))

25.



Here, $m_1 = 40\text{kg}$

$m_2 = 30\text{kg}, \theta = 30°$

Let T be the tension in the string and a be the acceleration of the system.

Their equations of motion are

$m_1 g\sin 30^\circ - T = m_1 a$

$T - m_2 g\sin 30^\circ = m_2 a$

Adding (i) and (ii), we get

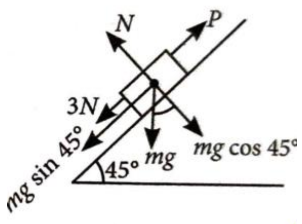
$(m_1 + m_2)a = (m_1 - m_2)g\sin 30^\circ$

Substituting the given values, we get $(40+30)a = (40-30) \times 9.8 \times \frac{1}{2} = 49$

$(40+30)a = (40-30) \times 9.8 \times \frac{1}{2} = 49$

$a = \frac{49}{70} = 0.7\text{ms}^{-2}$

26.



Limiting friction, $f_s = \mu mg\cos 45^\circ$

$= 0.6 \times 10 \times 10 \times \frac{1}{\sqrt{2}} = 30\sqrt{2}\text{N} = 42.43\text{N}$

When block starts to slide downward, the downward force on the block is

$F = 3 + mg\sin 45^\circ$

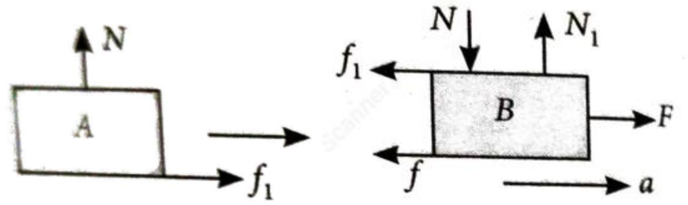
$= 3 + 10 \times 10 \times \frac{1}{\sqrt{2}}$

$= 3 + 50\sqrt{2} = 73.71\text{N} > f_s$

Block will not move if $P = F - f$

$P = 73.71 - 42.43 = 31.28\text{N} \approx 32\text{N}$

27. Free body diagram of A and B are given as follows:

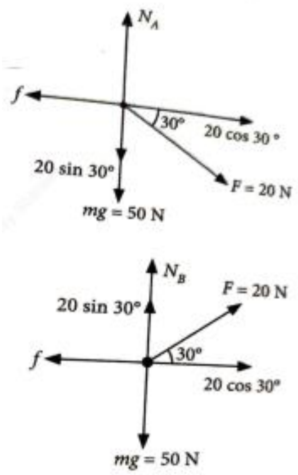


For block $A, f_1 = m_A a$

Also, $f_1 = \mu m_A g = (0.2)(1) \times 10 = 2\text{N} \Rightarrow a = \frac{2}{1} = 2\text{ms}^{-2}$

and $F - (f_1 + f) = m_B a \Rightarrow F = 3(2) + 8 + 2 = 16\text{N}$

28.



Case A : Free body diagram

When block is pushed.

$N_A = mg + 20\sin 30° = 60$

$10\sqrt{3} - f = ma_A$

$10\sqrt{3} - 0.2 \times 60 = 5 \times a_A$

$\Rightarrow a_A = 2\sqrt{3} - 2.4\text{m/s}^2$

case B : Free body diagram when block is pulled.

$N_B = 40; 10\sqrt{3} - f = ma_B$

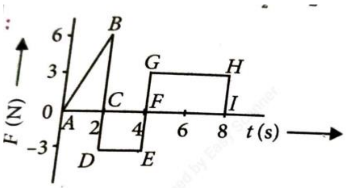
$\Rightarrow 10\sqrt{3} - 0.2 \times 40 = 5 \times a_B$

$\Rightarrow a_B = 2\sqrt{3} - 1.6\text{m/s}^2$

$\therefore a_B - a_A = 2\sqrt{3} - 1.6 - (2\sqrt{3} - 2.4)$

$= 0.8\text{ms}^{-2}$

29.

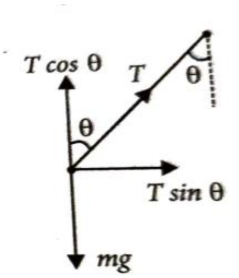


Change in momentum = Area under $F - t$ graph in that interval

$=$ Area of $\Delta ABC -$ Area of rectangle $CDEF$ $+$ Area of rectangle $FGHI$

$= \frac{1}{2} \times 2 \times 6 - 3 \times 2 + 4 \times 3 = 12\text{N}s$

30. FBD of the pendulum is shown in the figure.



$T\sin\theta = \frac{mv^2}{r}$

$T\cos\theta = mg$

$\tan\theta = \frac{v^2}{rg}$

$\theta = 45°, r = 0.4\text{m} \Rightarrow v^2 = rg$

$v = \sqrt{rg} = \sqrt{0.4 \times 10} = 2\text{m/s}$