Newton's First law of motion and Inertia DPP-01

1. Newton's first law of motion describes the following

(1) Energy (2) Work (3) Inertia (4) Moment of inertia

2. A person sitting in an open car moving at constant velocity throws a ball vertically up into air. The ball falls

(1) Outside the car
(2) In the car ahead of the person
(3) In the car to the side of the person
(4) Exactly in the hand which threw it up

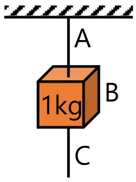
3. A particle is moving with a constant speed along a straight-line path. A force is not required to

(1) Increase its speed
(2) Decrease the momentum
(3) Change the direction
(4) Keep it moving with uniform velocity

4. When a bus suddenly takes a turn, the passengers are thrown outwards because of

(1) Inertia of motion
(2) Acceleration of motion
(3) Speed of motion
(4) Both (b) and (c)

5. A mass of 1 kg is suspended by a string A. Another string C is connected to its lower end (see figure). If a sudden jerk is given to C, then



(1) The portion AB of the string will break
(2) The portion BC of the string will break
(3) None of the strings will break
(4) The mass will start rotating

6. In the above Question, if the string C is stretched slowly, then

(1) The portion AB of the string will break
(2) The portion BC of the string will break
(3) None of the strings will break
(4) None of the above

7. A car is moving with uniform velocity on a rough horizontal road. Therefore, according to Newton's first law of motion

(1) No force is being applied by its engine
(2) A force is surely being applied by its engine
(3) An acceleration is being produced in the car
(4) The kinetic energy of the car is increasing

Answer Key

Question	1	2	3	4	5	6	7
Answer	3	4	4	1	2	1	2

SOLUTIONS

1. **(3)**

Newton's first law of motion defines the inertia of body. It states that everybody has a tendency to remain in its state (either rest or motion) due to its inertia.

2. **(4)**

Horizontal velocity of ball and person are same so both will cover equal horizontal distance in a given interval of time and after following the parabolic path the ball falls exactly in the hand which threw it up.

3. **(4)**

Particle will move with uniform velocity due to inertia.

4. **(1)**

5. **(2)**

When a sudden jerk is given to C, an impulsive tension exceeding the breaking tension develops in C first, which breaks before this impulse can reach A as a wave through block.

6. **(1)**

When the spring C is stretched slowly, the tension in A is greater than that of C, because of the weight mg and the former reaches breaking point earlier.

7. **(2)**

Since, force needed to overcome frictional force.

DAILY PRACTICE PROBLEM

Change in Momentum DPP-02

1. **A force of 10 Newton acts on a body of mass 20kg for 10 seconds. Change in its momentum is**

(1) 5 kg m/s (2) 100 kg m/s (3) 200 kg m/s (4) 1000 kg m/s

2. **When the speed of a moving body is doubled**

(1) Its acceleration is doubled (2) Its momentum is doubled

(3) Its kinetic energy is doubled (4) Its potential energy is doubled

3. **A body of mass m collides against a wall with a velocity v and rebounds with the same speed. Magnitude of change in its momentum is**

(1) 2 mv (2) mv (3) –mv (4) Zero

4. **If mass of body is increased by 10% and its speed is decreased by 10% then the percentage change in magnitude of momentum will be**

(1) Increased by 1% (2) Decreased by 1% (3) Increased by 2% (4) Decreased by 2%

5. **A car of mass m moving towards east with a constant velocity v. If after some time car takes a turn towards north and continues to move with same speed, find change in magnitude of momentum of the car.**

(1) Zero (2) 2mv (3) 3mv (4) $\sqrt{2}$ mv

Answer Key

Question	1	2	3	4	5
Answer	2	2	1	2	4

SOLUTIONS

1. **(2)**

dp = F × dt = 10 × 10 = 100 kg m/s

2. **(2)**

3. **(1)**

$|\Delta p| = |p_f - p_i| = |(-mv) - (mv)| = 2mv$

4. **(2)**

Let initial mass is m and initial speed is v.

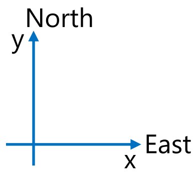
Then initial momentum is m × v.

If mass is increased by 10% then modified mass is 1.1×m.

If speed is decreased by 10% then modified speed is 0.9×v

Hence modified momentum is 1.1 × m × 0.9 × v = 0.99 × m × v ; hence momentum decreases by 1%

5. **(4)**



$\vec{P}_i = mv\hat{i}$

$\vec{P}_f = mv\hat{j}$

$\Delta\vec{P} = \vec{P}_f - \vec{P}_i = mv\hat{j} - mv\hat{i}$

$|\Delta\vec{P}| = \sqrt{2}\,mv$

DAILY PRACTICE PROBLEM

Basic problems based on Newton's Second Law of Motion DPP-03

1. When a constant force is applied to a body, it moves with uniform: -

(1) Acceleration (2) Velocity (3) Speed (4) Momentum

2. A body of mass 80 g is moving with a constant velocity of 4 cm/s on a horizontal frictionless table. The force on the body (in dynes) is: -

(1) Zero (2) 39200 (3) 78400 (4) 8000

3. An object with a mass 5 kg moves at a constant velocity of 8 m/s. A constant force then acts for 6 seconds on the object giving it a speed of 4 m/s in opposite direction. The acceleration produced is: -

(1) 1.5 m/s^2 (2) –2 m/s^2 (3) 0.67 m/s^2 (4) –0.5 m/s^2

4. The velocity acquired by a mass m in travelling a certain distance d starting from rest under the action of a constant force is directly proportional to: -

(1) $\sqrt{m}$ (2) m^0 (3) $\frac{1}{\sqrt{m}}$ (4) m

5. A body of mass 40 gm is moving with a constant velocity of 2cm/sec on a horizontal frictionless table. The force on the table by the body is :-

(1) 39200 dyne (2) 160 dyne (3) 80 dyne (4) zero

6. A body with mass 5 kg is acted upon by a force $\vec{F} = (-3\hat{i} + 4\hat{j})N$. If its initial velocity at t = 0 is $\vec{u} = (6\hat{i} - 12\hat{j}) ms^{-1}$, the time at which it will just have a velocity along the Y-axis is: -

(1) never (2) 10 s (3) 2 s (4) 15 s

7. A stone of mass 1 kg is lying on the floor of a train which is accelerating with 1 ms^{-2}. The net force acting on the stone is: -

(1) zero (2) 1 N (3) 5 N (4) 10 N

8. Newton's II law of motion connects: -

(1) Momentum and acceleration

(2) Change of momentum and velocity

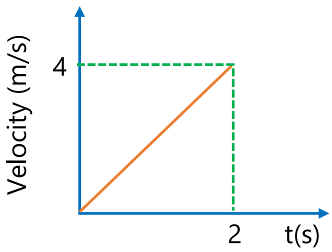
(3) Rate of change of momentum and external force

(4) Rate of change of force and momentum

9. A player catches a ball of 100 g moving with a speed of 5 m/s. If the time taken to complete the catch is 0.25 s, the force exerted on the player's hand is: -

(1) 8 N (2) 4 N (3) 2 N (4) 0 N

10. **For a body of 25 kg mass, the velocity-time graph is shown in figure. The force acting on the body is: -**



(1) 25 N (2) 50 N (3) 12.5 N (4) 100 N

Answer Key

Question	1	2	3	4	5	6	7	8	9	10
Answer	1	1	2	3	1	2	2	3	3	2

SOLUTIONS

1. **(1)**

F_{net} = ma, F_{net} = const, a = const.

2. **(1)**

F = 0 (as acceleration = 0)

3. **(2)**

$$a = \frac{-4-8}{6} = -2\ m/s^2$$

4. **(3)**

$$a = \frac{F}{m}$$

$$v^2 - 0 = 2\frac{F}{m} \times d \quad \therefore\ v \propto \frac{1}{\sqrt{m}}$$

5. **(1)**

F = mg = 40 × 980

F = 39200 dyne

6. **(2)**

$$\vec{a} = \frac{\vec{F}}{m} = -\frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}$$

$$\vec{v} = \vec{u} + \vec{a}t$$

$$\vec{v} = 6\hat{i} - 12\hat{j} + \left(-\frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}\right)t$$

$$\vec{v} = \left(6 - \frac{3t}{5}\right)\hat{i} + \left(\frac{4t}{5} - 12\right)\hat{j}$$

To have a velocity along y-axis, its x-component must be zero.

$6 - \frac{3t}{5} = 0 \Rightarrow$ t = 10 sec

7. **(2)**

F_{net} = ma

F_{net} = 1 N

8. **(3)**

$$F = \frac{dp}{dt}$$

9. **(3)**

$$F_{avg} = \frac{\Delta p}{\Delta t} = \frac{100 \times 10^{-3} \times 5}{0.25}$$

F_{avg} = 2N

10. **(2)**

F = m × a = 25 × $\frac{dv}{dt}$ = 25 × 2 = 50 N

DAILY PRACTICE PROBLEM

Impulse and Average Force DPP-04

1. **A 100 g tennis ball coming at a speed of 20 m/s is hit straight back by a bat to speed of 40 m/s. The magnitude of the average force F on the ball, when it is in contact for 5 ms with the bat is: -**

(1) 1200 N (2) 6000 N (3) 2400 N (4) 1000 N

2. **A ball weighing 50 g hits a hard surface vertically with a speed of 25 m/s and rebounds with the same speed. The ball remains in contact with the surface for 0.05 s. The average force exerted by the surface on the ball is: -**

(1) 100 N (2) 25 N (3) 50 N (4) 5 N

3. **A tennis ball is dropped on the floor from a height of 10 m. It rebounds to a height of 5 m. The ball was in contact with the floor for 0.01 s. What was its average acceleration during the contact? ($g=10 m/s^2$)**

(1) 800 m/s^2 (2) 200 m/s^2 (3) 1600 m/s^2 (4) 2400 m/s^2

4. **A 150 g ball, in horizontal flight with a speed of 40 m/s, is struck by a bat. After leaving the bat, the ball travels in the opposite direction with speed 40 m/s. If the impact time for the ball-bat collision is 1.20 ms, what average force acts on the ball?**

(1) 1500 N (2) 1000 N (3) 10000 N (4) 9800 N

5. **n bullet strike per second elastically on a wall with speed V and rebound. what will be the force exerted on the wall by bullets if mass of each bullet is m: -**

(1) mnv (2) 4mnv (3) 2mnv (4) $\frac{mnv}{2}$

Answer Key

Question	1	2	3	4	5
Answer	1	3	4	3	3

SOLUTIONS

1. **(1)**

Force F = Rate of change in the momentum

$$= \frac{m[v_2 - v_1]}{t}$$

$$= \frac{(0.1)[40-(-20)]}{(5\times10^{-3})} = 1200N$$

2. **(3)**

$$F_{avg} = \frac{2\times\frac{50}{1000}\times25}{0.05} = 50N$$

3. **(4)**

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

$$a = \frac{\sqrt{2gh_2} - \left(-\sqrt{2gh_1}\right)}{t}$$

$$a = \frac{\sqrt{2\times10\times5} + \sqrt{2\times10\times10}}{0.01}$$

$$a = \frac{10+14}{0.01} = 2400\ m/s^2$$

4. **(3)**

$$F_{avg} = \frac{2mv}{t}$$

$$\frac{2\times150\times10^{-3}\times40}{1.20\times10^{-3}} = 10000N$$

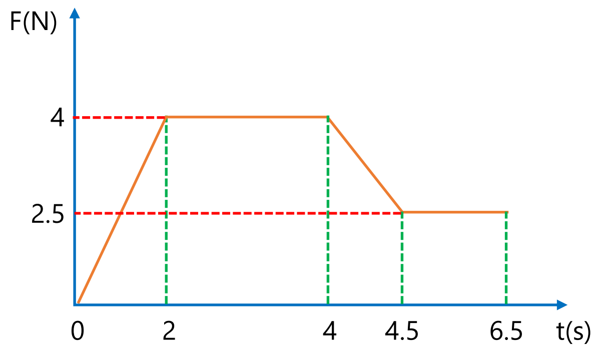
5. **(3)**

$$F = \frac{\Delta p}{\Delta t} = 2mnv$$

DAILY PRACTICE PROBLEM

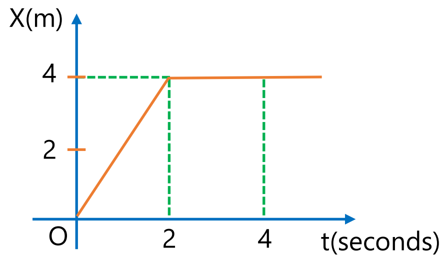
Impulse Momentum Theorem DPP-05

1. A body of mass 2 kg has an initial speed 5 ms^{-1}. A force acts on it for some time in the direction of motion. The force-time graph is shown in figure. The final speed of the body is: -



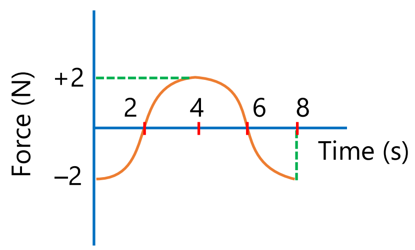
(1) 9.25 ms^{-1} (2) 5 ms^{-1} (3) 14.3 ms^{-1} (4) 4.25 ms^{-1}

2. In the figure given below, the position–time graph of a particle of mass 0·1 kg is shown. The impulse at t=2 sec is –



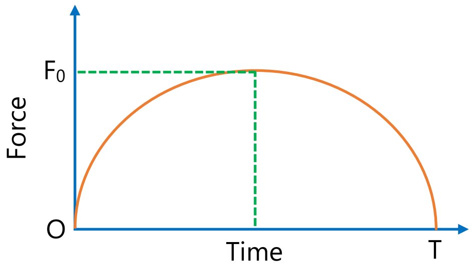
(1) 0·2 kg-m/s (2) –0·2 kg-m/s (3) 0·1 kg-m/s (4) –0·4 kg-m/s

3. The force-time (F – t) curve of a particle executing linear motion is as shown in the figure. The momentum acquired by the particle in time interval from zero to 8 second will be



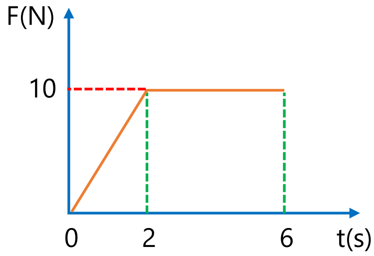
(1) – 2 N-s (2) + 4 N-s (3) 6 N-s (4) Zero

4. **A particle of mass m, initially at rest, is acted upon by a variable force F for a brief interval of time T. It begins to move with a velocity u after the force stops acting. F is shown in the graph as a function of time. The curve is a semicircle.**



(1) $u = \frac{\pi F_0^2}{2m}$ (2) $u = \frac{\pi T^2}{8m}$ (3) $u = \frac{\pi F_0 T}{4m}$ (4) $u = \frac{F_0 T}{2m}$

5. **A body of mass 3kg is acted on by a force which varies as shown in the graph below. The momentum acquired is given by**



(1) Zero (2) 5 N-s (3) 30 N-s (4) 50 N-s

Answer Key

Question	1	2	3	4	5
Answer	3	2	4	3	4

SOLUTIONS

1. **(3)**

$\Delta p =$ Area under F-t graph

m(v–u) = 4 + 8 + 1.625 + 5

2(v–5) = 18.625

v – 5 = 9.31

v = 14.3 m/s

2. **(2)**

$\vec{I} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$

= 0 – 0.2 = –0.2 kg ms^{-1}

3. **(4)**

Momentum acquired by the particle is numerically equal to area enclosed between the F-t curve and time axis. For the given diagram area in upper half is positive and in lower half is negative (and equal to upper half), so net area is zero. Hence the momentum acquired by the particle will be zero.

4. **(3)**

Initially particle was at rest. By the application of force its momentum increases.

Final momentum of the particle = Area of F – t graph

$\Rightarrow$ mu = Area of semi-circle

$$mu = \frac{\pi r^2}{2} = \frac{\pi r_1 r_2}{2} = \frac{\pi (F_0)(T/2)}{2} \Rightarrow u = \frac{\pi F_0 T}{4m}$$

5. **(4)**

Momentum acquired = Area of force-time graph

$$= \frac{1}{2}\times(2)\times(10) + 4\times 10 = 10 + 40 = 50 \text{ N-s}$$

DAILY PRACTICE PROBLEM

Conservation of Linear Momentum DPP-06

1. In which of the following cases forces may not be required to keep the

(1) Particle going in a circle
(2) The momentum of the particle constant
(3) Acceleration of the particle constant
(4) None of these

2. A wagon weighing 1000 kg is moving with a velocity 50km/hr on smooth horizontal rails. A mass of 250 kg is dropped into it. The velocity with which it moves now is

(1) 2.5 km/hr
(2) 20 km/hr
(3) 40 km/hr
(4) 50 km/hr

3. A man fires a bullet of mass 200 g at a speed of 5 m/s. The gun is of one kg mass. By what velocity the gun rebounds backwards

(1) 0.1 m/s
(2) 10 m/s
(3) 1 m/s
(4) 0.01 m/s

4. A body of mass M at rest explodes into three pieces, two of which of mass M/4 each are thrown off in perpendicular directions with velocities of 3 m/s and 4 m/s respectively. The third piece will be thrown off with a velocity of

(1) 1.5 m/s
(2) 2.0 m/s
(3) 2.5 m/s
(4) 3.0 m/s

5. A body of mass 0.25 kg is projected with muzzle velocity 100 m/s from a tank of mass 100 kg. What is the recoil velocity of the tank?

(1) 5 m/s
(2) 25 m/s
(3) 0.5 m/s
(4) 0.25 m/s

6. A bullet of mass 0.1 kg is fired with a speed of 100 m/s. The mass of gun is 50 kg. The velocity of recoil is

(1) 0.2 m/s
(2) 0.1 m/s
(3) 0.5 m/s
(4) 0.05 m/s

7. A bullet of mass 10 gm is fired from a gun of mass 1kg. If the recoil velocity is 5 m/s, the muzzle velocity is

(1) 0.05 m/s
(2) 5 m/s
(3) 50 m/s
(4) 500 m/s

Answer Key

Question	1	2	3	4	5	6	7
Answer	3	3	3	3	4	1	4

SOLUTIONS

1. **(3)**

If momentum remains constant then force will be zero because $F = \frac{dP}{dt}$

2. **(3)**

According to principle of conservation of linear momentum

$1000 \times 50 = 1250 \times v \Rightarrow v = 40$ km / hr

3. **(3)**

$v_G = \frac{m_B v_B}{m_G} = \frac{0.2 \times 5}{1} = 1\ m/s$

4. **(3)**

Momentum of one piece $= \frac{M}{4} \times 3$

Momentum of the other piece $= \frac{M}{4} \times 4$

$\therefore$ Resultant momentum $= \sqrt{\frac{9M^2}{16} + M^2} = \frac{5M}{4}$

The third piece should also have the same momentum. Let its velocity be v, then

$\frac{5M}{4} = \frac{M}{2} \times v \Rightarrow v = \frac{5}{2} = 2.5 m/s$

5. **(4)**

Using law of conservation of linear momentum, we get

$100 \times v = 0.25 \times 100 \Rightarrow v = 0.25$ m/s

6. **(1)**

According to principle of conservation of linear momentum,

$m_G v_G = m_B v_B$

$\Rightarrow v_G = \frac{m_B v_B}{m_G} = \frac{0.1 \times 10^2}{50} = 0.2$ m/s

7. **(4)**

$m_G v_G = m_B v_B \Rightarrow v_B = \frac{m_G v_G}{m_B} = \frac{1 \times 5}{10 \times 10^{-3}} = 500$ m/s

DAILY PRACTICE PROBLEM

Variable Mass Problems DPP-07

1. **A satellite in force free space sweeps stationary interplanetary dust at a rate (dM/dt) = $+\alpha v^2$. Here v is the velocity. The acceleration of satellite of mass M is: -**

(1) $-2\alpha v^2 / M$ (2) $-3\alpha v^2 / M$ (3) $-\alpha v^3 / M$ (4) $-\alpha v^2$

2. **A rocket of mass 60 kg. is fired in a gravity free space is ejecting gases with velocity 300 m/s w.r.t. rocket at the rate of 2 kg/s. What will be the initial acceleration of the rocket?**

(1) 30 m/s^2 (2) 5 m/s^2 (3) 10 m/s^2 (4) 15 m/s^2

3. **The force on a rocket, moving in gravity free space is 210 N. If the gases ejects from the rocket with speed 300 m/s (w.r.t. rocket) then the rate of combustion of the fuel is: -**

(1) 0.07 kg s^{-1} (2) 1.4 kg s^{-1} (3) 0.7 kg s^{-1} (4) 10.7 kg s^{-1}

4. **A rocket of mass 800 kg is to be projected vertically upwards. The gases are exhausted vertically downwards with velocity 40 m/s with respect to the rocket. What is the minimum rate of burning fuel, so as to just lift the rocket upwards against the gravitational attraction? (Take g = 10 m/s^2)**

(1) 80 kg/s (2) 400 kg/s (3) 200 kg/s (4) 800 kg/s

5. **Working of rocket or jet is based on: -**

(1) Newton's law (2) Newton's II law (3) Newton's III law (4) All the three laws

6. **When a horse pulls a wagon, the force that causes the horse to move forward is the force**

(1) He exerts on the wagon (2) The wagon exerts on him
(3) The ground exerts on him (4) He exerts on the ground

7. **A material body A of mass m exerts a force on another material body B of mass 2m. If the acceleration of B is 'a', the magnitude of the acceleration of A is :-**

(1) Zero (2) a (3) 2a (4) a/2

8. **Action and reaction: - (For a given system)**

(a) Act on the same object **(b) Have same direction**
(c) Have different magnitudes **(d) Have non-zero resultant**

(1) a, b, c (2) b, c, d (3) All of the above (4) None of the above

9. **A car accelerates on a horizontal road due to the force exerted by: -**

(1) the engine of the car (2) the driver of the car
(3) the car on earth (4) the road on the car

Answer Key

Question	1	2	3	4	5	6	7	8	9
Answer	3	3	3	3	3	3	3	4	4

SOLUTIONS

1. **(3)**

$$F = -\frac{vdm}{dt} = -\alpha v^3 \ \therefore a = \frac{-\alpha v^3}{M}$$

2. **(3)**

F = 2 × 300 = 600 N

$$\therefore \ a = \frac{600}{60} = 10\ m/s^2$$

3. **(3)**

$$\frac{dm}{dt} = \frac{210}{300} = 0.7\ kg/s$$

4. **(3)**

Minimum rate of burning fuel is $\frac{dm}{dt}$

$$\therefore \ mg = u\frac{dm}{dt}$$

or, $\frac{dm}{dt} = \frac{mg}{u} = \frac{800 \times 10}{40} = 200\ kg/s.$

5. **(3)**

Action $\rightleftharpoons$ Reaction (From Newton's third law)

6. **(3)**

Forces from ground causes horse motion.

7. **(3)**

$m_A a_A = m_B a_B$

$m a_A = 2m \times a$

$a_A = 2a$

8. **(4)**

None of the above

9. **(4)**

Force from road causes acceleration of car.

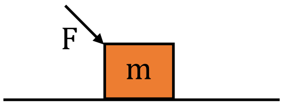
Common Forces in Mechanics and Free body diagram DPP-08

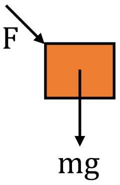
1. Which of the following is weakest force?

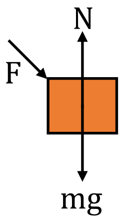
(1) Gravitational force (2) Electromagnetic force

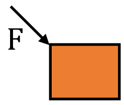
(3) Nuclear force (4) None

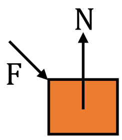
2. Correct FBD of



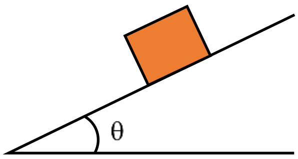
(1) 

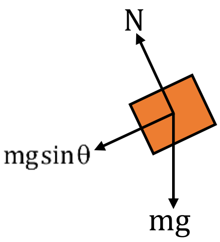
(2) 

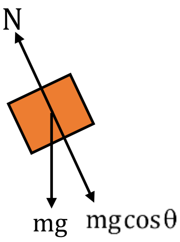
(3) 

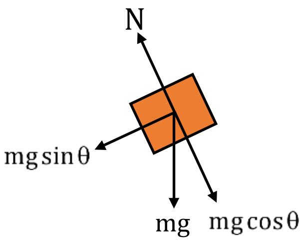
(4) 

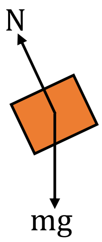
3. Correct FBD of



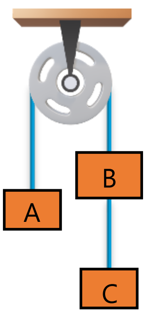
(1) 

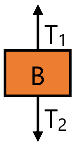
(2) 

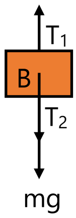
(3) 

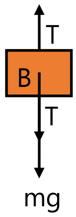
(4) 

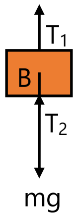
4. Correct FBD of block B (mass m)



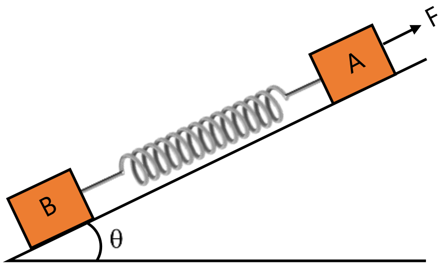
(1) 

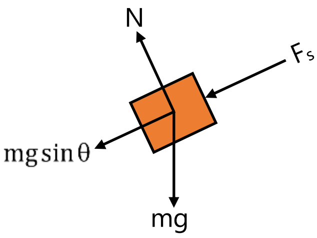
(2) 

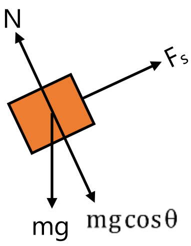
(3) 

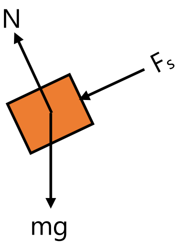
(4) 

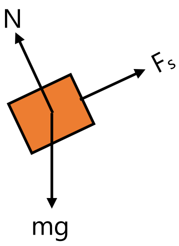
5. Correct FBD of Block B (mass m, F_s = spring force)



(1) 

(2) 

(3) 

(4) 

Answer Key

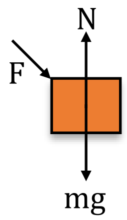
Question	1	2	3	4	5
Answer	1	2	4	2	4

SOLUTIONS

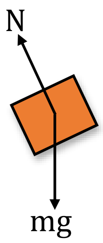
1. **(1)**

Gravitational force

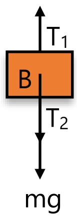
2. **(2)**



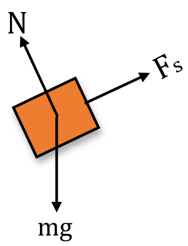
3. **(4)**



4. **(2)**

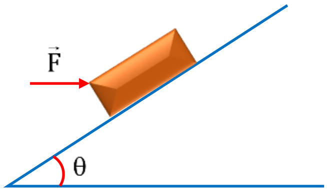


5. **(4)**



Problems on Normal Reaction DPP-09

1. **The figure shows a horizontal force $\vec{F}$ acting on a block of mass M on an inclined plane (angle θ). What is the normal reaction on the block?**



(1) $mg\sin\theta + F\cos\theta$ (2) $mg\sin\theta - F\cos\theta$ (3) $mg\cos\theta - F\sin\theta$ (4) $mg\cos\theta + F\sin\theta$

2. **Two blocks of masses 2 kg and 1 kg are in contact with each other on a frictionless table. When a horizontal force of 3.0 N is applied to the block of mass 1 kg the value of the force of contact between the two blocks is -**

(1) 2 N (2) 3 N (3) 5 N (4) 1 N

3. **A person is standing in an elevator. In which situation he finds his weight more?**

(1) when the elevator moves downward with constant velocity

(2) when the elevator moves downward with constant acceleration

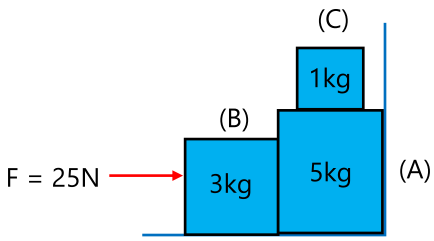
(3) when the elevator moves upward with uniform velocity

(4) when the elevator moves downward with decreasing velocity

4. **A man, of mass 60 kg, is riding in a lift. The ratio of the apparent weights of the man when the lift is accelerating upwards and downwards at 2 m/s^2 is:- (Taking g = 10 m/s^2)**

(1) 2 : 3 (2) 1 : 1 (3) 3 : 2 (4) None of these

5. **A block mass system is shown in the figure. Determine the normal force on block A due to the wall. Also find the normal force acting on block A due to ground.**



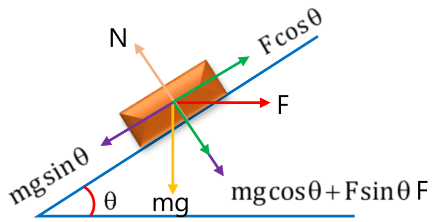
(1) 30N, 50N (2) 35N, 80N (3) 25N, 60N (4) 25N, 70N

Answer Key

Question	1	2	3	4	5
Answer	4	1	4	3	3

SOLUTIONS

1. **(4)**



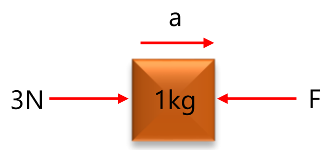
From the figure, the normal reaction on the block is $N = mg\cos\theta + F\sin\theta$.

2. **(1)**

$a = \frac{3}{2+1} = 1\ m/s^2$

3 – F = 1 × 1

F = 2N

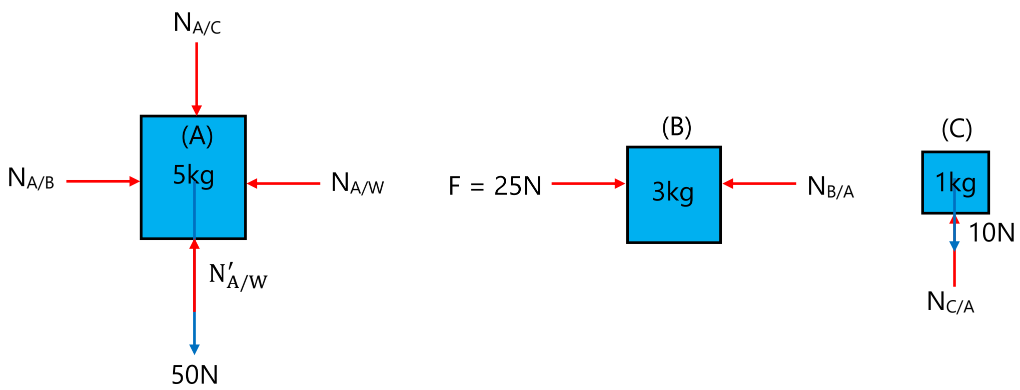


3. **(4)**

4. **(3)**

$$\frac{W_{app1}}{W_{app2}} = \frac{m(g+a)}{m(g-a)} = \frac{12}{8} = \frac{3}{2}$$

5. **(3)**



For block B

$25N = N_{B/A}$

For block C

$10N = N_{C/A}$

For block A

$N_{A/B} = N_{A/W} = N_{B/A} = 25N$

$N'_{A/W} = N_{A/C} + 50N$

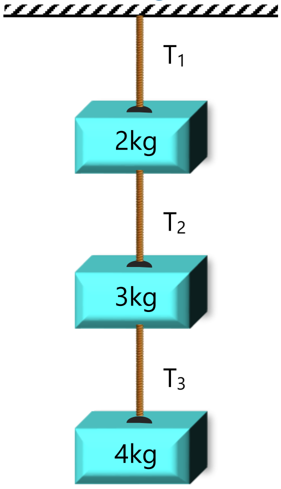
$= N_{C/A} + 50N$

= 10N + 50N

= 60N

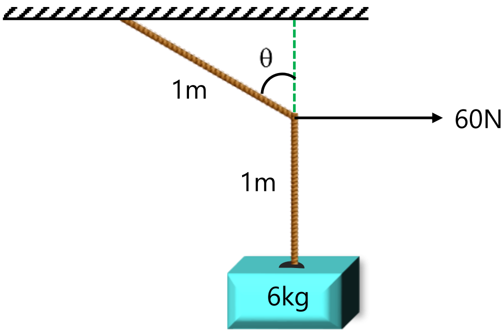
Problems based on Tension Force DPP-10

1. Find the ratio T_1/T_3 for the system shown in fig.



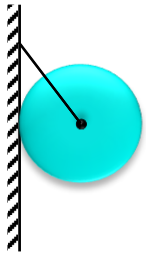
(1) 2 : 1 (2) 1 : 4 (3) 9 : 4 (4) 3 : 1

2. A mass of 6 kg is suspended by a rope of length 2 m from a ceiling. A force of 60 N is applied in horizontal direction at the mid-point of the rope. What is the angle between the rope and the vertical in equilibrium: -



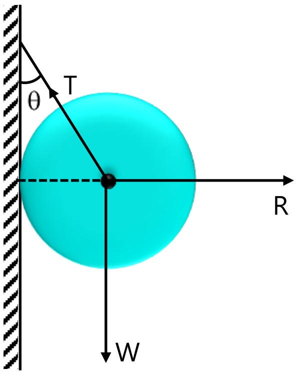
(1) $\tan^{-1}\left(\frac{4}{5}\right)$ (2) $\tan^{-1}\left(\frac{5}{4}\right)$ (3) $\tan^{-1}\left(\frac{5}{6}\right)$ (4) 45°

3. A uniform sphere of weight W and radius 3 m is being held by a string of length 5m attached to a frictionless wall as shown in the figure. The tension in the string will be: -



(1) $\frac{5}{4}W$ (2) $\frac{15}{4}W$ (3) $\frac{15}{16}W$ (4) None of these

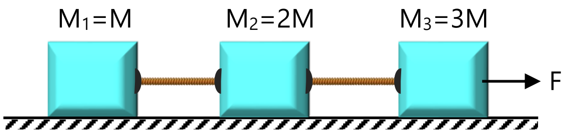
4. **A metal sphere is hung by a string fixed to a wall. The forces acting on the sphere are shown in fig. Which of the following statements is not correct?**



(a) $\vec{R}+\vec{T}+\vec{W}=0$ (b) $T^2 = R^2 + W^2$ (c) T = R + W (d) $R = W \tan\theta$

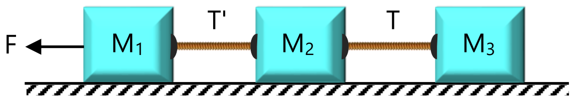
(1) a (2) b (3) c (4) d

5. **Three masses M_1, M_2 and M_3 are lying on a frictionless table. The masses are connected by massless threads as shown. The mass M_3 is pulled by a constant force F as shown. The tension in the thread between masses M_2 and M_3 is**



(1) $\frac{F}{2}$ (2) $\frac{F}{3}$ (3) $\frac{F}{4}$ (4) $\frac{F}{6}$

6. **Three blocks are connected as shown in fig. on a horizontal frictionless table. If M_1 = 1 kg, M_2 = 8 kg, M_3 = 27 kg and F = 36N, Then T' will be: -**



(1) 18N (2) 8N (3) 35N (4) 27N

7. **Two bodies A and B of masses 10 kg and 15 kg respectively kept on a smooth, horizontal surface are tied to the ends of a light string. If T represents the tension in the string when a horizontal force F = 500 N is applied to A (as shown in figure-1) and T' be the tension when F = 750 N is applied to B (figure-2), then which of the following is true?**

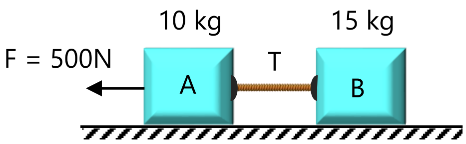


Figure (1)

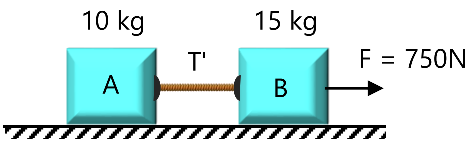
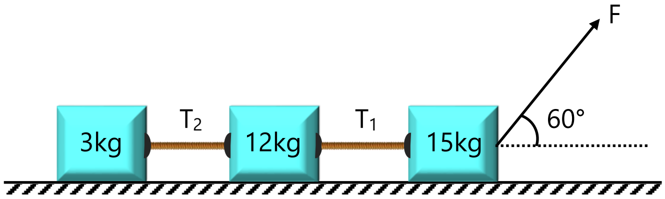


Figure (2)

(1) T = T' = 500 N (2) T = T' = 250 N

(3) T = 300 N, T' = 200 N (4) T = 300 N, T' = 300 N

8. The surface shown in diagram is frictionless and T_1 is 30 N, then the value of F is :-



(1) 30 N (2) 60 N (3) 120 N (4) 69.36 N

9. A block of weight 40 N is supported by two ropes. One rope is horizontal and the other makes an angle of 30° with the ceiling. The tension in the rope attached to the ceiling is approximately.

(1) 80 N (2) 40 N (3) $40\sqrt{3}$ N (4) $\frac{40}{\sqrt{3}}$ N

Answer Key

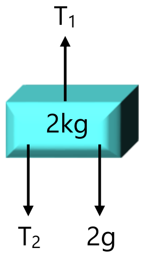
Question	1	2	3	4	5	6	7	8	9
Answer	3	4	1	3	1	3	4	3	1

SOLUTIONS

1. **(3)**

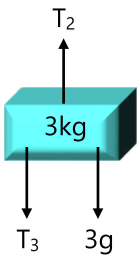
$T_1 = T_2 + 2g$

$T_1 = 9g$

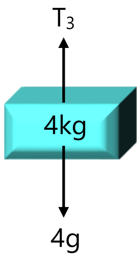


$T_2 = T_3 + 3g$

$T_2 = 7g$



$T_3 = 4g$



$\therefore \frac{T_1}{T_3} = \frac{9g}{4g} = \frac{9}{4}$

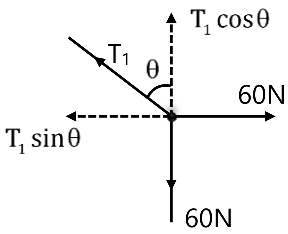
2. **(4)**

$T_1 \cos\theta = 60$

$T_1 \sin\theta = 60$

$\therefore \tan\theta = \frac{60}{60} = 1$

$\therefore \theta = 45°$

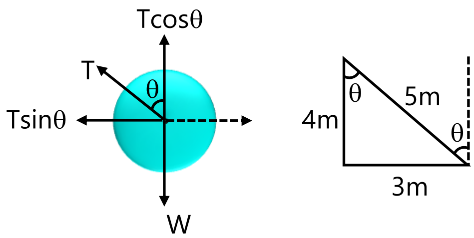


3. **(1)**

$T\cos\theta = w$

$T = \frac{w}{\cos\theta} = \frac{w}{\frac{4}{5}}$

$T = \frac{5w}{4}$



$\text{Cos } \theta = \frac{4}{5}$

4. **(3)**

$T\cos\theta = W; T\sin\theta = R; \tan\theta = \frac{R}{W}$

$T^2 = R^2 + W^2$

Also, as for equilibrium $\vec{R} + \vec{T} + \vec{W} = 0$

5. **(1)**

$$a = \frac{F}{(M_1 + M_2 + M_3)}$$

$$T = (M_1 + M_2)a = (M_1 + M_2)F / M_1 + M_2 + M_3 = \frac{3MF}{6M}$$

$$T = \frac{F}{2}$$

6. **(3)**

$$a = \frac{F}{(M_1 + M_2 + M_3)}$$

$$a = \frac{36}{36} = 1\ m/s^2$$

$$\therefore\ T' = (M_2 + M_3)a$$

$$\therefore\ T' = 35 \times 1 = 35N$$

7. **(4)**

For figure-1 : -

$$a = \frac{500}{25} = 20\ m/s^2$$

T = 15 × 20 = 300N

For figure-2 : -

$$a = \frac{750}{25} = 35\ m/s^2$$

$$T' = 10 \times 30 = 300N$$

Hence $T = T' = 300N$

8. **(3)**

T_1 = (12+3)a

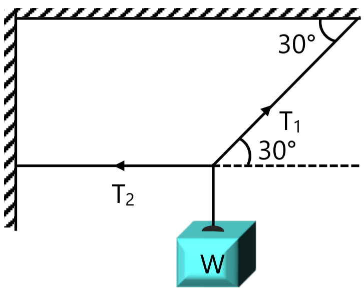
30 = 15a

a = 2 m/s^2

Fcos60° = 30 × 2

F = 120 N

9. **(1)**



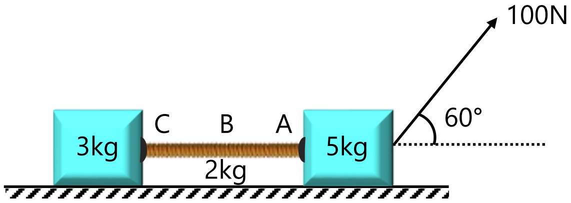
$$T_1 \sin 30° = W$$

$$T_1 \times \frac{1}{2} = 40$$

$$T_1 = 80N$$

Tension in rod and heavy strings DPP-11

1. **Two blocks of masses 5 kg and 3 kg connected by a rope of mass 2 kg are resting on a frictionless floor as shown in the following figure. If a constant force of 100 N is applied to 5 kg block, then the tension in the rope at points A, B and C are respectively given by: (B, is midpoint of the Rope)**



(1) 15 N, 20 N, 25 N (2) 25 N, 20 N, 15 N (3) 20 N, 20 N, 20 N (4) 50 N, 50 N, 50 N

2. **A uniform rope of length L resting on a frictionless horizontal surface is pulled at one end by a force F. What is the tension in the rope at a distance ℓ from the end where the force is applied.**

(1) F (2) $F(1+\ell/L)$ (3) F/2 (4) F(1–l/L)

3. **A string of length L and mass M is lying on a horizontal table. A force F is applied at one of its ends. Tension in the string at a distance x from the end other than at which force is applied is**

(1) Zero (2) Fx/L (3) F(L – x)/L (4) F(L – x)/M

4. **A block of mass m is pulled along a horizontal frictionless surface by a rope of mass m. If a force F is applied at one end of the rope, the tension at the mid-point of the rope is :-**

(1) $\frac{F}{2}$ (2) $\frac{3F}{4}$ (3) $\frac{F}{4}$ (4) $\frac{F}{3}$

5. **A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block will be**

(1) P (2) $\frac{Pm}{M+m}$ (3) $\frac{PM}{M+m}$ (4) $\frac{Pm}{M-m}$

Answer Key

Question	1	2	3	4	5
Answer	2	4	2	2	3

SOLUTIONS

1. **(2)**

$$A = \frac{100\cos 60^\circ}{10} m/s^2$$

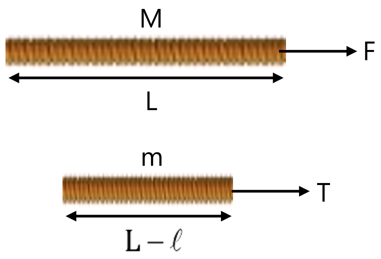
$$a = \frac{50}{10} = 5\ m/s^2$$

$$T_A = 5 \times 5 = 25N$$

$$T_B = 4 \times 5 = 20N$$

$$T_C = 3 \times 5 = 15N$$

2. **(4)**



$$a = \frac{F}{M}$$

$\because$ T = m × a

$$\therefore\ T = \frac{M}{L}(L - \ell) \times \frac{F}{M}$$

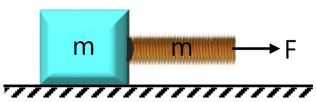
$$\therefore\ T = F\left(1 - \frac{\ell}{L}\right)$$

3. **(2)**

$$T = \frac{M}{L} \times x \times \frac{F}{M}$$

$$T = \frac{Fx}{L}$$

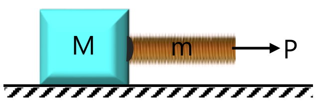
4. **(2)**



$$a = \frac{F}{m + m} = \frac{F}{2m}$$

Force at mid-point = $\left(m + \frac{m}{2}\right) \times \frac{F}{2m} = \frac{3F}{4}$

5. **(3)**



Acceleration of the system $= \frac{P}{m + M}$

The force exerted by rope on the mass $= \frac{MP}{m + M}$

Pulley block systems DPP-12

1. **Two particles of masses m and 2M (M > m) are connected by a cord that passes over a massless and frictionless pulley. The tension T in the string and the acceleration a of the particles is: -**

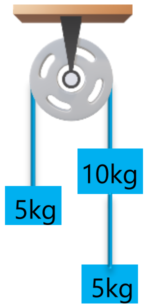
(1) $T = \frac{2mM}{(M-m)}g;\ a = \left(\frac{M-m}{M+m}\right)g$

(2) $T = \frac{4mM}{(2M+m)}g; a = \left(\frac{2M-m}{2M+m}\right)g$

(3) $T = \left(\frac{2M-m}{2M+m}\right)g;\ a = \left(\frac{4mM}{M+m}\right)g$

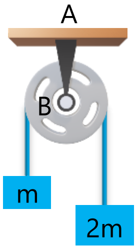
(4) $T = \left(\frac{2Mm}{2M+m}\right)g;\ a = \left(\frac{4mM}{2M+m}\right)g$

2. **What will be the acceleration of the blocks if they are set free to move? (g = acceleration due to gravity)**



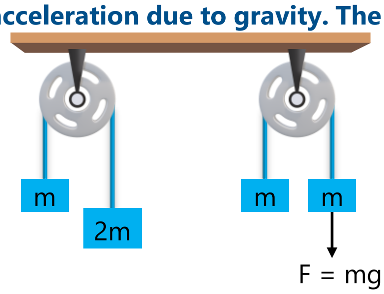
(1) g (2) g/2 (3) g/3 (4) g/4

3. **In the arrangement shown in the figure, the pulley has a mass 3m. Neglecting friction on the contact surface, the force exerted by the supporting rope AB on the ceiling is: -**



(1) 5.67 mg (2) 3 mg (3) 4 mg (4) 2.67 mg

4. **The pulley arrangements shown in the figure are ideal, the mass of the rope being negligible. In case (a) mass m is lifted by attaching a mass of 2m to the other end of the rope. In case (b) the mass m is connected with an another mass m which is pulling by a rope with a constant downward force F = mg, where g is the acceleration due to gravity. The acceleration of mass m in case (a) is :-**



(a) (b)

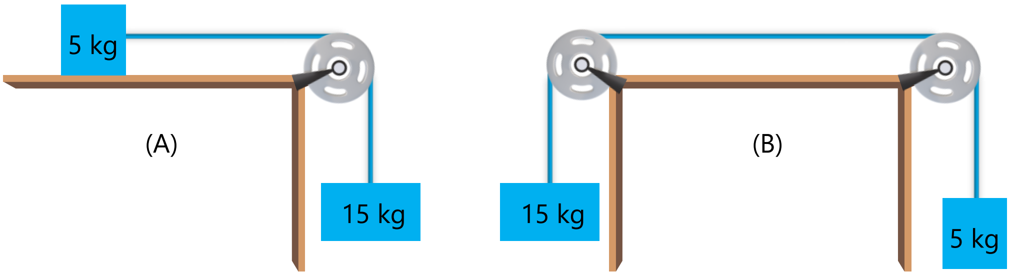
(1) Zero

(2) More than that in case (b)

(3) Less than that in case (b)

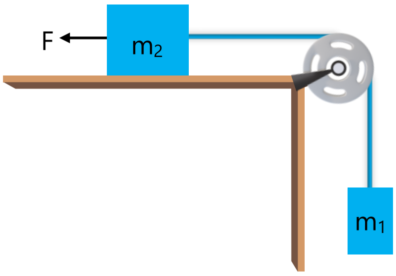
(4) Equal to that in case (b)

5. Two bodies of masses 15 kg and 5 kg are arranged in two different ways as shown in fig. (A) and (B). if the pulleys and the table are perfectly smooth, the acceleration of the 5 kg body in case (A) and (B) are respectively: -



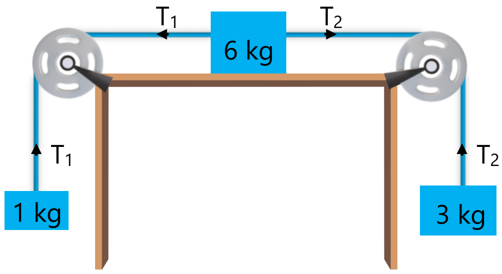
(1) 3g/4 and g/2 (2) g/5 and g/2 (3) g/2 and 3g/4 (4) 15g/2 and g/5

6. A constant force $F = m_1g/2$ is applied on the block of mass m_2 as shown in figure. The string and the pulley are light and the surface of the table is smooth. Find the acceleration of m_2



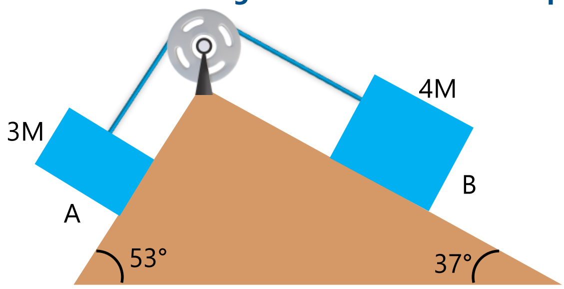
(1) $\frac{m_2 g}{m_1 + m_2}$ (2) $\frac{m_1 g}{m_1 + m_2}$ (3) $\frac{m_1 g}{2(m_1 + m_2)}$ (4) $\frac{m_2 g}{2(m_1 + m_2)}$

7. Three masses of 1 kg, 6 kg and 3 kg are connected to each other with threads and are placed on a table as shown in figure. The ratio $\frac{T_1}{T_2}$ is: - (Take g = 10 m/s²)



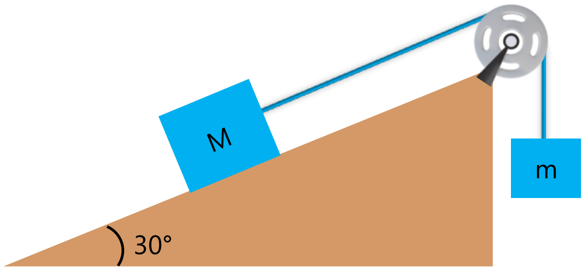
(1) 1 : 1 (2) 2 : 1 (3) 1 : 2 (4) 3 : 1

8. Two blocks of mass 3M and 4M are resting on frictionless inclined planes as shown in fig. then



(1) The block A moves down the plane (2) The block B moves down the plane
(3) Both the blocks remain at rest (4) Both the blocks move down the plane.

9. **In the fig. mass m = 10 kg then in order to keep it at rest, the value of mass M will be: -**



(1) 10 kg (2) 5 kg (3) 20 kg (4) 40 kg

Answer Key

Question	1	2	3	4	5	6	7	8	9
Answer	2	2	1	3	1	3	3	3	3

SOLUTIONS

1. **(2)**

For the particle of mass m,

$T - mg = ma$ ......(i)

For the particle of mass 2M,

$2Mg - T = 2Ma$ ......(ii)

Add (i) and (ii) to eliminate T.

$2Mg - mg = 2Ma + ma$

$g(2M - m) = a(2M + m)$

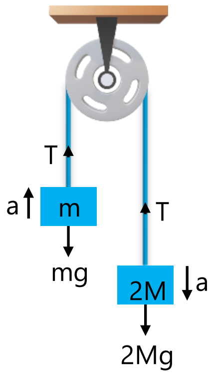
or $a = \left(\frac{2M - m}{2M + m}\right)g$ .....(iii)

Now $T - mg = m \times \left(\frac{2M - m}{2M + m}\right)g$

or $T = mg + mg\left(\frac{2M - m}{2M + m}\right)$

or $T = \frac{2mgM + m^2g + 2mgM - m^2g}{(2M + m)}$

or $T = \frac{4mM}{(2M + m)}g$ ....(iv)



2. **(2)**

$a = \frac{\text{net pulling force}}{\text{Total mass}} \Rightarrow \frac{(10 + 5)g - 5g}{20}$

$a = \frac{10g}{20} = \frac{g}{2}$

3. **(1)**

$T = \frac{2m_1m_2}{m_1 + m_2}g$

$\therefore\ T = \frac{2 \times m \times 2m}{m + 2m}g$

$\therefore\ T = \frac{4mg}{3}$

$\therefore\ F = 2T + 3\,mg$

$\therefore\ F = \frac{17}{3}mg = 5.67\,mg$

4. **(3)**

In case 'a': -

$a_a = \frac{2mg - mg}{3m} = \frac{g}{3}$

In case 'b': -

$a_b = \frac{2mg - mg}{2m} = \frac{g}{2}$

hence, $a_a < a_b$

5. **(1)**

For case A

$15g - T = 15a$ ...(i)

$T = 5a$ ...(ii)

$\therefore \ a = \frac{3g}{5}$

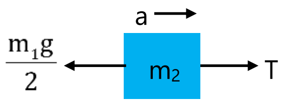
For case B

$15g - T = 15a$ ...(iii)

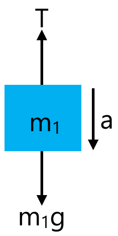
$T - 5g = 5a$ ...(iv)

$a = \frac{g}{2}$

6. **(3)**



$T - \frac{m_1 g}{2} = m_2 a$ .....(1)



$m_1 g - T = m_1 a$ .....(2)

equation (1) + equation (2)

$a = \frac{m_1 g}{2(m_1 + m_2)}$

7. **(3)**

$3g - T_2 = 3a$ ...(i)

$T_2 - T_1 = 6a$ ...(ii)

$T_1 - g = a$ ...(iii)

$\therefore$ By solving eq (i), (ii) and (iii)

$2g = 10a$

$a = 2 \text{ m/s}^2$

So, $T_1 = 10 + 2$

$T_1 = 12$ N

and $T_2 = 3 \times 10 - 3 \times 2$

$T_2 = 24$ N

have $\frac{T_1}{T_2} = \frac{12}{24} = \frac{1}{2}$

8. **(3)**

Force on block A in downward direction: -

F_A = 3 Mg sin 53° = $\frac{12Mg}{5}$

Force on block B in downward direction: -

F_B = 4 Mg sin 37° = $\frac{12Mg}{5}$

$\because$ $F_A = F_B$

Hence, both the blocks remain in rest.

9. **(3)**

$Mg \times \frac{1}{2} = mg$

$\frac{M}{2} = m$

M = 2m

M = 2 × 10 = 20 kg

DAILY PRACTICE PROBLEM

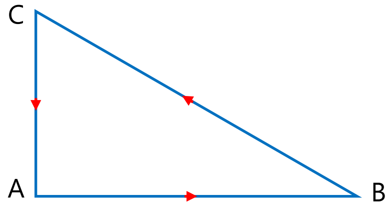
Translational Equilibrium DPP-13

1. Essential characteristic of equilibrium is: -

(1) Momentum equals zero (2) Acceleration equals zero

(3) K.E. equals zero (4) Velocity equals zero

2. Three forces start acting simultaneously on a particle moving with velocity $\vec{v}$. These forces are represented in magnitude and direction by the three sides of a triangle ABC (as shown). The particle will now move with velocity



(1) less than $\vec{v}$ (2) greater than $\vec{v}$

(3) $\vec{v}$, in the direction of largest force BC (4) $\vec{v}$ remains unchanged

3. Which of the following groups of forces could be in equilibrium?

(1) 3 N, 4 N, 5 N (2) 4N, 5 N, 10 N (3) 30N, 40 N, 80 N (4) 1N, 3 N, 5 N

4. From which of the following sets of concurrent forces equilibrium can be obtained?

(1) F_1=3N, F_2=5N, F_3=9N (2) F_1=3N, F_2=5N, F_3=1N

(3) F_1=3N, F_2=5N, F_3=15N (4) F_1=3N, F_2=5N, F_3=6N

5. When forces F_1, F_2, F_3 are acting on a particle of mass m such that F_2 and F_3 are mutually perpendicular, then the particle remains stationary. If the force F_1 is now removed then the acceleration of the particle is

(1) F_1/m (2) F_2F_3/mF_1 (3) $(F_2 - F_3)/m$ (4) F_2/m

Answer Key

Question	1	2	3	4	5
Answer	2	4	1	4	1

SOLUTIONS

1. **(2)**

$F_{net} = 0, a = 0$

2. **(4)**

$\vec{F}_{net} = 0 \Rightarrow \vec{a} = 0$

$\therefore$ $\vec{v}$ remains unchanged

3. **(1)**

For equilibrium of forces, the resultant of two (smaller) forces should be equal and opposite to third one.

4. **(4)**

Range of resultant of F_1 and F_2 varies between (3 + 5) = 8N and (5 – 3) = 2N. It means for some value of angle (θ), resultant 6N can be obtained. So, the resultant of 3N, 5N and 6N may be zero and from these forces equilibrium can be obtained.

5. **(1)**

For equilibrium of system, $F_1 = \sqrt{F_2^2 + F_3^2}$ As $\theta = 90°$

In the absence of force F_1, Acceleration $= \frac{\text{Net force}}{\text{Mass}}$

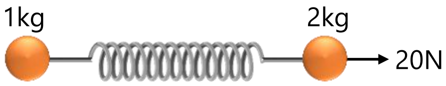
$$= \frac{\sqrt{F_2^2 + F_3^2}}{m} = \frac{F_1}{m}$$

Spring Force DPP-14

1. **A block of mass 4 kg is suspended through two light spring balances A and B in parallel. Then A and B will read respectively.**

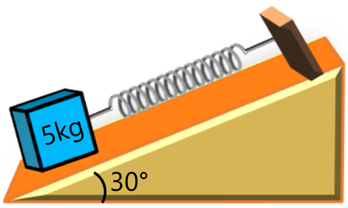
(1) 4 kg and zero kg (2) zero kg and 4 kg (3) 4 kg and 4 kg (4) 2 kg and 2 kg

2. **Two masses of 1 kg and 2 kg respectively are connected by a massless spring as shown in figure. A force of 20 N acts on the 2 kg mass at the instant when the 1 kg mass has an acceleration of 10 ms^{-2} towards right, the acceleration of the 2 kg mass is: -**



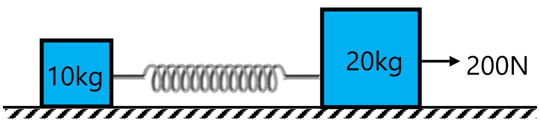
(1) 2 ms^{-2} (2) 5 ms^{-2} (3) 10 ms^{-2} (4) 20 ms^{-2}

3. **A body of mass 5kg is suspended by a spring balance on an inclined plane as shown in figure. The spring balance measure**



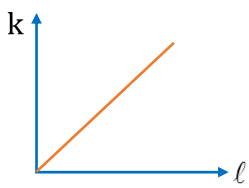
(1) 50 N (2) 25 N (3) 500 N (4) 10 N

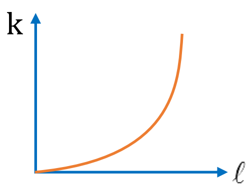
4. **The masses of 10 kg and 20 kg respectively are connected by a massless spring as shown in figure. A force of 200 N acts on the 20 kg mass. At the instant shown, the 10 kg mass has acceleration 12 m/s^2. What is the acceleration of 20 kg mass**

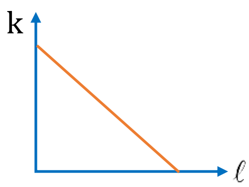


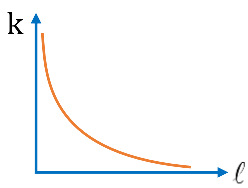
(1) 12 m/sec^2 (2) 4 m/sec^2 (3) 10 m/sec^2 (4) Zero

5. **Which of the following graph depicts spring constant k versus length l of the spring correctly?**

(1)


(2)


(3)


(4)


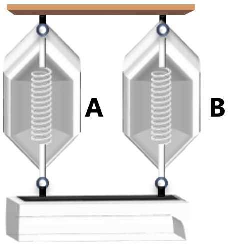
Answer Key

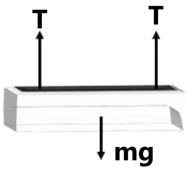
Question	1	2	3	4	5
Answer	4	2	2	2	4

SOLUTIONS

1. **(4)**

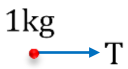
Both A and B reads 2 kg



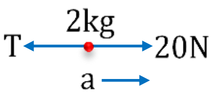


$2T = mg \Rightarrow T = \frac{mg}{2} \Rightarrow$ Reading will be 2kg for each spring balance

2. **(2)**



T = 1 × 10 = 10 N



20 – T = 2 × a

a = $\frac{20-10}{2}$ = 5 m/s^2

3. **(2)**

T = 5gsin30°

T = 25 N

4. **(2)**

As the mass of 10 kg has acceleration 12 m/s^2 therefore it applies 120N force on mass 20kg in a backward direction.

∴ Net forward force on 20 kg mass = 200 – 120 = 80N

∴ Acceleration = $\frac{80}{20} = 4 m/s^2$.

5. **(4)**

$k = \frac{F}{x}$ and increment in length is proportional the original length i.e. $x \propto \ell \therefore k \propto \frac{1}{\ell}$

It means graph between K and ℓ will be rectangular hyperbola.

Frame of Reference and Pseudo Force DPP-15

1. **In Newton's second Law $\vec{F} = m\vec{a}$ (for constant mass m) $\vec{a}$, is the acceleration of the mass m with respect to**

(1) any observer
(2) any inertial observer
(3) an observer at rest only
(4) an observer moving with uniform speed only

2. **A boy sitting on the upper berth in the compartment of an accelerated train, which is just left the railway station, drops an apple aiming at the open hand of his brother vertically below his hands at a distance of about 2 m. The apple will fall: -**

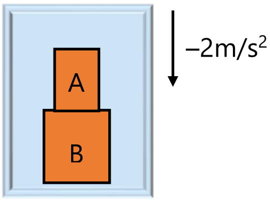
(1) In the hand of his brother
(2) Slightly away from the hands of his brother in the direction of motion of the train
(3) Slightly away from the hands of his brother in the direction opposite to the direction of motion of the train
(4) None of the above

3. **The force exerted by a person on the floor of an elevator is less than the weight of the person if the elevator is :-**

(a) Going up and slowing down
(b) Going up and speeding up
(c) Going down and slowing down
(d) Going down and speeding up

(1) a, c (2) b, c (3) a, d (4) b, d

4. **The elevator shown in figure is descending, with a retardation of 2 m/s². The mass of the block A is 0.5 kg. The force exerted by the block A on the block B is: -**



(1) 2 N (2) 4 N (3) 6 N (4) 8 N

5. **A block of mass m is placed on a smooth wedge of inclination θ. The whole system is accelerated horizontally so that the block does not slip on the wedge. The force exerted by the wedge on the block (g is acceleration due to gravity) will be :–**

(1) mg sin θ (2) mg (3) mg/cos θ (4) mg cos θ

6. **A body kept on a smooth inclined plane of inclination 1 in x will remain stationary relative to the inclined plane if the plane is given a horizontal acceleration equal to :-**

(1) $\sqrt{x^2-1}\ g$ (2) $\frac{\sqrt{x^2-1}}{x}g$ (3) $\frac{gx}{\sqrt{x^2-1}}$ (4) $\frac{g}{\sqrt{x^2-1}}$

7. **An object of mass 2 kg moving with constant velocity $10\hat{i}$ m/s is seen in a frame moving with constant velocity $10\hat{i}$ m/s. The value of 'pseudo force' acting on object in this frame will be: -**

(1) 20 N (2) 0 N (3) 10 N (4) 2 N

Answer Key

Question	1	2	3	4	5	6	7
Answer	2	3	3	3	3	4	2

SOLUTIONS

1. **(2)**

Newton's second law of motion is applicable only for inertial frame

2. **(3)**

Because of train's acceleration, pseudo forces acts in opposite to the direction of motion of train.

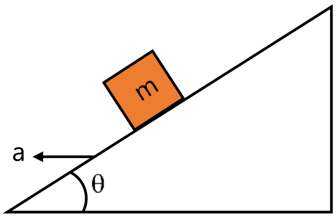
3. **(3)**

Force exerted by a person on the floor is less than his weight when lift has an downward acceleration or upward retardation ($g_{eff.} = g - a$).

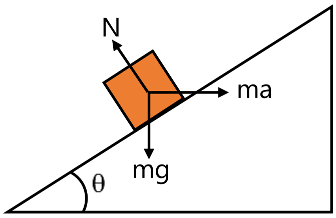
4. **(3)**

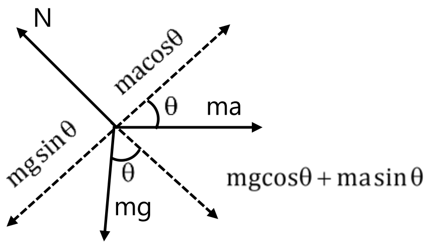
$N = m(g + a) = 0.5(10 + 2) = 6N$

5. **(3)**



FBD of m w.r.t. inclined plane.





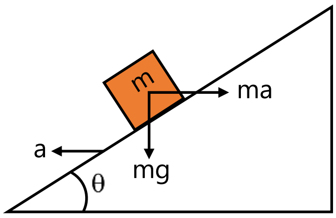
$\therefore$ $mg \sin\theta = ma \cos\theta$ .....(i)

$N = mg\cos\theta + ma\sin\theta$ .....(ii)

$\therefore$ $N = mg\cos\theta + m\sin\theta \times g \times \frac{\sin\theta}{\cos\theta}$

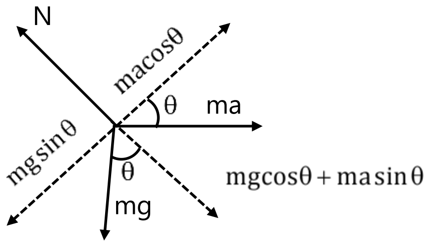
$N = \frac{mg}{\cos\theta}$

6. **(4)**



According to question $sin\,\theta = 1/x$ (1 in x)

So $\tan\theta = \frac{1}{\sqrt{x^2 - 1}}$



To keep the block stationary relative to the inclined plane

mgsin θ = macos θ

a = gtan θ

$\Rightarrow\ a = \frac{g}{\sqrt{x^2 - 1}}$

7. **(2)**

Since acceleration of frame, $a_{frame} = 0\ m/s^2$

Hence value of pseudo force = a_{frame} × mass of object = 0 N

DAILY PRACTICE PROBLEM

Weighing Machine DPP-16

1. Two equal masses are kept on the pans of a simple balance in a lift accelerating upward. Then

(1) Pans will remain at the some level. (2) Nothing can be said as data is incomplete

(3) Left side pan will lower down. (4) Right side pan will lower down.

2. The ratio of weights of a man in a lift moving with acceleration 'a' in upward direction and moving with acceleration 'a' in downward direction is 3 : 1. Then the value of a is :-

(1) $\frac{g}{3}$ (2) $\frac{g}{2}$ (3) $\frac{g}{5}$ (4) $\frac{4}{3}g$

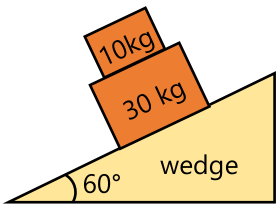
3. A man of weight mg is moving up in a rocket with acceleration 4g. The apparent weight of the man in the rocket is

(1) Zero (2) 4mg (3) 5mg (4) mg

4. A man (mass = 60 kg) standing on weighing balance falls freely. He will find the reading of the weighing balance equals to: -

(1) 60kgf (2) 120kgf (3) 0kgf (4) None of the above

5. Find the normal reaction force applied on wedge at rest by both blocks: -



(1) 400N (2) 340N (3) 200N (4) None of the above

Answer Key

Question	1	2	3	4	5
Answer	1	2	3	3	3

SOLUTIONS

1. **(1)**

2. **(2)**

$$\frac{m(g+a)}{m(g-a)}=\frac{3}{1}$$

(g + a) = 3(g – a) $\Rightarrow a=\frac{g}{2}$

3. **(3)**

R = m (g + a) = m (g + 4g) = 5mg

4. **(3)**

From Newton's Second Law of Motion,

mg – N = ma

mg – N = mg (since a = g, free falling)

Hence N = 0

5. **(3)**

$N=mg\cos\theta$

Where m = total mass of the blocks = 40 kg

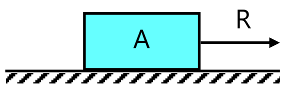
Hence, N = 40 × 10 × $\frac{1}{2}$ = 200 N

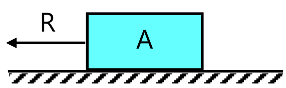
Types of Friction DPP-17

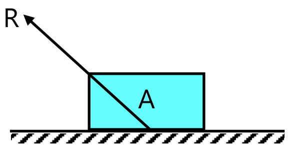
1. **A girl horizontally press her physics text book against a rough vertical wall with her hand. The direction of the frictional force on the book exerted by the wall is: -**

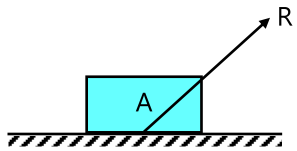
(1) downwards
(2) upwards
(3) out from the wall
(4) into the wall

2. **A box 'A' is lying on the horizontal floor of the compartment of a train running along horizontal rails from left to right. At time 't', it retards. Then the reaction R by the floor on the box is given best by: -**

(1) 

(2) 

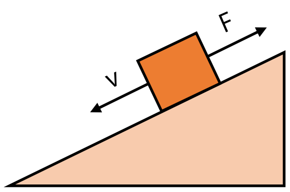
(3) 

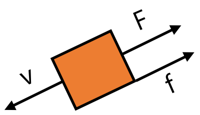
(4) 

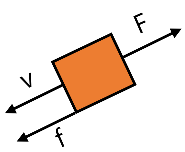
3. **The values of coefficient of friction can be: -**

(1) 0.5
(2) 0.8
(3) 1.5
(4) All of these

4. **Determine the direction of friction force: -**

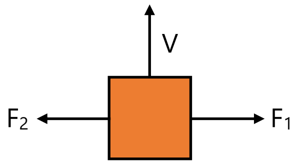


(1) 

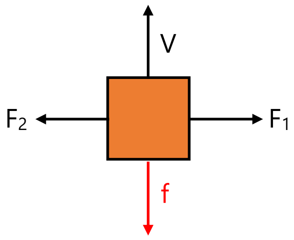
(2) 

(3) Can't be determined
(4) Insufficient data

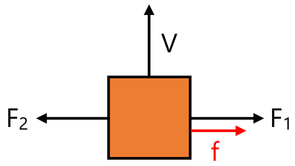
5. Determine the direction of friction force (each diagram is observed from top view): -



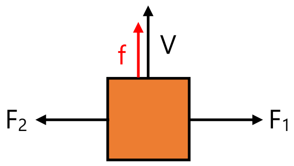
(1)



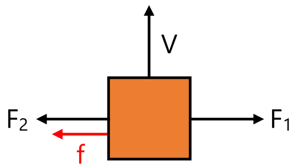
(2)



(3)



(4)



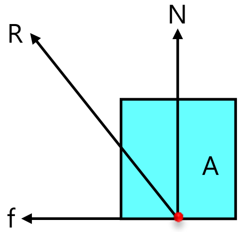
Answer Key

Question	1	2	3	4	5
Answer	2	3	4	1	1

SOLUTIONS

1. **(2)**

2. **(3)**



3. **(4)**

Values of coefficient of friction can exceeds unity.

4. **(1)**

Direction of friction will be opposite to relative motion between block and wedge.

5. **(1)**

Direction of friction will be opposite to relative motion between block and contact surface.

Motion and Equilibrium on rough horizontal surface DPP-18

1. **A block of mass 4 kg is placed on the floor. The coefficient of static friction is 0.4. Force of 8 N is applied on the block. The force of friction between the block and the floor is**

(1) 16 N (2) 8.0 N (3) 2.0 N (4) zero

2. **The frictional force of the air on a body of mass 0.5 kg, falling with an acceleration of 9.0 m/s^2, will be ($g = 10\ m/s^2$):**

(1) 4.9 N (2) 0.5 N (3) 4.5 N (4) 5 N

3. **A block of mass 10 kg is placed on a long trolley. The coefficient of friction between the block and trolley is 0.2. The trolley accelerates from rest with 0.5 m/s^2 for 20 s. then what is the friction force?**

(1) 20 N (2) 100 N (3) 5 N (4) 10 N

4. **A 20 kg block is initially at rest. A 75 N force is required to set the block in motion. After the motion start, a force of 60 N is applied to keep the block moving with constant speed. The coefficient of static friction is :-**

(1) 0.6 (2) 0.52 (3) 0.44 (4) 0.375

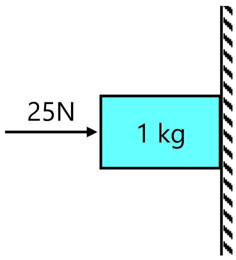
5. **A block of mass 1 kg lies on a horizontal surface in a truck. The coefficient of static friction between the block and the surface is 0.6. If the acceleration of the truck is 5 m/s^2, the frictional force acting on the block is: -**

(1) 5N (2) 6N (3) 10N (4) 15N

6. **A body of mass 10 kg lies on a rough horizontal surface. When a horizontal force of F newton acts on it, it gets an acceleration of 5m/s^2, and when the horizontal force is doubled, it gets an acceleration of 18m/s^2. The coefficient of friction between the body and the horizontal surface is**

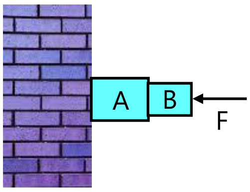
(1) 0.2 (2) 0.4 (3) 0.6 (4) 0.8

7. **A block of mass 1 kg is pressed against a wall with a horizontal force of 25 N as shown in the figure. If the coefficient of friction between the wall and the block is 0.5 then the frictional force acting on the block will be ($g = 9.8\ m/s^2$): -**



(1) 9.8 N (2) 2.5 N (3) 12.5 N (4) 4.9 N

8. **Adjoining figure shows two blocks A and B pushed against the wall with a force F. The wall is smooth but the surfaces in contact of A and B are rough. Which of the following is true for the system of blocks to be at rest against the wall?**



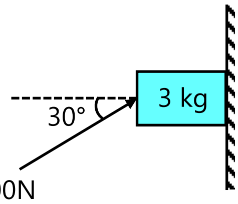
(1) F should be be more than the weight of A and B

(2) F should be equal to the weight of A and B

(3) F should be less than the weight of A and B

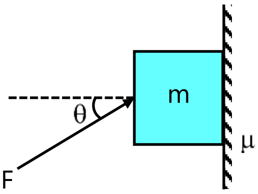
(4) System cannot be in equilibrium

9. A force of 100N is applied on a block of mass 3 kg as shown in the figure. The coefficient of friction between the surface and the block is $\mu = \frac{1}{\sqrt{3}}$. The frictional force acting on the block is: -



(1) 15 N downwards (2) 25 N upwards (3) 20 N downwards (4) 30 N upwards

10. The minimum value of force F required to keep the block stationary is: -



(1) $\frac{mg}{\mu\cos\theta}$ (2) $\frac{mg}{\sin\theta+\mu\cos\theta}$ (3) $\frac{mg}{\sin\theta-\mu\cos\theta}$ (4) $\frac{mg}{\mu\tan\theta}$

Answer Key

Question	1	2	3	4	5	6	7	8	9	10
Answer	2	2	3	4	1	4	1	4	3	2

SOLUTIONS

1. **(2)**

$f_{max} = 40 \times 0.4 = 16N$

$\therefore$ f = 8N (Applied force)

2. **(2)**

mg – f = ma

f = m(g–a)

= 0.5 × (10–9)

= 0.5N

3. **(3)**

Pseudo force = 10 × 0.5 = 5 N

$f_{max} = 10 \times 10 \times 0.2 = 20N$

$\therefore$ f = 5N

4. **(4)**

$F = f_{ms}$ (f_{ms} is maximum static friction)

$75 = \mu_S \times 20 \times 10$

$\mu_S = 0.375$

5. **(1)**

$f_{ms} = \mu_S mg$

$f_{ms} = 0.6 \times 1 \times 10 = 6$ N

F = 1 × 5 = 5N

$\because f_{ms} > F$

Hence f = F = 5N

6. **(4)**

F – f = 10 × 5 ...(1)

2F – f = 10 × 18 ...(2)

from eq^n (1) & eq^n (2)

$f = \mu mg = 80$ N

$$\mu = \frac{f}{mg} = \frac{80}{10 \times 10} = 0.8$$

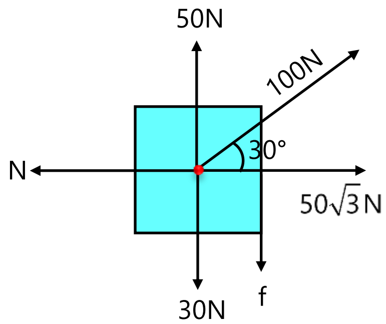
7. **(1)**

$f_{max} = 0.5 \times 25 = 12.5$ N

$f = mg = 1 \times 9.8 = 9.8 \text{ N} < f_{max}$

8. **(4)**

9. **(3)**

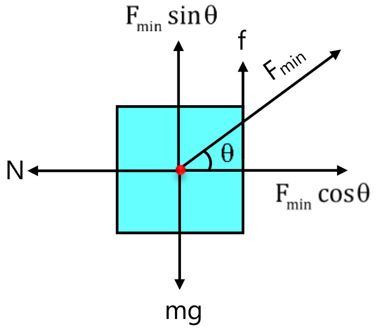


$$f_{ms} = N = \frac{1}{\sqrt{3}} \times 50\sqrt{3} = 50N$$

$$50N = f + 30N \Rightarrow f = 20N < f_{ms}$$

Hence f = 20N

10. **(2)**



$$F_{min}\sin\theta + f = mg$$

$$\Rightarrow F_{min}\sin\theta + \mu F_{min}\cos\theta = mg$$

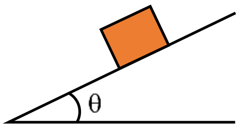
$$\Rightarrow F_{min}\left(\sin\theta + \mu\cos\theta\right) = mg$$

$$\Rightarrow F_{min} = \frac{mg}{\sin\theta + \mu\cos\theta}$$

DAILY PRACTICE PROBLEM

Angle of Repose DPP-19

1. For what value of θ block will slide ($\mu = 0.6$)



(1) 20° (2) 30° (3) 45° (4) 15°

2. Find angle of friction (μ = tan30°)

(1) 60° (2) 45° (3) 30° (4) 15°

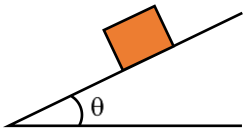
3. On which of the following angle of repose depends

(1) Angle of inclination (2) Friction force (3) Weight of block (4) Coefficient of friction

4. Angle of friction is angle between normal and resultant of

(1) Weight and Friction (2) Friction and Normal (3) Weight and Normal (4) None

5. Find net contact force if block is at rest (given:- $\mu = 0.75, \theta = 60°$)



(1) 12N (2) 14N (3) 10N (4) 16N

Answer Key

Question	1	2	3	4	5
Answer	3	3	4	2	4

SOLUTIONS

1. **(3)**

For block to be sliding

$\tan\theta > \mu$

And this is possible for option (3)

2. **(3)**

Let angle of friction be λ

$\tan\lambda = \mu$

And $\mu = \tan 30°$

Hence $\lambda = 30°$

3. **(4)**

4. **(2)**

5. **(4)**

Since block is at rest

Hence, $f = mg\sin\theta$

$N = mg\cos\theta$

Net contact force = $\sqrt{f^2 + N^2} = mg = 16N$

DAILY PRACTICE PROBLEM

Motion and Equilibrium on rough inclined surface DPP-20

1. A block slides with constant velocity on a plane inclined at an angle θ. The same block is projected up the plane with an initial velocity v_0. The distance covered by the block before coming to rest is

(1) $\frac{v_0^2}{2g\sin\theta}$ (2) $\frac{v_0^2}{4g\sin\theta}$ (3) $\frac{v_0^2\sin^2\theta}{2g}$ (4) $\frac{v_0^2\sin^2\theta}{4g}$

2. A given object takes n times as much time to slide down a 45° rough incline as it takes to slide down a perfectly smooth 45° incline. The coefficient of kinetic friction between the object and the incline is given by: -

(1) $\left(1-\frac{1}{n^2}\right)$ (2) $\left(\frac{1}{1-n^2}\right)$ (3) $\sqrt{\left(1-\frac{1}{n^2}\right)}$ (4) $\sqrt{\left(\frac{1}{1-n^2}\right)}$

3. A block 'A' kept on an inclined surface just begins to slide if the inclination is 30° with the horizontal. The block is replaced by another block 'B' and it is found that it just begins to slide if the inclination is 40° with the horizontal: -

(1) mass of A > mass of B (2) mass of A < mass of B

(3) mass of A = mass of B (4) all the three are possible

4. If the coefficient of friction of a surface is $\sqrt{3}$, then the angle of inclination of this surface from the horizontal to make a body on it just to slide, is: -

(1) 30° (2) 45° (3) 60° (4) 75°

5. A block of mass 4 kg rests on an inclined plane. The inclination of the plane is gradually increased. it is found that when the inclination is 3 in 5, the block just begins to slide down the plane. The coefficient of friction between the block and the plane is: -

(1) 0.4 (2) 0.6 (3) 0.8 (4) 0.75

Answer Key

Question	1	2	3	4	5
Answer	2	1	4	3	4

SOLUTIONS

1. (2)

$mg\sin\theta = \mu mg\cos\theta$

$\sin\theta = \mu\cos\theta$ ....(1)

when pushed up

acceleration $a = -(g\sin\theta + \mu g\cos\theta)$

$= -(g\sin\theta + g\sin\theta) = -2g\sin\theta$

$\therefore\ v^2 - v_0^2 = 2(a)\times s$

Final velocity v = 0

$-v_0^2 = 2$ as $\Rightarrow -v_0^2 = 2(-2g\sin\theta)s$

$\therefore\ s = \dfrac{v_0^2}{2(2g\sin\theta)}$

2. (1)

Let the length of incline is d

Case-I:

For rough incline plane

$a_r = g\sin 45° - \mu g\cos 45° = \dfrac{g - \mu g}{\sqrt{2}} = \left(\dfrac{1-\mu}{\sqrt{2}}\right)g$

Time taken to slide down (t_r) = $\sqrt{\dfrac{2d}{a_r}}$

Case-II:

For smooth incline plane

$a_S = g\sin 45° = \dfrac{g}{\sqrt{2}}$

$\Rightarrow\ t_s = \sqrt{\dfrac{2d}{a_s}}$

According to question

$nt_s = t_r \Rightarrow n^2 t_s^2 = t_r^2$

$n^2\left(\dfrac{2d}{g/\sqrt{2}}\right) = \dfrac{2d}{\left(\dfrac{1-\mu}{\sqrt{2}}\right)g}$

$n^2 = \dfrac{1}{1-\mu} \Rightarrow \mu = 1 - \dfrac{1}{n^2}$

3. (4)

Angle of repose independent of mass.

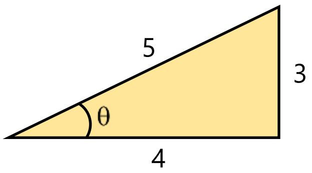
4. **(3)**

$\tan\theta = \mu_s$

$\tan\theta = \sqrt{3}$

$\theta = 60°$

5. **(4)**



$\therefore \quad \tan\theta = \mu_s$

$\frac{3}{4} = \mu_s$

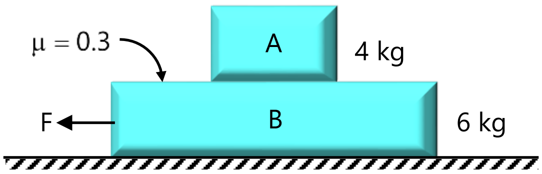
$\mu_s = 0.75$

Two Block Problems DPP-21

1. **A 8 kg block (A) is placed on 2 kg block (B) which rests on a table. Coefficient of friction between (A) and (B) is 0.5 and between (B) and table is 0.2. A 60 N horizontal force is applied on the block (A), then the friction force between the blocks (A) and (B) is: -**

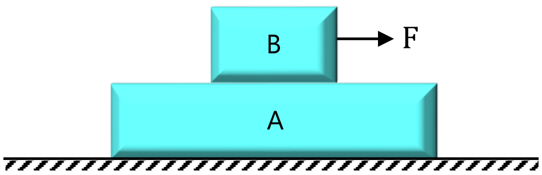
(1) Zero (2) 2.5 N (3) 28 N (4) 40 N

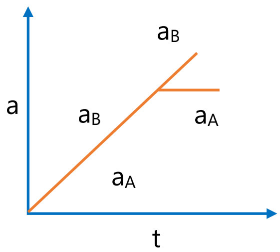
2. **Two blocks (A) 4 kg and (B) 6 kg rest one over the other on a smooth horizontal plane. The coefficient of static and dynamic friction between (A) and (B) is the same and equal to 0.3. The maximum horizontal force F that can be applied to (B) in order that both (A) and (B) do not have any relative motion is : -**

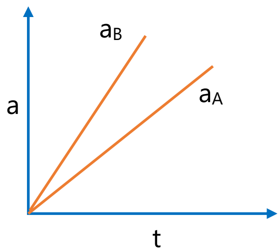


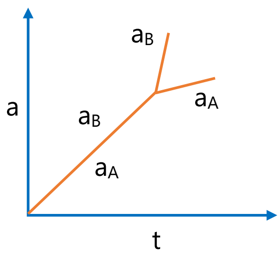
(1) 30 N (2) 30 kgf (3) 12 kgf (4) 12 N

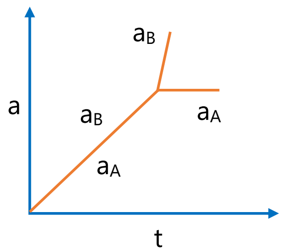
3. **A block B is placed on block A. The mass of block B is less than the mass of block A. Friction exists between the blocks, whereas the ground on which the block A is placed is taken to be smooth. A horizontal force F, increasing linearly with time begins to act on B. The acceleration a_A and a_B of blocks A and B respectively are plotted against t. The correctly plotted graph is**



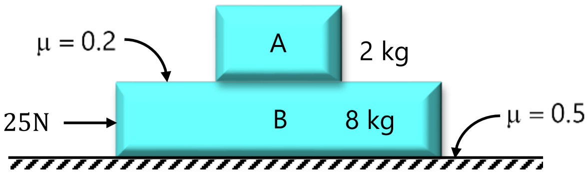
(1)


(2)


(3)


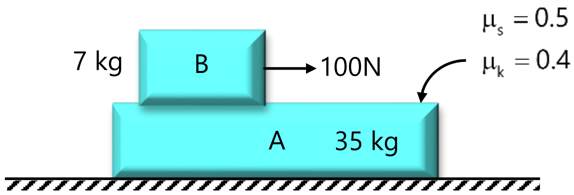
(4)


4. **A block A of mass 2kg rests on another block B of mass 8kg which rests on a horizontal floor. The coefficient of friction between A and B is 0.2, while that between B and the floor is 0.5. When a horizontal force of 25N is applied on B, the force of friction between A and B is ($g = 10\ m/s^2$): -**



(1) Zero (2) 4N (3) 5N (4) 50N

5. **Block A of mass 35 kg is resting on a frictionless floor. Another block B of mass 7 kg is resting on it as shown in the figure. The coefficient of static friction and kinetic friction are 0.5 and 0.4 respectively. If a horizontal force of 100 N is applied to block B, then the acceleration of the block A will be ($g = 10\ ms^{-2}$): -**



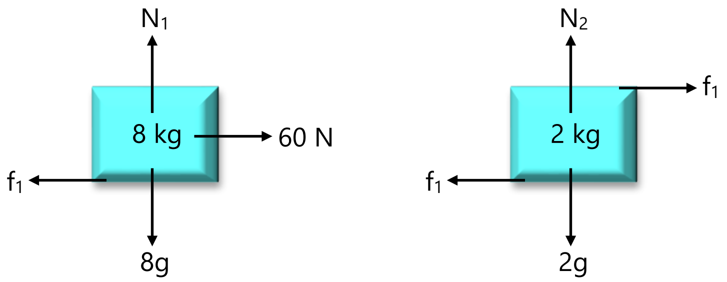
(1) $0.8\ m/s^2$ (2) $2.4\ m/s^2$ (3) $0.4\ m/s^2$ (4) $4.4\ m/s^2$

Answer Key

Question	1	2	3	4	5
Answer	3	1	4	1	1

SOLUTIONS

1. **(3)**



f_{1max} = 0.5 × 80 = 40 N

f_{2max} = 0.2 × 100 = 20 N

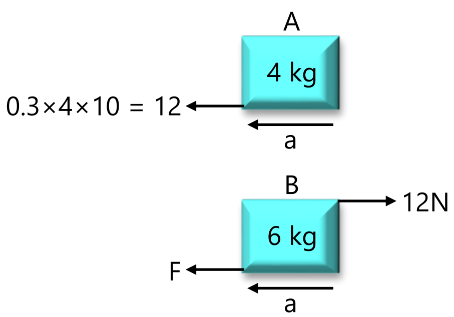
∴ combined acc.(a) = $\frac{60-20}{10}$ = 4 m/s^2

from FBD of 8 kg: -

Friction between A & B

f_1 = 60 – 8 × 4 = 28 N

2. **(1)**



$a = \frac{12}{4} = 3\ m/s^2$

F – 12 = 6 × a

F = 12 + 6 × 3 = 30 N

3. **(4)**

If the applied force is less than limiting friction between block A and B, then whole system move with common acceleration

i.e. $a_A = a_B = \frac{F}{m_A + m_B}$

But the applied force increases with time, so when it becomes more than limiting friction between A and B, block B starts moving under the effect of net force F – F_k

Where F_k = Kinetic friction between block A and B

$\therefore$ Acceleration of block B, $a_B = \frac{F - F_k}{m_B}$

As F is increasing with time so a_B will increase with time

Kinetic friction is the cause of motion of block A

$\therefore$ Acceleration of block A, $a_A = \frac{F_k}{m_A}$

It is clear that $a_B > a_A$. i.e. graph (d) correctly represents the variation in acceleration with time for block A and B.

4. (1)

Limiting Friction between block B and floor = 0.5 × 10 × 10 = 50N

Hence block B will not move.

Block A will also be at rest

Friction between block A and block B will be zero.

5. (1)

Static friction force between two blocks

$f_s \le \mu N$

N = mg = 7 × 10 = 70N

$f_s \le \mu_s \times 70$

$f_s \le 0.5 \times 70$

$f_s \le 35N$

here force applied is greater than static friction

hence body is in motion, then there is kinetic friction

$f_k = \mu_k \times 70$

$f_k = 0.4 \times 70$

$f_k = 28N$

for mass 35 kg force applied is only kinetic friction

$f_1 = f_k = 28N$

Acceleration of mass 35 kg is

$a = \frac{f_1}{35} = \frac{28}{35} = 0.8 \text{ m}/\text{s}^2$