Question1
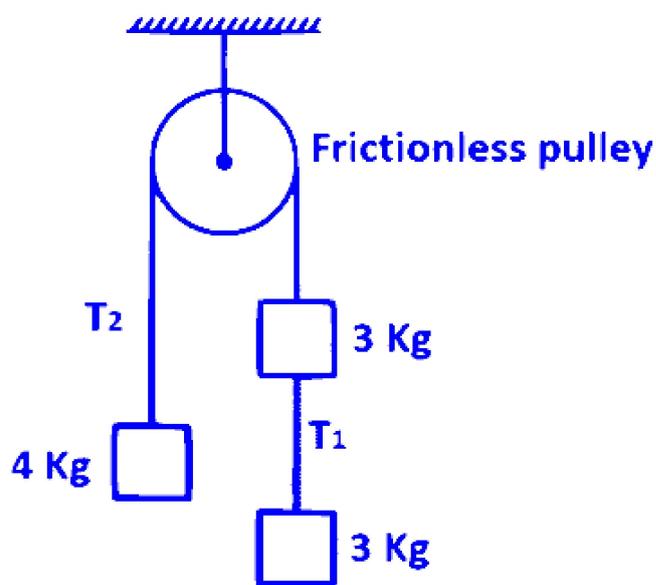
If the system of blocks shown in the figure is released from rest, the ratio of the tensions T_1 and T_2 is (Neglect the mass of the string shown in the figure)

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Options:

A.

1 : 1

B.

1 : 2

C.

1 : 3

D.

3 : 4

Solution:

Tension in the string connected to the 4 kg block $= T_2$

Tension in each side of the movable pulley (connected to 3 kg blocks) $= T_1$

Since, the pulley is ideal and frictionless, the net upward force on the pulley is

$T_2 = 2T_1$

$4g - T_2 = 4a(\text{ downward acceleration } a) \qquad \ldots (i)$

$T_2 = 4g - 4a$
$T_1 = 3g - 3a(\text{ acceleration upwards } a) \qquad \ldots (ii)$

$T_2 = 2T_1 \qquad \ldots (iii)$

From Eqs. (i) and (ii)

$$4g - 4a = 2(3g - 3a)$$
$$4g - 4a = 6g - 6a$$
$$2a = 2g$$
$$\Rightarrow \quad a = g$$

Substitute $a = g$ in Eq. (ii)

$T_1 = 3g - 3g = 0(\text{ invalid })$

Assuming equilibrium $a = 0$

Then, $T_1 = 3g$

(From Eq. (ii))

$T_2 = 2T_1$
$$\frac{T_1}{T_2} = \frac{1}{2}$$

(From Eq. (iii))

Question2

A man of mass 60 kg is standing in a lift moving up with a retardation of 2.8 ms^{-2}. The apparent weight of the man is

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Options:

A.

756 N

B.

168 N

C.

588 N

D.

420 N

Answer: D

Solution:

When a man standing in a lift moving up with a retardation of a m/s^2, then apparent weight $= m(g + a)$

$= 60(9.8 - 2.8) \therefore a = -2.8 \text{ m/s}^2$
$= 60 \times 7 = 420 \text{ N}$

Question3

A block of mass 5 kg is kept on a smooth horizontal surface. A horizontal stream of water coming out of a pipe of area of cross-section 5 cm^2 hits the block with a velocity of 5 ms^{-1} and rebounds back with the same velocity. The initial acceleration of the block is (density of water is 1 g/cc)

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Options:

A. 10 ms^{-2}

B. $2.5 \, \text{ms}^{-2}$

C. $12.5 \, \text{ms}^{-2}$

D. $5 \, \text{ms}^{-2}$

Answer: D

Solution:

Given:

Area of cross-section of the pipe, $A = 5 \, \text{cm}^2 = 5 \times 10^{-4} \, \text{m}^2$

Velocity of water, $v = 5 \, \text{m/s}$

Density of water, $\rho = 1 \, \text{g/cm}^3 = 1000 \, \text{kg/m}^3$

To find the mass flow rate $\left(\frac{dm}{dt} \right)$, we use the formula:

$$\frac{dm}{dt} = \rho \cdot A \cdot v$$

Calculating, we get:

$$\frac{dm}{dt} = 1000 \times 5 \times 10^{-4} \times 5 = 2.5 \, \text{kg/s}$$

The water hits the block and rebounds with the same velocity but in the opposite direction. The change in velocity (Δv) is:

$$\Delta v = v_{\text{final}} - v_{\text{initial}} = -5 - 5 = -10 \, \text{m/s}$$

The force exerted by the water stream F is calculated using the rate of change of momentum:

$$F = \frac{dm}{dt} \cdot \Delta v = 2.5 \times (-10) = -25 \, \text{N}$$

(Note: The negative sign indicates the direction; for magnitude, we use the positive value.)

Thus, the force is $F = 25 \, \text{N}$.

Using Newton's Second Law:

$$F = ma \quad \Rightarrow \quad a = \frac{F}{m} = \frac{25}{5} = 5 \, \text{m/s}^2$$

Therefore, the initial acceleration of the block is $5 \, \text{m/s}^2$.

Question4

A block is kept on a rough horizontal surface. The acceleration of the block increases from $6 \, \text{ms}^{-2}$ to $11 \, \text{ms}^{-2}$ when the horizontal

force acting on it increases from 20 N to 30 N . The coefficient of kinetic friction between the block and the surface is (acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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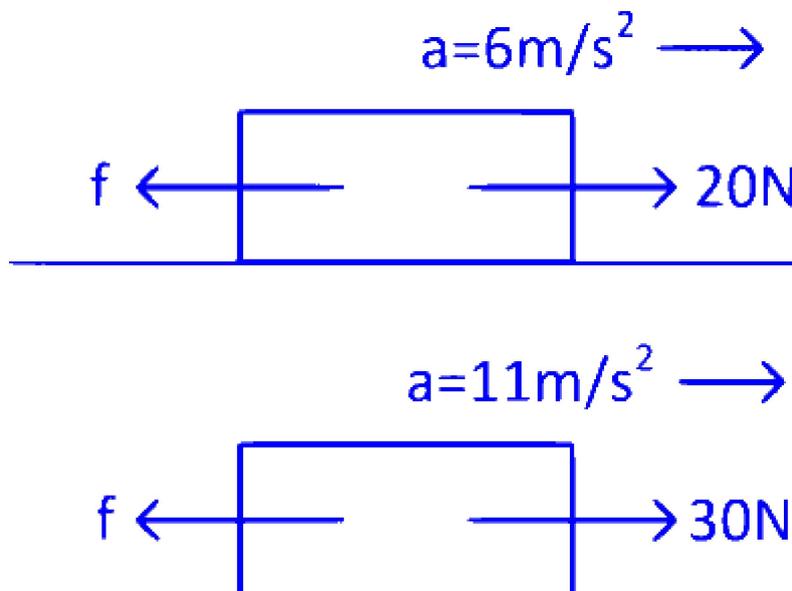
Options:

A. 0.2

B. 0.3

C. 0.4

D. 0.5

Answer: C

Solution:

From net force acting on the body, From figure (i) and figure (ii)

$20 - f = ma$

$20 - f = m \times 6$

$30 - f = m \times 11$

where f is frictional force (kinetic) From Eqs. (i) and (ii)

$m = 2$ kg and $f = 8$ N

$f = \mu_k mg$

$\mu_k = \dfrac{f}{mg} = \dfrac{8}{2 \times 10}$

$\mu_k = 0.4$

μ_k coefficient of kinetic energy.

Question5

A person initially at rest, starts walking towards east without slipping or skidding. What is the type of friction acting on the person from the ground and in which direction the frictional force acts?

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Options:

A. Static friction, towards west

B. Static friction, towards east

C. Kinetic friction, towards west

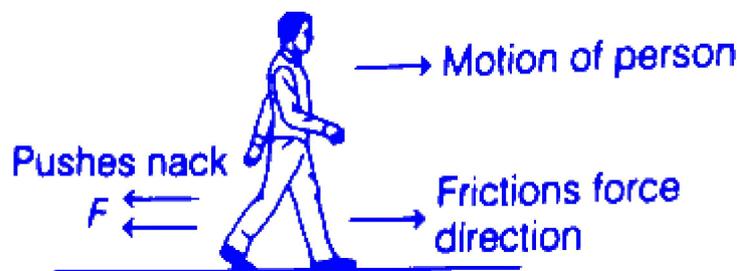D. Kinetic friction, towards east

Answer: B

Solution:

Given,

Initially the person is at rest, after that start walking toward east.

Person does not skid or slip.

We know that, when we walk, our feet are pushing backward and therefore friction opposes this motion of pushing.

So, the direction of friction is opposite to walking i.e., east direction.

As the person does not skid or slip or roll the friction force which is acting on him is static in nature.

Hence, friction force is static and toward east in nature.

Question6

A body of mass 6 kg is moving with a uniform velocity 4 ms^{-1}. Its velocity changes to 6 ms^{-1} when a force of 12 N acts on it. Then its displacement is

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Options:

A. 3 m

B. 5 m

C. 8 m

D. 12 m

Answer: B

Solution:

Mass of the Body: 6 kg

Initial Velocity (u): 4 m/s

Final Velocity (v): 6 m/s

Force Applied (F): 12 N

We start by determining the acceleration (a) using Newton's second law, defined as:

$$F = m \cdot a$$

Substituting the known values:

$$a = \frac{F}{m} = \frac{12}{6} = 2 \, \text{m/s}^2$$

Next, we use the first equation of motion to find the time (t) taken for the velocity change:

$$v = u + a \cdot t$$

Rearranging for t:

$$t = \frac{v - u}{a} = \frac{6 - 4}{2} = 1 \, \text{s}$$

To find the displacement (s), we use the second equation of motion:

$$s = u \cdot t + \frac{1}{2} a \cdot t^2$$

Substituting the known values:

$$s = 4 \times 1 + \frac{1}{2} \times 2 \times (1)^2$$

$$s = 4 + 1 = 5 \, \text{m}$$

Thus, the displacement of the body is 5 m.