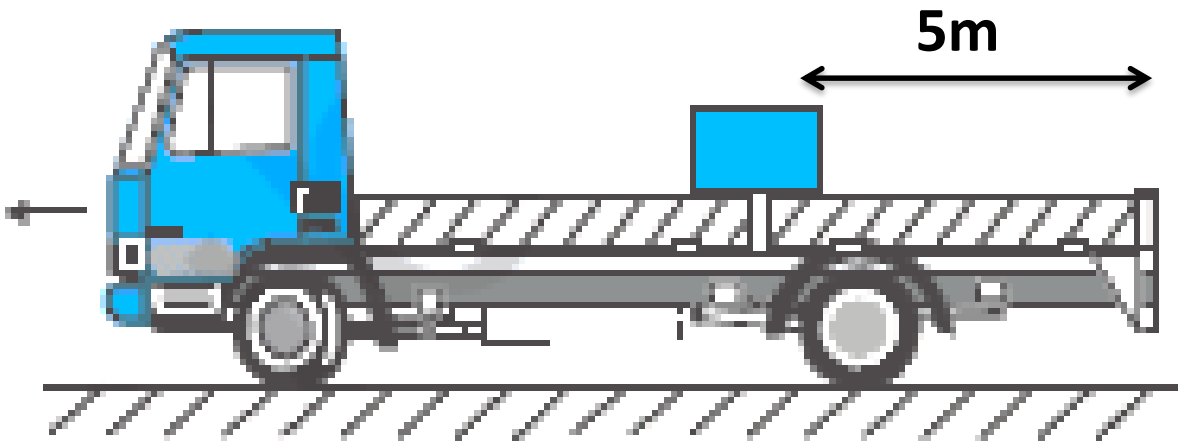
Problem on

Laws of motion

QUESTION:

The rear side of a truck is open and a box of 40 kg mass is placed 5 m away from the open end as shown in fig.



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The coefficient of friction between the box and the surface below it is 0.15. On a straight road, the truck starts from rest and accelerates with 2 m s^{-2}. At what distance from the starting point does the box fall off the truck? (Ignore the size of the box).

SOLUTION:

GIVEN:

Mass of the box, M = 40 kg;

Acceleration of the truck, a = 2 ms^{-2};

Distance of the box from the rear end, S= 5m

Coefficient of friction between the box and the surface below it, μ = 0.15

As the truck moves in forward direction with the acceleration a = 2 ms^{-2},

the box experiences a force F in the opposite (backward) direction given by (according to the Newton's law of motion)

$$F = Ma$$

$$= 40 \times 2$$

$$= 80N$$

Under the action of this force, the box will tend to move to the rear side of the truck. As it does so, its motion will be opposed by the force of friction.

The limiting friction acting between the box and truck,

$$f = \mu M g$$
$$= 0.15 \times 40 \times 10$$
$$= 60 \text{ N}$$

The net force on the box in the backward direction,

$$F_1 = F - f = 80 - 60 = 20\ N$$

Therefore, acceleration in the motion of the box in the backward direction,

$$a_1 = \frac{F_1}{M} = \frac{20}{40} = 0.5 ms^{-2}$$

If t is the time in which the box falls off the truck, then

$$S = u\,t + \frac{1}{2} a_1 t^2$$

$$\text{or } 5 = 0 \times t + \frac{1}{2} \times 0.5 t^2$$

Or $$t = \sqrt{\frac{5 \times 2}{0.5}} = \sqrt{20}\ s$$

The distance covered by the truck (a = 2 ms^{-2}) in this time is given by

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

$$= 0 \times \sqrt{20} + \frac{1}{2} \times 2 \times \left(\sqrt{20}\right)^2$$

$$= 20\ m$$

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