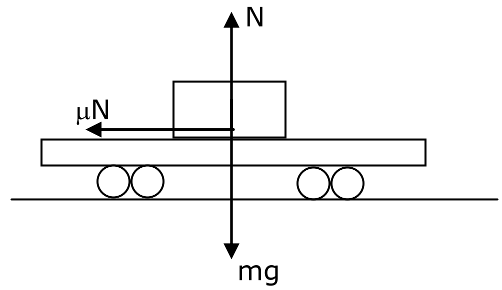
Q- The floor of a railroad flatcar is loaded with loose crates having a coefficient of static friction of 0.48 with the floor. If the train is initially moving at a speed of 54 km/h, in how short a distance can the train be stopped at constant acceleration without causing the crates to slide over the floor?



Initial speed of railroad car $u = 54$ km/h
$= 54(5/18)$ m/s
$= 15$ m/s

Final speed of railroad car $v = 0$

Let the car is stopped in the distance s

As the brakes applied the car starts decelerating (negative acceleration) while the crates will have tendency to move forward due to inertia. Because of this friction force between the surfaces appears and on the crate it will be in opposite direction trying to decelerate the crate. If the deceleration of crate due to friction is less than the deceleration of car the crate will slide forward relative to the car. For the crate not to slide on the car its deceleration should be same as that of the car and will have maximum value when the friction is having limiting value.

If the crate is just at verge of sliding then the friction force (limiting) on the crate will be

$$F_{friction} = -\mu N = -\mu mg$$

And hence the acceleration of the crate

$$a = F/m = -\mu g$$

The same will be the acceleration of the car and the distance moved by the car is given by the third equation of motion as

$$[v^2 = u^2 + 2as]$$

$$0 = u^2 + 2*(-\mu g)*s$$

Gives $s = u^2/(2\mu g) = (15)^2/(2*0.48*9.8) = 23.9$ m.

(If the harder breaks are applied, the car will stop in less distance but the friction cannot provide more retardation and the crates will slide forward on the surface.)