Q- A railroad hopper car weighs *50000 kg* when empty and contains *50000 kg* of coal. As it coasts along the track at *9 m/s* the hopper opens and steadily releases all the coal onto a platform below the rails over a period of *6 s*.

a) How fast does the car travel after all the coal is dumped?

b) What was the momentum absorbed by the platform?

c) If the coal comes to rest *1 second* after the dumping is finished, what was the average horizontal force on the platform?

d) If the coal fell *2 m*, what was the total energy converted to heat in the process of the coal coming to rest?

Answer

a) As there is no horizontal force acting on the hopper car its velocity will not change and thus remains 9 m/s.

b) The momentum absorbed by the platform is the momentum of the coal as it comes to rest on the platform.

Momentum of the coal before dumping is

P = mv = 50000*9 = 450000 = $4.5*10^5$ Kg.m/s

c) Force is the rate of change of momentum. The momentum of the coal is reduced to zero in 6+1 = 7 s. Thus rate of change of momentum of the coal i.e. the force experience by the coal is

$$F = \frac{Final\ momentum - initial\ momentum}{\Delta t}$$

Or $$F = \frac{0 - mv}{\Delta t} = -\frac{4.5*10^5}{7} = -6.43 * 10^4\ N$$

Hence the reactionary force on the platform will be $6.43 * 10^4\ N$ in forward direction

d) The total energy lost is the potential energy of the coal plus the kinetic energy of the coal

or $$\Delta U = mgh + \frac{1}{2}\ mv^2$$

or $$\Delta U = \frac{m}{2}\ (2gh + v^2) = \frac{4.5*10^5}{2}(2 * 10 * 2 + 9^2)$$

or $$\Delta U = \frac{4.5*10^5}{2} * 121 = 2.251 * 10^5\ J$$