Q. (a) What is the impulse needed to stop a 20 kg bowling ball moving at 5 m/s?

Impulse is the push given to the body and proportional to the force applied and the time both and hence given by

$I = F*\Delta t$

Now as according to second law of motion, the rate of change of momentum P is the force we have

$$F = \frac{\Delta P}{\Delta t}$$

And hence we have impulse equal to change in momentum

$$I = F*\Delta t = \Delta P$$

But here the change in momentum is

$\Delta P = m*(v_2 - v_1) = 20*(0 - 5) = - 100$ N s

Hence the impulse needed is 100 N.s in the direction opposite to the motion.

(b) A 2000 kg car accidentally drops from a crane and crashes at 30 m/s to the ground below and comes to an abrupt halt. What is the momentum at impact?

The momentum is given by the product of the mass and the velocity and hence is given by

$P = m* v = 2000*30 = 60{,}000$ kg m/s

(c) A railroad diesel engine weighs two times as much as a freight car. If the diesel engine coasts at 5 km/hr into a freight car that is initially at rest, how fast do the two coast after they couple together?

Let the mass of the car is m and that of the engine is 2m
The initial momentum of the engine is $2m*v_0$
The initial momentum of the car is $m*0 = 0$

Hence total initial momentum of the system of the two bodies will be $2mv_0$

If the velocity of the combined mass after collision is V then the final momentum of the system will be $(m + 2m)*v = 3mv$

As there is no external force on the system the momentum remains conserved and hence according to law of conservation of linear momentum we have

final momentum = Initial momentum

Gives $3mv = 2mv_0$

Or $v = 2v_0/3 = (2/3)*5 = 3.3333$ km/hr

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