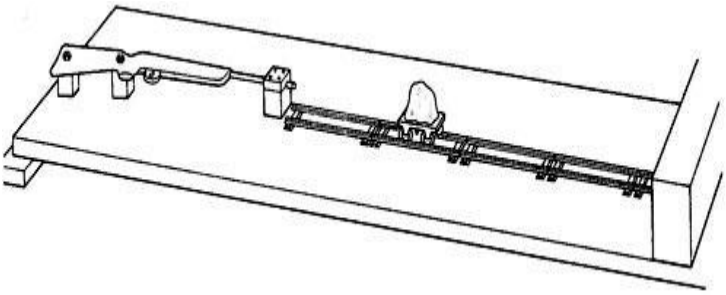
Forces and Motion

Chapter 4 – <u>Momentum</u>

Question 2, p.47

An air rifle pellet of mass 2 g is fired into a block of modeling clay mounted on a model railway truck. The truck and modeling clay have a mass of 0.1 kg. The truck moves off after the pellet hits the modeling clay with an initial velocity of 0.8 m/s.

a. Calculate the momentum of the modeling clay and truck just after the collision.
   (Hint: this is a case where after the collision, the pellet is embedded into the clay)
b. State the momentum of the pellet just before it hits the modeling clay.
   (Hint: by just stating the momentum, we mean to write down its formula with any known values)
c. Use your answers to **<u>a</u>** and **<u>b</u>** to calculate the velocity of the pellet just before it hits the modeling clay.
   (Hint: conservation of momentum)
d. State any assumptions you made in this calculation.



Answer:

a. The momentum of the modeling clay and truck just after the collision will be equal to:
   momentum of truck with pellet = (mass of modeling clay and truck + mass of pellet) x velocity of truck after the collision

   $\overrightarrow{p_{t+p}} = (m_{\text{truck with clay}} + m_{\text{pellet}}) \cdot v_{\text{truck wih clay and pellet}}$
   $= (0.100 + 0.002)\ \text{kg} \cdot 0.8\ \text{m/s} = 0.102 \cdot 0.8 = \mathbf{\underline{0.0816}}\ \text{kg m/s}$
b. The momentum of the pellet will be:

$\vec{p}_{pellet} = m_{pellet} \cdot u_{pellet} =$ **$0.002\ u_{pellet}$** kg m/s

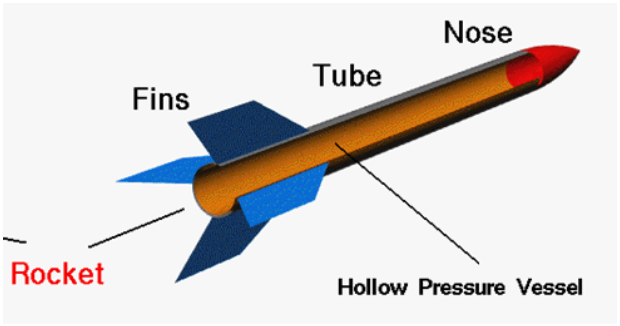
c. total moment befumore collision = total momentum after collision
→ momentum of pellet + momentum of truck at start = momentum of truck with pellet after
→ 0.002 x u_{pellet} + 0 (stationary truck) = 0.0816
→ $u_{pellet} = \frac{0{,}0816}{0.002} =$ **40.8** m/s

d. We assume that there are no energy losses during the collision and that ALL the kinetic energy of the pellet is transferred as kinetic energy of the truck with the pellet.

Question 3, p.47

A rocket of mass 1200 kg is travelling at 2000 m/s. It fires its engine for 1 minute. The forward thrust provided by the rocket engines is 10 kN (10,000 N).

See p. 41 for help where we have the same case only with the space shuttle though.



a. Use increase of momentum = *F* x *t* to calculate the increase of momentum of the rocket.
(Hint: use Figure 4.2 and the formulae as shown in page 41)

b. Use your answer to **a** to calculate the increase in velocity of the rocket and its new velocity after firing the engines.
(Hint: definition of momentum and u = 2000 m/s, v = ? m/s)

Answer:

a. increase in momentum = force x time = 10,000 N x 60 s
so the increase in momentum = **600,000 kg m/s**

b. As the question explains, the rocket travels with an initial velocity/momentum. Along the way, it ignites to produce a force which will accelerate it to a final velocity/momentum.

The initial momentum of the rocket
= mass of the rocket x initial velocity of the rocket
= m_{rocket} x u_{rocket} = 1200 kg x 2000 m/s = **2,400,000 kgm/s**

∴ final momentum = initial momentum + increase of momentum

= 2,400,000 kg m/s + 600,000 kg m/s
= **3,000,000 kg m/s**

So the new velocity now will be its **final velocity v** m/s. Again:

final momentum = mass of the rocket x final velocity of the rocket

final momentum = m_{rocket} x v_{rocket}

So $$v_{rocket} = \frac{final\ momentum}{m_{rocket}} = \frac{3{,}000{,}000\ kgm/s}{1200\ kg}$$

= **2500 m/s**.