2018-2019 Term 2

PHYS1001 Essential Physics

Assignment 4

Due date: 26th Feb, 2019 by 6:00 pm

(Please leave your homework in the box with the label "PHYS 1001" outside room 213 in Science Centre North Block)

Please answer **all** five questions

1. A girl (mass=40 kg) is initially sitting in a stationary boat (mass=30 kg). Suddenly she throws a 6 kg suitcase out horizontally with a speed of 5 m/s relative to the ground. What is the velocity of the boat right after the suitcase is thrown out?

   Answer:

   Applying conservation of momentum,

$$m_{girl}v_{girl,initial} + m_{boat}v_{boat,intiial} + m_{suitcase}v_{suitcase,initial} = m_{girl}v_{girl,final} + m_{boat}v_{boat,final} + m_{suitcase}v_{suitcase,final}$$

$$(40)(0) + (30)(0) + (6)(0) = (40)v + (30)v + (6)(5)$$

$$v = -0.43 \text{ m/s}$$

2. A 2000 kg car traveling at a velocity of 15 m/s to the right strikes a second car at rest. The two stick together and move off with a velocity of 8 m/s.
   (a) Choose a system in which the total momentum is conserved.
   (b) What is the mass of the second car?
   (c) If the impact time is 0.3 s, calculate the average impact force.

   Answer:

   (a) If the two cars are chosen as our system, there is no external force acting in the horizontal direction and the total momentum is conserved.
   (b) Applying conservation of momentum,

$$m_{car1}v_{init,car1} + m_{car2}v_{init,car2} = m_{car1}v_{final,car1} + m_{car2}v_{final,car2}$$

$$m_{car1}v_{init,car1} + m_{car2}v_{init,car2} = (m_{car1} + m_{car2})v_{final}$$

$$(2000)(15) + (m_{car2})(0) = (2000 + m_{car2})8$$

$$m_{car2} = 1750 \text{ kg}$$

   (c) The average impact force, say, on the 1750 kg car is:

$$F_{net} = \frac{p_{final} - p_{initial}}{\Delta t}$$

$$F_{net} = m\frac{v_{final} - v_{initial}}{\Delta t}$$

$$F_{net} = (1750)\frac{8 - 0}{0.3}$$

$$F_{net} = 46667 \text{ N (force pointing to the left)}$$

3. A 20 g bullet initially traveling at a velocity of 300 m/s penetrates a 2.0 kg block of wood. The bullet emerges on the other side of the block at a velocity of 200 m/s.
(a) Calculate the velocity of the block after the emergence of the bullet.
(b) If it takes 0.2s for the bullet to emerge from the other side of the block, calculate the average friction force between the block and the bullet.
(c) Calculate the total mechanical energy loss during this process

Answer:

(a) By conservation of momentum

$$m_{bullet}v_{bullet,init} + m_{wood}v_{wood,init} = m_{bullet}v_{bullet,final} + m_{wood}v_{wood,final}$$
$$(0.02)(300) + (2)(0) = (0.02)(200) + (2)v_{wood,final}$$
$$v_{wood,final} = 2 \text{ m/s}$$

The block moves at a speed of 2 m/s after collision

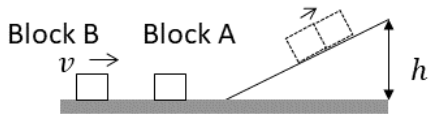
(b) $F_{net} = \frac{p_{final} - p_{initial}}{t} = \frac{(2)(0.02) - (0)(0.02)}{0.2} = 0.2$ N

(c) Initial total energy$= \frac{1}{2}m_{bullet}{v_{bullet,init}}^2 + \frac{1}{2}m_{wood}{v_{wood,init}}^2 = \frac{1}{2}(0.02)(300)^2 + \frac{1}{2}(2)(0)^2 = 900$ J

Final total energy$= \frac{1}{2}m_{bullet}{v_{bullet,final}}^2 + \frac{1}{2}m_{wood}{v_{wood,final}}^2 = \frac{1}{2}(0.02)(200)^2 + \frac{1}{2}(2)(2)^2 = 404$ J

Energy loss$= 900 - 404 = 496$ J

4. Block A (mass 5 kg) is initially at rest while block B (mass 2 kg) initially travels at 10 m/s. The two blocks collide with each other and stick together after the collision. Assume there is no friction between the blocks and the ground.



(a) Calculate the velocity of block A after the collision.
(b) The two blocks move up a slope after collision. Calculate the maximum height h reached by the two blocks?

Answer:

(a)
$$m_A v_{A,init} + m_B v_{B,init} = m_A v_{A,final} + m_B v_{B,final}$$
$$(5)(0) + (2)(10) = (5)v_{final} + (2)v_{final}$$
$$v_{final} = 2.86 \text{ m/s}$$

(b)
$$\frac{1}{2}m_A{v_{A,final}}^2 + \frac{1}{2}m_B{v_{B,final}}^2 = m_A gh + m_B gh$$

$$\frac{1}{2}(m_A + m_B){v_{final}}^2 = (m_A + m_B)gh$$

$$h = 0.42 \text{ m}$$

5. In everyday life, most moving objects eventually slow down and stop. Does this observation violate the principle of conservation of momentum? Explain your answer.

   Answer:

   The conservation of momentum states that when the net external force on a system of objects is zero, the total momentum of a system of objects is constant. However, the premise "next external force on a system of objects is zero" is almost never true in everyday examples due to the presence of friction. For example, the magnitude of the momentum of a block moving on a rough horizontal ground gradually decreases and becomes zero when the block comes to rest. The momentum is not conserved as the net external force is not zero in this case.