

# Homework 8 - Momentum

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## 1 Book

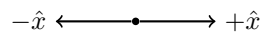
### 1.1 8.16

$$\begin{aligned}
 m_{(a)stronaut} &= 65.5 \text{ kg} \\
 m_{(t)ool} &= 2.50 \text{ kg} \\
 v_{t_1} &= 3.10 \text{ m s}^{-1} \\
 v_{a_1} &=?
 \end{aligned}$$

$$\begin{aligned}
 P_0 &= P_1 \\
 m_a v_{a_0} + m_t v_{t_0} &= m_a v_{a_1} + m_t v_{t_1} \\
 0 + 0 &= m_a v_{a_1} + m_t v_{t_1} \\
 v_{a_1} &= -\frac{m_t v_{t_1}}{m_a} \\
 v_{a_1} &= -\frac{(2.50 \text{ kg})(3.10 \text{ m s}^{-1})}{65.5 \text{ kg}} \\
 v_{a_1} &= -0.118 \text{ m s}^{-1}
 \end{aligned}$$

The astronaut will move at a speed of  $0.118 \text{ m s}^{-1}$  opposite of the tool's direction.

## 1.2 8.21



$$m_A = 0.360 \text{ kg}$$

$$m_B = 0.360 \text{ kg}$$

$$v_{B_0} = 0$$

$$v_{A_1} = -0.118 \text{ m s}^{-1}$$

$$v_{B_1} = 0.660 \text{ m s}^{-1}$$

$$v_{A_0} = ?$$

- (a) What was the speed of puck  $A$  before the collision?

$$P_0 = P_1$$

$$m_A v_{A_0} + m_B v_{B_0} = m_A v_{A_1} + m_B v_{B_1}$$

$$m_A v_{A_0} + 0 = m_A v_{A_1} + m_B v_{B_1}$$

$$v_{A_0} = \frac{m_A v_{A_1} + m_B v_{B_1}}{m_A}$$

$$v_{A_0} = \frac{(0.360 \text{ kg})(-0.118 \text{ m s}^{-1}) + (0.360 \text{ kg})(0.660 \text{ m s}^{-1})}{0.360 \text{ kg}}$$

$$v_{A_0} = 0.542 \text{ m s}^{-1}$$

- (b) Calculate the change in the total kinetic energy of the system that occurs during the collision.

**1.3 8.30**

**1.4 8.34**

**1.5 8.41**

**1.6 8.44**

**1.7 8.48**

**1.8 8.62**

**1.9 8.87**

## **2 Lab Manual**

**2.1 972**

**2.2 975**

**2.3 986**

## **3 Problem B**

Consider a Tsiolkovsky Rocket in a gravitational field,  $g$ . At time  $t = 0$ , the velocity of the rocket is  $v = v_0$ , and the mass is  $m = m_0$ . Let the mass loss rate of the rocket be constant in time:  $\dot{m} = -km_0$  [recall that a variable with a dot on top is the time derivative:  $\dot{m} = \frac{dm}{dt}$ ,  $\dot{v} = \frac{dv}{dt}$ , etc.]

1. Show that the acceleration of the rocket is

$$a = \dot{v} = -\frac{u_{rel}}{m}\dot{m} - g$$

2. Show that the mass as a function of time is

$$m = m_0(1 - kt)$$

3. Show that acceleration can also be written as

$$a = \dot{v} = \frac{ku_{rel}}{1 - kt} - g$$

4. Show that the  $\Delta V$  for a constant mass loss rate rocket is given by:

$$\Delta V = u_{rel} \ln \left[ \frac{1}{1 - kt} \right] - gt$$