Homework 8 - Momentum

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Contents

1 Book

1.1 8.16

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

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

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

1.2 8.21

$-\hat{x} \longleftarrow\!\bullet\!\longrightarrow +\hat{x}$

$$
\begin{aligned}
m_A &= 0.360\,\mathrm{kg} \\
m_B &= 0.360\,\mathrm{kg} \\
v_{B_0} &= 0 \\
v_{A_1} &= -0.118\,\mathrm{m\,s^{-1}} \\
v_{B_1} &= 0.660\,\mathrm{m\,s^{-1}} \\
v_{A_0} &= ?
\end{aligned}
$$

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

$$
\begin{aligned}
P_0 &= P_1 \\
m_A v_{A_0} + m_B v_{B_0} &= m_A v_{A_1} + m_B v_{B_1} \\
m_A v_{A_0} + 0 &= m_A v_{A_1} + m_B v_{B_1} \\
v_{A_0} &= \frac{m_A v_{A_1} + m_B v_{B_1}}{m_A} \\
v_{A_0} &= \frac{(0.360\,\mathrm{kg})(-0.118\,\mathrm{m\,s^{-1}}) + (0.360\,\mathrm{kg})(0.660\,\mathrm{m\,s^{-1}})}{0.360\,\mathrm{kg}} \\
v_{A_0} &= 0.542\,\mathrm{m\,s^{-1}}
\end{aligned}
$$

(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 ΔV for a constant mass loss rate rocket is given by:

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