1 Momentum

1.1 Formulas

Momentum: $\vec{p} = m\vec{v}$

Momentum is conserved for any system for which total external force vanishes.

$$\Delta p = I = F\Delta t$$

$m_1 v_{1\text{before}} + m_2 v_{2\text{before}} = m_1 v_{1\text{after}} + m_2 v_{2\text{after}}$

Elastic: $v_{1\text{before}} - v_{2\text{before}} = v_{2\text{after}} - v_{1\text{after}}$

Inelastic: $v_{2\text{after}} = v_{1\text{after}}$

Rocket Thrust: $(\Delta m/\Delta t) v_{\text{ejected gas}}$

Rocket Speed: $v = v_{\text{ejected gas}} \ln(m_0/m_f)$

1.2 Two Blocks and a Spring Problem

A massless spring with force constant 433 N/m is fastened at its left end to a vertical wall. The acceleration of gravity is 9.8 m/s^2.

Initially there is a 6 kg and a 5 kg block at rest on a horizontal surface with the 6 kg block in contact with the spring (but not compressing it) and with the 5 kg block in contact with the 6 kg block. The 6 kg block is then moved to the left, compressing the spring a distance of 0.6 m, and held in place while the 5 kg block remains at rest.

(a) Determine the elastic energy U stored in the compressed spring. Answer in units of J.

(b) The 6 kg block is then released and accelerates to the right, toward the 5 kg block. The surface is rough and the coefficient of friction between each block and the surface is 0.3. The two blocks collide, stick together and move to the right. Remember that the spring is not attached to the 6 kg block. Find the speed of the 6 kg block before it collides with the 5 kg block. Answer in units of m/s.

(c) Find the final speed of both blocks (stuck together) just after they collide. Answer in units of m/s.

(d) Find the horizontal distance the blocks move before coming to rest. Answer in units of m.

1.3 Neutron Collision Problem

A neutron in a reactor makes an elastic head-on collision with the nucleus of an atom initially at rest.

Assume the mass of the atomic nucleus is about 13.8 the mass of the neutron.

(a) What fraction of the neutron's kinetic energy is transferred to the atomic nucleus?

(b) If the initial kinetic energy of the neutron is 3.38×10^{-13} J, find its final kinetic energy. Answer in units of J.

1.4 Aircraft Thrust Problem

A jet aircraft is traveling at 208 m/s in horizontal flight. The engine takes in air at a rate of 100 kg/s and burns fuel at a rate of 2.7 kg/s. The exhaust gases are ejected at 472 m/s relative to the aircraft.

(a) Find the thrust of the jet engine. Answer in units of N.

(b) Find the delivered power. Answer in units of W.