

GENSET EDUCATION ACADEMY

*** PHYSICS 1015 SOLUTIONS
* TUTORIAL SHEET EIGHT
* COMPILED BY TUTOR JOHN**

On a frictionless surface, a 6.0-kg rock approaches from the left at 3.5 m/s. It collides elastically with a 9.0-kg rock which is approaching from the right at 1.7 m/s.

(a) Without changing coordinate systems, find the final velocities of the rocks.

(b) Use a coordinate system in which the 9.0-kg rock is not moving to find the final velocities of the rocks.

(c) Use a coordinate system in which the 3.5-kg rock is not moving to find the final velocities of the rocks.

(a) We are dealing with a collision, so we know we must conserve momentum,

$$m_1 v_{1f} + m_2 v_{2f} = m_1 v_{1i} + m_2 v_{2i} . \quad (1)$$

We are told that the collision is elastic which means that kinetic energy is conserved. For a 1D collision, this is the same as

$$v_{2f} - v_{1f} = -(v_{2i} - v_{1i}) . \quad (2)$$

Substituting in the give data, our equations become

$$6v_{1f} + 9v_{2f} = 6 \times 3.5 + 9 \times (-1.7) = 5.7 ,$$

$$v_{2f} - v_{1f} = -(-1.7 - 3.5) = 5.2 .$$

Solving the two equations in two unknowns, we find $v_{1f} = -2.74$ m/s and $v_{2f} = 2.46$ m/s.

(b) To switch to a coordinate system in which the second stone is not moving, we subtract v_{2i} to each,

$$u_{1i} = v_{1i} - v_{2i} = 3.5 \text{ m/s} - (-1.7 \text{ m/s}) = 5.2 \text{ m/s} ,$$

$$u_{2i} = v_{2i} - v_{2i} = 0 .$$

In all frames of reference, this is still an elastic collision, so the following is true,

$$m_1 u_{1f} + m_2 u_{2f} = m_1 u_{1i} + m_2 u_{2i} , \quad (3)$$

$$u_{2f} - u_{1f} = -(u_{2i} - u_{1i}) . \quad (4)$$

These equations become

$$6u_{1f} + 9u_{2f} = 6 \times 5.2 + 9 \times 0 = 31.2 ,$$

$$u_{2f} - u_{1f} = -(0 - 5.2) = 5.2 .$$

Solving, we find $u_{1f} = -1.04 \text{ m/s}$ and $u_{2f} = 4.16 \text{ m/s}$.

However, we want the results in our frame of reference. To undo our change we add v_{2i} to each

$$v_{1f} = u_{1f} + v_{2i} = -1.04 \text{ m/s} + (-1.7 \text{ m/s}) = -2.74 \text{ m/s} ,$$

$$v_{2f} = u_{2f} + v_{2i} = 4.16 \text{ m/s} + (-1.7 \text{ m/s}) = 2.46 \text{ m/s} .$$

Notice that we get exactly the same result.

(c) We first must determine the velocity of the centre of mass

$$V_{CM} = (\Sigma m_i v_i) / M_{total} = [6 \times 3.5 \text{ m/s} + 9 \times (-1.7 \text{ m/s})] / 15 \text{ kg} = 0.38 \text{ m/s} .$$

As in part (b), we find the velocity of each stone in the CM frame of reference by subtracting V_{CM} from each

$$u_{1i} = v_{1i} - V_{CM} = 3.5 \text{ m/s} - 0.38 \text{ m/s} = 3.12 \text{ m/s} ,$$

$$u_{2i} = v_{2i} - V_{CM} = -1.7 \text{ m/s} - 0.38 \text{ m/s} = -2.08 \text{ m/s} .$$

In a zero momentum frame of reference, an elastic collision only changes the direction of the velocities of each rock, $u_{1f} = -3.12 \text{ m/s}$ and $u_{2f} = +2.08 \text{ m/s}$.

However, we want the results in our frame of reference. To undo our change we add V_{CM} to each

$$v_{1f} = u_{1f} + V_{CM} = -3.12 \text{ m/s} + 0.38 \text{ m/s} = -2.74 \text{ m/s} ,$$

$$v_{2f} = u_{2f} + V_{CM} = +2.08 \text{ m/s} + 0.38 \text{ m/s} = 2.46 \text{ m/s} .$$

Again, we get exactly the same result but with a little less calculation.

9. If the collision in question #2 had been perfectly inelastic, what would have been the final velocity of the rocks? How

much kinetic energy would have been lost in the collision?

In any kind of collision, momentum is conserved so

$$m_1 v_{1f} + m_2 v_{2f} = m_1 v_{1i} + m_2 v_{2i} .$$

We are told that the collision is perfectly elastic which means that kinetic energy is not conserved and that the rocks stick together, $v_{1f} = v_{2f} = v_f$. Our equation becomes

$$(m_1 + m_2)v_f = m_1 v_{1i} + m_2 v_{2i} .$$

This allows us to find v_f immediately

$$v_f = [m_1 v_{1i} + m_2 v_{2i}] / (m_1 + m_2) = [6 \text{ kg} \times 3.5 \text{ m/s} + 9 \text{ kg} \times (-1.7 \text{ m/s})] / 15 \text{ kg} = 0.38 \text{ m/s} .$$

Notice that this is the same as the velocity of the Centre of Mass.

The initial kinetic energy is

$$K_i = \frac{1}{2} m_1 (v_{1i})^2 + \frac{1}{2} m_2 (v_{2i})^2 = \frac{1}{2} (6)(3.5)^2 + \frac{1}{2} (9)(-1.7)^2 = 49.755 \text{ J} .$$

The final energy is

$$K_f = \frac{1}{2} (m_1 + m_2) (v_f)^2 = \frac{1}{2} (6+9)(0.38)^2 = 1.083 \text{ J} .$$

The difference in energy is

$$\Delta K = K_f - K_i = -48.7 \text{ J} .$$

**REGISTER FOR
BOOT CAMPS AT
GENSET ACADEMY
@K65 PER MONTH**

CALL/WHATSAPP 0974780588 TO REGISTER

TUTOR JOHN (BAEZ) SOLUTIONS.

**CALL/WHATSAPP 0971052996/0765708988
FOR FULL SOLUTIONS.**

SERVICING WITH CONSISTENCY