Phys 111: Lecture 14

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"The 14th Day: To Mount Lanayru"

Homework Wk #7 Due Today

Exam #2 Tuesday 10/29/19

Today's Topics

1. 1D/2D Collisions
2. 1D/2D Explosions
3. Examples

Useful Laws of Science for Today

Conservation of Momentum

$$\vec{\mathbf{p}} = m\vec{\mathbf{v}}$$

$$\vec{\mathbf{p}}_o + \vec{\mathbf{J}} = \vec{\mathbf{p}}_f$$

$$\vec{\mathbf{J}} = \vec{\mathbf{F}}_{ave}\Delta t = \Delta\vec{\mathbf{p}}$$

Conservation of Energy

$$W = (Fcos\theta)s$$

$$E_o + W_{nc} = E_f$$

$$W_{net} = \Delta KE$$

Collisions & Explosions

Collisions are often classified according to whether the total kinetic energy changes during the collision:

1. **Elastic collision:** One in which the total kinetic energy of the system after the collision is equal to the total kinetic energy before the collision.
2. **Inelastic collision:** One in which the total kinetic energy of the system is not the same before and after the collision; if the objects stick together after colliding, the collision is said to be completely inelastic.

Reasoning Strategy

For 1D Collisions

1. Verify if the collision is elastic or inelastic.
2. Verify if the objects colliding form an isolated system.
3. Apply Energy & Momentum Problem Solving Steps appropriately.

For 2D Collisions

1. Verify if the collision is elastic or inelastic.
2. Verify if the objects colliding form an isolated system.
3. Apply Energy & Momentum Problem Solving Steps *for each direction*.

Exercise #1

C&J 7.3 The lead female character in the movie *Diamonds Are Forever* is standing at the edge of an offshore oil rig. As she fires a gun, she is driven back over the edge and into the sea. Suppose the mass of a bullet is $1.0 \times 10^{-2}\ kg$ and its velocity is $+720\ m/s$. Her mass (including the gun) is $51\ kg$.

a. What recoil velocity does she acquire in response to a single shot from a stationary position, assuming that no external force keeps her in place?

b. Under the same assumption, what would be her recoil velocity if, instead, she shoots a blank cartridge that ejects a mass of $5.0 \times 10^{-4}\ kg$ at a velocity of $+720\ m/s$?

Exercise #1 Answers

C&J 7.8 Find v_2 given $\vec{\mathbf{p}}_o = 0$, $v_1 = 720\ m/s$, $m_t = 51.0\ kg$ plus quantities for each case where $m_t = m_1 + m_2$.

$$\vec{\mathbf{p}}_o = \vec{\mathbf{p}}_f = 0$$

$$m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2 = 0$$

$$\vec{\mathbf{v}}_2 = -\frac{m_1}{m_2}\ \vec{\mathbf{v}}_1$$

a. $m_1 = 1.0 \times 10^{-2}\ kg$, $m_2 = 50.99\ kg$:

$$v_2 = 141\ mm/s$$

b. $m_1 = 5.0 \times 10^{-4}\ kg$, $m_2 = 50.9995\ kg$:

$$v_2 = 7\ mm/s$$

Problem Solving with Energy & Momentum

1. Determine the *system of interest* and *identify knowns, unknowns, and goals*. A sketch will help.
2. Verify if the system is isolated and set up momentum equations.
3. Verify if the system of interest has any non-conservative forces acting on it and set up energy equations.
4. Before solving, eliminate terms wherever possible to simplify the algebra. Ex. Set initial or final height to be zero.
5. Solve momentum and energy equations algebraicly so you have unknowns solved for in terms of knowns.
6. Plug in specific quantities to finish calculations.
7. *Check the answer to see if it is reasonable.* Check for $\pm$ signs and if speeds or heights are too large or too small.

Exercise #2

C&J 7.17 A $2.3\ kg$ cart is rolling across a friction-less, horizontal track toward a $1.5\ kg$ cart that is held initially at rest. The carts are loaded with strong magnets that cause them to attract one another. Thus, the speed of each cart increases. At a certain instant before the carts collide, the first cart's velocity is $+4.5\ m/s$, and the second cart's velocity is $-1.9\ m/s$.

a. What is the total momentum of the system of the two carts at this instant?

b. What was the velocity of the first cart when the second cart was still at rest?

Exercise #2 Answer

C&J 7.17 $m_1 = 2.3\ kg$, $m_2 = 1.5\ kg$, $v_{2o} = 0\ m/s$, $v_{1f} = 4.5\ m/s$, $v_{2f} = -1.9\ m/s$.

$$\vec{\mathbf{p}}_o = \vec{\mathbf{p}}_f$$

$$\vec{\mathbf{p}} = m_1\vec{\mathbf{v}}_1 + m_2\vec{\mathbf{v}}_2$$

a. $\vec{\mathbf{p}}_f = +7.5\ kg \cdot m/s$
b. $\vec{\mathbf{v}}_{1o} = +3.26\ m/s$

Exercise #3

C&J 7.21 A two-stage rocket moves in space at a constant velocity of $4900\ m/s$. The two stages are then separated by a small explosive charge placed between them. Immediately after the explosion the velocity of the $1200\ kg$ upper stage is $5700\ m/s$ in the same direction as before the explosion. What is the velocity (magnitude and direction) of the $2400\ kg$ lower stage after the explosion?

Exercise #3 Answers

C&J 7.21 Find $\vec{\mathbf{v}}_{lf}$ if $m_u = 1200\ kg$, $m_l = 2400\ kg$, $\vec{\mathbf{v}}_o = +4900\ m/s$, $\vec{\mathbf{v}}_{uf} = +5700\ m/s$.

$$\vec{\mathbf{p}}_o = \vec{\mathbf{p}}_f$$

$$(m_u + m_l)\vec{\mathbf{v}}_o = m_u\vec{\mathbf{v}}_{uf} + m_l\vec{\mathbf{v}}_{lf}$$

$$m_l\vec{\mathbf{v}}_{lf} = (m_u + m_l)\vec{\mathbf{v}}_o - m_u\vec{\mathbf{v}}_{uf}$$

$$\vec{\mathbf{v}}_{lf} = \frac{(m_u + m_l)\vec{\mathbf{v}}_o - m_u\vec{\mathbf{v}}_{uf}}{m_l}$$

$$\vec{\mathbf{v}}_{lf} = +4500\ m/s$$

Exercise #4

C&J 7.25 By accident, a large plate is dropped and breaks into three pieces. The pieces fly apart parallel to the floor. As the plate falls, its momentum has only a vertical component and no component parallel to the floor. After the collision, the component of the total momentum parallel to the floor must remain zero, since the net external force acting on the plate has no component parallel to the floor. Using the data shown in the drawing, find the masses of pieces 1 and 2.

Exercise #4 Image

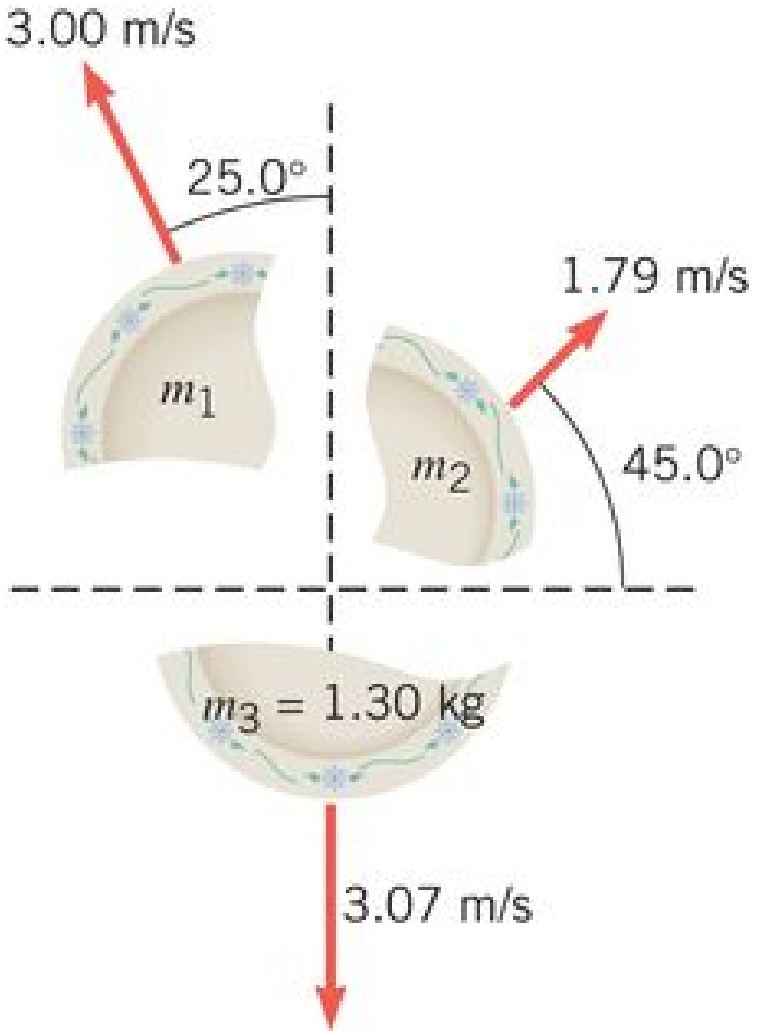

Figure: 14. Rank the masses without calculation

Exercise #4 Answers

C&J 6.4.35 $m_3 = 1.30\ kg$, $\vec{\mathbf{v}}_3 = -3.07\ m/s\ \hat{\mathbf{y}}$, $\vec{\mathbf{v}}_2 = 1.79\ m/s\ 45^\circ$ *CCW from* $+x$, $\vec{\mathbf{v}}_1 = 3.00\ m/s\ 25^\circ$ *CCW from* $+y$. Find m_1 and m_2.

$$\vec{\mathbf{p}}_o = \vec{\mathbf{p}}_f = 0$$

$$p_{1x} = p_{2x}$$

$$p_{1y} + p_{2y} = p_{3y}$$

$$m_2 = \frac{v_{1x}}{v_{2x}}\ m_1$$

$$m_1 v_{1y} + m_2 v_{2y} = m_3 v_3$$

Answer: $m_1 = 1.00\ kg$, $m_2 = 1.00\ kg$

The End

Thanks for your time and attention!

Any questions?