Physics 122

Formative Assessment – U1 S3&4 – Relative Velocity and Collisions/Explosions

Name - Key Date - Oct 31/18

Solve these problems on loose leaf.

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1. Formative Assessment – Relative Velocity (RV3.1)

Bathurst High School enters a float in the annual Santa Claus parade. The float travels at a velocity of 2.8 m/s north. Bubba, sitting at the front of the float, tosses a piece of candy to Figgy, sitting at the back of the float. The candy moves with a speed of 5.3 m/s relative to the float. What is the velocity of the candy relative to the street? *Use appropriate notation.* (3)

2. Formative Assessment – Relative Velocity (RV3.2)

A small aircraft heads north from Huntington to Clarenville, a distance of approximately 45 km, with an air speed of 180 km/h. The pilot does not adjust for a westerly wind (west to east) which is blowing at 60 km/h.

a) Draw a labeled sketch for this scenario. (3)
b) Determine the resultant speed of the plane. (2)
c) By how much (in degrees) will the plane be blown off course? (2)
d) How far from Clarenville will the pilot be if he lands directly east of the community? (2)
e) How long did the trip take? (2)

3. Formative Assessment – Relative Velocity (RV3.3)

A car and a truck approach an intersection. The car is traveling north at 4.16 m/s, while the truck is traveling west at 3.38 m/s. What is the velocity of the truck relative to the car? Include a labeled sketch showing the velocity of the truck relative to the car and its components. (6)

4. **Formative Assessment – 1D Collision and Type (CE4.1/CE4.3)**

A 23 g bullet traveling at 230 m/s [W] penetrates a 2.0 kg block of wood and emerges cleanly with a speed of 170 m/s.

a) If the block of wood is stationary on a frictionless surface when hit, what is its velocity after the bullet emerges? Assume the change in mass of the block of wood due to the bullet passing through it is negligible. (6)

b) What type of collision occurred? Justify your answer mathematically. (4)

5. **Formative Assessment – 2D Collision (CE4.4)**

A 0.156 kg puck travelling south at 5.0 m/s collides obliquely (not head-on) with a 0.170 kg puck initially at rest. After the collision, the 0.156 kg puck travels at 2.5 m/s at an angle of 34° south of west. What is the velocity of the 0.170 kg puck after the collision? (12)

6. **Formative Assessment – 2D Explosion (CE4.5)**

A child drops a shape made from three mega blocks. Each of the mega blocks has a mass of 22.0 g. The three pieces break apart when the shape hits the floor with the first piece having a velocity of 0.450 m/s, 62.0° N of E. The second piece has a velocity of 0.335 m/s, 2.0° S of W. What is the velocity of the third piece? (12)

Learning Target	Learning Category
RV3.1	
RV3.2	
RV3.3	
CE4.1	
CE4.3	
CE4.4	
CE4.5	

1. FA - Relative Velocity (RV3.1)

$\vec{V}_{fs} = 2.8\,m/s, N$
$\vec{V}_{cf} = 5.3\,m/s, S$
$\vec{V}_{cs} = ?$

$\vec{V}_{cs} = \vec{V}_{cf} + \vec{V}_{fs}$ ①
$\vec{V}_{cs} = (-5.3) + (2.8)$ ①
$\vec{V}_{cs} = -2.5\,m/s$ ①

The velocity of the candy relative to the street is $2.5\,m/s, S$.

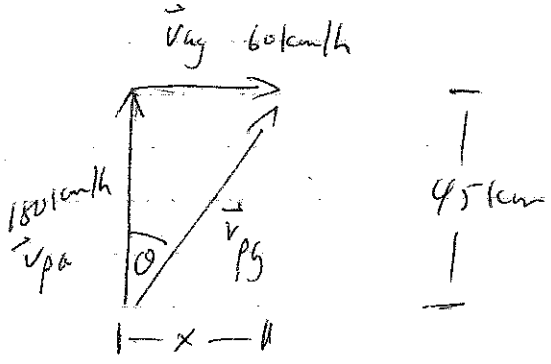
2. FA - Relative Velocity (RV3.2)

$\vec{V}_{pa} = 180\,km/h, north$

$\vec{V}_{ag} = 60\,km/h, east$

$\vec{V}_{pa}$ ⇒ airspeed
$\vec{V}_{ag}$ ⇒ wind
$\vec{V}_{pg}$ ⇒ plane rel to ground.

a)



③

b) $V_{pg} = \sqrt{180^2 + 60^2}$
$V_{pg} = 1.9 \times 10^2\,km/h$

The resultant speed is $1.9 \times 10^2\,km/h$. ②

c) $\tan\theta = \frac{60}{180}$
$\theta = 18°$

The plane will be blown off course by 18° E of N. ②

2. d) $\tan 18^\circ = \frac{x}{45}$

$x = 15\text{ km}$

He will be 15 km from Clarenville. ②

e) $v_{av} = \frac{d}{t}$

$t = \frac{45}{180}$]

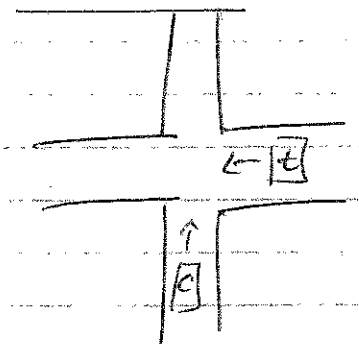
$t = 0.25\text{ h}$

or $v_{ag} = \frac{d}{t}$

$t = \frac{15}{60}$]

$t = 0.25\text{ h}$. ②

3. FA – Rel. Vel (RV 3.3)

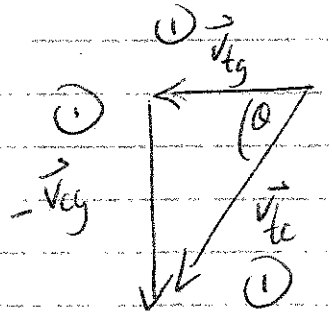


$\vec{v}_{cg} = 4.16\text{ m/s, N}$

$\vec{v}_{tg} = 3.38\text{ m/s, W}$

$\vec{v}_{tc} = \vec{v}_{tg} + \vec{v}_{gc}$

$\vec{v}_{tc} = \vec{v}_{tg} - \vec{v}_{cg}$ ①



$v_{tc} = \sqrt{(4.16)^2 + (3.38)^2}$

$v_{tc} = 5.36\text{ m/s}$ ①

$\tan\theta = \frac{4.16}{3.38}$

$\theta = 50.9^\circ$ ①

The velocity of the truck relative to the car is 5.36 m/s, 50.9° SoW.

4. FA - 1) Collision and Type (CEY.1 / CEY.3)

$m_b = 23g = 0.023kg$ ①

$\vec{v}_b = -230 m/s$]①

$\vec{v}_b' = -170 m/s$

$m_w = 2.0kg$

$\vec{v}_w = 0$ ①

$\vec{v}_w' = ?$

a) $m_b \vec{v}_b + m_w \vec{v}_w = m_b \vec{v}_b' + m_w \vec{v}_w'$

$\vec{v}_w' = \dfrac{m_b \vec{v}_b - m_b \vec{v}_b'}{m_w}$ ①

$\vec{v}_w' = \dfrac{(0.023)(-230) - (0.023)(-170)}{2.0}$

$\vec{v}_w' = -0.69 m/s$ ①

The velocity of the block of wood is $0.69 m/s$, west. ①

b) $\Delta E_K = E_K' - E_K$

$\Delta E_K = E_{Kb}' + E_{Kw}' \ominus (E_{Kb} + E_{Kw})$

$\Delta E_K = \frac{1}{2} m_b (v_b')^2 + \frac{1}{2} m_w (v_w')^2 - \frac{1}{2} m_b v_b^2 - \cancel{\frac{1}{2} m_w v_w^2}$ ①

$\Delta E_K = \left(\frac{1}{2}(0.023)(170)^2 + \frac{1}{2}(2.0)(0.69)^2\right) - \left(\frac{1}{2}(0.023)(230)^2\right)$

$\Delta E_K = -2.8 \times 10^2 J$ ①

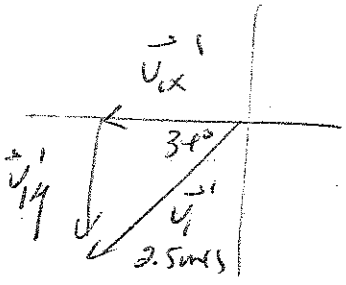
Kinetic energy was lost. The collision is inelastic ①

5. FA – 2D Collision (CE 4.4)

$m_1 = 0.156\ kg$
$\vec{v}_1 = 5.0\ m/s,\ S$
$\vec{v}_{1x} = 0$
$\vec{v}_{1y} = -5.0\ m/s$] (2)

$m_2 = 0.170\ kg$
$\vec{v}_{2x} = 0\ m/s$
$\vec{v}_{2y} = 0\ m/s$] (2)

$\vec{v}_1' = 2.5\ m/s,\ 34°\ S\ of\ W$



$\vec{v}_{1x}' = -2.5\cos 34°$
$\vec{v}_{1y}' = -2.5\sin 34°$] (2)

x/ $m_1\vec{v}_{1x} + m_2\vec{v}_{2x} = m_1\vec{v}_{1x}' + m_2\vec{v}_{2x}'$

$\vec{v}_{2x}' = -\dfrac{m_1\vec{v}_{1x}'}{m_2}$ (1)

$\vec{v}_{2x}' = \dfrac{-(0.156)(-2.5\cos 34°)}{0.170}$

$\vec{v}_{2x}' = 1.9\ m/s$ (1)

y/ $m_1\vec{v}_{1y} + m_2\vec{v}_{2y} = m_1\vec{v}_{1y}' + m_2\vec{v}_{2y}'$

$\vec{v}_{2y}' = \dfrac{m_1\vec{v}_{1y} - m_1\vec{v}_{1y}'}{m_2}$ (1)

$\vec{v}_{2y}' = \dfrac{(0.156)(-5.0) - (0.156)(-2.5\sin 34°)}{0.170}$

$\vec{v}_{2y}' = -3.31\ m/s$ (1)

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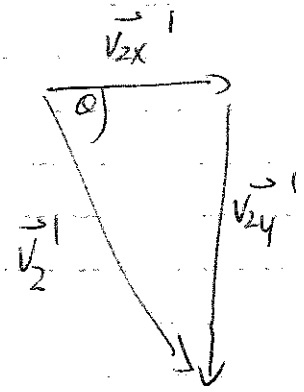


$$v_2' = \sqrt{(1.90)^2 + (3.31)^2}$$

$$v_2' = 3.8\ m/s \quad (1)$$

$$\tan\theta = \frac{3.31}{1.90}$$

$$\theta = 60^\circ \quad (1)$$

The velocity of the second puck after the collision is 3.8 m/s, 60° SofE

6. FA – 2D Explosion (CE 4.5)

$m_M = 66.0\ g$

$\vec{v}_M = 0\ m/s$

$\vec{v}_{Mx} = 0\ m/s$

$\vec{v}_{My} = 0\ m/s$] (2)

$m_1 = m_2 = m_3 = m$

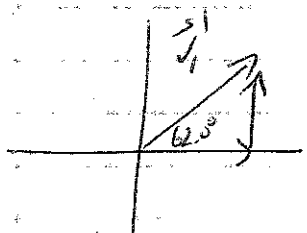
x/ $m_M \vec{v}_{Mx} = m_1 \vec{v}_{1x} + m_2 \vec{v}_{2x}' + m_3 (\vec{v}_{3x}')$

$\vec{v}_{3x}' = -\vec{v}_{1x}' - \vec{v}_{2x}'$ (1)

$\vec{v}_{3x}' = -0.450\cos 62.0^\circ - (-0.335\cos 2.0^\circ)$

$\vec{v}_{3x}' = 0.124\ m/s$ (1)

$m_1 = 22.0\ g$



$\vec{v}_{1x}' = 0.450\cos 62.0^\circ$

$\vec{v}_{1y}' = 0.450\sin 62.0^\circ$] (2)

y/ $m_M \vec{v}_{My} = m_1 \vec{v}_{1y} + m_2 \vec{v}_{2y} + m_3 (\vec{v}_{3y})$

$\vec{v}_{3y}' = -\vec{v}_{1y}' - \vec{v}_{2y}'$ (1)

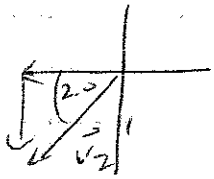
$\vec{v}_{3y}' = -0.450\sin 62.0^\circ - (-0.335\sin 2.0^\circ)$

$\vec{v}_{3y}' = -0.386\ m/s$ (1)

$\vec{v}_3' = 0.41\ m/s,\ 72^\circ$ SofE.

(1) (1)

$m_2 = 22.0\ g$



$\vec{v}_{2x}' = -0.335\cos 2.0^\circ$

$\vec{v}_{2y}' = -0.335\sin 2.0^\circ$] (2)