proprep™

Physics 1

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Relative Motion

Galilean Transforms

Questions:

1) Car Relative to Bus.

A car is traveling at a velocity of $30\,\mathrm{m/s}$ at a $\mathrm{S}\,30°$ relative to the x-axis.

A bus is traveling at a velocity of $50\,\mathrm{m/s}$ along the x-axis.

a. Find the velocity of the car relative to the bus.
b. Find the direction that the car is traveling relative to the bus.

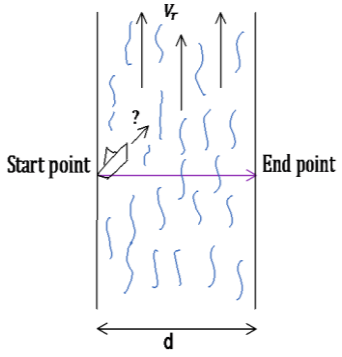
2) Angle of Rain Hitting the Windowpane.

A driver is driving at a velocity of $100\mathrm{km/h}$ and sees rain drops running down the windowpane in the opposite direction to the car's motion and at an angle of $45°$.
Another driver is driving at $70\ \mathrm{km/h}$ and sees the rain drops running down his windowpane at an angle of $30°$.
What is the velocity of the rain drops relative to the ground?

3) Boat in the River.

A river is flowing northward with a velocity of v_r.

Patricia, that is located on the western bank of the river, wants to reach the exect same point that she is at right now, but at the eastern side of the river. The velocity of her boat is v_{br}, relative to the river. The river's width is d.



a. In which direction Patricia will need to sail her boat?
b. What is the elocity of the boat, relative to the ground?
c. How long will it take for Patricia to cross the river?

4) Angle between bullets

Two bullets are shot at $t=0$. Their initial positions and velocities are given by:

$\vec{r}_1(0)=0,\ \ \vec{r}_2(0)=\hat{i},\ \ \ \vec{v}_1(0)=2\hat{i}+5\hat{j},\ \ \ v_2(0)=-\hat{i}+4\hat{j}$.

Both bulltes experience a pulling force which causes them to accelerate at $\vec{a}=3\hat{i}+\hat{j}$.

Units are in MKS.

a. Find $\vec{r}_1(t),\ \ \vec{r}_2(t)$.
b. What s the distance between the bullets as a function of time?
c. Find the angle between $\vec{v}_1$ and $\vec{v}_2$, at the time $t=3$.

Answer Key:

1) a. $v'_{2x} = -24.01\text{m/s}, \quad v'_{2y} = 15\text{m/s}$ b. $\theta = 148°$

2) $|v| = \sqrt{v_x^2 + v_y^2}, \quad \tan\theta_x = \dfrac{-70.79}{29.21}$

3) a. $\sin\theta' = \dfrac{-v_r}{v'_{br}}$ b. $v_{by} = 0, \quad v_{bx} = \sqrt{v'^2_{br} - v_r^2}$ c. $t = \dfrac{d}{\sqrt{v'^2_{br} - v_r^2}}$

4) a. $\vec{r}_1(t) = \left(-\dfrac{3}{2}t^2 + 2t\right)\hat{i} + \left(\dfrac{t^2}{2} + 5t\right)\hat{j}, \quad \vec{r}_2(t) = \left(-\dfrac{3}{2}t^2 - t + 1\right)\hat{i} + \left(\dfrac{t^2}{2} + 4t\right)\hat{j}$

b. $|\vec{r}_{1,2}| = \sqrt{10t^2 - 6t + 1}$ c. $\alpha = 13.82°$