2A. What is meant in physics by the phrase "frame of reference"? (see page 91 in the textbook) Describe how measurements of time and position in one dimension are compared when made in two "inertial reference frames". Use this comparison to generate the expression given in the textbook for relative velocities (equation 3.33 on page 91).

In classical physics, after clocks are set equal to zero, \( t = t' \) and \( x = x' - ut \).

Then, \[ v_x' = \frac{dx'}{dt'} = \frac{dx - u dt}{dt} = \frac{dx}{dt} - \frac{u}{c} dt = v_x - \frac{u}{c} \]

2B. A plane is flying at a constant altitude (z-coordinate does not change). Assume that at this location the x-axis points east and the y-axis points north. The velocity of the plane wrt the ground is 150. m/s @ 40.0° W of N. The velocity of the air wrt the ground is \{18.0\hat{i} - 24.0\hat{j}\} m/s.

1. Determine the cartesian representation of the velocity of the plane wrt the ground.

\[ \vec{V}_{PG} = \{ -96.4\hat{i} + 114.9\hat{j} \} \frac{m}{s} \]

2. Determine the magnitude and direction of the velocity of the air wrt the ground.

\[ \vec{V}_{AG} = 300 \frac{m}{s} @ 53.1° S \text{ of } E \]

3. Determine the magnitude and direction of the velocity of the plane wrt the air. Draw a vector diagram showing the three above described velocities.

\[ \vec{V}_{PA} = \vec{V}_{PG} + \vec{V}_{GA} \text{ where } \vec{V}_{GA} = -\vec{V}_{AG} \]

\[ \vec{V}_{PA} = \{-114.9\hat{i} + 138.9\hat{j}\} \frac{m}{s} \]

4. The direction of the velocity of the plane wrt the air now changes (its magnitude remains the same). What would the new direction of the velocity of the plane wrt the air have to be if the direction of the velocity of the plane wrt the ground changes to 20.0° E of N. (assume that the velocity of the air wrt the ground does not change)

\[ V_{PA} = 180.0 \frac{m}{s} \]

\[ \text{Law of Sines: } \frac{\sin \theta}{V_{PA}} = \frac{\sin \beta}{V_{PG}} \]

\[ \beta = 8.03° \]

\[ \theta = 20° - \beta \]

\[ \theta = 12.0° \text{ E of N} \]
\( V(t) \) \( \uparrow \) \( r \) \( \downarrow \) 
\( V_0 \) \( \Delta x_v = 3.4 \text{ m/s} \) 
\( v_x = \Delta x_v \) 
\( t_0 = 2 \)  
\( t_1 = 2 \)  
\( t_2 = 3.17 \) 
\( t_3 = \sqrt{\frac{2 \Delta x_v}{v_x}} \) 
\( \Delta x = 12.0 \text{ m} \) 
\( \Delta x_v = 1.12 \text{ m} \) 
\( \Delta x_v = 7.77 \text{ m} \) 

\( V_e \) \( \uparrow \) \( \downarrow \) 
\( \text{End} \) 
\( \vec{V}_e \) 
\( \Delta Y(\theta) = \frac{W \Delta V_e}{V_0} \cdot \sin \theta - W \cdot \frac{1}{2} \) 
\( \Delta Y(\theta) = 45.0 \text{ m} \) 
\( \theta = 53.1^\circ \) 

\( W = 60.0 \text{ m} \) 
\( V_0 = 1.20 \text{ m/s} \) 
\( \vec{V}_e = 1.50 \text{ m/s} \) 

\( \text{x-axis} \) 
\( \text{y-axis} \) 
\( \text{N-S} \) 
\( A \) 
\( B \) 
\( C \) 
\( D \) 
\( E \) 
\( F \) 
\( G \) 
\( H \) 

\( \Delta Y = \frac{W \Delta V_e}{V_0} \cdot \sin \theta - W \cdot \frac{1}{2} \) 
\( t = 83.3 \text{ s} \)