PHY 211 Homework 2

Due January 29, 2020

When solving the following problems, remember to follow the problem-solving steps we have discussed. Describe what you are doing in words and, where appropriate, draw pictures and translate the plain language question into a question about the variables.

Problem 1. Often in mechanics we aren't particularly concerned about time; we're only concerned with the change in position, change in velocity, and acceleration. These are related by the "third kinematics equation",

$$v_f^2 - v_0^2 = 2a(x_f - x_0)$$

Show algebraically that this equation is simply a consequence of the other two.

Problem 2. Dr. John Paul Stapp was a U.S. Air Force officer who studied the effects of extreme acceleration on the human body. On December 10, 1954, Stapp rode a rocket sled, accelerating from rest to a top speed of 282 m/s (1015 km/h) in 5.00 s and was brought jarringly back to rest in only 1.40 s. For *each of the two accelerations* on the trip (speeding up and slowing down) answer the following questions.

(a) What was his acceleration?

(b) How far did he travel during that time?

Assume the accelerations are constant during the periods of acceleration. Use the equations of motion for constant acceleration to solve these problems. Be careful about positive and negative signs for the accelerations. Express each acceleration in multiples of g ($9.80\,\mathrm{m/s^2}$) by taking its ratio to the acceleration of gravity.

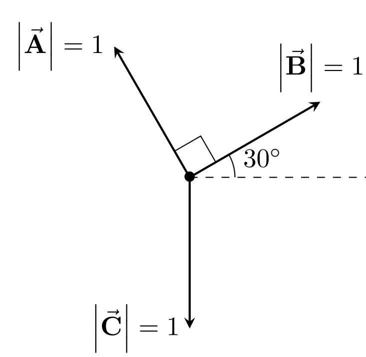
Problem 3. A small plane flies 40.0 km in a direction 60° north of east and then flies 30.0 km in a direction 15° west of north.

(a) Draw a picture of the path of the plane, using vectors to represent each displacement. Draw the coordinate axis and label it. Find the total displacement vector graphically.

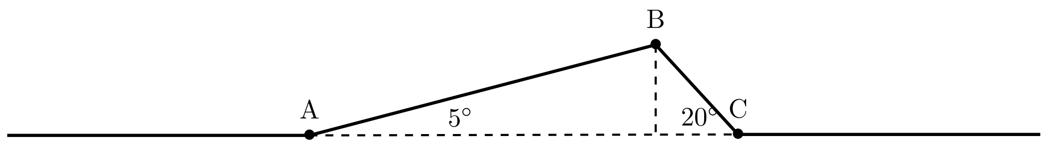
(b) Use the component form to calculate the components of the total displacement vector.

(c) Express the total displacement in terms of its magnitude and direction. Be sure to specify from which axis you measure the angle.

Problem 4. Three vectors are shown in the diagram to the right. Find the magnitude and direction of the sum $\vec{\mathbf{S}} = \vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}}$. Be sure you clearly identify what coordinate system you use and which angle you give for the direction of $\vec{\mathbf{S}}$. *Hint: check the steps in the previous problem if you aren't sure how to proceed.*



Problem 5. A car is traveling down a long, straight road at 30.0 m/s, when the bored driver suddenly nudges the steering wheel a little bit, causing the car to veer off at an angle of 5.00° while still going the same speed ($|\vec{\mathbf{v}}_{AB}| = 30.0\,\mathrm{m/s}$). The car then hits the rumble strip, and the driver quickly corrects back to the lane with an angle of 20.0°, while slowing down to 25.0 m/s ($|\vec{\mathbf{v}}_{BC}| = 25.0\,\mathrm{m/s}$). The path of the car as seen from above is shown below:



(a) Draw two velocity vectors, one representing the velocity while the car is travelling from point A to point B ($\vec{\mathbf{v}}_{AB}$), and one while the car is travelling from point B to point C ($\vec{\mathbf{v}}_{BC}$). Be as careful as you can about the relative lengths of the two vectors. Then, find $\Delta\vec{\mathbf{v}} = \vec{\mathbf{v}}_{BC} - \vec{\mathbf{v}}_{AB}$, the change in velocity from before point B to after point B, graphically.

(b) Define a coordinate system, showing which directions you choose as positive x and positive y. Then determine the components of $\vec{\mathbf{v}}_{AB}$ and $\vec{\mathbf{v}}_{BC}$. First, write out the components in terms of the magnitudes and sin or cos, and then calculate the numerical value.

(c) Calculate the components of $\Delta\vec{\mathbf{v}}$, and then determine its magnitude and direction. When giving the direction, be careful to specify what angle you are calculating, such as by drawing a picture.

Problem 6. A Lockheed Martin F-35 II Lighting jet takes off from an aircraft carrier with a runway length of 90 m and a takeoff speed 70 m/s at the end of the runway. Jets are catapulted into airspace from the deck of an aircraft carrier with two sources of propulsion: the jet propulsion and the catapult.

(a) What is the initial acceleration of the F-35 on the deck of the aircraft carrier to make it airborne? That is, what acceleration is needed to achieve the takeoff speed over the runway length?

(b) Write the position and velocity of the F-35 in unit vector notation from the point it leaves the deck of the aircraft carrier.

Problem 7. After leaving the deck of the aircraft carrier with the velocity you found in problem 6, the F-35's acceleration decreases to a constant acceleration of $5.0\,\mathrm{m/s^2}$ at 30° above the horizontal (this is the total acceleration including gravity and the effect of other forces).

(a) At what altitude is the fighter 5.0 s after it leaves the deck of the aircraft carrier?

(b) What is the magnitude and direction of its velocity at this time?

(c) How far has it traveled horizontally during this time?