Homework Assignment 1

Due: Monday, May 23, 2016

Problem 1: James and Mary wish to purchase a pizza for movie night. They find two coupons to use: one coupon lists a 12 inch diameter pizza for \$9.00 and the other coupon lists a 16 inch diameter pizza for \$12.00; both prices include tax.

(a) Find the area of both pizzas in units of m^2.

(b) If both pizzas have the same thickness, which coupon gives the better deal? To find this, calculate the cost to area ratio in $\$/m^2$ for each coupon and compare them.

(c) Is the answer to (b) still valid if the 12 inch pizza is "deep dish" (1 inch thick) and the 16 inch pizza is "hand tossed" (0.7 inch thick)? HINT: What's the relevant ratio to use for the comparison?

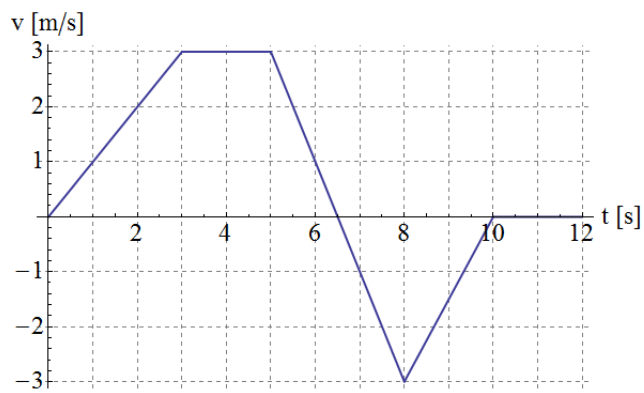
Problem 2: Becky wishes to pick up an order from a neighboring town. She leaves from her house, heading due East along a straight highway for 45 km before stopping for gas, and then continues on for another 70 km to her destination. After picking up her order, she returns home along the same route in a single trip.

(a) What is Becky's displacement from when she leaves the gas station to when she returns home with her order?

(b) What is Becky's displacement for the total trip, from when she leaves home to when she returns? What is the total distance that she travels?

Problem 3: A train is traveling along a straight segment of track when the passenger cars in the back decouple from the locomotive. If the locomotive moves at a constant speed of 20 m/s and the passenger cars travel at a constant speed of 13 m/s in the same direction after separating, how long will it take the separation distance between the passenger cars and the locomotive to reach 350 m?

Problem 4: A metal cart sits on a track and is constrained to move only in the $x-$direction. The first twelve seconds of the cart's motion are described in the figure below:



(a) Describe the motion of the cart for the following time intervals: 0 s $< t \leq$3 s; 3 s $< t \leq$5 s; 5 s $< t \leq$8 s.

(b) What is the displacement of the cart after eight seconds, assuming it starts at $x = 0$ m?

(c) What is the total distance traveled by the cart in the first twelve seconds?

(d) Find the average speed and average velocity of the cart after twelve seconds of motion.

(e) Calculate the average acceleration of the cart after five seconds of motion.

(f) Sketch the position vs. time and acceleration vs. time graphs of the cart for these twelve seconds of motion.

Problem 5: A passenger train makes a turn and enters a long stretch of straight track at $v_p = 60$ m/s. The conductor of the passenger train notices that another locomotive is traveling in the same direction at a constant speed, $v_\ell = 25$ m/s, ahead on the same track. The conductor immediately applies the breaks, accelerating the passenger train at the maximum rate comfortable for the passengers, $a = 4.3$ m/s^2. If the locomotive is 160 m in front of the passenger train when the brakes are applied, will the passenger train collide with the locomotive?

Problem 6: A model rocket is launched from rest vertically from the Earth's surface with a net constant acceleration of $a_r = 6.3$ m/s^2 upward. After 10 s of constant thrust, the engine burns out and the rocket begins to fall back toward the Earth.

(a) What is the rocket's velocity when the engine is exhausted?

(b) What is the maximum height that the rocket reaches above the ground?

(c) How long does the rocket spend in the air?

(d) If a tennis ball is shot upward with an initial velocity $v_b = 85$ m/s from the surface of the Earth directly below the rocket when the rocket engine burns out, at what height above the ground will the ball and rocket collide?

Problem 7: A vector $\vec{A}$ has a magnitude of 33 cm and makes an angle of 125° with the positive x-axis. Plot the vector, assuming it starts at the origin of your coordinates. What are the x- and y-components of $\vec{A}$?

Problem 8: Two vectors, $\vec{A}$ and $\vec{B}$, are defined by their x- and y-components as follows:

$$\vec{A} = 2\hat{x} - 7\hat{y},$$
$$\vec{B} = 6\hat{x} + 3\hat{y}.$$

(a) Find the x- and y-components of $\vec{A} - \vec{B}$.

(b) Find the x- and y-components of $2\vec{A} + 3\vec{B}$

(c) Find the magnitude and direction of $\vec{A} + \vec{B}$.

(d) Find the magnitude and direction of $\vec{B} - \vec{A}$.

Problem 9: Damien needs to drive to a doctor's appointment. To get there, he drives for 15 minutes along a residential road headed 15° East of North, and then turns onto a highway headed 30° North of East. After driving 15 km on the highway, he arrives at his appointment exactly 24 minutes after he departed.

(a) Find Damien's average velocity while driving on the highway (in units of m/s).

(b) The speed limit on the residential road is 30 mph. Find Damien's displacement and the total distance he travels to get to the doctor, assuming that he makes no stops. State your answer in meters.

(c) What are Damien's average speed and average velocity for the entire trip (in units of m/s)?

Problem 10: A particle leaves the origin with an initial velocity $\vec{v}_0 = (3.0\hat{x} + 2.0\hat{y})$ m/s and acceleration $\vec{a} = (5.0\hat{x} + a_y\hat{y})$ m/s^2. What magnitude and direction of acceleration are required for the particle to cross the $+x$-axis when it is 25 m away from the origin?