Physics 151
Homework Assignment #3
Due June 20

#1 Ships A and B leave port together. For the next two hours, ship A travels at $20\,mph$ in a direction $30°$ west of north, while ship B travels $20°$ east of north at $30\,mph$. How far apart are the two ships two hours after they depart? (Assume they both have constant velocities.)

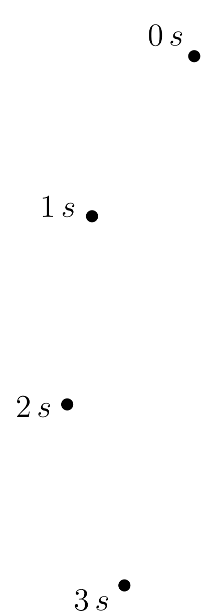
#2 Shown is the motion diagram for a car traveling along a road with constant speed.

(a.) On the picture, draw the car's three average velocity vectors, $\overrightarrow{\mathbf{v}}_{01}$, $\overrightarrow{\mathbf{v}}_{12}$, $\overrightarrow{\mathbf{v}}_{23}$. ($\overrightarrow{\mathbf{v}}_{01}$ is the average velocity between $0\,s$ and $1\,s$, and so on.)

(b.) Beside or below the picture, use your preferred method to draw the two change in velocity vectors, $\overrightarrow{\Delta\mathbf{v_1}} = \overrightarrow{\mathbf{v}}_{12} - \overrightarrow{\mathbf{v}}_{01}$ and $\overrightarrow{\Delta\mathbf{v_2}} = \overrightarrow{\mathbf{v}}_{23} - \overrightarrow{\mathbf{v}}_{12}$.

(c.) At points 1 and 2 on your motion diagram, draw the car's average acceleration vectors, $\overrightarrow{\mathbf{a}}_1$ and $\overrightarrow{\mathbf{a}}_2$.

(d.) If the car is traveling with a constant speed, why aren't the acceleration vectors zero?



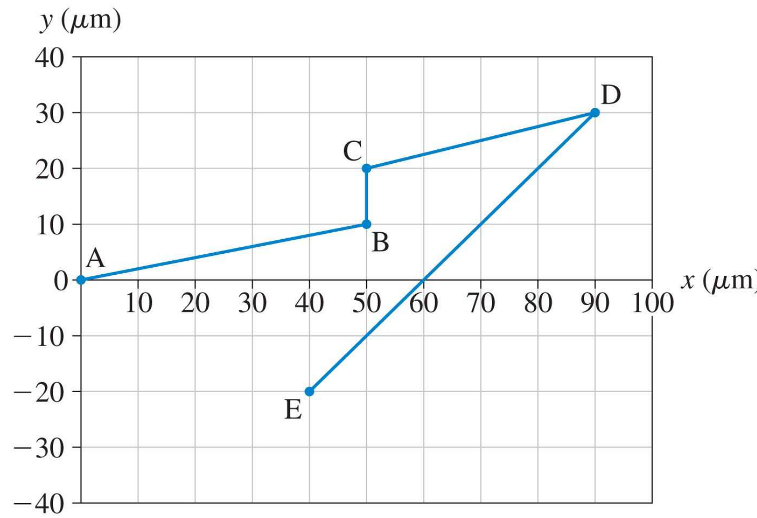
#3 A skydiver deploys his parachute when he is 1000 m directly above his desired landing spot. Due to his parachute, he falls through the air at a steady 6-m/s speed. There is also a steady breeze blowing to the west at 2.5 m/s.

(a.) Using the typical map directions (north being up and east to the right), find the standard angle at which the falls toward the ground.

(b.) At what angle from the vertical does the man fall?

(c.) By what distance does the man miss his desired landing spot?

#4 The figure shows the trajectory followed by an *E.-coli* bacterium as it swims through a medium. Assume as it swims from points A to E that the *E. coli* swims with a constant speed of 25 $\mu m/s$.

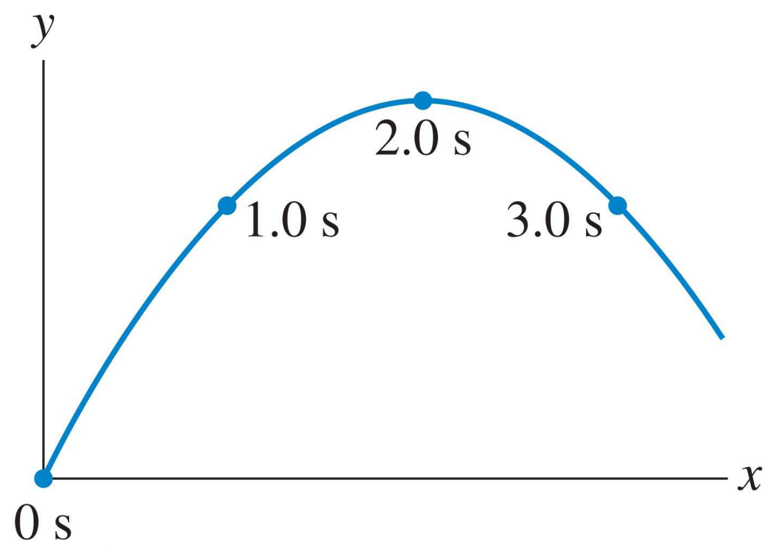


(a.) For each of the four segments in the bacterium's trajectory, calculate the x- and y-components of its displacement and its velocity.

(b.) Calculate both the total distance traveled and the magnitude of the net displacement for the entire motion.

(c.) What are the magnitude and direction of the bacterium's average velocity for the entire trip?

#5 A physics student on Planet Exidor throws a ball, and it follows the parabolic trajectory shown in the figure. The ball's position is indicated at $1.0\,s$ intervals (until $t = 3.0\,s$). At $t = 1.0\,s$, the ball's velocity has components $v_x = 2.8\,m/s$ and $v_y = 3\,m/s$.



(a.) Determine the x- and y-components of the ball's velocity at $t = 0.0\,s$, $2.0\,s$, and $3.0\,s$.

(b.) What is the value of g on Planet Exidor?

(c.) What was the ball's launch angle?

#6 A tennis player hits a ball $1.6\,m$ above the ground. The ball leaves the racket with a speed of $12\,m/s$ at an angle $8.0°$ above the horizontal. The net is a horizontal distance of $7.0\,m$ away from the player and is $1.0\,m$ high.

(a.) Does the ball clear the net? Explain you determined this.

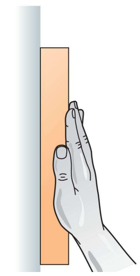
(b.) If the ball clears the net, by what distance does it clear it? If not, by what distance does it miss?

#7 For each of the following situations, identify all the forces acting on the objects and draw its free-body diagram. Each diagram should have the forces drawn to scale.

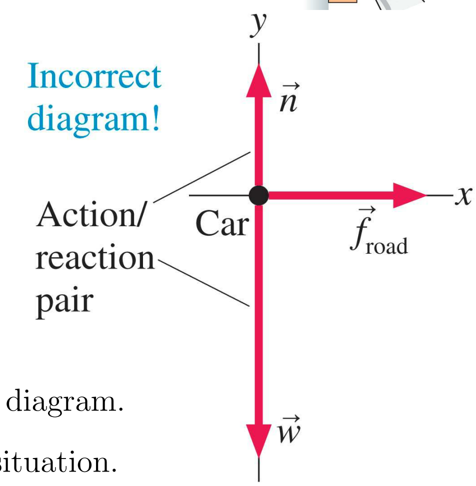
(a.) A car is accelerating from a stop. (Include air resistance.)

(b.) An ascending elevator, hanging from a cable, is coming to a stop. (Ignore air resistance here.)

(c.) As shown in the figure, a picture is held motionless against a wall by being pressed on.



#8 A student draws the flawed free-body diagram shown in Figure P4.50 to represent the forces acting on a car traveling at constant speed on a level road.



(a.) Identify and explain the three errors in the diagram.

(b.) Draw a correct free-body diagram for this situation.

#9 A weightlifter stands up from a squatting position while holding a heavy barbell across his shoulders.

(a.) Draw the free-body diagram for the barbell. Assume the weightlifter accelerates the barbell as he is standing.

(b.) What are the reactions to the forces acting on the barbell?

(c.) Is the weightlifter accelerating? **Hint:** Replace the weightlifter with a particle.

(d.) Draw the free-body diagram for the weightlifter.

#10 An 85-kg sprinter is running the 100 m dash. At one instant, early in the race, his acceleration is $5.3\, m/s^2$.

a. What *total* force does the track surface exert on the sprinter? Assume his acceleration is parallel to the ground. Give your answer as a magnitude and angle with respect to the horizontal.

b. The force is applied to one foot (the other foot is in the air), which for a fraction of a second is stationary with respect to the track surface. Because the foot is stationary, the net force on it must be zero. Thus the force of the lower leg bone on the foot is equal but opposite to the force of the track on the foot. If the lower leg bone is $60°$ from horizontal, what are the components of the leg's force on the foot in the directions parallel and perpendicular to the leg? (Force components perpendicular to the leg can cause dislocation of the ankle joint.)