78. [II] Figure P78 shows the displacement-time graph of a gerbil running inside a straight length of clear plastic tubing. (a) How far did it travel during the interval from 15 s to 20 s? (b) What distance did it traverse in the first 35 s? (c) What is its average speed during the first 35 s? (d) What is its instantaneous speed at $t = 20$ s?

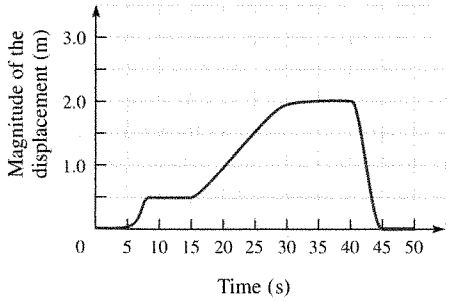

Figure P78

79. [II] Refer to Fig. P78 and assume the gerbil starts out heading north. (a) What is his velocity at $t = 12$ s; at $t = 38$ s? (b) What is his velocity at 42.5 s?

80. [II] A toy train travels around a closed circular loop of track having a 12.57-m circumference, at a constant speed of 0.50 m/s. The kid playing with the train starts a stopwatch when the engine passes its most northerly point (heading east). Is the velocity of any point on the train ever constant? What's the maximum displacement of the engine from the starting point? What's the velocity at the point of maximum displacement?

SOLUTION: No, the velocity is not constant anywhere on the train. The magnitude of the maximum displacement is one diameter. The circumference equals $2\pi R = 12.57$ m and therefore $R = 2.00$ m, and so the maximum displacement is 4.001 m–SOUTH. The velocity is 0.50 m/s–WEST.

81. [II] THIS PROBLEM WILL HELP US BETTER UNDERSTAND THE NOTION OF VELOCITY. Just as it comes out of a cannon a projectile has a vertical speed of 200 m/s and a horizontal speed of 100 m/s. (a) What is the relationship between the magnitudes of any two perpendicular vector components and the magnitude of their resultant? (b) At what speed did the projectile leave the gun?

82. [II] THIS PROBLEM WILL HELP US BETTER UNDERSTAND THE NOTION OF VELOCITY. Fired, at a speed v, from a pipe making an angle θ of 60.0° up from the ground, a tennis ball rises into the air along a path lying in a vertical east-west plane. (a) Write an expression in terms of θ and v for the horizontal scalar component of the velocity. (b) If the ball is launched with a horizontal speed of 20.0 m/s, at what net speed, v, did it leave the pipe?

83. [II] Ideally, a bullet fired straight up at 300 m/s will constantly slow down as it rises to a height of 4588 m in 30.6 s, at which point it will come to a midair stop. It then plummets back down again (overlooking friction losses) and will speed up, reaching the gun barrel at the original 300 m/s after falling 30.6 s. Determine its average speed and average velocity on both the upward leg and on the round trip. Draw a diagram.

84. [II] Referring to the previous problem: (a) What is the velocity of the bullet just as it leaves the gun? (b) What is the bullet's velocity at $t = 30.6$ s; at $t = 61.2$ s?

85. [II] A chicken is resting at a location 3.0 m north of a stationary farmer who weighs 185 lb. The chicken then meanders to a new location 3.0 m east of the farmer in a time of 2.0 s. Compute the bird's average velocity during its little journey.

86. [II] A trolley travels along a straight run of track and Fig. P86 is a plot of its velocity versus time. Approximately how far did it travel in the first 3.0 s of its journey? How far from its starting point is it at $t = 6.0$ s?

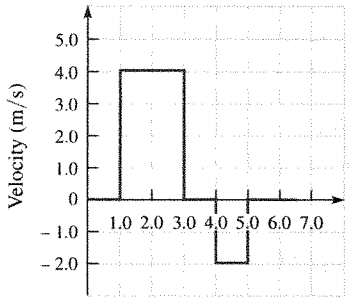

Figure P86

87. [III] A cannon is fired due north with an elevation of 45°. The projectile arcs into the air and then descends, crashing to the ground 600 m downrange 3 s later. With the Sun directly overhead, the projectile's shadow races along the flat stretch of Earth at a fairly constant speed. (a) Compute the instantaneous velocity of the shadow at the moment of impact. (b) What was the average velocity of the shell for the entire flight?

88. [III] An observer on a golf course, at 2:00 in the afternoon, stands 60 m west of a player who drives a ball due north down the fairway. If the ball lands 2.0 s later, 156 m from the observer, what was its average velocity? Draw a diagram.

SECTION 2.9: VELOCITY WITH RESPECT TO ...

89. [I] Each of two runners at either end of a 1000-m straight track jogs toward the other at a constant 5.00 m/s. How long will it take before they meet?

90. [I] The jet stream is a narrow current of air that flows from west to east in the stratosphere above the temperate zone. Suppose a passenger plane capable of cruising at an air speed of 965 km/h (i.e., 600 mi/h) rode the jet stream on a day when that current remained at a constant 483 km/h (i.e., 300 mi/h) with respect to the Earth. Find the plane's ground speed.

91. [I] Suppose that a fly were to go back and forth, essentially without a pause, from one runner to the other in Problem 89 at an average speed of 10 m/s. How far will it have traveled in total by the time the athletes meet? [*Hint: How long is the fly in the air?*]

92. [I] A deckhand on a ship steaming north walks toward the rear of the vessel at 5.00 km/h carrying a horizontal wooden plank. A ladybug on the plank scampers away from the human at 0.01 km/h–SOUTH. If the ship cuts through the calm sea at 15.00 km/h: (a) What is the speed of the ladybug with respect to the ship? (b) What is the speed of the plank with respect to the Earth? (c) What is the velocity of the bug with respect to the shore?

93. [I] While on a bike heading east at 5.0 m/s a kid throws a ball due east at 10.0 m/s toward a stationary friend. At what speed does the ball approach her friend? Now suppose the friend is running west at 3.0 m/s. At what speed is the ball approaching her? If at the instant the ball is launched the two kids are 9.0 m apart, how long would the ball be in flight before it's caught?