

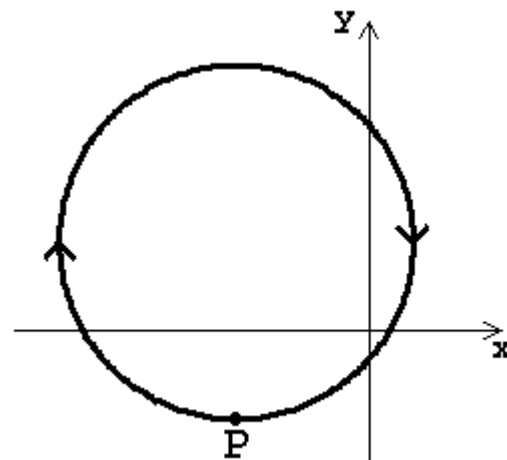
**Possibly Useful Information:** 1 liter =  $10^{-3} \text{ m}^3$  1 ft = 0.3048 m 1 hr = 3600 s  $g = 9.80 \text{ m/s}^2$

**Problem 1** Multiple Choice (3 points each)

\_\_\_\_\_ [i] When a ball is thrown horizontally out of a window at a speed of 18 m/s it hits the ground at a speed of 30 m/s. If a ball were dropped out the same window, what would be its speed when it hit the ground?  
 (a) 0 m/s (b) 12 m/s (c) 18 m/s (d) 24 m/s (e) 30 m/s (f) 35 m/s (g) 48 m/s (h) none of the above

\_\_\_\_\_ [ii] A 150 lb person stands in an elevator that moves downward and has an upward acceleration of  $g/3$ . What is the normal force of the floor on the person?  
 (a) 50 lb (b) 100 lb (c) 150 lb (d) 200 lb (e) 250 lb (f) none of the above

**Problem 2** (2 points each) The graph to the right shows the *trajectory* of a car. At position P the car's speed is *decreasing*. Complete the table below with the signs of the components of the car's velocity  $\mathbf{v}$  and acceleration  $\mathbf{a}$  at point P. Answer +, - or 0.



$v_x$	$v_y$	$a_x$	$a_y$

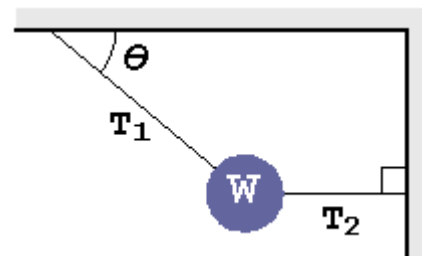
**Problem 3**  $x(t) = t^4 - 2t^2 + 3$  (in SI units) describes the position of a 12 kg particle moving along a line.

(6 points each)

(a) What is the *average velocity* between 0 and 2 s?

(b) What is the *net force* at 3 s?

**Problem 4** A weight W hangs from two strings as shown. What are both tensions? (6 points)



**Problem 5** (7 points each)

(a) A sailboat sails 4 km to the West and then 5 km in the direction  $35^\circ$  East of South. What is the net displacement of the boat? Also what are the magnitude and direction of the net displacement?

(b) A helicopter accelerates vertically from the ground from rest at  $3 \text{ m/s}^2$ . 4 s after the helicopter leaves the ground a mailbag is dropped from the helicopter. How long after it is dropped does the bag hit the ground?

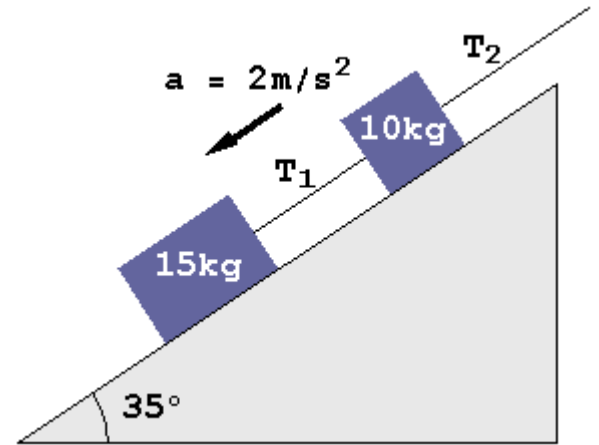
(c) Junior throws a rock at 9 m/s from the ground at an angle of  $55^\circ$  from horizontal toward a building. If the base of the building is 5 m from him, then how high above the ground does the rock hit the building?

(d) Rain falls vertically at 80 mi/hr. A car drives at 60 mi/hr in this rain. What is the speed of the rain with respect to the car and what angle, measured from vertical, does the rain hit the car?

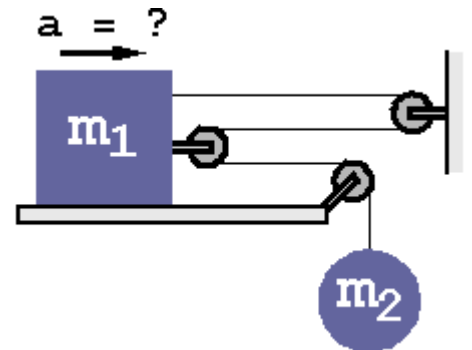
**Problem 6** A ball is thrown straight upward from the ground at 16 m/s. What is the velocity of the ball 2 s after it is thrown? (6 points)

**Problem 7** (8 points each)

(a) 15 kg and 10 kg masses slide down a  $35^\circ$  frictionless inclined plane with a downward acceleration of  $2 \text{ m/s}^2$  as shown. What are both tensions?



(b)  $m_1$  slides without friction and is connected by a string over an arrangement of ideal pulleys to  $m_2$  as shown. What is the acceleration of  $m_1$ ?



**Problem 8** (6 points each)

(a) A staircase drops vertically by 5m over a horizontal distance of 8m. If some irate Physics students throw their instructor with a horizontal initial velocity from the top of the stairs, then what is the smallest initial speed at the top needed to clear the staircase?

(b) Newton's law of universal gravitation says that  $F = G m_1 m_2 / r^2$ , where  $F$  is a force (with dimension  $[F] = M \cdot L / T^2$ ),  $m_1$  and  $m_2$  are masses ( $[m_1] = [m_2] = M$ ) and  $r$  is a distance ( $[r] = L$ ). What is  $[G]$ , the dimension of  $G$ ?

(c) Water flows through a pipe at a rate of 0.3 liter/s. What is this in  $\text{ft}^3/\text{hr}$ ?