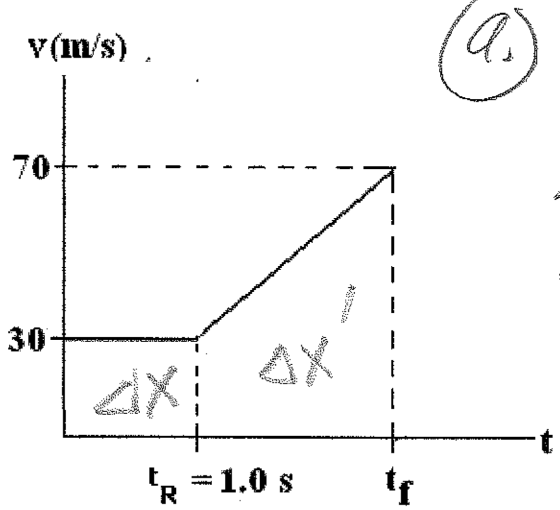
TEST 1 AU13 ANSWERS BELOW.

1. (40 points) A race car travels down a straight track at constant velocity 30.0 m/s. At t = 0, the driver decides to speed the car up to test its performance. After a reaction time t_R = 1.0 seconds, the driver steps on the accelerator pedal and the car then *accelerates* (speeds up) at constant acceleration with *magnitude* 4.00 m/s^2 until time t_f. Below is the velocity v vs. time t graph of the race car's motion. Assume at t = 0, the car's position is x = 0 m.



(a.) $\frac{\Delta v}{\Delta t} = 4 \frac{m}{s^2}$

$\Delta t = \frac{70-30}{4} = \frac{40}{4} = 10s$

$t_f = 1s + 10s = 11 s$

(b.) $x = 30\frac{m}{s} \cdot (0.5 s) = 15 m$

(c.) $\Delta X = 30 m$ (obvious?)

(a) (11 points) What is the time t_f ?
(b) (5 points) What is the car's displacement x (in m) at t = 0.5 seconds?
(c) (5 points) What is the car's displacement x (in m) at t = 1.0 seconds?
(d) (11 points) What is the car's *average* velocity (in m/s) in the time interval between t_R and t_f (when the car is speeding up)?
(e) (8 points) What is the *total* displacement between t = 0 and t = t_f .

(d.) $\frac{70+30}{2} = \frac{100}{2} = 50\frac{m}{s}$

(e.) $\Delta X_{TOT} = 30 m + \overset{*}{500} m = 530 m$

$* \quad 70^2 = 30^2 + 2(4)\Delta X'$

$\Delta X' = \frac{4900 - 900}{8} = \frac{4000}{8} = 500 m^*$

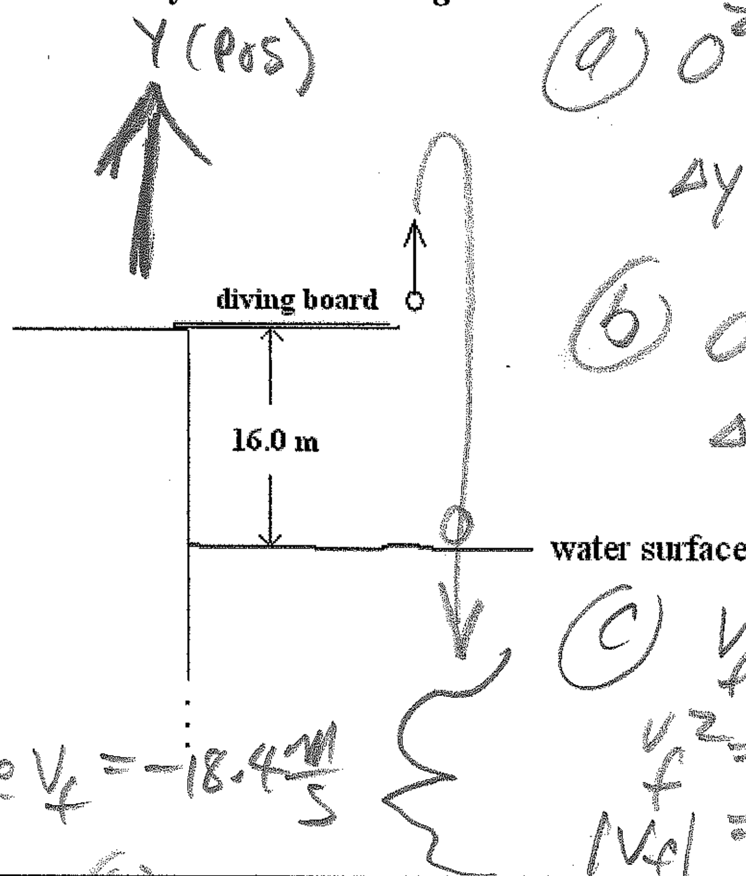
2. (40 points) A ball is *thrown* upward with *initial speed* 5.00 m/s from a diving board that is 16.0 m above the surface of the water. The body of water is *very deep.* While the ball is in the air, it is in *free fall* with acceleration of magnitude g directed *downward.* After the ball hits the water surface, it *slows down* and sinks downward with an upward acceleration of *magnitude* 2.00 m/s^2.

(a) (10 points) What is the greatest height (in m) *above the diving board* that the ball reaches ?

(b) (10 points) How many seconds does it take the ball to reach the greatest height *above the diving board*?

(c) (10 points) What is the ball's speed *just before* it hits the water surface?

(d) (10 points) What is the *maximum* depth D below the water surface reached by the *decelerating* ball?



(a) $0^2 = (5)^2 - 2g\Delta Y$

$\Delta Y = \frac{25}{19.6} = 1.276\,(m)$

(b) $0 = 5 - g\Delta t$

$\Delta t = \frac{5}{9.8} = 0.51\,(s)$

(c) $V_f^2 = (5)^2 - 2g(-16)$

$V_f^2 = 25 + (19.6)(16)$

$|V_f| = 18.4\,\frac{m}{s}$ = speed.

NOTE $V_f = -18.4\,\frac{m}{s}$

(d) $0 = (18.4)^2 + 2\cdot(2)\cdot(-D)$

$\rightarrow D = 18.4^2/4 = 84.7\,(m)$

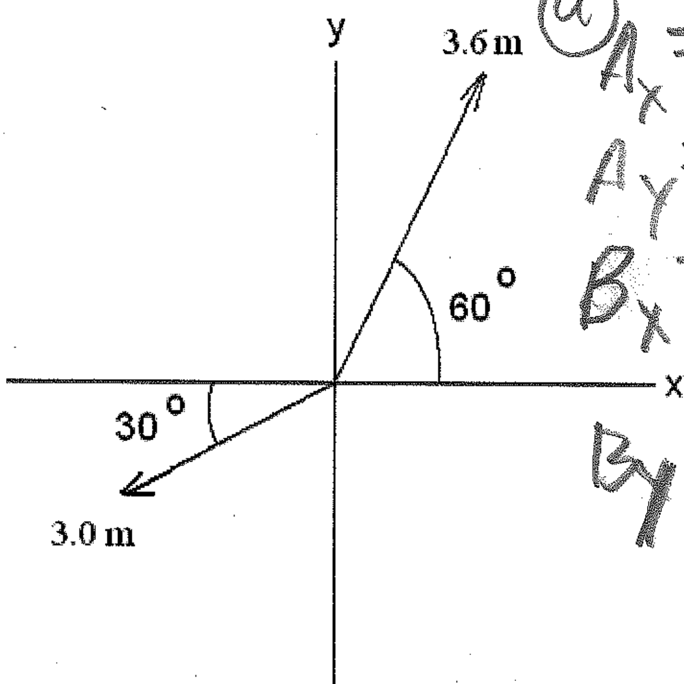
3. (a) (30) In the diagram below, $\vec{A}$ has magnitude 3.6 m with the direction shown. $\vec{B}$ has magnitude 3.0 m and points in the 3[rd] quadrant with direction shown. Write each *vector component* in the blanks provided. Show *work* in spaces below and next pages.

(b) (5) Compute the *magnitude* $|\vec{C}|$ of the vector sum $\vec{C} = \vec{A} + \vec{B}$. Show *work* in spaces below and next pages .

(c) (5) Find the *direction* of the vector *sum* $\vec{C} = \vec{A} + \vec{B}$ by doing the following:

(i) Show the direction by drawing this vector *sum* in the correct *quadrant* on the blank axes provided on next page.

(ii) Calculate the related (reference) angle θ_R the vector makes with the x-axis. Show this angle in sketch, with work.



(a) $A_x = 3.6 \cos 60°$

$A_y = 3.6 \sin 60°$

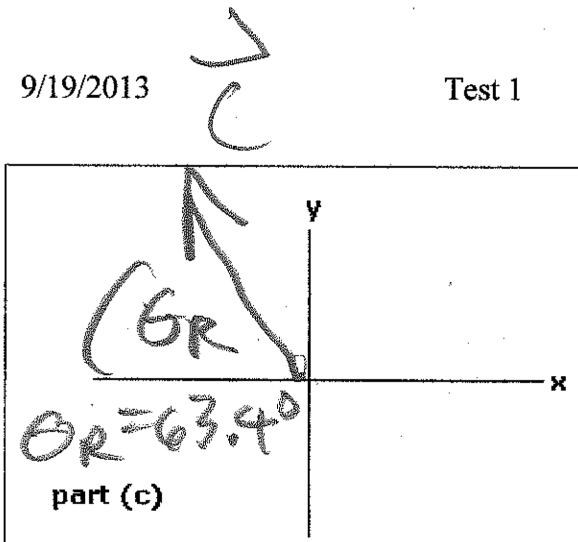
$B_x = -3.0 \cos 30°$

$B_y = -3.0 \sin 30°$

A_x = 1.8 A_y = 3.1

B_x = −2.6 B_y = −1.5

(b) $|\vec{C}| = \sqrt{(1.8-2.6)^2 + (3.1-1.5)^2} = 1.8$ m



part (c)

$$\tan\theta_R = \frac{|C_y|}{|C_x|}$$

$$\tan\theta_R = \frac{|1.6|}{|-0.8|}$$

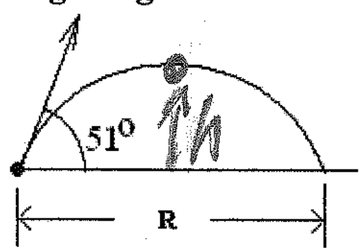
$$\theta_R = \tan^{-1} 2 = 63.4°$$

in Q2

note: $C_x = 1.8 - 2.6$
$= -0.8$
$C_y = 3.1 - 1.5$
$= +1.6$
since $C_x < 0$
and $C_y > 0$,
QUADRANT 2

4. (20 points EXTRA CREDIT) A place kicker kicks a football. When kicked (at t = 0), the ball leaves the ground (at y = 0) with speed 21.00 m/s at an angle of 51 degrees *with the horizontal.* Below is a schematic of the ball's path and the ball at the *start* of its motion.

(a) (4 POINTS) How many seconds does it take the ball to reach its maximum height above the ground?
(b) (4 POINTS) What is the maximum height above the ground that the ball reaches?
(c) (4 points) What is the y-component of velocity V_y when the ball reaches the maximum height the ground? (Hint: the velocity vector is always tangent to the curve, including at the top of the curve.)
(d) (4 points) What is the x-component of velocity V_x when the ball reaches the maximum height above the ground?
(e) (4 points) What the total horizontal distance R the ball travels before hitting the ground?



$0 = 21 \cdot \sin 51 - g \Delta t$

$\Delta t = \frac{21 \cdot \sin 51}{9.8}$

$= 1.7 \text{ (s)}$

$0 = (21 \sin 51)^2 - 2g \cdot h$

$h = \frac{(21 \sin 51)^2}{19.6} = 13.6 \text{ m}$

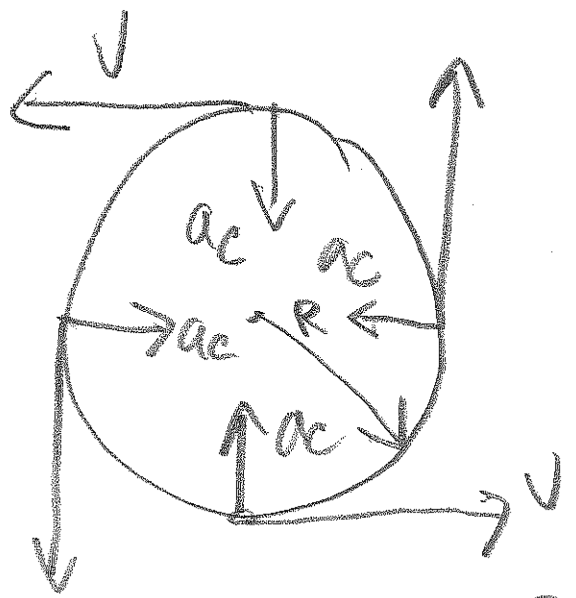
(c) 0

(d) $21 \cdot \cos 51 = 13.2$

(e) $(21 \cdot \cos 51) \cdot 3.4$

$= 44.9 \text{ (m)}$

5. (3 points EXTRA CREDIT) You swing a 2.2 kg stone in a circle of radius r = 75 cm. At what speed v should you swing it so its centripetal acceleration has magnitude $a_C = 8.0\ m/s^2$?



NOTE: MASS not needed.

v

$$a_c = \frac{v^2}{R}$$

$$8.8\ \frac{m}{s^2} = \frac{v^2}{0.75\ m}$$

$$v = \sqrt{(0.75\,m)\cdot 8.8\,\frac{m}{s^2}}$$

$$\boxed{v = 2.57\ \frac{m}{s}}$$

Short Answers. Multiple choice: Mark your scantron with a #2 pencil.

1. It is possible to be moving and have zero acceleration.
(a) True (b) False

2. An object moves in a straight line at constant speed. The net force on the object must be (a) not zero (b) zero (c) infinite (d) none of the above

3. When the velocity of an object is zero, the object is
(a) moving (b) at rest

4. When the velocity and acceleration point in THE SAME DIRECTION, the speed of the object (a) increases (b) decreases (c) is constant

5. Assume no air resistance. An object is released from rest above the ground. As the object moves down, the acceleration magnitude is
(a) 0 (b) 9.8 m/s^2

6. Assume no air resistance. An object is *thrown* downward from above the ground. As the object moves down, the acceleration magnitude is
(a) 0 (b) more than 9.8 m/s^2 (c) 9.8 m/s^2

7. Assume no air resistance. An object is thrown upward from above the ground. As the object rises, its acceleration magnitude
(a) decreases (b) increases (c) is constant

8. The slope of a line connecting two points on a position (x) versus time (t) graph gives (a) the average velocity (b) the instantaneous velocity.

9. The slope of a tangent line at a given time on a position (x) versus time (t) graph gives (a) the average velocity (b) the instantaneous velocity.

10. Assume no air resistance. A stone is thrown up. As the stone rises, its speed (a) increases (b) decreases.

11. Assume no air resistance. A stone is thrown up. What is its speed at the highest point? (a) the same as the initial speed (b) 0

12. When the velocity of an object is zero, the object's acceleration must be zero. (a) True (b) False