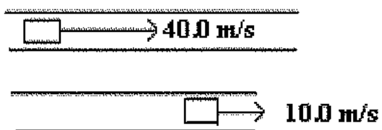
**4A Test 1 SPRING 2013 Name____________________**

**1. (40 points) A *freight train* is $1.00\text{x}10^{2}$ m ahead of an unmanned *maintenance train* at t = 0. Assume rightward is the positive direction of motion. See the *schematic* below of the two trains at t = 0. Dimensions shown not necessarily to scale. The two train vehicles are on *different, parallel tracks* and are moving in the same direction. In the figure below, see the top view of the situation at t = 0 looking down from above.**




**At t = 0, the *freight train* has *initial* velocity + 10.0 m/s and is *speeding up with constant* acceleration of *magnitude* 2.00 m/s². The maintenance train has *constant* velocity + 40.0 m/s. SHOW ALL WORK . *LABEL* ALL PARTS. It may be helpful to sketch the position versus time graphs of both trains on the same x vs t axes.**

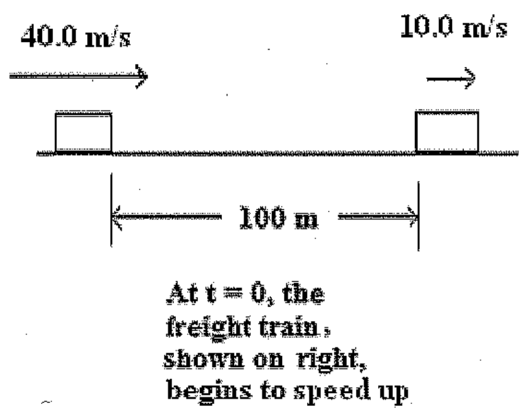
**(a) (12 points) What is the velocity of the freight train when the *maintenance train catches up with freight train?***

**(b) (5 points) What is the average velocity of the freight train between t = 0 and the moment the *maintenance train catches up with the freight train?***

**(c) (8 points) *AFTER* the *maintenance train passes the freight train, the freight train later catches up with* the maintenance train. At what time t does the freight train catch up with the maintenance train?**

**(d) (12 points) At what time is the *velocity of the freight train equal to the velocity of the maintenance train?***

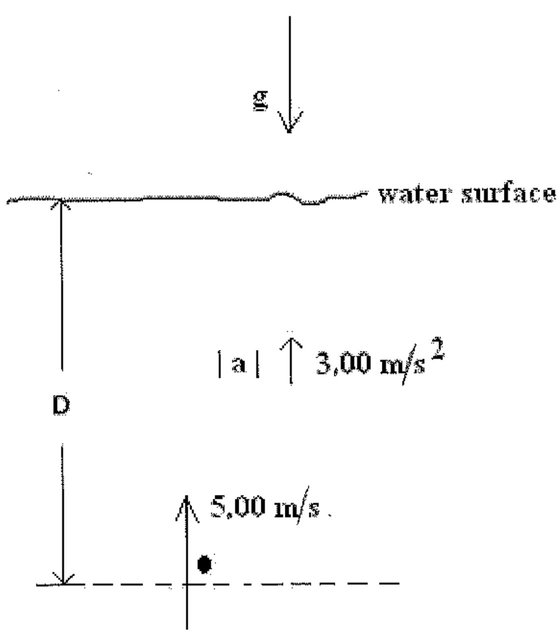
(e) (3 points) *While* ***freight train is catching up*** with maintenance train, what is the ***maximum distance*** between freight and maintenance train?



**2. (40 points) In a high school physics experiment, a ball is shot *vertically upward* from an *underwater* cannon and has initial velocity of magnitude 5.00 m/s. *In the water,* the *magnitude* of the *upward* directed acceleration is $|a| = 3.00\ m/s^2$. The ball is initially a distance D = 20.00 m below the water surface.**

***Above the water surface* there is no air resistance. Since the experiment is performed in Ecuador, the magnitude of the effective *downward* directed acceleration of gravity above the water is $g = 9.78\ m/s^2$.**

(a) **(18 points) What is the maximum height $H_{max}$ of the ball *above* the surface of the water?**
(b) **(18 points) After rising above the water surface the ball returns to the surface and *moves downward underwater.* At what distance D' below the surface does the ball travel before momentarily coming to *rest ?***
(c) **(4 points) What is the speed of the ball when it arrives moving *upward* at the water surface *again for the second time?***



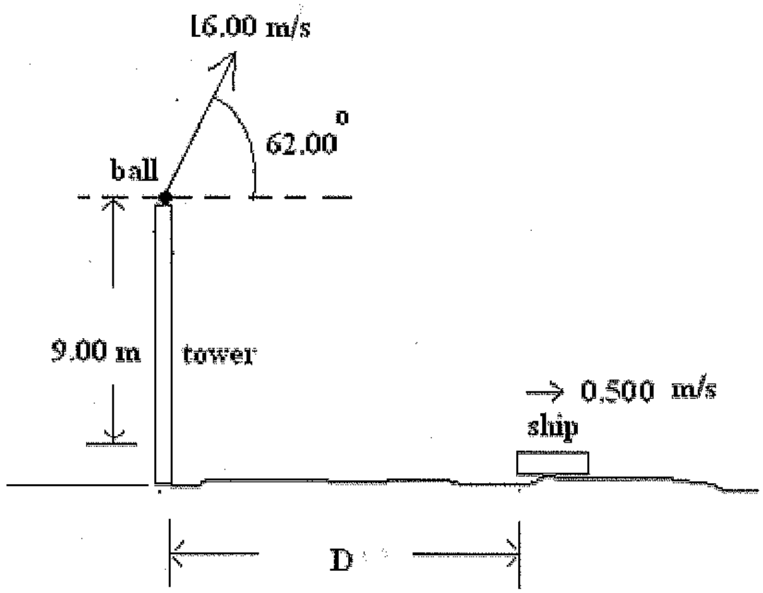
**3. (40 points) As a ship is *moving away* from a dock at 0.500 m/s, a ball is launched from the top of a tower on shore. At t = 0, the ball is launched at a height 9.00 m above the ship's deck, which is near water surface level as shown. The ball's initial velocity has magnitude 16.00 m/s and has a direction 62.00 degrees above the horizontal. Neglect air resistance. The ball lands at the *back* of the moving ship.**

**(a) (15 points) What is the maximum height $H_{max}$ of the ball above the ships deck ?**

**(b) (15 points) How long does it take the ball to reach the maximum height in part (a)?**

**(c) (15 points) What rightward horizontal distance d does the ship move *while ball is in the air?***

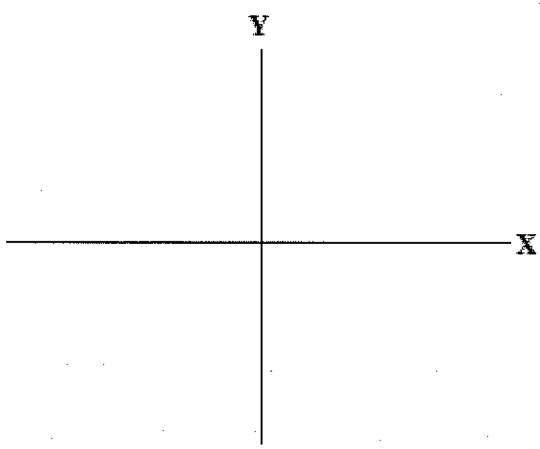
**(d) (5 points) At what distance D from the dock was the *back* of the ship when the ball was launched at t = 0?**




Ball launched at
t = 0.

**4. (40 points) Two forces $\vec{F}_1$ and $\vec{F}_2$ act at a point at the origin. The magnitude of $\vec{F}_1$ is 8.00 N and its direction is 60.0 degrees *above* the x-axis in the first quadrant. The magnitude of $\vec{F}_2$ is 9.00 N and its direction is 55.0 degrees *below* the x-axis in the *third* quadrant. This problems deals with vector addition and the resultant force $\vec{R} = \vec{F}_1 + \vec{F}_2$ . SHOW WORK, *LABEL* PARTS.**

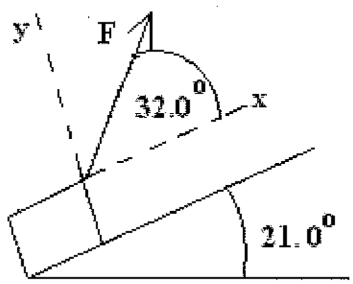
**(a) (9 points) What is the x-component $R_x$ of the resultant force?**
**(b) (9 points) What is the y-component $R_y$ of the resultant force?**
**(c) (10 points) What is the magnitude$|\vec{R}|$ of the resultant force?**
**(d) (4 points) In what quadrant does the resultant force point?**
**(e) (4 points) What related angle $\theta_R$ does the resultant force make with the x-axis?**
**(f) (4 points) On the axes below, make a sketch of the resultant force with its tail at the origin. Label the angle the resultant force makes with the x-axis.**



**5. (10 points) A man is dragging a trunk up the loading ramp of a mover's truck. The ramp has a slope angle of 21.0 degrees with the *horizontal* and the man pulls with a force whose direction make an angle of 32.0 degrees with the ramp. The x-axis may be considered to be parallel with the ramp and the y-axis is perpendicular to ramp as shown below.**

**(a) (5 points) What is the magnitude F of the pull force if the component $F_x$ parallel to the ramp is 62.00 (N)?**

**(b) (5 points) How large will the component $F_y$ perpendicular to the ramp be?**



**6. EXTRA CREDIT (6 POINTS)**

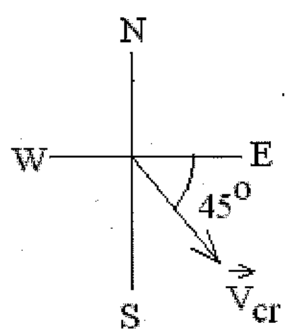
**A canoe is on a river that is flowing due EAST with speed $V_{rs}$ *relative to the shore.* River speed $V_{rs}$ = 0.60 m/s. The canoe has a velocity $\vec{V}_{cr}$ with magnitude 0.50 m/s and *direction* southeast *relative to the river.* Let the positive x direction be East and the positive y direction be North. See the schematic of the problem below. The velocity of the canoe relative to the river is sketched in the diagram. SHOW ALL WORK!**

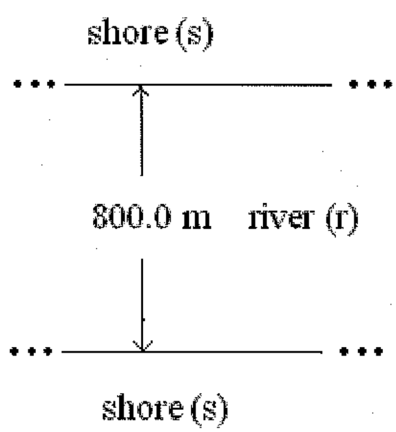
**Find:**

**(a) (2 points) the *magnitude* of the velocity $\vec{V}_{cs}$ of the canoe *relative to the shore.***

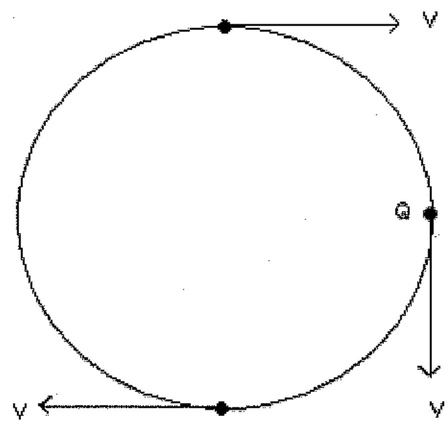
**(b) (2 points) the *direction* of velocity $\vec{V}_{cs}$ of the canoe *relative to the shore.* Find this direction by computing the *angle* between the x axis and velocity $\vec{V}_{cs}$. In what quadrant does $\vec{V}_{cs}$ point? Make a careful sketch.**

**(c) (2 points) Suppose the river is 800 m wide. Suppose the canoe starts on the northern shore, i.e., upper shore, in the diagram. How long (in seconds) does it take the canoe to cross the river? Convert your answer to hours.**



**7. Extra Credit (6 points) A rock is swung in a vertical circular path on a <u>string</u> that is 0.480 m long. Assume the speed v of the rock is 3.95 m/s. Three points on the circular path are shown: the top, the bottom and point Q at the end of a *horizontal*, radial line segment. Assume g = 9.80 m/s$^2$.**




**What is,**

**(a) (2 points) the magnitude $a_C$ of the centripetal acceleration at point Q? Write correct units.**

**(b) (2 points) the direction of the centripetal acceleration at point Q? Draw an arrow whose tip points in the correct direction.**

**(c ) (1 point) the direction of the centripetal acceleration at the top? Draw an arrow whose tip points in the correct direction.**

**(d ) (1 point) the direction of the centripetal acceleration at the bottom? Draw an arrow whose tip points in the correct direction.**

**4A Test 1 SPRING 2013 Name____________________**

**Short Answers. Multiple choice: Mark your scantron with a #2 pencil.**
**1. Is it possible to have zero acceleration and still be moving? Yes or No.**
**(a) Yes (b) No**

**2. In straight line motion, when the velocity and acceleration point in the same direction, the speed of the object is**
**(a) increasing (b) decreasing**

**3. In straight line motion, when the velocity and acceleration point in opposite directions, the speed of the object is**
**(a) increasing (b) decreasing**

**4. Assume no air resistance. An object released *from rest* above the ground has acceleration of magnitude 4.9 m/s$^2$ . True or False.**
**(a) True (b) False**

**5. Assume no air resistance. An object *thrown downward* from above the ground has acceleration of magnitude 9.8 m/s$^2$ . True or False.**
**(a) True (b) False**

**6. Assume no air resistance. An object *thrown upward* from above the ground has acceleration less than magnitude 9.8 m/s$^2$ . True or False.**
**(a) True (b) False**

**7. The slope of a line connecting two points on a velocity (v) versus time (t) graph gives (a) the average velocity (b) the average acceleration.**

**8. The slope of a tangent line at a given time on a velocity (v) versus time (t) graph gives (a) the instantaneous velocity (b) the instantaneous acceleration**

**9. Assume no air resistance. A stone is thrown up. What is its acceleration magnitude at the highest point? (a) 0 (b) 9.8 m/s$^2$ .**

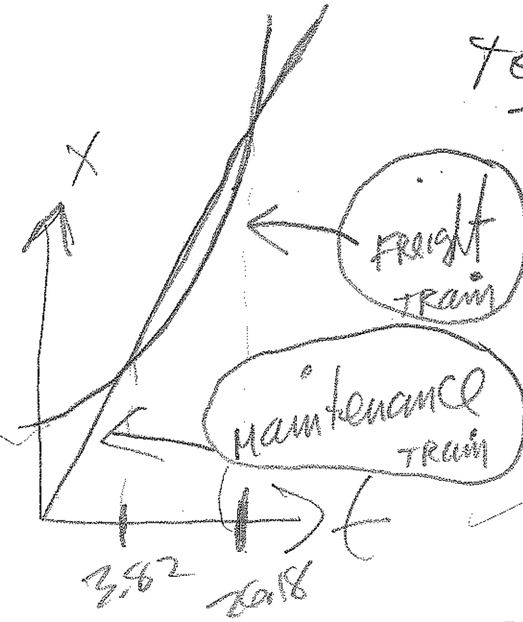
**10. Assume no air resistance. A stone is thrown up. What is its speed at the highest point? (a) 0 (b) not enough information to give an answer.**

**11. Assume no air resistance. A stone is thrown upward. What is the magnitude of the net force on the stone at the highest point?**
**(a) 0 (b) the magnitude of the stone's weight .**

**12. Is it possible for an object to experience a zero net force and still be moving? True or False. (a) True (b) False**

# test1 key

1.




$$40t = 100 + 10t + \tfrac{1}{2}(2)t^2$$

$$0 = 100 - 30t + t^2$$

$$t^2 - 30t + 100 = 0$$

$$t = \frac{30 \pm \sqrt{(-30)^2 - 4(1)(100)}}{2(1)}$$

$$= \frac{30 \pm \sqrt{900 - 400}}{2}$$

$$= \frac{30 \pm \sqrt{500}}{2}$$

$$= \frac{30 \pm 22.36}{2}$$

$$= \frac{52.36}{2}, \frac{7.64}{2}$$

$$= 26.18,\ 3.82$$

catch up 2 (26.18), catchup 1 (3.82)

a. $V_{FT} = 10.0\frac{m}{s} + \left(2\frac{m}{s^2}\right)(3.82)$

$= 17.64\frac{m}{s}$

b. $\dfrac{10\frac{m}{s} + 17.64\frac{m}{s}}{2}$

$= 13.82\, m/s$

c. 26.18(s) see above derivation

d. $40 = 2t + 10$

$t = 15(s)$

e. $t = 15(s)$

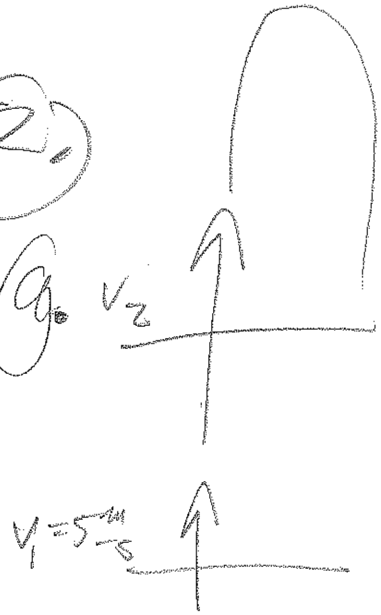
$\Rightarrow (40)(15) - (15^2 + (10)(15) + 100)$

$= 600 - (225 + 150 + 100)$

$= 125(m)$

2.

a.




$v_2^2 = v_1^2 + 2\cdot3(20)$

$v_2^2 = 5^2 + (6)(20)$

$v_2^2 = 25 + 120$

$v_2^2 = 145$ m

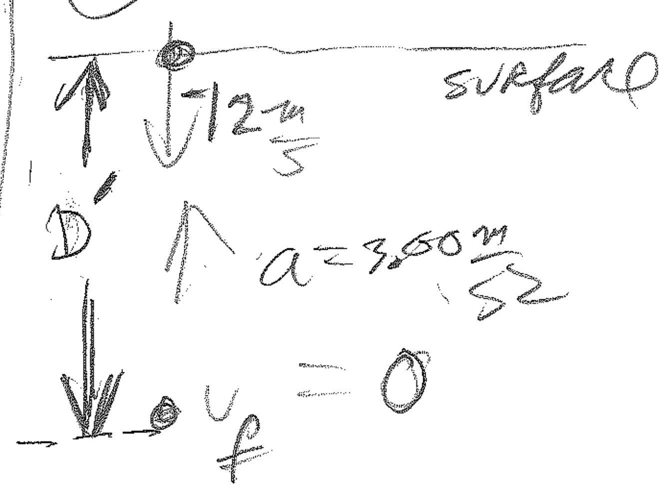
$v_2 \approx 12.04\frac{m}{s}$

$v_{top}^2 = 0 = (12)^2 - 2(9)(D)$

$D = \frac{144}{19.6} = 7.3$ (m)

b. returns at $-12\frac{m}{s}$

b. On water:




$v_f^2 = 0 = (-12\frac{m}{s^2})^2 - 2\cdot3\cdot D'$

$D' = \frac{144}{6} = 24$ (m)

c. $v_f^2 = 0^2 + 2\cdot3\cdot24$

$v_f^2 = 6\cdot24$

$v_f = 144\frac{m}{s} \cdot 21$

$v_f = 12\frac{m}{s}$ SURPRISE!

test 1

(2.)

(a)

$$V_{top_y}^2 = (16\cdot\sin 62)^2 - 2g\cdot D$$

$$D = \frac{256\cdot\sin^2 62}{(19.6)}$$

$$= 10.182 \text{ (m)}$$

$$H_{MAX} = 9.00 + 10.182$$
$$= \boxed{19.182 \text{ (m)}}$$

(b) $0 = 16\cdot\sin 62 - g\Delta t$

$$\Delta t = \frac{16\cdot\sin 62}{9.8}$$

$$= 1.44 \text{ (s)}$$

(c) $d = 0.500 \frac{m}{s} \cdot \Delta t_{TOTAL}$

<u>time</u> FROM TOP TO SHIP:

$$\frac{1}{2}g\Delta t'^2 = (9.00 + 10.182)$$

$$\frac{1}{2}g\Delta t'^2 = 19.182$$

$$\Delta t' = \sqrt{\frac{(2)\cdot 19.182}{9.8}}$$

$$\Delta t' = \sqrt{\frac{38.364}{9.8}}$$

$$= 1.97$$

$$\Delta t_{TOTAL} = 1.97 + 1.44$$
$$= 3.4185$$

$$d = (0.500 \tfrac{m}{s})(3.4185)$$

$$= \boxed{1.7093 \text{ (m)}}$$

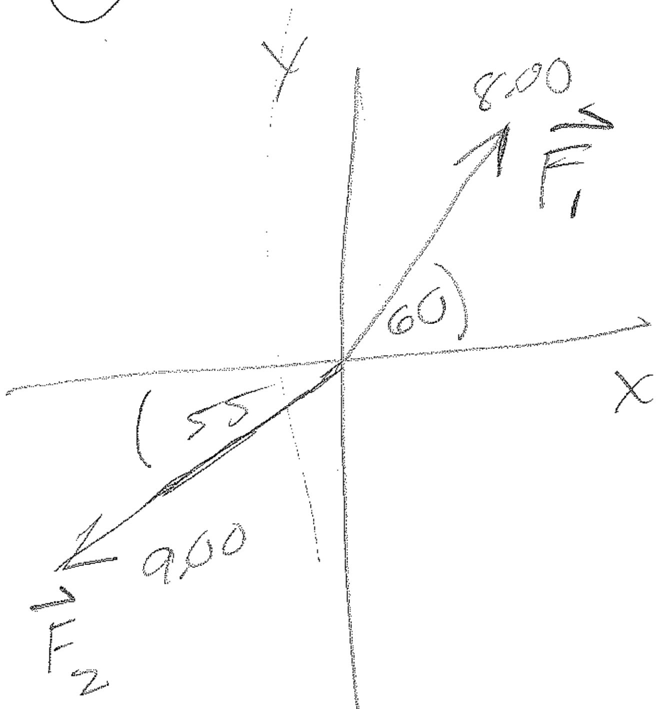
(d.)

$$D = 16\cdot\cos 62\cdot\Delta t_{TOTAL} - 0.500\cdot\Delta t_{TOTAL}$$

$$D = (16\cdot\cos 62 - 0.500)\Delta t_{TOTAL}$$

$$D = \boxed{23.9 \text{ (m)}}$$

(4)




(a) $R_y = 8\cos 60 - 9\cos 55$

$= -1.162 < 0$

(b) $R_x = 8\sin 60 - 9\sin 55$

$= -0.444 < 0$

(c) $|\vec{R}| = \sqrt{(-1.162)^2 + (-0.444)^2}$

$= \sqrt{1.3502 + 0.1973}$

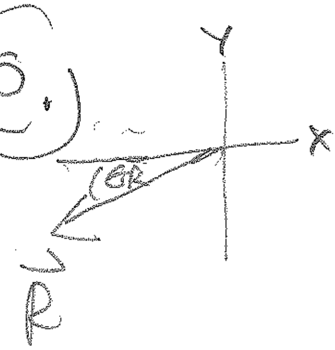
$= \sqrt{1.5475}$

$= 1.24 \geq 0$ ALWAYS

$R_x < 0$, $R_y < 0$ } → Q III

(d) QUAD. (III)

(e)




$\theta_R = 20.9^\circ \approx 21^\circ$

$\tan\theta_R = \frac{0.444}{1.162}$

$\theta_R = 21^\circ$

(5.) (a) $F \cdot \cos 32^\circ = 62$

$F = \frac{62}{\cos 32}$

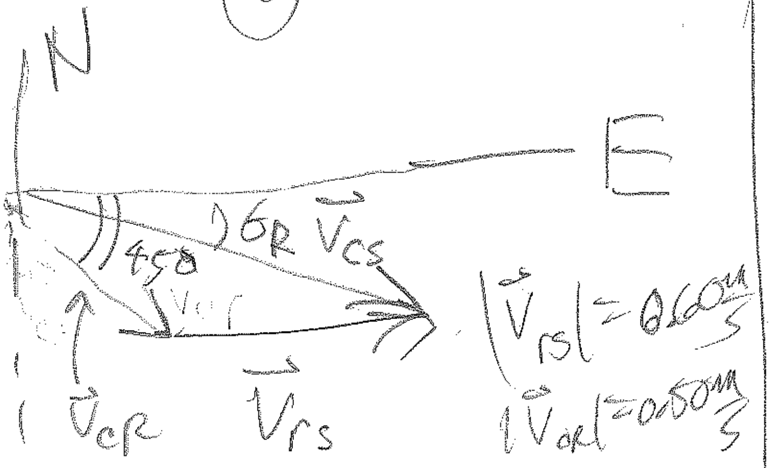
$= 73.1 (N)$

(b) $F_y = F \cdot \sin 32$

$= 73.1 \cdot \sin 32$

$= 38.7 (N)$

(b)




$V_{CS_x} = (0.50\cos 45) + 0.60$

$V_{CS_y} = -(0.50\sin 45)$

$V_{CS_x} = 0.3535 + 0.6$
$= 0.9535 > 0$

$V_{CS_y} = -0.3535 < 0$

$|\vec{V}_{CS}| = \sqrt{(0.9535)^2 + (-0.3535)^2}$
$= \sqrt{1.0341}$
$= 1.07 \frac{m}{s}$

$\tan\theta_R = \frac{0.3535}{0.9535}$

$\theta_R = 20.3^\circ$

(c)

$\frac{800 m}{V_{CR} \sin 45^\circ}$

$= \frac{800 m}{(0.50)\sin 45}$

$= 2263 (s)$

$\approx 0.63 h$

7

(a.) $a_c = \frac{v^2}{R}$

$= \frac{(3.95 \frac{m}{s})^2}{(0.480 m)}$

$= 32.5 \frac{m}{s^2}$

(b.) ←

(c.) ↓

(d.) ↑

Scantron key

1. a
2. a
3. b
4. b
5. a
6. b
7. b
8. b
9. b
10. a
11. b
12. a