P113
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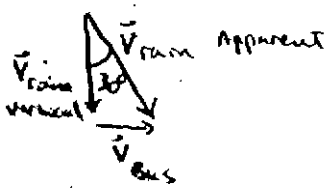
Exam 1 (September 24, 1999)

Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show all your work. Partial credit will be given.

Problem 1 (25 pts):

Suppose you are sitting in a bus in pouring rain. Being an overzealous P113 student, you observe the raindrops appear to fall with an angle of 30 degrees to the vertical. In addition, you are just behind the driver and can see on the instruments that the bus is travelling at 10 kilometers per hour. There is no wind on this day. What is the terminal velocity of the raindrops? (That is to say, what is the vertical speed of descent of the raindrops?) You are welcome to give your answer in units of kilometers per hour, if you wish.



$$\tan 30^\circ = \frac{opp}{Adj} = \frac{|\vec{V}_{Bus}|}{|\vec{V}_{rain\ vertical}|} = \frac{10\ km/hr}{|\vec{V}_{rain\ vert.}|}$$

$$|\vec{V}_{rain\ vertical}| = 17.3\ km/hr$$

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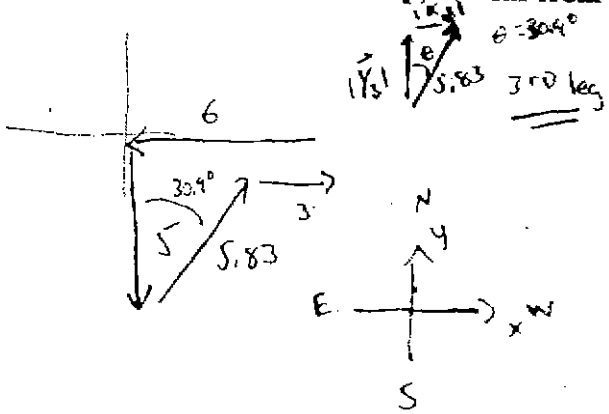
Problem 2 (25 pts):

Episode I in the saga of troublesome Leonard Gannon, the grasshopper

Young Leonard was a bit strange for a grasshopper. He had a few spirited friends attributed to his being conceived under the stage at a Grateful Dead concert. Leonard dreamed of leaving home and exploring the world. One morning he ate his Wheaties and decided the time had arrived! So he rubbed legs with his mother and set off to see the world. Leonard decided to walk because he thought he would miss too many things if he hopped around, spending most of his time in the air.

- **On the first leg of his trip, Leonard walked 6.00 meters west.**
- **On the second leg of his trip (starting at the end point of the first leg), Leonard walked 5.00 meters south.**
- **On the third leg of his trip (starting at end point of second leg), Leonard walked 5.83 meters in a direction 30.9 degrees east of north.**
- **On the final leg of his trip (starting at the end point of the third leg), Leonard walked 3.00 meters east.**

At the end of his trip, how far from home was Leonard?



x component $= (5.83)\sin(30.9^\circ) = 3$ m

y component $= (5.83)\cos 30.9 = 5$ m

Σ x components $= -6 + 3 + 3 = 0$

Σ y components $= -5 + 5 = 0$

Leonard ends up back at Home

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Problem 3 (25 pts):

A ball is thrown straight upward and is observed to have a height, y, above the ground described by $y = At - Bt^2$, where A = 23 m/s and B = 5.3 m/s^2.

(a) What is the initial velocity of the ball?

$\frac{dy}{dt} = A - 2Bt$. at $t=0$, this becomes A $\therefore V_{oy} = 23\ M/s$

$V_{ox} = 0$

$\frac{dx}{dt} = 0$

$\therefore \vec{V}_o = V_{oy}\hat{j} = 23\ M/s$ upward

(b) What is the acceleration of the ball as a function of time?

$\frac{d^2x}{dt^2} = 0$

$\frac{d^2y}{dt^2} = a_y = -2B$ → Constant as Fn of Time

$\vec{a}_y = (5.3\ m/s^2)(2)$ downward

$\vec{a} = 10.6\ m/s^2$ down = (acceleration)

(c) What is the average velocity of the ball between t = 0 seconds and t = 2 seconds?

~~$\frac{dy}{dt} = A - 2Bt = 23\ M/s - (2)(5.3)\ m/s^2$~~

$y_0 = 0$

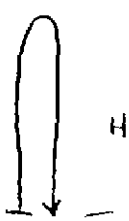
$y_2 = A(2) - B2^2$

$y_2 = (23)(2) - (5.3)4 = 24.8\ m$

$V_{ave} = V_{ave_y} = \frac{\Delta x}{\Delta t} = \frac{y_2 - y_0}{t_2 - t_0} = \frac{24.8 - 0}{2 - 0} = 12.4\ M/s$

because $V_x = 0$

(d) How much time elapses before the ball returns to the height from which it was thrown?



How much Time?

Height at which thrown is $y = 0$

so $0 = At - Bt^2 = t(A - Bt)$

one solution is $t = 0$, ⇒ this is start (initial condition)

other soln is $A = Bt$

$t = A/B = \frac{23\ M/s}{5.3\ m/s^2} = 4.3$

other solns possible

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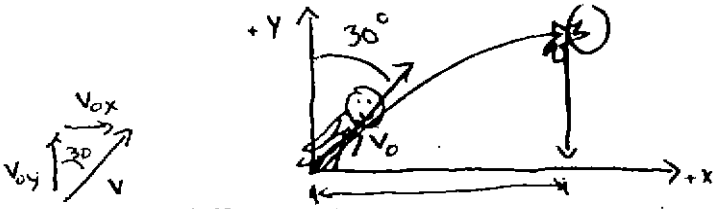
Problem 4 (25 pts):

Episode II in the saga of troublesome Leonard Garcia, the young grasshopper

Young Leonard was not satisfied with his first adventure. So he decided to take another trip. This time he chose to hop along instead of walking. After rubbing legs with his mother, Leonard hopped upward in a direction of 30 degrees with the vertical with an initial velocity of 2.0 m/s. Unfortunately, he didn't look where he was going and hit a tree branch right when he reached the peak of his motion. Immediately after hitting the branch, Leonard fell to the ground and declared his second journey over. Air resistance may be neglected throughout.



(a) How much time elapses during Leonard's journey?

$V_{0x} = V \sin 30 = (2) \sin 30 = 1.0$ m/s

$V_{0y} = V \cos 30 = (2) \cos 30 = 1.7$ m/s

1st part of Motion

in Y use $V_y^2 = V_{0y}^2 + 2a_y(y - y_0)$

$0 = (1.7)^2 - 2(9.8)(y - 0)$

at peak of height $y = \frac{(1.7)^2}{2(9.8)} = 0.15$ m

Time for 1st part

$y = y_0 + \left(\frac{V_{0y} + V_y}{2}\right)t$

$0.15 = 0 + \left(\frac{1.7 + 0}{2}\right)t$

Time for 1st leg

$t = \frac{(2)(0.15)}{1.7} = 0.18$ s

(b) How far from home is Leonard when his journey ends?

d = distance in x

only need consider part ① of motion

$x - x_0 = \left(\frac{V_{0x} + V_x}{2}\right)t$

$d = \frac{1.0 + 1.0}{2}t = t$

t = flight time for 1st part = 0.18 s

∴ d = 0.18 m = DISTANCE FROM Home to Leonard!

look at 2nd leg now

$V_y^2 = V_{0y}^2 + 2a_y(y - y_0)$

$V_y^2 = 0^2 + 2(9.8)(0.15)$

$V_y = 1.7$ m/s

Again $t = 0.18$ s

(same as above)

∴ TOTAL Time elapsed

$t_{TOT} = (2)(.18\text{ s}) = 0.$

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