

**Problem 3:** ~~(projectile motion, softball)~~

~~A softball is hit over a third baseman's head. The third baseman, as soon as it is hit, turns around and runs straight back with an average velocity of  $v_1 = 7.0\text{m}\cdot\text{s}^{-1}$  for a time interval  $\Delta t = 2.0\text{s}$  and catches the ball at the same height it left the bat. The third baseman was initially  $d_1 = 1.8 \times 10^1\text{m}$  from home plate.~~



- ~~a) Describe the strategy you have chosen for solving this problem. You may want to consider the following issues. What type of coordinate system will you choose? Where is a good place to choose your origin?~~
- ~~b) What was the initial speed and angle of the softball when it left the bat?~~
- ~~c) Write down a vector expressions for the position and velocity of the softball 0.1 s before the ball was caught?~~

**Problem 4:** (Experiment 3 Modeling Forces Three Pre-Lab Question)

In your *Experiment 3: Modeling Forces*, you will measure the magnitude of the force  $|\vec{F}|$  between small magnets as a function of the distance  $x$  between the centers of the magnets.

- Suppose the magnitude of the force decreases exponentially according to  $|\vec{F}| = ae^{-bx}$  where  $a$  and  $b$  are constants. Suppose you plot the natural logarithm of the magnitude of the force,  $\ln|\vec{F}|$ , vs. the distance  $x$  between the centers of the magnets. What information can you deduce from the slope of this plot?
- Suppose for some range of separation of the magnets, the magnitude of the force obeys a power law,  $|\vec{F}| = cx^d$  where  $c$  and  $d$  are constants. Describe a graphical procedure which we enable you to determine the power law constant  $d$ .

Hence the initial angle was

$$\tan \theta_0 = \frac{v_{y0}}{v_{x0}} = \frac{g\Delta t^2}{2(d_1 + v_1\Delta t)} \approx 0.55 \approx 31.5^\circ \quad (19)$$

and the initial velocity was

$$v_0 = \sqrt{v_{x0}^2 + v_{y0}^2} = 18.8 \text{ m/s} \quad (20)$$

c) The moment of time corresponding to 0.1 s before the ball was caught is  $t = \Delta t - 0.1$  s. Using (16) and (17), we obtain

$$x = 30.4 \text{ m} \quad v_x = v_{x0} = 16 \text{ m/s} \quad (21)$$

$$y = 0.9 \text{ m} \quad v_y = -8.8 \text{ m/s}, \quad (22)$$

which can be written in vector form as

$$\vec{r} = (30.4\vec{i} + 0.9\vec{j}) \text{ m} \quad (23)$$

and

$$\vec{v} = (16\vec{i} - 8.8\vec{j}) \text{ m/s}. \quad (24)$$

Here  $\vec{i}$  and  $\vec{j}$  are vectors of unit length in the direction of  $x$  and  $y$  correspondingly.

#### Problem 4. Pre-Lab question.

a) Since  $\ln |\vec{F}| = \ln a - bx$ , the tangent of slope of the graph gives constant  $b$ :  $\tan \theta = -b$ .

b) This time  $\ln |\vec{F}| = \ln c + d \ln x$ . Hence  $d$  can be obtained from the slope of the graph of  $\ln |\vec{F}|$  vs  $\ln x$ .

#### Problem 5. Experiment 2 Data analysis.

**Part A** We performed the projected ball experiment. The tube was set at the angle  $\theta_0 = 30^\circ$  and the exit point was  $1.21 \text{ m}$  above the ground. We estimate the uncertainty in the measurement of height to be  $2 \text{ mm} = 2 \cdot 10^{-3} \text{ m}$