PHYS 172 – Fall 2010 Exam 2 **Hand-written Portion (30 points total)**

Name (Print): ______________________________

Signature: ______________________________

PUID: ______________________________

You will lose points if your explanations are incomplete, if we can't read your handwriting, or if your work is sloppy.

Hand-Written Problem: Tossing a Ball

You toss a ball (mass = 140 g) straight up into the air. The ball leaves your hand with a speed of 10 m/s, at a height of 1.5 meters above the ground, such that the initial position vector is <0,1.5,0> m. Our unit vectors are defined such that the y-direction points straight up into the air.

In this problem you'll use the energy principle to predict the speed of the ball when it has reached a certain height. You'll also compute how high the ball will rise before it starts falling back down.

Consider two possible choices for "system" and "surroundings".
Choice 1: The system includes everything in the universe.
Choice 2: The system consists of just the ball. All else resides in the surroundings.

In parts A-D, assume Choice 2 for the system and surroundings.

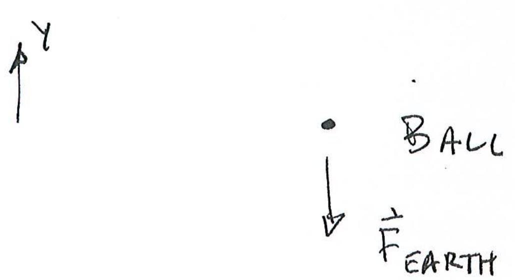
A. (5 points) The energy principle is $\Delta E_{system} = W_{external} + Q$. Express all of the terms in the energy principle for this selection of system and surroundings.

$$\Delta E_{SYS} = \Delta K = W_{EXT} = W_{EARTH} + W_{AIR} + \cancel{Q}^{\to 0}$$

−1 pt for EACH missing term (ΔK, W_{EARTH}, W_{AIR})

−2 if ΔU is included!

B. (5 points) List the external objects that interact significantly with the system. Make a carefully labeled free-body diagram showing the interaction between each object in the surroundings with each object in the system.



IGNORE { DRAG, HEAT FLOW

C. (8 pts) Use the energy principle to find the speed of the ball when it has risen to the position <0, 3, 0> m. Show all steps, clearly identify your initial and final states, indicate any approximations you're making, include units, and **circle the final answer**.

We suggest working with symbols, simplifying the algebra, and then plugging in numbers only at the end. (This will help you in part D).

$$\Delta K = \frac{1}{2}m\left(v_f^2 - v_i^2\right) = W_{EARTH} = \vec{F}_{EARTH} \cdot \Delta\vec{x}$$

$$= \langle 0, -mg, 0\rangle \cdot \langle 0, y_f - y_i, 0\rangle = -mg\left(y_f - y_i\right)$$

$$v_f^2 = v_i^2 - 2g\left(y_f - y_i\right)$$

$$= 10^2 - 2\cdot(9.8)(1.5)$$

$$v_f = 8.4 \text{ m/s}$$

D. (8 points) Use the energy principle to find the maximum height of the ball above the ground. Show all steps, clearly identify your initial and final states, indicate any approximations you're making, include units, and **circle the final answer.** You may quote any results that you derived in part C.

$\vec{x}$ $\vec{v}$

INITIAL STATE: $\langle 0, 1.5\,m, 0\rangle, \langle 0, 10\,\frac{m}{s}, 0\rangle$

final state: $\langle 0, y_f, 0\rangle, \langle 0, 0, 0\rangle$

$\Delta K = W_{EARTH}$

$\frac{1}{2} m(v_f^2 - v_i^2) = -mg(y_f - y_i)$

$v_f = 0$

$\frac{1}{2}\frac{v_i^2}{g} + y_i = y_f$

$\frac{1}{2}\frac{(10)^2}{9.8} + 1.5 = y_f = 6.6\,m$

E. (4 points) If you had taken Choice 1 as system and surroundings, how would your expression for the terms in the energy principle $\Delta E_{system} = W_{external} + Q$ have changed?

$W_{ext} = 0$, MUST INCLUDE POTENTIAL ENERGY TERM

$\Delta E_{sys} = \Delta K + \Delta U = 0$

$= \frac{1}{2} m(v_f^2 - v_i^2) + mg(y_f - y_i) = 0$