PHYS 101: General Physics 1 **KOÇ UNIVERSITY** **Fall Semester 2011**

College of Sciences

Section 5 **Quiz 1** **29 September 2011**

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

Determined to test the law of gravity for himself, a student walks off a skyscraper 180 m high, stopwatch in hand and starts his free fall (zero initial velocity). Five seconds later, superman arrives at the scene and dives off the roof to save the student. Superman leaves the roof with an initial speed v_0 that he produces by pushing himself downward from the edge of the roof with his legs of steel. He then falls with the same acceleration as any freely falling body.

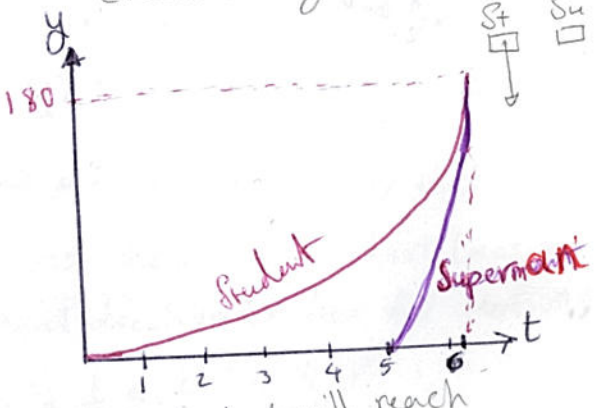
a) What must the value of v_0 be so that superman catches the student just before they reach the ground?

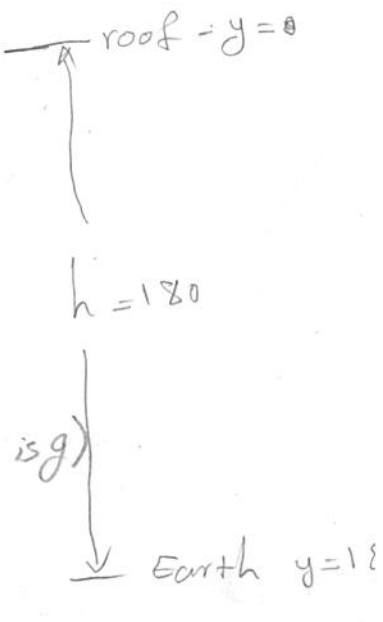
b) On the same graph, sketch the positions of the student and of superman as functions of time. Take superman's initial speed to have the value calculated in part (a).
(take g=10 m/s^2)

choosing the roof as origin of coordinates and direction of +y axis downward we have:

At $t_0 = 0 \Rightarrow \begin{cases} V_{St_0} = 0 \\ V_{Su_0} = 0 \end{cases}$

At $t_1 = 5s \Rightarrow \begin{cases} V_{St_1} = ? \\ V_{Su_1} = V_0 \end{cases}$





At $t_2 = ?$ => the moment that Student will reach earth with free-falling acceleration (that is g) will be determind by equation of motion

for Student:

$y_{St_2} = y_{St_0} + V_{St_0} t_2 + \frac{1}{2} a_{St} t_2^2 \Rightarrow 180 = 0 + 0 + \frac{1}{2} \times 10\, t_2^2$

$\Rightarrow t_2 = 6$ m/s

So Superman should go from roof to earth ($h = 180$ m) in $\Delta t = 6 - 5 = 1s$ with $a_{S_4} = 10 m/s^2$ and v_0, So we will write equation of motion with initial velocity of v_0

$y_{Su_2} - y_{Su_1} = v_0 \Delta t + \frac{1}{2} 10\, \Delta t^2$

$180 = v_0 \times 1 + 5 \times 1$

$v_0 = 175$ m/s (a)

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Section 4 Quiz 1 29 September 2011

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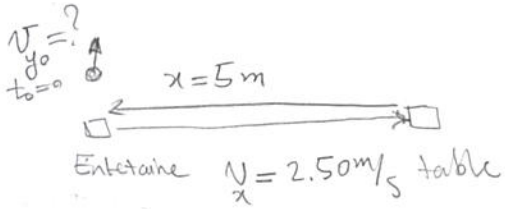
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

An entertainer juggles balls while doing other activities. In one act, she throws a ball vertically upward and while it is in the air, she runs to and from a table 5.0 m away at a constant speed of 2.50 m/s, returning just in time to catch the ball.

a) With what minimum initial speed must she throw the ball upward to accomplish this feat?
b) How high above its initial position is the ball just as she reaches the table?

(take g=10 m/s^2)



The time she will spend to go to table and come back will be given by equation of motion for constant velocity ($v_x = 2.5\,m/s$).

So we have: $\Delta x = v_x \Delta t \Rightarrow \Delta t = \frac{10}{2.5} = 4\,s$

she should throw the ball with an initial velocity such that it takes 4s for ball to go up and come back to ground as she arrives to first location so we should write equation of motion in vertical direction for free fall motion:

$$y_1 - y_0 = \frac{1}{2} a_y \Delta t^2 + v_{y_0} \Delta t$$

$$0 = \frac{-1}{2} \times 10 \times 4 + v_{y_0} = 0 \Rightarrow \boxed{v_{y_0} = 20\,m/s} \quad (a)$$

when she reaches table just half of the time elapses so we can find the height of ball by equation of motion at $t = 2\,s$

$$y = y_0 + \frac{1}{2} a_y t^2 + v_{y_0} t \Rightarrow y = 0 - \frac{1}{2} \times 10 \times 2^2 + 20 \times 2 = 20\,m \quad (b)$$

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Section 2 Quiz 1 29 September 2011

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Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A flowerpot falls off a windowsill and falls past the window below. You may ignore air resistance. It takes the pot 0.2 s to pass from the top to the bottom of this window, which is 1.80 m high. How far is the top of the window below the windowsill from which the flowerpot fell?
(take g=10 m/s^2)

We can take positive direction of y axis downward

given information are:

$y_2 - y_1 = 1.80\,m$

$t_2 - t_1 = 0.2\,s$

$g = 10\,m/s$

$y_0 = 0 \;, t_0 = 0 \;, v_0 = 0$

$y_1 = ? \;, t_1 = ? \;, v_1 = ?$

$y_2 = ? \;, t_2 = ? \;, v_2 = ?$

In free fall motion we can write equation of motion from t_1 to t_2 to find v_1

$$y_2 - y_1 = v_1(t_2 - t_1) + \frac{1}{2} g (t_2 - t_1)^2 \Rightarrow 1.80 = v_1 \times 0.2 + \frac{1}{2} \times 10 \times (0.2)^2$$

$$1.80 - 0.2 = 0.2 \times v_1 \Rightarrow v_1 = \frac{1.6}{0.2} = 8\ m/s$$

Then we will write again the time independent equation of motion between $t_0 \rightarrow t_1$ or $v_0 \rightarrow v_1$ to find $\Delta y = y_1 - y_0$ that is distance between windowsill and top of the window.

$$v_1^2 - v_0^2 = 2g(y_1 - y_0) \Rightarrow \Delta y = y_1 - y_0 = \frac{64}{2 \times 10} = 3.2\ m$$

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Section 1 **Quiz 1** **29 September 2011**

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Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

A ball is thrown straight up from the ground with speed v_0. At the same instant, a second ball is dropped from rest from a height of H, directly above the point where the first ball was thrown upward. There is no air resistance.

a) Find the time at which the two balls collide. (in terms of v_0 and H)

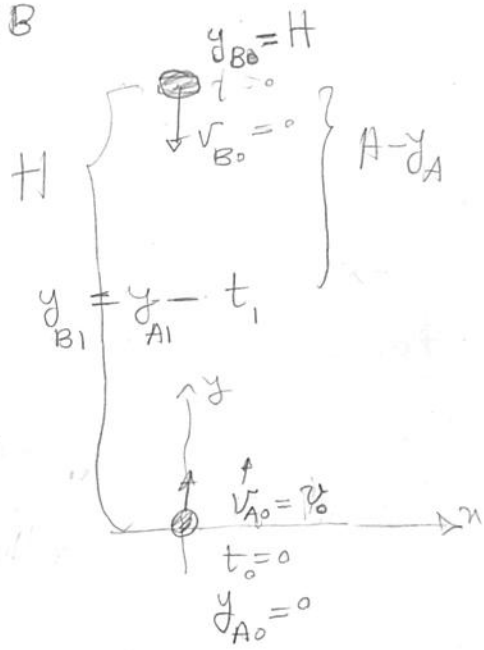
b) Find the value of H in terms of v_0 and g so that at the instant when the balls collide, the first ball is at the highest point of its motion.

Suppose that two balls will collide at moment t_1

So at moment t_1 position of ball A will be equall to ball B

$y_{A1} = y_{B1}$, both of motion are free falling

If we take upward as positive y we can write equation of motion for two balls in the same coordinate system as:



(1) $y_{A1} = y_{A0} + V_{A0}(t_1 - t_0) - \frac{1}{2} g (t_1 - t_0)^2$

(2) $y_{B1} = y_{B0} + V_{B0}(t_1 - t_0) - \frac{1}{2} g (t_1 - t_0)^2$ $\Rightarrow$

t_1 is the time at which two balls collide

$\Rightarrow y_{A1} = y_{B1} \Rightarrow v_0 t_1 - \frac{1}{2} g t_1^2 = H - \frac{1}{2} g t_1^2$

$\Rightarrow \boxed{t_1 = \frac{H}{v_0}}$ (3) (a)

Velocity of ball A at its maximum will be zero so we have: $v_{A1}^2 - v_{A0}^2 = -2 g y_{A1}$

$y_{A1} = \frac{v_0^2}{2g}$ (4), and we can substitute (3), (4) to (1) to reach:

$\frac{v_0^2}{2g} = v_0 \frac{H}{v_0} - \frac{1}{2} g \frac{H^2}{v^2} \Rightarrow g H^2 - 2 v_0^2 H + \frac{v_0^4}{g} = 0 \Rightarrow \left(H - \frac{v_0^2}{g}\right)^2 = 0$

$\boxed{H = \frac{v_0^2}{g}}$ (b)

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Section 3 **Quiz 1** **29 September 2011**

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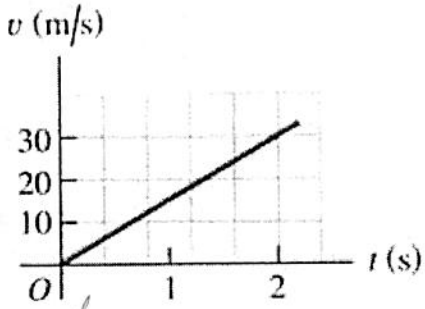
Quiz duration: 15 minutes

Name: **Student ID:** **Signature:**

On Planet X, you drop a stone from rest and measure its speed at various times. Then you use the data you obtained to construct a graph of its speed v as a function of time t. From the information in the graph, answer the following questions.

a) What is g on Planet X?
b) An astronaut drops a piece of equipment from rest out of the landing module, 30.0 m above the surface of Planet X. How long will it take this equipment to reach the ground and how fast will it be moving when it gets there?



a) g is the acceleration for this motion or the slop of the v-t graph. so we can write:

$$g = \frac{\Delta v}{\Delta t} = \frac{30-0}{2-0} = 15\ m/s^2 \quad (a)$$

b) part(b) is a simple free-falling problem with gravitational acceleration of $a = -g = -15\ m/s^2$ so we can write: $y_f - y_i = v_0 t - \frac{1}{2} g t^2$

$$0 - 30 = 0 \times t - \frac{1}{2} \times 15 \cdot t^2 \Rightarrow t = \sqrt{\frac{30 \times 2}{15}} = 2\ s \quad (b)$$

$$v_f - v_i = -gt$$

$$v_f = -15 \times 2 = -30\ m/s \quad \text{downward} \quad (b)$$