Physics 161, Homework 3

Due 12:00 pm, Friday, Feb 26; No Exceptions

Lubna Rana, Sections 0201-0206

Read Chapter 4 Sections 4.3- 4.6 by Monday, Feb 23; Start Ch 5 after that.

Short Answer Questions: S1, S2, S3, S4, S5: Problems P1, P2, P3, P4, P5, P6 = Serway & Beichner Ch 4, P 40.

Special Note: Please always:

1). PRINT your name and SECTION NUMBER CLEARLY on the front page of your HW. Failure to do so will now cost you points.

2). STAPLE all your pages. It is your responsibility to make sure that your hw gets submitted in one piece.

3). DO ALL THE PROBLEMS IN ORDER.

4). Show complete work and write logically consistent explanations for ALL PROBLEMS to receive credit.

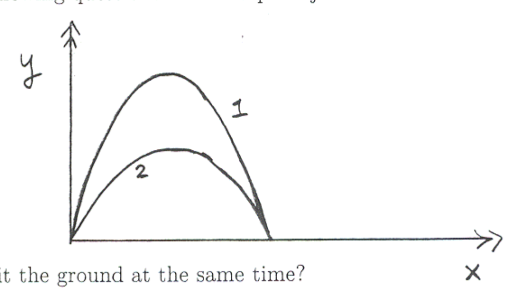
5). Write units next to all dimensionful quantities.

Short Answer Questions

S0). Make sure you have read the special notes 1-5 above.

S1). Figure S1 shows the path of two projectiles with the same range but different maximum heights. Please answer the following questions with complete justification:

a). Can we definitively say that one projectile was thrown with a higher initial vertical velocity v_{0y} than the other? Why or why not?



b). Is there any way in which both projectiles can have the same flight time, i.e., if fired simultaneously they hit the ground at the same time?

c). Could the two projectiles have been thrown with the same initial speed? If not, then which one has the higher initial speed?

S2). Suppose I take a ball and <u>throw</u> it with speed v_0 straight down at the floor, and I take another ball and throw it with the same initial speed but in a direction parallel to the floor.

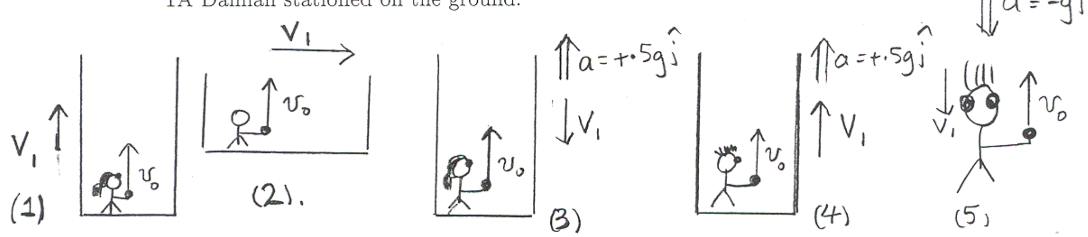
a). First give a physical argument as to which one takes less time to hit the floor.

b). Now find the exact expression for the time it takes each ball to reach the ground.

S3). Read Example 4.4, Serway & Beichner page 87-88. In the last paragraph, the textbook states a certain relation between v_i, $sin\theta$, g and d. Derive this condition.

S4. An object moving through a fluid, such as air, experiences a "drag force" that is directed opposite to its velocity. In many cases, the magnitude of this drag force is propotional to the square of the speed. (I know we haven't discussed forces yet. For now just assume that the acceleration due to this drag force is directed opposite to the velocity and propotional to the square of the instantaneous speed.) Would you expect the effects of air resistance to be greater on the horizontal or the vertical motion of a projectile fired at 45^0 to the horizontal. Why or why not? On the same graph, plot the "ideal" as well as the trajectory in the presence of air drag for such a projectile.

S5). Five Physics 161 students are placed in five different laboratories. Each of the five students have synchronized their clocks and at a pre-arranged time all five of them are going to throw a ball up at a speed v_0 as measured by each one in their respective lab. **At that instant**, the labs are moving in the following ways as observed by their TA Damian stationed on the ground:



Student 1: Lab moving vertically upwards with constant speed V_1 with respect to Damian.

Student 2: Lab moving horizontally to the left with constant speed V_1 with respect to Damian.

Student 3: Lab moving down with speed V_1 but accelerating upwards with $\vec{a} = +0.5g\,\hat{j}$ as recorded by Damian. (*Hmmm...moving down but accelerating upwards...is that possible? You can ask now, but you should never have to ask again.)*

Student 4: Lab moving upwards with speed V_1 at that instant and accelerating upwards with $\vec{a} = +0.5g\,\hat{j}$ as recorded by Damian.

Student 5: Student thrown out of a plane, falling freely with speed V_1 at that instant and acceleration of course equal to the acceleration due to gravity $\vec{a} = -g\hat{j}$ as measured by Damian. (*Assume negligible air friction*).

Question: Rank the time to reach maximum height (if applicable) by the ball in each lab as measured by the student in that lab as well as that measured by Damian. Assume that the magnitude of v_0 is greater than the magnitude of V_1, i.e., $|v_0| > |V_1|$.

Problems

P1). The Accelerated Funnel Cart. This problem relates to the demo with the accelerated funnel cart and the ball. Recall that we did the demo two ways: In Case I, when we accelerated the cart (with negligible friction) using a hanging weight, the cart sped up while the ball was in the air so the ball fell behind. However, in Case II, i.e., when we accelerated the cart by letting it slide down an incline (with negligible friction), the ball landed back in the cart.

a). First try to resolve the difference in the two outcomes by analyzing the problem physically. Try to pin down the key difference between the ball's motion after it is launched.

b). Now decide on a convenient coordinate system to analyze each case. Report your choice of the coordinate system in each case. Now write down an expression for $\vec{r}_{cart}(t)$ and $\vec{r}_{ball}(t)$ for the cart and the ball for Case I and Case II. (*Remember that we found that the acceleration of the cart along the incline is given by* $g\,sin\theta$.) Use these expressions to explain the fact that the ball falls behind the cart in one case and lands back in the cart in the other.

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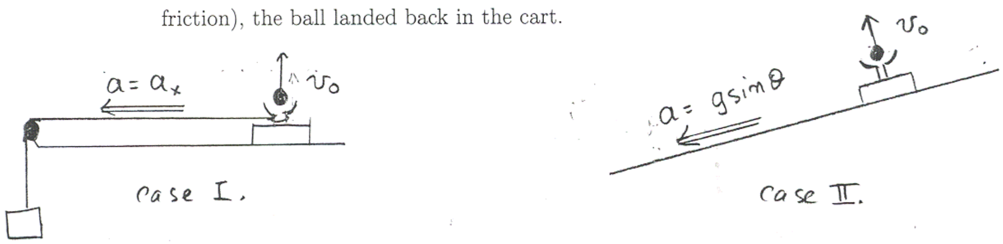

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P2). A projectile lands at the level from which it was fired.

a). For what initial angle is the horizontal range equal to the maximum height?

b). For what initial angle is the range equal to half the maximum height.

c). Prove Galileo's prediction that for initial angles of projection, $\theta_1 = 45^0 - \alpha$ and $\theta_2 = 45^0 + \alpha$, the horizontal ranges are the same.

P3). A projectile is fired with an initial speed v_0 at an angle θ above the horizontal from a point h as is Fig P3.

a). Find the horizontal range in terms of v_0, θ, g and h.

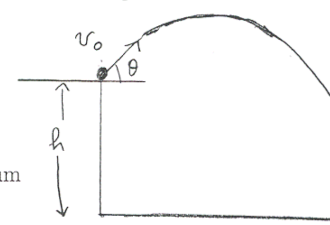

Fig P3

b). As shown in the textbook, the maximum range for a projectile for which the initial and the final height are the same is achieved at a launch angle of 45^0. Do you expect the same result to hold in this case where $y_i \neq y_f$ or should the launch angle be smaller or larger. Support your answer with a physical argument.(*Hint: Drawing a diagram helps.*)

P4). In Fig P4, a trail bike takes off from a ramp at angle θ to clear a ditch of width x and land on the other side, which is elevated at a height H.

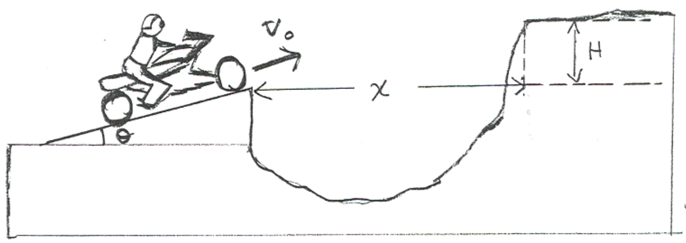

Fig P4.

a). For a given angle θ and distance x, what is the upper limit for H such that the bike has any chance of making the jump?

b). For H less than this upper limit, what is the minimum take-off speed v_0 necessary for a successful jump? (Neglect the size of the bike, and assume that covering a horizontal distance x and a vertical distance H is sufficient to clear the ditch.)

P5). The position of a particle is given by the vector:

$$\vec{r}(t) = -10m\,cos\omega t\,\hat{i} + 10m\,sin\omega t\hat{j}$$

where $\omega = 2s^{-1}$.

a). Show that the motion is a circle. What is the radius of the circle?

b). What is the velocity $\vec{v}(t)$?

c). What is the acceleration $\vec{a}(t)$ What is the magnitude of the acceleration? Does the particle have a tangential acceleration?

d). Express the particle's position $\vec{r}(t)$, velocity $\vec{v}(t)$ and acceleration $\vec{a}(t)$ in terms of unit vectors $\hat{\theta}$ and $\hat{r}$.

P6). Serway & Beichner , Chapter 4, Problem 40.