PHY151H1F FALL 2022 HW1

Prakash Shivesh

TOTAL POINTS

18 / 24

QUESTION 1

1 Question 1 11 / 12

✓ + **6 pts** Accuracy and Logic

✓ + **6 pts** Explanation

- **1** Point adjustment

Accuracy and Logic: 6/6, Explanation: 5/6

1 How did you get this?

QUESTION 2

2 Question 1cont. 0 / 0

✓ - **0 pts** Correct

should be included in the first part of the question marks

QUESTION 3

3 Question 2 7 / 12

+ **4 pts** Communicating Assumptions

✓ + **4 pts** Solving the Physics Problem

+ **4 pts** Evaluating the Answer

✓ + **3 pts** Communicating Assumptions

+ **3 pts** Solving the Physics Problem

+ **3 pts** Evaluating the Answer

+ **2 pts** Communicating Assumptions

+ **2 pts** Solving the Physics Problem

+ **2 pts** Evaluating the Answer

+ **1 pts** Communicating Assumptions

+ **1 pts** Solving the Physics Problem

+ **1 pts** Evaluating the Answer

+ **0 pts** Solving the Physics Problem

+ **0 pts** Communicating Assumptions

✓ + **0 pts** Evaluating the Answer

+ **0 pts** No submission

If you check the rubric for the written homework on quercus it will state that the evaluation portion of the modelling problem is worth 4 marks and has the criteria: 4 marks for evaluating your answer for being reasonable as follows:

– 4/4 marks for evaluating whether the answer was reasonable by comparing it with a simple solution using the given numerical values and dimensional analysis or similar arguments.

– 3/4 marks for evaluating whether the answer was reasonable by comparing it with an intuited estimate which was vaguely explained and based on the given numerical values.

– 2/4 marks for evaluating whether the answer was reasonable by comparing it with a reasonable, intuited value without any justification for the intuited value.

– 1/4 marks for evaluating whether the answer was reasonable by comparing it with an unreasonable value.

– Note: if the answer is unreasonable and you correctly identify this you get full credit for the evaluation step. If you cannot solve the problem at all except for a trivial solution using dimensional analysis, it's still worth at least 4/12 total.

2 do not need both assumptions

3 did not evaluate answer

4 need to state that you are assuming constant acceleration of 9.8 for both balls before they hit terminal velocity

5 for the pingpong ball falling at a constant acceleration of g it will have a velocity of 15.6 m/s after 1.59 s so this contradicts your assumption that

the terminal velocity is 9.5 m/s (large difference)

6 alternatively, if we assume that the terminal velocity of 9.5 m/s is correct then it would only take 0.97s to reach it not 1.59s (again large difference)

QUESTION 4

4 Question 2cont 0 / 0

✓ **- 0 pts Correct**

should be included in the first part of the question marks

PHY151 Written Homework 1

Due Sept. 25, 2022

Two questions, one per page

Please check out the rubrics on Quercus before submitting this

1. Traditional Problem: A rubber ball is shot straight up from the ground with speed v_0. Simultaneously, a second rubber ball at height h directly above the first ball is dropped from rest. At what height do the balls collide? What's the maximum value of h such that this is a well-posed question?

The first takes a total time of $\frac{2V_0}{g}$ seconds to go up and fall back to the ground. For this question to be well-posed the collision between the two balls must happen before the first ball hits the ground.
Let τ be a time in the time interval $0 \rightarrow \frac{2V_0}{g}$, the position of the first ball with respect to the ground at can be calculated as: $h_1 = V_0 \tau - \frac{1}{2} g \tau^2$ (from $s = v_i t + \frac{1}{2} a t^2$)

The position of the second ball with respect to ground at any time is given by:
$h_2 = h - \frac{1}{2} g \tau^2$ (from $s = v_i t + \frac{1}{2} a t^2$. where $s = h_2 - h$)

Now, for the balls to collide at time τ, their position with respect to the ground must be same. This implies --> $h_1 = h_2 \Rightarrow V_0 \tau - \frac{1}{2} g \tau^2 = h - \frac{1}{2} g \tau^2$

$\Rightarrow V_0 \tau = h$

$\Rightarrow \tau = \frac{h}{V_0}$

Using this we can find the position of the collision with respect to he ground to be:

$$h_1 = h_2 = h - \frac{1}{2} g \left(\frac{h}{V_0}\right)^2 = h - \frac{gh^2}{2V_0^2} = d$$

For this collision to be valid the time τ must be less than $\frac{2V_0}{g}$ and the position of collision $d \geq 0 \Rightarrow$

$\tau \leq \frac{2V_0}{g}$

$\Rightarrow \frac{h}{V_0} \leq \frac{2V_0}{g}$

$\Rightarrow h \leq \frac{2V_0^2}{g}$

$d \geq 0$

$h - \frac{gh^2}{2V_0^2} \geq 0$

$\cancel{h} \geq \frac{gh^{\cancel{2}}}{2V_0^2}$

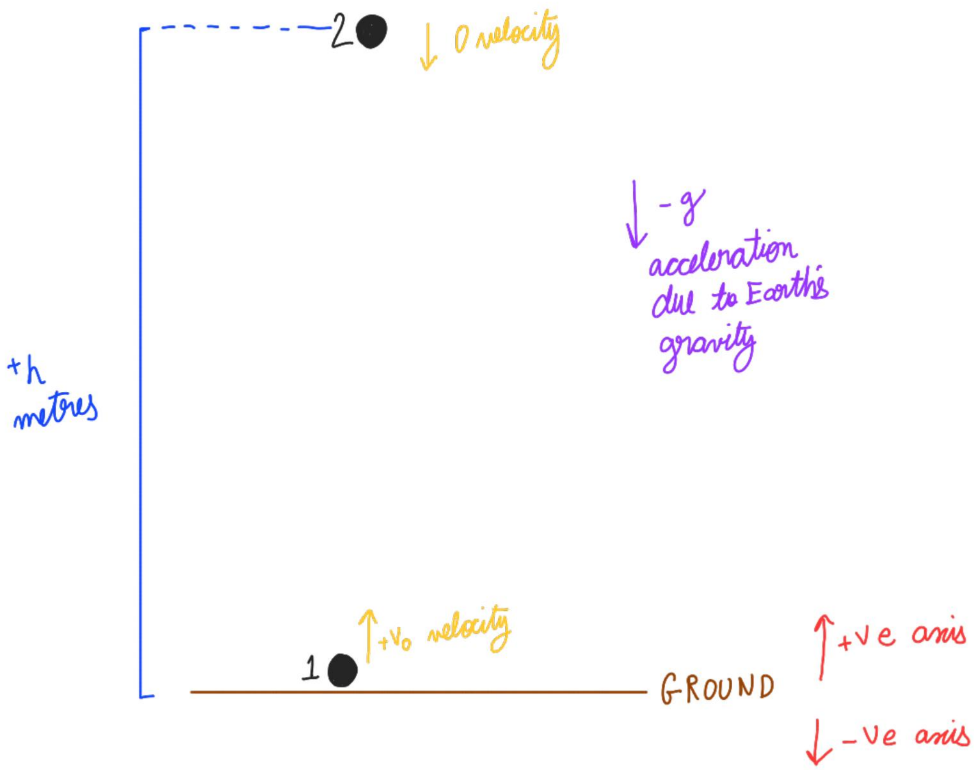
$2V_0^2 \geq gh$

$h \leq \frac{2V_0^2}{g}$

Both the argument lead to the same conclusion which is that for this to be a well poised question h must be less than $\frac{2V_0^2}{g}$. The position of the collision is $h - \frac{gh^2}{2V_0^2}$ and the time of the collision is $\frac{h}{V_0}$.

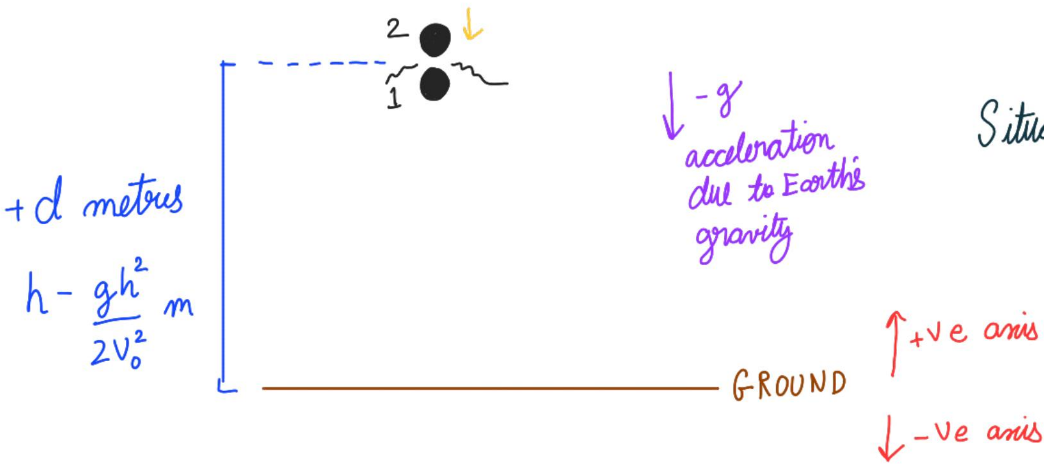
Some important assumptions made here are that air resistance is insignificant and none of the balls reach terminal velocity. Another crucial assumption made is that the complete motion takes place strictly in one dimension with no deviations.

Question 1 continued (if needed)



Situation at time

$t = 0$ s



Situation at time

$t = \tau$

$= \frac{h}{v_0}$ s

2. Modelling Problem: If you drop a steel ball and a ping pong ball from a 50 m tall building, estimate the time delay between when they hit the ground. Note: a ping pong ball will definitely reach terminal speed (constant speed) if it falls from that great a height as you cannot ignore the air for a ping pong ball falling that height. Also note: you are NOT expected to consider the drag force here, just make some simple assumptions about the motion of the ping pong ball.

The measured terminal velocity of a ping pong ball is 9.5 m/s, 98% of which is attained after falling 12.5 m. Source: American Journal of Physics, Volume 52, Issue 10, pp. 890-893 (1984). Continuing with this assumption, let's calculate the time taken for the ping pong ball to reach the ground.

Time taken by the ping pong ball to fall 12.5 m --> $12.5 = \frac{1}{2} g t_1^2$ (from $S = U_i t + \frac{1}{2} a t^2$)

$$\Rightarrow t_1^2 = \frac{25}{9.8} = 2.55$$

$$\Rightarrow t_1 = 1.59 \text{ seconds}$$

Time taken by the ping pong ball to fall 37.5 m further with terminal velocity --> $t_2 = \frac{37.5}{9.5}$ (from $V = \frac{d}{t}$)

$$\Rightarrow t_2 = 3.95 \text{ seconds}$$

Thus the total time taken by the ping pong ball to reach the ground is -->

$$t_1 + t_2 = 1.59 + 3.95 = 5.54 \text{ seconds} = t_3$$

The time taken by the steel ball to reach the ground, assuming it doesn't reach terminal velocity -->

$$t_4 = \sqrt{\frac{2 \times 50}{9.8}} \quad \left(\text{from } t = \sqrt{\frac{2h}{g}}, \text{ where acceleration is constant}\right)$$

$$\Rightarrow t_4 = \sqrt{\frac{100}{9.8}} = \sqrt{10.2} = 3.19 \text{ seconds}$$

Therefore, the time delay between the ping pong and steel ball is --> $t_3 - t_4 = 5.54 - 3.19$

$$= 2.35 \text{ seconds}$$

Quest 2 continued (if needed)