Projectile motion

Identification page

Instructions: Print this page and the following ones before your lab session to prepare your lab report. Staple them together with your graphs at the end. If you forgot to print it before your lab, you can reproduce it by hand but you have to follow the exact format (same number of pages, same items on each page, same space to answer question).

Complete all the identification fields below or 10% of the lab value will be deduced from your final mark for this lab.

For in-lab reports, hand in your report to your demonstrator at the end of the sessions or you will receive a zero for this lab.

For take-home reports, drop your report in the right box or 10% of the lab value will be deduced from your mark. Refer to the *General information* document for the details of the late report policy.

Experiment title: Projectile motion ____________________

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Name: ______________________________

Student number: ______________________________

Lab group number: ______________________________

Course code: PHY ______________________________

Demonstrator: ______________________________

Date of the lab session: ______________________________

Partner's name: ______________________________

Data sheet

Instructions: This lab report is due at the end of the lab session. We recommend completing the *Data sheet* before starting the *Questions* section.

Basic launching procedure

[1] Record the data displayed by the Logger Pro program during a launch in the table below.

Table 1 – Data recorded by the software during a launch

Time (s)	GateState	PT (s)	Speed (m/s)

Measuring the launch velocity

[4] **Table 2 - Measuring the initial velocity**

Trial	Launch velocity v_0 (m/s)
1	
2	
3	
4	
5	

Complete the lines below using the above values for v_0 (you can use *Excel* to do this). Keep 3 decimal places.

Average, $\overline{v_0}$	
Standard deviation	
Standard error	

Predict the time of flight from the launch velocity

[4] Calculate the time of flight, t_{cal}, and the horizontal range, x_{cal}. Do the proper error calculations. Consider only the uncertainties on $\overline{v_0}$ (i.e., assume $\theta = 45° \pm 0°$).

[4] **Table 3 - Measuring the time of flight**

Trial	**Time of flight** **t** **(s)**
1	
2	
3	
4	
5	

Complete the lines below using the above values for *t* (you can use *Excel* to do this). Keep 3 decimal places.

Average, $\bar{t}_{\mathrm{exp}}$	
Standard deviation	
Standard error	

Attempt to hit a target

[4] Calculate the horizontal distance, $x_{\text{prediction}}$, where the target should be placed to be hit by the projectile (no need for error propagation calculation).

SHOULD BE COMPLETED BY YOUR TA (TA SHOULD WRITE HIS/HER INITIALS):
$\theta =$ ____________________ (a value between 50° and 70°, increment by 5°)
$y =$ ____________________ (a value between 20 cm and 25 cm, increment by 1 cm)

[2] How many points did you get for your three shots in the presence of your TA. You'll get the sum of these points or a maximum of 2 points. If you get zero, you will have a chance to get half the points back in the *Questions* section.

SHOULD BE COMPLETED BY YOUR TA (TA SHOULD WRITE HIS/HER INITIALS):		
Shot 1: _______ points.	Shot 2: _______ points.	Shot 3: _______ points.

Conservation of energy

[1] Estimate the maximum height of the ball compared to the launching point

$h_{\max} = (\_\_\_\_\_\_\_\_\_\_ \pm \_\_\_\_\_\_\_\_\_\_)$

[1] Record the launch velocity (no uncertainty) and measure the mass of the ball.

$v_0 = \_\_\_\_\_\_\_\_\_\_$

$m = (\_\_\_\_\_\_\_\_\_\_ \pm \_\_\_\_\_\_\_\_\_\_)$

Questions

Basic launching procedure

[1] Use the data you got to explain how the program calculates the initial speed. Note that the distance between the two photogates is 5 cm.

Measuring the launch velocity

[1] For practical reasons, we measured the launch speed at $\theta = 45°$. Theoretically, it would have been better to do this part at another angle. What is that angle, $\theta = 0°$ or $\theta = 90°$? Are we over or underestimating the launch velocity when we use $\theta = 45°$. Explain.

Predict the time of flight from the launch velocity

[1] Compare your experimental value for the flight time with your prediction (the calculated one). Calculate the percentage difference

$$\%\text{diff} = \left| \frac{t_{\text{cal}} - \bar{t}_{\text{exp}}}{\left(\frac{t_{\text{cal}} + \bar{t}_{\text{exp}}}{2}\right)} \right| \times 100\,,$$

and discuss.

Attempt to hit a target

If you got a zero for this challenge, can you explain what did not work? Give a good explanation and get up to half the points back.

Conservation of energy

[4] Calculate the initial kinetic energy, K, of ball. Calculate the potential energy, U, of the ball at the maximum height. Both energies should be calculated in joules. Calculate the uncertainties considering the errors on m and $h_{\max}$ only.

[1] Compare both energy values. Was energy conserved? Discuss.

[1] If we had access to a hollow steel ball (same size, same surface but lighter), how high would that new ball go compared to the one used for this experiment? Explain. Assume that both balls would have the same initial speed.

Total : ________ / 30 (for the report)