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)**
0.000000	1		
0.004175	0		
0.012520	1	0.012520	3.994
0.016791	0		

Measuring the launch velocity

[4] Table 2 - Measuring the initial velocity

Trial	**Launch velocity v_0 (m/s)**
1	4.007
2	4.223
3	4.232
4	4.183
5	4.274

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

Average, $\overline{v_0}$	4.184 m/s
Standard deviation	0.104 m/s
Standard error	0.047 m/s

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 $\bar{v}_0$ (i.e., assume $\theta = 45° \pm 0°$).**

$v_0 = 4.184$ m/s ± 0.047
$g = 9.81$ m/s^2
$\sin 45° = 1/\sqrt{2}$

$$t = \frac{2(v_0)(\sin\theta)}{g}$$

$$t = \frac{2(4.184\,m/s)(1/\sqrt{2})}{9.81\,m/s^2}$$

$t = 0.603$ s

$$\Delta t = \frac{2\sin\theta}{g} \cdot \Delta \bar{v}_0$$

$$\Delta t = \frac{2(1/\sqrt{2})}{9.81\,m/s^2} \cdot 0.047$$

$\Delta t = 0.007$ s

$\boxed{t_{cal} = 0.603 \pm 0.007\,s}$

$x_{cal} = v_0(\cos\theta)t$

$x_{cal} = 4.184\,m/s(1/\sqrt{2})(0.603s)$

$x_{cal} = 1.78$ m

$$\Delta x = 1.78399m\sqrt{1^2\left(\frac{0.047}{4.184}\right)^2 + 1^2\left(\frac{0.007}{0.603}\right)^2}$$

$\Delta x = 0.02881$ m

$\Delta x = 0.03$ m

$\boxed{x_{cal} = 1.78 \pm 0.03\,m}$

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[4] Table 3 - Measuring the time of flight

Trial	Time of flight t (s)
1	0.613428
2	0.608522
3	0.614447
4	0.614224
5	0.614770

4/4

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

Average, $\bar{t}_{exp}$	0.613 s
Standard deviation	0.003 s
Standard error	0.001 s

Attempt to hit a target

[4] **Calculate the horizontal distance, $x_{prediction}$, 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)

θ = 60° (a value between 50° and 70°, increment by 5°) EJ

y = 22 cm (a value between 20 cm and 25 cm, increment by 1 cm)

$$\boxed{\begin{aligned} V_0 &= 4.184\ m/s \\ g &= 9.81\ m/s^2 \\ y_0 &= 14.6\ cm \end{aligned}}$$

$$y = y_0 + (V_0 \sin\theta)t - \frac{1}{2}gt^2$$

$$0.22m = 0.146m + (4.184(\tfrac{\sqrt{3}}{2}))t - \tfrac{1}{2}(9.81)t^2$$

$$0.074m = 3.623t - 4.905t^2$$

$$-4.905t^2 + 3.623t - 0.074 = 0$$

$$t_{1,2} = \frac{-3.623 \pm \sqrt{(3.623)^2 - 4(-0.074)(-4.905)}}{2(-4.905)}$$

$$t_{1,2} = 0.021023s,\ 0.71765s$$

$$x = (V_0 \cos\theta)t$$

$$x = 4.184m/s \cdot (\tfrac{1}{2})(0.71765s)$$

$$x = 1.5013238m$$

4/4

[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: 0.5 points.	Shot 2: 1 points.	Shot 3: 0.5 points.

EJ

2/2

Conservation of energy

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

1/1 h_{max} = (80.4 cm ± 1 cm)

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

1/1 v_0 = 4.188 m/s

m = (21.4 g ± 0.1g)

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.**

1/1 The program knows the distance between the two photogates (5cm) and can get the time at which the ball passes by each photogate. From this, the initial speed is distance divided by change in time.

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.**

1/1 In theory, it would have been better to launch the initial speed at $\theta = 0°$ since the impact of gravity is minin By measuring it at $\theta = 45°$, the impact of gravity is more pr therefore lowering the initial velocity. This means by doing s we are underestimating the launch velocity.

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**

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

$$\%\text{diff} = \left| \frac{0.603 - 0.613}{\frac{(0.603 + 0.613)}{2}} \right| \times 100 = 1.64\%$$

and discuss.

The experimental value is bigger than the calculated time. This is logical since as the ball is travelling it incounters resistance (from air) which slows it down, thus making it need more time to reach the pad.

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.

[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.**

$K = \frac{1}{2} m v_0^2$

$m = 21.4g \pm 0.1g$

$K = \frac{1}{2}(4.188 m/s)^2 (21.4 g)$

$V_0 = 4.188 m/s$

$K = 187.6709 J$ Should be kg for Joules

$h = 80.4 \pm 1 cm$

3.5/4

$\Delta K = \frac{1}{2} V_0^2 (\Delta m)$

$\Delta U = 168.787\sqrt{\left(\frac{0.1}{21.4}\right)^2 + \left(\frac{0.01}{0.804}\right)^2}$

$\Delta K = \frac{1}{2}(4.188)^2 (0.1g)$

$\Delta U = 2.2426 J$

$\Delta K = 0.8769$

$\Delta U = 2J$ ✓

$\Delta K = 0.9 J$ ✓

$\boxed{U = 169 \mp 2 J}$ ✓

$\boxed{K = 187.7 \mp 0.9 J}$

$U = mgh$

$U = 21.4g \cdot 9.81 m/s^2 \cdot 0.804m$

$U = 168.787 J$ ✓

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

1/1

The potential energy is less than the Kinetic energy value. This means that energy was lost. This is logical as the experiment was not conducted in an isolated system. This means there will be energy loss due to heat, resistance, and other interactions with the system. We do still expect $K = U$.

[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.**

0/1

It would go lower because its mass is less. Since Vo is constant the initial K value would be lower in the hollow ball. Since, ideally, $K = U$, that means the potential energy would have to be lower also. Since g is constant, if U is lower, then h would have to be lower.

Total: 28.5 / 30 (for the report)

= 95%.

$K = U$

$\frac{1}{2} \cancel{m} v_0^2 = \cancel{m} gh$ mass does not matter