Motion on a linear air track

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 <u>all the identification fields below</u> 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: Motion on a linear air track

Name: Sameed Ahmed

Student number: 300366534

Lab group number: A02

Course code: PHY 1124

Demonstrator: Utharsm Singh

Date of the lab session: 28th February, 2024

Partner's name: Nico Lamberti

Data sheet

Instructions: Use a pen to complete this section before the end of the lab session. Ask your TA to initialize your data before you leave the laboratory.

Preliminary manipulations (simple motion on an incline)

[6] Prepare Graphs 1 and 2. Print them to a pdf file. Send the file to yourself by email or save it on a USB key. Print the graphs and attach them at the end of your report.

[1] What are the values of the A and B parameters in the quadratic equation in Graph 1? Provide the units.

$A = (-0.04780 \pm 0.0004178)\ t^2$ $\quad B = (0.4752 \pm 0.004141)\ t$

[1] What are the values of m (slope) and b (Y-intercept) in Graph 2? Provide the units.

$m = (-0.07567 \pm 0.003189)\ m/s^2$ $\quad b = (0.3636 \pm 0.0176)\ m/s$

Part 1 - Determining g on an incline

[1] Record the thicknesses of the 3 discs using the vernier caliper. Provide the units.

Thickness of disc 1 = (1.0 cm $\pm$ 0.05 cm)

Thickness of disc 2 = (2.0 cm $\pm$ 0.05 cm)

Thickness of disc 3 = (2.0 cm $\pm$ 0.05 cm)

[5] Fill the following table (you do not have to provide uncertainties for this table):

Table 1 - Acceleration of a glider sliding down various inclines

Track elevation	Measured height, h (m)	Distance between the legs of the track, d (m)	$\sin\theta$ (h/d)	Acceleration			Average acceleration (m/s²)
				Trial 1 (m/s²)	Trial 2 (m/s²)	Trial 3 (m/s²)	
≈ 1 cm	0.01	1.000	0.01	−0.09882	−0.09874	−0.1004	−0.09932
≈ 2 cm	0.02	1.000	0.02	−0.1985	−0.1974	−0.1951	−0.1970
≈ 3 cm	0.03	1.000	0.03	−0.2940	−0.2927	−0.2919	−0.2929
≈ 4 cm	0.04	1.000	0.04	−0.3898	−0.3864	−0.3853	−0.3873
≈ 5 cm	0.05	1.000	0.05	−0.4833	−0.4839	−0.4864	−0.4845

[4] Prepare Graph 3. Send the file to yourself by email or save it on a USB key. Print the graph and attach it at the end of your report.

Part 2 - Investigating Newton's second law

[1] Measure the mass of the glider with string attachment:

$M = (\ 191.4 \pm 0.1\ )\ g$

[5] Fill the following table (you do not have to provide uncertainties for this table):

Table 2 - Acceleration of a glider horizontally pulled by various forces

Hanging mass description	Hanging mass, m (g)	$m' = \dfrac{m}{M+m}$	Acceleration Trial 1 (m/s²)	Acceleration Trial 2 (m/s²)	Acceleration Trial 3 (m/s²)	Average acceleration (m/s²)
Empty hook	4.9	0.025	0.2320	0.2328	0.2348	0.2332
Hook + ≈ 5 g	9.9	0.049	0.4760	0.4738	0.4773	0.4757
Hook + ≈ 10 g	14.9	0.072	0.7041	0.7040	0.7012	0.7031
Hook + ≈ 15 g	19.9	0.094	0.9226	0.9200	0.9222	0.9216
Hook + ≈ 20 g	24.9	0.115	1.133	1.132	1.128	1.131
Hook + ≈ 25 g	29.9	0.135	1.340	1.338	1.327	1.335

[4] Prepare Graph 4. Send the file to yourself by email or save it on a USB key. Print the graph and attach it at the end of your report.

Questions

Instructions: You can finish this section at home. We encourage you to start answering these questions while you are still in the lab and the TA is available to help you.

Preliminary manipulations (simple motion on an incline)

[2] On Graph 2, identify the moment(s) when the glider was:

- being pushed by your hand;
- moving freely up the ramp;
- farthest from its initial position;
- rolling freely down the ramp.

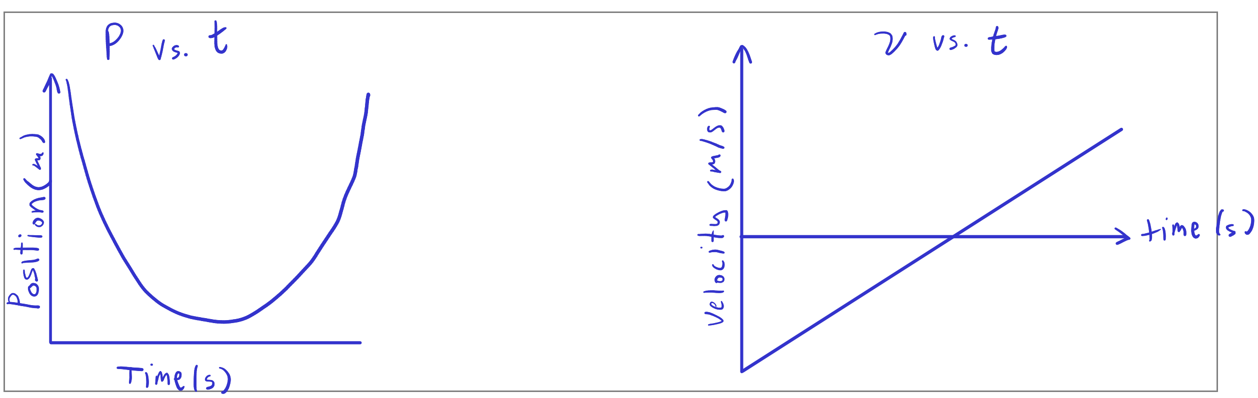
[2] The slope of a graph represents the rate of change of the variables that were plotted. What can you say about the rate of change of the velocity as a function of time while the cart was rolling freely? In your discussion, you will give a name to this quantity. What is the significance of the algebraic sign of the slope?

The slope of the graph displays the change in velocity over time, as the force of gravity pulling down on the object increases as it slides down the incline. The graph displays the coefficient of gravity. The algebraic sign is negative because is accelerating down the ramp, and travelling in a negative direction

[1] What is the relationship between A and m? Between B and b?

m is seen as almost double A whilst B is almost the same as b. However, this is due to inaccuracies in measurement

[2] Qualitatively sketch the position vs. time and velocity vs. time graphs you would get if the motion detector was placed at the other end of the track.



Part 1 - Determining g on an incline

[1] Use the linear fit from Graph 3 to determine your experimental value for g with uncertainty.

$g = ($ 9.607 $\pm$ 0.03034 $)\ m/s^2$

[1] Compare your value of g with the accepted value of 9.81 m/s^2. Calculate the percentage difference

$$\%\text{diff} = \left|\frac{g_{\text{accepted}} - g_{\text{experimental}}}{g_{\text{accepted}}}\right| \times 100,$$

and discuss.

The percentage difference is 2.07 %, indicating the experiment has been performed to a high degree of accuracy. The minor inaccuracy can be a result of friction.

[1] In the linear fit of Graph 3, what is the physical meaning of the Y-intercept value?

The y-intercept is the acceleration at $\theta = 0$. The graph shows that at a angle of $0°$ acceleration is zero and can therefore assumed to be motionless

Part 2 - Investigating Newton's second law

[1] Use the linear fit from Graph 4 to determine your experimental value for g with uncertainty.

$g = ($ 9.991 $\pm$ 0.02183 $)\ m/s^2$

[1] Compare your value of g with the accepted value of 9.81 m/s^2. Calculate the percentage difference

$$\%\text{diff} = \left|\frac{g_{\text{accepted}} - g_{\text{experimental}}}{g_{\text{accepted}}}\right| \times 100,$$

and discuss.

This experiment has a percent difference of 1.85 %, suggesting that the experiment was performed with a high-degree of accuracy.

[1] In the linear fit of Graph 4, what is the physical meaning of the Y-intercept value?

The y-intercept is supposed to represent the dimensionless hanging mass at 0. The graph does not show the y-intercept, and it can therefore be assumed that the track was not frictionless and the cart's movement was affected even before adding additional weight

[1] Do your results agree with Newton's 2nd law?

Our results agree with Newton's Second Law, which is stating that the force is directly proportional to ma. The graph is a linear regression, and it can be determined that the force and ma are directly proportional

[2] Suppose that you have a situation with a combination of acceleration due to the inclined plane as well as the force of the weights as in *Figure 1* bellow:

- Derive an equation that predicts the total acceleration of the glider.
- Derive an equation that will allow the system to be in equilibrium (i.e., glider is stationary) for a height, h.

$$1. F = ma$$

$$a = \frac{F}{m}$$

$$a = \frac{mg - Mg\sin\theta}{m+M}$$

$$a = \frac{mg - Mg\frac{h}{d}}{m+M}$$

$$a = \frac{g(m - M\frac{h}{d})}{m+M}$$

$$2. \text{Equilibrium}, \ a = 0$$

$$o = \frac{g(m - M\frac{h}{d}}{m+M}$$

$$o = g(m - M\frac{h}{d})$$

$$o = m - M\frac{h}{d}$$

$$\frac{m}{M} = \frac{h}{d}$$

$$h = \frac{m}{M}d$$

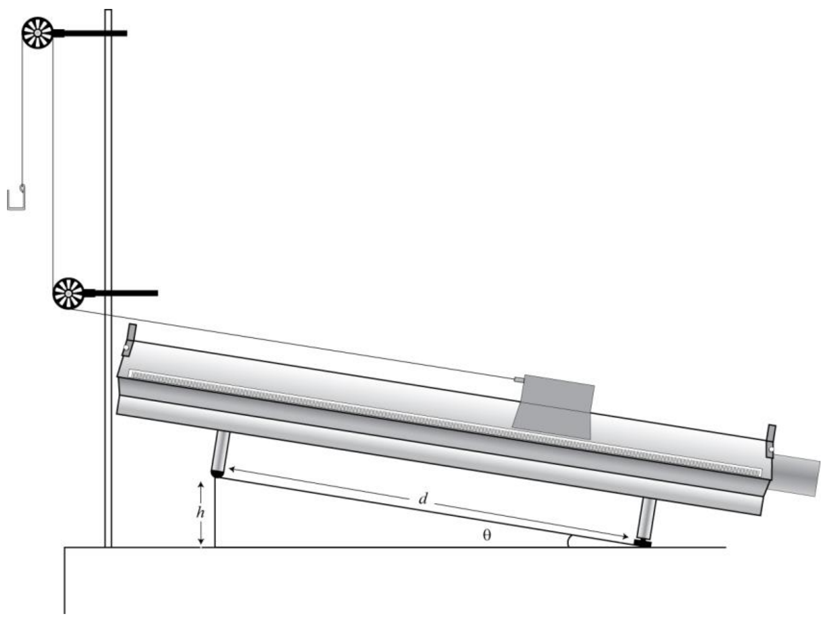


Figure 1 - Glider pulled by a constant force on an inclined air track.

Total : _______ / 44 (for the report)