Southern New Hampshire University

PHY-150 Lab 2-1: Kinematics

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1 Activity 1: Graph and interpret motion data of a moving object

Time (t) in seconds	**Position $p(t)$ in metres**
0	0
5	20
10	40
15	50
20	55
30	60
35	70
40	70
45	70
50	55

Table 1: **Position of train versus the time passed**

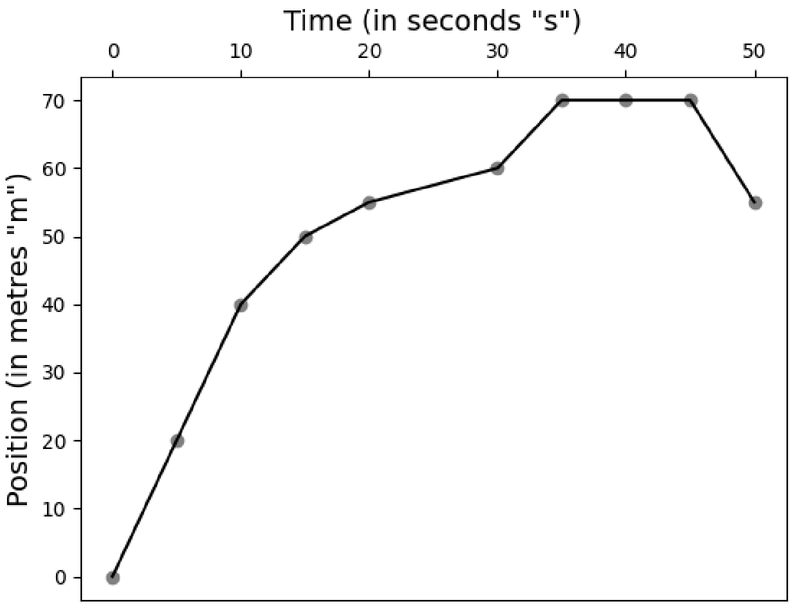

Figure 1: **Position of train versus the time passed**

1.1 Questions for Activity 1

1. What is the average speed of the train during the time interval from $0s$ to $10s$?

> **Answer:** I will first identify the $(t, p(t))$ pair to be analysed. In this case, the time segments that are of interest is $t = 0s$ and $t = 10s$. Looking at Activity 1's table, I have worked out the following pairs:
>
> $$(t = 0s, p(t) = 0m)$$
> $$(t = 10s, p(t) = 40m)$$
>
> I will ignore the $t = 0s$ pair, since working out its speed is nonsensical and would lead to an arithmetic error. So instead, I will focus on the $t = 10s$ pair and work out the solution with the following formula:
>
> $$s = \frac{\Delta x}{\Delta t} = \frac{40m}{10s} = 4m/s$$
>
> **The average speed is four metres per second ($4m/s$).**

2. Using the equation: $\frac{s_2 - s_1}{t_2 - t_1}$ calculate the average speed of the train as it moves from position $x = 50m$ to $x = 60m$.

> **Answer:** First, I will need to work out the s_1 and s_2. For $p(t) = 50m$, the $t = 15s$ and for $p(t) = 60m$, the $t = 30s$, so their respective s_1 and s_2 coefficients are:
>
> $$s_1 = \frac{\Delta x}{\Delta t} = \frac{50m}{15s} \approx 3.33m/s$$
>
> ... and ...
>
> $$s_2 = \frac{\Delta x}{\Delta t} = \frac{60m}{30s} = 2m/s$$
>
> The final solution can be worked out by "plug-and-chug" method into the following formula:
>
> $$\bar{s} = \frac{2m/s - 3.33m/s}{30s - 15s} \approx -.866m/s^2$$
>
> **The average speed is $\bar{s} \approx -.867m/s^2$.**

3. What does the slope of the line during each time interval represent?

Answer: The slope of the line represents the speed of the locomotive.

4. From time $t = 35s$ until $t = 45s$, the train is located at the same position. What is slope of the line while the train is stationary?

Answer: I have worked out slope of the line can be worked out as follows:

$$\frac{\Delta p}{\Delta t} = \frac{p_f - p_i}{t_f - t_i} = \frac{70m - 70m}{45s - 35s} = \frac{0m}{10s} = 0$$

The slope is flat or zero (0).

5. Calculate the average speed of the train as it moves from position $x = 70m$ to $x = 55m$. What does the sign of the average velocity during this time interval represent?

Answer: Recall that

$$\bar{s} = \frac{s_2 - s_1}{t_2 - t_1}$$

I will first need to work out the s_1 and s_2 of $p(t) = 70m$ and $p(t) = 55m$:

$$s_1 = \frac{70m}{45s} \approx 1.56m/s$$

... and ...

$$s_2 = \frac{55m}{50s} = 1.1m/s$$

The $\bar{s}$ is calculated as

$$\bar{s} = \frac{1.1m/s - 1.56m/s}{50s - 45s} = -0.46m/s^2$$

The average speed is $-0.46m/s^2$ where the negative slope represents the opposite direction on my coordinate system.

6. What is the displacement of the train from time $t = 0s$ until $t = 50s$?

Answer: Displacement is a vector quantity that refers how far a body is from its starting point. The formula to calculate the displacement, the Δx, is

$$\Delta x = x_f - x_i$$

Specifically for this problem, on $p(t) = 55m$ and $p(t) = 0m$, I have worked out the displacement to:

$$\Delta x = 55m - 0m = 55m$$

7. What is the total distance traveled by the train from time $t = 0s$ until $t = 50s$?

Answer: Distance is a scalar quantity that refers to "how much ground an object has covered" regardless of its direction. I will work out the distance from $t = 0$ to $t = 50$ with the following formula:

$\sum_{\text{t=0s,t=50s}} = (20m - 0m) + (40m - 20m) + (50m - 40m) + (55m - 50m) + (60m - 55m) + (70m - 60m) + (70m - 70m) + (70m - 70m) + (70m - 70m) + (55m - 70m) = 55m$

The total distance traveled is 55 metres.

8. What is the slope of the line during the time interval $t = 45$ to $t = 50$?

Answer: I was able to work this problem out with the following formula:

$$\text{Slope} = \frac{\Delta x}{\Delta t} = \frac{p(t_f) - p(t_i)}{t_f - t_i} = \frac{55m - 70m}{50s - 45s} = -3m/s$$

9. What does the sign of the slope in question 8 represent in terms of the motion of the train?

Answer: The sign of the slope in question 8 represents the locomotive moving "in reverse." or backwards in regards to the coordinate system that I have set up.

10. What is the average velocity of the train during the interval $t = 0s$ to $t = 50s$?

Answer: The average velocity of a thing is:

$$\bar{v} = \frac{v_i + v_f}{2}$$

And the $v_i = 0m/s$ whilst the $v_f = \frac{x_f}{t_f} = 1.1m/s$

So, specifically, the average velocity in this case is:

$$\bar{v} = \frac{(0m/s + 1.1m/s)}{2} = 0.55m/s$$

11. Does the train's average velocity during the interval $t = 0s$ to $t = 50s$ provide a complete picture of the train's motion during this time?

Answer: "Complete picture" is a bit subjective, but I would say "no" because the $\bar{v}$ does not take into account the deceleration of the locomotive, nor does it take into account it "moving backwards."

2 Activity 2: Calculate the velocity of a moving object.

Time (s)	Displacement (m)*
0.00	0.00
0.60	0.25
1.10	0.50
1.67	0.75
2.27	1.00
2.87	1.25
3.47	1.50
4.07	1.75
4.67	2.00

Table 2: **Displacement of toy car given time passed.**

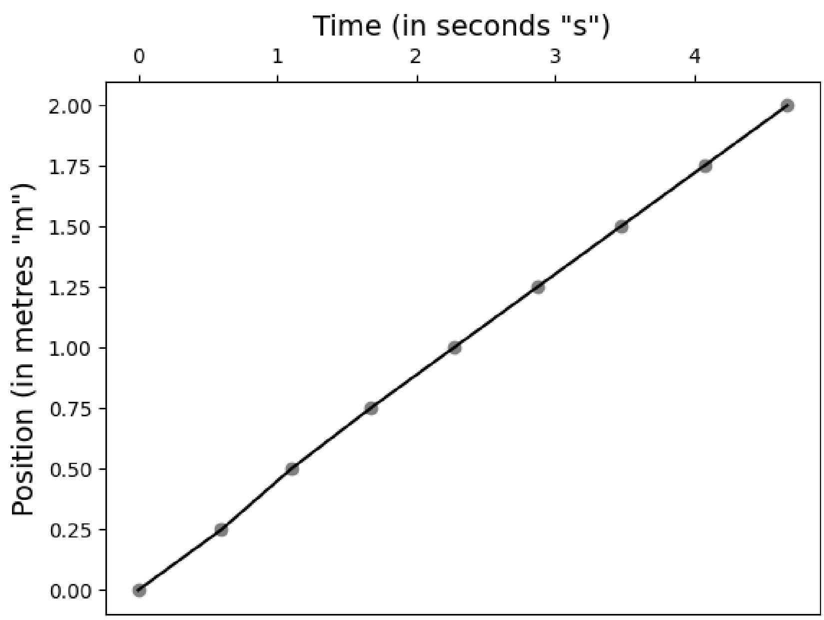

Figure 2: **Displacement of toy car given time passed.**

Time (s)	Displacement (m)	Velocity (m/s)
0	0.0000	0.00000 m/s
1	0.6779m	0.67790 m/s
2	1.1184m	0.89815 m/s
3	1.5374m	1.11123 m/s
4	1.9168m	1.31265 m/s

Table 3: **Displacement of toy car given time passed.**

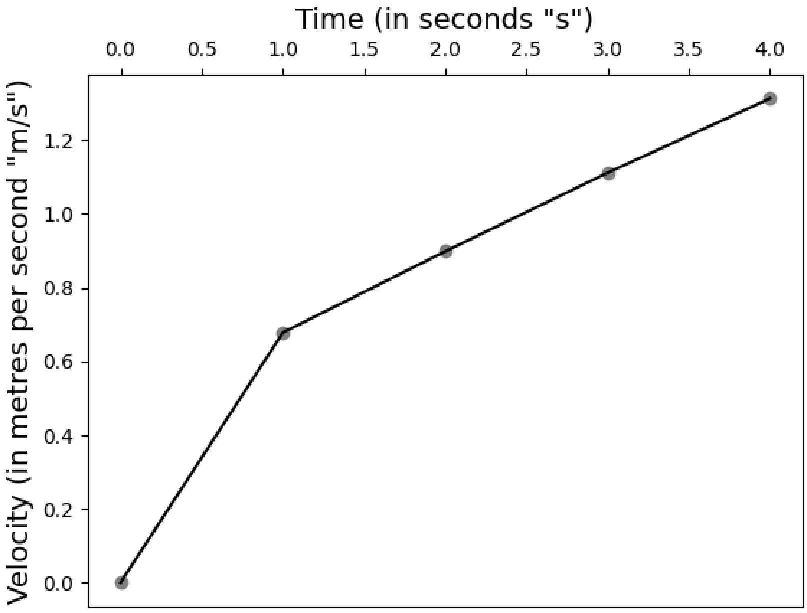

Figure 3: **Velocity of toy car given time passed.**

3 Activity 3: Graphing the motion of an Object with Constant Acceleration

Time (s)	**Average Time** (s)	**Squared Average Time** (s^2)	**Distance** (m)
Trial 1 = 0.00 Trial 2 = 0.00 Trial 3 = 0.00	0	0	0
Trial 1 = 1.20 Trial 2 = 1.57 Trial 3 = 1.30	1.35667	1.84054	0.1
Trial 1 = 2.48 Trial 2 = 2.05 Trial 3 = 1.99	2.17333	4.72338	0.2
Trial 1 = 2.73 Trial 2 = 2.67 Trial 3 = 2.73	2.71	7.3441	0.3
Trial 1 = 2.92 Trial 2 = 3.00 Trial 3 = 3.04	2.98667	8.92018	0.4
Trial 1 = 3.46 Trial 2 = 3.22 Trial 3 = 3.45	3.37667	11.4019	0.5
Trial 1 = 3.74 Trial 2 = 3.61 Trial 3 = 3.76	3.70333	13.7147	0.6
Trial 1 = 3.93 Trial 2 = 3.75 Trial 3 = 3.87	3.85	14.8225	0.7
Trial 1 = 3.55 Trial 2 = 3.85 Trial 3 = 4.02	3.80667	14.4907	0.8

Table 4: **Displacement, time and squared-time data of the ramp experiment with the silver sphere.**

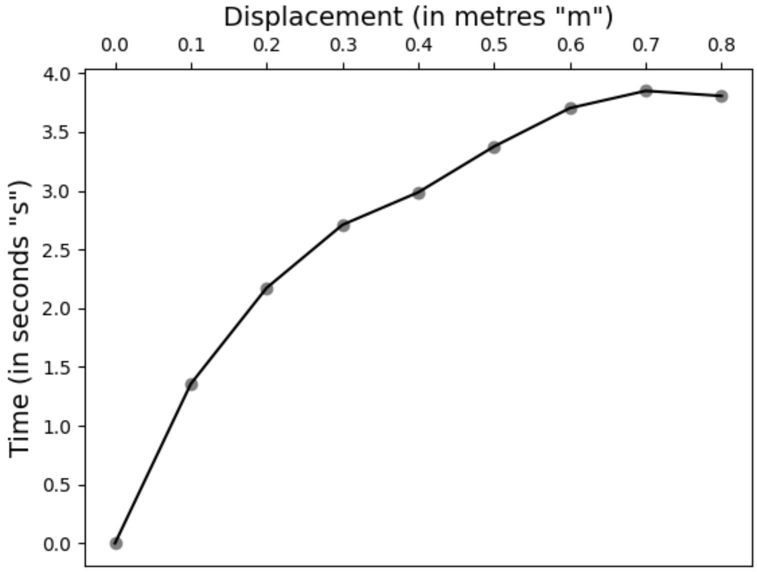

Figure 4: **Displacement of the silver sphere given time.**

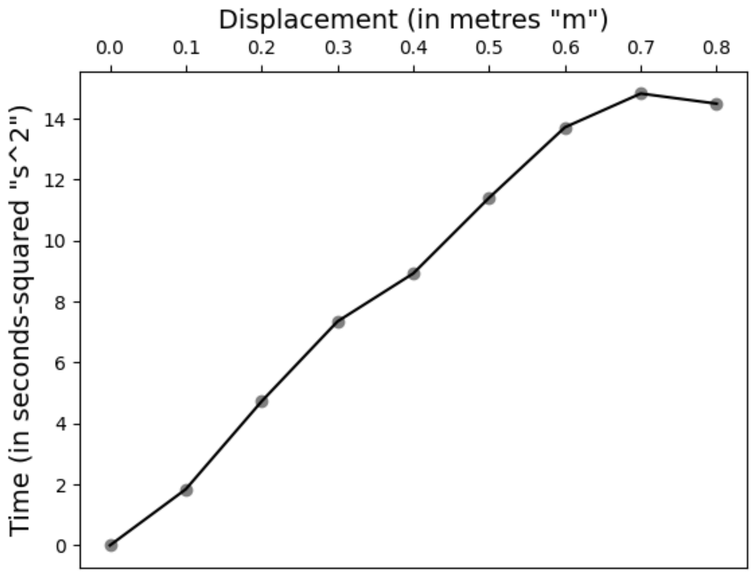

Figure 5: **Displacement of the silver sphere given time squared.**

3.1 Questions for Activity 3

1. What is the shape of the graph when displacement is graphed vs. time?

   > **Answer:** The shape of the graph showing displacement versus time (Fig. 4) looks a bit like a quadratic function (where the t^2 coefficient is $t^2 < 0$), with some noise of course.

2. What is the shape of the graph when displacement is graphed against time squared?

   > **Answer:** The shape of the graph showing displacement versus time-squared (Fig. 5) is more linear, with a bit of noise of course.

3. What do the shapes of these graphs tell you about the relationship between distance and displacement for an object traveling at a constant acceleration?

   > **Answer:** The quadratic shape of displacement plotted against time and the linear shape of the displacement plotted against time-squared tells me that the acceleration function is constant, which makes sense since there are no significant external forces acting on this system.

4 Activity 4: Predict the time for a steel sphere to roll down an incline.

		Steel Sphere	Acrylic Sphere
A	Length of Track (cm) (s) (Step 1, use 80 cm)	80cm	80cm
B	Angle of elevation (θ) in Degrees (Step 1)	10°	10°
C	Calculated Time from $s = 0$ to $s = 80$ (formula from step 2)	11.51s	11.51s
D	Measured Time from $s = 0$ to $s = 80$ (step 3 with stopwatch)	3.87s	3.87s
E	Per cent Difference (step 4) $\%_{\text{diff}} = \frac{\text{first value}-\text{second value}}{\left(\frac{\text{first value}+\text{second value}}{2}\right)} \times 100\%$	99%	99%

Table 5:

Question for Activity 4: What effect does the type of the sphere have on the time of the object to travel the measured distance, explain?

Answer: I appear to have done the experiment incorrectly. My predictions do not match observation (with a 99% error rate), so either I have setup the experimental apparatus incorrectly or I am computing the predicted time incorrectly. I cannot answer this question.

5 Activity 5: Demonstrate that a sphere rolling down the incline is moving under constant acceleration.

Note: As with the fourth activity, I tried to setup this experiment and got inconsistent results— and as a result, I cannot answer the questions in this set.