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SUBMISSION: GROUP 8

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NEWTON'S SECOND LAW OF MOTION

(EXPERIMENT 1)

Equipment:

- *PAScar*
- *PAScar track*
- *Pulley and pulley clamp*
- *Mass set*
- *Stopwatch*
- *String*
- *Balance*

Setup:

- *Place the pascar on the track with a string attached to one end.*
- *Place the string over the pulley*
- *Ensure a hook is attached to the string*
- *To this hook add varying masses.*

Procedure:

- *Place the car on the track with the string attached to it*
- *Ensure to note the mean position of the car so its kept constant throughout the experiment*
- *Add the mass to the hook*
- *Immediately start the stop watch*
- *Note time for the travel of the car*
- *Repeat this for each mass*

***Abstract**:*

In this experiment, we measured the acceleration of a car pulled by a hanging mass over a pulley. The hanging mass was changed each trial while the car mass stayed the same. Time was recorded to calculate experimental acceleration, and theoretical acceleration was found using Newton's Second Law. The results showed that acceleration increased when the hanging mass increased, with slight errors due to friction and timing.

Purpose:

Using the attached mass to accelerate the car we prove Newton's second law

Theory:

When a hanging mass pulls a car through a string over a pulley, the weight of the hanging mass causes the motion. Force acting: F = m g According to Newton's Second Law: F = (M + m) a So the theoretical acceleration is: theoretical acceleration = (m g) / (M + m) From the measured distance "d" and time "t", the experimental acceleration is: experimental acceleration = $\frac{2d}{t^2}$ *As the hanging mass increases, the force increases, so acceleration also increases. Any difference between theoretical and experimental values happens due to friction and human error in timing.*

Calculations:

Without added masses(250g):

D=80cm

Mass of hook=5g

Total mass=M=250g

m=5+mass of weights

Trial	Mass(g)	time(s)	a(exp)(cms^{-2})	a(theor.)(cms^{-2})	%diff.
1	20	1.57	64.91	89.082	17%
2	30	1.20	111.11	120.344	8.3%
3	40	1.08	137.17	149.45	8.9%
4	50	0.99	163.25	177.282	7.9%
5	60	0.77	269.86	202.174	13%

Experimental acceleration,

$$a(exp.) = \frac{2d}{t^2}$$

$$a(exp.) = \frac{2 \times 80}{1.57^2}$$

$$a(exp.) = 64.91cms^{-2}$$

Theoretical acceleration,

$$a(theor.) = \frac{m}{m+M}g$$

$$a(theor.) = \frac{25}{25+250} \times 980$$

$$a(theor.) = 89.082cms^{-2}$$

Percentage error,

$$\%diff. = \frac{(theor. - exp.)}{exp} \times 100$$

$$\%diff. = \frac{89.082 - 64.91}{64.91} \times 100$$

$$\%diff. = 17\%$$

With added masses(750g):

D=80cm

Mass of hook=5g

Total mass=M=750g

m=mass of weights+5g

Trial	*Mass(g)*	*Time(s)*	$a(exp)(cms^{-2})$	*a(theor.)*(cms^{-2})	*%diff.*
1	*10*	*3.30*	*14.69*	*19.2157*	*20.8%*
2	*20*	*2.55*	*24.61*	*31.6129*	*22%*
3	*30*	*2.16*	*34.29*	*43.6943*	*0.22%*
4	*40*	*1.83*	*47.77*	*55.4716*	*0.14%*
5	*50*	*1.42*	*79.35*	*66.956*	*18%*

Experimental acceleration,

$$a(exp.) = \frac{2d}{t^2}$$

$$a(exp.) = \frac{2 \times 80}{2.55^2}$$

$$a(exp.) = 24.61cms^{-2}$$

Theoretical acceleration,

$$a(theor.) = \frac{m}{m+M}g$$

$$a(theor.) = \frac{25}{25+750} \times 980$$

$$a(theor.) = 31.6129cms^{-2}$$

Percentage error,

$$\%diff. = \frac{(theor. - exp.)}{exp} \times 100$$

$$\%diff. = \frac{31.6129 - 24.61}{24.61} \times 100$$

$$\%diff. = 22\%$$

Conclusion and Results:

In this experiment, we investigated how the acceleration of a PAScar changes when the hanging mass pulling it is varied. The results *supported Newton's Second Law: as the hanging mass increased, the net force increased, and so did the acceleration*

Discussion:

Can you think of any systematic errors that would affect your results ? Explain how they would skew the results .

Systematic errors that could affect the results in this experiment might include:

- Measurement errors in mass (m): Inaccurate weighing of masses could skew results.
- Timing errors: Inaccurate measurement of average time could impact calculations of (a) and comparisons.
- Distance (d) measurement error: If (d) isn't measured accurately, it affects (a) calculations.
- Friction or air resistance: If the experiment involves movement, unaccounted friction or air resistance could affect results.
- Instrument calibration: Poorly calibrated instruments for measuring time or mass could introduce systematic errors

SIMPLE HARMONIC MOTION

(EXPERIMENT 2)

Equipment:

- *PAScar*
- *PAScar track*
- *Mass set*
- *Stop watch*
- *Harmonic springs*
- *Weighing pan*

Setup:

- *Place the PAScar on the track*
- *Attach two springs to either side of the PAScar*
- *Hook these springs to the walls of the track*
- *With one of the ends of the spring hanging from the edge and having a hook, add weights of different masses (m)*
- *Repeat the experiment twice. Once with only the mass of PAScar (250) and once with added mass to the PAScar (750 g) [this will be M]*

Procedure:

- *The PAScar has been attached with springs to its track there is no added mass on the PAScar [M = 250g]*
- *Note the mean position of PAScar this will be our x_i this should be kept constant throughout the experiment*

- *Add varying masses to the hook (eg 10g, 15g, 20g etc) [m]*
- *As the mass is added note farthest point to which the car moves to. This will be our* x_f
- *For each mass added note the* x_f
- *Subtract* x_f *from* x_i *to obtain Δx*
- *Repeat the process until you have 5 to 6 sets of readings*

Process for PAScar with added mass:

- *The added mass results in PAScar being of 750g therefore, [M = 750g]*
- *The hanging mass [m] will be kept constant*
- *Once the mass is addd and the car oscillates we will observe the time taken for 5 complete oscillations.*
- *We will repeat this until we have atleast 5 trials*
- *Once sufficient data has been collected we average the readings.*

Abstract:

In this experiment, the spring constant of a spring was found by hanging different masses and measuring the extension. Force versus extension showed a straight-line relationship, which follows Hooke's Law. The spring constant was calculated from the ratio of force to extension.

Purpose:

Using PAScar attached to springs to verify SIMPLE HARMONIC MOTION and determine the spring's constant.

Theory:

A spring extends when a force pulls it downward. For small extensions, the relationship is linear and follows Hooke's Law: F = kx

Where: F = force (m g)

x = extension

k = spring constant

The value of k can be found by:

$k = \frac{F}{x}$

or: $k = \frac{F2-F1}{x_{f-x_i}}$

If the graph of F vs x is a straight line through the origin, the spring obeys Hooke's Law

Calculations:

Mass of PAScar with added masses = 750 g

Mass of PAScar (cart only) = 250 g

Spring constant:

Without added mass (250g);

Hanging mass(g)	x = $x_f - x_i(cm)$	F = mg(N)
20	+0.6	19600
30	+1	29400
40	+1.4	39200
60	+2	58800

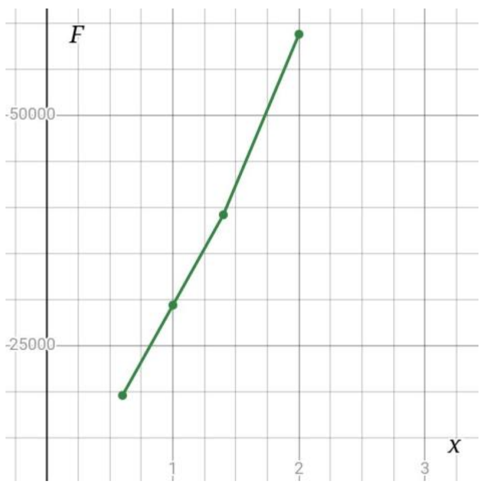
$$k = \frac{\triangle F}{\triangle x}$$

$$k = \frac{F2 - F1}{x2 - x1}$$

$$k = \frac{39200 - 29400}{1.4 - 1}$$

$$k = 24500\,\frac{N}{cm}$$

Graph:



theoretical time period (T):

Without added mass (250g),

Putting value of k in time period formula (SHM);

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{250}{24500}}$$

$$T = 0.6347s$$

With added mass (750g),

$$T = 2\pi\sqrt{\frac{750}{24500}}$$

$$T = 1.099s \quad \ldots (2)$$

Experiment time period (T) with % errors:

Having a standard mass of m = 200g

No.of oscillations noted = 5

Without added mass (250g),

Trial	***Time for 5 oscillations(t)(s)***	***Time period($\frac{t}{5}$)(s)***
1	*4.00*	*0.8*
2	*3.98*	*0.796*
3	*3.75*	*0.75*
4	*4.07*	*0.814*
5	*4.01*	*0.802*

Average experimental time period =T=0.7924 s

Comparing with (1),

$$\%error = \frac{experimental\ value - theoretical\ value}{theoretical\ value} \times 100$$

$$\%error = \frac{0.7924 - 0.6347}{0.6347} \times 100$$

$$\%error = 24.85\%$$

With added mass(750g),

Trial	***Time for 5 oscillations (t)(s)***	***Time period $\left(\frac{t}{5}\right)$ (s)***
1	5.76	1.152
2	5.89	1.178
3	5.67	1.134
4	5.96	1.192
5	5.52	1.104

Average experimental time period =T=1.152 s

Comparing with (2),

$$\%error = \frac{experimental\ value - theoretical\ value}{theoretical\ value} \times 100$$

$$\%error = \frac{1.152 - 1.099}{1.099} \times 100$$

$$\%error = 4.82\%$$

Conclusions and Results:

In this experiment on Simple Harmonic Motion, the PAScar system was tested with two different masses: the cart alone (250 g) and the cart with added masses (750 g). Using the calculated spring constant, the theoretical time periods were found using the SHM formula, and these were compared with the experimental values obtained from timing 5 oscillations across multiple trials. For the 250 g mass, the average experimental time period was 0.7924 s, and for the 750 g mass, it increased to 1.152 s, matching the expected trend that greater mass increases the oscillation period. The percentage error without masses was 20.45% and without masses 4.82%