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Period 5

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**Calculating *g***

AP Physics C, Night Lab 1

Report due: Thursday @ 11:59 PM

You will be investigating different ways to calculate the acceleration due to gravity *g*. Each method for computing *g* will have a different level of accuracy: the sources of error differ for each experiment, and it is necessary to understand which experiments yield the most accurate results for further studies and for applications.

This lab will not require much use of lab software. At most, you will need Capstone, and if you do, you can describe the graph in words in your report rather than screenshotting them from your phone and having to email them to yourself and download them, until we get software on the laptops. The lab report will be uploaded to Schoology. Please complete this individually. Data and answers to Pre-lab questions should be recorded in your lab notebook to start, but you can type out the procedure as you go along, in your report. Make sure to include notes, calculations, and diagrams as needed in your notebook so that you can type the report easily.

The materials available include **tennis balls, measuring devices (rulers, tracks, calipers), string, cars, motion detectors with interfaces, and masses**. I can bring other materials from the prep room if needed, although I will need to listen to your description of your experiment(s) before doing so.

**Prelab questions**

1. Based on your knowledge from AP Physics I, which units of study could aid in this laboratory? Justify your answer.
   Oscillations (pendulum), kinematics (tennis ball + ramp).
2. What are the restrictions on the experiments that you have in mind to calculate *g*? Would they work with any initial conditions?
   We are calculating gravitational force without considering air resistance and friction (both negligible). They wouldn't work with any initial conditions. We should try to have initial conditions that would minimize friction (such as smooth surfaces), and also minimize air resistance (using objects that experience minimal drag)

**Discussion questions**

1. Which experiment yielded the most accurate calculation for *g*? Why?

The experiment that yielded the most accurate calculation was the ramp experiment. Friction had a low impact in that experiment and timing the car wasn't too hard either. For the tennis ball, air resistance and friction could have affected the result and the timing could have been inaccurate since drops were very quick. For the pendulum, the timing may have been off, or our angle could have not been small enough.

a. Compare your values for *g* using the percent difference formula
$\frac{|experimental-theoretical|}{theoretical} * 100\%$
$g = 9.81\ m/s^2$
Ramp: $9.871\ m/s^2$
$\frac{|9.871-9.81|}{9.81} * 100\% = 0.62\%$ difference

Tennis Ball: $7.531\ m/s^2$
$\frac{|7.531-9.81|}{9.81} * 100\% = 26.3\%$ difference

Pendulum: $10.311\ m/s^2$
$\frac{|10.311-9.81|}{9.81} * 100\% = 4.98\%$ difference

2. List sources of error and potential ways to minimize them.
Sources of error include human reaction time/timer inaccuracy because humans are used to measure the times, as well as possible effects of air resistance/friction. Instead of humans for timers, sensors and motion detectors could be used to measure the time, and air resistance and friction could be included in our calculations/we could use smooth surface and objects that don't experience much drag to minimize them.
3. Based on the experiments you have conducted, where could you apply the results in the real world? What are some of the issues with the applications?
These results could be applied wherever gravity is applicable, such as projectile motion or calculating normal force for friction calculations. However, our calculated result of g is not that close to g's theoretical value, so precise calculations cannot use the experimental value.
4. What other experiments could you do to measure *g*, more accurately than in this laboratory?
Other experiments include seeing exactly how far a car travels down a ramp in one second and use this displacement to calculate g. We can also test how much force is required to hang some mass at rest.

## Data

Ramp

| Trial | Initial height (m) | Final Height (m) | Ramp length(m) | Time (s) |
| --- | --- | --- | --- | --- |
| 1 | .17 | .06 | 1.0 | 1.29 |
| 2 | .17 | .06 | 1.0 | 1.39 |
| 3 | .17 | .06 | 1.0 | 1.40 |

Tennis Ball

| Trial | Height (m) | Time to reach ground (s) |
| --- | --- | --- |
| 1 | 2.0 | 0.53 |
| 2 | 2.0 | 0.46 |
| 3 | 2.0 | 0.63 |

Pendulum

| Trial | Length of string (m) | Period (s) |
| --- | --- | --- |
| 1 | 2.42 | 2.95 |
| 2 | 2.42 | 3.23 |
| 3 | 2.42 | 3.06 |
| 4 | 2.42 | 3.05 |
| 5 | 2.42 | 3.18 |

## Calculations

**Ramp**

$a = g \cdot \sin(\theta)$

$g = \frac{a}{\sin(\theta)}$

$\sin(\theta) = \frac{\Delta h}{\Delta x}$, $\Delta h$ is height (m), $\Delta x$ is the ramp length (m)

$\Delta x = v_0 t + \frac{1}{2} a t^2$

$a = \frac{2\Delta x}{t^2}$

$g = \frac{a}{\sin(\theta)} = \frac{2\Delta x}{t^2} \cdot \frac{\Delta x}{h}$

Trial 1: $g = \frac{2 \cdot 1.0}{1.29^2} \cdot \frac{1.0}{0.11} = 10.926\ m/s^2$

Trial 2: $g = \frac{2 \cdot 1.0}{1.39^2} \cdot \frac{1.0}{0.11} = 9.410\ m/s^2$

Trial 3: $g = \frac{2 \cdot 1.0}{1.40^2} \cdot \frac{1.0}{0.11} = 9.276\ m/s^2$

| Trial | Gravity ($m/s^2$) |
|---|---|
| 1 | 10.926 |
| 2 | 9.410 |
| 3 | 9.276 |
| Average | 9.871 |

**Tennis Ball**

$\Delta x = v_0 t + \frac{1}{2} g t^2$

$g = \frac{\Delta x - v_0 t}{\frac{1}{2} t^2}$

Trial 1: $g = \frac{2.0}{\frac{1}{2} \cdot 0.53} = 7.547\ m/s^2$

Trial 2: $g = \frac{2.0}{\frac{1}{2} \cdot 0.46} = 8.696\ m/s^2$

Trial 3: $g = \frac{2.0}{\frac{1}{2} \cdot 0.63} = 6.349\ m/s^2$

| Trial | Gravity ($m/s^2$) |
|---|---|
| 1 | 7.547 |
| 2 | 8.696 |
| 3 | 6.349 |
| Average | 7.531 |

**Pendulum**

$T = 2\pi \sqrt{\frac{L}{g}}$

$g = \frac{4\pi^2 L}{T^2}$

Trial 1: $g = \frac{4\pi^2 \cdot 2.42}{2.95^2} = 10.978\ m/s^2$

Trial 2: $g = \frac{4\pi^2 \cdot 2.42}{3.23^2} = 9.157\ m/s^2$

Trial 3: $g = \frac{4\pi^2 \cdot 2.42}{3.06^2} = 10.203\ m/s^2$

Trial 4: $g = \frac{4\pi^2 \cdot 2.42}{3.05^2} = 10.270\ m/s^2$

Trial 5: $g = \frac{4\pi^2 \cdot 2.42}{3.18^2} = 10.948\ m/s^2$

| Trial | Gravity ($m/s^2$) |
|---|---|
| 1 | 10.978 |
| 2 | 9.157 |
| 3 | 10.203 |
| 4 | 10.270 |
| 5 | 10.948 |
| Average | 10.311 |