# AP Physics C: Circular Motion

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## 1 Objective

The purpose of the Circular Motion lab was to determine the acceleration due to gravity on a plane that is flying around in a circle.

## 2 Procedure

After the plane is launched, the system for the following procedures can be seen in Figure 1.

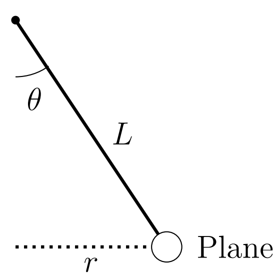


Figure 1: Diagram of lab setup.

Collect any required data to determine $\overline{r}$:

1. Set up the lab as detailed in the Lab Procedure.
2. Grab and stop the plane while it is still flying.
3. Place a meter stick directly under the magnetic hook to establish a origin of rotation for the plane.

4. Using a meter stick, measure $r$ by measuring the distance from the origin of rotation to the plane.

5. Repeat Steps 1-4 around five times.

6. Calculate $\overline{r}$ with collected data.

Collect any required data to determine $\overline{\omega}$:

1. Set up the lab as detailed in the Lab Procedure.

2. Start and hold a timer in front of a slow-motion capable camera.

3. Begin recording the rotation of the plane in slow-motion. Ensure timer is in frame.

4. End recording after around 5-10 revolutions of the plane.

5. Find period with recorded footage by analyzing time between revolutions using the timer in the footage.

6. Calculate $\overline{T}$ with collected data.

7. Calculate $\overline{\omega}$ with $\overline{T}$.

## 3 Observations and Data

We found that $L$ equals 1 m.

To calculate $\overline{r}$, we captured five data points, shown in Figure 2.

| Trial | $r$ |
|---|---|
| 1 | 70 cm |
| 2 | 69 cm |
| 3 | 69 cm |
| 4 | 68 cm |
| 5 | 66 cm |

Figure 2: Table of the data collected for $\overline{r}$.

To measure $\overline{T}$, we captured an indeterminate amount of data points. This data is unavailable due to unforeseen circumstances.

# 4 Analysis

Using the data for $r$, we can calculate that $\overline{r}$ equals $68.4 \pm 0.5$ cm. As well, using the data for $T$, we can calculate that $\overline{T}$ equals $1.81 \pm 0.1$ s. Using T, we can then find $\overline{\omega}$.

$$\frac{2\pi}{\overline{\omega}} = \overline{T}$$
$$\frac{\overline{\omega}}{2\pi} = \frac{1}{\overline{\overline{T}}}$$
$$\overline{\omega} = \frac{2\pi}{\overline{\overline{T}}}$$

Using $\overline{T}$, we can calculate that $\overline{\omega}$ equals 3.47 rad/s.

To calculate the $F_g$, and thus the acceleration due to gravity, we must first make clear the mechanics that the plane is undergoing. As shown in 3, the $F_t$ is angled and, in the diagram, is comprised of two components. Since the plane is not falling, we know that $F_{t_z}$ must be equal to $F_g$. As well, we also know that $F_{t_r}$ must equal $m \cdot a_c$, where $m$ is the mass of the plane and $a_c$ is the centripetal acceleration.

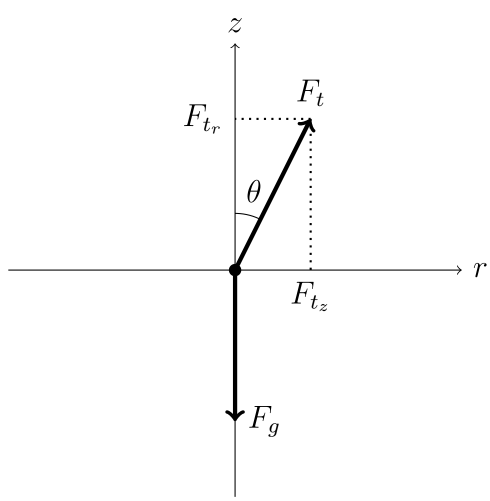


Figure 3: Free body diagram of the plane in flight.

So, utilizing the fact that we know $F_{t_r}$, we can solve for $F_t$:

$$
\begin{aligned}
F_{t_r} &= ma_c \\
F_{t_r} &= mw^2 r \\
F_{t_r} &= mw^2 L \sin\theta \\
F_t &= mw^2 L
\end{aligned}
$$

With $F_t$, we can now solve for $F_g$, and then $g$.

$$
\begin{aligned}
F_{t_y} &= F_g \\
mw^2 L \cos\theta &= F_g \\
mw^2 L \cos\theta &= mg \\
w^2 L \cos\theta &= g
\end{aligned}
$$

With $\overline{r}$, we can calculate $\theta$ to be about 0.753 rad. With that, we can calculate $g$ to be about 8.79 m/s$^2$.

# 5 Conclusion

With a $g$ of 8.79 m/s$^2$, the percent error of our prediction is -10.306%. By far the factor that introduced the most error would be the misalignment of the origin of rotation meter stick while trying to measure $r$. Due to human error, the origin of rotation meter stick was not perfectly aligned with the magnetic hook on the ceiling, nor did it point perfectly down in the direction of gravity. This would introduce error as the $r$ values measured could be misaligned relative to the axis of rotation.