Investigating Circular Motion

General safety protocols for this activity

- Wear sanitized safety glasses with side shields or indirectly vented chemical splash goggles during the setup, hands-on, and takedown segments of the activity.
- Secure loose clothing, wear closed-toe shoes, and tie back long hair.
- Follow procedures set up by your teacher for disposal of materials.
- Make sure there are no fragile items in the activity zone, especially in the area where the orbiting object is being swung.
- Lightly tug on the orbiting object before beginning to ensure that it is properly attached.
- Use caution when working with glass or plastic - sharp ends can cut/puncture skin.
- Wash hands with soap and water or use hand sanitizer wipes immediately after completing this activity.

Data collection protocol

1. Holding the tube vertically, with the orbiting object on top, begin to gently move the setup in a circle so that the orbiting object rotates around the tube like a helicopter blade.
2. Continue this movement, experimenting with different speeds to get the orbiting object spinning fast enough that the bottom sticky tack is neither rising nor falling. Note: Do not let the bottom sticky tack touch the tube!
3. Once the system is stable, the person spinning to the device will count 20 revolutions. Another person should use the stopwatch to time the 20 revolutions.
4. Record this time on the table. Repeat the process until you collect the time for 20 revolutions for each trial.
5. Calculate the average velocity.
6. Repeat steps 1-5 for the second radius.
<table>
<thead>
<tr>
<th>Trial</th>
<th>Radius of orbit (meters)</th>
<th>Time for 20 revolutions (seconds)</th>
<th>Time for 1 revolution (seconds)</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>t</td>
<td>T = t/x</td>
<td>(2<em>π</em>r)/T</td>
</tr>
<tr>
<td>1</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average velocity:**

|       | 1                        |                                  |                                 |                |
| 1     | 0.40                     |                                  |                                 |                |
| 2     | 0.40                     |                                  |                                 |                |
| 3     | 0.40                     |                                  |                                 |                |

**Average velocity:**

**Data analysis**

Compare the average velocity for the 0.20 m and 0.40 m conditions. Based on your results, how does increasing the distance affect the velocity of the orbiting object?

Based on your results and your ideas about the relationship between gravity and the velocity of orbiting objects, develop an explanation for:

A. how space objects can remain in stable orbits and
B. how their orbits can change.

In your explanation, describe how the distance between objects affects this relationship.