For this lab, we were recording a pendulum period with a photogate. The period of a pendulum is the amount of time it takes for a pendulum to cross a point twice. We varied the string length, the angle we let the pendulum go, and the mass of the pendulum. For part 1 we decided to do two separate sets of trials with different angles, one 20 degrees, and one 60 degrees. The angle we dropped the mass was a rough approximation and was not exact. One way we could have made it exact is by using a straight edge against the correct angle, then pulling the string to have tension throughout the entire string. With this setup, we could line up the string to an exact angle every time which would reduce the standard deviation which would mean our error would be reduced.

|  |  |  |
| --- | --- | --- |
| Trials | 20deg | 60deg |
| 1 | 1.5043 (seconds) | 1.6155 (seconds) |
| 2 | 1.5005 (seconds) | 1.5904 (seconds) |
| 3 | 1.5006 (seconds) | 1.5955 (seconds) |
| 4 | 1.5001 (seconds) | 1.6021 (seconds) |
| 5 | 1.5026 (seconds) | 1.6157 (seconds) |
| Average | 1.50162 (seconds) | 1.601014 (seconds) |
| Standard Deviation | 0.001596746692497 (seconds) | 0.010293998251408 (seconds) |

Here you can see the data we got from our trials. Theory says that the period should be the same given we drop the pendulum at the same angle. So this shows that our drops were pretty accurate but not perfect.

For part 2 we had three sets of trials, one using four different masses for pendulums, different angles, and different string lengths. First we performed the trials with different masses, with 0.0952kg, then 0.0715kg, then 0.0313kg, and 0.0231kg. We predicted that as the masses get smaller the period would increase because the mass would generate less force. For our method instead of doing what was stated in the lab manual which was recording the pendulum's average period for 30 seconds, we decided that more accurate results could be yielded by recording only a single period. We did this because the angle would decrease over time when the pendulum swings which could cause errors.

|  |  |
| --- | --- |
| Mass (kg) | Period (s) |
| 0.0952 kg | 1.4479 s |
| 0.0715 kg | 1.4525 s |
| 0.0313 kg | 1.4557 s |
| 0.0231 kg | 1.4557 s |
| Average | 1.45295 s |
| Standard Deviation | 0.003194 s |

Here you can see that as the mass decrease the period stays the same, which is not what we predicted. Looking back at a previous lab where we were testing if two balls of the same mass would hit the ground at the same time. In that way, it makes sense because in that lab mass didn't affect the acceleration because acceleration is a constant in the equation F=ma where the acceleration is gravity, the only acceleration acting on it. This causes the force to increase but not the mass. Another way to think about it is a=F/m, so if only mass and force are increasing the acceleration would be constant since they are proportional.

The next set of trials we did was decreasing the length of the string with the same mass and angle. We predicted that as the length of the string decreases the period would decrease.

|  |  |
| --- | --- |
| Length (m) | Period (s) |
| 0.55 | 1.5023 |
| 0.50 | 1.4291 |
| 0.45 | 1.3483 |
| 0.40 | 1.2567 |
| Average | 1.3841 |
| Standard Deviation | 0.091526 |

From analyzing the table you can see that as the length of the string decreases the period also decreases. This makes sense because a pendulum is moving in a semi-circular motion which means the pendulum can be analyzed as a circle. When the length of the string decreases it decreases the radius of the circle created by the motion of the pendulum. So when the mass and angle are the same but the string gets shorter you are decreasing the amount of distance the pendulum would have to travel to complete the period would be less. This can be shown with the circumference equation c = 2 \* pi \* r, so when the radius is decreasing the circumference (which in this case is the distance the pendulum will travel) is less. And since the acceleration is constant (gravity) the amount of time will decrease along with the travel distance because acceleration is defined as m/s^2.

In the next experiment performed we increased the angle after each trial recording the period. We would use the same mass and string length for each trial. The predictions made were that the period would increase as the angle grows.

|  |  |
| --- | --- |
| Angle (deg) | Period (s) |
| 20 deg | 1.2572 |
| 35 deg | 1.2784 |
| 50 deg | 1.3023 |
| 65 deg | 1.3464 |
| Average | 1.296075 |
| Standard Deviation | 0.033147 |

Looking at the table you can see that our predictions played out as expected. With each 15-degree increase in angle, the period increased by a nearly linear amount. This makes sense when we look at the path of the pendulum as the partial circumference of a circle. In the trials, the radius stayed the same but the amount of the circle traveled increased by 15 degrees. So logically we can conclude that the period would also increase due to the acceleration being constant.

In conclusion, our experiments suggest that the only factors that affect the period of a simple pendulum on earth are the length of the string and the angle the pendulum is dropped at. The best way to analyze our simple pendulum is through two equations, the force equation and the circumference of a circle equation. The force equation F=ma where a=g explains why the mass of the pendulum didn't affect the period because the force is what increases when the mass is increasing and not the acceleration. For the other two experiments with varying string lengths and varied angles, the period did change between trials. This is best explained by the other equation c=2 pi r because the pendulum swings around the circumference of a circle. For the trials where the string length was varied, the radius of the circle was decreased which decreases the circumference of the circle the pendulum travels, which decreases the period but the same amount of the circle is traveled. For the trials where the drop angle was varied the circumference of the circle traveled is increased because it is traveling more of the circle.