Conical Pendulum

Task: Use your understanding of circular motion to analyze the forces acting on a conical pendulum and predict the length of the string, \( L \).

Materials: ringstand, pendulum clamp, pendulum ball, balance, stopwatch, string, scissors, ruler.

No metersticks!

Procedure:
1. Mass the ball.
\[ m = \phantom{0000} \]

2. Set up a long conical pendulum with the ringstand and pendulum clamp, string and ball. Set up the pendulum so that the ball swings very close to the floor and the edge of the lab table does not interfere with the motion of the string. Make a tight pivot point at the clamp that will not slip.

3. Place the '0' end of the ruler directly under the ball at rest at the center of the circle.

4. Gently start the pendulum moving in a circle of radius \( r \), as measured on your ruler. Use a second ruler (or the pattern of the floor tiles or other method) to define the circular path.

5. Record the radius of the circle and determine the period by measuring the time to complete 3 cycles. Calculate the velocity and centripetal acceleration of the ball. Show your data and work.

\[ r = \phantom{0000} \]

\[ T_{avg} = \phantom{0000} \]

\[ v = \phantom{0000} \]
6. Draw the free-body diagram.
   Sketch the coordinate axes, ±r and ±p.
   Sketch and label any vector components.

7. In the vertical direction, is this a first law
   or second law situation? _____
   Calculate F_{T_p}: Show your work.

8. In the radial direction, is this a first law
   or a second law situation? _____
   Calculate F_{T_r}: Show your work.

9. Given F_{T_p} and F_{T_r}, calculate F_T and θ. Show your work.

10. Knowing r and θ, you can now calculate L, the length of the string:
    Show your work.

11. When you have a prediction, the teacher will measure your string with a meterstick.
    Record L_{measured} and calculate the percent error.

   \[ \text{Percent error} = \left( \frac{|L_p - L_m|}{L_p} \right) \times 100 \]