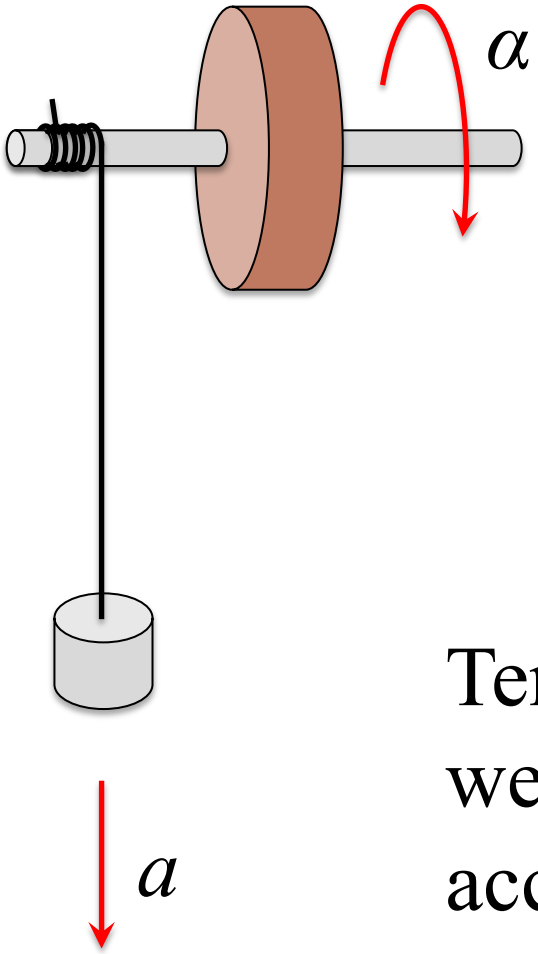
Mini-Lab: Rotational Dynamics

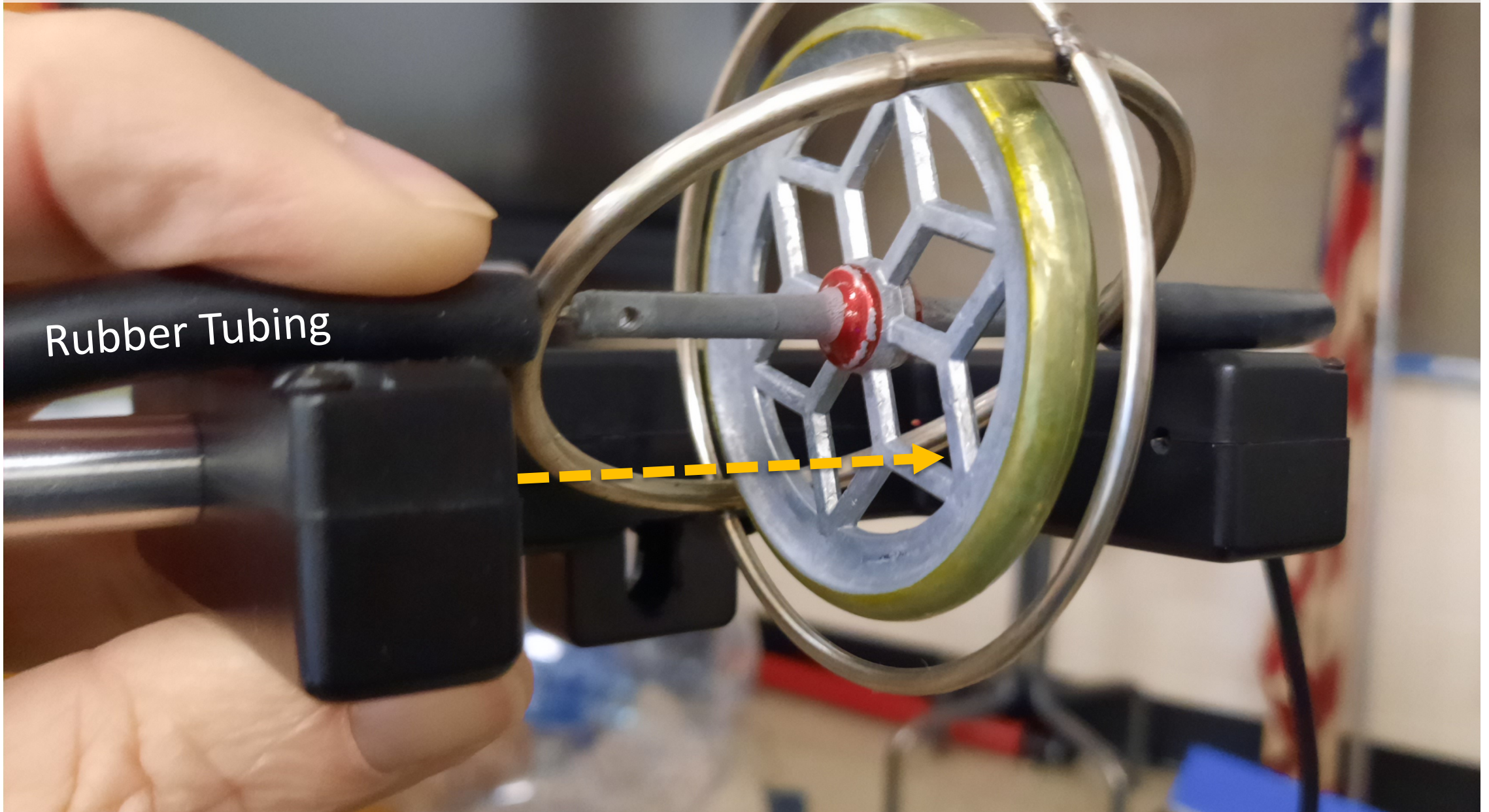
Goal: test rotational dynamics concepts and equations by accelerating a gyroscope with a dangling mass.



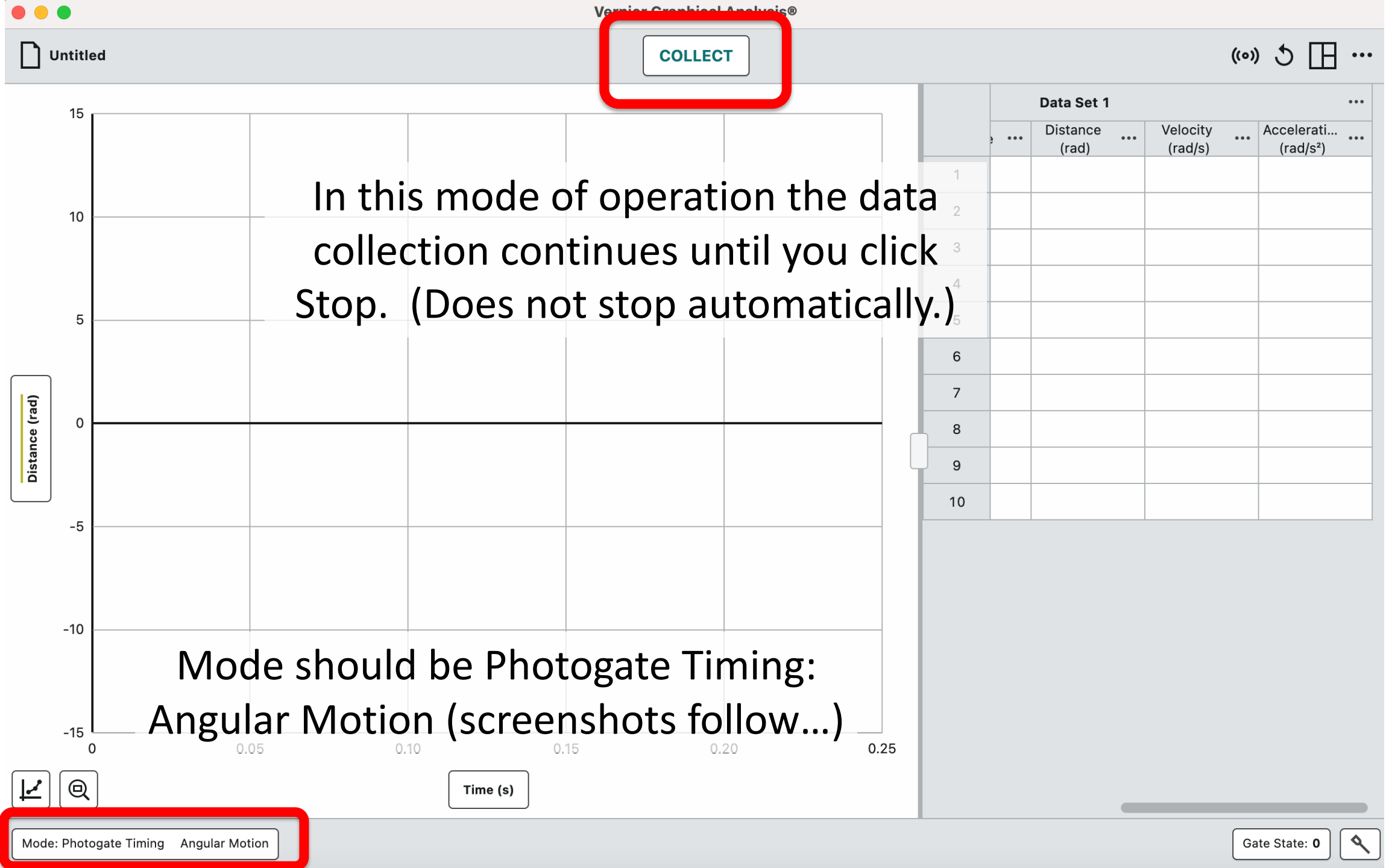
String is wrapped around axle. Tension in string produces torque which accelerates the wheel.

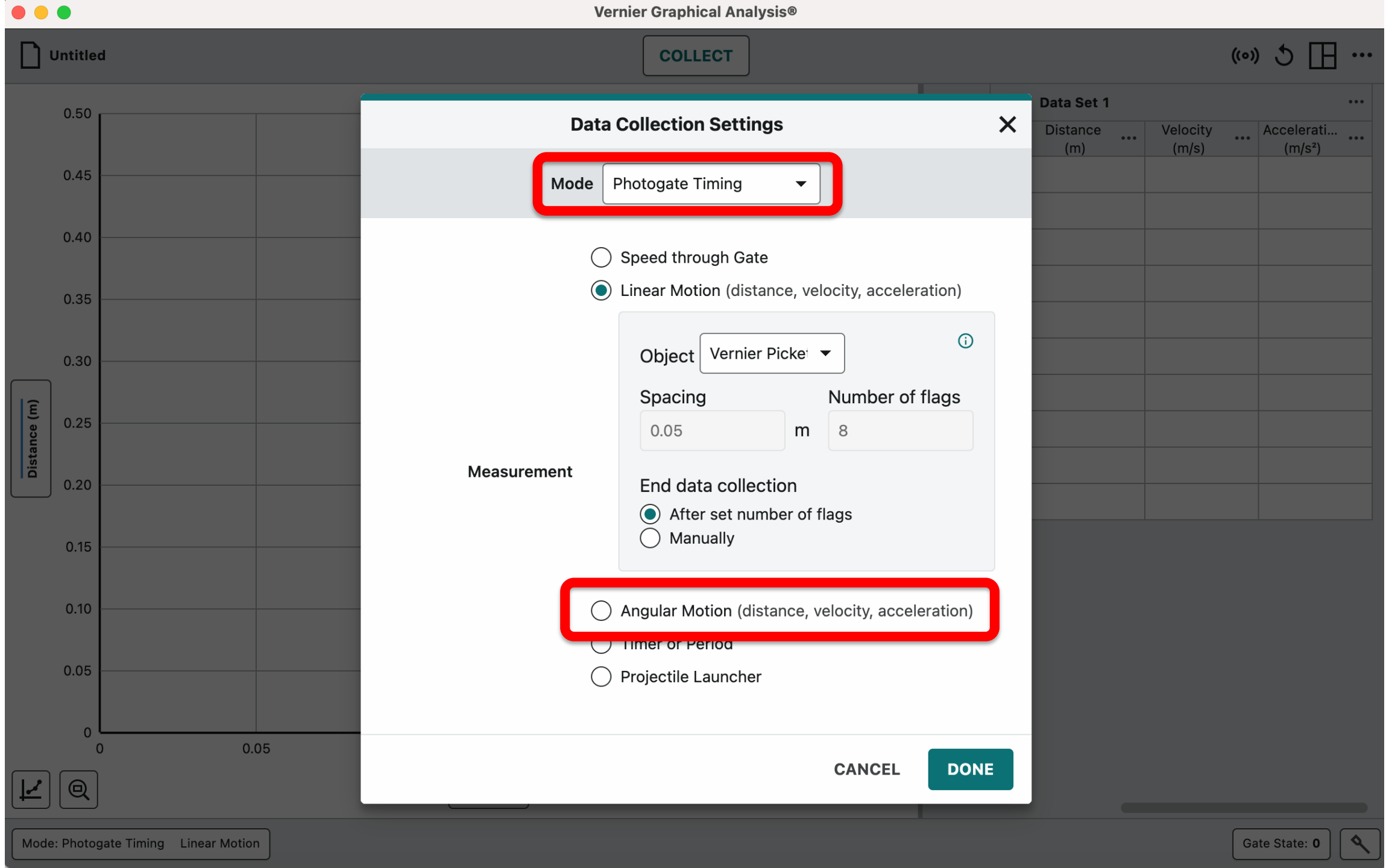
Tension in the string relates to the weight of the hanging mass. The linear acceleration of the mass relates to the angular acceleration of the wheel.

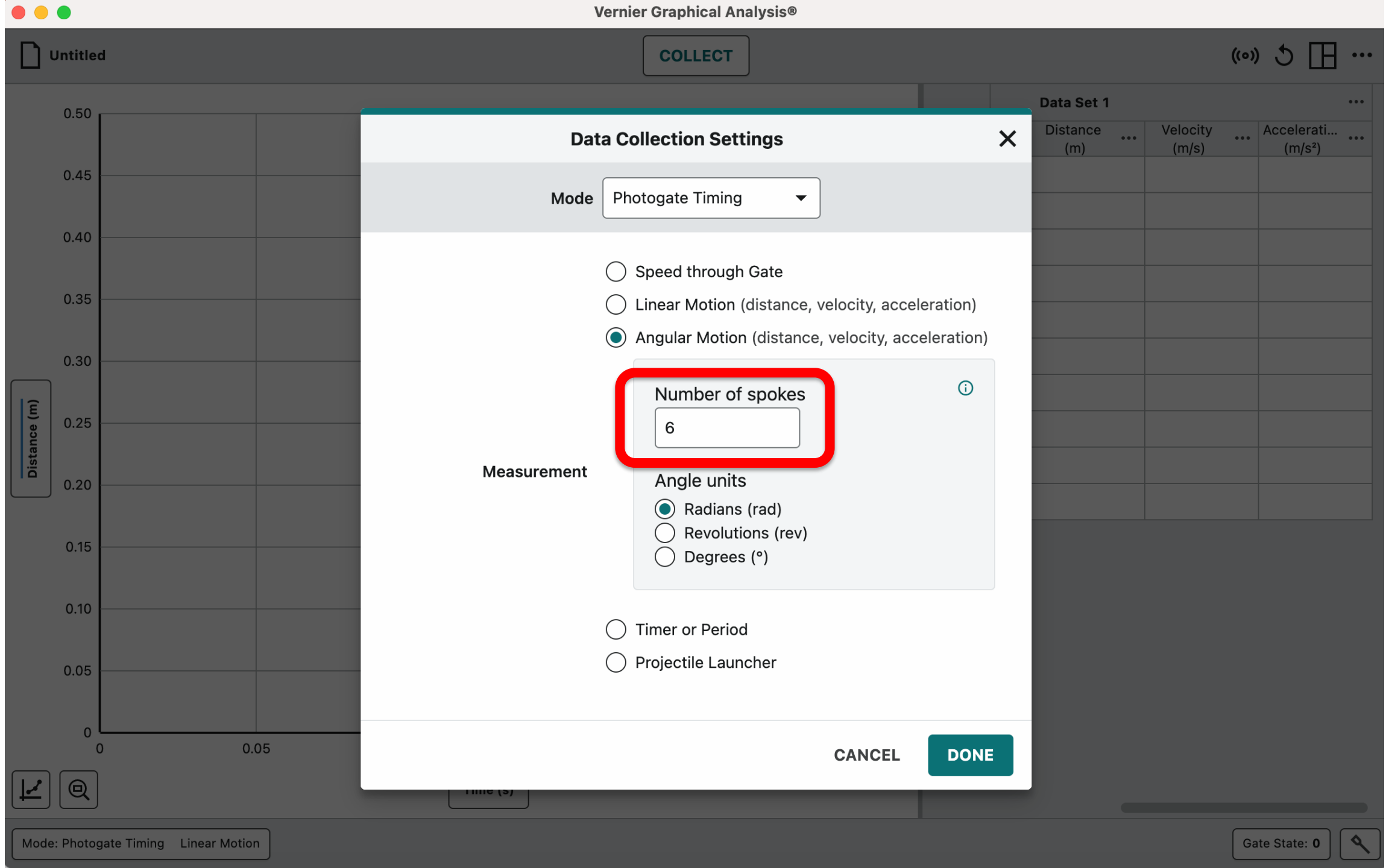
Hold gyroscope against photogate, directly above the sensor opening so that the beam can shine through diamond shaped openings in the wheel.

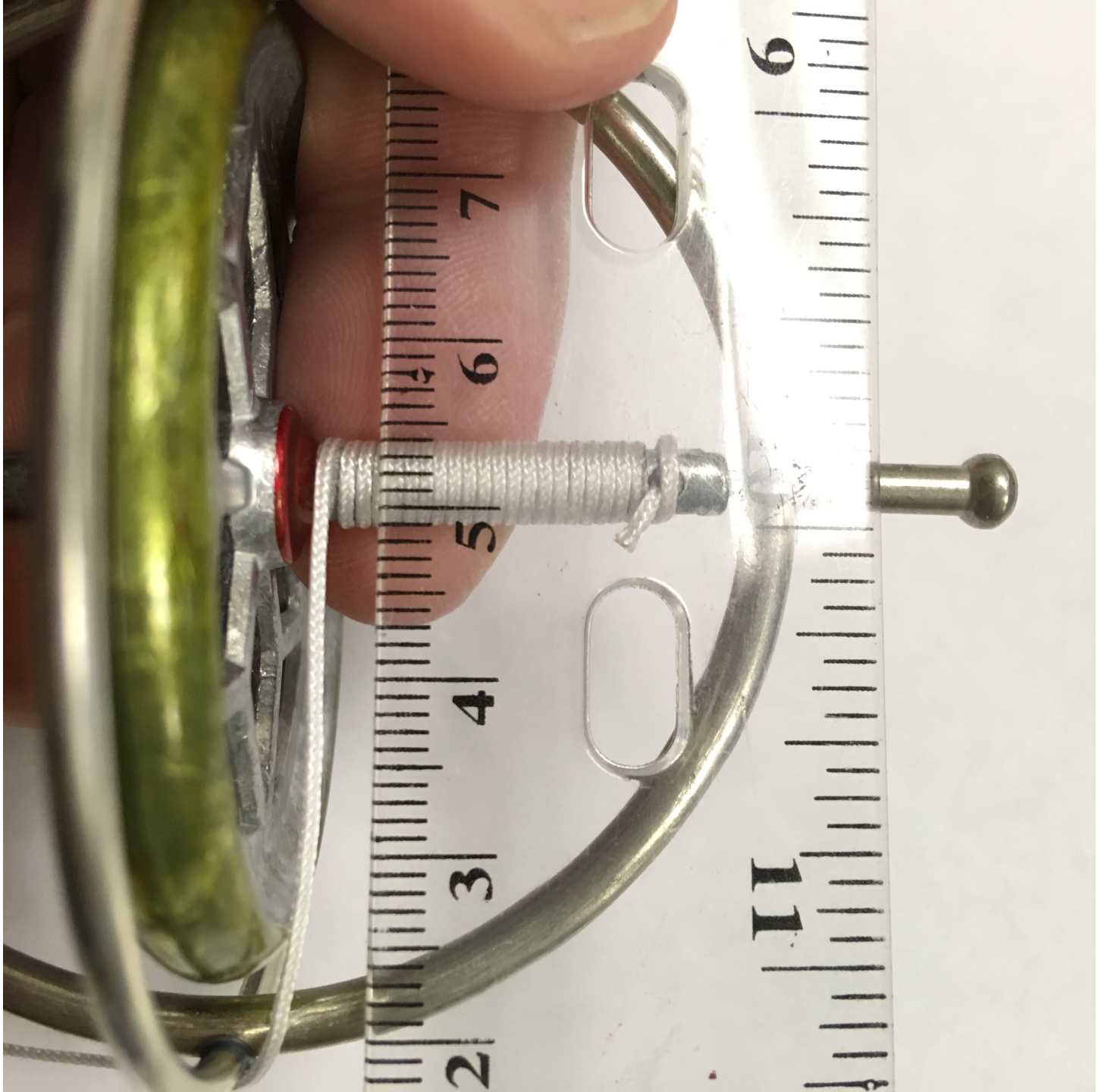


1. Carefully wrap string around axle of gyroscope so that there is one layer of single turns (about 20 will fit).
2. By measuring the length of string per certain amount of turns you can determine the radius of the axle and the distance the hanging mass will fall. (Or use given radius if time is fleeting.)
3. Holding the gyroscope with the axle horizontal, hang the 10.0 g mass on the end of the string. Use graphical analysis and photogate to measure the motion as the mass descends after its release.
4. Use the data to determine the best value for the angular acceleration of the wheel as the mass was falling.
5. Repeat the experiment at least once with 20.0 g and/or 50.0 g mass.
6. Working as a group use the results of the multiple trials to determine your best estimate of the rotational inertia of the gyroscope wheel.
7. Optional Challenge (time permitting): use the equipment to measure the effect of friction and adjust your answer.


Vernier Graphical Analysis®
Untitled
COLLECT
Data Set 1
Distance (rad)
Velocity (rad/s)
Accelerati... (rad/s²)
In this mode of operation the data collection continues until you click Stop. (Does not stop automatically.)
Mode should be Photogate Timing: Angular Motion (screenshots follow…)
Distance (rad)
Time (s)
Mode: Photogate Timing Angular Motion
Gate State: 0


Vernier Graphical Analysis®
Untitled
COLLECT
Data Set 1
Distance (m)
Velocity (m/s)
Acceleration (m/s²)
Data Collection Settings
Mode
Photogate Timing
Speed through Gate
Linear Motion (distance, velocity, acceleration)
Measurement
Object
Vernier Picket
Spacing
0.05
m
Number of flags
8
End data collection
After set number of flags
Manually
Angular Motion (distance, velocity, acceleration)
Timer or Period
Projectile Launcher
CANCEL
DONE
Distance (m)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
0.05
Mode: Photogate Timing Linear Motion
Gate State: 0


Vernier Graphical Analysis®
Untitled
COLLECT
Data Set 1
Distance (m)
Velocity (m/s)
Acceleration (m/s²)
Data Collection Settings
Mode
Photogate Timing
Speed through Gate
Linear Motion (distance, velocity, acceleration)
Angular Motion (distance, velocity, acceleration)
Measurement
Number of spokes
6
Angle units
Radians (rad)
Revolutions (rev)
Degrees (°)
Timer or Period
Projectile Launcher
CANCEL
DONE
Distance (m)
Time (s)
Mode: Photogate Timing Linear Motion
Gate State: 0



Rotor Info:
mass: 45.8 g
axle radius: 0.23 cm
axle length: 6 cm
axle mass: 2.8 g
(assumed aluminum)

Main ring:
$m = 43.0$ g
$r_1 = 2.05$ cm
$r_2 = 2.85$ cm
$I = 2.65 \times 10^{-5}$ kg m^2
(best estimate!)