Mini-Lab: Rotational Dynamics

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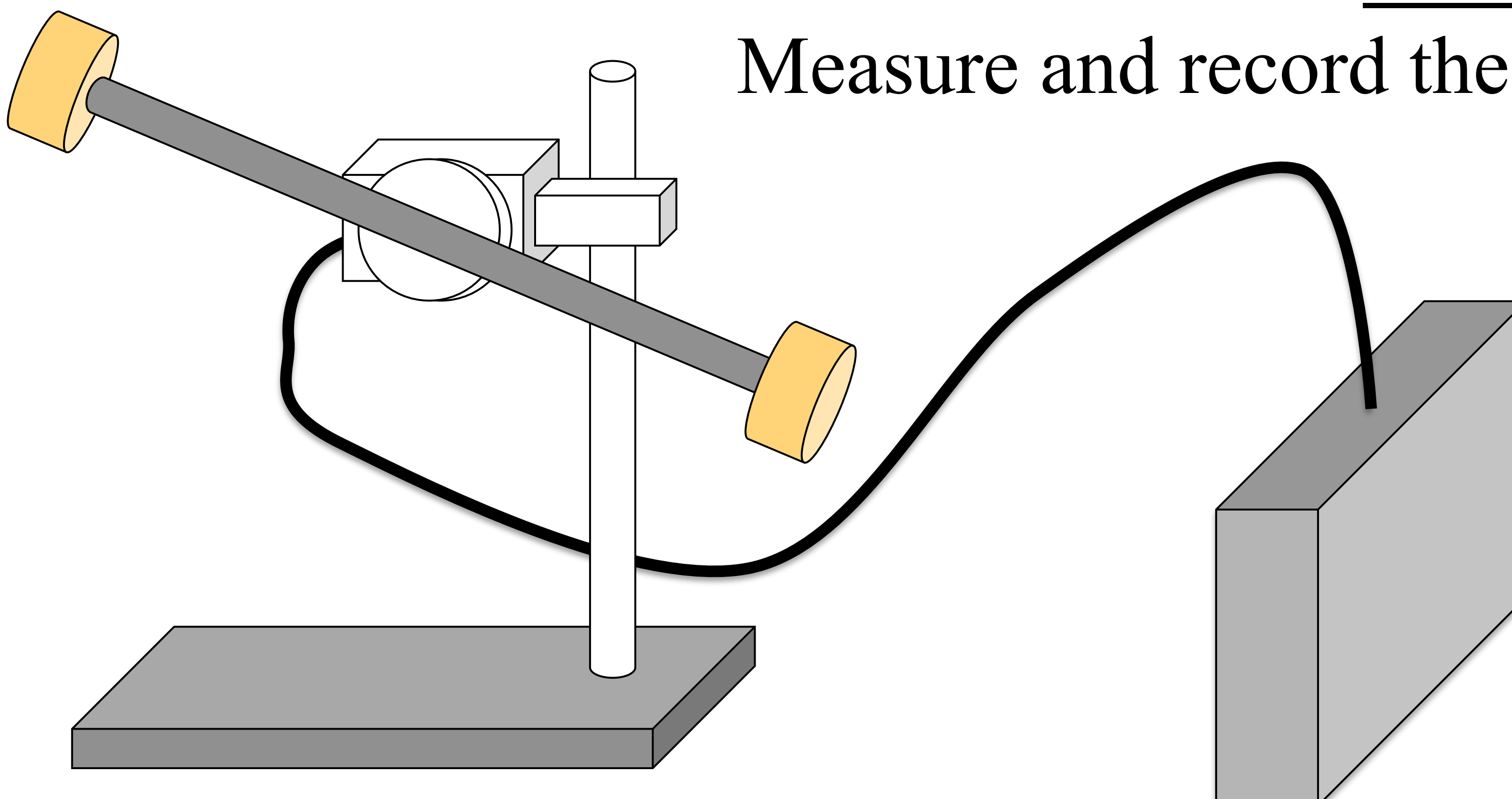
Basic Lab Setup:

Adjust the two brass masses to *equal distances* on either side of the bar so that it is balanced! Measure and record the distance.



Ring stand and Rotary Motion Sensor

LabQuest tablet computer

1. Plug Rotary Sensor into DIG 1 (under rubber flap).
2. Under the **Sensors** menu, choose **Sensor Setup…** and set **DIG 1** to **Rotary Motion**.
3. Change the length of the experiment from 10 seconds down to just 3.0 seconds.
4. Without clicking on collect, try simply looking at the live readout and rotate the bar from zero radians to 1.0 radians – about how many degrees has it rotated? Try rotating the bar precisely 1.0 revolutions or 10 revolutions in either direction. What is the equivalence in radians?
5. Click to collect data and then ***gently*** set the bar rotating and let go. Explore the graphs. Angular acceleration can best be determined by slope from a line of best fit.

In order to apply torque, simply tape string to axle…

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…and then wind it up in a *single layer*.

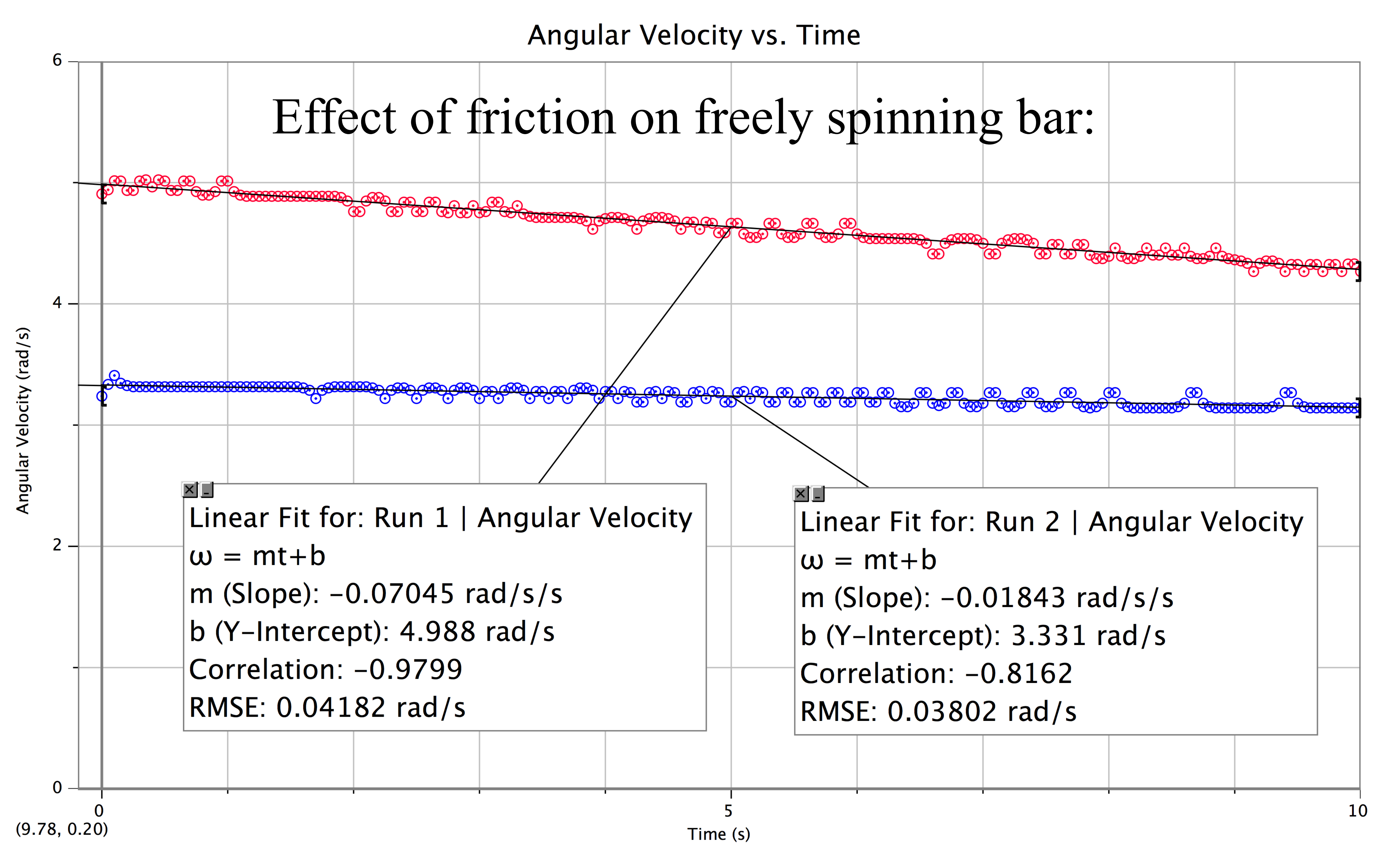
Attach a spring scale to the other end and pull with a *steady amount of force* that can be used to determine the amount of torque.

1. Always adjust the position of the sliding masses so that the bar is balanced. Calculate I_{total} using mr^2 for the two masses (75 g each) and including the bar ($I_{\text{bar}} = 3.4 \times 10^{-4}$ kg m^2).
2. Use LabQuest to measure the angular acceleration caused by friction. Calculate the torque of friction. Repeat using a different position of the sliding masses – same torque?
3. Move masses to the greatest radius. Apply a torque using a particular amount of force acting on a string wrapped around the axle, radius = 0.35 cm. Use LabQuest to determine the angular acceleration that results with this torque applied.
4. Calculate the expected angular acceleration based on torque applied, frictional torque, and rotational inertia. Compare!
5. Repeat with different amounts of torque, producing a table of torque vs. angular acceleration. Graph the results.

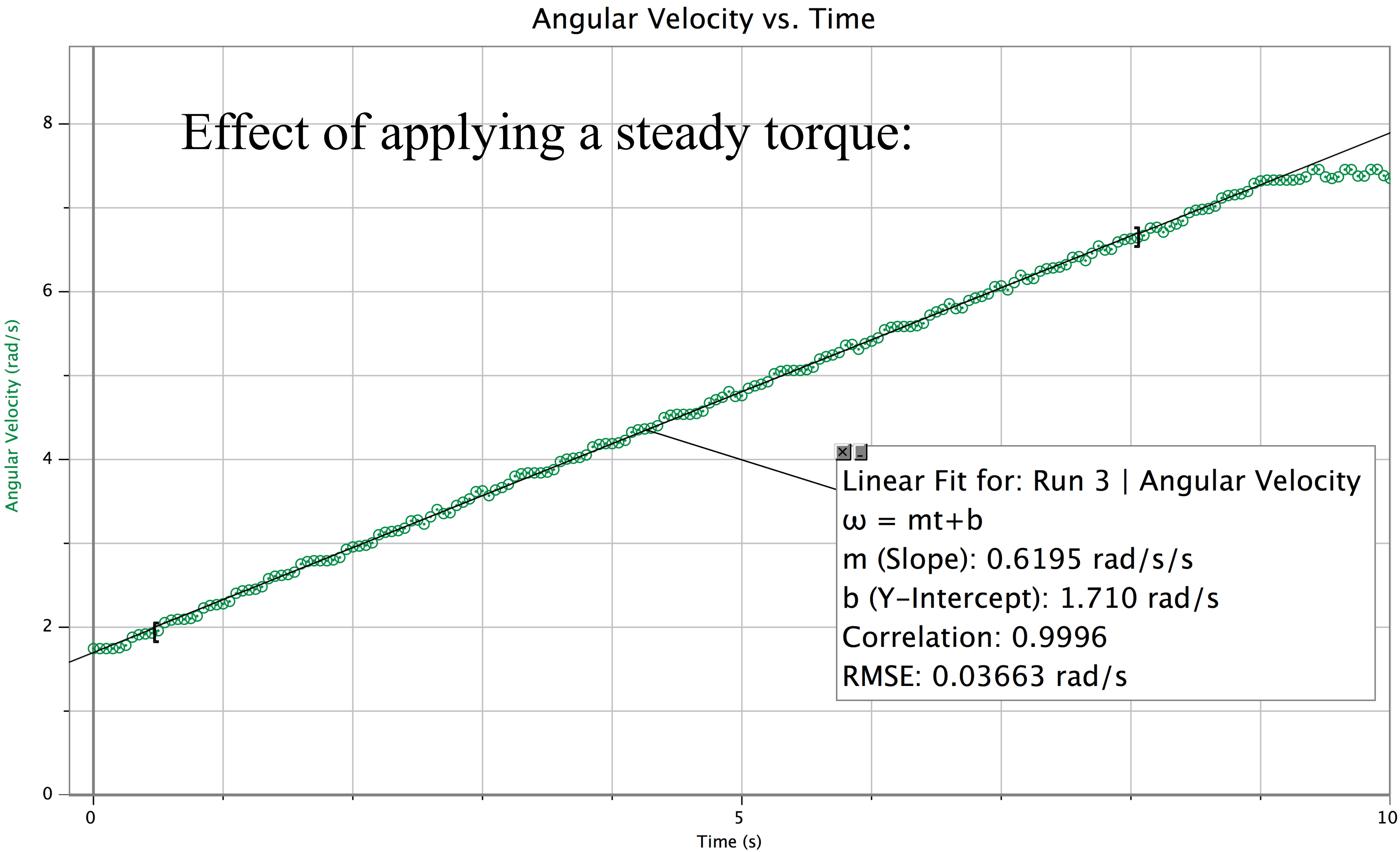
Report: (can be done on a single piece of graph paper!)

1. Produce a graph of Torque vs. Angular Acceleration.
2. Determine the line or curve of best fit, including equation.
3. Determine the rotational inertia based on the masses and dimensions of the spinning apparatus – show all work.
4. Determine the rotational inertia based on one of the coefficients of the graph's equation.
5. Discuss the results scientifically and critically, including consideration and evaluation of error.

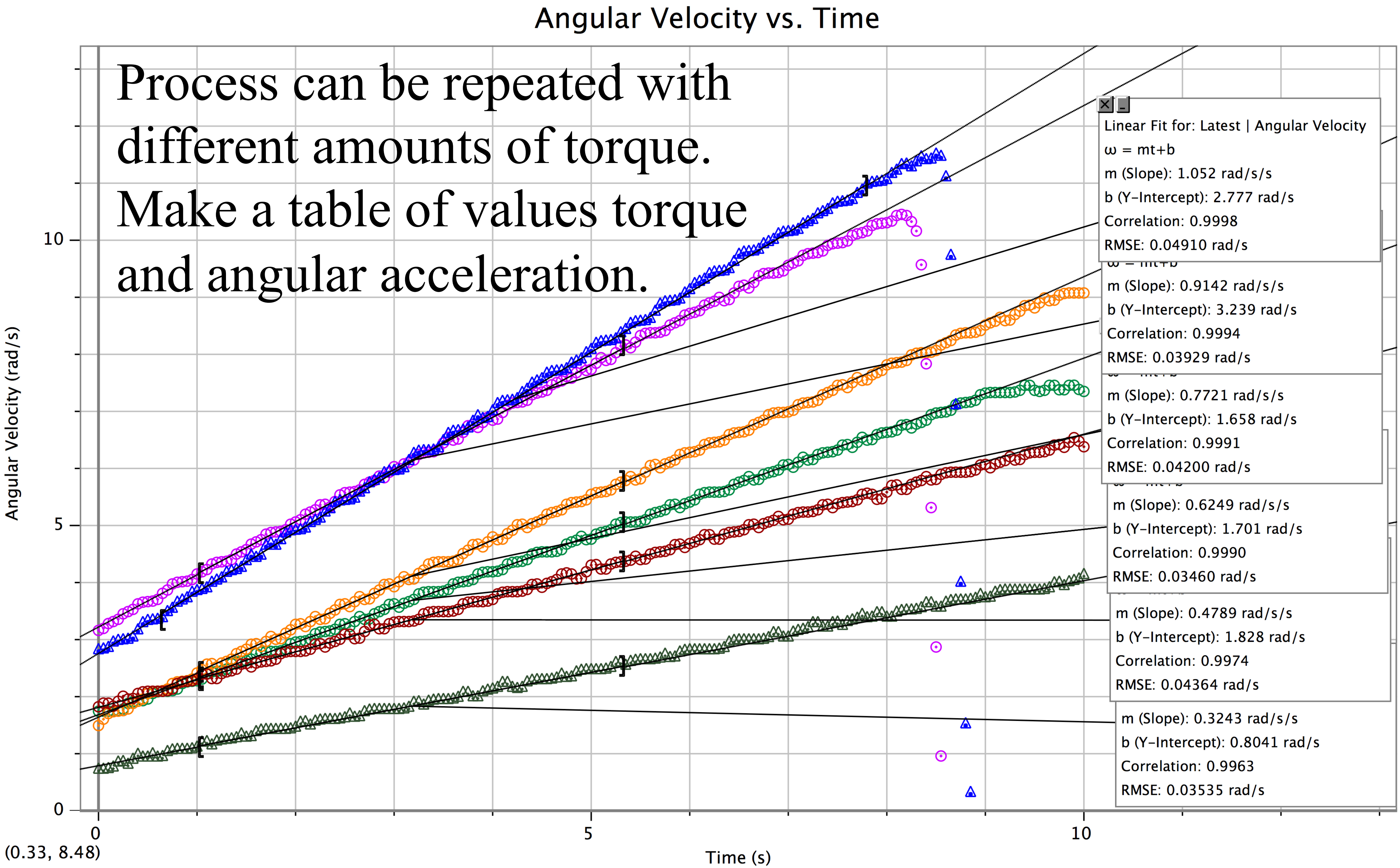
The graphs you observe with LabQuest and the graph you create yourself should resemble the following…


Angular Velocity vs. Time
Effect of friction on freely spinning bar:
Angular Velocity (rad/s)
6
4
2
0
0
5
10
Time (s)
(9.78, 0.20)
Linear Fit for: Run 1 | Angular Velocity
ω = mt+b
m (Slope): −0.07045 rad/s/s
b (Y−Intercept): 4.988 rad/s
Correlation: −0.9799
RMSE: 0.04182 rad/s
Linear Fit for: Run 2 | Angular Velocity
ω = mt+b
m (Slope): −0.01843 rad/s/s
b (Y−Intercept): 3.331 rad/s
Correlation: −0.8162
RMSE: 0.03802 rad/s

Effect of applying a steady torque:



Process can be repeated with different amounts of torque. Make a table of values torque and angular acceleration.



Final graph showing the results of five or six trials: