cLAB: Rotational Motion

Name:_______________________________________

TO BEGIN: Go to **http://phet.colorado.edu/en/simulation/torque** and click **Run Now!**

- DO NOT update Java – click Later.
- Turn on the sound for the computer – either unmute or turn up the speakers.
- *Answer the conceptual questions in complete sentences. For calculations, show all formulas, units, and work. Circle your answers.*

Part I: Torque

1. Define torque.

2. In the PhET app, click the tab at the top that says **Torque**.
3. Set the **Applied Force** equal to 1 N.
4. Click **Go** and let this run for about 30 seconds
5. Calculate the torque on the wheel (include direction).

6. What eventually happens to the lady bug?

   ** **Note:** The lady bug can be moved back to the wheel by clicking and dragging her back.

7. When considering angular motion, what do net torque produce?

8. What must be the centripetal force that keeps the lady bug moving in a circle?

9. Why does this force eventually fail?

10. **Reset all** and check that the **Applied Force** is set to 1 N.

11. Click **Go** and observe the acceleration vector. Describe how it changes.

12. **Reset all** and check that the **Applied Force** is set to 1 N.
13. Click **Go**, wait about 2 seconds, and set the **Force of Brake** to 1 N. Hit Enter and observe. Describe the motion of the wheel.

14. What happened to the acceleration vector? Explain why.

15. Calculate the NET torque. Don't forget <u>direction</u>! *(Hint: Refer to the data in the bottom graph!)*

16. **Reset all** and check that the **Applied Force** is set to 1 N.
17. Hit **Start**. After a few seconds, set the **Force of Brake** equal to 3N and hit Enter.
18. Calculate the NET torque at the point right after you set the brake force. Use the data on the graph. *Hint: you can click on Playback, Pause, and/or move the time marker to the area on the graph that displays the braking data.*

19. In the bottom graph, observe the red line that represents the **Braking Torque**. It changed after the disk stopped. Why? *(Hint: What is the Braking Torque value after the disk stops?)*

Part II: Moment of Inertia

1. Define Moment of Inertia *(I)*.

2. Click the **Moment of Inertia Tab** at the top of the PhET app.
3. Use the (-) and (+) buttons to the right of the Torque Graph to change the scale to show a range of 20 to -20.
4. Set the Moment of Inertia Graph to show a range of 2 kg m^2 to – 2 kg m^2
5. Set the Angular Acceleration Graph to show 1000 degrees/s^2 to –1000 degrees/s^2
6. Calculate the moment of inertia for the disk using the information provided in the table under the rotating disk AND the formula for the moment of inertia of a disk: $I = ½mr^2$

7. Move the cursor over the disk so the cursor finger is pointing anywhere between the green and pink circles.
8. Left click on this spot and at the same time drag across to the right to apply a force.
9. Once you get the hang of it, click **Stop** and then **Clear** (NOT Reset!).
10. Repeat the step above and try to apply a force that creates a torque of around **10 Nm**.
11. Click on the ruler to determine the radius between the green and pink circles. Radius = _________m
12. Calculate what the applied force must have been. *Remember the formula for torque!*

13. Use a second formula for torque **($T = I\,\alpha$)** to calculate the Angular Acceleration (α) of the disk. Your answer will be in SI units, rad/s^2. Convert this unit to degrees/s^2 by multiplying by the conversion factor **180°/π rad**. Compare to the graph to check your answer.

14. Click **Stop** and **Clear**.

15. Again, move the cursor over the disk so the cursor is pointing anywhere between the green and pink circles.
16. Left click on this spot and at the same time drag across to the right to apply a force. Vary the force in both magnitude and direction. Observe the graphs and describe what happens to torque. Explain why.

17. Observe the graphs and describe what happens to moment of inertia. Explain why.

18. Click **Stop** and **Clear**.
19. Predict what will happen to the moment of inertia if you keep the mass of the platform the same, but you create a hole in the middle (increase inner radius).

20. Reset the **Torque** to 10 Nm.
21. Click **Go**. While the disk is spinning, gradually increase the **Inner Radius** by moving the slider to the right.
22. Check your prediction by looking at the Moment of Inertia Graph. What happened? Explain why.

23. In summary, when the mass of an object increases, the moment of inertia ___________________________.

    When the distance of the mass from the axis of rotation increases, the moment of inertia

    ___________________________.

Part III: ANGULAR MOMENTUM

1. Define angular momentum (L).

2. Click the **Angular Momentum** tab at the top pf the PhET app.
3. Set the scale of both the Moment of Inertia and the Angular Momentum graphs to show a range of about 3 to -3 *(you will have to estimate this)*.
4. Set the **Platform Mass** to 0.05 kg and set the **Angular Velocity** (ω) to 90 degrees/s.
5. Click **Go** let this run for a couple of seconds. Click **Stop** and record the moment of inertia (I) and the angular momentum (L) from the graphs. *Be sure and include units!*

6. Click **Go**. While the disk is spinning, gradually increase the **Platform Mass** by moving the slider to the right.
7. Click **Stop**. Record the final values for angular velocity, moment of inertia, and angular momentum.

8. Observe the graphs. As the mass increased, describe what happened to angular velocity, moment of inertia, and angular momentum? Explain why. *Hint: Don't forget* $\boldsymbol{L = I \omega}$

9. Click **Clear**. Reset the **Platform Mass** to 0.05 kg and the angular velocity to 90 degrees/s.
10. Click **Go**. While the disk is moving, gradually increase the **Inner Radius** by moving the slider to the right.
11. Observe the graphs. As the inner radius of the disk increased, what happened to angular velocity, moment of inertia, and angular momentum? Explain why.