Physics Web Quest: Torque

Name Key
Period

Open the Physics Animations Folder

Open **torque** (http://phet.colorado.edu/simulations/sims.php?sim=Torque)

Part I: Torque

1. Click the tab at the top that says torque
2. Set the force equal to 1 N.
3. Click Go let this run for at least 10 seconds → from Right Hand Rule
4. What is the torque on the wheel (include direction).

   $\vec{\tau} = \vec{r} \times \vec{F}$ $\tau = .004 \times 1 = .004\,\hat{k}$ Nm

   ↳ out of page (counter clockwise)

5. What eventually happens to the lady bug? flys off
6. From Newton's second law, a force will cause an acceleration
7. When considering angular motion, a torque will cause an angular acceleration (consider both torque equations)
8. What must be the centripetal force that keeps the lady bug moving in a circle? friction
9. Why does this force eventually fail? Static friction has a max value. $F_c = ma_c \rightarrow F_c = v^2/r$ As vel goes ↑ F_c needs to go up, but F_f maxes out.
10. Reset all, and set the force back to 1 N.
11. Observe the acceleration vector as you start. Describe how it changes. Gets larger and points closer to center
12. Will the acceleration vector ever point directly to the center? No Why / Why not? (the next steps might help you answer this question) Not if there is a tangential component of acceleration (which would be the case if there is a net torque)
13. Reset all. Set the force back to 1 N.
14. Hit start, wait about 2 seconds, and set the brake force to 1 N. Hit enter and observe.
15. Describe the motion of the wheel: Constant angular velocity
16. What happened to the acceleration vector? points to center Why? Now there is no tangential component. Only centripetal acceleration applies
17. What is the net torque? 0
18. Reset all. Set the Force back to 1 N. Hit Start.
19. After a few seconds, set the brake force equal to 3N and hit enter.
20. Right after you set the break force, calculate the net torque (check with the graph): $\tau_{net} = \tau_1 + \tau_2$

    $= -(4 \times 3) + (4 \times 1)$

    $= -12 + 4$

    $= -8$ Nmm → -.008 Nm

    * negative, for into the page

21. Eventually the disc stops and the net torque is zero. This is because the breaking torque changed as you can see in the graph. Why did it change?

    Breaking force only opposes motion. It can cause an object to stop, but not reverse directions, so once stopped it would = applied force

Part II: Moment of Inertia

1. Click the Moment of Inertia Tab at the top.
2. Disregard any millimeter units. They should all be meters.
3. To best see the graphs, set the scale of the torque graph 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 1,000 degrees / s^2 to –1000 degrees / s^2
6. Calculate the moment of Inertia for the disk with the given information.

$I = \frac{1}{2}mr^2$ $\quad$ $I = \frac{1}{2}(.12)(4^2)$ $\quad$ $\boxed{I = .96 \, kg\, m^2}$

7. Hold the mouse over the disk so the mouse finger is pointing anywhere between the green and pink circles.
8. Hold down the left mouse button. Move your mouse to apply a force.
9. Look at the graph and try to apply a force that creates a torque of 10.
10. Use the ruler to determine the radius at any point between the green and pink circles. r = ___3___ m
11. Calculate what the applied force must have been.

$\tau = r \times F$

$10 = 3 \times F$ $\quad$ $\boxed{F = 3.3\, N}$

12. Calculate the angular acceleration of the disk. Work in SI units, and then convert to degrees / s^2. Compare to the graph to check your answer.

$\tau = I\alpha$ $\quad$ $\alpha = 10.42 \frac{rad}{s^2} \times \frac{180°}{\pi\, rad} = 597°/s^2$

$10 = (.96)(\alpha)$

13. 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).
Increase $\Rightarrow$ mass is farther from center, $r^2 \uparrow$ $I = \int r^2 dm$
14. Set the inner radius equal to 2. Calculate the moment of inertia for this shape. Set the disk in motion and check your answer by looking at the moment of inertia graph.

$I = \frac{1}{2}m(r_1^2 + r_2^2)$

$I = \frac{1}{2}(.12)(2^2 + 4^2)$ $\quad$ $\boxed{I = 1.2\, kg\, m^2}$

15. Even when the force on the platform changes, the moment of inertia graph remains constant. Why? moment of inertia is only related to mass and the location of this mass (m & r^2)
16. Fill in the blanks: When the mass of an object increases, the moment of inertia ___$\uparrow$___. When the distance of the mass from the axis of rotation increases, the moment of inertia ___$\uparrow$___.

Part III

1. Click the Angular Momentum tab at the top.
2. Set the scale of the moment of inertia and angular momentum graphs to show a range of 2 to -2.
3. Set the angular speed to be 45 degrees / s.
4. What is the SI unit for angular momentum? $\vec{L} = \vec{r} \times \vec{p}$ (m, $kg\,m/s$) ______ $kg\,m^2/s$
5. Calculate the angular momentum in SI units (you should have already calculated the moment of inertia in part II).

$\vec{L} = I\vec{\omega}$ $\quad L = .96\left(\frac{\pi}{4}\right)$ $\quad 45°/s = \frac{\pi}{4}$ rad/s

$L = .754\ kg\,m^2/s$

6. While the disk is moving, change the inner radius to 2.
7. Observe the graphs.
8. Changing the inner radius automatically changes the angular velocity to 36 degrees / s. Why? (mention moment of inertia and angular momentum in your answer).

$L_i = L_f$

$I_i \omega_i = I_f \omega_f$

so if I increases by adding a hole to the middle (but keeping mass constant) ω will decrease