Names:

Torque Play

In this lab we will use torque to explain several very odd phenomena.

0.1 Review Before we begin the experiments, we need to recall the key equations.

1. Write down the definition of torque.

2. Write down the relation between torque and change in angular momentum.

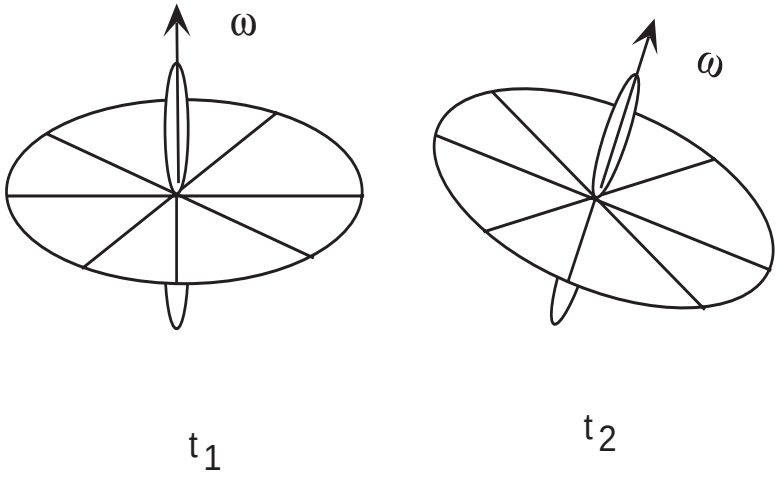
3. How do we denote a vector into the page? out of the page?

0.2 Turning the Wheel Over Spin up the bicycle wheel so that $\vec{\omega}$ is pointing upward. With your right hand on the top handle and left hand on bottom, turn the wheel over to your right so that you end up with your right hand on bottom and your left hand on top. (You would have to flip your hands to be able to turn it to your left.)

Describe how it feels as you turn it.

Now we will find the most efficient way to turn over the wheel, using the following steps and our understanding of torque. We will focus on just the initial phase of turning over, but the same ideas apply through the whole turn.

1. First, based on the sketches below, sketch $\vec{L}_1$ and $\vec{L}_2$.



2. Now sketch $\Delta\vec{L} \equiv \vec{L}_2 - \vec{L}_1$.

3. What direction must the torque be in to induce such a change in $\vec{L}$? (Drawn it on the sketch.)

4. If you apply a force at the end of the top and bottom handle, what is the moment arm $\vec{r}$ in each case?.

5. Given $\vec{\tau}$ and $\vec{r}$, what direction must $\vec{F}$ be in to give the torque we need?

6. Now you need to check your prediction. Spin up the wheel as before and exert the forces needed that you found in the last question. Describe what you feel.

7. Now spin the wheel in just the opposite way (clockwise as seen from above) and try to turn it over with the same force as you did before. Describe what you feel.

8. Explain, using the notion of torque, what you initially felt when you tried to turn over the wheel.

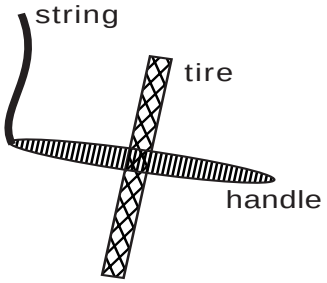
0.3 Dropping the Wheel Loop the string over your wrist, then spin up the wheel. Let the wheel fall while holding onto the string.

1. Describe what you see.

2. What happens if you spin the wheel the other way and then drop it?

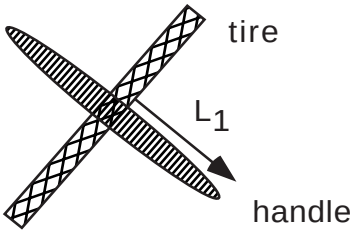
3. On the diagram below (which should be a good representation of what you see), sketch the force of gravity, the moment arm for gravity, the torque due to gravity. Hint: you can recognize the axis of rotation because it is the still point of the motion.

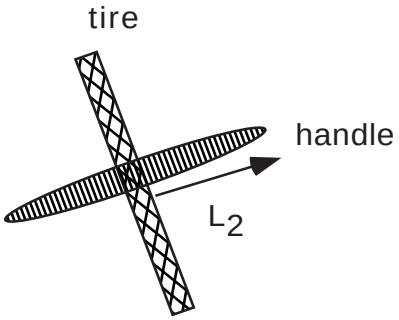
SIDE VIEW



4. On the diagram below, I have sketched $\vec{L}$ for two closely spaced times. **We have now switched to a top view**. Sketch the direction of the torque due to gravity based on your sketch above.

TOP VIEW





t1 t2

5. Is your direction of torque consistent with the direction in the change in angular momentum?

6. What direction would torque have to be in to make the wheel fall over as it does when it is not rotating (it might help to refer back to the last experiment where you turned the wheel over). Can gravity provide such a torque?