Names: Spring 2

Recall : $\overrightarrow{\Delta L} = \vec{\tau}\Delta t$, *and* $\overrightarrow{L_f} = \overrightarrow{L_o} + \overrightarrow{\Delta L}$

For EVERY exercise. Please make a drawing indicating the direction of torque and initial angular momentum and predict what will happen. Document this with a drawing. ONLY AFTER YOU'VE FINISHED THIS, can you do the exercise!! *(please)*

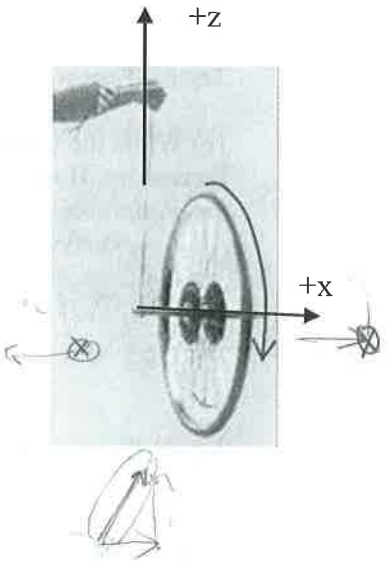
WHEEL STATION

Gyroscopic Bicycle Wheel

1a) The bike wheel is spinning about the axis shown (right handed system). If you are just holding the rope, about which axis will the wheel rotate?

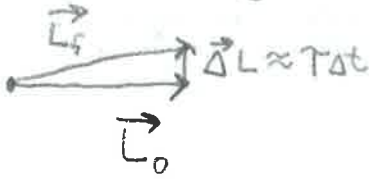
___ +y X +z ___ -y ___ -z

___ it won't rotate except in the spin direction



explain what happens and why. Explain your answer using a sketch of the vectors, words, and equations

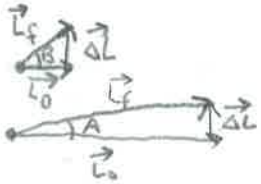
The wheel will rotate in the + z direction because the initial ang momentum is to the right, and the torque due to gravity is downwards, making the rotation into the paper. Therefore, using the right hand rule, the wheel rotates around the + z axis.



Now, spin the wheel in a vertical plane as fast as you can with the string attached onto a side handle (like the figure at right). Then hold onto the string and watch what happens to the wheel "gyroscope". *Were you right?* Yes

1b) Spin the wheel faster. How will this change the outcome? Again, *explain your answer using a sketch of the vectors and equations.*

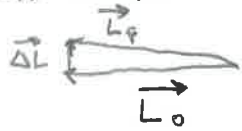
Spinning the wheel faster will create a larger initial angular momentum, so the torque of gravity changes the direction of the angular momentum by a smaller amount, giving the new momentum a small angle, and having the wheel precess less.



Try it! *Were you right?*

Yes

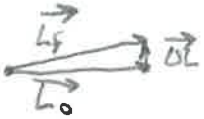
1c) Change the direction of the wheel's rotation. How will this change the outcome? Again, *explain your answer using a sketch of the vectors and equations.*

Changing the direction of the wheel's rotation will reverse the direction of its precession, because $\Delta\vec{L}$ 

so the wheel will rotate around the $-\hat{z}$ axis.

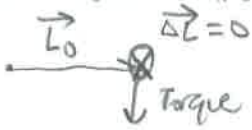
Try it! *Were you right?* yes

1d) Move the point of contact of the supporting string closer to the center of the wheel's hub. How will this change the outcome? Again, *explain your answer using a sketch of the vectors and equations.*

The wheel would precess slower because the torque from gravity will decrease because the radius away from the wheel is less, decreasing the angle 

Try it! *Were you right?* yes

1e) While the wheel is precessing, get in the way of the outer end of the axis, preventing it from precessing. How will this change the outcome? Again, *explain your answer using a sketch of the vectors and equations.*

By preventing precession, the wheel would fall, because the torque will rotate the wheel downward because it can't precess. 

Try it! *Were you right?*

(2) Hold one of the wheel handles with one hand, so the other handle pointing straight away from you. As you look out from your body/arm, spin the wheel CW. Then rotate your arm and body to the right, rotating your body in the positive *z* direction.

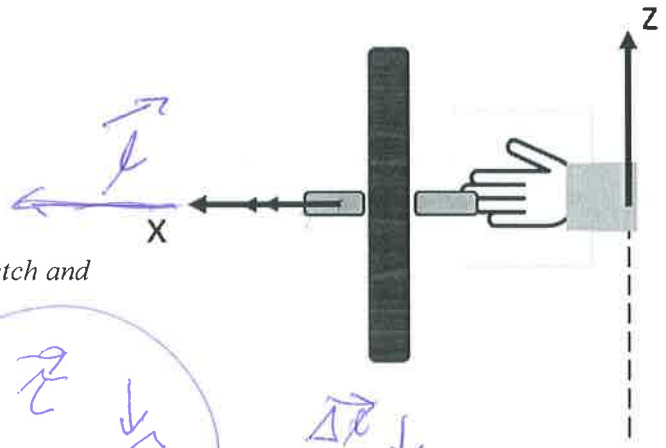
$\odot\hat{Y}$

About which axis does the wheel try to rotate?

___ +y ___ +z ___ -y ___ -z

___ it won't rotate except in the spin direction

explain your answer using a sketch of the vectors and equations.



Now run the activity, show why this happens using a sketch and appropriate equations. Make sure everyone does it.

because you are turning in $-\hat{z}$ rotation $\Delta\vec{L}$ is downward, rotating wheel in $+\hat{Y}$ direction

$\vec{L}$ $\downarrow$ $-\hat{z}$

$\Delta\vec{L}$ $\downarrow$

(3) Counter Steering: The wheel is spinning about the y axis as shown, just like you're riding down the street. Pull in on you right hand and push out on your left hand, as if you're turning the handlebars to the right. In which direction will the wheel turn?

___ +x ___ +z ___ -x ___ -z

___ it won't rotate except in the spin direction

explain your answer using a sketch of the vectors and equations.

if you pull in on your right hand, $\vec{F} \downarrow$, so $\Delta \vec{L} \downarrow$, rotating $\vec{L}$ ~~down~~ downward, rotating wheel in $-\hat{z}$ direction.

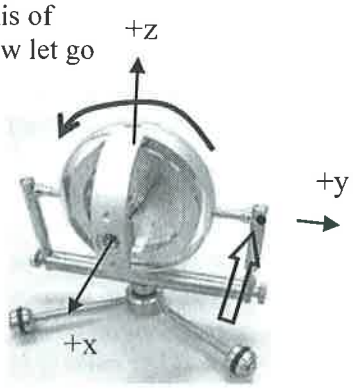
Let everyone on the team do this.

If you're riding a motorcycle down the street and you want to lean the bike over to the right, which way do you turn the handlebars?

counter steering - ~~to~~ on a bike, you push the handlebars in the opposite direction you want to turn in order to lean the bike.

Precision Gyroscope (Please do not drop these; they are very expensive)

(4) You have a gyroscope. Imagine that you put one of the short supports along the axis of rotation (opposite of where you attach the motor). Put this side down, but you will allow let go of the gyroscope when it is at about a 30 degree angle with the vertical. What will happen? *explain your answer using a sketch of the vectors and equations.*



Then try it! *Were you right?*