

Name: _____

RECITATION HANDOUT #11: Rotation II

1. Spin a top so that the angular momentum vector \vec{L} points **upward**. When gravity acts on the top (or you push it), the top does not fall over if it is spinning sufficiently fast. Instead, it “precesses” or moves _____ (CW or CCW).

Spin a top so that the angular momentum vector \vec{L} points **downward**. When gravity acts on the top (or you push it), the top moves _____ (CW or CCW).

The motion of the \vec{L} vector is due to the torque caused by gravity (or you). You should be able to predict this motion by finding the torque direction (or $\Delta\vec{L}$ direction) and adding it to the tip of the \vec{L} vector. The next four problems will help you practice this procedure.

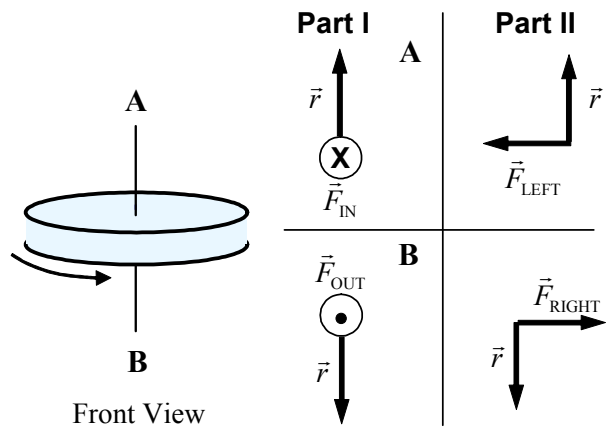
2. If a wheel rotates as shown, **draw** the angular momentum vector \vec{L} on the picture.

PART I: If you push **IN** at **A** and pull **OUT** at **B**, find the direction of the resultant **torque** $\vec{\tau}$ (or $\Delta\vec{L}$). Remember that $\vec{\tau} = \vec{r} \times \vec{F}$ and **draw** the $\vec{\tau}$ vectors for **points A & B** on the cross products shown in the drawing.

Direction $\vec{\tau} =$ _____

Due to this torque the wheel’s axis moves

_____ (CW or CCW) from front view.



PART II: If you pull **LEFT** at **A** and pull **RIGHT** at **B**, find the direction of the resulting **torque** $\vec{\tau}$.

Draw the $\vec{\tau}$ vectors for **points A & B** on the cross products shown in the drawing.

Direction $\vec{\tau} =$ _____

Due to this torque the wheel’s axis moves _____ (CW or CCW) from right-side view.

3. If the wheel rotates in the **opposite** direction as shown, **draw** the angular momentum vector \vec{L} on the picture.

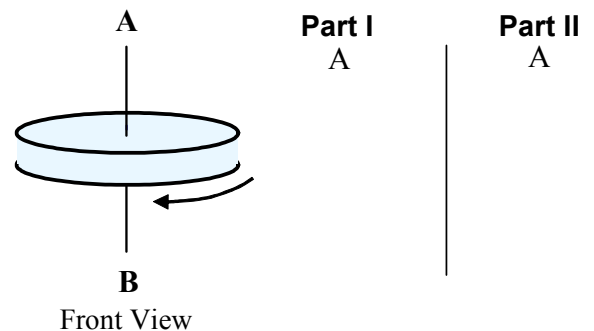
PART I: If you push **IN** at **A** and pull **OUT** at **B**,

draw the $\vec{\tau} = \vec{r} \times \vec{F}$ vectors for **point A**.

Direction $\vec{\tau} =$ _____

Due to this torque the wheel’s axis moves

_____ (CW or CCW) from front view.



PART II: If you pull **LEFT** at **A** and pull **RIGHT** at **B**, **draw** the $\vec{\tau} = \vec{r} \times \vec{F}$ vectors for **point A**.

Direction $\vec{\tau} =$ _____

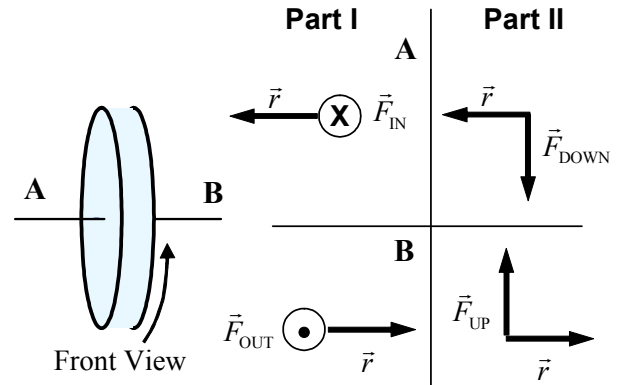
Due to this torque the wheel’s axis moves _____ (CW or CCW) from right-side view.

4. If a wheel rotates as shown, **draw** the angular momentum vector \vec{L} on the picture.

PART I: If you push **IN** at **A** and pull **OUT** at **B**, find the direction of the resultant **torque** $\vec{\tau}$ (or $\Delta\vec{L}$). Remember that $\vec{\tau} = \vec{r} \times \vec{F}$ and **draw** the $\vec{\tau}$ vectors for **points A & B** on the cross products shown in the drawing.

Direction $\vec{\tau} =$ _____

Due to this torque the wheel's axis moves _____ (CW or CCW) from front view.



PART II: If you pull **DOWN** at **A** and pull **UP** at **B**, find the direction of the resulting **torque** $\vec{\tau}$.

Draw the $\vec{\tau}$ vectors for **points A & B** on the cross products shown in the drawing.

Direction $\vec{\tau} =$ _____

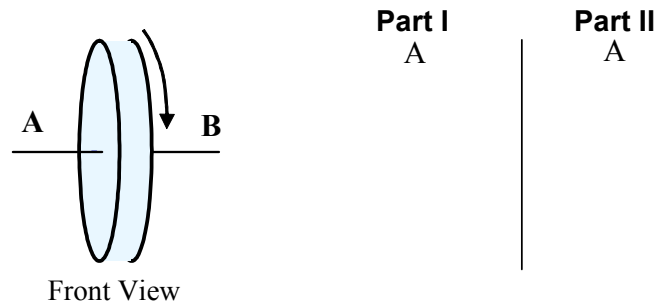
Due to this torque the wheel's axis moves _____ (CW or CCW) from top view.

5. If the wheel rotates in the **opposite** direction as shown, **draw** the angular momentum vector \vec{L} on the picture.

PART I: If you push **IN** at **A** and pull **OUT** at **B**, **draw** the $\vec{\tau} = \vec{r} \times \vec{F}$ vectors for **point A**.

Direction $\vec{\tau} =$ _____

Due to this torque the wheel's axis moves _____ (CW or CCW) from front view.

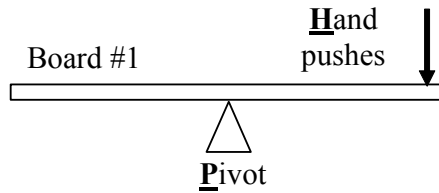


PART II: If you pull **DOWN** at **A** and pull **UP** at **B**, **draw** the $\vec{\tau} = \vec{r} \times \vec{F}$ vectors for **point A**.

Direction $\vec{\tau} =$ _____

Due to this torque the wheel's axis moves _____ (CW or CCW) from top view.

6. A board #1 balanced on a pivot is initially at rest and horizontal when a student briefly exerts a downward force on the right end.



While the hand is **pushing**, give the **directions** of the following vectors, e.g. up/down, right/left, into page/out of page, none.

Direction $\vec{\alpha}$ = _____

Direction $\vec{\omega}$ = _____

Direction \vec{a}_{cm} = _____

Direction \vec{v}_{cm} = _____

At an instant **after** the hand has **stopped pushing**, give the **directions** of the following vectors.

Direction $\vec{\alpha}$ = _____

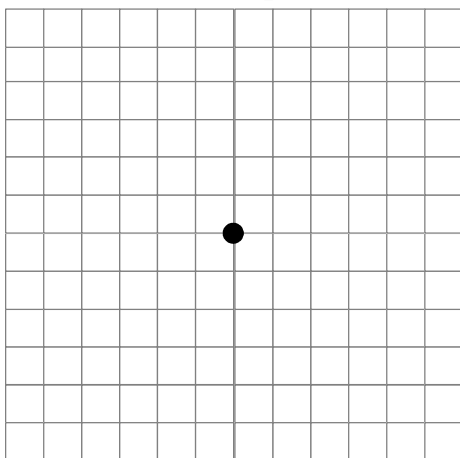
Direction $\vec{\omega}$ = _____

Direction \vec{a}_{cm} = _____

Direction \vec{v}_{cm} = _____

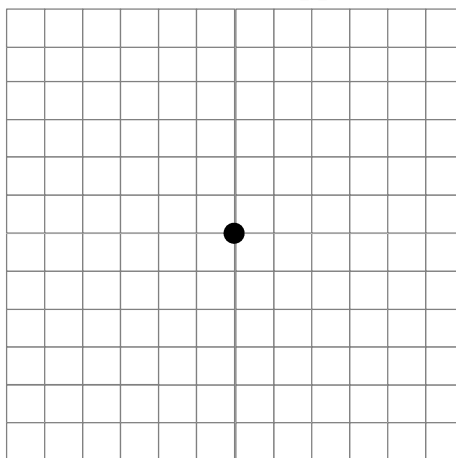
Draw the **free body diagrams** when the hand is **pushing** and when it has **stopped**. Assume that the board has a mass of 2 kg and that the student briefly exerts a force of 10 N.

FBD: Hand **pushing**



1 div = 5 N

FBD: Hand **stopped**



1 div = 5 N