Part C: Torque

The torque from a single force

$$\vec{\tau} = \vec{r} \times \vec{F}$$

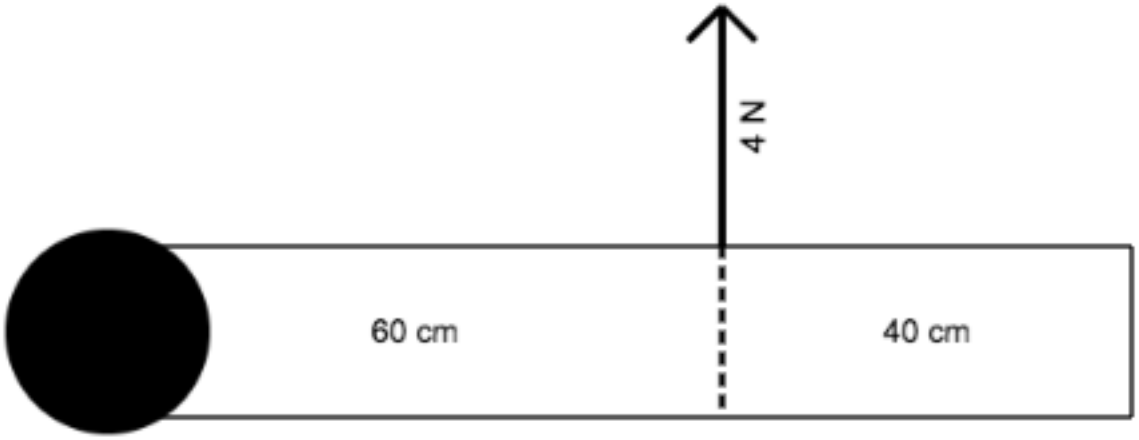
Symbol	Quantity	SI Unit	Description
$\vec{\tau}$	Torque	N-m	Vector analogous to force for rotational motion.
$\vec{r}$	Displacement from axis	meters	Vector pointing from the axis of rotation to where the force is applied
$\vec{F}$	Force	Newton	Force vector

Exercise 1: single torques, perpendicular to the axis:

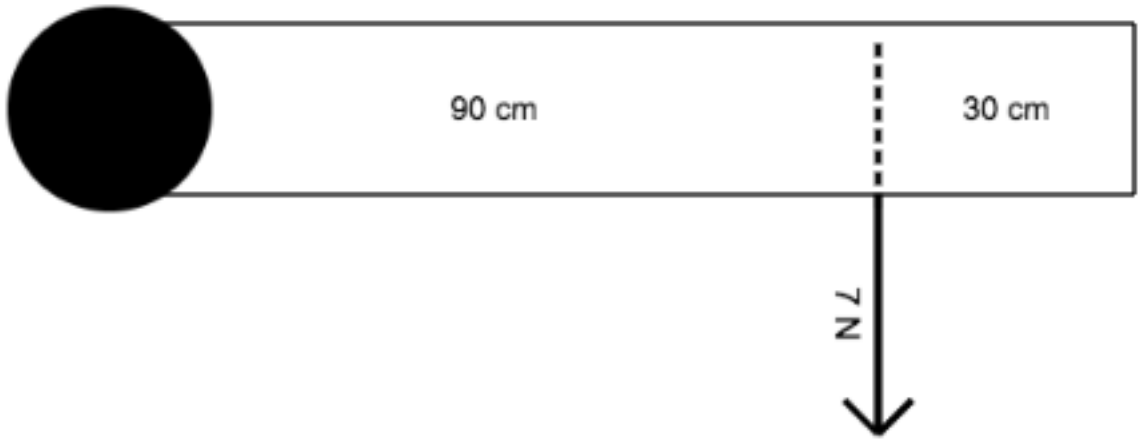
Figure out the magnitude and direction of each torque.

For direction, you can write *clockwise* or *counterclockwise*, and you can intuitively figure out which.

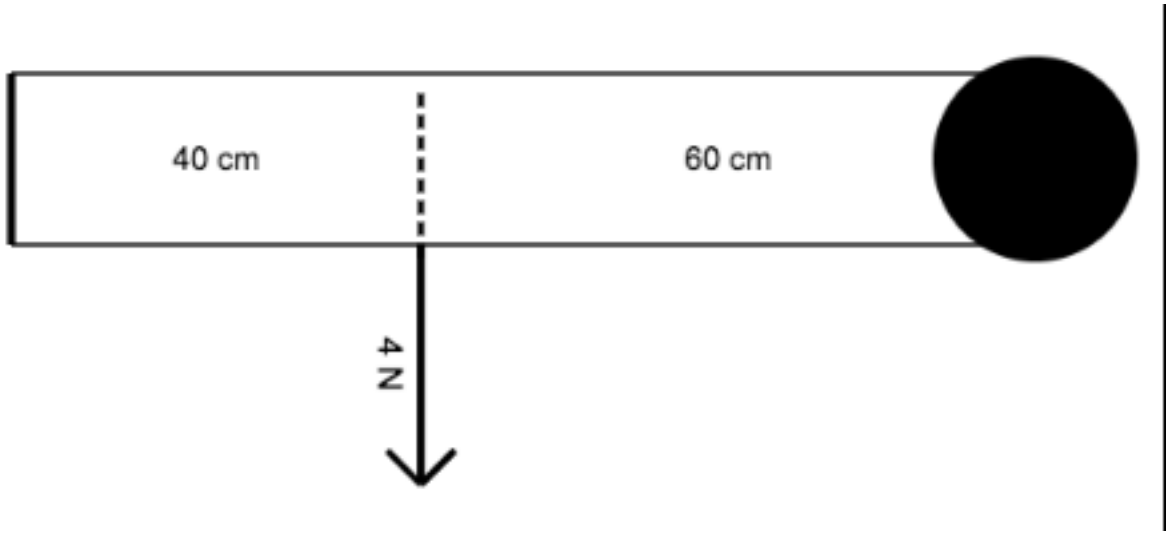
C.1



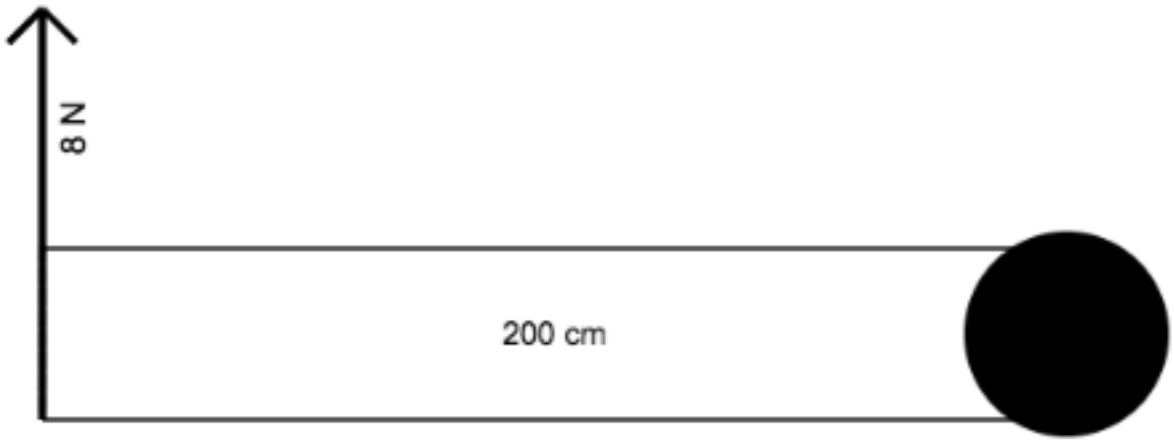
C.2



C.3



C.4



Exercise 2: single torques at different angles

Cross Product

$\vec{r} \times \vec{F}$ is pronounced "r cross F" and means the *perpendicular components* of the vectors r and F

- if *r* and *F* are perpendicular, you simply need to multiply them.

- if *r* and *F* are parallel or antiparallel, the troque is zero

- if *r* and *F* are at a different angle, you need to draw and use trigonometry, but typically the magnitude of torque is
r * F * sin(θ) in which θ is the angle between *r* and *F*.

Exercise 3: The torque from multiple forces

If multiple torques act on an object, you must find the *net torque*.

$$\sum \vec{\tau} = \sum_i \vec{r}_i \times \vec{F}_i$$

Net Torque

Net torque is calculated the same way as

Exercise 4: Rigorous direction of torque

Conceptually, you can think of torques as clockwise or counterclockwise, but we give them a more direct object.

Direction of Torque 1: Intuitive Direction

You can call a torque *clockwise* or *counterclockwise* depending upon which way a particular force will pull the rod!

Direction of Torque 2: Right hand rule

In more advanced physics classes, you will need to use the vector direction of torque.

Get your right hand (not your left!) and wrap your fingers in the direction the torque is pulling an object (either clockwise or counterclockwise).

Your thumb is pointing in the direction of the torque.
(On every one of these problems, the torque is either *into the page* or *out of the page*.)

- Place the fingers of your right hand in the direction of $\vec{r}$ and curl them into the direction of $\vec{F}$. Your thumb is now pointing in the direction of torque.