

Name \_\_\_\_\_

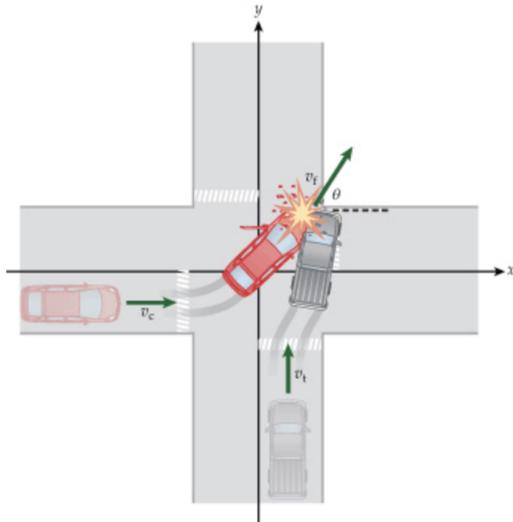
Conservation of Momentum in 2d:  $p_{0Ax} + p_{0Bx} = p_{fAx} + p_{fBx}$  and  $p_{0Ay} + p_{0By} = p_{fAy} + p_{fBy}$

Torque = Force applied an object such that it rotates

$\tau = rF \sin \theta$  (units of Nm) where  $r$  is magnitude of vector drawn from axis of rotation (pivot point) to place where force is applied,  $F$  is magnitude of Force vector,  $\theta$  is angle measured counterclockwise from  $r$  vector to  $F$  vector

Torque due to force is positive (negative) if it causes counterclockwise (clockwise) rotation

- Two cars collide at an intersection and move together. The red car ( $m=800\text{kg}$ ) was initially moving at  $10\text{m/s}$  because the light just turned green but the black car ( $m=1000\text{kg}$ ) was trying to make it through the light and was speeding at  $30\text{m/s}$ . With what final speed and direction do the two cars move immediately after the collision?



- Take your pen/pencil (like the blue rod) and hold it in place in the middle and try applying equal forces in different directions as shown by the arrows.

(a) Which of the forces apply a torque to the pencil? Indicate whether they apply a positive or negative torque.



- Repeat the above, but now hold the pen/pencil at the edge. Based on your experiment, how do you think torque depends on how force is applied, i.e. what are the best ways to maximize the torque for a given force? Hint: Think about how you open a door.

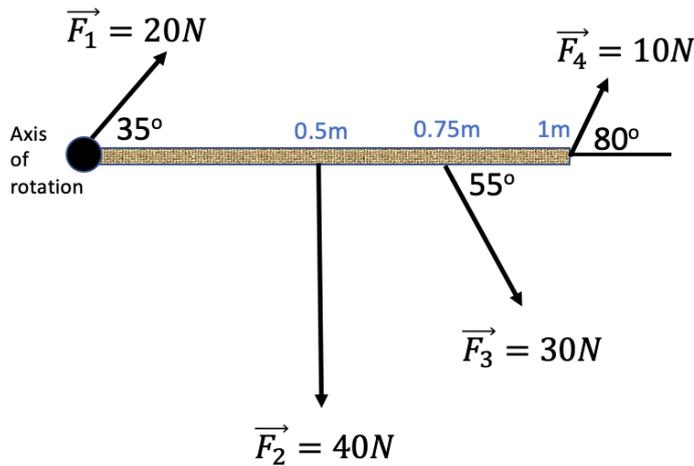
$$\tau = rF \sin \theta$$

1.  $\sin 0 =$
- $\sin 90 =$
- $\sin 180 =$
- $\sin 270 =$

Use your results above to confirm that the torque equation makes sense for the following forces: Which colored arrows correspond to which angles?



2. Calculate the torque produced by each force. Include the sign of the torque as well (+ if the Force produces a counterclockwise rotation, - if it produces a clockwise rotation). For each force, draw the  $r$  vector and then draw  $F$  starting from the same point to determine  $\theta$ .



What is the net torque, i.e. which direction will the object rotate?