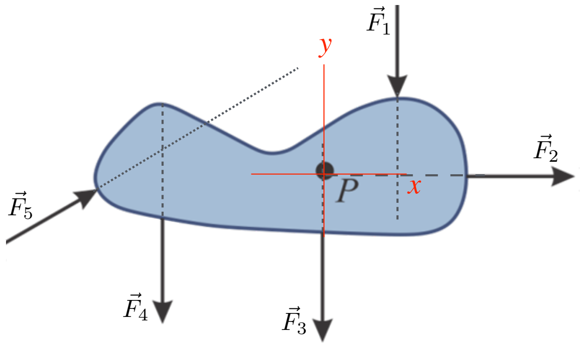
Solving Rotational Equilibrium Problems:

Setup Stage: Sketch a Free-Body Diagram.
Because distances, either r (from pivot to force) or $r_\perp$ ($\perp$ from pivot to line of action), are essential for calculating torques, you should provide some idea of the geometry of the object of interest.

Do not simply represent the object as a dot at the origin of a coordinate system for torque problems.



Analysis Stage: Apply Newton's Laws for Rotations (i.e. "Read" the free-body diagrams).
▶ Similar to translational motion problems, **EACH STEP IS GRADED**.

- **Physics Principle:** write Newton's First Law for Rotational Motion (corollary of Newton's 1st Law). i.e. $\Sigma\tau = 0$ and indicate the point used as pivot.

example:

$$\sum \vec{\tau} = \vec{0} \qquad \text{(about point P)}$$

- **Application:** Write the explicit sum of torque vectors; include a torque term for every force in the FBD. Recall: If the line of action of a force crosses the pivot, it exerts no torque.

$$\vec{\tau}_1 + \cancel{\vec{\tau}_2} + \cancel{\vec{\tau}_3} + \vec{\tau}_4 + \vec{\tau}_5 = \vec{0}$$

- **Sign Convention:** Separate magnitude and direction. Use the right-hand rule to determine direction of torque terms about pivot; represent it with +/– signs. Note: the τ terms are now magnitudes, so no arrow caps; the direction is described by the +/– signs.

$$-\tau_1 + \tau_4 - \tau_5 = 0$$

- Using the torque definition and either method of visualizing it, express each torque term as a function of r or $r_\perp$, and *F*.

$$\tau_1 = r_1 F_1 \sin\phi_1 \quad \text{or} \quad \tau_1 = r_{\perp 1}\, F_1$$
$$\tau_4 = r_4 F_4 \sin\phi_4 \quad \text{or} \quad \tau_4 = r_{\perp 4}\, F_4$$

- Identify and solve for the desired quantity.