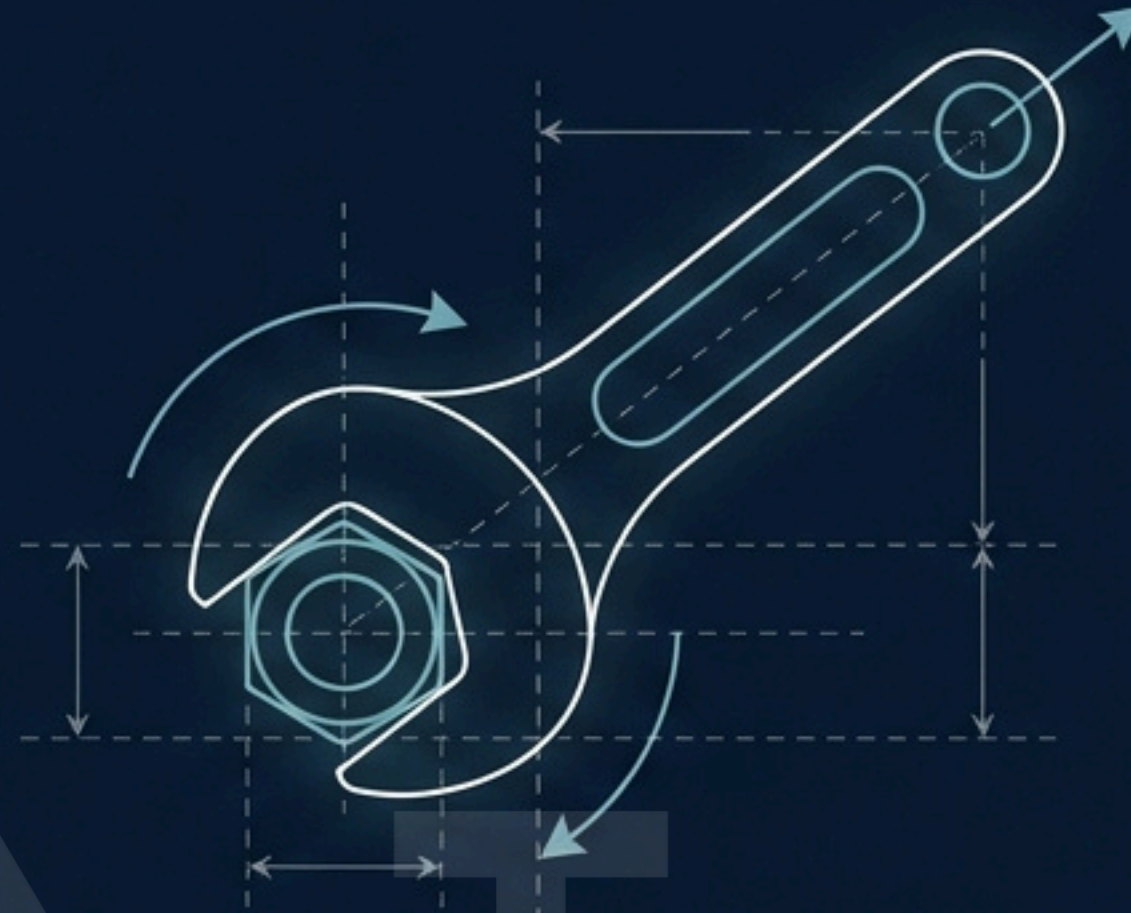




CLASS 11 PHYSICS • CHAPTER 6

Moment of Force (Torque)

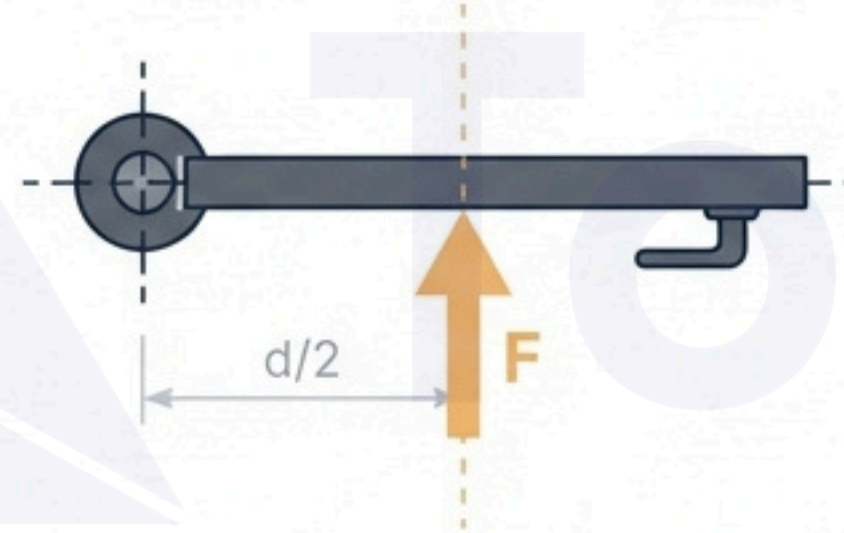
Systems of Particles and Rotational Motion (Section 6.7.1)

Why doesn't any force just work?

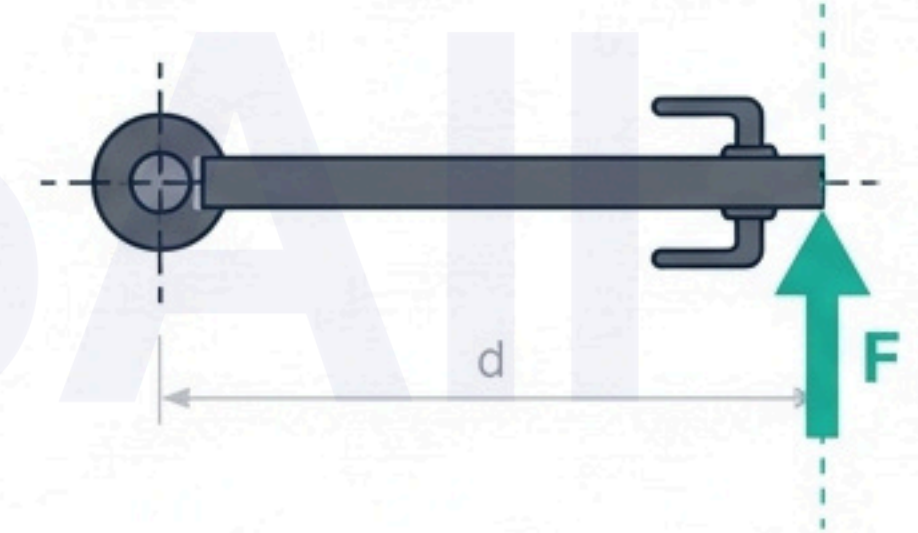
To open a door, applying force isn't enough. Where and how you apply it determines the turning effect.



Zero Rotation



Hard to Turn

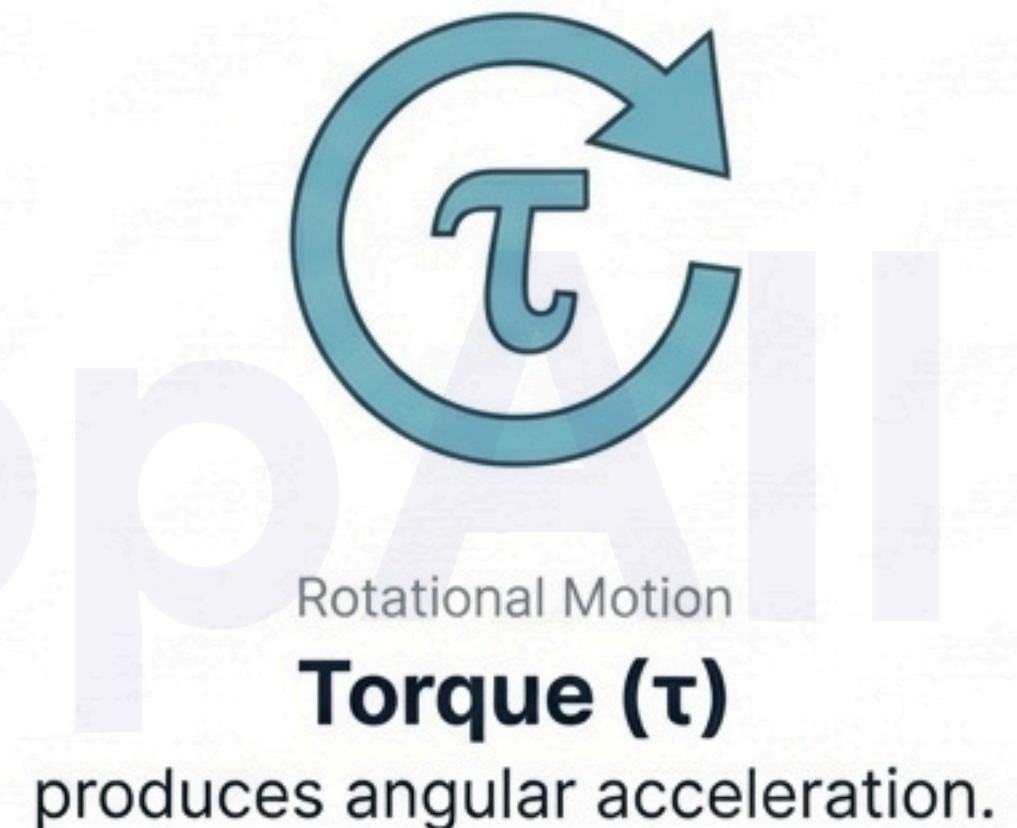
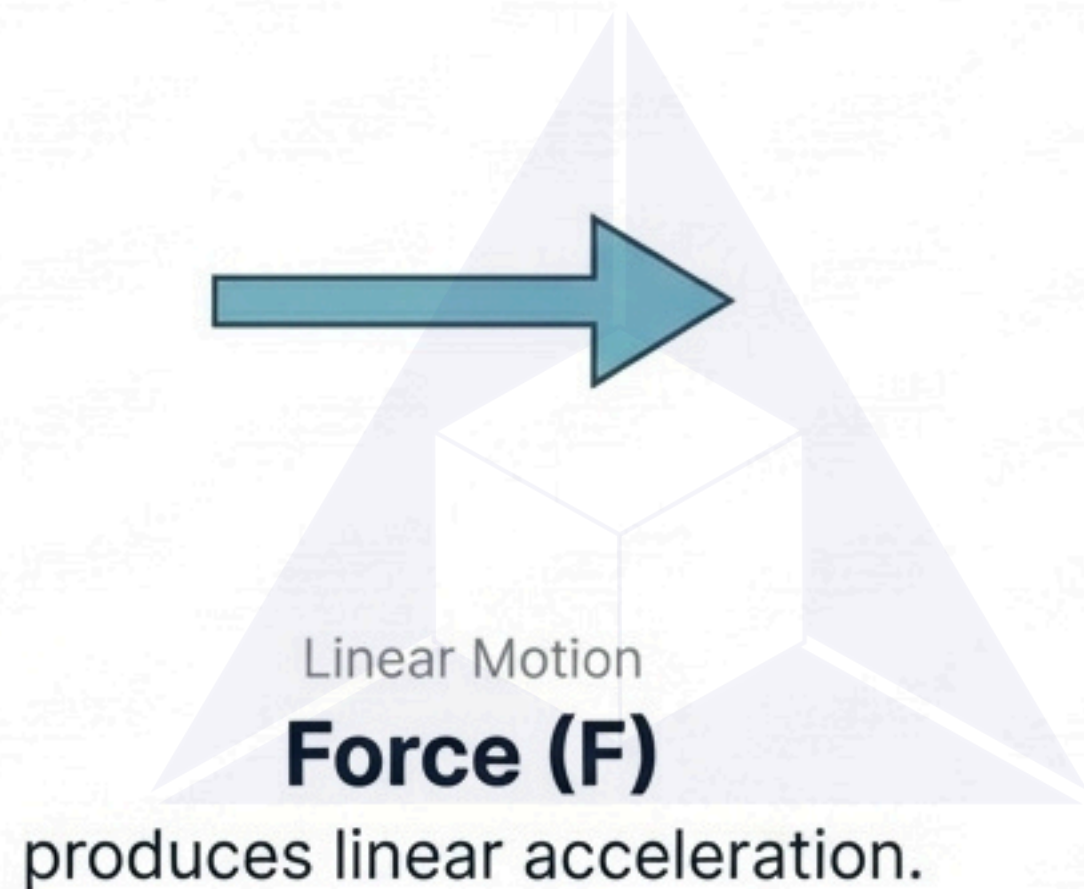


Most Effective

The Rotational Analogue of Force



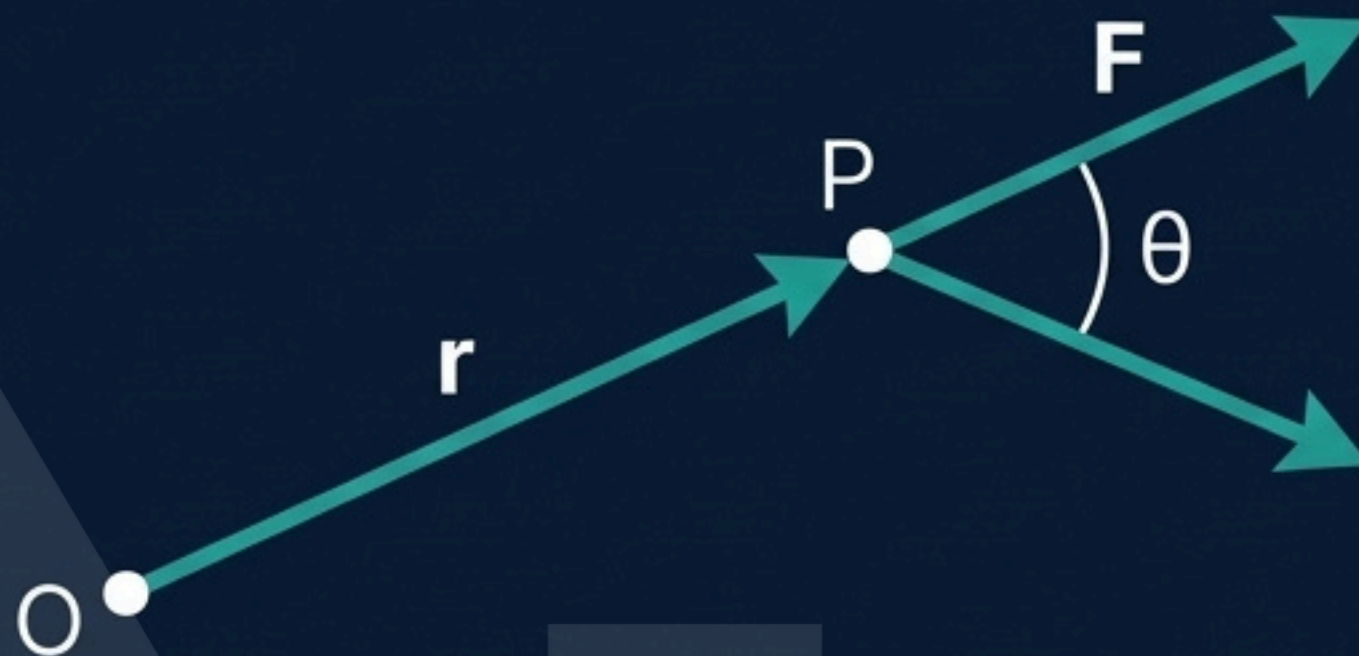
In linear motion, a force changes the translational state of a body. In rotational motion, the direct analogue of force is the Moment of Force, also known as Torque.



SI Unit: Newton metre (N m)

Dimensions: $M L^2 T^{-2}$

The Anatomy of Torque



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

Position (r)

The distance from the origin or axis of rotation to the point of application.

Force (F)

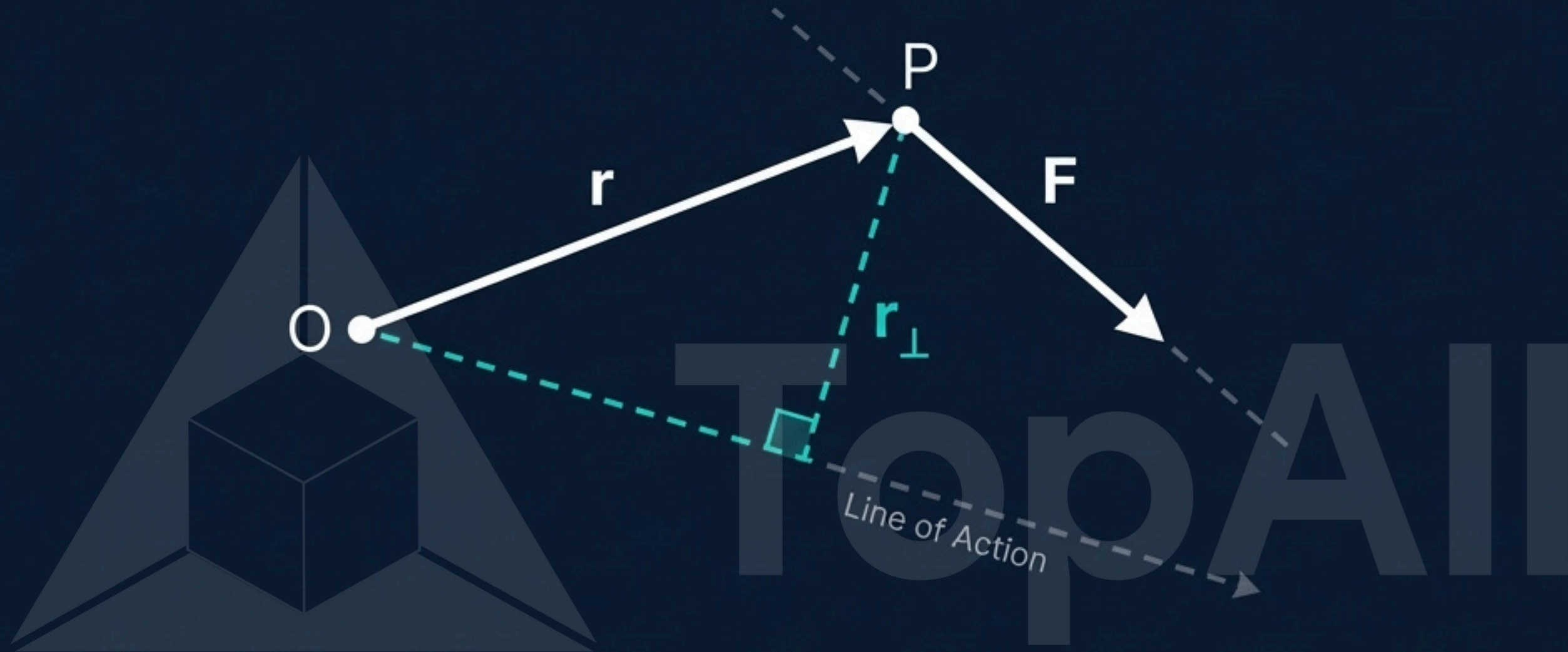
The magnitude of the applied force.

Angle (θ)

The angle between the position vector and the force vector.

The Line of Action Perspective

Torque can be cleanly understood through perpendicular components.



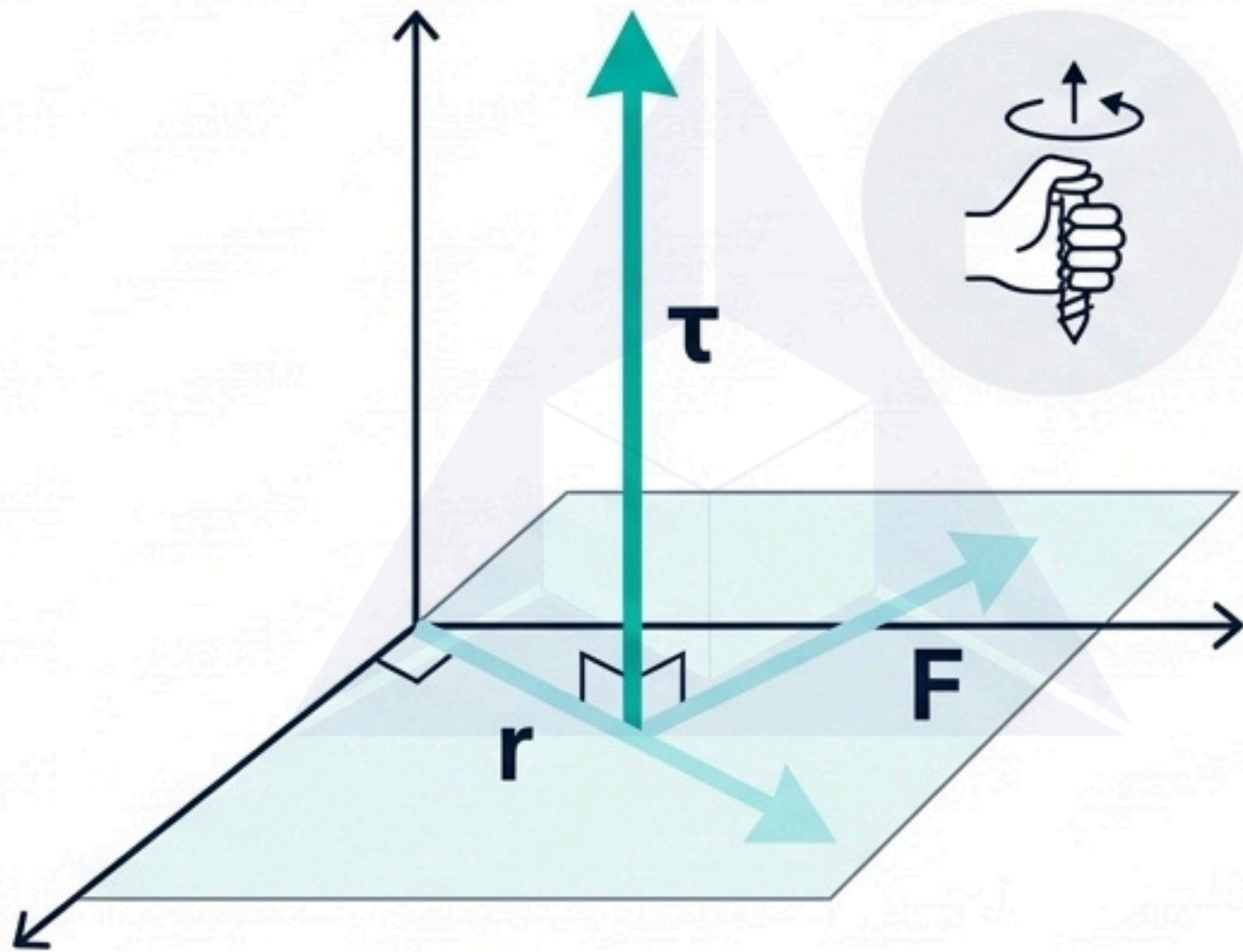
$$\tau = (\mathbf{r})(\mathbf{F}_{\perp}) \rightarrow \text{Force component perpendicular to position.}$$

$$\tau = (\mathbf{r}_{\perp})(\mathbf{F}) \rightarrow \text{Force multiplied by perpendicular distance from origin to the line of action.}$$

$$r_{\perp} = r \sin\theta$$

Torque is a Vector Product

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



$\boldsymbol{\tau}$ is strictly perpendicular to the plane containing $\mathbf{r}$ and $\vec{\mathbf{F}}$.



Direction is determined by the Right-Handed Screw Rule.



Reversing the direction of $\vec{\mathbf{F}}$ reverses the torque. Reversing both $\mathbf{r}$ and $\vec{\mathbf{F}}$ keeps the torque identical.

Key Takeaways & Edge Cases

When is Torque Zero?

- ✓ If the applied Force is zero ($F = 0$)
- ✓ If force is applied exactly at the origin ($r = 0$)
- ✓ If the line of action passes directly through the origin ($\theta = 0^\circ$ or 180°)

[EXAM TRAP: DIMENSIONAL CONFUSION] ⚠

Torque has the dimensions $[M L^2 T^{-2}]$ and units of N m. These are the exact same dimensions as Work and Energy.

However, they are entirely different physical quantities! Work is a scalar (calculated via dot product), while Torque is a vector (calculated via cross product).