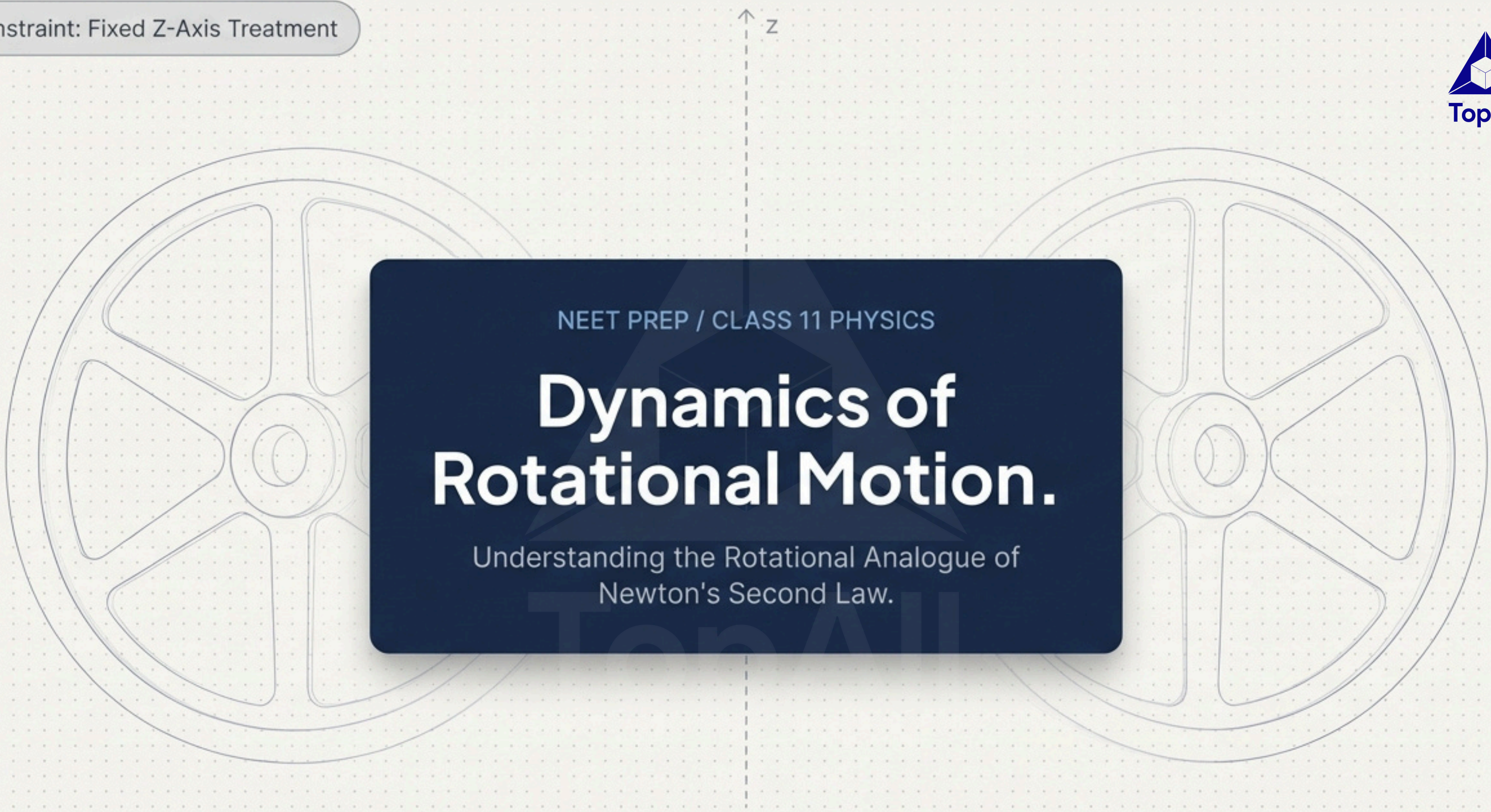


The background features two large, faint line drawings of wheels, one on the left and one on the right. A vertical dashed line with an upward-pointing arrow and the letter 'z' is positioned in the center, representing the z-axis.

NEET PREP / CLASS 11 PHYSICS

Dynamics of Rotational Motion.

Understanding the Rotational Analogue of Newton's Second Law.

A precision blueprint for translating linear mechanics into rotational dynamics.

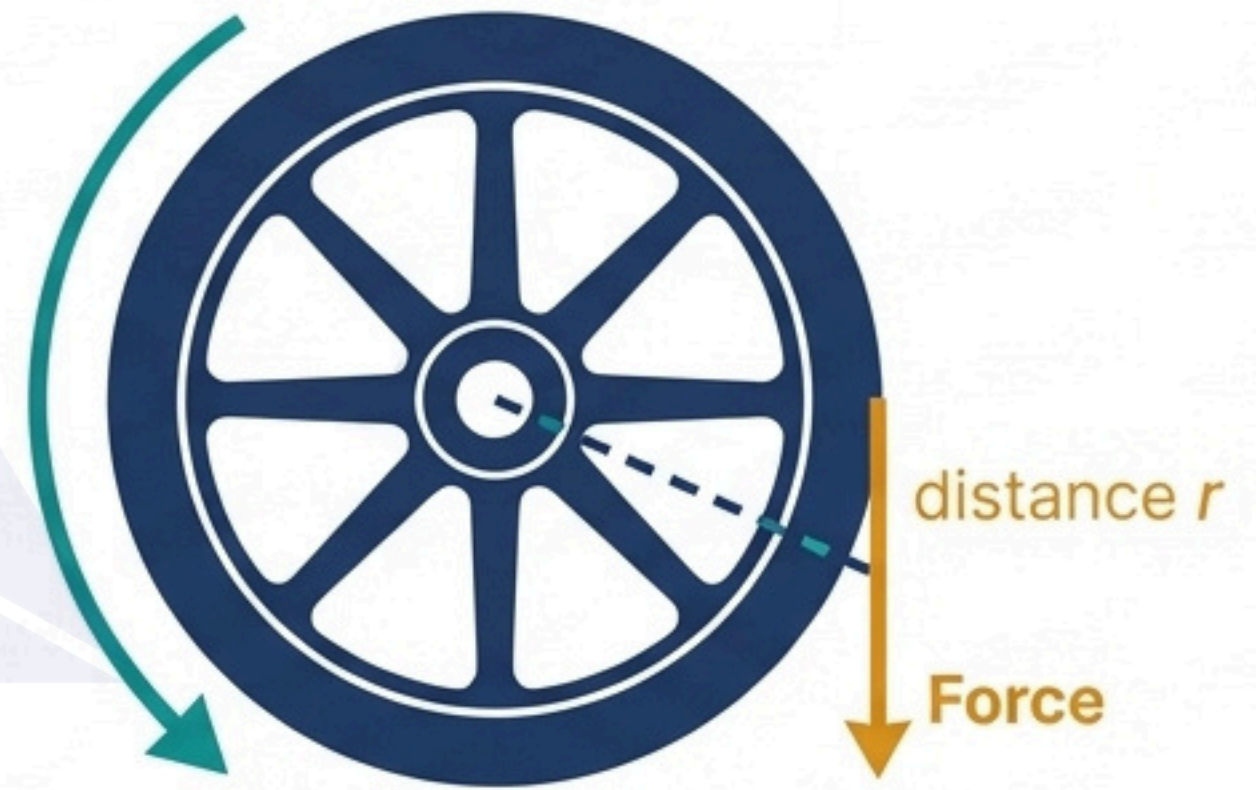
Force alone doesn't guarantee rotation.

The Failure



0 Rotation

The Solution



Generates Rotation

Enter Torque (τ).

In linear motion, a net force guarantees acceleration. In rotational motion, *where* and *how* you apply the force matters just as much as the magnitude. Torque is the rotational analogue of force: $\tau = r \times F$.

The Rotational Analogue of Newton's Second Law.

τ (Total External Torque)

The rotational cause.

$$\tau = I\alpha$$

I (Moment of Inertia)

The resistance to rotational change.

α (Angular Acceleration)

The resulting rotational effect.

Just as force dictates linear acceleration ($F = ma$), total external torque dictates angular acceleration ($\tau = I\alpha$).

Mass isn't enough: The Role of "I"

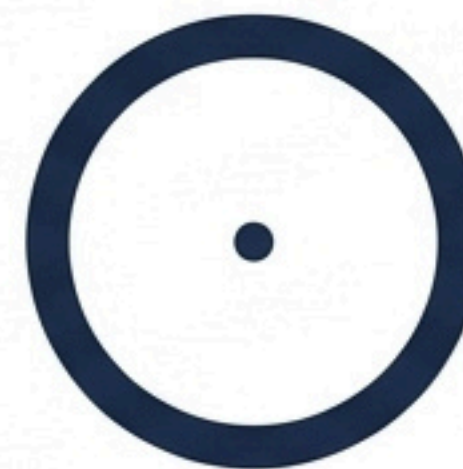
The Solid Disc



- Mass distributed closer to the axis

Lower $I \rightarrow$ Easier to accelerate (α is higher for a given τ)

The Thin Ring

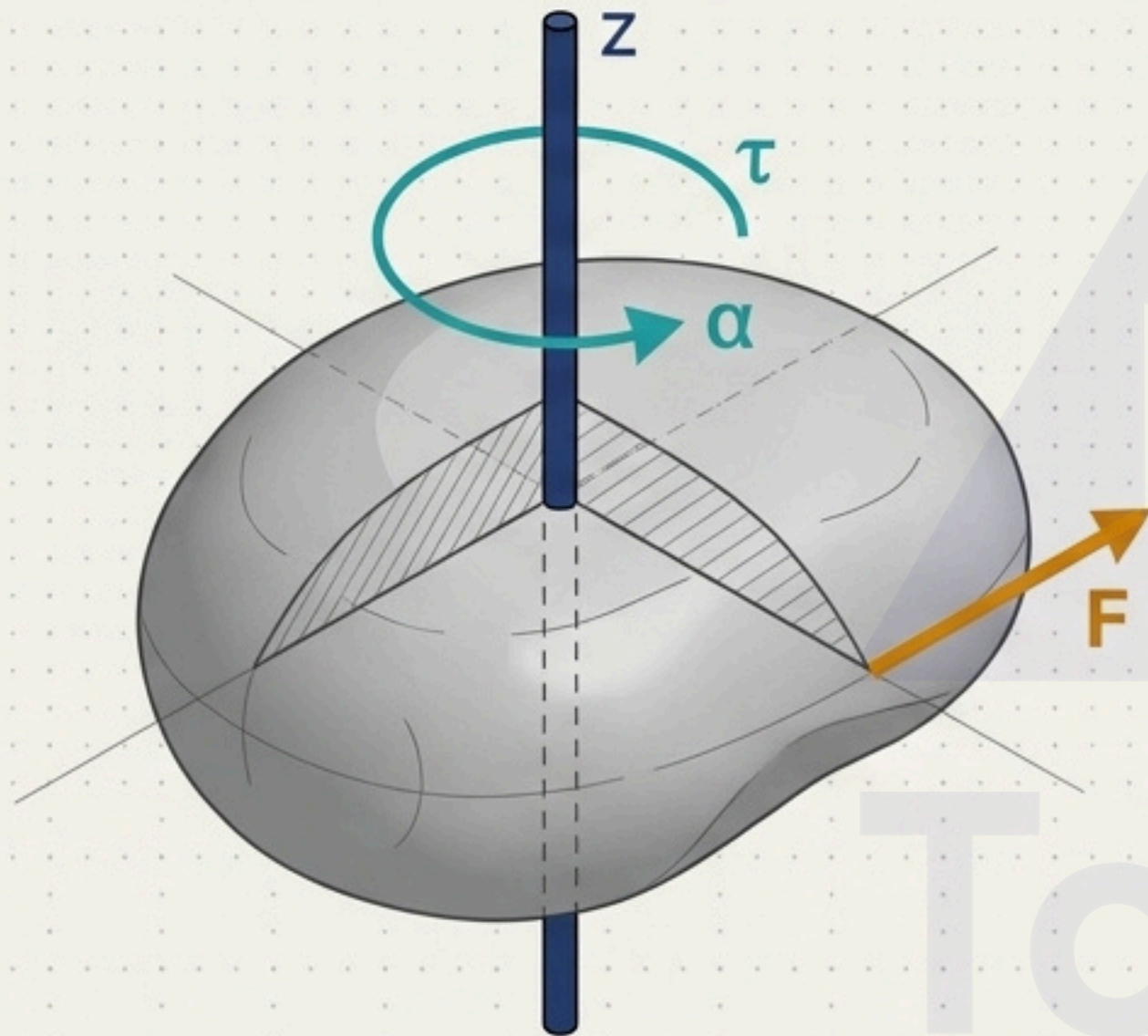


- Mass concentrated entirely at the outer edge

Higher $I \rightarrow$ Harder to accelerate (α is lower for a given τ)

In $F = ma$, mass (m) acts as linear inertia. In $\tau = I\alpha$, Moment of Inertia (I) acts as rotational inertia. It depends on both the total mass and *how that mass is distributed* relative to the axis of rotation.

Dynamics on a Fixed Axis



The Fixed Axis Treatment

- ✓ **Active Components:** Only torque components *parallel* to the fixed axis cause rotation.
- ✓ **Zero Effect:** Forces applied parallel to the axis produce zero effective rotational torque.
- ✓ **Cancellation:** Perpendicular torque components are completely cancelled out by the hinges/mounts holding the axis fixed (forces of constraint).

Because the axis is constrained, the complex 3D vector equation simplifies to a straightforward scalar equation: $\tau_z = I\alpha$.

The Translation Matrix: Linear vs. Rotational

Concept	Linear Motion	Rotational (Fixed Axis)
Inertia	Mass (m)	Moment of Inertia (I)
Cause of Motion	Force (F)	Torque (τ)
Resulting Motion	Acceleration (a)	Angular Accel. (α)
Newton's 2nd Law	$F = ma$	$\tau = I\alpha$
Work Done	$W = F \cdot \Delta x$	$W = \tau \cdot \Delta \theta$
Power	$P = F \cdot v$	$P = \tau \cdot \omega$

 **NEET Pro-Tip:** If a body is in rotational equilibrium, the net external torque ($\Sigma \tau$) is exactly zero, meaning $\alpha = 0$ (it maintains constant angular velocity).