

Moment of Inertia Cheat Sheet

Rotational inertia, shape formulas, vehicle examples

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Definition (point masses)	$I = \sum m r^2$	r = distance from the axis; $\text{kg}\cdot\text{m}^2$ (CGS: $\text{g}\cdot\text{cm}^2$)
Torque and angular acceleration	$\tau = I \alpha$	Rotational counterpart of $F = m a$
Rotational kinetic energy	$K = \frac{1}{2} I \omega^2$	Point masses and solid bodies
Hoop (about centre axis)	$I = M R^2$	Thin ring
Uniform rod (about centre)	$I = M L^2 / 12$	
Solid disk	$I = \frac{1}{2} M R^2$	Wheels and rotors
Solid / hollow sphere	$I = (2/5) M R^2 / (2/3) M R^2$	Axis through centre
Parallel-axis theorem	$I = I_{\text{cm}} + M D^2$	D = distance between the two axes
Cross-section (area) version	$I_x = \int y^2 dA$, y from $-H/2$ to $H/2$	Used for rectangles and I-sections in bending

Key takeaways

- Do not confuse it with the law of inertia (Newton's first law). Moment of inertia resists a change in rotational speed and depends on mass and where it sits relative to the axis.
- Vehicle axes: I_x is roll, I_y is pitch, I_z is yaw (resistance to turning or spinning about a vertical axis).
- Barbell example (article): two masses m at distance R give $2mR^2$ about the centre but $4mR^2$ about one end, so rotating it about its end is twice as hard.
- Diver example (article): moving from layout to tuck can cut I by a factor of seven, so she spins faster.
- Vehicle estimate (article): treat each major subsystem as a point mass at its distance from the centre of gravity, then sum $m r^2$ for an early dynamics estimate.
- Measured vehicle inertia values are in SAE 1999-01-1336 (see the article's link). EV battery packs shift mass distribution and change handling.
- Higher I means more torque is needed for the same angular acceleration; handling, acceleration, ride and braking all respond to it.

Automotive examples discussed in the article

Example	What it shows
Vehicle as point masses	Subsystems at distance r from the CG sum to $I = \sum m r^2$
Wheels and brake rotors	Disk formula $\frac{1}{2} M R^2$, which the article applies to wheels and rotors
Red Bull RB7 (2011), Newey	Engine pushed forward, heavy KERS battery moved rearward to keep balance and a tight rear end; car won 12 of 19 races
Early rear-engine Porsche 911, Newey	Engine behind the rear axle gives a large yaw inertia that is hard to stop once it swings; easy to spin
Mass between the axles	Newey's 2 kg dumbbell analogy: same mass concentrated at the ends is far harder to rotate; teams moved gear clusters ahead of the rear axle from about 1986
EV battery packs	Large heavy pack changes mass distribution and vehicle dynamics