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Rolling and equations of rotational motion

Formulas and units, JEE Main. Status: Reviewed on 2026-11-20.

Result	Formula	Units or note
Rotational second law	tau = I alpha Valid when: rigid body, fixed axis or axis through centre of mass; tau and I about same axis	N m
Rotational kinetic energy and power	KE = (1/2) I w^2; P = tau w; W = tau theta Valid when: rigid body rotating about a fixed axis; w in rad/s; W = tau theta for constant torque	J (W)
Rolling without slipping	v_cm = w R; a_cm = alpha R Valid when: pure rolling (no slipping) on a fixed surface	m/s (m/s^2)
Kinetic energy of rolling	KE = (1/2) m v^2 (1 + k^2/R^2) Valid when: pure rolling; k is radius of gyration about the axis through the centre	J
Shape factor k^2/R^2	ring 1; disc 1/2; solid sphere 2/5; hollow sphere 2/3 Valid when: uniform bodies; k is about the central axis	dimensionless
Acceleration down an incline	a = g sin(theta)/(1 + k^2/R^2) Valid when: pure rolling down a rough incline, no slipping	m/s^2
Friction and minimum mu for rolling	f = m g sin(theta) (k^2/R^2)/(1 + k^2/R^2); mu >= tan(theta) (k^2/R^2)/(1 + k^2/R^2) Valid when: pure rolling down a rough incline; static friction	N
Massive pulley with two blocks	a = (m1 - m2) g/(m1 + m2 + I/R^2) Valid when: string does not slip on the pulley; uniform pulley I; blocks move with the string	m/s^2
Sliding to rolling (from v0, no spin)	v = v0/(1 + k^2/R^2) Valid when: sliding with speed v0 and no spin on a rough horizontal surface until rolling starts	m/s

Full lesson with worked examples:
https://www.engineeringrise.in/learn/learn/jee-main/physics/rotational-motion/rolling-and-equations-of-rotational-motion

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