EngineeringRise

Kepler laws, gravitational potential energy and potential

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

Result	Formula	Units or note
Kepler second law (areal velocity)	dA/dt = L/(2m) = r v/2 at the apsides Valid when: central force; r v/2 form only where velocity is perpendicular to r	m^2/s
Apsis speeds	v1 r1 = v2 r2 Valid when: at nearest and farthest points, where velocity is perpendicular to r	m^2/s
Kepler third law	T^2 = 4 pi^2 a^3/(G M) Valid when: bound orbit about mass M, a is the semi-major axis (r for a circle)	s^2
Ellipse semi-major axis	a = (r_min + r_max)/2 Valid when: ellipse, r_min and r_max measured from the focus	m
Potential energy of a pair	U = -G M m/r Valid when: point masses or spheres, zero of potential energy at infinity	J
Gravitational potential	V = -G M/r Valid when: field of a point or spherical mass, zero of potential at infinity	J/kg
Surface potential	V = -g R = -6.27 x 10^7 for the Earth Valid when: Earth treated as a uniform sphere, zero of potential at infinity	J/kg
Work to move from r1 to r2	W = G M m (1/r1 - 1/r2) Valid when: point or spherical masses, r2 > r1 (work done against gravity)	J
Equilateral triangle of equal masses	U = -3 G m^2/a Valid when: three equal masses at the corners of an equilateral triangle of side a	J
Escape from a point with potential V	v = root(-2 V) Valid when: escape from a point, only that gravity acting, zero of potential at infinity	m/s

Full lesson with worked examples:
https://www.engineeringrise.in/learn/learn/jee-main/physics/gravitation/kepler-laws-gravitational-potential-energy-and-potential

EngineeringRise is an unofficial study site. It is not affiliated with NTA, the IITs, BITS, VIT, SRM or any exam body.