EngineeringRise

Simple harmonic motion and energy

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

Result	Formula	Units or note
Defining condition	a = -omega^2 x; F = -k x with omega^2 = k/m Valid when: restoring force proportional to displacement, directed to the mean position	m/s^2 (N)
Displacement	x = A sin(omega t + phi) Valid when: x measured from the mean position; phase in radians	m (phase in rad)
Period, frequency, angular frequency	T = 2 pi/omega = 1/f; omega = 2 pi f Valid when: any periodic motion; for SHM omega = sqrt(k/m) of the system	s (Hz, rad/s)
Velocity and acceleration	v = A omega cos(omega t + phi); a = -A omega^2 sin(omega t + phi) Valid when: SHM with x = A sin(omega t + phi); phase in radians	m/s (m/s^2)
Speed at a position	v = omega sqrt(A^2 - x^2); v_max = A omega; a_max = A omega^2 Valid when: SHM; x measured from the mean position	m/s (m/s^2)
Kinetic energy	KE = (1/2) m omega^2 (A^2 - x^2) Valid when: SHM; x is displacement from the mean position	J
Potential energy	PE = (1/2) m omega^2 x^2 = (1/2) k x^2 Valid when: SHM; x is displacement from the mean position	J
Total energy	E = (1/2) m omega^2 A^2 = (1/2) k A^2 Valid when: SHM with no energy loss (undamped, conservative)	J
Special positions	KE = PE at x = A/sqrt(2); KE/PE = n at x = A/sqrt(n + 1) Valid when: SHM; x measured from the mean position	m
Reference-circle times	mean to A/2: T/12; extreme to A/2: T/6; mean to extreme: T/4 Valid when: SHM, time measured along the reference circle	s

Full lesson with worked examples:
https://www.engineeringrise.in/learn/learn/jee-main/physics/oscillations-and-waves/simple-harmonic-motion-and-energy

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