EngineeringRise

Potential energy, conservation of energy and vertical circle

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

Result	Formula	Units or note
Gravitational potential energy (near the ground)	U = m g h Valid when: near Earth's surface where g is constant; h from a chosen reference level	J
Spring potential energy	U = 0.5 k x^2 (x from the natural length) Valid when: ideal spring within Hooke's law range; x from the natural length	J
Work to change spring extension	W = 0.5 k (x2^2 - x1^2) Valid when: ideal spring within Hooke's law range; x1 and x2 from the natural length	J
Conservation of mechanical energy	K1 + U1 = K2 + U2 (only conservative work) Valid when: only conservative forces do work; other forces absent or do no work	J
With friction	K1 + U1 + W_nc = K2 + U2, W_nc = -mu N (path length) Valid when: kinetic friction is the only non-conservative work; use total path length	J
Vertical circle, string: top and bottom	v_top >= sqrt(g R); v_bottom >= sqrt(5 g R) Valid when: smooth circle in a vertical plane with a string or inside a track (no inward push)	m/s
Vertical circle, rod or bead	v_top >= 0; v_bottom >= sqrt(4 g R) Valid when: smooth vertical circle with a rod, tube or wire that can push and pull	m/s
String tension at angle theta from the bottom	T = m v_b^2/R + m g (3 cos(theta) - 2) Valid when: string stays taut in a vertical circle; theta from lowest point, v_b at the bottom	N
Loop track: least start height; leaving a smooth hemisphere	h = 2.5 R; leaves at cos(theta) = 2/3 Valid when: smooth surfaces, body sliding (not rolling) from rest at the stated start	h and R in m; cos(theta) has no unit

Full lesson with worked examples:
https://www.engineeringrise.in/learn/learn/jee-main/physics/work-energy-and-power/potential-energy-conservation-of-energy-and-ve

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