Work, Energy and Power

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Note : The notes given in this file is no substitute to the much detailed discussion held in the online/contact classes with active participation of students. It , at best, serves the purpose of ready reference for important concepts/derivations covered in the classes.

W E P

Law of conservation of energy

Verification : Freely falling body

Verification : Vertically projected body

Law of conservation of energy

If internal forces are conservative in nature and external forces do no work on the system then total energy of the system remains constant.

From the work-energy theorem we get

$$W_{\text{ext}} + W_{\text{INC}} + W_{\text{IC}} = \Delta KE$$

When work done by the external forces is zero we get

$$W_{\text{INC}} + W_{\text{IC}} = \Delta KE$$

When internal forces are conservative then work done by them is given by – ΔPE therefore

$$-\Delta PE = \Delta KE$$

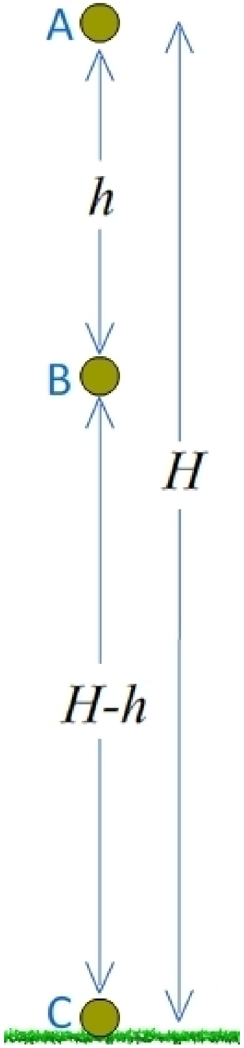
$$\Delta KE + \Delta PE = 0$$

Law of conservation of energy - freely falling body

Consider a body of mass m dropped from a height H above the ground.

As the body reaches the ground its kinetic energy increases and its potential energy decreases.

Consider three points A, B and C along its path of its descent , as shown in the figure.



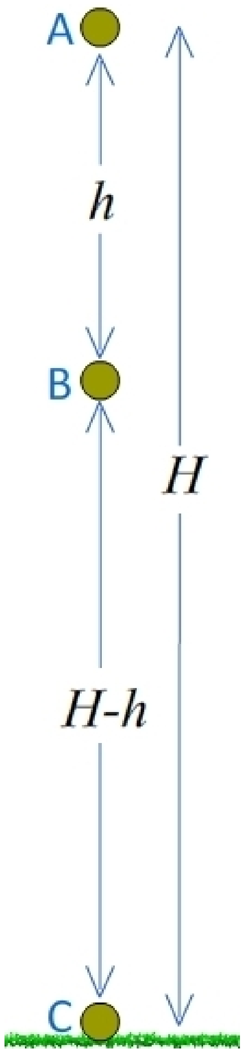
At point A

$$TE_A = KE_A + PE_A$$

$$TE_A = 0 + PE_A$$

$$TE_A = mgH \quad \text{i}$$

Law of conservation of energy - freely falling body



At point B

$$TE_B = KE_B + PE_B$$

$$TE_B = \frac{1}{2}mv_B{}^2 + mg(H-h) \quad \boxed{\text{ii}}$$

considering motion from A to B

$$v^2 - u^2 = 2aS$$

$$v_B{}^2 = 2gh \quad \boxed{\text{iii}}$$

Substituting this in eq (ii)

$$TE_B = \frac{1}{2}m2gh + mg(H-h)$$

$$TE_B = mgH \quad \boxed{\text{iv}}$$

At point C

$$TE_C = KE_C + PE_C$$

$$TE_C = \frac{1}{2}mv_C{}^2 + 0 \quad \boxed{\text{v}}$$

considering motion from A to C

$$v^2 - u^2 = 2aS$$

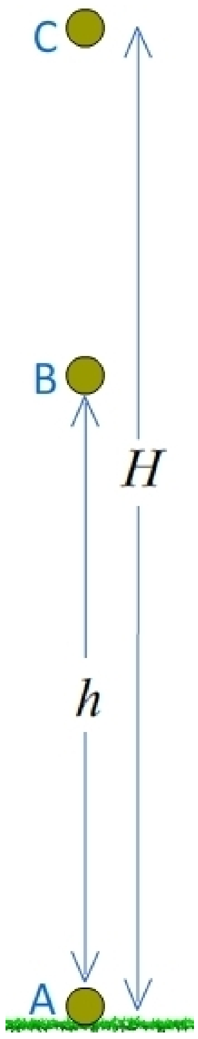
$$v_C{}^2 = 2gH \quad \boxed{\text{vi}}$$

Substituting this in eq (v)

$$TE_C = mgH \quad \boxed{\text{vii}}$$

From eqs (i), (iv) and (vii) it is verified that total energy of a freely falling body remains constant

Law of conservation of energy – vertically projected body



Consider a body of mass m projected vertically up with an initial velocity u.

As the body ascends its kinetic energy decreases and its potential energy increases.

Consider three points A, B and C along the path of its ascent, as shown in the figure.

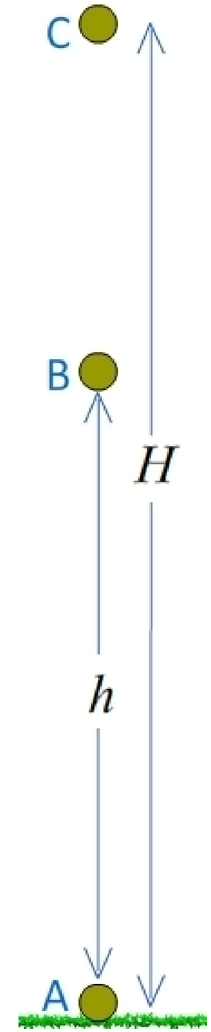
At point A

$$TE_A = KE_A + PE_A$$

$$TE_A = \frac{1}{2}mu^2 + 0$$

$$TE_A = \frac{1}{2}mu^2 \quad \text{i}$$

Law of conservation of energy – vertically projected body



At point B

$$TE_B = KE_B + PE_B$$

$$TE_B = \frac{1}{2}mv_B{}^2 + mgh \tag{ii}$$

considering motion from A to B

$$v^2 - u^2 = 2aS$$

$$v_B{}^2 - u^2 = 2(-g)h$$

$$h = \frac{(u^2 - v_B{}^2)}{2g} \tag{iii}$$

Substituting this in eq (ii)

$$TE_B = \frac{1}{2}mv_B{}^2 + mg\frac{(u^2 - v_B{}^2)}{2g}$$

$$TE_B = \frac{1}{2}mu^2 \tag{iv}$$

At point C

$$TE_C = KE_C + PE_C$$

$$TE_C = 0 + mgH \tag{v}$$

considering motion from A to C

$$v^2 - u^2 = 2aS$$

$$0 - u^2 = 2(-g)H$$

$$H = \frac{u^2}{2g} \tag{vi}$$

Substituting this in eq (v)

$$TE_C = \frac{1}{2}mu^2 \tag{vii}$$

From eqs (i), (iv) and (vii) it is verified that total energy of a vertically projected body remains constant