Work, Power, Energy

① Workdone by constant force

$W = F \cdot S = FS\cos\theta$ $\quad \{F = \text{Force}, S = \text{Displacement}, \theta = \text{Angle b/w F \& s}\}$

② Workdone by variable force

$$W = \int_{S_1}^{S_2} F \cdot dS$$

Work Maximum when $\theta^\circ = 0$
Work Minimum when $\theta^\circ = 180$

③ Work done by Spring force

$$W = \int_{x_1}^{x_2} F\,dx = \int_{x_1}^{x_2} -kx\,dx = \frac{1}{2}K(x_1^2 - x_2^2)$$

④ Combination of Spring

In parallel $\Rightarrow$ $K_{eq} = K_1 + K_2$

In series $\Rightarrow$ $\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$

⑤ Work-energy theorem

$W_{net} = \Delta K \cdot E$

⑥ Potential energy

$$\int_i^f dU = -\int_{r_i}^{r_f} F \cdot dr \Rightarrow \Delta U = -\int_{r_i}^{r_f} F \cdot dr$$

(7) Three Type of Equilibrium

S. No.	Stable Equilibrium	Unstable Equilibrium	Neutral Equilibrium
1.	Net force is zero.	Net force is zero.	Net force is zero.
2.	$\frac{dU}{dr} = 0$ or slope of *U-r* graph is zero.	$\frac{dU}{dr} = 0$ or slope of *U-r* graph is zero.	$\frac{dU}{dr} = 0$ or slope of *U-r* graph is zero.
3.	When displaced from its equilibrium position a net restoring force starts acting on the body which has a tendency to bring the body back to its equilibrium position.	When displaced from its equilibrium position, a net force starts acting on the body which moves the body in the direction of displacement or away from the equilibrium position.	When displaced from its equilibrium position the body has neither the tendency to come back nor to move away from the original position. It is again in equilibrium.
4.	Potential energy in equilibrium position is minimum as compared to its neighbouring points. or $\frac{d^2U}{dr^2} = \text{positive}$	Potential energy in equilibrium position is maximum as compared to its neighbouring points. or $\frac{d^2U}{dr^2} = \text{negative}$	Potential energy remains constant even if the body is displaced from its equilibrium position. or $\frac{d^2U}{dr^2} = 0$
5.	When displaced from equilibrium position the centre of gravity of the body goes up.	When displaced from equilibrium position the centre of gravity of the body comes down.	When displaced from equilibrium position the centre of gravity of the body remains at the same level.

(8) Power of a Force

$$P = \frac{dW}{dt} = F \cdot \frac{dx}{dt} = F \cdot v = Fv\cos\theta$$

{ F = Force
v = Velocity
θ = Angle b/w F & v }

(9) Average power

$$P_{av} = \frac{W_{total}}{t_{total}}$$

{ W = Work
t = time }

(10) Conservation of Energy

$$(\text{Total Energy})_{intial} = (\text{Total energy})_{final}$$