# 11.SIMPLE HARMONIC MOTION

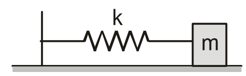
**S.H.M.**

$F = -kx$

General equation of S.H.M. is $x = A \sin(\omega t + \phi)$; $(\omega t + \phi)$ is phase of the motion and $\phi$ is initial phase of the motion.

**Angular Frequency (ω) :** $\omega = \dfrac{2\pi}{T} = 2\pi f$

**Time period (T) :** $T = \dfrac{2\pi}{\omega} = 2\pi\sqrt{\dfrac{m}{k}}$




**Speed :** $v = \omega\sqrt{A^2 - x^2}$

**Acceleration :** $a = -\omega^2 x$

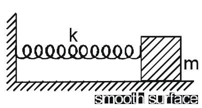
**Kinetic Energy (KE) :** $\dfrac{1}{2}mv^2 = \dfrac{1}{2}m\omega^2(A^2 - x^2) = \dfrac{1}{2}k(A^2 - x^2)$

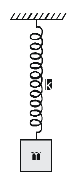
**Potential Energy (PE) :** $\dfrac{1}{2}Kx^2$

**Total Mechanical Energy (TME)** = K.E. + P.E. $= \dfrac{1}{2}k(A^2 - x^2) + \dfrac{1}{2}Kx^2 = \dfrac{1}{2}KA^2$ (which is constant)

**SPRING-MASS SYSTEM**

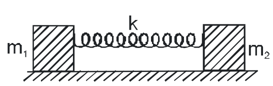
**(1)**




$T = 2\pi\sqrt{\dfrac{m}{k}}$

**(2)**




$T = 2\pi\sqrt{\dfrac{\mu}{K}}$, where $\mu = \dfrac{m_1 m_2}{(m_1 + m_2)}$ known as reduced mass

**COMBINATION OF SPRINGS**

**Series Combination :** $1/k_{eq} = 1/k_1 + 1/k_2$

**Parallel combination :** $k_{eq} = k_1 + k_2$

**SIMPLE PENDULUM** $T = 2\pi\sqrt{\dfrac{\ell}{g}} = 2\pi\sqrt{\dfrac{\ell}{g_{eff.}}}$ (in accelerating Reference Frame); $g_{eff}$ is net acceleration due to psuedo force and gravitational force.

**COMPOUND PENDULUM / PHYSICAL PENDULUM**

**Time period (T) :** $T = 2\pi\sqrt{\frac{I}{mg\ell}}$

where, $I = I_{CM} + m\ell^2$ ; $\ell$ is distance between point of suspension and centre of mass.

**TORSIONAL PENDULUM**

**Time period (T) :** $T = 2\pi\sqrt{\frac{I}{C}}$ where, C = Torsional constant

**Superposition of SHM s along the same direction**

$x_1 = A_1 \sin \omega t$ & $x_2 = A_2 \sin (\omega t + \theta)$

If equation of resultant SHM is taken as $x = A \sin (\omega t + \phi)$

$A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos\theta}$ & $\tan\phi = \frac{A_2 \sin\theta}{A_1 + A_2\cos\theta}$