Chapter 15: Oscillations

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General

Quantities

$$
\begin{aligned}
T &= \text{period of oscillation} \\
f &= \text{frequency of oscillation} \\
x &= \text{displacement} \\
x_m &= \text{maximum displacement} \\
\omega &= \text{angular frequency} \\
\phi &= \text{phase angle} \\
v &= \text{velocity} \\
a &= \text{acceleration} \\
F &= \text{force} \\
k &= \text{spring constant} \\
U &= \text{potential energy} \\
K &= \text{kinetic energy} \\
E &= \text{total mechanical energy}
\end{aligned}
$$

1 Simple Harmonic Motion

Period of Oscillation

$$T = \frac{1}{f} \tag{1}$$

Angular Frequency

$$\omega = \frac{2\pi}{T} = 2\pi f \tag{2}$$

Displacement

$$x(t) = x_m \cos(\omega t + \phi) \tag{3}$$

Velocity

$$v(t) = -\omega x_m \sin(\omega t + \phi) \tag{4}$$

Acceleration

$$a(t) = -\omega^2 x_m \cos(\omega t + \phi) \tag{5}$$

$$a(t) = -\omega^2 x(t) \tag{6}$$

In SHM, the acceleration a is proportional to the displacement x but opposite in sign, and the two quantities are related by the square of the angular frequency ω.

Hooke's Law

$$F = -kx \tag{7}$$

2 Energy In Simple Harmonic Motion

Potential Energy

$$U(t) = \frac{1}{2}kx^2 = \frac{1}{2}kx_m^2 \cos^2(\omega t + \phi) \tag{8}$$

Kinetic Energy

$$K(t) = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2 x_m^2 \sin^2(\omega t + \phi) \tag{9}$$

Total Mechanical Energy

$$E = U + K = \frac{1}{2}kx_m^2 \tag{10}$$