

# Physics

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# 1 Periodic Motion

## 1.1 Frequency

**Definition 1.1** (Period). The period  $T$  is the time to complete one cycle, measured in seconds.

**Definition 1.2** (Angular Frequency). Angular frequency  $\omega$  is radians per second, with units  $\text{s}^{-1}$ . Radians are unitless.

$$\omega = \frac{2\pi}{T}.$$

**Definition 1.3** (Frequency). Frequency is a measure of cycles per second, or  $\omega/2\pi$ . It is measured in hertz (Hz) with units  $\text{s}^{-1}$ . Cycles are unitless.

**Definition 1.4** (Restoring force). The restoring force  $F_x$  relative to displacement from equilibrium  $x$  is

$$F_x = -kx.$$

$k$  is the spring constant with units  $\text{N/m}$ .

**Definition 1.5.** The equation used to derive the equation for simple harmonic motion with respect to time is

$$\frac{d^2x}{dt^2} = -\frac{k}{m}x.$$

Eigenvalues for this equation are  $\pm i\sqrt{\frac{k}{m}}$ , so displacement from equilibrium for simple harmonic motion with respect to time is

$$x = c_1 \cos\left(\sqrt{\frac{k}{m}}t\right) + c_2 \sin\left(\sqrt{\frac{k}{m}}t\right).$$

In phase-amplitude form this equation is

$$x = A \cos(\omega t + \phi).$$

**Definition 1.6** (SHM frequency). It follows from the displacement equation for SHM that angular frequency for SHM is

$$\omega = \sqrt{\frac{k}{m}}.$$

## 1.2 Energy in SHM

**Definition 1.7** (Mechanical energy). Work in Joules (Nm) is equal to displacement times force in simple scenarios. For forces that vary with one-dimensional displacement  $x$  from  $a$  to  $b$ , work is expressed by equation

$$E = \int_a^b F(x)dx.$$