MECH20442 Dynamics
Formula Sheet

1 Vibrations

1.1 Undamped Free Vibration

$$\ddot{x} + \omega_n^2 x = 0 \quad \text{Standard Form of Equation of Motion} \quad (1)$$

$$\omega_n = \sqrt{\frac{k}{m}} \quad \text{Natural Frequency (Mass-Spring)} \quad (2)$$

$$x = A\sin\omega_n t + B\cos\omega_n t \quad \text{Displacement (General Solution of EoM)} \quad (3)$$

$$v = \dot{x} = A\omega_n\cos\omega_n t - B\omega_n\sin\omega_n t \quad \text{Velocity (First Time Derivative)} \quad (4)$$

$$a = \ddot{x} = -A\omega_n^2\sin\omega_n t - B\omega_n^2\cos\omega_n t \quad \text{Acceleration (Second Time Derivative)} \quad (5)$$

$$x = C\sin(\omega_n t + \phi) \quad \text{Displacement (Amplitude Form)} \quad (6)$$

$$\phi = \tan^{-1}\left(\frac{B}{A}\right) \quad \text{Phase Angle} \quad (7)$$

$$C = \sqrt{A^2 + B^2} \quad \text{Amplitude} \quad (8)$$

$$\tau = \frac{2\pi}{\omega_n} = 2\pi\sqrt{\frac{m}{k}} \quad \text{Period of Oscillation} \quad (9)$$

$$f = \frac{1}{\tau} = \frac{\omega_n}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad \text{Frequency (Hertz)} \quad (10)$$