Chapter 16 Oscillations

Period, \( T = 1/f \)
Frequency, \( f = 1/T \) [Hz = 1 cycle/second]
Amplitude, \( x_m \) (maximum displacement)

Simple Harmonic Motion

\[ x = x_m \cos(\omega t + \phi) \]
\[ v = -v_m \sin(\omega t + \phi) \quad - \quad v_m = \omega x_m \]
\[ a = \frac{d^2x}{dt^2} = -\omega^2 x \quad - \quad a_m = \omega^2 x_m \]

Angular frequency \( \omega = \frac{2\pi}{T} \) [s\(^{-1}\)]

Mass on a Spring - \( \omega = \sqrt{k/m} \)

Pendulum - \( \omega = \sqrt{g/l} \)

Resonance - oscillators have the greatest response to external vibration at their natural frequency

Chapter 17 Waves

Wavelength - \( \lambda \)
Angular wavenumber - \( \kappa = \frac{2\pi}{\lambda} \) [m\(^{-1}\)]
Wavespeed - \( v = \frac{\lambda}{T} = \frac{\omega}{\kappa} \)

Traveling Sine Waves - \( y = y_m \sin(\kappa x \pm \omega t) \); (- to the right, + to the left)
Standing Waves - nodes, anti-nodes, \( y = y_m \sin(\kappa x) \cos(\omega t) = (y_m/2)(\sin(\kappa x-\omega t)+ \sin(\kappa x+\omega t)) \)

Speed of wave on a stretched string: \( v = \sqrt{\tau/\mu} \)

where, \( \tau = \) tension in the string and \( \mu = \) mass/unit length of the string
Resonant modes (of a string, spring, etc... fixed at both ends)
Standing waves with a node at each end
\( \lambda_n = \frac{2L}{n} \quad n=1,2,3,4... \quad L = \) length of string, spring, etc...
\( f_n = n\nu/2L = nf_1 \)
distance between consecutive nodes or anti-nodes = \( \lambda/2 \)

Chapter 18 Sound

Sound Waves

Speed of Sound in air, \( v = (343m/s)\sqrt{T/293K} = 343 \text{ m/s at room temperature} \)

Drop of intensity with distance: \( I = \frac{P_s}{4\pi r^2} \), \( P_s = \) power output of the source
Decibel Scale: \( \beta = 10\text{dB} \log(I/I_o) \), \( I_o = 1.0 \times 10^{-12} \text{ W/m}^2 \)
Doppler Effect for sound: \( f' = \frac{(v\pm v_D)(v\pm v_s))}{v_s}f \)

\( v_D = \) speed of detector, \( v_s = \) speed of source

Interference from two sources vibrating in phase
Maximum: \( r_2-r_1 = m\lambda \)
Minimum: \( r_2-r_1 = (m+1/2)\lambda \)
\( m = 0, \pm1, \pm2, \pm3,... \)

Beats: beat frequency, \( f_b = |f_2-f_1| \)
Chapter 34 Electromagnetic waves

Plane waves: $\vec{E} = \vec{E}_m \sin(\kappa x \pm \omega t)$; $\vec{B} = \vec{B}_m \sin(\kappa x \pm \omega t)$; $(\vec{E} \perp \vec{B}) \perp \text{Direction}$

$\vec{E} \times \vec{B} = \mu_0 \vec{S}$ = Direction

Speed of light, $c = \sqrt{1/\mu_0 \varepsilon_0} = 3.00 \times 10^8 \text{ m/s}$

Intensity, $I = E_m B_m / 2 \mu_0 = E_m^2 / 2 \mu_0 c = c B_m^2 / 2 \mu_0 = \mathcal{P} / 4 \pi$

The Law of Reflection - incident angle = reflected angle

Index of Refraction - $n = c/\nu = \text{(speed of light in vacuum)}/\text{(speed of light in media)}$

The Law of Refraction - $n_1 \sin \theta_1 = n_2 \sin \theta_2$ or $\sin \theta_1/\nu_1 = \sin \theta_2/\nu_2$

Total Internal Reflection

The Critical Angle - $\theta_c = \sin^{-1} (n_{\text{low}}/n_{\text{high}})$

Chapter 35 Lenses and Mirrors

Planar mirror images - virtual image, $i = -p$

Thin lenses: converging ($f>0$), diverging ($f<0$), focal length

Ray Tracing

Images: real, virtual, sign conventions

Thin lens equation: $1/f = 1/p + 1/i$

Magnification: $M = -i/p$

Chapter 15 Fluids

Fluids: liquids, gases, density, pressure

Bouyancy

Incompressible fluids (liquids):

density, $\rho = \text{constant}$

Hydrostatics: $P = P_o - \rho g y$

Steady Fluid Flow:

Continuity: $A_1 v_1 = A_2 v_2$

Bernoulli’s Equation: $P_1 + (1/2) \rho v_1^2 + \rho g y_1 = P_2 + (1/2) \rho v_2^2 + \rho g y_2$