

Physics 303K Handout 14

1 Chapter 17: Oscillations

Harmonic motion with damping is described by:

$$m \frac{d^2x}{dt^2} + b \frac{dx}{dt} + kx = 0. \quad (1)$$

This second order ordinary differential equation has solutions:

$$x(t) = Ae^{-bt/2m} \cos(\omega' t + \phi), \quad (2)$$

where

$$\omega' = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2}. \quad (3)$$

2 Chapter 18: Wave Motion

1. We can classify waves into *transverse* and *longitudinal* waves.
2. A sinusoidal wave can be written: $y(x, t) = A \sin(kx + \omega t + \phi)$, where $k = \frac{2\pi}{\lambda}$, ϕ is the phase, and $\omega = 2\pi f$.
3. On a stretched string, the wave speed is $v = \sqrt{F/\mu}$.
4. The average power (the average rate at which energy is transmitted along the string) is

$$P_{av} = \frac{1}{2} \mu \omega^2 y_m^2 v. \quad (4)$$

The average intensity (the average transmitted power per unit area) is $I = \frac{P_{av}}{A}$.

5. The principle of superposition states that waves combine by addition.
6. Standing waves can be described as two counterpropagating waves each with amplitude A . By superposition, $y(x, t) = 2A \sin(kx + \psi) \sin(\omega t + \phi)$. The parameters are determined by the string's excitation, the boundary conditions, the string properties, etc.
7. A wave incident on a rigid boundary is reflected and inverted. A wave incident on a loose boundary (a ring sliding on a pole) is only reflected.

3 Chapter 19: Sound Waves

1. Sound waves are transverse waves. They are the compression and rarefaction of the supporting medium. The speed of sound waves is

$$v = \sqrt{\frac{B}{\rho_0}}, \quad (5)$$

where $B = \frac{\Delta p}{\Delta V/V}$ is the bulk modulus and ρ is the density.

2. The average power of sound waves is

$$P_{av} = A \frac{\Delta(p_m)^2}{2\rho p}. \quad (6)$$

The average intensity is $I = \frac{P_{av}}{A}$. The sound level SL is measured in decibels: $SL = 10 \log(I/I_0)$. +3 dB means an intensity ratio of 2. +10 dB means an intensity ratio of 10.

3. For a spherical wave (3D), intensity falls off like $I = \frac{P}{4\pi r^2}$. For a circular wave (2D), intensity falls off like $I = \frac{P}{2\pi r}$. For a linear wave (1D), intensity remains constant I .
4. For destructive interference of two waves is $\Delta L = (m + \frac{1}{2})\lambda$. Be sure to read Chapter 19 Section 5.
5. For an open end of a tube, the boundary condition is that the vibration amplitude is at a maximum. For a closed end of a tube, the boundary condition is that the vibration amplitude is zero.
6. Two waves of different frequencies superposing produces a beat frequency

$$\omega_{beat} = \frac{|\omega_1 - \omega_2|}{2}. \quad (7)$$

7. The Doppler effect can be written:

$$f' = f \frac{v \pm v_O}{v \mp v_S}. \quad (8)$$

Matt Thrasher, thrasher@physics.utexas.edu, 4/04
adapted from Resnick, Halliday, and Krane.