Oscillations

Periodic motion: motion that repeats from *equilibrium position* via *restoring force*.
Parameters of motion: $T, f = \frac{1}{T}, \omega = 2\pi f$.

Simple harmonic motion if

$$F_x = -kx$$

Then

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

frequency does not depend on amplitude.

Expression for displacement as a function of time

$$x = A\cos(\omega t + \varphi)$$

Energy

$$E = ½mv_x^2 + ½kx^2 = ½kA^2 = \text{constant}$$

Examples of SHM:

- Simple pendulum: $\omega = \sqrt{g/L}$ for small angles
- Physical pendulum: : $\omega = \sqrt{mgd/I}$ for small angles

Damped oscillations: if damping force has form

$$F_x = -bv_x$$

then system oscillates with frequency

$$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}} < \omega \quad \text{undamped frequency}$$

$$b = 2\sqrt{km} \quad \text{critical damping}$$

Driven oscillations/resonance: get peak amplitude with driving frequency $\omega_d = \omega$

Wave motion

Particles move in SHM $\Leftrightarrow$ sinusoidal wave
Parameters $f, \lambda, v = f\lambda$
Wave function: describes particle displacement as a function of position and time

$$y(x,t) = A\cos(kx - \omega t)$$

Wave speed depends only on medium

- String: $v = \sqrt{F/\mu}$
- Fluid: $v = \sqrt{B/\rho}$

Standing waves: occur when wave is reflected

$$y(x,t) = (A\sin kx)\ \sin\omega t$$

Two fixed ends: *normal modes*

- String: $f_n = n\frac{v}{2L}$
- Open pipes: $f_n = n\frac{v}{2L}$
- Closed pipes: $f_n = n\frac{v}{4L}, n$ odd

Be able to draw the different modes in a string or a pipe.

Interference:

- *Constructive* when $d = n\lambda$
- *Destructive* when $d = n\lambda/2, n$ odd

Beats: $f_{beat} = |f_a - f_b|$

Doppler effect:

$$f_L = \frac{v + v_L}{v + v_S} f_S$$

Shock waves:

$$\sin\alpha = \frac{v}{v_S}$$

where $v =$ sound speed, $v_S =$ source speed.