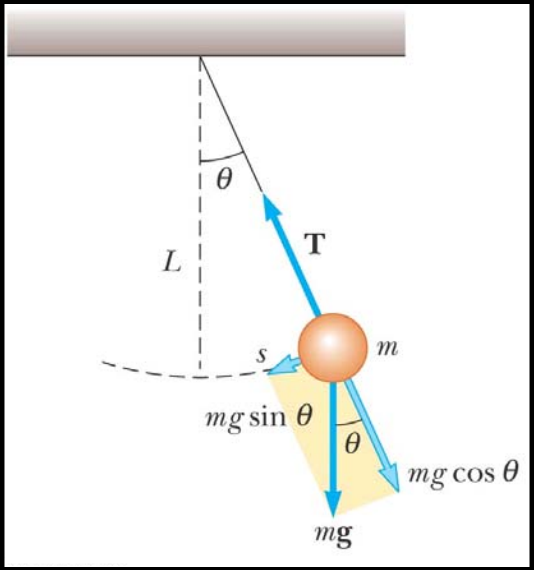
15.5. The Simple Pendulum



A simple pendulum is one which can be considered to be a point mass suspended from a string or rod of negligible mass.

$$\theta(t) = \theta_{\max} \cos(\omega t + \phi)$$

where

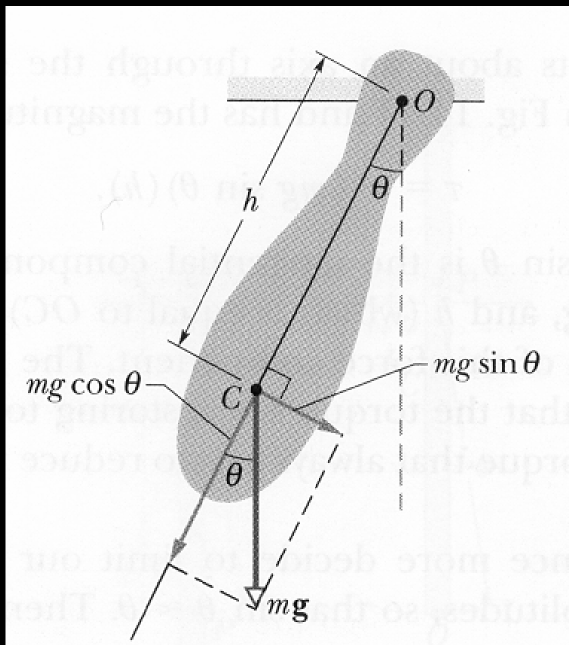
$$\omega = \sqrt{\frac{g}{L}}$$

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$$

$$T = \frac{1}{f} = 2\pi\sqrt{\frac{L}{g}}$$

***T* and *f* of a simple pendulum depend only on the length *L* of the string and the acceleration due to gravity. They are independent of the mass *m*.**

15.6. The Physical Pendulum



When the pendulum is displaced through an angle θ from its equilibrium position, a restoring torque τ appears.

$$\tau = -(mg \sin\theta)(h)$$

With small angle approximation :

$$\frac{d^2\theta}{dt^2} + \frac{mgh}{I}\theta = 0$$

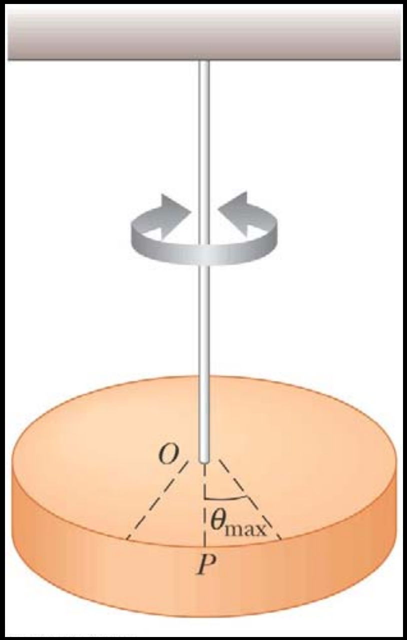
$$\theta(t) = \theta_{max} \cos(\omega t + \phi)$$

where

$$\omega = \sqrt{\frac{mgh}{I}}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{mgh}}$$

- **Torsional Pendulum**

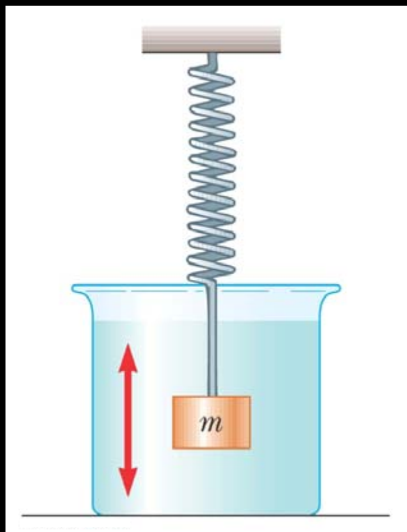


A torsional pendulum consists of a rigid object suspended by a wire attached to a rigid support. The object oscillates about the line OP with an amplitude θ_{max}.

$$T = 2\pi\sqrt{\frac{I}{\kappa}}$$

where κ is the torsion constant.

15.6. Damped oscillations (*descriptive*)

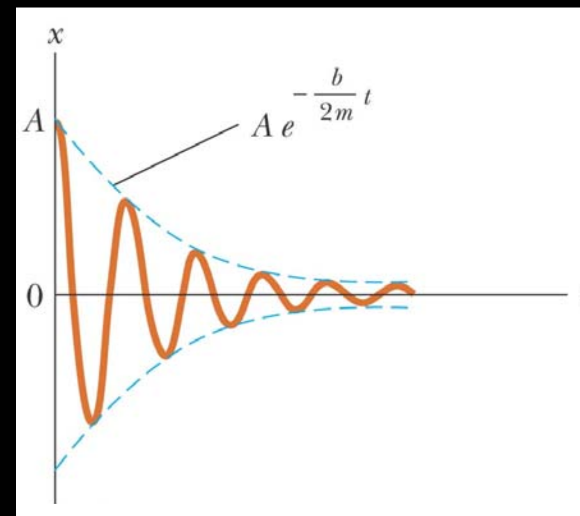


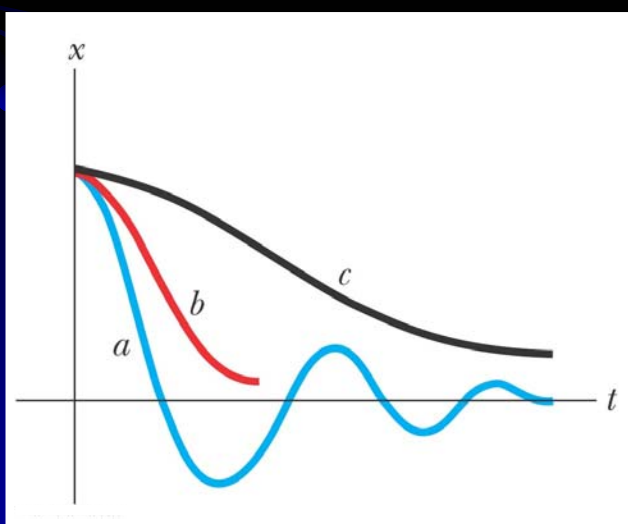
One example of a damped oscillator is an object attached to a spring and submersed in a viscous liquid.

$$x(t) = A\, e^{-\alpha t} \cos(\omega t + \phi)$$

where $\alpha = b/2m$

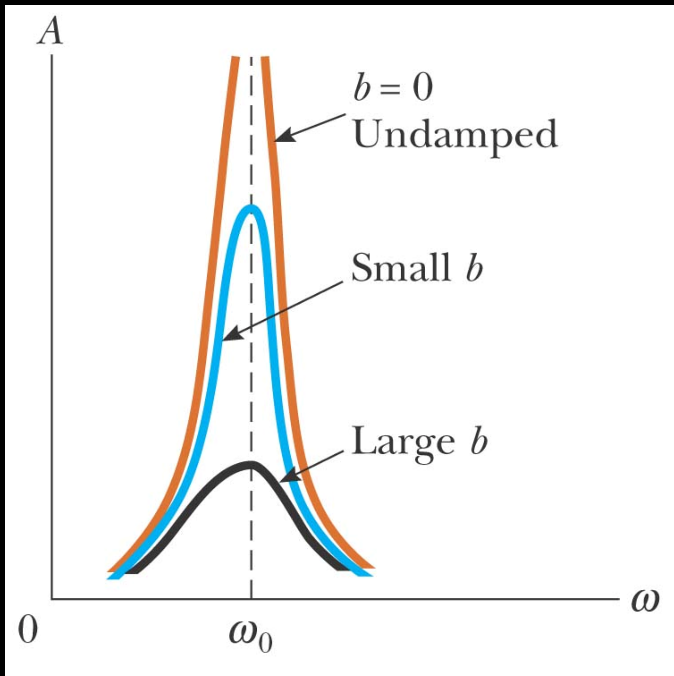
$$\omega = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}} = \sqrt{\omega_0^2 - \left(\frac{b}{2m}\right)^2}$$





Graphs of position versus time for (a) an underdamped oscillator, (b) a critically damped oscillator, and (c) an overdamped oscillator.

15.7. Forced Oscillations (*descriptive*)



Graph of amplitude versus frequency for a damped oscillator when a periodic driving force is present. When the frequency ω of the driving force equals the natural frequency ω_0 of the oscillator, *resonance* occurs. Note that the shape of the resonance curve depends on the size of the damping coefficient *b*.

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

$$A = \frac{F_0/m}{\sqrt{(\omega^2 - \omega_0^2)^2 + \left(\frac{b\omega}{m}\right)^2}}$$

Chapter 16. Wave Motion

Main types of waves :

- Mechanical waves : sound waves, water waves… (physical medium involved)
- Electromagnetic waves : light, radio waves, television signals … (no medium)
- Matter waves : a beam of particles, e.g. electrons (Quantum Physics)