Chapter 11

Thursday, February 18, 2021 8:35 AM

I. Simple Harmonic Motion (SHM)
   a. Periodic Motion: Object vibrates/oscillates back and forth
   b. Equilibrium position:: Where the spring is at its natural length with no net force on block
   c. Restoring force: Force by spring causing motion toward equilibrium
      i. Represented with Hooke's law: $F = -kx$ (Force should always oppose displacement)
      ii. Note: Acceleration is not constant
   d. Relevant Symbols and Terms

Term	Symbol	Definition
Displacement	x	Distance of mass from equilibrium point
Amplitude	A	Greatest distance from equilibrium point
Cycle		One complete back and forth movement
Period	T	Time to complete a cycle
Frequency	f	Number of cycles per second

   e. Displacement (x): Distance of amss from equilibrium point
   f. Amplitude (A): Greatest distance from equilibrium point
   g. Cycle: One complete back and forth movement
   h. Period: Time to complete a cycle
   i. Frequency: Number of cycles per second
   j. SHM: When a vibrating system exerts a restoring force directly proportional to the negative displacement
   k. SHO: A system that exhibits SHM

II. Energy in a SHO
   a. Spring Mass System:
      i. Finding Total Energy
         1) At any given point: $E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$
         2) Using Potential Energy: $E = \frac{1}{2}kA^2$ (Relevant to $\frac{1}{2}kx^2$)
         3) Using Kinetic Energy: $E = \frac{1}{2}mv_{max}^2$ (Max velocity will show total energy)
      ii. Period and Frequency
         1) Amplitude does not affect period
         2) Period: $T = 2\pi \sqrt{\frac{m}{k}}$

III. Simple Pendulum
   a. Setup
      i. Small object hanging from a lightweight cord
      ii. Cord's mass is small compared to object's mass
      iii. Negligible friction and air resistance
   b. Is a pendulum a SHO?
      i. Restoring force for a pendulum: Tangent component of weight
         1) $F = mg\sin(\theta)$
         2) Angles less than 15°: $F = mg\theta$
         3) $x = r\theta = L\theta$
         4) $F = -mg\left(\frac{x}{L}\right) = -\left(\frac{mg}{L}\right)x$
         5) Note: θ is in radians
         6) Mass, gravity and length are constants
         7) Noticing similarities
            a) $F = -kx$ (Hooke's law)
            b) $F = -\left(\frac{mg}{L}\right)x$
   c. Period and Frequency
      i. Period: $T = 2\pi \sqrt{\frac{L}{g}}$

IV. Wave Motion
   a. Waves: Carries energy from one place to another without physically moving to that place
      i. Crest/Trough: From highest point to bottom
      ii. Amplitude: From the center to crest or trough
      iii. Wavelength(λ): The length between the crests or troughs
      iv. Frequency/Period:
      v. Wave Velocity: $v = \frac{d}{t} = \frac{\lambda}{T} = \lambda f$

V. Types of Waves
   a. Mechanical Waves: Requires Medium
      i. Transverse: Direction of wave and motion of medium are perpendicular
      ii. Longitudinal: Direction of wave and motion of medium are parallel
         1) Crests: Compressions
         2) Troughs: Rarefactions
   b. Electromagnetic Wave: Doesn't require medium
      i. Radio
      ii. Microwave
      iii. Infrared
      iv. Visible
      v. Ultraviolet
      vi. X-ray
      vii. Gamma ray

VI. Energy Transported by Waves
   a. Every particle in a wave undergoes SHM
   b. Each particle's energy: $E = \frac{1}{2}kA^2$

VII. Interference
   a. Interference: The interaction of two waves that pass the same region at the same time
   b. Principle of Super Position
      i. Resultant displacement: Sum of individual displacements
      ii. Destructive interference: Less resultant displacement
      iii. Constructive: Greater resultant displacement
   c. Phase: Relative position between waves
      i. In phase: Crests and troughs are aligned (doesn't have to be identical)
         1) Causes constructive interference
      ii. Out of phase
         1) Crests and troughs are misaligned
         2) Out of phase by $\frac{1}{2}$ wavelength: Destructive interference
         3) Out of phase by $\frac{1}{2}$ wavelength and same amplitude: Destructive interference
         4) Out of phase not by $\frac{1}{2}$ wavelength: Partially destructive interference

VIII. Resonance
   a. All systems vibrate at their own individual frequency (natural frequency)
   b. Forced vibration: External force that has its own frequency
   c. Resonance: When a forced vibration on an object matches the natural frequency of that object and a large amplitude is reached (constructive interference)

IX. Standing Waves
   a. Standing wave: A wave that doesn't seem to travel
   b. Node: Points of completely destructive interference
   c. Antinode: Points of constructive interference; greatest amplitude
   d. Mode: Number of antinodes in the standing wave
   e. Resonant Frequencies: Frequencies that can cause a standing wave
      i. Each resonant frequency is a multiple of the lowest frequency
   f. Fundamental Frequency: Lowest Resonant Frequency
      i. Overtone: The other natural frequencies
      ii. Harmonic: Each multiple of the fundamental frequency

Relevant Equations

- $T = \frac{1}{f}$
- $T = \frac{t}{c} = \frac{time}{cycles}$

Conclusions:

- $\frac{1}{2}kA^2 = \frac{1}{2}mv_{max}^2$
- $v = \pm A\sqrt{\frac{k}{m}}$