Ch 15 Wave Motion

Key words: traveling waves (transverse & longitudinal); velocity, energy, and intensity of traveling wave; interference; standing waves (resonance); resonant frequencies (harmonics/overtones).

Note: MasteringPhysics Ch 15 Homework is due Monday 4/12 @11:59pm

Objective:

I. Analyze the **Traveling Wave equation $y(x,t)$**

- ☐ By examining the equation $y(x,t)$ in its different forms.
- ☐ By creating 2 graphs: **position-graph** (y vs x) & **time-graph** (y vs t)

II. Solve problems that involve **a traveling wave**

- ☐ By constructing our own equation $y(x,t)$ to fit the situation.

Content Review: [10mins]

- The **Traveling Wave equation $y(x,t)$** is a function of 2 variables: x and t

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

where the variables are:

$y =$ $A =$ $k =$ $x =$

$\omega =$ $t =$ time $\phi =$

- For a wave traveling **on a string**, the velocity is given by

$$v_{\text{string}} =$$

where T is the tension and μ is the string's mass density (units of $\mathrm{kg/m}$)

- For traveling waves **in general**, the velocity is given by

$$v =$$

where ω is the angular frequency and k is the wave number

- For a string with 2 sections of **differing mass density** (μ_1 and μ_2), the tension T and frequency f throughout the string is constant.
  - ☐ If tension was NOT the same, then the joint between the 2 sections would accelerate and disrupt the string's motion.
  - ☐ If frequency was NOT the same, then the wave would not be a smooth wave i.e. different points of the string would not oscillate in-phase.

Guided Practice [10mins]

A sinusoidal wave traveling on a string in the negative x direction has amplitude $1.00\,\mathrm{cm}$, wavelength $3.00\,\mathrm{cm}$, and frequency $245\,\mathrm{Hz}$. At $t = 0$, the particle of string at $x = 0$ is displaced a distance $0.80\,\mathrm{cm}$ above the origin (equilibrium) and moving upward.

(i) Construct the equation representing this traveling wave as a function of x and t

(ii) Plot the following 2 equations and describe their physical representation:

- ☐ Holding $t = 0\,\mathrm{s}$, graph $y(x, t)$ over distance x.
- ☐ Holding $x = 5.00\,\mathrm{cm}$, graph $y(x, t)$ over time t.

■ Here is a link to Desmos online graphing calculator

Solution

(i) $y(x, t) = (1.00\,\mathrm{cm}) \sin\left[(2.09\,\mathrm{cm}^{-1})\, x + (1540\,\mathrm{rad/s})\, t + 0.93\,\mathrm{rad}\right]$
where x is in centimeters and t in seconds.

(ii) and (iii) link to Desmos graph

Group Activity [20mins]

A cord has 2 sections with linear mass densities of $0.10\,\mathrm{kg/m}$ and $0.20\,\mathrm{kg/m}$. An incident wave given by $D = (0.05\,\mathrm{m})\sin(7.5x - 12.0t)$, where x is in meters and t in seconds, travels along the lighter cord.

(i) Determine wavelength on the lighter section of cord

(ii) Determine the tension in the cord

(iii) Determine the wavelength when the wave travels on the heavier section

Solution

(i) $\lambda_{\text{light}} = 0.84\,\mathrm{m}$

(ii) $T = 0.26\,\mathrm{N}$

(iii) $\lambda_{\text{heavy}} = 0.59\,\mathrm{m}$