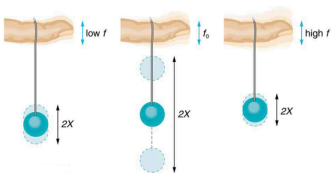
Introduction to Physical Science

Waves

Presented by Robert Wagner

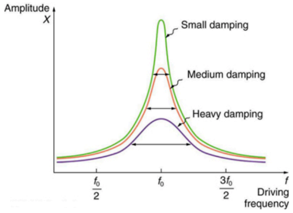
Forced Oscillation

- Objects can be forced to oscillate by using a driving force at a specific frequency
  - Not how the object wishes to oscillate
  - Natural frequency - How the system would oscillate if there were no driving or damping forces.
- Resonance
  - A system being driven at its natural frequency



Resonance

- Increase the amplitude of the wave by driving it at its natural frequency
  - Less damping => higher peak
- Examples
  - Pushing a child on a swing
  - MRI - Magnetic resonance Imaging
  - Tacoma Narrows bridge



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Waves

- What is a wave?
  - A disturbance that propagates from where it was created
  - Water waves, sound waves, etc.
- Wave velocity
  - The speed at which the disturbance moves
  -

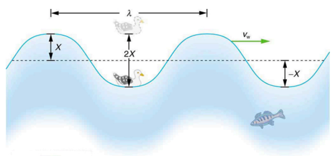
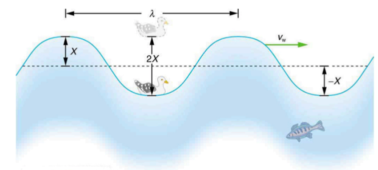


Figure 16.30 An idealized ocean wave passes under a sea gull that bobs up and down in simple harmonic motion. The wave has a wavelength λ, which is the distance between adjacent identical parts of the wave. The up and down disturbance of the surface propagates parallel to the surface at a speed v_w.

Example

- Calculate the velocity of the ocean wave shown if the distance between crests is 10.0 m and the time for a seagull to bob up and down is 5.00 s.
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve



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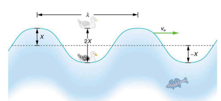

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$$\lambda = 10.0\,m\,;\; T = 5.00\,s$$

$$f = \frac{1}{T} = \frac{1}{5.00\,s} = 0.200\,s^{-1}$$

$$v_w = f\lambda$$

$$v_w = (0.200\,s^{-1})(10.0\,m)$$

$$v_w = 2.00\,m/s$$

Transverse and Longitudinal Waves

- Transverse or shear wave
  - Disturbance is perpendicular to the direction of motion
- Longitudinal or compressional wave
  - The disturbance is parallel to the direction of propagation

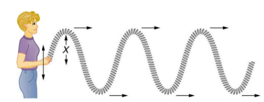

Figure 16.31 In this example of a transverse wave, the wave propagates horizontally, and the disturbance in the cord is in the vertical direction.

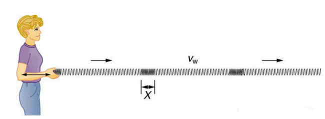

Figure 16.32 In this example of a longitudinal wave, the wave propagates horizontally, and the disturbance in the cord is also in the horizontal direction.

Superposition of Waves

- Waves superimpose upon one another when they arrive at the same point at the same time.
  - Amplitudes of the disturbances will add together
- Constructive interference
  - Waves reinforce each other
- Destructive interference
  - Waves cancel each other

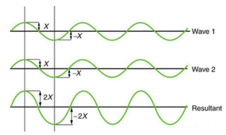

Figure 16.36 Pure constructive interference of two identical waves produces one with twice the amplitude, but the same wavelength.

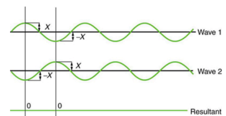

Figure 16.37 Pure destructive interference of two identical waves produces zero amplitude, or complete cancellation.

Superposition of Waves (2)

- Can be more complex - may have some constructive and some destructive interference
- Example
  - Wave pool

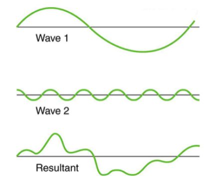

Figure 16.38 Superposition of non-identical waves exhibits both constructive and destructive interference.

Superposition of Waves (2)

- Can be more complex - may have some constructive and some destructive interference
- Example
  - Wave pool

Summary

- A natural frequency is the frequency at which a system would oscillate if there are no external forces or damping forces
- A wave is a disturbance that propagates away from the location at which it was created
- Waves will superimpose on each other - reinforcing each other or canceling each other