Arvind Borde / PHY 11, Week 9: Oscillations & Waves

(1) What's an oscillation?

1

Springs: Hooke's law

$$\vec{F} = -k\vec{x}$$

Max displacement: A (amplitude)

Frequency (number of oscillations/sec): f (Hz)

Period (time per oscillation): $T = \dfrac{1}{f}$ (sec).

2

(2) What is the spring constant of the shock absorbers of a 1500 kg car if they depress 2 cm with a 200 kg load?

3

Energy

Spring PE:

Total energy:

4

(3) At maximum amplitude, what is v?

(4) Solve for v.

5

(5) What is the maximum value for x?

Also

or

(6) If A doubles how do E and $v_{\max}$ change?

6

ADDITIONAL NOTES

(7) If you hang a mass of $0.30\,\text{kg}$ on a spring and it stretches $0.150\,\text{m}$, what is k?

(8) If you place the same spring horizontally and pull the mass horizontally by $10\,\text{cm}$, what is $v_{\max}$?

7

Period: $T = 2\pi\sqrt{\dfrac{m}{k}}$

Frequency: $\dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$

Position: $x = A\,cos\left(\dfrac{2\pi t}{T}\right) = A\,cos(2\pi f t)$.
(Assuming you start at maximum amplitude.)

8

Spring motion is example of _____ _____.

Another example is a pendulum (small swing).

Here $k = \dfrac{mg}{\ell}$, where ℓ is the length of the pendulum, and m the swinging mass.

(9) What is T?

9

Waves

What's a wave? _____

Examples: Water waves, sound waves, etc.

The two key attributes of waves are:
▷ How long they are (_____, λ), and
▷ How frequently they pass (_____, f).
The _____ of a wave, v, is related to these two by _____

10

(10) If two waves (Wave A and Wave B) have the same speed, but Wave A has twice the wavelength of Wave B, how are their frequencies related?

_____

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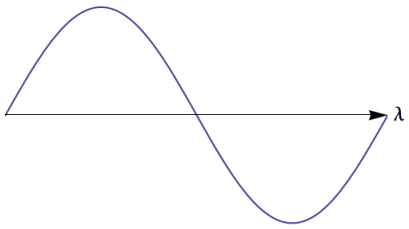
Visualizing wavelength



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ADDITIONAL NOTES

Huygens' Principle

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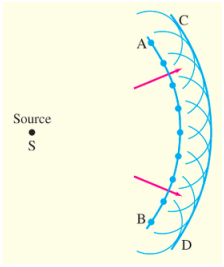

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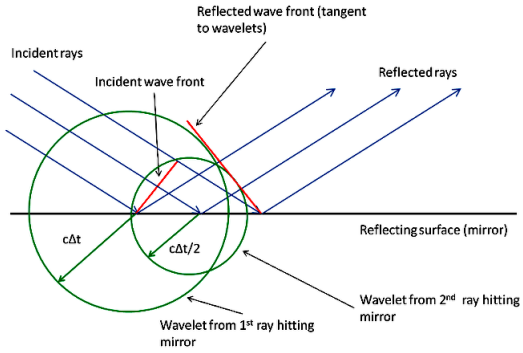
Reflection of Waves



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If θ_i is the angle at which the waves hit the reflector, and θ_r the angle at which they are reflected, it follows that

$$\theta_r = \theta_i$$

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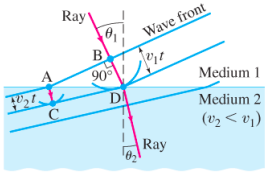
Refraction of Waves

As waves go from one medium to another (air to water, for example) they bend. This bending is called refraction and it occurs because the waves travel at different speeds in different media.

The _____ in a medium is the reciprocal of the speed of the wave, $1/v$, in that medium.

17



Δ ABD: $sin\,\theta_1 =$

Δ ACD: $sin\,\theta_2 =$

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ADDITIONAL NOTES

So

Or,

This is called _____

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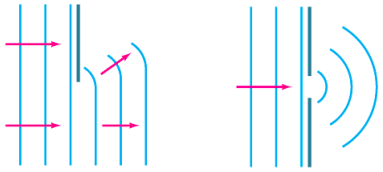
Diffraction of Waves



Waves can bend a little around obstacles. The smaller the size of the obstacle compared to the wavelength, the more they can bend around it.

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In the mid-1600s, Francesco Grimaldi observed that when sunlight entered a darkened room through a tiny hole in a screen, the spot on the opposite wall was larger than you'd expect.

This expansion of the image spot is because of diffraction. (He also observed that the border of the image was not clear but was surrounded by colored fringes.)

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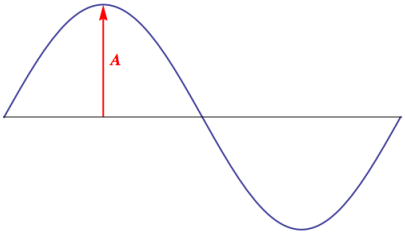
Interference of Waves



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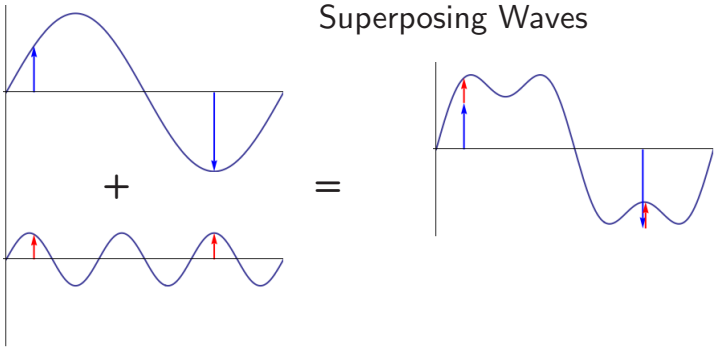
Superposing Waves



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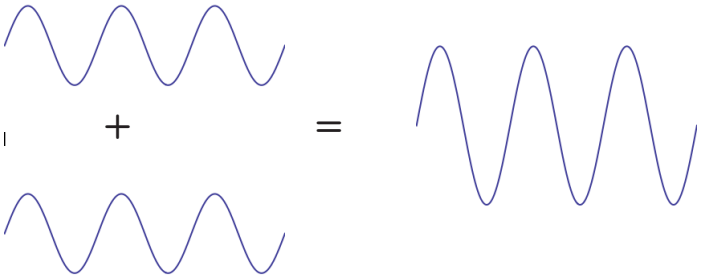
23 _____

Constructive Interference



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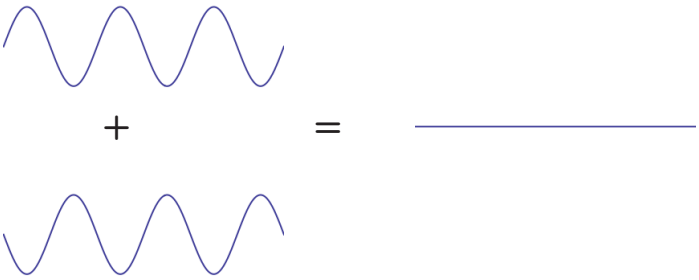
ADDITIONAL NOTES

Destructive Interference



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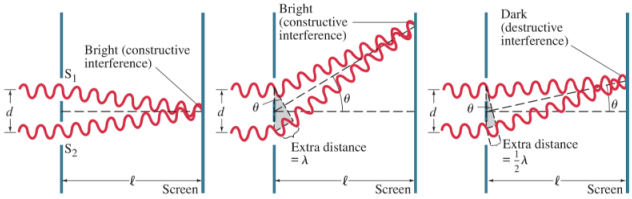
These effects, where waves can reinforce each other or cancel each other, lead to patterns of dark and light lines called an interference pattern.



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Particle v Wave Motion

The particles in the medium carrying the wave move back and forth, while the wave itself travels forward. The velocity of the particles is not the same as the velocity of the waves.

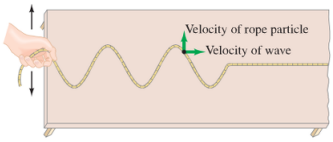

FIGURE 11–22 Wave traveling on a rope or cord. The wave travels to the right along the rope. Particles of the rope oscillate back and forth on the tabletop.

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Transverse v Longitudinal Waves

In transverse waves, the particles oscillate at right angles to the wave potion.
Example: water waves.

In longitudinal waves, the particles oscillate in the same direction as the wave motion.
Example: sound waves.

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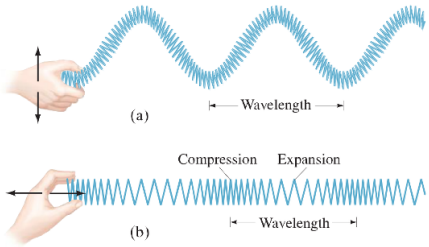

(a) Transverse wave; (b) longitudinal wave.

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Speeds

Transverse waves on a string: $v = \sqrt{F_T/\mu}$.
F_T is the tension in the string. μ is m/ℓ where m is the mass and ℓ the length of the string.

Longitudinal waves: $v = \sqrt{\text{elasticity}/\rho}$.
The elasticity is given property (called "bulk modulus" if the medium is a gas or a liquid) of the medium, and ρ is its density (more Greek: "rho").

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ADDITIONAL NOTES

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