<u>Waves and Sound</u>

Name: ____________________

Video
903
(5:05)

Simple Harmonic Motion

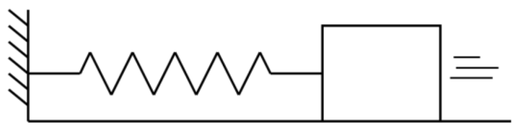
<u>restoring force</u>:

When a stable system at equilibrium is tweaked, often some kind of restoring force naturally kicks in.

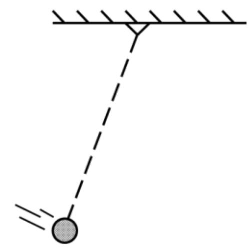
In <u>simple harmonic motion (SHM)</u>, the restoring force is directly proportional to the displacement from equilibrium, i.e.,

As Δx ↑, F . As Δx ↓, F . When $\Delta x = 0$, F

We will learn about two cases that exhibit (or nearly so) SHM.



mass-spring system



pendulum

<u>amplitude</u>:

For m-s systems:

-- symbolized A

-- measured in

For pendulums:

-- symbolized θ

-- measured in

Mass-Spring System

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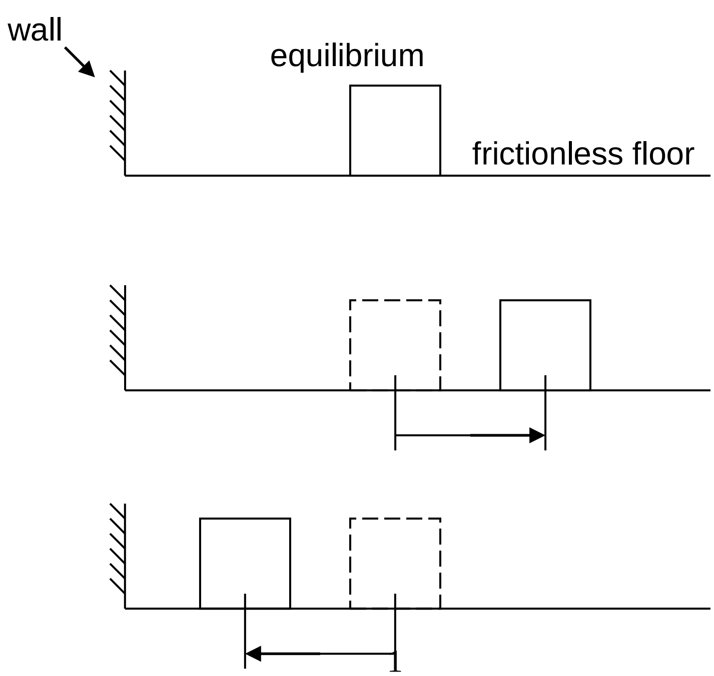
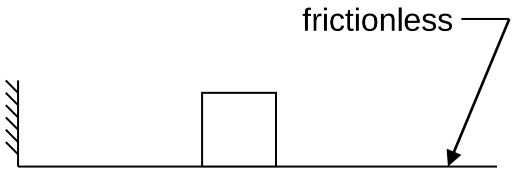


Mass-Spring System



Δx_{max} is better known as the…

At that point, we also have maximum…

Energy of a Mass-Spring System

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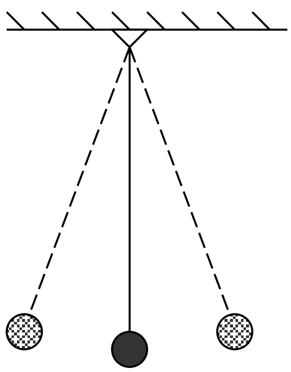
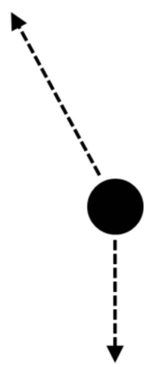
Pendulum

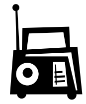




θ (deg)	sin θ	θ (rad)
0		
5		
10		
15		
20		
25		

Energy of a Simple Pendulum

 period, *T*:

 frequency, *f*:

For mass-spring systems:

m = mass (kg)

k = spring constant (N/m)

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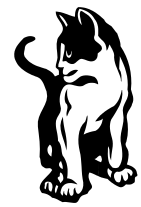
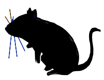
(5:54)

A 5.5 kg cat is attached to a fixed horizontal spring of stiffness 22.8 N/m and is set in motion on a frictionless surface. Find the period of motion of…

…the cat.





…a 120 g mouse, with the same spring and surface.

What stiffness must a spring have so that the period of the mouse's motion is the same as that of the cat?

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(4:26)

A 1645 kg car carries two passengers with masses 75 kg and 86 kg. The car has four shock absorbers, each with a spring constant of 1.7×10^4 N/m. Find the freq. of the vehicle's motion after it hits a pothole.

For simple pendulums:

Period T is independent of…

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(6:44)

EX. The period of a pendulum is 5.2 s. Find…

A. …its length

B. …the mass of the bob

EX. On Io, a moon of Jupiter, a 0.87 m pendulum has a period of 8.74 s. What is g on Io?

Video
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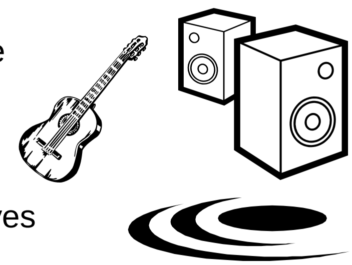
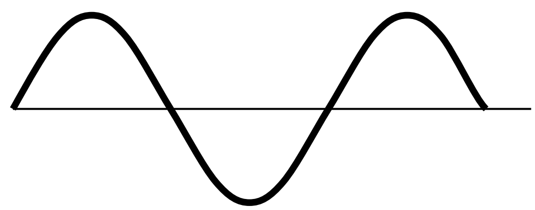
(7:13)

Waves → vibrations moving through space and time

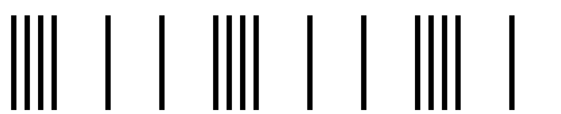


<u>medium</u>: the matter through which the energy of <u>mechanical waves</u> moves

<u>transverse waves</u>: particles of medium move ⊥ to direction of wave travel



<u>longitudinal (compressional) wave</u>: particles of medium move // to direction of wave travel



<u>pulse wave</u>:

vs. <u>periodic wave</u>:

Video 924 (2:27)

For mechanical waves:

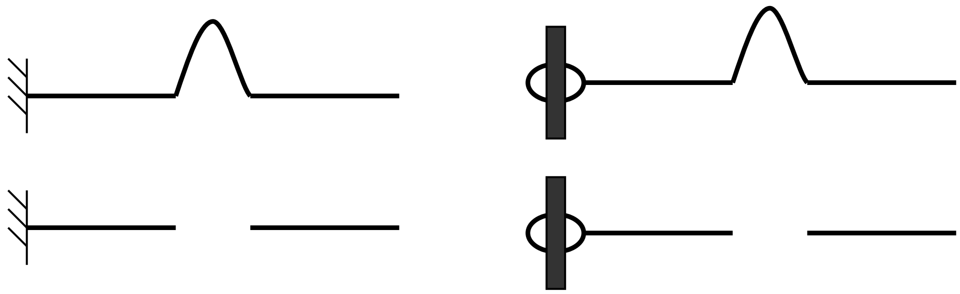
If A doubles, energy…

If A triples, energy…

If A drops to, say, 35% of the original level, energy…

Video
927
(2:55)

Wave Reflection fixed boundary vs. free boundary



Wave Interference Two waves (unlike two objects) can occupy the same place at the same time.

Video
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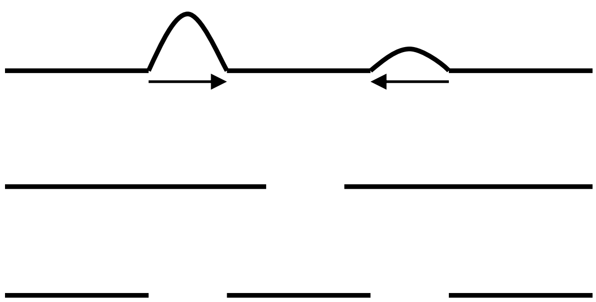
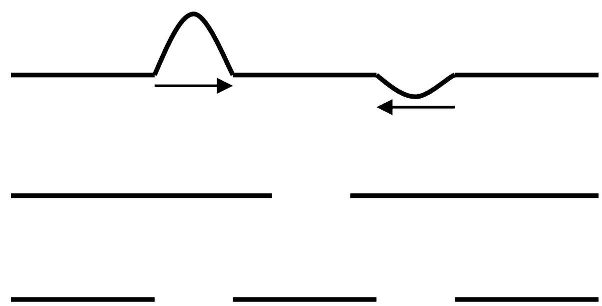
(4:06)

constructive interference:



destructive interference:



Video 933
(6:18)

Wave Velocity Equation: v (m/s); f (Hz); λ (m)

EX. A wave of wavelength 8.5 m washes past a boat at anchor every 4.75 s. Find wave's velocity.

The speed of any mechanical wave depends ***only*** on the properties of the medium through which it travels.

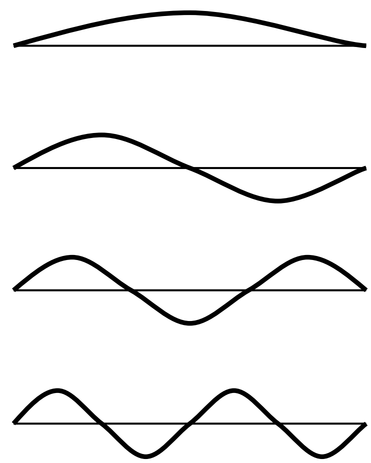
e.g.,

The speed of sound in air is related to the air temperature:

Standing Waves Incident and reflected waves interfere to produce an unchanging wave pattern. <u>Antinodes</u> have a max. amplitude, while <u>nodes</u> have zero amplitude.

Video
936
(5:24)

Standing waves are most easily visualized on a string, where nodes remain motionless and antinodes go from max. (+) to max. (–) displacement.



wavelength of the n^{th} harmonic on a string:

EX. Waves travel along a 96.1 cm guitar string at 492 m/s. Find fundamental frequency of string.

Video
937
(4:06)

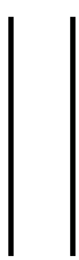
Find the frequency of the 5^{th} harmonic.

frequency of the n^{th} harmonic:

Video
939
(6:35)

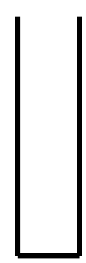
Standing Waves in Open Tubes

wavelength of the n^{th} harmonic of an <u>open tube</u>:



Closed Tubes

wavelength of the n^{th} harmonic of a <u>closed tube</u>:



EX. Find fundamental freq. for an open tube of length 1.24 m. Air temp. is 20.0°C.

EX. Find fundamental freq. for a closed tube of length 1.24 m. Air temp. is 20.0°C.

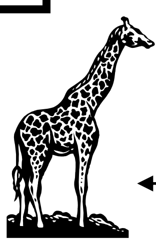
doubling (or halving) of frequency =

100 Hz ⟷ 200 Hz ⟷ 400 Hz ⟷ 800 Hz

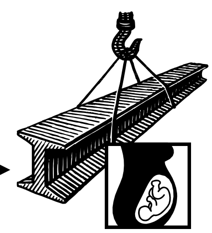
Video 942 (6:42)

Sound <u>compression</u>:

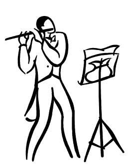
<u>rarefaction</u>:



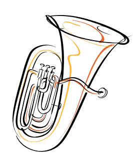
← 20 Hz 20,000 Hz →



Fundamental frequency determines <u>pitch</u>.

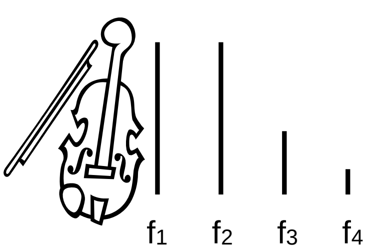


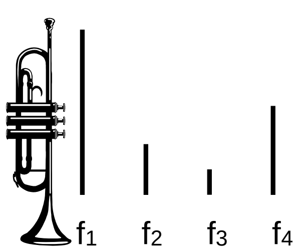
high f =

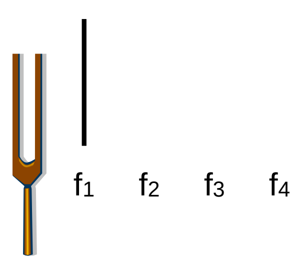


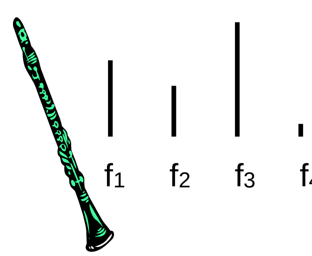
low f =

The # and intensity of an instrument's harmonics give it its unique sound quality, or _______.



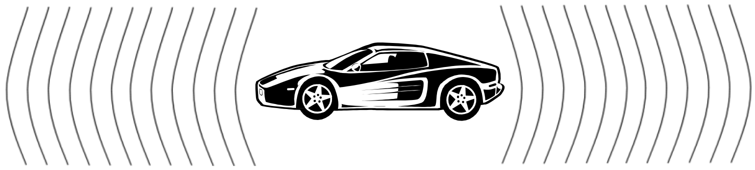


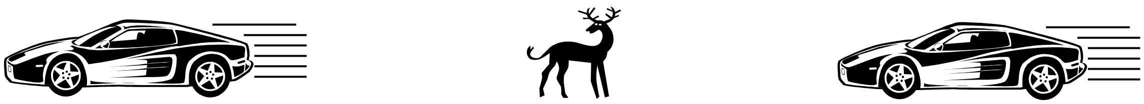




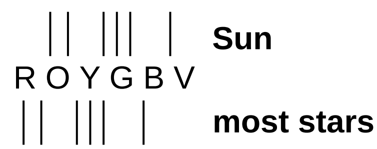
Video 945 (5:27)

The Doppler Effect Relative motion between wave source and observer causes a change in the ____________ frequency.



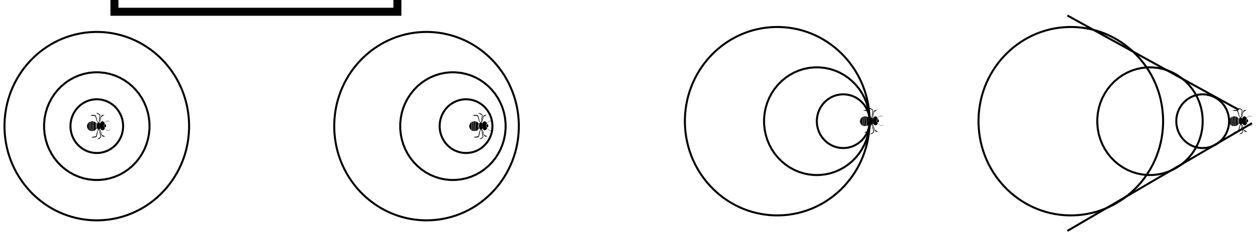


Other examples of the Doppler effect:



Video 948 (4:54)

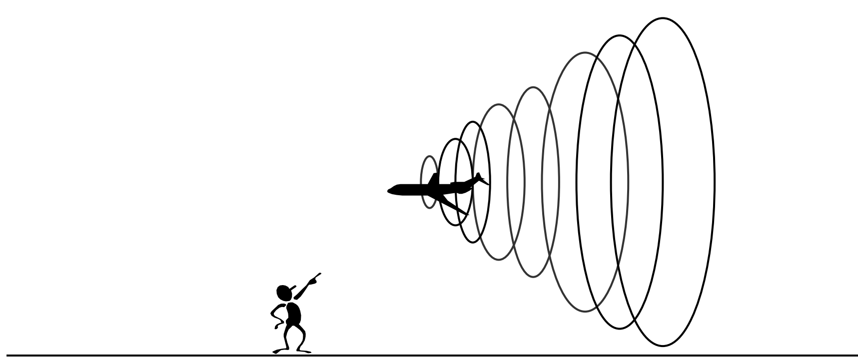
Traveling Very Fast



supersonic: “faster than sound” (vs. subsonic)

shock wave:

sonic boom:



Video 951
(3:30)

Sound Intensity Equation:

EX. If a piano's power output is 0.302 W, find the sound intensity at a distance of…

A. …1.0 m B. …2.0 m

Video 954
(4:31)

Intensity is related to <u>volume</u> (or <u>relative intensity</u>):

--

-- measured in decibels (dB)

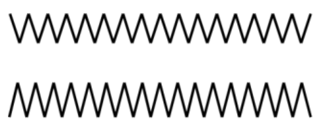
A difference of 10 dB changes the sound intensity by a factor of 10 and the volume by a factor of 2.

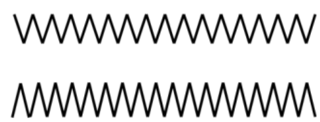
<u>50 dB</u> vs. 40 dB

<u>60 dB</u> vs. 90 dB

Beats → alternating loud-and-soft sounds resulting from interference between two slightly-different frequencies

Video
957
(5:16)





Equation:

Video
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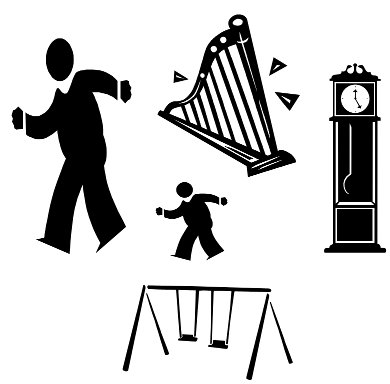
Forced Vibrations and Resonance



<u>natural frequency</u>:

<u>forced vibration</u>:

<u>resonance</u>:

-- result of resonance =

Examples: