Physics 1901 Advanced
Tutorial 7: Waves

A. Qualitative Questions:

1. ***Wave and particle speeds***

a. For transverse waves on a string, is the wave speed the same as the maximum speed of any part of the string?

b. What about for longitudinal waves on a rod?

c. The pulse pressure wave from your heart reaches your feet in around 0.2 s, while your blood flow rate is less than 1 $m.s^{-1}$. Explain this observation.

2. ***Travelling wave equation***

A travelling wave is described by the equation:

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

a. Define and give the units for each symbol in the above equation.

b. Is this a transverse or longitudinal wave? Why?

Two otherwise identical waves are out of phase by 100°. Draw graphs of these waves on the same axes at:

c. a moment in time, and at

d. a point in space.

B. Demonstration Questions:

1. ***Interference***

Observe the interference patterns with the HeNe laser and the double slits.

Why does this pattern occur?

What happens to the pattern on the screen as the slit width is changed?

There are various slits available. Observe the patterns using these slits.

2. ***Chladni's plates***

Metal plates are mounted on a supporting beam. Sand is sprinkled onto the plate which is then made to vibrate using a violin bow. What do you observe?

What happens when you change the pressure and speed of the bow?

There is a square and a circular plate, why are the patterns different on these plates?

Try using your finger to damp (stop vibrations) the plate at a point on the edge. What do you observe? Explain what has happened.

3. ***A computer simulation***

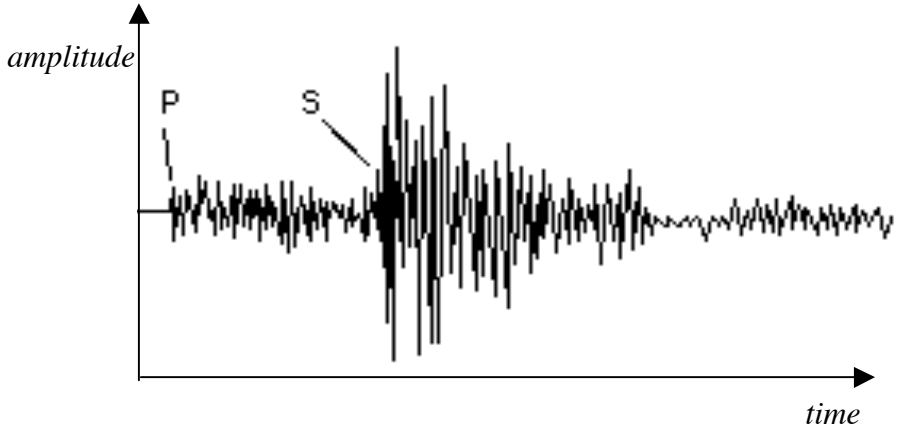
Investigate superposition of waves using the computer program.

What happens when you add waves of different frequency?

C. Quantitative Questions:

1. ***Earthquakes***

Earthquakes generate sound waves in the earth. Unlike in a gas, there are both transverse (S) and longitudinal (P) sound waves in a solid and these travel at different speeds. This is shown in the seismograph trace below.



[diagram from *http://www.geo.mtu.edu/UPSeis/reading.html*]

Typically the speed of S waves is about 4.5 km.s^{-1} and that of P waves 8.0 km.s^{-1}. A seismograph records P and S waves from an earthquake.

a. If the first P waves arrive 3.0 minutes before the first S waves, how far away did the earthquake occur? (Assuming the waves travelled in a straight line.)

In the Mexico City earthquake of 19th September 1985, areas with high damage alternated with areas of low damage. Also, buildings between 5 and 15 storeys high sustained the most damage.

b. Discuss these effects in terms of standing waves and resonance.

2. ***Wave superposition***

Two identical transverse sinusoidal waves travel in opposite directions along a string. Each wave has an amplitude of 3.0 mm and a wavelength of 60 mm. The speed of a transverse wave on the string is 1.5 m.s^{-1}.

a. Write the equation for each of the travelling waves.

b. Describe the waveform that results from the superposition of the two travelling waves.

c. Write down the equation for the superposed resultant wave.

d. Plot the shape of the string at t = 0 ms (arbitrary), t = 5.0 ms, t = 10 ms, t = 15 ms, and t = 20 ms.

[You will need the following trigonometric identity: sin(A ± B) = sinA cosB ± cosA sinB]

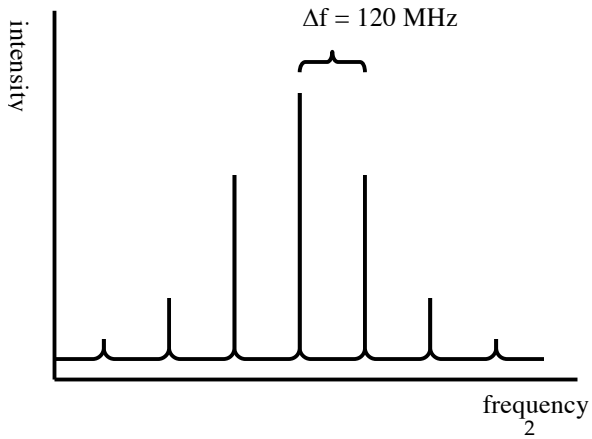
Extra Question:

1. ***Monochromatic laser***

a. How would you expect intensity to vary with frequency for a monochromatic laser? Sketch a graph of your prediction.

Shown opposite is a high resolution spectrum of a monochromatic laser.

b. Why do you think the laser has a line spectrum?



c. What is the length of the tube?