Workshop Tutorials for Introductory Physics

WI3: **Interacting Waves**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
diffraction, standing, sum, reflected, sound, echo, interference, superimposed, destructive, constructive, wavelength

Interacting Waves

Have you ever called out to someone and heard your voice come back to you? Maybe you were in the bush and there was a cliff nearby. The _____ waves that left your mouth were reflected off the cliff and came back to you as an _____. In the same way, when you pluck a guitar string you start the string vibrating and waves move down the string. The waves are _____ from the fixed end of the string and return along the string. In both cases the incoming and reflected waves occupy the same space and we say the two waves are _____ on each other.

This superposition of the waves results in interference. At any given point in space the resultant disturbance is the _____ of the individual disturbances of the two waves in question. At some places the two disturbances will add to give zero displacement - a point of _____ interference. At some places the waves will add to a maximum disturbance, a point of _____ interference. This superposition of waves and the resulting interference occurs for any type of waves – think what happens to your car radio when you pass under a transmission line. In this case there is interference between the electromagnetic radio waves from the station and electromagnetic waves from the transmission lines. Mobile phones have to be turned off in aeroplanes so they don't interfere with navigation signals.

In some cases when waves superimpose there is a regular interference pattern set up which has points of destructive and constructive interference that are constant in time. These are called _____ waves. Standing waves on violin strings and in the air columns of flutes and clarinets give notes of fixed frequency that are the bases of musical sounds.

Another strange property of waves, called _____, occurs when they bend around obstacles and move through narrow spaces. This diffraction is most noticeable when the obstacle or narrow space has a size of the order of the _____ of the wave. Hold two fingers very close together and up to the light. The light will diffract around your fingers and interfere. Can you see some fine lines between your fingers? This is an _____ pattern.

Discussion Question
You are sitting with your friends in a cafe which is very noisy. How would you design an environment in which you could hear conversations more easily.

B. Activity Questions:

1. Ripple tank

Use the long wave source to produce parallel wavefronts.
What happens when you put a small object in front of the wave?
What about a larger object?
What happens when these waves pass through a small gap in a barrier?
Explain your observations.

2. 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?

3. Standing waves on a string.
What happens when you adjust the frequency?
Sketch the patterns formed by the string, noting the frequency at which they occur.
What happens when you change the tension in the string?

4. Chladni's plates.
Sprinkle sand or cork dust on the plates. With a well resined bow excite the plate by bowing with a long firm stroke at an edge. What do you observe? How many patterns can you form on a given plate?
Sketch one of the patterns you produce and label the nodes and antinodes.
Why are the patterns different on different plates?
Try damping a point on the edge of a plate while bowing. What do you observe and why?

C. Qualitative Questions:

1. Why is it that if you hide behind something, such as a large tree, you cannot be seen, but if you make a noise you can still be heard?

2. Musicians often use tuning forks or electronic sound generators which produce a pure tone. They sound the pure tone, and at the same time play a note on their instrument, while listening for beats.
a. Explain how two notes can produce beats. Draw diagrams to help explain your answer.
b. How does beat production help a musician to tune their instrument? What does the musician do?

D. Quantitative Question:

You will need to estimate some sizes.
Waves are disturbed by and reflected from objects of similar size to, or larger than, their wavelength, while they simply pass by smaller objects. Many animals such as bats use echolocation to navigate and to hunt by. The hunter produces a sound which bounces off the prey and can then be detected by the hunter. What frequency would you expect the chirps of a hunting insectivorous bat to be?
Note : $v_{sound} \sim 340\ m.s^{-1}$ in air.