Ripple Tank Diffraction

WARNING – This experiment is not suitable for people who have photosensitive epilepsy. Tell a demonstrator immediately.

Using the Ripple Tank, you will explore the property of diffraction. Diffraction is a property of waves causing them to spread out after going through a gap. By setting up a single slit experiment, you will explore how gap/slit size affects the strength of diffraction. You will also use a theoretical method to work out the wavelength of the water waves. **Follow these instructions:**

1. Make sure the Ripple generator is on. Set the frequency to 20.6Hz and the amplitude to half of maximum. Make sure that the light source is on 'Strobe' and that the delta dial is set to -1. The gap/slit should be fully open.

2. Make a sketch of the waves before and after the gap/slit. Describe the effect of the gap/slit on the waves. **If you see no effect, ask for help**.

3. Move the sliding parts of the gap/slit. How is the shape of the wave affected by reducing the gap size? Measure the maximum gap at which the waves appear to radiate from a point.

4. To calculate the wavelength, λ, of water waves, the frequency, f, and velocity, v, need to be known. The velocity of a water wave in shallow regions can be calculated by,

   $$v = \sqrt{gd},$$

   where d is the depth of the water and g is the acceleration due to gravity (9.81 m/s^2). **Calculate the wavelength of the water waves**. How does this compare to the gap size you found in part 3? (HINT: $v = \lambda f$, ensure correct units)

Now you will look at what happens when two gaps/slits are used. Interference occurs when two or more waves are combined. Their amplitude is either reinforced (constructive interference) or cancelled (destructive interference).

Looking at the Ripple tank, you will observe regions of large amplitude corresponding to peaks (bright) and troughs (dark). There are also regions of small amplitude (from destructive interference) resulting in a uniform shade.

Using a computer, we can calculate the intensity of the waves at each point (squaring the average amplitude). This is equivalent to what is observed in the X-Ray experiment, where bright and dark regions correspond to constructive and destructive interference. **Follow these instructions:**

5. Using the same setup as before (frequency = 20.6Hz, delta = -1). Place the smallest block into the centre of the gap to create a double slit experiment. Note the size of the block. Make the size of the gaps/slits the same as the wavelength calculated in part 4.

6. Add on the width of one of the slits to the width of the block. This value is the slit separation, this is the distance from the centre of slit one to the centre of slit two.

7. Reduce the amplitude of the waves to zero. Then on the computer press calibrate. **Once calibrate is pressed, don't move the slits or the apparatus**. This sets the program up to do this part of the experiment as we remove background light levels from the images.

8. Set the amplitude to half of the maximum. You should now see two sources of diffracted waves. Make sure you can see these on the top left of the computer screen.

9. Then press 'RECORD DATA'. Don't move the webcam. After completion, in the top right corner, you will see bright lines of constructive interference and darker shades of destructive interference. **Ask for help if you cannot see this**.

10. The blue line on the top right image shows the position of an imaginary screen. The observed intensity pattern is then shown in the lower left corner. Sketch the intensity pattern with approximate locations of the peaks. Press SAVE after you have completed the sketch.

11. Change the size of the block in the centre of the gaps/slits, to the larger version. Follow steps 5 to 11 again. There are 3 sizes of centre block, once complete, move to part 12.

12. What effect does the size of the centre block (and therefore slit separation) have on the peaks sketched in part 10? Use the VIEW button to compare saved data.

The interference pattern produced by differently spaced slits in the ripple tank is analogous to the interference pattern produced by X-Rays for differently spaced atoms in a crystal. Now we will look at your X-Rays!

X-Ray Diffraction

In this practical, you will use X-Rays to identify an unknown sample of a crystal labelled A or B. **Follow these instructions:**

1. Put the small side of the X-Ray film into the holder. Make sure the slit on the film is facing away from the sample. You can check with the demonstrator to ensure this is correct.

2. Close the door of the machine.

   Old style: Turn the red dial to the left and pull. The door should now be locked. Press the 'HV-ON' button and then the 'START'/'STOP' button.

   New style: Close the door, press the lock button. The door should now be locked. Press the 'START' button.

3. It will take 15 minutes to fully expose the films. The demonstrator will then develop the film for you.

In the meantime, move over to the Ripple Tank.

EXTENSION ACTIVITIES:

1 – Change the distance between the slits by adding more or taking away metal segments from the centre of the diffractor. Get your partners to guess the how many blocks are between the slits.

2 – What happens when there are more than two slits? Can you explain this new pattern?