Demonstrator Setup Guide:

Equipment checklist

Ripple Tank:

Ripple generator (and mains plug with plane wave dipper)

Strobe light

Wave blocker

Black flexi-board

X-Ray Phywe Machine:

1-2mm aperture

Dental quick developing film

Holder for film

MATLAB:

Full installation (Minimum 2016b + Image Processing Toolbox + Curve Fitting Toolbox)

GUI Custom .m file (in folder)

Image Acquisition Toolbox Support Package for OS Generic Video Interface (infolder)

USB Webcam

Powerful PC (4 threads, 6GB Ram, SSD (Lab PC))

How to setup each of the experiments:

Ripple Tank

Place the tank onto a smooth, level surface and use the screw feet to level the tank (use a spirit level). Make sure the reflector and screen is attached under the tank. If the tanks have not been used in a while, clean the screen and any object used in the water. Cleaning may require stronger material than a paper towel.

Shut the drain hole. Add 1000 ml of water to the tank, press the foam beaches to allow them to soak some of the water.

To set up the ripple generator, attach the long flat bottomed plane wave dipper to the ripple generator. Place it on one of the sides ripple tank, at the same level as the ripple tank (figure (1) for example). Use the red dials on the generator for fine adjustment of its position. The water and the plane wave dipper should just be touching, water should have a meniscus to the dipper (figure (1) for example).

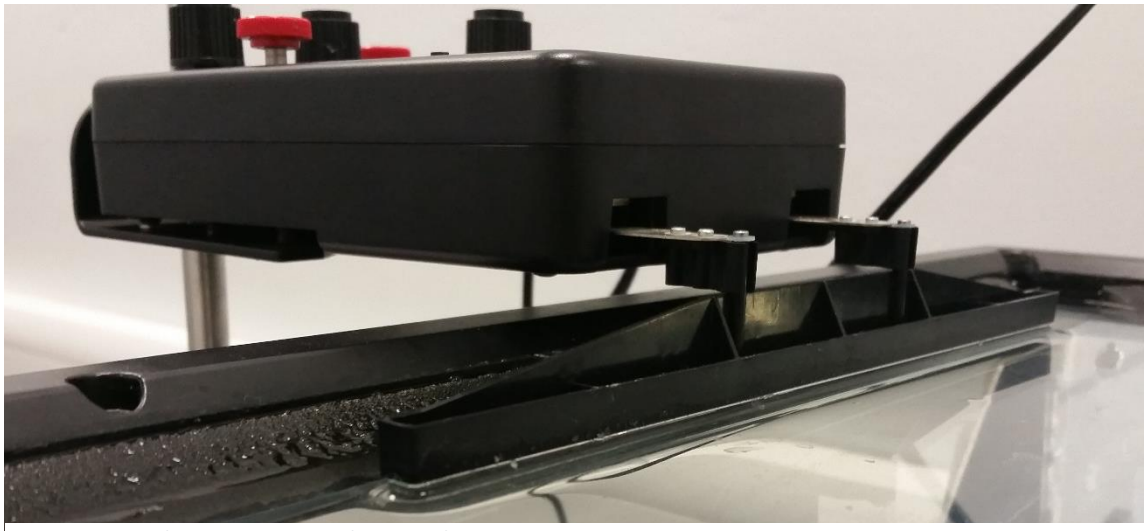


Figure 1: Water has a meniscus to the wave dipper.

Place the sliding apparatus close to the plane wave dipper. Ensure the apparatus is approximately 5cm from the dipper, parallel to it. Plug in the strobe light to the ripple generator and attach the light to the clamp stand attached to the tank approximately ¾ the way up.

To test

Turn on the ripple generator and set the lighting to strobe. Use the set the delta to -1. You should see waves traveling to the right side of the tank on the screen.

MATLAB

Start MATLAB, the version should be 2016b or above. The image processing toolbox and curve fitting toolbox is also required, to test for this, use this command:

```
license('test', 'image_toolbox')
license('test', 'Curve_Fitting_Toolbox')
```

If the ans = 1, the toolbox is installed. If the ans = 0, the toolbox is not installed, please install the image processing toolbox or the Curve fitting toolbox.

The ‘Image Acquisition Toolbox Support Package for OS Generic Video’ Interface must be installed, this can be done by searching for it using the add-on menu or using the file inside the folder of this document. Requires administrator privileges. Requires active MATLAB account to sign in to download and install.

The program is set to run if a webcam is plugged into the USB. Please disable any other cameras if the incorrect camera is displayed on the screen. (Use device manager in the control panel to switch off any other camera, if the incorrect camera is being displayed).

Set the camera up on a clamp stand (height in the middle of the screen) to be far enough away so the camera can only view between the top and bottom of the ripple tank screen. Place the black flexi-board behind the webcam, covering as much of the incoming light onto the screen as possible.

To test

Run the program. You should see the camera view on the top left.

X-Ray Phywe Machine

There are two versions of the X-Ray machine, the older (figure (2)) and the newer (figure (3)).

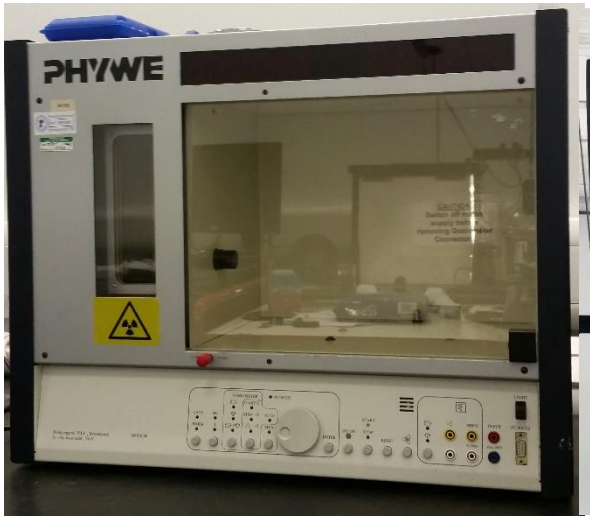


Figure 2

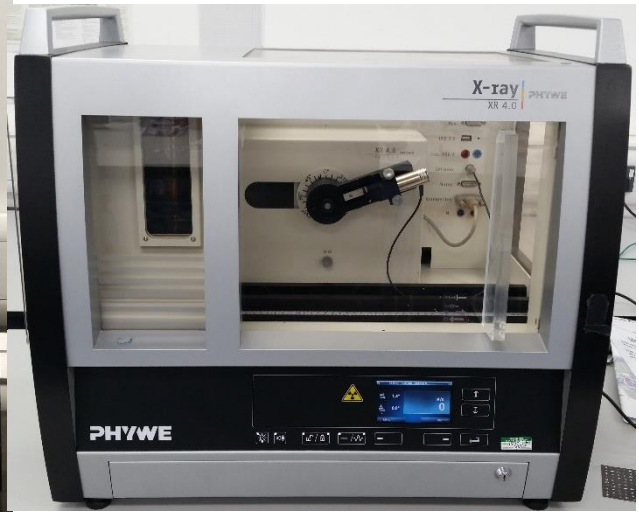


Figure 3

<u>To set up the newer version</u>:

The goniometer (angle measurer) should already be removed, if not **ensure the device is switched off and then remove it**.

Insert the aperture into the hole in the machine (1-2mm available).

To switch the machine on, ensure it is plugged in at the back, switch on the switch next to the plug.

Press 'Menu', then press 'Timer' and then 'Set Parameters'. Set a 15-minute timer (don't adjust the delay). Use the enter button enter this time. And set the timer to 'on'.

This should be setup. Every time you want to run the 15 minutes X-Ray, press 'Start'.

<u>To set up the older version</u>:

The goniometer (angle measurer) should already be removed, if not **ensure the device is switched off and then remove it**.

Insert the aperture into the hole in the machine (1-2mm available).

To switch the machine on, ensure it is plugged in at the back, switch on the switch next to the plug. This machine forgets set parameters after a power cycle, so every time it is switched off, this guide must be followed.

To interact with the machine, use the switches shown in figure (4). **After inputting every parameter, the enter button must be pressed**.

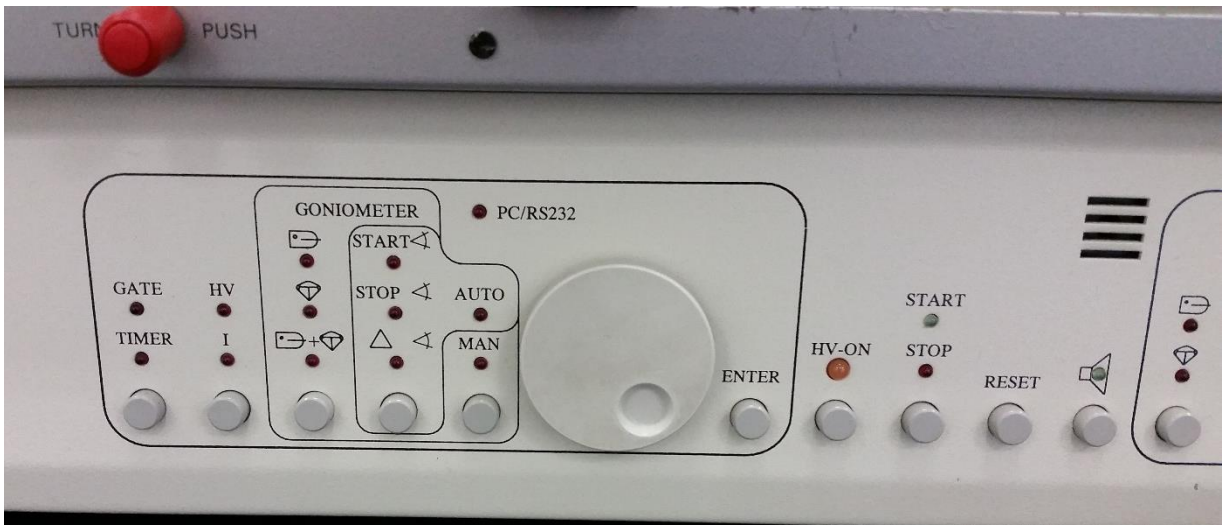


Figure (4): The controls for the old X-Ray machine. The top left red dial is the locking mechanism for the door when it is closed.

When first switching it on, the HV light should be illuminated. Turn the large dial until the voltage is set at 35.0kV. **Then press the enter button**.

Press the button under the HV and I lights, the I light should now be illuminated. Turn the large dial until the current is set at 1.00mA. **Then press the enter button**.

Press the button under ‘GATE’ and ‘TIMER’, until the timer light is illuminated. Turn the large dial until the time is set to be [TIME]. **Then press the enter button**.

To check this has been done correctly, press the buttons under the HV, I and TIMER lights, the corresponding parameters you set should still be there. If they are not, you didn’t press the enter button after setting the parameter.

Once this has been set up, close the door, using the locking mechanism to ensure the door is locked (it should be sticking out more when it is locked). To then switch on the X-Rays with the timer, press the ‘HV-ON’ button, then the button under ‘START’ and ‘STOP’, this starts the count down until the X-Rays turn off.

X-Ray Diffraction Experiment Demonstrator Instructions

Guide to the Experiment (~45 Minutes):

1. **Initial Talk** (~5 Minutes) – Give X-Ray film
2. **Student Practical** (~25 Minutes) – 15 Minutes into this, develop the film
3. **Final Talk** (~15 Minutes)
4. **TROUBLESHOOTING**

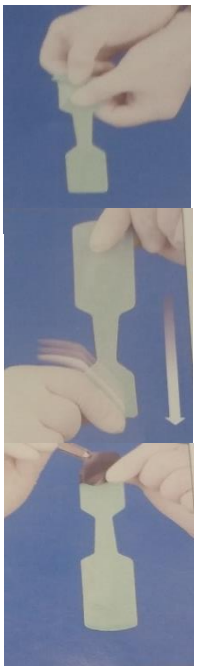
Initial Talk Points (Takes ~5 Mins)

- Use X-Ray images from the practical to discover what crystal the students have imaged.
- Use knowledge of diffraction and interference to understand how the X-Ray images are formed from the different arrangement of atoms in crystals.
- Using the Ripple Tank and a computer, see diffraction and interference.

GIVE 1 FILM TO EACH OF THE GROUPS – KEEP THE OTHER FILMS AWAY FROM THE MACHINE TO AVOID EXPOSING THEM.

ENSURE THAT THE TIMER IS GOING DOWN ON THE X-RAY MACHINE AND THE LIGHT IS ON IN THE GENERATOR SECTION.

How to develop the film (Wear gloves)



1- After exposure to X-Rays, hold the film container so that the smallest section is lower than the larger section. Roll the liquid pouch so that the pouch pops. Unroll the pouch.
2- Slide your fingers from the top to the bottom to start agitation. **You must agitate the liquid with the film for 50 seconds.**
3- Once 50 seconds has been completed, open the film package using the flap and pull out the film.
4- Wash the film under running water whilst running your fingers over the surface to clean off the developing residue. **Wash the film for 1 minute**. Then hang the film to dry.

Final Talk Points (~15 Mins before the end)

Use the 3D macroscopic crystals to inform throughout.

- When X-Rays are incident upon a crystal, the wave spreads out from each atom, much like a gap on the Ripple tank.
- When two or more waves interact with each other, they interfere and produce areas of high amplitude (constructive interference) and low amplitude (destructive interference). Seen on the Ripple tank.
- Picking a place to view the interference pattern we see the intensity waves. Some of the constructive interferences give a negative amplitude. On the ripple tank, that was the blue line on the computer. On the X-Rays, that's the X-Ray film.
- Why do we need X-Rays over larger wavelength waves? As with the Ripple tank, the gap for diffraction must be around the same size as the wavelength of the wave.
- X-Rays have a similarly sized wavelength (0.1-10nm) to the size of atoms (0.03-0.3nm) and the spacing between atoms (~0.2nm). This allows for diffraction of the X-Rays to occur and the pattern to form.
- A double slit setup in the Ripple tank is good at showing diffraction and interference, but using more gaps/slits would produce a better pattern. The crystal has more "gaps/slits", therefore, producing a clear image.

Look at the images that have been drying. They may require further drying with a paper towel. Discuss what their X-Ray films look like and what crystal it could be using the set supplied. Show the variations of crystal structures that are present in nature!

Troubleshooting

MATLAB

- No buttons working, or the program doesn't respond.

The m-file may have crashed. Run the m-file and calibrate the camera before recording data. (Turn the wave amplitude to zero, press calibrate with nothing in the way of the camera. Then continue as normal).

- The image is too dark to see

Use both contrast controls to adjust what can be seen. If that doesn't work, more light isolation may be required. Prevent light getting to the apparatus, close the blinds, switch of the lights. Try adding more water to the tank, only if still at the foam beaches level.

- Strange ghost shadows

When the calibrated and the background changes, this may occur. Or there are reflections from moving objects onto the surface of the Ripple screen. Recalibrate and add a blocking screen to prevent reflections on the Ripple screen. (Ripple screen = the one viewed by the camera).

Ripple Tank

- There are floating parts in the water

The tank should have been cleaned. Remove the large pieces, it may cause bright spots on the MATLAB program.

- Water leaking

Check the tank for damage. Close the tap at the back!!!

- Waves not moving forward, or moving too quickly

Put the light on strobe and turn the delta dial to -1.

X-Ray Machine

- The timer is not going down

Is the STOP light illuminated? If no, press the button below the STOP light.