

13.012 Hydrodynamics for Ocean Engineers

Prof. A.H. Techet

Fall 2003

Laboratory #1: Waves, phase speed, and group speed

This lab will demonstrate the difference in both deep and shallow water waves. The relationship between group and phase speed and wavelength and frequency will be explored. Data will also be compared to theory.

Deep water linear waves:

Linearity: $2A/\lambda < 1/7$

Deep water assurance: $(H/\lambda) < \pi$

Dispersion relationship: $\omega^2 = g k$

Phase Speed: $V_p = \omega/k$

Phase speed relationship: $V_g = \frac{1}{2} V_p$

Shallow water waves:

Linearity: $2A/\lambda < 1/7$

Deep water assurance: $(H/\lambda) < \pi/10$

Dispersion relationship: $\omega^2 = g k^2 H$

Phase Speed: $V_p = \sqrt{gH}$

Phase speed relationship: $V_g = V_p$

Items to do:

- 1) Measure the distances between the wave probes and wave paddle.**
- 2) Measure the depth of the water.**
- 3) Generate wave 6-8 different wave trains with varying frequency. The Lab TA will assist you in determining which settings to use. Record the data with the data acquisition system. Look at the data to assure that you have at least one shallow water wave train. The majority of your waves will be deep water waves. Data is saved in ASCII format.**

Attempt to measure wave amplitude and wavelength by eye as well.

- 4) Using your data choose two of the series to re-do and observe the particle orbits using black pepper. Choose a deep water wave train and a shallow water wave train. Sketch the orbits and include the information in your lab write-up.
- 5) Spend some time playing with the wave generator to create a deep water wave train where you can see the effects of group and phase speed. You should be able to see at the front wave train that the front-most wave crest disappears as the group of waves moves forward.
- 6) Look at the surface of the waves using glitter to observe how particles on the surface move.

For write up:

- 1) Use the data collected for each wave train to determine the frequency, wavelength and phase and group speeds of the waves. Discuss your results for each wave train in the context of linear wave theory. Does the data make sense? Does the ratio of V_p/V_g make sense? Comment on any discrepancies between theory and experiments.

When using the data to determine V_p and V_g use the largest wave crest at the front of the packet as a reference. There is some damping in the waves from the beginning to the end of the tank due to surface tension effects so you will probably see a slight decrease in amplitude.

- 2) For one deep water wave plot the time traces for the three wave probes to show the arrival time of the front of the wave trains.
- 3) Comment on your observations.
- 4) Discuss all data and any discrepancies you might see.