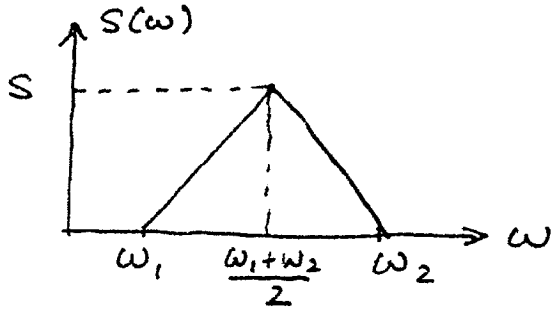
13.022

SURFACE WAVES AND THEIR INTERACTION WITH FLOATING BODIES

Problem Set # 6
Due Wednesday, November 22nd, 1999

1. You are conducting an experiment in a towing tank to model the seakeeping behaviour of a ship advancing at a constant forward speed U in head waves. In full scale the spectrum of unidirectional incident waves the ship encounters is given below:



Where all quantities correspond to full scale values and are measured relative to a reference frame fixed in space.

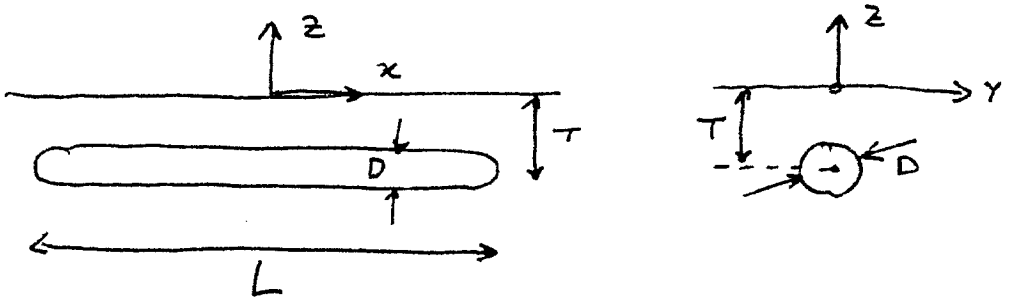
a) Define the shape of the spectrum you want to generate in the tank.
b) If the standard deviation of the heave acceleration at the bow in the experiment is α, what is the corresponding full scale value?
c) Repeat b) for the heave relative velocity at the bow.

2. While onboard a ship advancing in a long-crested seaway at an angle β and constant velocity U, you carry out a measurement of the wave elevation at the bow over a sufficiently long time interval.

Assume that the measured wave elevation is unaffected by the waves generated by the ship and that the measured spectrum is given by the function $S(\omega)$, where ω is the frequency of encounter. Determine the spectrum $S_0(\omega_0)$ you would measure if your wave probe was fixed in space.

3. An oil company considers the construction of a submarine supertanker of very large length designed to operate at a depth much smaller than its length. Preliminary studies indicate that even at small angles of pitch, one of its ends may pierce the free surface while the other may end up sufficiently submerged to cause structural collapse due to excessive hydrostatic pressure.

Assume that the hull of the tanker is symmetric fore and aft and is of uniform cross section of circular shape with diameter D, small compared to its length.



a) Deep water waves with length $\lambda >> D$ are incident upon the tanker. Determine the angle β between its axis and the wave direction for which the tanker will not undergo a pitch motion .

b) At the same operating condition, determine the amplitude and phase of the heave motion.

c) The structural analysis revealed that the first natural frequency of the **dry** hull flexural vibrations is Ω. Based on your knowledge that Ω is inversely proportional to the sectional mass distribution, determine the length of the ambient waves which excite resonance **in water**. Is your answer dependent on the wave direction?