

13.42 Design Principles for Ocean Vehicles
Homework #5

Out: Thursday, 4 March 2004
Due: Thursday, 11 March 2004

1. Consider the following spectrum of a unidirectional seastate in deep water.

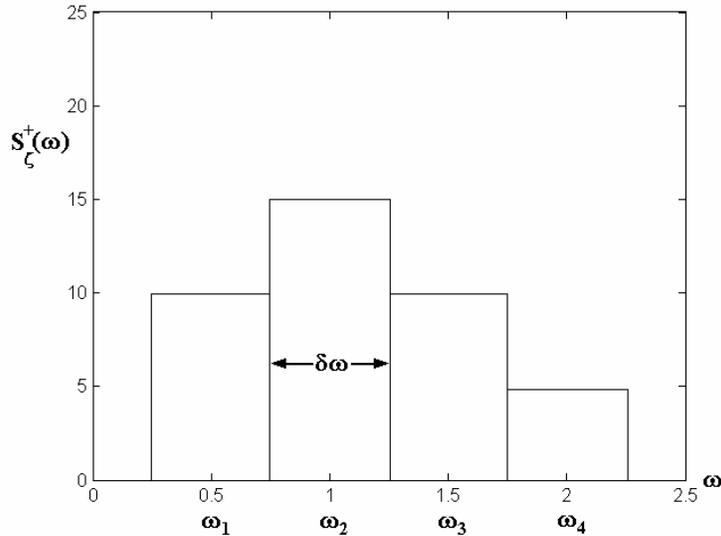


Figure 1

- Find the variance of the wave elevation.
- Find the average energy flux through a plane of constant x for the given seastate.
- Suppose a pressure probe is fixed 10 meters below the surface. Determine the variance of the linear hydrodynamic pressure signal recorded by the probe.
- Determine the average frequency of upcrossings of the plane $z = 3.5$ m (in upcrossings/second).
- Suppose a wave probe is moving with constant velocity $U = 2$ m/s in the direction of the ambient waves. Sketch the spectrum of the wave elevation recorded by the probe.

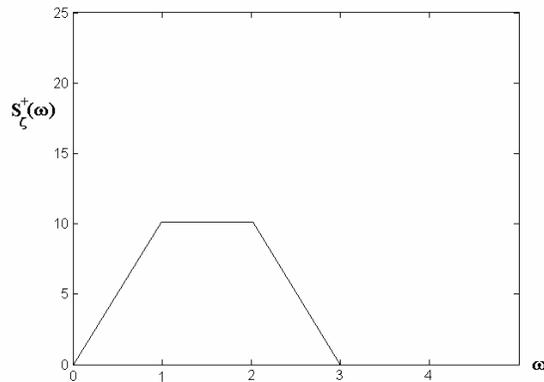
2. Consider the following linear system:

$$m\ddot{x} + c\dot{x} + kx = f(t)$$

where input $f(t) = \sum_{i=1}^N f_i \cos(\omega_i t + \phi_i)$ and ϕ_i is a uniformly distributed random variable. Assume that $f(t)$ is a Gaussian random process with $\mu_f = 0$.

- Given the spectrum of the input $S_f(\omega_i)$, $i = 1, \dots, N$, derive an expression for the variance of the response x , and its acceleration \ddot{x} .
- Find the mean of $|\dot{x}|^2$ and derive an expression for its variance.

3. Consider the following sea spectrum:



where

$$S_{\zeta}^{+}(\omega) = \begin{cases} 10\omega, & 0 \leq \omega < 1 \\ 10, & 1 \leq \omega < 2 \\ 30 - 10\omega, & 2 \leq \omega < 3 \\ 0, & \text{otherwise} \end{cases}$$

Determine the minimum deck clearance, h , required for an offshore platform such that the deck is flooded less than 20 times per hour. Assume that the presence of the platform has no effect upon the ambient waves.

4. Ocean Waves:

- a. Discuss the evolution of water waves generated when wind blows over the ocean surface from developing seas to decaying seas. What are the main physical mechanisms for wave production by wind? Think in terms of the boundary conditions at the air-sea interface and basic fluid mechanics.
- b. Sketch a typical spectrum for developing, fully-developed, and decaying ocean waves on one plot. Discuss briefly why the spectra differ in shape.
- c. Explain what significant wave height is and why it is so widely used to describe ocean waves and sea states.
- d. Why is the Bretschneider Spectrum so widely used? What are its limitations?