Lecture #1: Background

READINGS AND FIGURES

Readings: Frisk, Chapter 1, sections 1.3 and 1.4; Chapter 2, sections 2.1, 2.2, 2.3, 2.4.

Figures used: COA, Figures 1.1, 1.2, 1.3, 1.5

DESCRIPTION OF NOTES

The first two pages of the notes are my own answers to two important questions about any scientific/engineering topic: 1) why bother and 2) what's new? Though ocean acoustics is now a rather mature field, there are still many new applications and science questions, as shown in these pages.

The next pages are from Frisk, Sections 1.3 and 1.4.

In Section 1.3, Frisk shows the basic time dependent wave equation (Eq. 11), the stratified medium wave equation (Eq. 12), and the reduced wave equation or Helmholtz equation (Eq. 13). These fluid medium equations are the basic ones for underwater acoustics. (The fluid assumption is generally a good one. The only big exceptions are sea ice and hard rock sea bottoms, such as in fjords). The simple messages from these equations are: 1) the basic equation for acoustics is a simple, second order, linear partial differential equation, 2) the ocean and seabed are stratified to first order, so that one can often work with constant density layers, and 3) one can Fourier decompose the wave equation, and work with one frequency at a time via the Helmholtz equation. This makes computations simpler, and then one can simply add the fields at each frequency to create a broadband field at the end.

In section 1.4, Frisk shows the equivalence of the Helmholtz equation and the time independent Schoedinger equation, something that one might think to be of only academic interest at first, but which is actually quite important. This equivalence lets one use the large array of analysis techniques that have been developed in the context of quantum mechanics, such as WKB theory, mode theory, scattering theory, and so on. The analogies to quantum mechanical systems are very close in many ways, and many researchers have exploited this.

The next few pages are my own descriptions of the first few figures from COA (Figs 1.1, 1.2, 1.3, 1.5. The message in all these figures is that, to quote the old Marshall McLuhan phrase, "the medium is the message." The complexity of the ocean and seabed medium, and also the general lack of detailed information we have about details down to the fine level needed for "exact" acoustics calculations, is really the main thing that keeps ocean and seabed acoustics interesting. The physical oceanography, the geology, and the biology of the ocean all affect acoustics, and a large amount of effort is spent in either: 1) obtaining adequate knowledge of the ocean to input into the wave equation for forward problems, or 2) figuring out what the ocean and seabed are from acoustic (and other) data using inverse methods. A take-away message here is that if one wants to seriously pursue ocean acoustics, knowledge of the oceanography, biology, and geology of the ocean is needed, and not just a frill.

The last part of lecture #1 is a quick ride through Chapter 2 of Frisk, in which he shows basic solutions for the 1D, 2D, and 3D wave equations, in rather general form. Sections 2.1 – 2.3 are very basic reviews of the 1D and 3D wave equations and their solutions (linear and spherical waves, and should be purely a review of old results at this level. The 2D wave equation result, curiously, is the most interesting insofar as this course is concerned. That is because the 3D wave equation collapses to a 2D wave equation when the ocean is stratified, and thus cylindrically symmetric. The 2D wave equation in cylindrical coordinates is actually one that has the most immediate uses in ocean acoustics. Section 2.4 discusses the radial part of the 2D solution in cylindrical coordinates, which just turns out to be the familiar Bessel's equation. The exact and asymptotic forms of the solution are shown, and a little emphasis made that the spreading law is cylindrical (intensity falls as R, not R^2).