The University of British Columbia

BIOL/PHYS 438 Assignment # 6:

ACOUSTICS

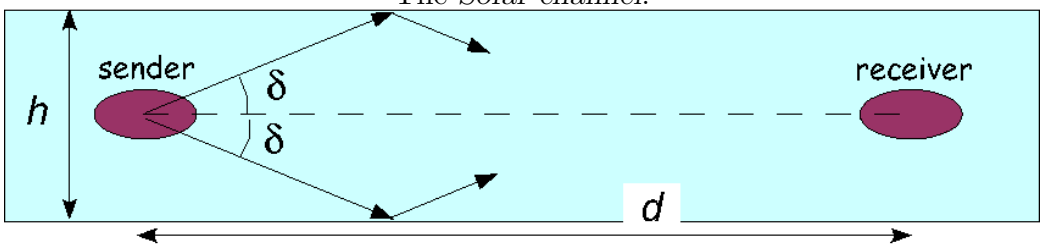
Thu. 15 Mar. 2007 — finish by **Thu. 29 Mar.**

1. SHARK ATTACK: A diver makes a deep dive wearing a facemask that covers eyes, nose and mouth. At 35 m depth he suddenly notices a shark cruising towards him; he lets out a short shriek at the top of his voice with an intensity of 95 dB. What is the intensity of his voice transmitted into in the water just outside his face mask? (Neglect the acoustic impedance of the lens of his face mask; just consider the transition of sound from the air to the water).[1]

2. LONG DISTANCE TALK OF WHALES:

(*a*) Determine the critical angle of total internal reflection for sound waves in the Sofar channel. What is the beam angle 2δ (critical angle of TIR) into which an animal should emit its voice in order to match the *Sofar channel* sound wave guide?

The *Sofar channel*.



(*b*) Suppose a whale in the *Sofar channel* talks to a friend 2000 km away. The animal emits a sound signal of power $P = 1.2$ W and frequency $f = 10$ Hz into a conical beam with the half angle δ calculated above. What is the *intensity* of this sound wave at a distance $d = 2000$ km? Express your result as a sound level β [in dB] using $I_{\text{ref}} = 10^{-12}$ W/m^2. With reference to Fig. **7.16** on p. 254 of the textbook, assume $h = 800$ m. Consider both the spreading of the wave with distance and the attenuation due to absorption.

(*c*) Determine the displacement amplitude s_0 and the pressure amplitude Δp_0 of the sound signal at the distance $d = 2000$ km.

(*d*) How long does it take for the message to travel from the sender to the receiver?

[1] *Hint:* you must first find the pressure and density at that depth. Look at sections **9.2**, **9.2.1** and **9.2.9** in the textbook.

3. VOICES:

(*a*) Assume that elephants and mice roar like organ pipes, closed at one end. What is the lowest frequency of their voices? (*Hint:* You must guess or find from physiology texts the length of their "trumpets".)

(*b*) Bass singers produce sounds somewhat like Helmholtz resonators, where the lips and mouth from a pipe shaped opening of area A (a few cm^2) and length L in which a plug of air resonates, driven by the flow of air from the lungs. Suppose a certain singer has a lung volume $V = 7.5$ liters and he opens his mouth to $A = 1.5$ cm^2. To what length L does he have to shape his "mouth pipe" in order to produce the frequency $f = 65$ Hz, and what tone is that?[2]

(*c*) When frogs croak they blow up a part of their skin above an air sack. Approximate the skin (typically $A = 10^{-4}$ m^2, $m = 10^{-5}$ kg) as a piston driven by an air spring in a cylinder, and determine what sound frequency this device would produce. Compare this frequency to the frog data in Fig. **9.28** on p. 346 of the textbook, and comment.

(*d*) Name three animals *other than* mammals, frogs or birds that produce sounds; at least one of these should be under water, and at least one on land.[3]

[2]The tone sf A has the frequency $f_{\mathsf{A}} = 440$ Hz. One octave corresponds to a factor of 2 in frequency. Each of the 12 semitones within one octave differs from its neighbor by the frequency ratio $2^{1/12}$. For instance, $f_{\mathsf{F}}/f_{\mathsf{E}} = 2^{1/12}$ and $f_{\mathsf{A}}/f_{\mathsf{G}} = 2^{2/12}$.

[3]Actually this question could lead to a nice project: *How* do they make the sound (PHYSICS), and *why* do they do it (ZOOLOGY)?