Sonar Equation Problem Set #1

Note: Assume sound speed in water is 1500 ms^{-1}.

1) Convert the following levels into decibel units:

a) 10 V = ________**20**___ dB_V

b) 0.1 V = _______ **-20**__ dB_V

c) 3 x 10^{-5} μPa =________**-90.5**_ dB || μPa

d) 400 watts = ________ **26** __ dB || watt

e) 0.2 watts/m^2 = _______**-7**___ dB || watt m^{-2}

2) Convert the following levels in dB into the appropriate linear units:

a) 218 dB || μPa = ____**7.94 x 10^{10}**___ μPa

b) -12 dB_v = ____**0.25**_________ V

c) 10 dB_v = _____**3.16** _______ V

d) 40 dB || watt = ____**10,000**_______ watts

3) Estimate the length in meters of a transmitted sound pulse traveling through the water column at pulse durations (or pulse lengths) of 3 ms, 1 ms, and 0.1 ms.

3ms = 4.5 meters 1 ms = 1.5 meters 0.1 ms = 0.15 meters ($c\tau$)

4) What is the wavelength in centimeters corresponding to a sound frequency of 38 kHz, 120 kHz, 200 kHz, and 420 Khz?

$\lambda = c/f$ = 1500/38,000 x100cm/m = 3.95 cm

120 kHz = 1.25 cm 200 kHz = 0.75 cm 420 kHz = 0.357 cm

5) Calculate the number of cycles in each transmission, given the following pulse durations and frequencies.

	Frequency (f)		
Pulse Duration	**38 kHz**	**70 kHz**	**200 kHz**
5 ms	**190**	**350**	**1000**
1 ms	**38**	**70**	**200**
0.2 ms	**7.6**	**14**	**40**

Complete number of cycles/transmission in each cell

6) For the three transmitted pulse durations (5, 1 and 0.2 milliseconds) given in Problem #4, estimate the minimum range in meters between two targets that would allow them to be resolved.

$r = c\tau/2 = (1500 * 0.005)/2 = 3.75$ m, 1 ms = 0.75 m and 0.2 ms = 0.15 m

7) Given a requirement to resolve targets which are 30 or more cm apart, what is the maximum pulse duration in milliseconds that can be used?

Same formula as #6, solve for τ. $0.3 = (1500 * d)/2$ $\therefore$ 4E-04 sec, or 0.4 ms

8) An echo sounder receives the echo return from the sea bed exactly 0.5 sec after transmission. What is the bottom depth?

Travel time = $r/c+r/c = 2r/c$ $2r/1500 = 0.5$ $r = (0.5*1500)/2 = 375$ m

9) Given that we must allow sufficient time for a transmitted echo to return to the transducer before "pinging" again, what is the maximum transmission rate (in pings s^{-1}) at 60 meters depth?

Max Ping Rate = $c/2r = 1500/(2*60) = 12.5$ pps

10) Based on the nominal transducer beamwidths listed below, calculate the beam diameter (units meters) and the cross-sectional area (units m^2) at each depth (i.e. the "footprint" of the beam).

Nominal Beam Angle	Depth (m)	Beam Diameter (m)	Beam Cross-sectional Area (m^2)
3 degrees	10	0.524	0.216
	50	2.620	5.393
	100	5.241	21.572
	200	10.482	86.286

Nominal Beam Angle	Depth (m)	Beam Diameter (m)	Beam Cross-sectional Area (m^2)
6 degrees	10	1.051	0.868
	50	5.255	21.691
	100	10.510	86.762
	200	21.021	347.049

Nominal Beam Angle	Depth (m)	Beam Diameter (m)	Beam Cross-sectional Area (m^2)
15 degrees	10	2.679	5.639
	50	13.397	140.973
	100	26.795	563.891
	200	53.590	2255.562

11) What is the reduction in the acoustic level of a transmitted signal on the acoustic axis (units decibels) at 100, 200 and 300 m from the transducer?

a) Assuming no other sources of acoustic signal loss other than spreading.

TL = 20log(r)   20log(100)= 40 dB, 200 m = 46 dB, 300 m = 49.54 dB

b) Assuming an absorption coefficient of 0.1 dB m^{-1}, in addition to the spreading losses.

TL = 20log(r) + αr   20log(100) + (0.1*100)= 50 dB, 200 m = 66.02 dB, 300 m = 79.54 dB