Homework 1 Solutions

Problem 1:

The speed of sound in air is about 343m/sec. The wavelength of a high C is therefore
$\lambda = \frac{343\text{m}}{1046.502\text{Hz sec}} \approx 0.33\text{m}.$

The speed of sound in water is about 1500 m/sec. This gives
$\lambda = \frac{1500\text{ m}}{1046.502\text{ Hz sec}} = 1.43\text{ m}.$

The speed of sound in steel depends on the type of steel and is about 5900 m/sec. This gives
$\lambda = \frac{5900\text{m}}{1046.502\text{ Hz sec}} = 5.64\text{ m}.$

Problem 2:

The attenuation over 200 m is 200×0.072 db $= 14.40$ db . To calculate the signal strength, we solve $-14.40 = 10\log_{10}(\frac{P}{1\text{mW}})$. This gives $-1.440 = \log_{10}(\frac{P}{1\text{mW}})$. By using exponentiation with base 10, we get $0.036 = 10^{-1.44} = \frac{P}{1\text{ mW}}$ or $P = 0.0363$ mW. Thus, the resulting power is 36.3 μW.

Problem 3:

The Shannon capacity formula for the desired SNR ρ is

$$2000 \times \log_2(\rho + 1) > 50000.$$

Thus,

$$\log_2(\rho + 1) > 25$$

or

$$\rho > 2^{25} - 1 = 33{,}554{,}431.$$

This is a fantastically large SNR that is not obtainable in practice.

Problem 4:

A geostationary satellite is about 35,800 km from the surface of the earth, so that the signal has to travel at least twice this ($71600 = 7.16 \times 10^7$m). At the speed of light and disregarding processing at the satellite, a single message between base stations has a propagation delay of

$$\frac{7.16 \times 10^7\text{ m}}{2.99792458 \times 10^8\text{ m/sec}} = 0.238832\text{sec}.$$

To send one 1KB datagram, it takes 10×10^{-9} second per bit or

$$1000 \times 8 \times 10 \times 10^{-9} \text{ sec} = 8 \times 10^{-5} \text{ sec.}$$

We can neglect this quantity. The time between sending one datagram and the next is two round trips (one for the data, one for the acknowledgment) or 0.477664 sec. To find the average number X of bits we can send over in a second, we get

$$\frac{X}{1\text{sec}} = \frac{1 \text{ KB}}{0.477664 \text{ sec}}$$

which resolves to 16748.2 bits per second. The real number is slightly less.

Problem 5:

RFC 1149 was released on April Fool's day 1990 and describes IP using carrier pigeons or similar birds. It never became an official internet standard.