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Chapter 1 problems 1.1-1.32

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1) Calculate the free space wavelength in meter for the following frequencies:
    a) 2kHz
    b) 200kHz
    c) 20 MHz
    d) 2 GHz

a) $\lambda = \frac{C}{f} = \frac{3X10^8}{2X10^3} = 150 \text{ km}$

b) $\lambda = \frac{C}{f} = \frac{3X10^8}{200X10^3} = 1.5 \text{ km}$

c) $\lambda = \frac{C}{f} = \frac{3X10^8}{20X10^6} = 15 \text{ m}$

d) $\lambda = \frac{C}{f} = \frac{3X10^8}{2X10^9} = 15 \text{ cm}$

2) Calculate the free space wavelength in meter for the following frequencies:
    a) 80 kHz
    b) 8 MHz
    c) 800 MHz
    d) 8 GHz

a) $\lambda = \frac{C}{f} = \frac{3X10^8}{80X10^3} = 3750 \text{ m}$

b) $\lambda = \frac{C}{f} = \frac{3X10^8}{8X10^6} = 37.5 \text{ m}$

c) $\lambda = \frac{C}{f} = \frac{3X10^8}{800X10^6} = 0.375 \text{ m}$

d) $\lambda = \frac{C}{f} = \frac{3X10^8}{8X10^9} = 3.75 \text{ cm}$

3) Calculate the free space wavelength in miles for the frequency of 400 Hz.

$$\lambda = \frac{C}{f} = \frac{3X10^8}{400} = 750 \text{ Km} = (750 \text{ km})\left(\frac{1 \text{ mile}}{1.609 \text{ km}}\right) = 466 \text{ miles}$$

4) Calculate the free space wavelength in miles for the frequency of 1.5 kHz.

$$\lambda = \frac{C}{f} = \frac{3X10^8}{1.5X10^3} = 200 \text{ Km} = (200 \text{ km})\left(\frac{1 \text{ mile}}{1.609 \text{ km}}\right) = 124 \text{ miles}$$

5) A sinusoidal signal has a free-space wavelength of 80 m. calculate the frequency.

$$f = \frac{C}{\lambda} = \frac{3X10^8}{80} = 3.75 \text{ MHz}$$

6) A sinusoidal signal has a free-space wavelength of 6 m. calculate the frequency.

$$f = \frac{C}{\lambda} = \frac{3X10^8}{80} = 50 \text{ MHz}$$

7) A digital signal utilizes pulses whose minimum widths are about 3 ns. Assuming the speed of light, determine the longest lengths of wire-pair that can be allowed based on the 10% rule.

$$t_1 = (0.1)(3ns) = 0.3ns$$

$$d = ct_1 = (3X10^8)(0.3X10^{-9}) = 9 \text{ cm}$$

8) The longest connecting wires in a digital system are about 20 cm. assuming the speed of light, determine the shortest acceptable pulse width based on the 10% rule.

$$d = ct_1 \longrightarrow \; t_1 = \frac{d}{c} = \frac{20X10^{-2}}{3X10^8} = 0.67 \text{ ns}$$

$$\text{Width} = \frac{0.67X10^{-9}}{0.1} = 6.7 \text{ ns}$$

9) A communication system operates a frequency of 800 MHz. Assuming the speed of light, determine the length of connecting line that could be used without considering frequency-domain effects based on the 10% rule.

$$\lambda = \frac{C}{f} = \frac{3X10^8}{800X10^6} = 0.375 \text{ m}$$

$$d = (0.1)(0.373) = 3.75 \text{ cm}$$

10) The length of a connecting cable between two points in a radio frequency system is 50 cm. Assuming the speed of light, determine the high operating frequency that should be used without considering frequency domain effects based on the 10% rule.

$$\lambda = \frac{d}{0.1} = \frac{50X10^{-2}}{0.1} = 5 \text{ m}$$

$$f = \frac{c}{\lambda} = \frac{3X10^8}{5} = 60 \text{ MHz}$$

11) In a coil, a current of 100 mA results in magnetic flux of 50 μWb. Determine the inductance.

$$\text{Inductance} = \frac{\text{flux}}{\text{current}} = \frac{50\ \mu\text{Wb}}{100\ \text{mA}} = 500\ \mu\text{H}$$

12) A current of 4 mA is flowing in a 20 μH coil. Determine the magnetic flux.

$$\text{Inductance} = \frac{\text{flux}}{\text{current}}$$

$$\longrightarrow \text{flux} = (\text{current})(\text{Inductance}) = (4\text{X}10^{-3}\text{A})(20\text{X}10^{-6}\text{H}) = 80\ \text{nWb}$$

13) In a capacitor, a voltage of 20V result in charge storage of 5 μC. Determine the capacitance.

$$\text{C} = \frac{\text{Charge}}{\text{voltage}} = \frac{5\text{X}10^{-6}\text{c}}{20\ \text{V}} = 0.25\ \mu\text{F}$$

14) A capacitance of 40 μF is charged to a voltage of 12 V. Determine the electric charge.

$$\text{C} = \frac{\text{Charge}}{\text{voltage}} \longrightarrow \text{charge} = (\text{Capacitance})(\text{voltage}) = (40\text{X}10^{-6})(12\ \text{V}) = 0.48\text{mC}$$

15) A lossless transmission line has an inductance of 320 nH/m and a capacitance of 57 pF/m. Determine the characteristic impedance.

$$\text{R}_\text{o} = \sqrt{\frac{\text{L}}{\text{C}}} = \sqrt{\frac{320\text{X}10^{-9}\ \text{H/m}}{57\text{X}10^{-12}\ \text{F/m}}} = 74.93\Omega$$

16) A lossless transmission line has an inductance of 1.2 μH/m and a capacitance of 15 pF/m. determine the characteristic impedance.

$$\text{R}_\text{o} = \sqrt{\frac{\text{L}}{\text{C}}} = \sqrt{\frac{1.2\text{X}10^{-6}\ \text{H/m}}{15\text{X}10^{-12}\ \text{F/m}}} = 282.8\Omega$$

17) The dielectric constant of mica is 6. Determine the permittivity.

$$\in = \in_\text{r} \in_\text{o} = (6)(8.84\text{X}10^{-12}\ \text{F/m}) = 5.3\text{X}10^{-11}\ \text{F/m}$$

18) The permittivity of a material is $14\text{X}10^{-12}$ F/m. Determine the dielectric constant.

$$\in = \in_\text{r} \in_\text{o} \longrightarrow \in_\text{r} = \frac{\in}{\in_\text{o}} = \frac{14\text{X}10^{-12}\ \text{F/m}}{8.84\text{X}10^{-12}\ \text{F/m}} = 1.6$$

19) The permeability of nickel is 800. Determine the actual permeability.

$$\mu = \mu_\text{r}\mu_0 = (800)(4\pi\text{X}10^{-7}\ \text{H/m}) = 1\text{X}10^{-3}\ \text{F/m}$$

20) The permeability of a ferromagnetic material is 10^{-4} H/m. Determine the relative permeability.

$$\mu_r = \frac{\mu}{\mu_0} = \frac{10^{-4}\ \mathrm{H/m}}{4\pi X10^{-7}\ \mathrm{H/m}} = 79.5$$

21) Determine the velocity of propagation of the transmission line of problem 15.

$$v = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(320X10^{-9}\ \mathrm{H/m})(57X10^{-12}\ \mathrm{F/m})}} = 2.34X10^{8}\ \mathrm{m/s}$$

22) Determine the velocity of propagation of the transmission line of problem 16.

$$v = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(1.2X10^{-6}\ \mathrm{H/m})(15X10^{-12}\ \mathrm{F/m})}} = 2.36X10^{8}\ \mathrm{m/s}$$

23) The dielectric constant in a transmission line is 4.7 and $\mu=\mu_o$. Determine the velocity of propagation.

$$v = \frac{c}{\sqrt{\epsilon_r}} = \frac{3X10^{8}}{\sqrt{(4.7)}} = 1.38X10^{8}\ \mathrm{m/s}$$

24) The dielectric constant in a certain transmission line is 3 and $\mu=\mu_o$. Determine the velocity of propagation.

$$v = \frac{c}{\sqrt{\epsilon_r}} = \frac{3X10^{8}}{\sqrt{(3)}} = 1.73X10^{8}\ \mathrm{m/s}$$

25) A coaxial cable has the following specification: $R_o = 73\ \Omega$, and velocity of propagation = $2.1X10^8$ m/s. Determine L and C.

$$L = \frac{R_o}{v} = \frac{73}{2.1X10^{8}} = 347.6\ \mathrm{nH}$$

$$C = \frac{1}{R_o v} = \frac{1}{(73)(2.1X10^{8})} = 65.2\ \mathrm{pF}$$

26) A transmission line has the following specification: $R_o = 150\ \Omega$, and velocity factor of 0.8. Determine L and C.

$$L = \frac{R_o}{0.8c} = \frac{150}{0.8(3X10^{8})} = 0.625\ \mu\mathrm{H}$$

$$C = \frac{1}{0.8cR_o} = \frac{1}{(0.8)(3X10^{8})(150)} = 27.78\ \mathrm{pF}$$

27) The lower end of a commercial AM band is about 550 KHz. AM station use "quarter wave" vertical antenna whose length are 0.25λ. Determine the length in meters of a vertical antenna operating at the lower end.

$$0.25\lambda = 0.25\frac{C}{f} = 0.25\frac{3X10^8}{550X10^3} = 1.36 \text{ m}$$

28) The upper end of a commercial AM band referred to problem 27 is about 1610 KHz. Determine the length in meters of a vertical antenna operating at the upper end.

$$0.25\lambda = 0.25\frac{C}{f} = 0.25\frac{3X10^8}{1610X10^3} = 46.6 \text{ m}$$

29) One popular single antenna is the "half wave" horizontal antenna whose theoretical length is 0.5λ at the operating frequency. In practice, however, the antenna is usually shortened by about 5% due to the end effect. Determine the practical length in meters for a half wave antenna to provide optimum reception at the lower end of the commercial FM band, which is about 88 MHz.

$$0.5\lambda = 0.5\frac{C}{f} = 0.5\frac{3X10^8}{88X10^6} = 1.7 \text{ m}$$

$$\text{Pactical length} = 1.7(1 - 0.05) = 1.619 \text{ m}$$

30) Based on the discussion of problem 29, determine the practical length in meters for a half wave antenna to provide optimum reception at the upper end of the FM band, which is 108 MHz.

$$0.5\lambda = 0.5\frac{C}{f} = 0.5\frac{3X10^8}{108X10^6} = 1.39 \text{ m}$$

$$\text{Pactical length} = 1.39(1 - 0.05) = 1.319 \text{ m}$$

31) Show that the free space velocity of light in feet/second is very closed to $982X10^6$ ft/s.

$$c = 3X10^8\ {}^{m}/_{s} = (3X10^8\ {}^{m}/_{s})\left(3.28\ {}^{ft}/_{m}\right) = 984X10^6\ {}^{ft}/_{s}$$

32) Show that the free space wavelength in feet can be expressed as $\lambda(\text{ft}) = \frac{982}{f(\text{MHz})}$.

$$\lambda = \frac{c({}^{m}/_{s})}{f(\text{Hz})} = \frac{(3X10^8\ {}^{m}/_{s})(3.28\ {}^{ft}/_{m})}{f(\text{Hz})} = \frac{984X10^6\ {}^{ft}/_{s}}{f(\text{Hz})} = \frac{984}{f(\text{MHz})}$$