4+4+4+6+8 = ~~28~~ 26 points

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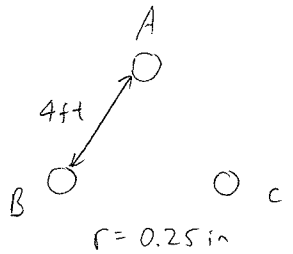
ECE 476
HW 4
Fall '2012

Problem 1:

4 points

2 points per answer



-0.5 points are taken of if units given do not match.
Ie., ask for H/m, answer is in H/km

By symmetry, $L_A = L_B = L_C$

$$L_A = \frac{\mu_0}{2\pi}\ln\left(\frac{D}{r'}\right)$$

$$= \frac{\mu_0}{2\pi}\ln\left(\frac{4\times 12}{\frac{1}{4}e^{-1/4}}\right)$$

$$= 2\times10^{-7}\ln(192e^{1/4})$$

$$= \boxed{1.101\times10^{-6}\ \text{H/m}}$$

$$X_L = \omega L_A = 2\pi(60)(1.101\times10^{-6})(1000) = \boxed{0.415\ \Omega/\text{km}}$$

Problem 2:

~~8 points~~

4 points

$$C = \frac{2\pi\varepsilon}{\ln\left(\frac{D}{r}\right)} = \frac{2\pi\varepsilon}{\ln\left(\frac{4\times12}{0.25}\right)} = \boxed{1.058\times10^{-11}\ \text{F/m}}$$

$$Z = \frac{1}{j\omega C} = \frac{1}{j2\pi60C} = \frac{1}{j3.988\times10^{-9}}\ \Omega/\text{m}$$

$$Y = \frac{1}{Z} = \boxed{j3.988\times10^{-6}\ \text{S/km}}$$

Problem 3:

4 points

a) $D = 4.8\,ft = 57.6\,in$

$$C = \frac{2\pi\varepsilon}{\ln\left(\frac{57.6}{0.25}\right)} = \boxed{1.0226 \times 10^{-11}\ F/m}$$

$$Y = j\omega C = \boxed{j\,3.855 \times 10^{-6}\ S/km}$$

b) $D = 3.2\,ft = 38.4\,in$

$$C = \frac{2\pi\varepsilon}{\ln\left(\frac{38.4}{0.25}\right)} = \boxed{1.105 \times 10^{-11}\ F/m}$$

$$Y = j\omega C = \boxed{j\,4.166 \times 10^{-6}\ S/km}$$

Increase D by 20%, C and Y decrease by 3.3%

Decrease D by 20%, C and Y increase by 4.4%

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Problem 4

6 points

a) $Z_c = \sqrt{z/y} = \sqrt{\frac{0.03+j0.35}{j4.4\times10^{-6}}} = 282.29 - 12.076j\ \Omega$

1 point

$= \boxed{282 \angle -2.45°\ \Omega}$

↳ -0.043 rad

b) $\gamma = \sqrt{zy} = \sqrt{(0.03+j0.35)(j4.4\times10^{-6})} = 5.313\times10^{-5} + 0.00124j\ \ km^{-1}$

1 point

$\gamma l = 500 \cdot \gamma = \boxed{0.0266 + j0.621} = 0.6216 \angle 87.55°$

↳ 1.528 rad

↑ km ↑ already in km^{-1}

c) This is a "long" line.

4 points

$A = D = \cosh(\gamma l) = \frac{e^{\gamma l} + e^{-\gamma l}}{2} = \frac{e^{0.0266}\, e^{j0.621} + e^{-0.0266}\, e^{-j0.621}}{2}$

$= \boxed{0.8136 + j0.0155}$

$B = Z_c \sinh(\gamma l) = (282 \angle -2.45°)\left(\frac{e^{\gamma l} - e^{-\gamma l}}{2}\right) = \boxed{13.02 + j164\ \Omega}$

$C = \left(\frac{1}{Z_c}\right)\sinh(\gamma l) = -1.29\times10^{-5} + j0.00206\ S = \boxed{0.00206 \angle 90.36°\ S}$

↳ 1.68 rad

See Table 5.1 in Book. This will be useful

Problem 5

8 points

a) $Z_c = \sqrt{z/y} = \sqrt{\frac{j0.34}{j4.5\times10^{-6}}} = \boxed{274.87\ \Omega}$ — 1 point

b) $\gamma l = \sqrt{zy}\, l = \sqrt{j0.34 \times j4.5\times10^{-6}} \cdot 320 = \boxed{j0.396}$ — 1 point

c) This is a lossless line

4 points $\beta = Im(\gamma) \Rightarrow \beta l = Im(\gamma l) = 0.396$

$A = D = \cos(\beta l) = \cos(0.396) = \boxed{0.923}$

$B = j Z_c \sin(\beta l) = j(274.87)\sin(0.396) = \boxed{j106.02\ \Omega}$

$C = \frac{j\sin(\beta l)}{Z_c} = \frac{B}{Z_c^2} = \frac{j106.02}{274.87^2} = \boxed{j0.0014\ 5}$

d) $\gamma = j0.00123$ from part b)

1 point $\beta = Im(\gamma) = 0.00123$ Note: β can also be computed from 5.4.5

$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{1.23\times10^{-3}} = \boxed{5.108\ km}$ formula 5.4.15

e) $SIL = \frac{V_{rated}^2}{Z_c}$ formula 5.4.21 from book — 1 point

$= \frac{(500\times10^3)^2}{274.87}$

$= 9.095\times10^8\ W$

$= \boxed{909.5\ MW}$ 3ϕ