Assignment #2

P2.1

Assuming that the dielectric material is non-magnetic we find that the phase velocity is

$$v_p = \lambda f = \frac{c}{\sqrt{\varepsilon_r}}$$

From the above, the effective relative permittivity is

$$\varepsilon_r = \left(\frac{c}{\lambda f}\right)^2 = \left(\frac{3\times 10^8}{0.1\times 10^9}\right) = 9$$

P2.3

To solve this problem we use superposition principles which state that the total field produced by the two conductors will be the sum of the fields produced by the individual conductors. If we denote the distance between the centers of the conductors as $D = 2d$, then the field due to the left conductor located at $x = -d$ is:

$$H_1(r) = \begin{cases} \dfrac{I(r+d)}{2\pi a^2} & for\ -a \le (r+d) \le a \\ \dfrac{I}{2\pi(r+d)} & for\ (r+d) < -a\ or\ (r+d) > a \end{cases}$$

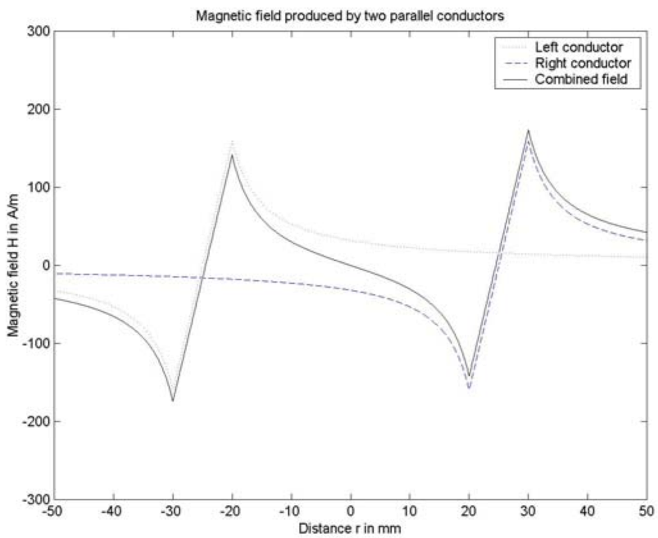
The field produced by the conductor at $x = d$ is

$$H_2(r) = \begin{cases} \dfrac{I(r-d)}{2\pi a^2} & for\ -a \le (r+d) \le a \\ \dfrac{I}{2\pi(r+d)} & for\ (r-d) < -a\ or\ (r-d) > a \end{cases}$$

The total field is simply the sum of $H_1(r)$ and $H_2(r)$ and is computed using the following Matlab code:

```
% Problem p2_3.m
II=5; % current in the conductors
a=5e-3; % radius of the wire
D=8*a+2*a; % distance betwen the centers of the conductors
d=D/2;

r=-10*a:a/100:10*a;

H1_inside=II*(r+d)/(2*pi*a^2);
H1_outside=II./(2*pi*(r+d));
H1=H1_inside.*((r+d)>-a & (r+d)<a) + H1_outside.*((r+d)<=-a | (r+d)>=a);

H2_inside=II*(r-d)/(2*pi*a^2);
H2_outside=II./(2*pi*(r-d));
H2=H2_inside.*((r-d)>-a & (r-d)<a) + H2_outside.*((r-d)<=-a | (r-d)>=a);

close all;
```

```
plot(r/1e-3,H1,'r:',r/1e-3,H2,'b--',r/1e-3,H1+H2,'k');
title('Magnetic field produced by two parallel conductors');
xlabel('Distance r in mm');
ylabel('Magnetic field H in A/m');
legend('Left conductor','Right conductor','Combined field',1);
axis([-50 50 -300 300]);
print -deps 'p2_3.eps'
```



P2.8
Since all distributed capacitances are connected in parallel, the total capacitance of a 1 m long cable will be equal to twice the capacitance of a 0.5 m long cable, i.e., C = 2 × 33.6 pF = 67.2 pF.

Since for a lossless cable the characteristic impedance is $Z_o = \sqrt{L/C}$, we obtain

$L = Z_o^2 C = 378$ nH.

P2.10
(a) When $G << \omega C$ and $R << \omega L$ the propagation constant k can be written as:

$$k = \alpha + j\beta = \frac{1}{2}\left(GZ_o + \frac{R}{Z_o}\right) + j\omega\sqrt{LC}$$

Therefore, the attenuation constant α becomes

$$\alpha = \frac{1}{2}\left(GZ_o + \frac{R}{Z_o}\right)$$

From Table 2-1 we find that for a coax cable

$$R = \frac{1}{2\pi\sigma_{cond}\delta}\left(\frac{1}{a} + \frac{1}{b}\right)L =$$