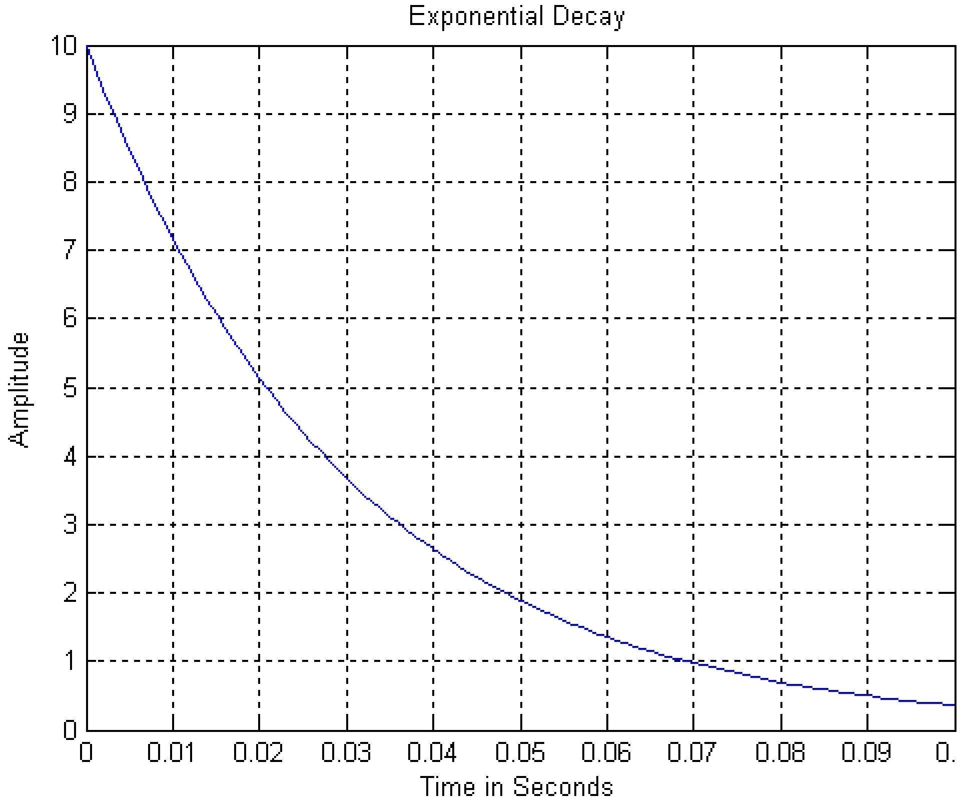
Short Quiz 1

1. What is the time constant for the following plot?



2. What is the relationship between current and voltage for a resistor?
   a. $V = IR$
   b. $I = VR$
   c. $I = L\frac{dV}{dt}$
   d. $I = C\frac{dV}{dt}$
   e. $V = L\frac{dI}{dt}$
   f. $V = C\frac{dI}{dt}$
3. What is the relationship between current and voltage for a capacitor?
   a. $V = IR$
   b. $I = VR$
   c. $I = L\frac{dV}{dt}$
   d. $I = C\frac{dV}{dt}$

   e. $V = L\frac{dI}{dt}$
   f. $V = C\frac{dI}{dt}$

4. What is the relationship between current and voltage for an inductor?
   a. $V = IR$
   b. $I = VR$
   c. $I = L\frac{dV}{dt}$
   d. $I = C\frac{dV}{dt}$
   e. $V = L\frac{dI}{dt}$
   f. $V = C\frac{dI}{dt}$
5. What is the correct expression for the restoring force in a spring-mass system?
   a. $F = -kx$
   b. $F = kx$
   c. $F = -\frac{1}{2}kx^2$
   d. $F = \frac{1}{2}kx^2$

Short Quiz 2

1. What is a typical velocity of propagation for an RG/58U cable?
   a. $v = 3x10^8$ m/s
   b. $v = 2x10^8$ m/s
   c. $v = 1x10^8$ m/s
   d. $v = 3x10^7$ m/s
   e. $v = 2x10^7$ m/s
2. What is the free space wavelength for a typical FM radio station (assume the frequency is 100MHz.)
   a. $\lambda = 3$ cm
   b. $\lambda = 30$ cm
   c. $\lambda = 3$ m
   d. $\lambda = 30$ m
   e. $\lambda = 300$ m
3. Which of the following are correct? (More than one can be correct.)
   a. $\beta = \frac{\omega}{2\pi}$
   b. $\beta = \frac{2\pi}{\omega}$
   c. $\beta = \frac{2\pi}{T}$
   d. $\beta = \frac{2\pi}{\lambda}$
   e. $\omega = \frac{2\pi}{T}$

Short Quiz 3:

1. What are the inductance and capacitance per unit length for the RG58/U cable we use? Capacitance per unit length ______ Inductance per unit length _______

2. What is the characteristic impedance of the RG58/U cable we use?
   a. 25 Ohms
   b. 50 Ohms
   c. 75 Ohms
   d. 100 Ohms
   e. 300 Ohms

3. Does the characteristic impedance of a transmission line consisting only of capacitors and inductors represent loss?
   a. Yes
   b. No
   c. Maybe

4. The voltage on a transmission line is given by $V = 10\cos\left(20\pi x 10^6 t - 0.1\pi z\right)$.

   Determine the following characteristics of this voltage wave:
   a. Angular frequency ω:
   b. Frequency f:
   c. Wave number β:
   d. Wavelength λ:
   e. Amplitude:
   f. Velocity of propagation *v*:
   g. The direction of propagation:
      i. Positive z
      ii. Negative z

5. Some physical process is characterized by the wave equation $\frac{\partial^2 F}{\partial x^2} = K\frac{\partial^2 F}{\partial t^2}$.

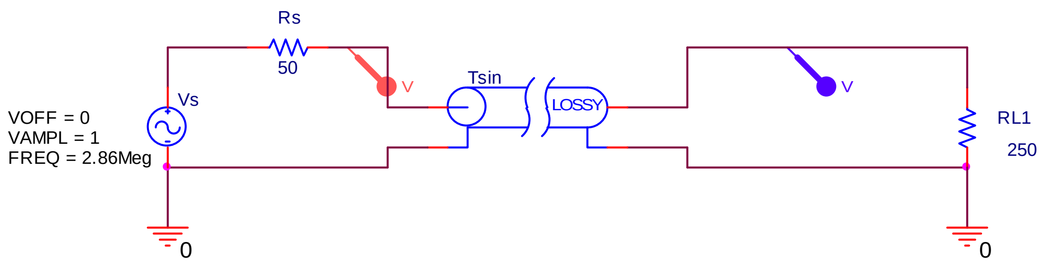
   What is the velocity of propagation for this wave? *Hint: Compare the wave equation for the voltage on a transmission line.*
   a. K
   b. K^2
   c. $\sqrt{K}$
   d. $\frac{1}{\sqrt{K}}$
   e. $\frac{1}{K}$
   f. $\frac{1}{K^2}$

Short Quiz 4:

1. The space-time form of the voltage wave equation is given by $\frac{\partial^2 V}{\partial z^2} = lc\frac{\partial^2 V}{\partial t^2}$.

   What is the phasor form of the wave equation?
   a. $\frac{\partial^2 V}{\partial t^2} = -\frac{\beta^2}{lc}V$
   b. $\frac{\partial^2 V}{\partial z^2} = -\omega^2 lcV$
   c. $\frac{\partial^2 V}{\partial z^2} = \omega^2 lcV$
   d. $\frac{\partial^2 V}{\partial t^2} = \frac{\beta^2}{lc}V$
   e. $\omega^2 V = -\frac{\beta^2}{lc}V$
2. The general phasor form of the voltage on the line is given by
   a. $V = \left(V_m^+ e^{-j\beta z} + V_m^- e^{+j\beta z}\right)e^{j\omega t}$
   b. $V = V_m^+ e^{-j\beta z} - V_m^- e^{+j\beta z}$
   c. $V = V_m^+ e^{-j\beta z}$
   d. $V = V_m^- e^{+j\beta z} e^{j\omega t}$
   e. $V = -V_m^- e^{+j\beta z}$
   f. $V = V_m^+ e^{-j\beta z} + V_m^- e^{+j\beta z}$
3. Demonstrate that your answer to question 2 is the solution to your answer to question 1.

Short Quiz 5:



A standard (lossless or low loss) transmission line is connected in a typical configuration. Assuming that this line is lossless, we know the following about this configuration before we use any specific information:

The characteristic impedance is given by $Z_o = \sqrt{\frac{l}{c}}$

The reflection coefficient at the load is given by $\Gamma_L = \frac{Z_L - Z_o}{Z_L + Z_o}$

The standing wave ratio is given by $S = \frac{1+|\Gamma_L|}{1-|\Gamma_L|}$

The propagation constant is $\beta = \omega\sqrt{lc}$

The voltage on the line is given by $V(z) = V_m^+ e^{-j\beta z} + V_m^- e^{+j\beta z}$

The current on the line is given by $I(z) = \frac{V_m^+}{Z_o} e^{-j\beta z} - \frac{V_m^-}{Z_o} e^{+j\beta z}$

The reflected voltage amplitude is given by $V_m^- = \Gamma_L V_m^+$

The input impedance of the line is given by $Z_{IN} = Z_o \frac{Z_L + jZ_o \tan\beta d}{Z_o + jZ_L \tan\beta d}$

Assume that a 100 meter long line with a characteristic impedance of 50 Ohms and a velocity 2.86x10^{8}m/s is driven by a 1V, 2.86MHz sinusoid and is connected to a 250 Ohm load. Evaluate all of the expressions above. *Hint: first find ω and β and then the input impedance Z_{IN}. If the input impedance does not greatly simplify, you are doing something wrong. The point of this exercise is to go through all the steps for a case where the math is simple. From the input impedance you can find the voltage at the input end $V(z=-100)$. Then evaluate the reflection coefficient at the load Γ_L and the standing wave ratio S. Finally, you have enough information to find the magnitude of the positive traveling wave V_m^+.*

Short Quiz 6:

Determine the attenuation factor α and the resistance per meter for a standard RG58 cable at 100MHz. You can use one of the following sources or any other source as long as you indicate what you use.

http://www.timesmicrowave.com/cgi-bin/calculate.pl

http://www.therfc.com/attenrat.htm

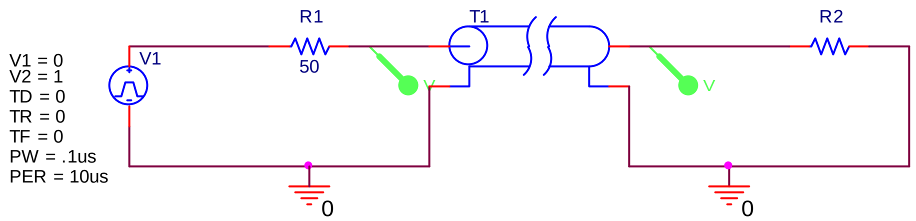
http://www.rfcafe.com/references/electrical/coax_chart.htm (does not have f = 100MHz)

http://www.universal-radio.com/catalog/cable/coaxperf.html

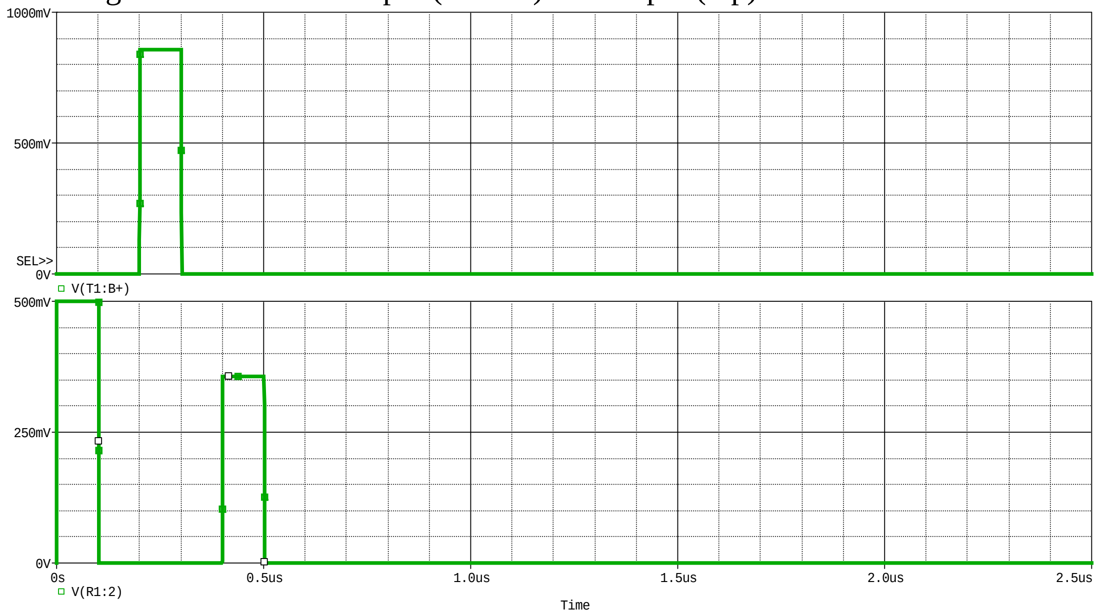
http://www.phptr.com/articles/article.asp?p=169518&seqNum=2&rl=1

Short Quiz 7:

A pulse is launched onto the transmission line shown below:



The voltages observed at the input (bottom) and output (top) ends of the line are



1. Given that the input pulse has a magnitude of 1V, what is the characteristic impedance of the line?
   a. 300Ω
   b. 200Ω
   c. 100Ω
   d. 50Ω
   e. 25Ω
2. What is the load impedance R2?
   a. 300Ω
   b. 200Ω
   c. 100Ω
   d. 50Ω
   e. 25Ω

Short Quiz 8:

Given the following vectors, $\vec{A} = 5\hat{x} + 10\hat{y} + 5\hat{z}$ and $\vec{B} = 15\hat{x} + 5\hat{y} + 15\hat{z}$,

1. $\vec{A} + \vec{B} = ?$
   a. $5\hat{x} + 10\hat{y} + 5\hat{z}$
   b. $20\hat{x} + 15\hat{y} + 20\hat{z}$
   c. $10\hat{x} - 5\hat{y} + 10\hat{z}$
   d. $-10\hat{x} + 5\hat{y} - 10\hat{z}$
   e. 55
2. $\vec{A} \cdot \vec{B} = ?$
   a. $20\hat{x} + 15\hat{y} + 20\hat{z}$
   b. 15
   c. 55
   d. 200
   e. 150
3. $\vec{A} \times \vec{B} = ?$
   a. $75\hat{x} + 50\hat{y} + 75\hat{z}$
   b. $125\hat{x} + 10\hat{y} + 125\hat{z}$
   c. $125\hat{x} - 125\hat{z}$
   d. $125\hat{x} + 100\hat{y} + 100\hat{z}$
   e. $125\hat{x} + 125\hat{z}$

If some object experiences a force given by $\vec{F} = F_o\hat{x}$,

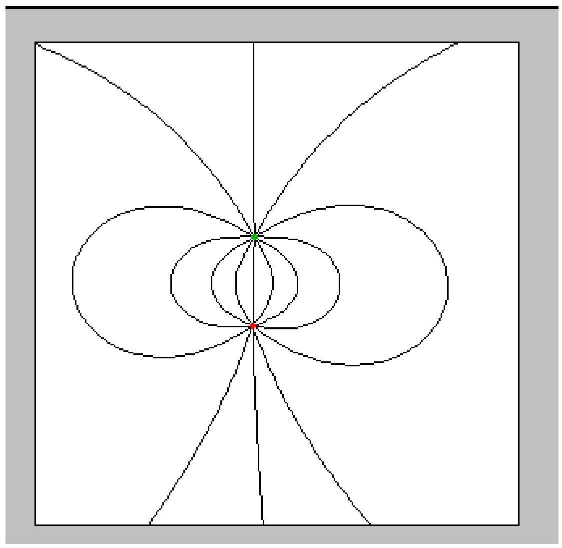
4. How much work is done moving the object from *(0,0,0)* to (x_o,0,0)?
   a. $F_o x_o$
   b. $\frac{1}{2} F_o {x_o}^2$
   c. 0
   d. $-F_o x_o$
   e. $-\frac{1}{2} F_o {x_o}^2$
5. How much work is done moving the object from *(0,0,0)* to *(0,y_o,0)*?
   a. $F_o y_o$
   b. $\frac{1}{2} F_o {y_o}^2$
   c. 0
   d. $-F_o y_o$
   e. $-\frac{1}{2} F_o {y_o}^2$

Short Quiz 9:

1. The gradient of the following scalar $h = ax + by^2 + cz$ is equal to:
    a. $\nabla h = 2a\hat{x} + y\hat{y} + c\hat{z}$
    b. $\nabla h = a\hat{x} + 2by\hat{y} + c\hat{z}$
    c. $\nabla h = a + 2by + c$
    d. $\nabla h = 2\hat{x} + 2\hat{y} + 2\hat{z}$
    e. $\nabla h = a\hat{x} + by\hat{y} + c\hat{z}$
2. The divergence of the correct answer to question 1 is equal to:
    a. $\nabla \cdot \nabla h = ax + 2by + c$
    b. $\nabla \cdot \nabla h = a + 2by + c$
    c. $\nabla \cdot \nabla h = 2b$
    d. $\nabla \cdot \nabla h = by$
    e. $\nabla \cdot \nabla h = 0$
3. The curl of the correct answer to question 1 is equal to:
    a. $\nabla \times \nabla h = 0$
    b. $\nabla \times \nabla h = 2b\hat{x}$
    c. $\nabla \times \nabla h = 2b\hat{z}$
    d. $\nabla \times \nabla h = a\hat{x}$
    e. $\nabla \times \nabla h = c\hat{x}$
4. The curl of the following vector $\vec{H} = r\hat{r} + \theta\hat{\theta} + \phi\hat{\phi}$
    a. $\nabla \times \vec{H} = 0$
    b. $\nabla \times \vec{H} = \frac{\hat{r}\phi\cot\theta}{r} - \frac{\hat{\theta}\phi}{r} + \frac{\hat{\phi}\theta}{r}$
    c. $\nabla \times \vec{H} = \hat{r} + \hat{\theta} + \hat{\phi}$
    d. $\nabla \times \vec{H} = r + \phi + \theta$
    e. $\nabla \times \vec{H} = \hat{r}\phi\cot\theta - \hat{\theta}\phi + \hat{\phi}\theta$
5. The divergence of the curl of a vector is identically zero
    a. True
    b. False

Short Quiz 10:

1. Unlike charges attract, like charges repel.
    a. True
    b. False
2. The force between two charged particles decays as the square of the distance between the particles.
    a. True
    b. False
3. Volts are the units of the electric field.
    a. True
    b. False



4. The electric field lines shown above are for two identical positive charges.
    a. True
    b. False
5. There are free positive and negative charges in the air we breathe.
    a. True
    b. False

Short Quiz 11:

Gauss' Law is given in integral form as $\oint \vec{D}\cdot d\vec{S} = \int \rho_v dv = Q_{encl}$.

1. Assuming that $\rho_v = \rho_v(r)$, where r is cylindrical radius, simplify the electric flux density vector $\vec{D} = D_r(r,\phi,z)\hat{r} + D_\phi(r,\phi,z)\hat{\phi} + D_z(r,\phi,z)\hat{z} = ?$
   a. $\vec{D} = D_\phi(r,\phi,z)\hat{\phi}$
   b. $\vec{D} = D_\phi(r)\hat{\phi}$
   c. $\vec{D} = D_r(r,\phi,z)\hat{r}$
   d. $\vec{D} = D_r(r)\hat{r}$
   e. $\vec{D} = D_z(r,\phi,z)\hat{z}$
   f. $\vec{D} = D_z(r)\hat{z}$
2. Again, assuming that $\rho_v = \rho_v(r)$, what Gaussian surface will work well if we are to use Gauss' Law to find $\vec{D}$? Also, what $d\vec{S}$ goes with the surface?
   a. An open cylinder at radius $r = constant$ with $d\vec{S} = \hat{r}rd\phi dz$
   b. A closed cylinder consisting of a surface at radius $r = constant$ with $d\vec{S} = \hat{r}rd\phi dz$, length l and end caps at $z = 0$ and $z = l$ with $d\vec{S} = \pm\hat{z}drrd\phi$
   c. A closed cylinder consisting of a surface at radius $r = constant$ with $d\vec{S} = \hat{\phi}rd\phi dz$, length l and end caps at $z = 0$ and $z = l$ with $d\vec{S} = \pm\hat{z}drrd\phi$
   d. A closed cylinder consisting of a surface at radius $r = constant$ with $d\vec{S} = \hat{r}rd\phi dz$, length l and end caps at $z = 0$ and $z = l$ with $d\vec{S} = \pm\hat{\phi}drrd\phi$
3. Given your solution to questions 1 and 2, evaluate the left hand side of Gauss' Law $\oint \vec{D}\cdot d\vec{S}$
   a. $\oint \vec{D}\cdot d\vec{S} = D_r(r)2\pi rl$
   b. $\oint \vec{D}\cdot d\vec{S} = D_r(r)\pi r^2 l$
   c. $\oint \vec{D}\cdot d\vec{S} = D_r(r)\pi r^2$
   d. $\oint \vec{D}\cdot d\vec{S} = 0$

Short Quiz 12:

A coaxial cable consists of an inner conductor of radius *a* and an outer conductor of inner radius *b* and outer radius *c*. The total charge per unit length on the inner conductor is Q_o and the total charge per unit length on the outer conductor is $-Q_o$. The space between the conductors is empty (air). For the following questions, keep in mind that the units of Q_o are Coulombs per meter, not just Coulombs when you check your units.

1. The electric field inside the inner conductor ($r<a$) is
   a. $\vec{E}=\frac{Q_o}{2\pi\varepsilon_o r}\hat{r}$
   b. $\vec{E}=\frac{Q_o}{2\pi\varepsilon_o r^2}\hat{r}$
   c. $\vec{E}=0$
   d. $\vec{E}=\frac{Q_o}{4\pi\varepsilon_o r^2}\hat{r}$
   e. $\vec{E}=\frac{Q_o}{4\pi\varepsilon_o r}\hat{r}$
2. The field in the region between the conductors ($a<r<b$) is
   a. $\vec{E}=\frac{Q_o}{2\pi\varepsilon_o r}\hat{r}$
   b. $\vec{E}=\frac{Q_o}{2\pi\varepsilon_o r^2}\hat{r}$
   c. $\vec{E}=0$
   d. $\vec{E}=\frac{Q_o}{4\pi\varepsilon_o r^2}\hat{r}$
   e. $\vec{E}=\frac{Q_o}{4\pi\varepsilon_o r}\hat{r}$
3. The field in the outer conductor ($b<r<c$) is
   a. $\vec{E}=\frac{Q_o}{2\pi\varepsilon_o r}\hat{r}$
   b. $\vec{E}=\frac{Q_o}{2\pi\varepsilon_o r^2}\hat{r}$
   c. $\vec{E}=0$
   d. $\vec{E}=\frac{Q_o}{4\pi\varepsilon_o r^2}\hat{r}$
   e. $\vec{E}=\frac{Q_o}{4\pi\varepsilon_o r}\hat{r}$
4. The field in the region outside the outer conductor ($c<r$) is
   a. $\vec{E}=\frac{Q_o}{2\pi\varepsilon_o r}\hat{r}$

b. $\vec{E} = \frac{Q_o}{2\pi\varepsilon_o r^2}\hat{r}$

c. $\vec{E} = 0$

d. $\vec{E} = \frac{Q_o}{4\pi\varepsilon_o r^2}\hat{r}$

e. $\vec{E} = \frac{Q_o}{4\pi\varepsilon_o r}\hat{r}$

5. The voltage between the inner and outer conductors $V(a) - V(b) = -\int_b^a \vec{E} \cdot d\vec{l}$ is

a. $V(a) - V(b) = \frac{Q_o}{2\pi\varepsilon_o}\ln\frac{b}{a}$

b. $V(a) - V(b) = \frac{Q_o}{2\pi\varepsilon_o}\left(\frac{1}{a} - \frac{1}{b}\right)$

c. $V(a) - V(b) = 0$

d. $V(a) - V(b) = \frac{Q_o}{4\pi\varepsilon_o}\left(\frac{1}{a} - \frac{1}{b}\right)$

e. $V(a) - V(b) = \frac{Q_o}{4\pi\varepsilon_o}\ln\frac{b}{a}$

Assume that the inner conductor is replaced by a uniform volume charge distribution but the total charge per unit length is still equal to Q_o .

6. What is the volume charge density in this case?

a. $\rho_V = \frac{Q_o}{2\pi a}$

b. $\rho_V = \frac{Q_o}{\pi a^2}$

c. $\rho_V = Q_o 2\pi a$

d. $\rho_V = Q_o \pi a^2$

7. For the region outside the inner conductor ($a < r$), the electric field will remain the same as for the solid inner conductor, since the charge enclosed remains the same. However inside the charge, the answer will be different. What is the electric field inside the charge ($0 < r < a$)?

a. $\vec{E} = \frac{Q_o}{2\pi\varepsilon_o r}\hat{r}$

b. $\vec{E} = \frac{Q_o r}{2\pi\varepsilon_o a^2}\hat{r}$

c. $\vec{E} = \frac{Q_o r}{2\pi\varepsilon_o}\hat{r}$

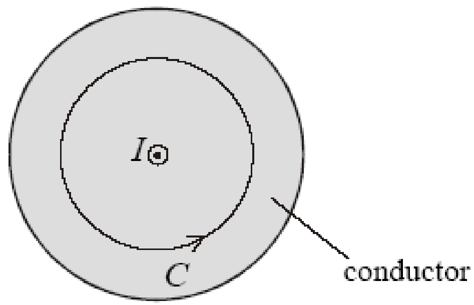
d. $\vec{E} = \frac{Q_o}{2\pi\varepsilon_o r^2}\hat{r}$

Short Quiz 13:

1. A typical value for the conductivity of a good conductor (e.g. copper, silver, gold, aluminum, platinum, etc.) that we might make wire out of is:
   a. $\sigma = 200 \, S/m$
   b. $\sigma = 0.003 \, S/m$
   c. $\sigma = 2x10^4 \, S/m$
   d. $\sigma = 6x10^7 \, S/m$
   e. $\sigma = 10^{-6} \, S/m$
2. The resistance of a cylindrical conductor with a uniform circular cross section of radius *a*, a uniform conductivity $\sigma_o \, S/m$, and a length d, is given by:
   a. $R = \dfrac{\sigma_o d}{\pi a}$
   b. $R = \dfrac{\sigma_o d}{\pi a^2}$
   c. $R = \dfrac{d}{\sigma_o \pi a^2}$
   d. $R = \dfrac{d}{\sigma_o 2\pi a}$
   e. $R = \dfrac{\sigma_o \pi a^2}{d}$
3. The current density in some region is given by $\vec{J} = \hat{z} J_o \left(1 - \dfrac{r}{a}\right) \dfrac{A}{m^2}$. The total current $I = \int \vec{J} \cdot d\vec{S}$ in the region between $0 \le r \le a$ is
   a. $J_o \pi a^2$
   b. $\dfrac{J_o \pi a^2}{2}$
   c. $\dfrac{J_o \pi a^2}{3}$
   d. $\dfrac{J_o \pi a^2}{4}$
   e. $\dfrac{J_o \pi a^2}{6}$

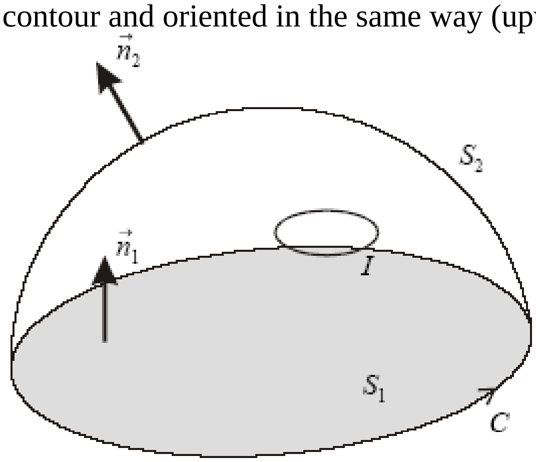
Short Quiz 14:

1. A cylindrical conductor of a circular cross section carries a time-invariant current I ($I>0$). The line integral of the magnetic flux density $\vec{B}$ along a closed circular contour C positioned inside the conductor (the contour radius is smaller than the conductor radius) is



(A) $\mu_0 I$.
(B) $-\mu_0 I$.
(C) greater than $\mu_0 I$.
(D) positive and less than $\mu_0 I$.
(E) zero.

2. A small wire loop with a time-invariant current I is situated in free space. If Φ_1 designates the magnetic flux (flux of the vector $\vec{B}$) through a flat surface spanned over the contour C, the magnetic flux Φ_2 through a hemispherical surface spanned over the same contour and oriented in the same way (upward) is



(A) $\Phi_2 = \Phi_1$.
(B) $\Phi_2 = 2\Phi_1$.
(C) $\Phi_2 = \Phi_1/2$.
(D) $\Phi_2 = -\Phi_1$.
(E) Depends on the direction of the current in the loop.

Short Quiz 15:

Maxwell's Equations for static electric fields (and some related info) are given by

$\oint \vec{E} \cdot d\vec{l} = 0$ and $\oint \vec{D} \cdot d\vec{S} = \int \rho_v dv = Q_{encl}$ in integral form and

$\nabla \times \vec{E} = 0$ and $\nabla \cdot \vec{D} = \rho_v$ in differential form with $\vec{D} = \varepsilon \vec{E}$

Maxwell's Equations for static magnetic fields (and some related info) are given by

$\oint \vec{H} \cdot d\vec{l} = \int \vec{J} \cdot d\vec{S} = I_{encl}$ and $\oint \vec{B} \cdot d\vec{S} = 0$ in integral form and

$\nabla \times \vec{H} = \vec{J}$ and $\nabla \cdot \vec{B} = 0$ in differential form with $\vec{B} = \mu \vec{H}$.

The boundary conditions for the electric field are

$E_{\tan 1} = E_{\tan 2}$ and $D_{norm1} - D_{norm2} = \rho_s$

1. Which of the following are the boundary conditions for the magnetic field? (You should be able to answer this question by inspection from the equations above.)
   a. $B_{\tan 1} = B_{\tan 2}$
   b. $H_{\tan 1} - H_{\tan 2} = J_s$
   c. $B_{norm1} = B_{norm2}$
   d. $H_{norm1} - H_{norm2} = J_s$
   e. $B_{norm1} - H_{norm2} = J_s$

A coil of wire is wrapped around a cylindrical paper tube resulting in *N* total turns in a length *d*. The radius of the tube is *a*.

2. What is the inductance of this solenoidal coil?
   a. $L = \frac{\mu_o NI}{d}$
   b. $L = \frac{\mu_o NI\pi a^2}{d}$
   c. $L = \frac{\mu_o N^2 \pi a^2}{d}$
   d. $L = \frac{\mu_o N 2\pi a}{d}$
   e. $L = \frac{\mu_o NI^2 2\pi a}{d}$

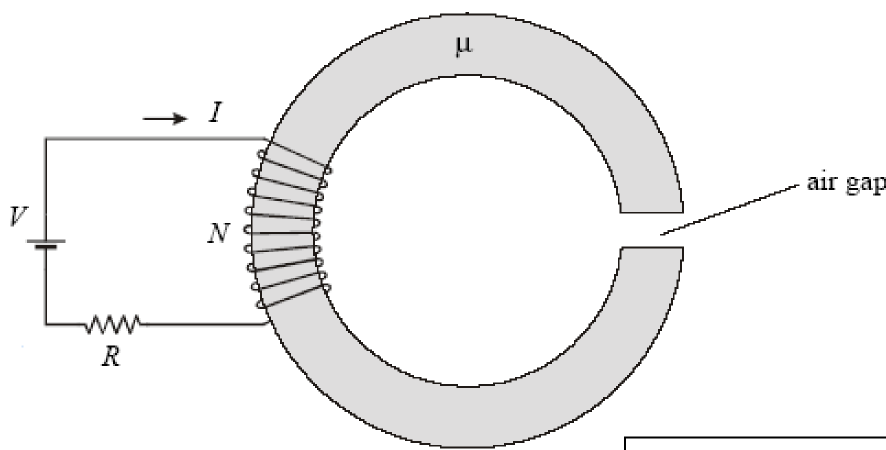
Short Quiz 16:

1. The resistance of a cylindrical conductor of radius *a* and length *d* is given by
   a. $R = \dfrac{\sigma}{l\pi a^2}$
   b. $R = \dfrac{l}{\sigma \pi a^2}$
   c. $R = \dfrac{l\pi a^2}{\sigma}$
   d. $R = \dfrac{\sigma \pi a^2}{l}$
2. The boundary condition that is based on the conservation of magnetic flux is
   a. $H_{\tan 1} = H_{\tan 2}$
   b. $B_{\tan 1} = B_{\tan 2}$
   c. $H_{\tan 1} - H_{\tan 2} = J_s$
   d. $B_{norm1} = B_{norm2}$
3. Is the geographic north pole
   a. a north magnetic pole
   b. a south magnetic pole
   c. neither
   d. both

4. Three engineers and three accountants were traveling by train to a conference. At the station, the three accountants each bought tickets and watched as the three engineers bought only one ticket. "How are three people going to travel on only one ticket?" asked an accountant. "Watch and you'll see", answered an engineer. They all boarded the train. The accountants took their respective seats, but the three engineers all crammed into a rest room and closed the door behind them. Shortly after the train departed, the conductor came around collecting tickets. He knocked on the restroom door and said, "Ticket, please". The door opened just a crack and a single arm emerged with a ticket in hand. The conductor took it and moved on. The accountants saw this and agreed it was a quite clever idea. So, after the conference, the accountants decide to copy the engineers on the return trip and save some money (being clever with money, and all that). When they got to the station, they bought a single ticket for the return trip. To their astonishment, the engineers didn't buy a ticket at all. "How are you going to ride without a ticket?" said one perplexed accountant. "Watch and you'll see", answered an engineer. When they boarded the train, the three accountants crammed into a restroom and the three engineers crammed into another one nearby. The train departed. What did the engineers do to ride on the train with no ticket?

Short Quiz 17:

1. A thin toroidal core, made of a ferromagnetic material of permeability μ, has an air gap, as shown in the figure. There is a time-invariant current through the winding. The magnitude of the <u>magnetic field intensity vector in the ferromagnetic core</u> with respect to the clock-wise reference direction is $\vec{H}$. The magnitude of the magnetic field intensity vector in the air gap (H_o) with respect to the same reference direction is



Square cross-section magnetic core (*hxh*)

(A) $H_0 = H$

(B) $H_0 = 0$

(C) $H_0 = \mu_0 H$

(D) $H_0 = \mu_0 H/\mu$

(E) $H_0 = \mu H/\mu_0$

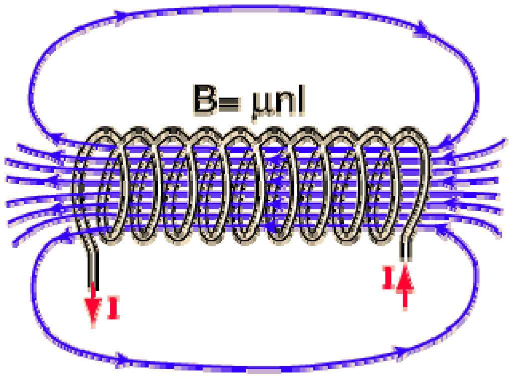
(μ_0 is the permeability of a vacuum).

2. The magnitude of the magnetic flux density (B) in both the core and the air gap is
   a. $B = \mu H$
   b. $B = 0$
   c. $B = \mu_o H$
   d. H/μ
   e. H/μ_o
3. When a toroidal core is thin, we can assume that the magnetic field in the core and gap is constant and equal to the value at the center of the core. When we use this approximation to determine the magnetic flux in the core, our answer will be
   a. a little too large
   b. a little too small
   c. exactly correct

   or, maybe,

   d. we have too little information to tell.

Short Quiz 18:



A solenoidal inductor is made by winding wire around a cylindrical core. This can be a plastic or paper tube or an iron rod. If the core cylinder has a radius equal to r_c and we wind a coil N times around the cylinder to cover a length d, the inductor will have an inductance equal to:

$$L = \frac{(\mu_0 N^2 \pi r_c^{\ 2})}{d} Henries$$

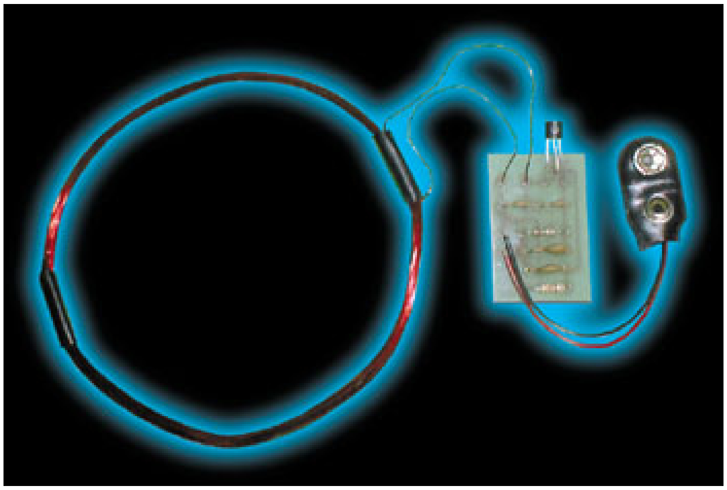
where $\mu_o = 4\pi \times 10^{-7}$ Henries/meter. If the core is not air, but rather some magnetic material, replace μ_o with μ, which is usually many times larger than μ_o. By many times we can mean as much as 10^5 times larger. You should know that this formula only works well when the length d is much larger than the radius r_c.

For other applications, it tends to over-estimate the value of the inductance and, thus, it is only useful to find a ballpark number. For example, if the coil has a radius and a length similar to that of a coin, it will look something like a finger ring. Then, the inductance is given approximately by

$$L \cong \mu N^2 r_c \{\ln(\frac{8r_c}{r_w}) - 2\}$$

where r_c is the major radius of the coil and r_w is the radius of the wire.

1. The inductance of a 1000 turn, air-core solenoid with a radius of 2cm and a length of 20cm is approximately
   a. *8mH*
   b. *0.8mH*
   c. *3.2mH*
   d. *.32mH*
   e. *80mH*



2. The inductance of a 10 turn, air-core coil (like the one shown above) with a radius of 10cm and a wire radius of 2mm is
   a. *50mH*
   b. *5mH*
   c. *.5mH*
   d. *.05mH*
   e. *.005mH*

One of the characteristics of practical inductors that is quite different from practical capacitors is their loss. Loss in a capacitor comes from the leakage through the insulator that separates the capacitor plates. Insulators are so good now that this leakage is generally negligible. Loss in an inductor comes from the finite, if small, resistance of the wires used to make the inductors. Unless we use superconductors to make coils, this resistance will always be an issue and any circuit model of an inductor must include a resistance. To see this, calculate the resistance of the 10 turn, air-core coil of the previous problem. The resistance of the wire can be determined from

$$R = \frac{l}{\sigma A}$$

where l is the length of the wire, A is the cross-sectional area of the wire (not the loop), and σ is the conductivity of the wire (for copper, $\sigma = 5.8x10^7$).

3. The total length of wire used in this coil is (in meters)
   a. 20π
   b. 0.002π
   c. 2π
   d. 0.004π
   e. 200π

4. The cross-sectional area of the wire is (in meters)
   a. $\left(2x10^{-6}\right)\pi$
   b. $\left(4x10^{-3}\right)\pi$
   c. 2π
   d. $\left(4x10^{-6}\right)\pi$
   e. $\left(2x10^{-3}\right)\pi$

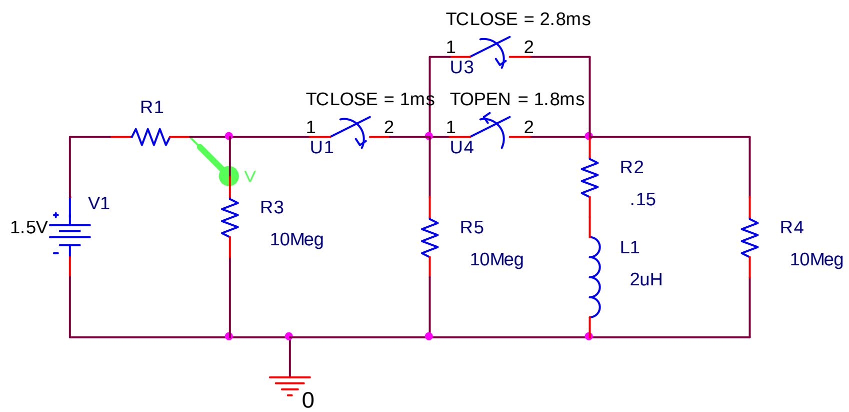
5. The resistance of the wire is (in Ohms)
   a. 0.00086
   b. 0.0086
   c. 0.086
   d. 0.86
   e. 8.6

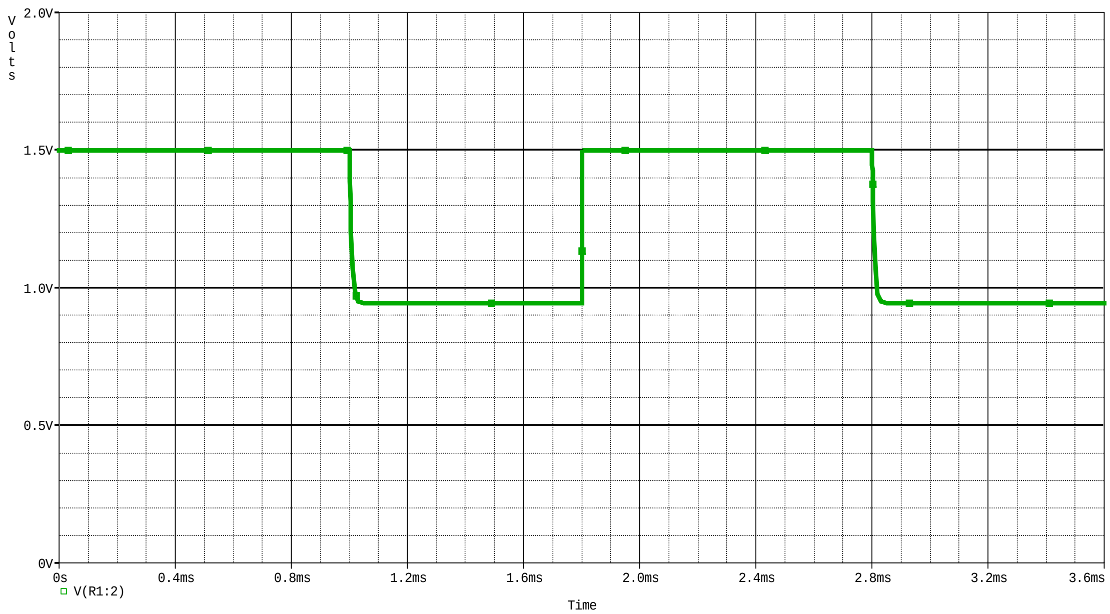
Check your result using the wire resistance calculator at the online site Megaconverter http://www.megaconverter.com/mega2/ . You cannot specify the radius of the wire, so you will have to choose the wire gauge that has a radius that is closest to 2mm.

6. What gauge wire has the closest dimensions?
   a. 4
   b. 5
   c. 6
   d. 7
   e. 8

Short Quiz 19:

The following circuit was used to simulate the operation of the Beakman's motor as it connects to and disconnects from the battery each cycle. The values used are typical for smaller coils. The 10Meg resistors are included only so that one end of the switches does not float since PSpice does not like floating terminals.



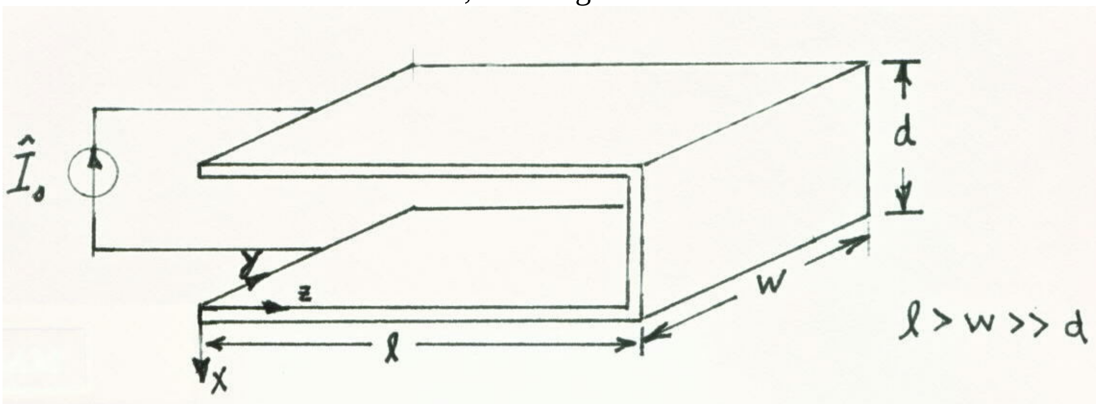


Given this information, what is the resistance of the battery R1?

a. 1 Ω
b. 0.5 Ω
c. 0.1 Ω
d. 0.05 Ω
e. 0.001 Ω

Short Quiz 20:

1. A simple, air insulated, parallel plate inductor, as we would have with a stripline transmission line with a shorted end, is configured as



For this configuration, the magnetic field is given by $\vec{H} = \hat{y}\frac{I(t)}{w}$, where $I(t) = I_o \cos\omega t$.

According to Faraday's Law, $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$, this magnetic field will produce a corresponding electric field. Which of the following is the electric field for this case?

a. $\vec{E} = \hat{x}\frac{\omega\mu_o I_o \sin\omega t}{w}(z-l)$

b. $\vec{E} = \hat{x}\frac{\omega\mu_o I_o \cos\omega t}{w}(z-l)$

c. $\vec{E} = -\hat{x}\frac{\omega\mu_o I_o \sin\omega t}{w}(z-l)$

d. $\vec{E} = \hat{z}\frac{\omega\mu_o I_o \sin\omega t}{w}(z-l)$

e. $\vec{E} = -\hat{z}\frac{\omega\mu_o I_o \sin\omega t}{w}(z-l)$

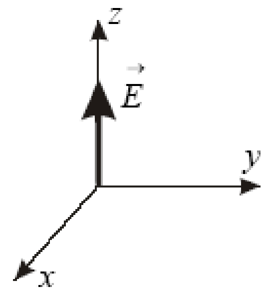
f. $\vec{E} = \hat{z}\frac{\omega\mu_o I_o \cos\omega t}{w}(z-l)$

Short Quiz 21:

1. A uniform plane wave with the electric field intensity vector

$$\boldsymbol{E} = E_o \cos(\omega t - \beta x)\, \boldsymbol{a}_z$$

where $\boldsymbol{a}_z$ is the unit vector along the z-axis, propagates in a medium with intrinsic impedance η. The Magnetic field intensity vector of the wave is



(A) $\boldsymbol{H} = \frac{E_0}{\eta}\cos(\omega t - \beta x)\, \boldsymbol{a}_z$.

(B) $\boldsymbol{H} = \frac{E_0}{\eta}\cos(\omega t - \beta x)\, \boldsymbol{a}_y$.

(C) $\boldsymbol{H} = \eta E_0 \cos(\omega t - \beta x)\, \boldsymbol{a}_y$.

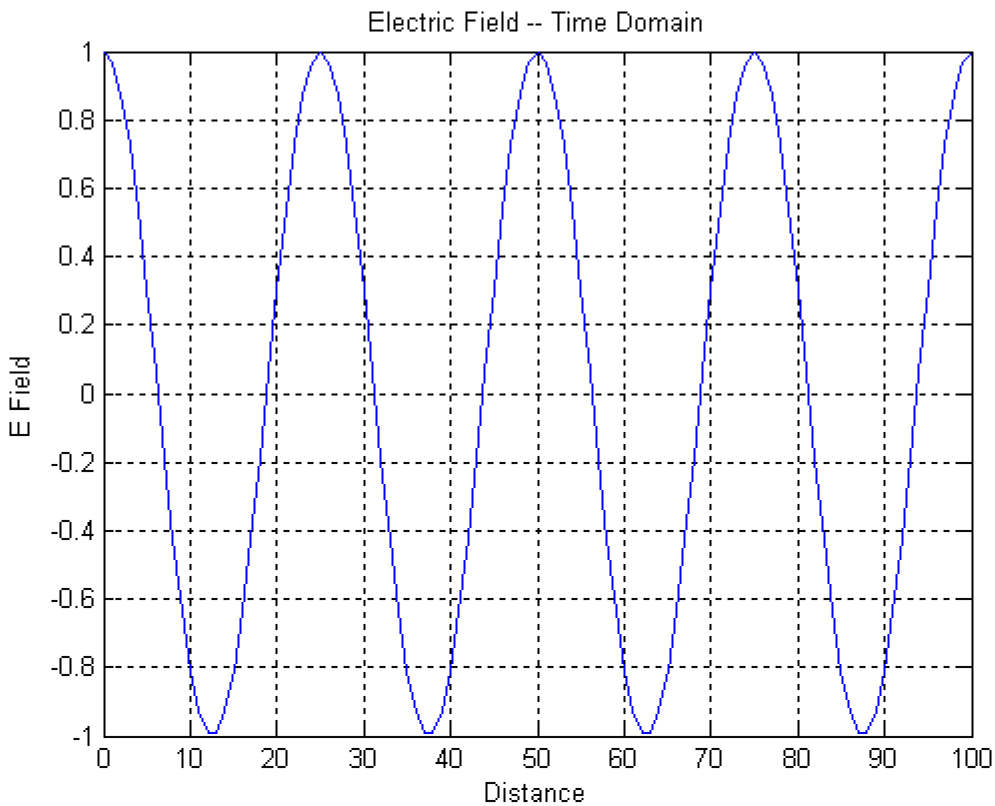
(D) $\boldsymbol{H} = -\frac{E_0}{\eta}\cos(\omega t - \beta x)\, \boldsymbol{a}_y$.

(E) $\boldsymbol{H} = \frac{E_0}{\eta}\cos(\omega t - \beta y)\, \boldsymbol{a}_x$.

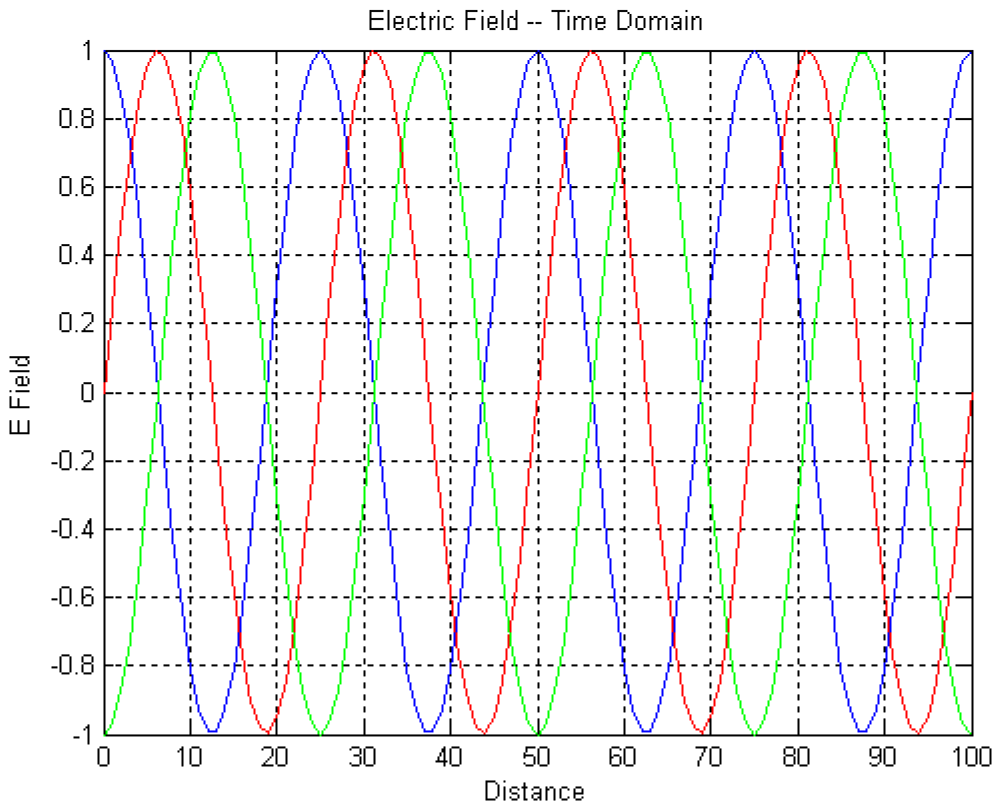
2. In order to prevent the electric and magnetic fields from entering or leaving a room, the walls of the room are shielded with 1-mm thick aluminum foil. The best protection is achieved at

(A) 1 kHz.
(B) 10 kHz.
(C) 100 kHz.
(D) 1 MHz.
(E) No difference.

Short Quiz 22:



1. At time *t* = *0*, the electric field of a uniform plane wave looks like the figure above. What are the wavelength λ and wave number β for this wave?
   a. $\lambda = 10m$ and $\beta = 0.1m^{-1}$
   b. $\lambda = 25m$ and $\beta = 0.25m^{-1}$
   c. $\lambda = 10m$ and $\beta = \frac{\pi}{5}m^{-1}$
   d. $\lambda = 25m$ and $\beta = \frac{\pi}{25}m^{-1}$
   e. $\lambda = 25m$ and $\beta = \frac{2\pi}{25}m^{-1}$
2. The amplitude of the electric field is equal to
   a. $1\frac{V}{m}$
   b. $2\frac{V}{m}$
   c. $1V$
   d. $2V$
   e. $\frac{1}{\sqrt{2}}\frac{V}{m}$



3. The electric field at three different times is plotted above: $t = 0, T/4, \& T/2$. From this plot, determine the propagation velocity u_p and the frequency f of the electric field.
    a. $u_p = 2x10^8 m/s$ and $f = 10^7 Hz$
    b. $u_p = 2x10^8 m/s$ and $f = 8x10^6 Hz$
    c. $u_p = 1.5x10^8 m/s$ and $f = 8x10^6 Hz$
    d. $u_p = 1.5x10^8 m/s$ and $f = 10^7 Hz$
    e. $u_p = 3x10^8 m/s$ and $f = 8x10^6 Hz$

4. Write the phasor form of the electric field, assuming that it is in the x-direction and propagates in the z-direction.

Short Quiz 23:

1. A dielectric slab inserted between two media with different intrinsic impedances is designed to provide quarter-wave matching (the slab thickness equals a quarter of the wavelength) at a given frequency, yielding zero reflection in the incident region. Which of the following changes would not affect the matching properties of the slab:

   (A) The slab thickness doubled.

   (B) The wave frequency doubled.

   (C) Both the thickness and the frequency doubled.

   (D) The thickness doubled and the frequency halved.

   (E) The slab thickness halved.

2. Fresh water of parameters $\varepsilon_r = 80$ (relative permittivity), $\mu_r = 1$ (relative permeability), and $\sigma = 10^{-3}\ S/m$ (conductivity) acts as

   (A) a good conductor.

   (B) a good dielectric.

   (C) a conductive medium midway between a good conductor and a good dielectric.

   (D) None of the above.

   (E) Need more information.

3. Brewster's angle is generally larger than the critical angle.
   a. true
   b. false

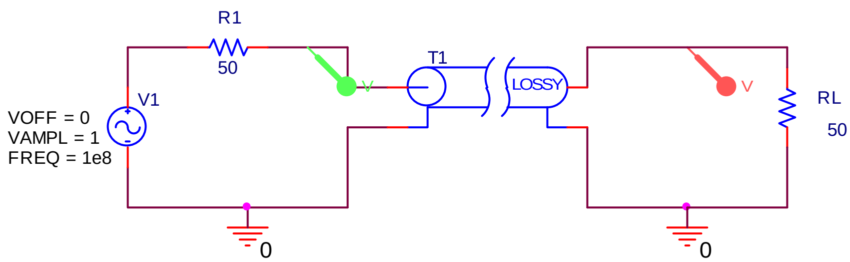
4. Identify which transmission line parameters are the analog of parameters for uniform plane electromagnetic wave.

   a. V
   b. I
   c. Z_o

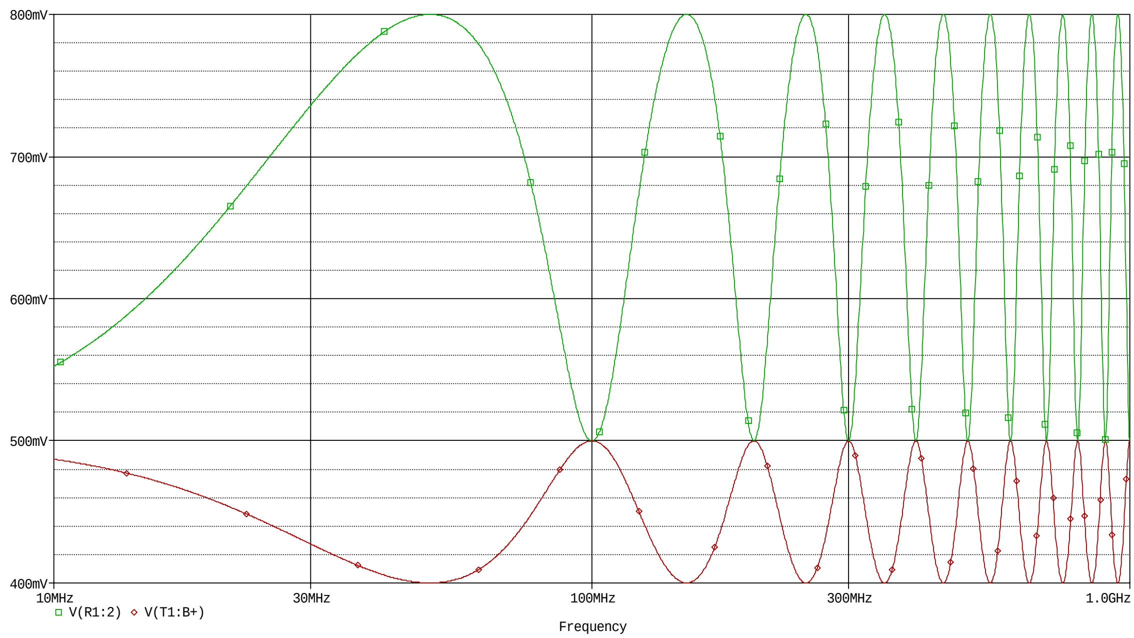
   a. E
   b. H
   c. η

Short Quiz 24:

A transmission line with an unknown characteristic impedance is connects a 50 Ohm load to a source with a 50 Ohm internal impedance. The length of the line is exactly 1 meter.



The input and output voltages are measured at a wide variety of frequencies with the following result.



1. What is the velocity of propagation on this transmission line?
   a. $u_p = 1x10^8\ m/s$
   b. $u_p = 1.5x10^8\ m/s$
   c. *cannot tell*
   d. $u_p = 2x10^8\ m/s$
   e. $u_p = 2.5x10^8\ m/s$
2. What is the characteristic impedance of the line?
   a. *cannot tell*
   b. $Z_o = 150\Omega$
   c. $Z_o = 200\Omega$
   d. $Z_o = 75\Omega$
   e. $Z_o = 100\Omega$

Short Quiz 25:

1. The dielectric constant of the core region of an optical fiber is
   a. less than that of the outer (cladding) region
   b. greater than that of the outer (cladding) region
   c. the same as that of the outer (cladding) region
   d. always the same as free space

2. Which angle is also known as the polarizing angle?
   a. the critical angle
   b. the angle of incidence
   c. the angle of reflection
   d. the angle of transmission
   e. Brewster's angle

3. A practical choice for the thickness of an anti-reflection coating can be which of the following? Circle all correct answers.
   a. one quarter wavelength
   b. one half wavelength
   c. three quarters wavelength
   d. one wavelength
   e. five quarters wavelength

4. Anti-reflective coatings are added to lenses to eliminate all reflections.
   a. true
   b. false

5. Antennas for satellite communication use circular polarization so that signals can be received even when there are anomalies such as Faraday Rotation.
   a. true
   b. false
   c. not enough information to answer

6. Which of the following is true?
   a. sunlight is randomly polarized as is the light emitted from a laser
   b. sunlight has a specific polarization while laser light is randomly polarized
   c. sunlight has a specific polarization while laser light is randomly polarized
   d. sunlight is randomly polarized while light emitted by a laser is specific polarization
   e. none of the above is true

7. The thickness and type of material for a radome are chosen to make it invisible to the radar signal.
   a. true
   b. false

8. Which of the following is a practical choice for the thickness of a radome? Circle all correct answers.
   a. one quarter wavelength
   b. one half wavelength
   c. three quarters wavelength
   d. one wavelength
   e. five quarters wavelength

9. From the typical parameters provided in the lecture, at which of the following frequencies will ham be a good conductor? Circle all correct answers.
   a. 100 Hz
   b. 1 kHz
   c. 1 MHz
   d. 1 GHz
   e. none of the above or not enough information to answer

10. From the typical parameters provided in the lecture, at which of the following frequencies will ham be a low loss dielectric? Circle all correct answers.
   a. 100 Hz
   b. 1 kHz
   c. 1 MHz
   d. 1 GHz
   e. none of the above or not enough information to answer

11. True or false, the electric field in a lossy material decays more rapidly than the Poynting vector.
   1. true
   2. false