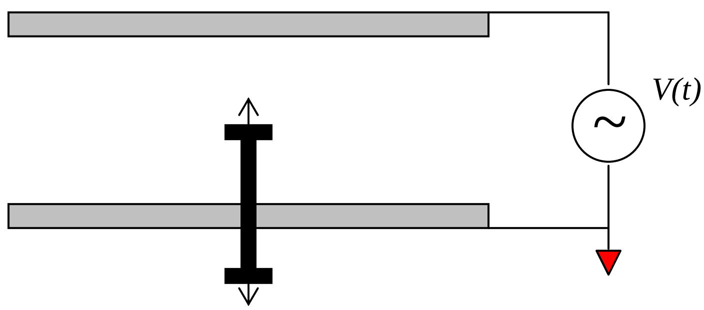
EXTRA CREDIT

To receive credit for these questions, you must input your answers on the LMS site. Also, for this set of questions, you will be given only one opportunity to provide your answer, so make sure you have correctly solved the problem before submitting your answer. Some questions have only one answer and some have more than one or, at least, could have more than one. The way the questions are asked should tell you what is the case.

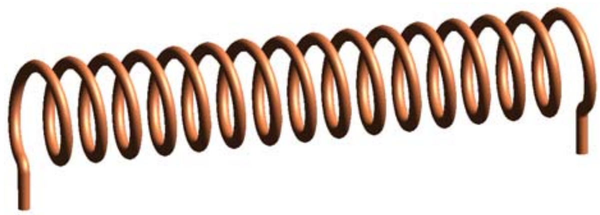
1. **Electric Field and Forces –** A parallel plate capacitor, with fixed plates, is modified as shown. A hole is drilled in the bottom plate and a bolt is passed through the hole. A nut is screwed onto the end outside of the capacitor making a pin with a stop on either end of it. Thus, the pin is free to move along the direction indicated by the arrow, but cannot move fully into or out of the E field region of the capacitor. The high voltage source driving the capacitor is sinusoidal, so that the top plate alternates between a positive and negative voltage. The bottom plate is grounded and the pin is electrically connected to the bottom plate.



Which of the following statements is true about this configuration?

a. There is no force on the pin so it will not move.
b. The pin will move toward the top plate when the voltage is positive and toward the bottom plate when the voltage is negative.
c. The pin will move toward the top plate when the voltage is either negative or positive.
d. The pin will move toward the bottom plate when the voltage is either negative or positive.
e. The pin will move toward the top plate when the voltage is negative and toward the bottom plate when the voltage is positive.

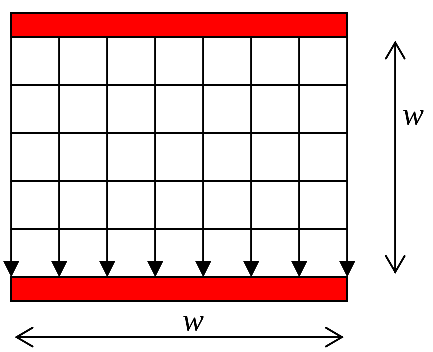
2. **Slinky Inductor** – A slinky is used to create an inductor. A large current is passed through the coil. Since the slinky is very flexible, the windings of the coil can move if they experience any force. Assume that the slinky is straight, like the inductor shown at the right.

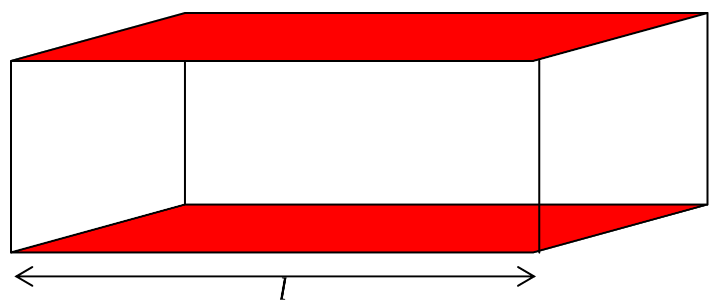


Which of the following statements are true about this current-carrying inductor?

a. There is no force, so the shape of the slinky will not change.
b. The length of the coil will increase.
c. The length of the coil will decrease.
d. The radius of the coil will increase
e. The radius of the coil will decrease.

3. **Ideal Parallel Plate Transmission Line** – A square cross-section parallel plate transmission line is to be treated as ideal. That is the equipotentials are all straight lines, as are the field lines (no fringing).





Assuming that the insulator is a simple dielectric with permittivity ε, which of the following is true about this line?

a. The characteristic impedance is $Z_o = \eta = \sqrt{\frac{\mu_o}{\varepsilon}}$

b. The characteristic impedance is $Z_o = \eta \frac{w}{l} = \sqrt{\frac{\mu_o}{\varepsilon}} \frac{w}{l}$

c. The characteristic impedance is $Z_o = \eta \frac{l}{w} = \sqrt{\frac{\mu_o}{\varepsilon}} \frac{l}{w}$

d. The characteristic impedance is $Z_o = \eta_o = \sqrt{\frac{\mu_o}{\varepsilon_o}}$

e. The characteristic impedance is $Z_o = 50\Omega$

4. **Resistance –** An odd experiment is performed to determine the effect of conductor shape on resistance. The shapes considered are the 26 capital letters. The two electrodes are flat and just touch the top and bottom of each letter, respectively. Which of the following statements are true?

ABCDEFGHIJKLMNOPQRSTUVWXYZ

- **a. The resistance of I is greater than the resistance of any other vowel.**
- b. The resistance of **E** is greater than the resistance of **F**.
- c. The resistance of **A** is greater than the resistance of **V**.
- **d. The resistance of R is less than the resistance of P or I.**
- **e. The combined resistance of EE is greater than the combined resistance of ME.**

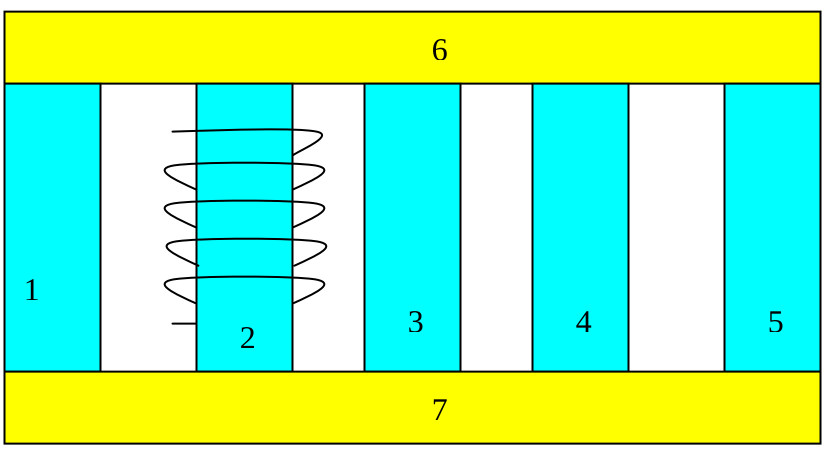
5. **Transmission Lines – Transients –** A *20V DC* source (battery), with an internal impedance of *1 Ohm* is connected to a *100m* long transmission line at time $t = 0$. The characteristic impedance of the transmission line is *50 Ohms* and the velocity of propagation is $u = 2x10^8 m/s$. There is no load on the line (open circuit). Which of the following statements are true?
   - **a. The voltage at the load is zero at time $t = 0$.**
   - **b. The voltage at the load is *20V* at time $t = \infty$.**
   - c. The voltage at the load is *9.8V* at time $t = \infty$.
   - d. The voltage at the load is *9.8V* at time $t = 500ns$
   - **e. The voltage at the load is *19.6V* at time $t = 500ns$**

6. **Transmission Line – Steady State –** For a sinusoidal voltage wave propagating down a lossless 50 Ohm transmission line, it is found that 80% of the power propagating toward the load resistance is dissipated in the load. This could happen for at least two different resistive loads. For which of the following will this be the case?
   - a. $R_L = 25\Omega$ or $R_L = 200\Omega$
   - b. $R_L = 33.3\Omega$ or $R_L = 75\Omega$
   - c. $R_L = 5.56\Omega$ or $R_L = 450\Omega$
   - d. $R_L = 2.8\Omega$ or $R_L = 897\Omega$
   - **e.** $R_L = 19\Omega$ **or** $R_L = 130.9\Omega$

7. **Uniform Plane Wave Propagation in Lossless or Lossy Media** – A uniform plane wave (average power density = 1000 W per square meter) is incident normally on the boundary of a lossy medium for which the complex relative permittivity is $\varepsilon_r = 8 - j0.08$. What is the approximate reflected power density and the power density absorbed as heat in the lossy medium? That is, which of the following answers is the closest to the actual answers?

   a. $S_{reflected} = 700\, W/m^2$ and $S_{absorbed} = 300\, W/m^2$
   b. $S_{reflected} = 337\, W/m^2$ and $S_{absorbed} = 663\, W/m^2$
   c. $S_{reflected} = 228\, W/m^2$ **and** $S_{absorbed} = 772\, W/m^2$
   d. $S_{reflected} = 400\, W/m^2$ and $S_{absorbed} = 600\, W/m^2$
   e. $S_{reflected} = 300\, W/m^2$ and $S_{absorbed} = 700\, W/m^2$

8. **Magnetic Circuit** – A magnetic circuit is configured as shown. All legs of the circuit are formed using square cross-section magnetic core materials. N turns of wire are wrapped around leg 2. The permeability of the vertical legs μ_v is not the same as the permeability of the horizontal legs μ_h. All vertical legs have the same dimensions as do all horizontal legs.



Which of the following statements are true?
   a. The magnetic flux in leg 2 is equal to the magnetic flux in leg 6 and leg 7.
   b. The magnetic flux in leg 1 is equal to the magnetic flux in leg 5.
   c. The total magnetic flux leaving any node in the magnetic circuit is zero
   d. The magnetic flux in leg 1 is three times the magnetic flux in legs 3, 4 and 5.
   e. The magnetic flux in leg 3 is equal to the magnetic flux in leg 5.

9. **Material Properties and Plane Waves** – A large slab of material is configured using a magnetic insulator. That is, the material is a good insulator, but also has magnetic properties. For the purposes of this problem, we will assume that the slab is infinitely thick, so we do not have to be concerned about reflections off of the back surface. The permeability is μ and the permittivity is ε. The former can be up to 1000 times greater than free space while the latter can be up to 10 times greater, for this problem. For all questions, assume there is some kind of material in region 2 so that only region 1 is free space.

Which of the following statements are true?

a. The intrinsic impedance of region 2 (the slab material) is always $\eta < \eta_o$

b. The intrinsic impedance of region 2 (the slab material) can be either $\eta > \eta_o$ or $\eta < \eta_o$, but not $\eta = \eta_o$.

c. The intrinsic impedance of region 2 (the slab material) is always $\eta > \eta_o$

d. The intrinsic impedance of region 2 (the slab material) can be either $\eta \geq \eta_o$ or $\eta \leq \eta_o$.

e. The intrinsic impedance of region 2 (the slab material) η can be 30 times greater than η_o.

10. **Solving Laplace's and/or Poisson's Equations** – A spherical shell of uniform surface charge density ρ_{so} is located at $r = a$. This charge is surrounded by a floating conducting shell in the region $2a \leq r \leq 3a$ If the voltage is referenced to zero at $r = \infty$, what is the value of the potential at the origin $r = 0$?

a. $\dfrac{2\rho_{so}a^2}{3\varepsilon_o}$

b. $\dfrac{7\rho_{so}a}{9\varepsilon_o}$

c. $\dfrac{5\rho_{so}a}{6\varepsilon_o}$

d. $\dfrac{\rho_{so}a}{6\varepsilon_o}$

e. $\dfrac{2\rho_{so}a^2}{3\varepsilon_o}$

11. **Using Ampere's Law to find Magnetic Fields** – An infinitely long, straight, cylindrical wire, diameter = *a*, carries a current *I*. Which of the following statements are true?
    - **a.** **The magnetic flux density B is zero on the axis of the wire.**
    - b. There is no magnetic flux inside the wire.
    - **c.** **The magnetic flux per unit length inside the wire is non-zero and finite.**
    - **d.** **The magnetic flux per unit length outside the wire is infinite**
    - e. The magnetic flux per unit length outside the wire is non-zero and finite
    - f. The magnetic flux outside the wire is zero

12. **Faraday's Law** – A swing set is constructed of metal as shown below. The chains that hold up the seat are also metal. Assume that the person in the swing has a voltmeter in their lap (that can measure both AC and DC) connected to the ends of the chains where they attach to the seat. The chains also make good electrical contact to the horizontal pipe from which they are suspended. Which of the following statements are true?

    - a. The voltage seen will always be zero.
    - b. The voltage seen can never be zero.
    - **c.** **The voltage will be periodic in time and small.**
    - **d.** **The general direction of the earth's field can be determined by noting whether the voltage is increasing or decreasing while swinging forward or backward, respectively.**
    - **e.** **The intensity of the voltage will vary with the direction of the horizontal pipe (shown with the arrow above).**
    - f. The intensity of the voltage will not vary with the location of the swing.