1. Suppose we have two closely wound circular coils of wire with the same number of turns, but the second coil has twice the radius of the other. Then when we compare the second coil to the first:
   (A) because the magnetic field for a given current is half the strength, but distributed over 4 times the area, the self inductance of the second coil should be twice that of the first.
   (B) because the magnetic field for a given current is twice the strength, but distributed over 4 times the area, the self inductance of the second coil should be 8 times that of the first.
   (C) because the magnetic field for a given current is the same strength, but distributed over 4 times the area, the self inductance of the second coil should be twice that of the first.
   (D) because the magnetic field for a given current is half the strength, but distributed over twice the area, the self inductance of the second coil should be twice that of the first.
   (E) the self inductance will be the same because they have the same number of coils!

2. A current $i$ goes through an ideal inductor in the direction indicated in the figure at right. If the current is increasing, then:
   (A) the potential at (a) is higher than at (b).
   (B) the potential at (a) is the same as at (b).
   (C) the potential at (a) is lower than at (b).
   (D) the potential at (a) is independent of the potential at (b).
   (E) none of the above.

3. An series LRC circuit is connected to a switch. The capacitor is initially charged when the switch is closed at $t=0$. Which graph below best describes the voltage across the capacitor as a function of time?

   (A) ![Graph A]
   (B) ![Graph B]
   (C) ![Graph C]
   (D) ![Graph D]
   (E) none of the above.

4. The LRC series circuit is analogous to:
   (A) the simple harmonic oscillator.
   (B) the damped harmonic oscillator.
   (C) sliding friction on an inclined plane.
   (D) free fall.
   (E) none of the above.
5. The impedance of a series RLC circuit as a function of frequency
   (A) is zero.
   (B) is actually constant.
   (C) is a maximum at the resonant frequency.
   (D) is a minimum at the resonant frequency.
   (E) is negative at frequencies above the resonant frequency.

6. The unit of reactance is:
   (A) Farads.
   (B) Ohms.
   (C) Henries.
   (D) Mhos.
   (E) Hertz.

7. The power delivered by the secondary in a step-up transformer is
   (A) greater than that delivered to the primary.
   (B) less than that delivered to the primary.
   (C) the same as that delivered to the primary.
   (D) independent of that delivered to the primary.
   (E) none of the above.

8. At an instant in time the Electric and Magnetic fields at appoint in space where there is an electromagnetic wave. The electric field is directed in the east and the magnetic field is directed up. The direction in which the wave is moving is
   (A) east.
   (B) up.
   (C) south.
   (D) north.
   (E) west.

9. The radiation pressure exerted on a transparent surface is
   (A) twice that exerted on a absorbing surface.
   (B) half that exerted on a absorbing surface.
   (C) twice that exerted on a reflecting surface.
   (D) half that exerted on a reflecting surface.
   (E) zero.

10. Electromagnetic waves in vacuum
    (A) travel at a speed which is independent the frequency of the waves.
    (B) are consistent with Maxwell's equations.
    (C) carry energy.
    (D) carry momentum.
    (E) all of the above.
11. As two positive charges are brought closer together
   (A) the repulsive force between them will decrease in magnitude.
   (B) the repulsive force between them will increase in magnitude.
   (C) the attractive force between them will decrease in magnitude.
   (D) the attractive force between them will increase in magnitude.
   (E) trick question since the force does not depend upon the separation between the charges.

12. A rectangular area is oriented in a uniform Electric field directed left to right in the geometries shown below. Which geometry results in the greatest electric flux through the area?

   (A)  
   (B)  
   (C)  
   (D)  
   (E) the flux is the same in all these cases.

13. The electric potential is
   (A) is potential energy per unit charge.
   (B) is electrical force per unit charge.
   (C) is simply electrical energy.
   (D) is simply electrical charge.
   (E) always zero within conductors.

14. The electric field lines at a certain location
   (A) never cross.
   (B) are parallel to the electric force on a test charge placed at that location.
   (C) are perpendicular to lines (surfaces) of constant electric potential at that location.
   (D) start on positive charges and end on negative charges.
   (E) all of the above.

15. The dielectric strength for a material is
   (A) the factor by which the capacitance increases when the material is inserted between the plates of a parallel plate capacitor.
   (B) the factor by which the magnitude of the electric field decreases when the material is inserted between the plates of a parallel plate capacitor.
   (C) the factor by which the potential decreases when the material is inserted between the plates of a parallel plate capacitor.
   (D) the maximum electric field the material can withstand before dielectric breakdown.
   (E) all of (A) through (C) above.
16. The current-voltage characteristics at right indicate a device whose resistance is
(a) increasing with increasing current.
(b) remaining constant.
(c) decreasing with increasing current.
(d) changing uncontrollable with increasing current.
(e) none of the above.

17. The principles used to analyze electrical circuits were
(a) conservation of energy and conservation of momentum.
(b) conservation of charge and conservation of momentum.
(c) symmetry and conservation of energy.
(d) conservation of energy and conservation of charge.
(e) all of the above.

18. The work done on a free electric charge by the magnetic force as the charge moves through the magnetic field will
(A) depend upon the direction of the velocity of the charge.
(B) depend upon the direction of the magnetic field.
(C) depend upon the speed of the charge.
(D) all of the above.
(E) always be zero.

19. The features (a) and (b) of the magnetization versus applied magnetic field plot at right are
(A) permanent magnetization and hysteresis, respectively.
(B) saturation and permanent magnetization, respectively.
(C) hysteresis and permanent magnetization, respectively.
(D) hysteresis and saturation, respectively.
(E) none of the above.

20. The magnetic field at the center of a loop of wire carrying a current clockwise will be
(A) clockwise.
(B) counterclockwise.
(C) into the page.
(D) out of the page.
(E) zero.
1) A long, straight solenoid has $N_s$ turns, a uniform cross-section area $A$, length $L$, and is filled with a material with magnetic permeability $\mu$. A coil with $N_c$ turns and radius $r$ is loosely wrapped around the outside of the solenoid as shown. If the solenoid carries a current $I$,

(A) determine the magnetic field within the solenoid in terms of the parameters given above,

(B) determine the total magnetic flux through the coil in terms of the parameters given above,

(C) use the above information to determine the mutual inductance in terms of the parameters given above.
2) For an LC circuit, the charge as a function of time is given by
\[ q(t) = Q \cos(\omega t + \phi) \]
\[ Q, \omega = 1/\sqrt{LC}, \phi \text{ are constants} \]
and the relation between the charge and the current is
\[ i = \frac{dq}{dt}. \]
The total energy of the circuit is given by the sum of the inductor's stored energy and the capacitor's stored energy:
\[ E = U_L + U_C = \frac{1}{2} Li^2 + \frac{1}{2C} q^2. \]
Show that rate of change of total energy,
\[ \frac{dE}{dt} = \frac{d}{dt} \left( \frac{1}{2} Li^2 + \frac{1}{2C} q^2 \right), \]
is equal to zero (that is, the total energy is constant!)
3. An L-R-C series circuit is constructed with a 2.00 H inductor, two resistors in series (R₁ = 200 Ω, R₂ = 40 Ω), and a 2.50 µF capacitor. If the circuit is driven by a 4.00 V (amplitude) source with a frequency of 200 rad/s, calculate the
(A) inductive reactance of the inductor,
(B) capacitive reactance of the capacitor,
(C) impedance of the entire series combination,
(D) the current amplitude for the current through the combination,
(E) the phase angle for the current relative to the voltage,
(F) the voltage amplitude for the capacitor,
(G) the voltage amplitude for the resistor R₂,
(H) the impedance of just the series combination of the inductor and R₁, and
(I) the voltage amplitude across just the series combination of the inductor and R₁.
4. It is proposed that powerful ground based lasers can provide means of propulsion for a space probe (similar to a solar sail). A 2000 Kg payload is supported by a circular reflecting sail 15 km in radius. The weight (i.e. force of gravitational attraction) just above the atmosphere is about 20.0E4 N. The force that must be provided by the sail is to just balance the gravitational attraction.

(A) What is the necessary radiation pressure on the sail (assume that sail is completely and uniformly illuminated)?

(B) What is the radiation intensity required for this pressure to be exerted on the reflecting sails?

(C) What is the minimum total power of the laser beam?

(D) What is the electric field amplitude within the beam?

(E) What is the magnetic field amplitude within the beam?
5. A +200 μC charge \( (Q_1) \) is placed at \( x = 0 \) m, \( y = 2 \) m. A −200μC charge \( (Q_2) \) is placed (2m,2m). A charge of +400μC charge \( (q) \) is located at (2m,2m).

(A) What are the components of the electric field at the location of \( q \) due to the other two charges? \( (q \) will effectively be the "test charge"

(B) What are the components the force on \( q \)?

(C) What is the electrostatic potential at the location of \( q \) due to the other two charges?

(D) What is the potential energy of \( q \) due to the presence of the other two charges?
6. In the figure at right, determine
   a) the equivalent capacitance of the capacitor,
   b) the charge on the equivalent capacitance,
   c) the energy stored in the equivalent capacitance,
   d) the charge on and voltage across each of the three individual capacitors, and
   e) the energy stored in the individual capacitors
7) In the figure shown at right, use Kirchoff’s laws to determine
(A) the unknown current $I$,
(B) the unknown emf $\mathcal{E}$, and the
(C) the unknown resistance $r$. 

![Circuit Diagram]
8) Charges are accelerated by an accelerating potential of 40 kV (of appropriate polarity for positive or negative charges) into a region of uniform magnetic field (directed out of the page).

If the charges are electrons,
(A) What is the speed of the electrons as they enter the magnetic field?

(B) Indicate the path of the electrons on the diagram at right (label the path e).

(C) What is the radius of the circular path taken by the electrons as they travel in the uniform magnetic field?

If the charges are protons,
(D) What is the speed of the protons as they enter the magnetic field?

(E) Indicate the path of the protons on the diagram at right (label the path p).

(F) What is the radius of the circular path taken by the protons as they travel in the uniform magnetic field?
Useful Constants:

- \( k = 9.0 \times 10^9 \text{ Nm}^2/\text{C}^2 \)
- \( \epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{N m}^2) \)
- \( e = 1.6 \times 10^{-19} \text{ C} \)
- \( m_e = 9.1 \times 10^{-31} \text{ kg} \)
- \( m_p = 1.67 \times 10^{-27} \text{ kg} \)
- \( 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} \)
- \( g = 9.8 \text{ m/s}^2 \)
- \( \mu_0 = 4\pi \times 10^{-7} \text{ N s}^2/\text{C}^2 \)
- \( c = 3.00 \times 10^8 \text{ m/s} \)
- \( 1u = 1.66 \times 10^{-27} \text{ kg} \)