Physics 114
Final 2020

Name ________________________

Clearly mark which problems will be graded If a problem or question is not to be graded write NG where the score would be recorded.

You need to do **10 of 12 questions and 6 of 7 problems.**

Questions	Score	Problems	Score
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8			
9			
10			
11			
12			

If you need help with these instructions, contact the instructor. If you do not follow the rules and end up doing too many problems (or questions), only the first ones in each category will be graded. If you do not do enough problems (or questions) in each category you will get a zero for the ones you do not do.

Each question is worth 5 points and each problem is worth 10 points.
Clearly give your reasoning for each question and problem.

If you are sending you answers on a separate piece of paper (that is not scanning a printout), clearly mark on a cover sheet which questions and problems to grade and not grade.

You have 3 hours to complete the exam. You must join the webex meeting throughout the exam and have the camera on. Do not leave the webex meeting until you have emailed your solutions. This is closed book exam – no extra notes or web pages.

Include a statement and signature that you have followed the honor code and not cheated on this exam.

Answer 10 of the following 12 Questions

1.

Suppose a point charge is located at the center of a spherical surface. The electric field at the surface of the sphere and total flux through the sphere are determined. Now the radius of the sphere is decreased by a factor of 3. What happens to the total flux through the sphere and the magnitude of the electric field at the surface of the sphere?

2.

What does it mean to say that the electrostatic force is conservative

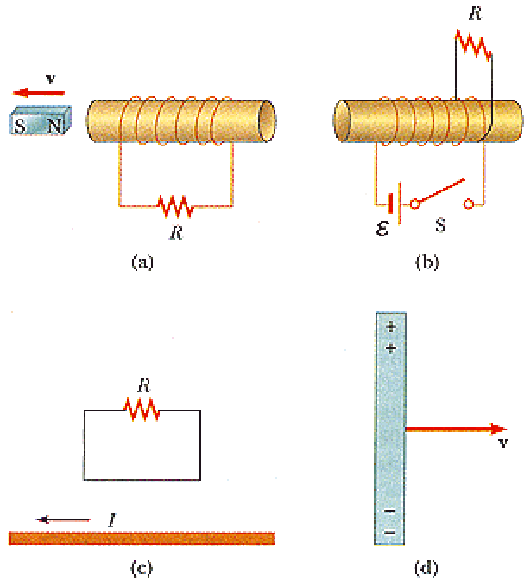
3.

If a charged particle moves in a straight line through some region of space, can one say that the magnetic field in that region is zero

4.

You connect an ideal battery to a resistor, producing a potential difference V across it and causing a current to flow through the resistor. Next, the resistor is removed from the circuit and cut in half crosswise (so its length is halved). One of the halves is placed back into the circuit, with the battery connected to it. (a) What happens to the potential difference across the resistor? (b) What happens to the current across the resistor? Now imagine the battery is real (that is it has internal resistance). (c) How would your answers to parts (a) and (b) change?

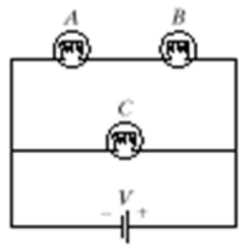
5. Use Lenz's law to answer the following questions concerning the direction of induced currents.



(a) What is the direction of the induced current in resistor R in Figure a when the bar magnet is moved to the left?
(b) What is the direction of the current induced in the resistor R right after the switch S in Figure b is closed?
(c) What is the direction of the induced current in R when the current I in Figure c decreases rapidly to zero?
(d) A copper bar is moved to the right, as in Figure d, while its axis is maintained perpendicularly to a large, uniform magnetic field. If the top of the bar becomes positive relative to the bottom, what is the direction of the magnetic field?

6.

6. The following circuit has three identical light bulbs connected to an ideal battery. (a) How do the brightnesses of the three bulbs compare? (b) Which draws the most current? (c) What happens to the brightness of A and B when C is unscrewed? (d) What happens to the brightness of B and



C if A is unscrewed?

7.

Three pith balls supported by insulating threads hang from a support. We know that ball Y is positively charged. When ball Y is brought near balls Z and X without touching them, it attracts Z and repels X. Since pith is an insulating material, what can we conclude (if anything) about the charges of Z and X?

8.

Two capacitors C_1 and C_2 are connected in a series connection. Suppose that their capacitances are in the ratio $C_2/C_1 = 2/1$. When a potential difference, V, is applied across the capacitors,

(a) What is the ratio of the charges Q_2 and Q_1 on the capacitors, Q_2/Q_1 ?

(b) What is the ratio of voltage drops across them, V_2/V_1?

(c) What is the ratio of energy stored in them?

Now imagine the capacitors are placed in parallel instead of in series, now what are

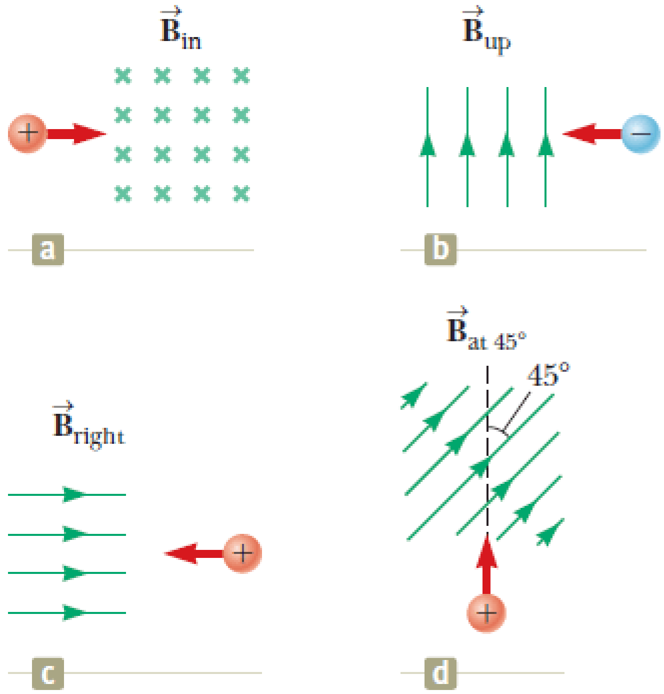
(d) Q_2/Q_1 and

(e) V_2/V_1?

(f) the ratio of the energy in each now (that they are in parallel)

(g) Which pair is more dangerous to handle; the ones in parallel or the ones in series- why (assuming they are connected to the same voltage)?

9. Determine the initial direction of the deflection of the charged particles as they enter the magnetic field shown



10.

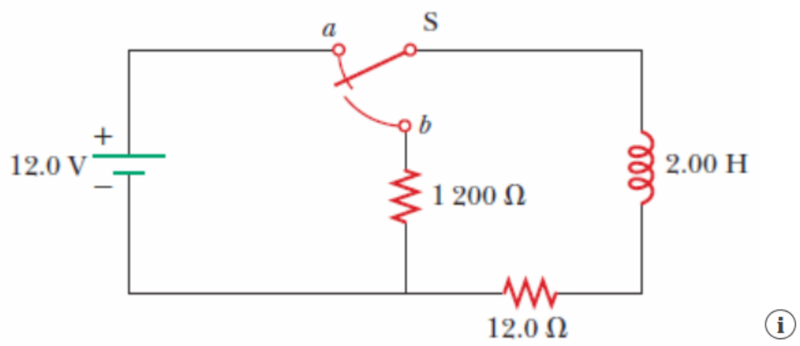
An electron is moving in a constant electric field parallel to the x axis. At the origin, its speed is 2×10^6 m/s and at $x = 2$ cm its speed is 4×10^6 m/s. (a) Is the electron's potential energy in the electric field increasing or decreasing. (b) Is it moving towards a point of higher or lower electric potential?

11.

A planar electromagnetic wave is propagating through space. Its electric field vector is given by $\mathbf{E} = E_o \cos(kz - \mathrm{w}t)\ \hat{\imath}$. Write an expression for its Magnetic field. [Your answer can be in terms of E_o, k, w and c].

12.

In the figure below, the switch is left in position *a* for a long time interval and is then quickly thrown to position *b*. Rank the magnitudes of the voltages across the four circuit elements a short time thereafter from the largest to the smallest.



Answer 6 of the following 7 Problems

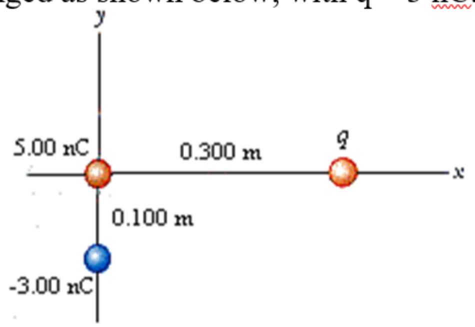
1.

A solid conducting sphere of radius 2.00 cm has a charge 4.00 μC. A conducting spherical shell of inner radius 4.00 cm and outer radius 5.00 cm is concentric with the solid sphere and has a charge -4.00 μC. (Take radially outward as the positive direction.)

(a) Find the electric field at r = 1.00 cm from the center of this charge configuration.
(b) Find the electric field at r = 3.00 cm from the center of this charge configuration.
(c) Find the electric field at r = 4.50 cm from the center of this charge configuration.
(d) Find the electric field at r = 7.00 cm from the center of this charge configuration.

2.

Three point charges are arranged as shown below, with q = 3 nC.



Imagine the 5.00 nC is taken away.

(a) Find the vector electric field that the **q = 3 nC** and -3.00 nC charges together create at the origin.

(b) What is the electric potential at the origin?

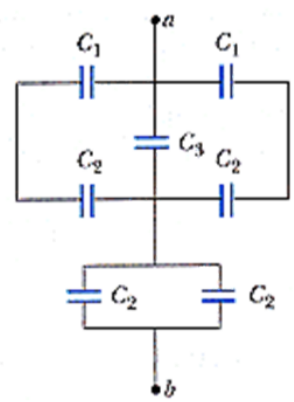
Now imagine the 5.00 nC charge is put back.

(c) Find the vector force on the 5.00 nC charge.

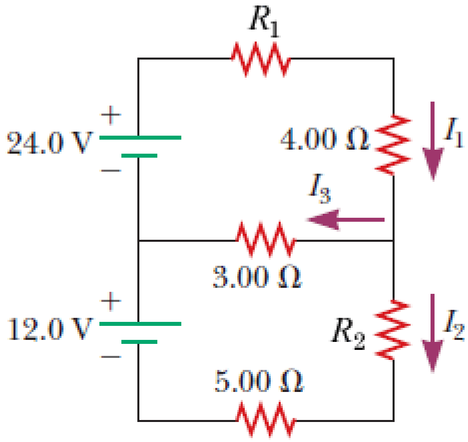
(d) Find the electric potential energy of the system of three charges.

3.

(a) Find the equivalent capacitance between points a and b for the group of capacitors connected as shown in Figure below if $C_1 = 5.00\ \mu F$, $C_2 = 10.0\ \mu F$, and $C_3 = 2.00\ \mu F$. (b) Find the charge stored on C_3 if a potential difference of 30.0 V is applied between points a and b



4. Consider the figure below. (Let $R_1 = 2.0\ \Omega$, and $R_2 = 1.0\ \Omega$.)



(a) Which resistors are in series (if any)?
(b) Which resistors are in parallel?
(c) Use Kirchoff's junction rule to obtain an equation relating I_1, I_2, and I_3.
(d) Apply Kirchoff's loop rule to the top loop to obtain an equation relating I_1 and I_3.
(e) Apply Kirchoff's loop rule to the bottom loop to obtain an equation relating I_2 and I_3

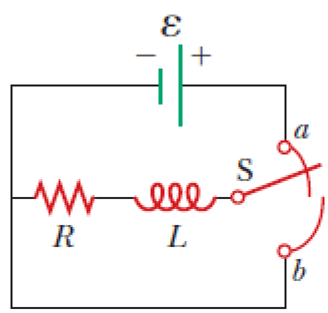
5.

An electron is projected into a uniform magnetic field **B** = (1.40 **i** + 2.10 **j**) T. Find the vector expression for the force on the electron when its velocity is **v** = 3.70 x 10^4 **j** m/s.

6.

An inductor in the form of a solenoid contains 420 turns, is 16.0 cm in length, and has a cross-sectional area of 3.00 cm^2. What uniform rate of decrease of current through the inductor induces an emf of 175 mV?

7. A 140-mH inductor and a 4.9 Ω resistor are connected with a switch to a 6.00-V battery as shown in the figure below.



(a) After the switch is first thrown to *a* (connecting the battery), what time interval elapses before the current reaches 220 mA?
(b) What is the current in the inductor 100.0 s after the switch is closed?
(c) Now the switch is quickly thrown from *a* to *b*. What time interval elapses before the current in the inductor falls to 160 mA?

Possibly Useful Information

$$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$$

$e = 1.6 \text{ X } 10^{-19}$ C, $m_e = 9.11 \text{ x } 10^{-31}$ Kg
$m_p = 1.67 \text{ x } 10^{-27}$ Kg

$$E = \frac{|q|}{4\pi\varepsilon_0 r^2}$$

$\Delta x = x_2 - x_1$, $\Delta t = t_2 - t_1$

$\bar{s} = (\text{total distance}) / \Delta t$

$\bar{a} = \Delta v / \Delta t$

$v = v_o + at$

$x - x_o = v_o t + (½)at^2$

$v^2 = v_o^2 + 2a(x - x_o)$

$x - x_o = ½(v_o + v)t$

$x - x_o = vt - 1/2at^2$

$\vec{a} = d\vec{v} / dt$

$\Delta U = U_f - U_i = -W$
$\Delta V = V_f - V_i = -W/q_0 = \Delta U/q_0$

$$V_f - V_i = -\int_i^f \vec{E}.d\vec{s}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$E = \sigma/\varepsilon_0$

$$E_s = \frac{\partial V}{\partial s}$$

$$E = \frac{\Delta V}{\Delta s}$$

$Q = CV$

$$C = 2\pi\varepsilon_0 \frac{l}{\ln(b/a)}$$

$$C = 4\pi\varepsilon_0 R$$

$\varepsilon_o = 8.85 \text{ X } 10^{-12} (C^2 / N - m^2)$

$$\vec{E} = \vec{F}/q_0$$

$$\varepsilon_0 \Phi = \varepsilon_0 \oint \vec{E}.d\vec{A} = q_{enc}$$

$\bar{v} = \Delta x / \Delta t$

$v = dx/dt$

$a = dv/dt = d^2x/dt^2$

$g = 9.8 \text{ m/s}^2$

$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$

$\Delta\vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$

$\bar{\vec{v}} = \Delta\vec{r} / \Delta t$, $\vec{v} = d\vec{r} / dt$

$\bar{\vec{a}} = \Delta\vec{v} / \Delta t$

$U = -W_\infty$
$V = -W_\infty/q_0$

$$V = -\int_i^f \vec{E}.d\vec{s}$$

$$V = \sum_{i=1}^n V_i = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^n \frac{q_i}{r_i}$$

$$V = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r}$$

$$E_x = -\frac{\partial V}{\partial x}; E_y = -\frac{\partial V}{\partial y}; E_z = -\frac{\partial V}{\partial z}$$

$$U = -W = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$C = 4\pi\varepsilon_0 \frac{ab}{b-a}$$

$C_{eq} = \sum C_j$ (parallel)

$$\frac{1}{C_{eq}} = \sum \frac{1}{C_j} \text{ (series)}$$

$$U = \frac{Q^2}{2C} = \tfrac{1}{2} CV^2$$

$u = \tfrac{1}{2}\varepsilon_0 E^2$

$C = \kappa C_0$

I= dQ/dt

$\rho = 1/\sigma$

$R = \rho L / A$

V = IR

P = IV

$P = I^2R = V^2/R$

$I = \varepsilon / (R + r)$

$P_{emf} = I\varepsilon$

$$R_{eq} = \sum R_j \text{ (series)}$$

$q(t) = Q(1-e^{-t/RC})$

$$\frac{1}{R_{eq}} = \sum \frac{1}{R_j} \text{ (parallel)}$$

$I = (\varepsilon/R)e^{-t/RC}$

$q(t) = Qe^{t/RC}$

$I = (Q/RC)e^{-t/RC}$, $I_0 = (Q/RC)$

$\vec{F} = q\vec{v} \times \vec{B}$

$\vec{F} = I\vec{L} \times \vec{B}$

$d\vec{F} = Id\vec{s} \times \vec{B}$

$\tau = \vec{\mu} \times \vec{B}$

$\vec{\mu} = NI\vec{A}$

$d\vec{B} = \frac{\mu_0}{4\pi} \frac{Id\vec{s} \times \vec{r}}{r^3}$, $\mu_0 = 4\pi \times 10^{-7}$ T·m/A

$$\mathbf{B} = \frac{\mu_0 I}{4\pi} \int \frac{d\mathbf{s} \times \hat{\mathbf{r}}}{r^2}$$

$$B = \frac{\mu_0 I}{4\pi a}\left(\cos\theta_1 + \cos\theta_2\right)$$

$B = \mu_0 I/2\pi r$

$B = \mu_0 nI$ (solenoid)

$F/l = (\mu_0 I_1 I_2)/2\pi a$

$\oint \vec{B}.d\vec{s} = \mu_0 I_{enc}$

$B = (\mu_0 I/4\pi r)[\cos(\theta 1) + \cos(\theta 2)]$

$B = (\mu_0 IN)/(2\pi r)$ (toroid)

$\Phi_B = \int \vec{B}.d\vec{A}$

$L = N\Phi / I$

$\varepsilon = \oint \vec{E}.d\vec{s} = -N \, d\Phi_B / dt$

$\varepsilon = -L\, dI/dt$

$L = \mu_0 N^2 A/l$

$I = I_0 e^{-t/\tau}$

$I = (\varepsilon/R)(1-e^{-t/\tau})$, $\tau = L/R$

Inductance = NΦ/I

$U_B = (1/2)LI^2$

$$\omega = \frac{1}{\sqrt{LC}}$$

$E_0 = cB_0$

$\mu_B = B^2/(2\mu_0)$

$$\mathbf{E}(x, y, z, t) = \mathbf{E}_0 \sin(kx - \omega t)$$

$$\mathbf{B}(x, y, z, t) = \mathbf{B}_0 \sin(kx - \omega t)$$