Multiple choice questions. Circle the correct answer. No work needs to be shown and no partial credit will be given.

(6 pts) 1. A thick spherical shell made of conducting metal has inner radius \( R_1 = 0.200 \text{ m} \) and outer radius \( R_2 = 0.300 \text{ m} \). The shell has a net charge of \( q_1 = -7.0 \times 10^{-9} \text{ C} \). At the center of the hollow space inside the shell there is a very small sphere that has charge \( q_2 = +3.0 \times 10^{-9} \text{ C} \). What is the magnitude of the resultant electric field at a distance of \( r = 0.500 \text{ m} \) from the center of the shell?

(a) zero  
(b) 72 N/C  
(c) 108 N/C  
(d) 144 N/C  
(e) 180 N/C  
(f) 252 N/C  
(g) None of the above answers

(6 pts) 2. In a region of space near the origin there is a uniform electric field \( \vec{E} \) that is in the +y-direction. A very small object with negative charge is at the origin. The direction of the force that the field \( \vec{E} \) exerts on the object is

(a) +x  
(b) −x  
(c) +y  
(d) −y  
(e) +z  
(f) −z

(6 pts) 3. A negative point charge \( q \) is at the origin. What is the direction of the electric field produced by this field at point \( P \), which is on the +y-axis at \( y = +0.200 \text{ m} \)?

(a) +x  
(b) −x  
(c) +y  
(d) −y  
(e) +z  
(f) −z
4. The circuit shown in the sketch consists of a battery with zero internal resistance, three identical resistors and a switch that is initially open. When the switch is closed, the current $I$ that flows through the battery
(a) increases
(b) decreases
(c) stays the same

5. The circuit shown in the sketch consists of two resistors and a battery with negligible internal resistance. $R_1 = 2.0 \, \Omega$ and $R_2 = 4.0 \, \Omega$. The current in resistor $R_1$ is $I_1 = 3.0 \, A$. The rate at which electrical energy is being consumed (dissipated) in the resistor $R_2$ is
(a) zero
(b) $9.0 \, W$
(c) $16.0 \, W$
(d) $36.0 \, W$
(e) $64.0 \, W$
(f) $144.0 \, W$
(g) none of the above answers

On the following problems show all your work. Partial credit will be given, if earned. Write your answers in the blanks provided. All answers must include the correct plus or minus sign and the correct units.

6. Positive point charge $q_1 = +6.0 \times 10^{-9} \, C$ is at the origin and negative point charge $q_2 = -4.0 \times 10^{-9} \, C$ is on the negative x-axis at $x = -0.200 \, m$. Point $A$ is on the $+x$-axis at $x = 0.100 \, m$ and point $B$ is on the $+x$-axis at $x = 0.300 \, m$. How much work does the resultant electric field of $q_1$ and $q_2$ do on a third point charge $q_3 = -5.0 \times 10^{-3} \, C$ when it moves from point $A$ to point $B$?

Ans. $-1.56 \, J$
7. The circuit shown in the sketch consists of a battery and two capacitors. \( C_1 = 3.0 \times 10^{-9} \) F and \( C_2 = 6.0 \times 10^{-9} \) F. The charge on capacitor \( C_1 \) is \( Q_1 = 5.0 \times 10^{-9} \) C.

- a) What is \( Q_2 \), the charge on capacitor \( C_2 \)?
  
  Ans. \( 1.00 \times 10^{-8} \) C

- b) What is the emf of the battery?
  
  Ans. \( 1.67 \) V

8. An air-filled parallel-plate capacitor has capacitance \( C = 8.0 \times 10^{-9} \) F. The distance between its plates is 4.0 mm. The capacitor is connected to a battery that has emf 48.0 V until it is fully charged and then it is disconnected from the battery without being discharged. After the capacitor is disconnected from the battery, a dielectric with dielectric constant \( K = 3.0 \) is inserted between the plates of the capacitor. After the dielectric has been inserted, what is

- a) the potential difference between the plates of the capacitor?
  
  Ans. \( 16.0 \) V

- b) the magnitude of the electric field at a point midway between the plates?
  
  Ans. \( 4.0 \times 10^2 \) V/m
(18 pts) 9. A positive point charge $q_1 = +4.0 \times 10^{-9}$ C is at the origin and a negative point charge $q_2 = -8.0 \times 10^{-9}$ C is on the negative x-axis at $x = -0.400$ m. Point $P$ is on the negative y-axis at $y = -0.300$ m. What are the $x$ and $y$ components of the resultant electric field produced by $q_1$ and $q_2$ at point $P$? (In each case be sure to indicate if your answer is positive or negative.)

Ans. $x$ component $-230 \ \text{N/C}$

$y$ component $-227 \ \text{N/C}$