1. A point charge of 10 nano-coulombs is located at the center of a cube. Each of the six faces of the cube is 25 cm. by 25 cm. in size. What is the total electric flux through the surface of the cube?

A) 8.85 x 10^{-12} \text{N} \cdot \text{m}^2/\text{C}  
B) 1130 \text{N} \cdot \text{m}^2/\text{C}  
C) 188 \text{N} \cdot \text{m}^2/\text{C}  
D) 0.0 \text{N} \cdot \text{m}^2/\text{C}  
E) 94.2 \text{N} \cdot \text{m}^2/\text{C}

2. The circular surface shown in the sketch has a radius of 10 cm. It is immersed in a uniform electric field with magnitude 120N/C. The field lines make a 45° angle with the vector normal to the surface, as shown in the sketch. What is the electric flux through the surface in N.m^2/C:

A) 7.1 x 10^{-3}  
B) 2.7  
C) 3.8  
D) -0.098  
E) 9.4

3. A positive charge Q = 25 nC is placed inside the cavity of an egg shaped, electrically neutral conducting shell as shown. How much charge will be induced on the inner and outer surfaces of the shell?

A. \(Q_{\text{inner}} = 25 \text{ C.} \) \(Q_{\text{outer}} = 0 \text{ C} \)
B. \(Q_{\text{inner}} = 0 \text{ nC.} \) \(Q_{\text{outer}} = +25 \text{ nC} \)
C. \(Q_{\text{inner}} = -25 \text{ nC.} \) \(Q_{\text{outer}} = 0 \text{ C} \)
D. \(Q_{\text{inner}} = -25 \text{ nC.} \) \(Q_{\text{outer}} = +25 \text{ nC} \)
E. \(Q_{\text{inner}} = 25 \text{ nC.} \) \(Q_{\text{outer}} = -25 \text{ nC} \)
4. Four point charges are located at the corners of a diamond-shaped parallelogram as shown in the sketch. The value of \( Q = 20 \, \mu C \). The length of each side of the figure is \( a = 30 \, \text{cm} \), with an 60° angle located as shown. The potential at infinity is the zero reference level. Find an expression for the electric potential \( V \) at point \( P \), the center of the diamond shape.

Note: \( k_e \) is the constant \( 1 / 4\pi\varepsilon_0 \)

A) \( V = 0 \)
B) \( V = \frac{2k_e Q}{a\sqrt{3}} \)
C) \( V = \frac{-4k_e Q}{a} \)
D) \( V = \frac{-k_e Q}{a\sqrt{3}} \)
E) \( V = \frac{-2k_e Q}{a} \)

5. Find the electric field 0.3 cm away from an infinitely long thin charged line with linear charge density \( \lambda = 2.0 \, \mu C/m \).

A. \( 12 \times 10^6 \, \text{V/m} \)
B. \( 12 \times 10^7 \, \text{V/m} \)
C. \( 4.5 \times 10^5 \, \text{V/m} \)
D. \( 9 \times 10^9 \, \text{V/m} \)
E. \( 4.5 \times 10^6 \, \text{V/m} \)

6. The equi-potential surfaces near an infinite charged sheet are planes. If the potential difference between a pair of equi-potentials that are 8 meters apart is 1200 volts, what is the magnitude of the electric field between the sheets?

A) \( 1.7 \times 10^{-3} \, \text{V/m} \)
B) 300 \, \text{V/m} 
C) 150 \, \text{V/m} 
D) 2400 \, \text{V/m} 
E) \( 1.7 \times 10^{13} \, \text{V/m} \)
7. A metal sphere is charged to a potential of 300 volts. Its radius is 2 meters. The potential at a point 1 meter from the center of the sphere is:
A) 300 V.
B) -100 V.
C) – 300 V.
D) 0 V.
E) 100 V.

8. An electron is moved through a displacement \( \Delta x \) parallel to the direction of a uniform electric field. During this displacement:
A) the potential energy of the electron and the electric potential do not change.
B) the potential energy of the electron increases, the electric potential increases.
C) the potential energy of the electron increases, the electric potential decreases.
D) the potential energy of the electron decreases, the electric potential decreases.
E) the potential energy of the electron decreases, the electric potential increases.

9. The capacitor in the sketch has a capacitance of 24.0 \( \mu F \) and is initially uncharged. The battery maintains a potential difference of 3.0 V. How much total charge flows out of the battery until the capacitor is fully charged (the current stops flowing)?
A) 3.20 \( \mu C \)
B) 8.00 \( \mu C \)
C) 72.0 \( \mu C \)
D) 12,000 \( \mu C \)
E) 30.0 \( \mu C \)

10. A parallel plate capacitor being designed is supposed to have a capacitance of 400 pF (1 pF = 10\(^{-12}\) F = 10\(^{-6}\) \( \mu F \)). It will be filled with a material whose dielectric constant is close to 1.5 (glass). The distance between plates will be 0.3mm. Approximately, what should the area of the plates be?
A) 1.10 m\(^2\)
B) 0.028 m\(^2\)
C) 0.014 m\(^2\)
D) 0.009 m\(^2\)
E) 0.9 m\(^2\)
11. Three capacitors are connected in the series/parallel arrangement shown in the sketch. Suppose $C_1 = 30\mu\text{F}$, $C_2 = 30\mu\text{F}$, and $C_3 = 15\mu\text{F}$. The potential difference across the combination $V_{ab} = 40\text{ V}$. The equivalent capacitance between points a and b is closest to:

A) 15 $\mu\text{F}$  
B) 30 $\mu\text{F}$  
C) 7.5 $\mu\text{F}$  
D) 45 $\mu\text{F}$  
E) 12 $\mu\text{F}$

12. In problem 11, calculate the voltage across capacitor $C_2$ (in volts)

A) 60  
B) 40  
C) 10  
D) 20  
E) $6\times10^{-4}$

13. Two wires made of the same material are joined end-to-end and a potential difference is maintained across the combination, from a to b in the sketch. The thin wire has cross sectional area $A/3$ and length $L$. The fatter wire has area $A$ and length $2L$. Which of the following quantities are the same for both wires:

1. The resistivity of each wire  
2. The resistance of each wire  
3. The current density inside each wire  
4. The current through each wire  
5. The potential difference across each wire

A) 1, 2, and 3  
B) 1, 2, 4, and 5  
C) 1 only  
D) 2 only  
E) 1 and 4 only
14. In the circuit shown in the sketch, switches S₁ and S₂ are initially open. Capacitor C₁ = 30.0 nF is then charged by closing switch S₁ which connects it to the battery whose EMF $\mathcal{E} = 90$ V. Switch S₁ is then opened, thereby disconnecting C₁ from the battery. Switch S₂ is then closed, thereby connecting the charged capacitor C₁ to the uncharged 15.0 nF capacitor C₂. Find the final potential difference across capacitors C₁ and C₂. (Hint: after being disconnected, the total charge on the combination C₁, C₂ remains constant).

A. 60 V  
B. 30 V  
C. 4 V  
D. 10 V  
E. 120 V

15. For the previous problem, the final charge on capacitor C₁ is closest to:

A) 2.0 µC  
B) 0.8 nC  
C) 0.2 µC  
D) 1.2 nC  
E) 1.8 µC

16. Assume that the batteries in the figure have negligible internal resistance. Assume that the current flows counterclockwise. Find the magnitude of the current in the circuit and the power dissipated in resistor R₁.

A) $i = 0.67$ A, $P_1 = 2.7$ watts  
B) $i = 1.33$ A, $P_1 = 5.4$ watts  
C) $i = 1.5$ A, $P_1 = 24$ watts  
D) $i = 0.67$ A, $P_1 = 1.8$ watts  
E) $i = 1.5$ A, $P_1 = 9$ watts
Extra Credit:

17. The sketch shows edge views of two parallel conducting sheets with identical positive charges \( Q = 4 \mu\text{C} \) on each. The area of each plate area is 2 m\(^2\). What is the electric field \( E_{IN} \) midway between the plates; also, what is \( E_p \) at point P, which is 1 mm above the upper plate as shown? Hint: The dashed line Gaussian surfaces may be helpful.

A) \( E_{IN} = 0, \quad E_p = 5.65 \times 10^4 \text{ V/m} \)
B) \( E_{IN} = 0, \quad E_p = 2.26 \times 10^5 \text{ V/m} \)
C) \( E_{IN} = 1.1 \times 10^5 \text{ V/m}, \quad E_p = \text{zero} \)
D) \( E_{IN} = 0, \quad E_p = 1.1 \times 10^5 \text{ V/m} \)
E) \( E_{IN} = 0, \quad E_p = 0 \)

18. The figure shows a plastic rod of length \( L = 2.5 \text{ m} \), with a non-uniform linear charge density \( \lambda = \alpha x \) with \( \alpha = 10^{-3} \text{ C/m}^2 \). The rod is lying on the x axis. Assuming \( V = 0 \) at infinity, find the electric potential (in volts) at the left end of the rod – in other words, at the origin. Select the closest answer.

A) Zero
B) \( 2.7 \times 10^{10} \text{ volts} \)
C) \( 2.25 \times 10^7 \text{ volts} \)
D) \( 1.35 \times 10^8 \text{ volts} \)
E) Infinity
ANSWER KEY: Fall 2010 Physics 121 Common Exam 2, Version D

1. B
2. B
3. D
4. E
5. A
6. C
7. A
8. C
9. C
10. D
11. B
12. D
13. E
14. A
15. E
16. D
17. B
18. C
1. Potential energy of point-charges: Consider the group of three +2.4 nC point charges shown in the figure. What is the electric potential energy of this system of charges relative to infinity? 
\( (k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \)

A) \(4.1 \times 10^{-6} \text{ J}\)  
B) \(4.6 \times 10^{-6} \text{ J}\)  
C) \(4.2 \times 10^{-6} \text{ J}\)  
D) \(4.4 \times 10^{-6} \text{ J}\)

2. The resistivity of gold is \(2.44 \times 10^{-8} \Omega \cdot \text{m}\) at room temperature. A gold wire that is 1.8 mm in diameter and 11 cm long carries a current of 170 mA. How much power is dissipated in the wire? 
A) \(0.030 \text{ mW}\)  
B) \(0.0076 \text{ mW}\)  
C) \(0.013 \text{ mW}\)  
D) \(0.019 \text{ mW}\)  
E) \(0.025 \text{ mW}\)

3. Potential energy of point-charges: An electron is released from rest at a distance of 9.00 cm from a proton. If the proton is held in place, how fast will the electron be moving when it is 3.00 cm from the proton? \( (m_{\text{el}} = 9.11 \times 10^{-31} \text{ kg}, e = 1.60 \times 10^{-19} \text{ C}, k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2) \)
A) \(75.0 \text{ m/s}\)  
B) \(106 \text{ m/s}\)  
C) \(130 \text{ m/s}\)  
D) \(1.06 \times 10^3 \text{ m/s}\)  
E) \(4.64 \times 10^5 \text{ m/s}\)
4. A certain electric furnace consumes 24 kW when it is connected to a 240-V line. What is the resistance of the furnace?
   A) 1.0 kΩ
   B) 10 Ω
   C) 2.4 Ω
   D) 0.42 Ω
   E) 100 Ω

5. A 1500-W heater is connected to a 120-V line. How much heat energy does it produce in 2.0 hours?
   A) 1.5 kJ
   B) 3.0 kJ
   C) 0.18 MJ
   D) 11 MJ
   E) 18 MJ