AP Physics C Name: _____

Unit 2&3 Test: Electric Potential, Conductor & Capacitance Period: _____

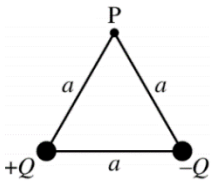
Part 1: Multiple Choice - Choose the answers that best answers the questions below. If an exact answer is not present, chose the closest available answer. (4 points each)

1. The electric potential along an x-axis is given by the expression, $V(x) = 12x - 2x^2$, where a and b are constants. At point is the electric field zero?
   A) (3,0) B) (6, 0) C) (2,0) D) (0,0) E) (4, 0)

2. A small sphere of mass m and charge $-q$ is released from rest at point T. If the electric potentials at points S and T are V_S and V_T, respectively, what is the speed of the sphere when it reaches point S. Ignore the effects of gravity.
   A) $\frac{2q}{m}(V_S + V_T)$ B) $\frac{4q}{m}(V_S + V_T)$ C) $\sqrt{\frac{q}{2m}(V_S + V_T)}$
   D) $\sqrt{\frac{q}{2m}(V_S - V_T)}$ E) $\sqrt{\frac{2q}{m}(V_S - V_T)}$

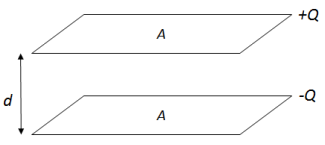
3. The electric field is zero everywhere within a certain region of space. The electric potential in this region:
   A) must be zero
   B) must be uniform
   C) must be positive
   D) must be negative
   E) olive the above

4. Two small sphere have charges +Q and –Q are located at the bottom corners of an equilateral triangle, as shown. The equilateral triangles has sides of length a, and point P is at the top corner of the triangle. The electric potential at point P due to the two spheres is:



   A) Zero B) $\frac{Q}{4\pi\varepsilon_0 a}$ C) $\frac{Q}{4\pi\varepsilon_0 a^2}$
   D) $\frac{Q}{2\pi\varepsilon_0 a}$ E) $\frac{Q}{2\pi\varepsilon_0 a^2}$

5. A parallel-plate capacitor consists of 2 charged conducting plates of equal area, A. Each plate has a charge magnitude Q. The upper plate has a charge of $+Q$ and the lower plate has a charge of $-Q$. The plates are separated by a distance d.



   What is the magnitude of the electric field in the region between the plates?
   A) $\frac{2Q}{A\varepsilon_0}$ B) $\frac{Q}{2A\varepsilon_0}$ C) $\frac{Q}{A\varepsilon_0}$ D) $\frac{Q}{d\varepsilon_0}$ E) $\frac{2Q}{d\varepsilon_0}$

6. A capacitor stores energy U_1 when it holds charge Q. The same capacitor stores U_2 when it holds charge $16Q$. What is the ratio U_2/U_1?
   A) 8 B) 16 C) 64 D) 128 E) 256

7. If the power required to move a +2.50 C charge from point **A** to point **B** in 10 seconds is 50 W, what is the potential difference between the two points?
   A) 0 V B) 500 V C) 13 V D) 250 V E) 200 V

(8-9) A capacitor is constructed of two large, identical parallel metal plates seperated by a small distance d. A battery fully charges the capacitor and is then disconnected.

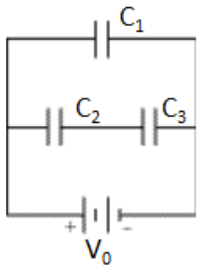
8. The plate seperation is now increased to a distance of $2d$. Which of the following correctly describes the changes, if any, of the voltage across the capactior, the electric field between the plates, and the energy stored in the capactior.

	Voltage	Electric Field	Energy
A)	Doubles	Doubles	Doubles
B)	Doubles	Does not change	Doubles
C)	Doubles	Doubles	Does not change
D)	Does not change	Doubles	Does not change
E)	Does not change	Does not change	Does not change

9. Instead of seperating the plaes, the empty space between the plates is filled with a slab of insulating material that has a dielectric constant of $\kappa = 2$ Which of the following correctly describes the changes, if any, of the voltage across the capactior, the electric field between the plates, and the energy stored in the capactior.

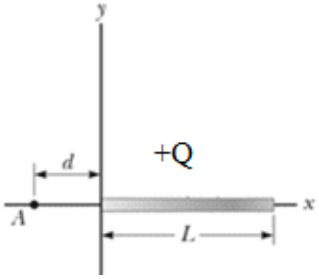
	Voltage	Electric Field	Energy
A)	Halves	Halves	Halves
B)	Halves	Halves	Does not change
C)	Does not change	Halves	Halves
D)	Does not change	Does not change	Halves
E)	Does not change	Does not change	Does not change

10. Refer to the picture on the right, where C_1 = 5.0 μF, C_2 = 15 μF, C_3 = 30 μF, and V_0 = 24 V. Find the total equivalent charge in the circuit.



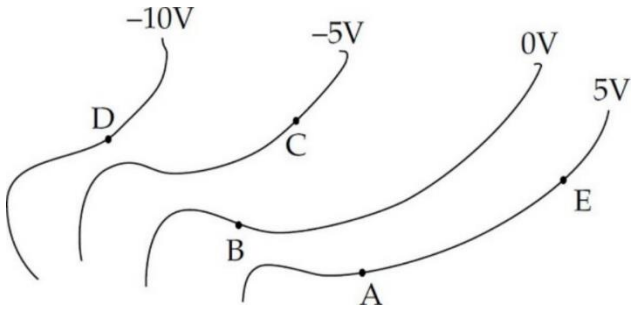
A) 360 μC
B) 288 μC
C) 1.20 mC
D) 80 μC
E) 12 μC

11. A rod of uniform charge Q extends from the origin to (L,0) as shown. Which gives the value of the electric potential at point A, which is at (-d,0)?



A) $\frac{Q}{4\pi\varepsilon_0 L}\int_0^L \frac{dx}{(x+d)}$
B) $\frac{Q}{4\pi\varepsilon_0 L}\int_0^L \frac{dx}{(x-d)^2}$
C) $\frac{Q}{4\pi\varepsilon_0 L}\int_{-d}^0 \frac{dx}{L+x}$
D) $\frac{Q}{4\pi\varepsilon_0 L}\int_{-d}^0 \frac{dx}{L-x}$
E) $\frac{Q}{4\pi\varepsilon_0 L}\int_0^L \frac{dx}{(x+d)^2}$

(12-13) Consider a field with the equipotential lines shown.



12. What is the direction of the field at point E?

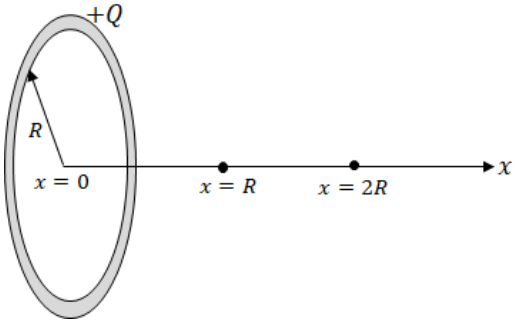
A) ← B) ↙ C) ↘

D) → E) ↖

13. A charged particle of charge $q = -4\ \mu C$ is moved from rest at point D on the diagram to rest at point A through the field shown on the diagram using the path DCBEA. What is the work required to accomplish this task?

A) -60 μJ B) 20 μJ C) -80 μJ D) 60 μJ E) -80 μJ

14. A thin ring of radius R has charge +Q distributed uniformly around the ring. The center of the ring is at the origin of an x-axis that is perpendicular to the plane of the ring. A point charge of +q at positive x = R is released from rest. What is the kinetic energy of the particle when it reaches x = 2R?

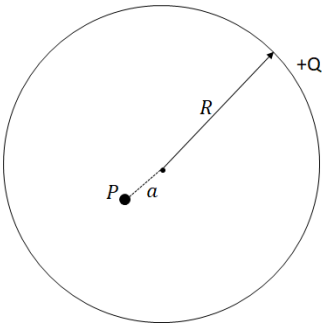


A) $\frac{3kQq}{10R}$ B) $\frac{kQq}{2R}$

C) $\frac{kQq}{R}\left(\frac{\sqrt{2}}{2} - \frac{\sqrt{5}}{5}\right)$ D) $\frac{kQq}{R}$

E) $\frac{kQq\sqrt{3}}{3R}$

15. Consider the charged sphere shown. The sphere has a radius of R and a charge of +Q. Which of the following could be used to find the potential at P, a point inside at a distance of a from the center?



A) $V = -\int_{\infty}^{a} \frac{kQ}{R^2} dr$

B) $V = -\int_{\infty}^{R} \frac{kQ}{R} dr - \int_{R}^{a} 0 dr$

C) $V = -\int_{\infty}^{R} \frac{kQ}{R} dr - \int_{R}^{a} \frac{kQ}{R} dr$

D) $V = -\int_{\infty}^{R} \frac{kQ}{R^2} dr - \int_{R}^{a} 0 dr$

E) $V = -\int_{\infty}^{R} \frac{kQ}{R^2} dr - \int_{R}^{a} \frac{kQ}{R^2} dr$

Bonus: (3 points) Calculate the electric potential at a distance of .05 m from the center of a uniformly charged **non-conducting** sphere of radius 0.2 m and total charge 10 mC.

Part 2: Free Response. **You must show all steps** required to arrive at the correct answer for the problem below, including any diagrams. **All answers must be given with correct units. (14 points each)**

16. A charge +Q is uniformly distributed over a quarter circle of radius R, as shown in Figure 1. Points A and C are symmetric relative to the x-axis. Express all algebraic quantities in terms of givens and constants.

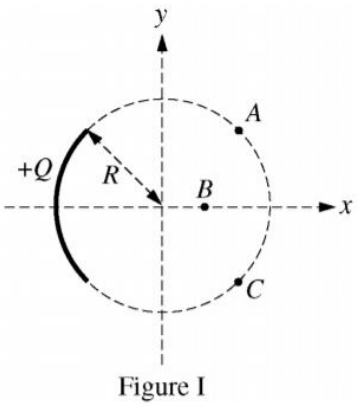


Figure I

a) Rank the potential from greatest to least at the three points, with 1 being the greatest. If two points have the same potential, give them the same ranking.

_____V_A _____V_B _____V_C

Justify your ranking.

b) Point P is at the origin, as shown in Figure 2, and is the center of curvature of the quarter-circle shaped charge distribution.

i. A positive charge q with mass m is placed at point P at rest. Derive an expression for the speed of the particle when it is very far from P using the work-energy of theorem.

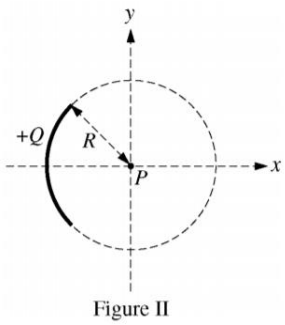
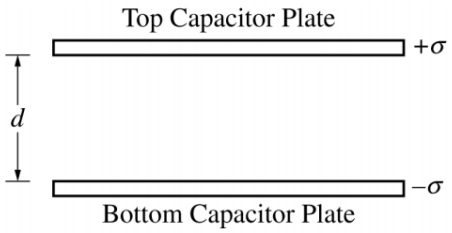


Figure II

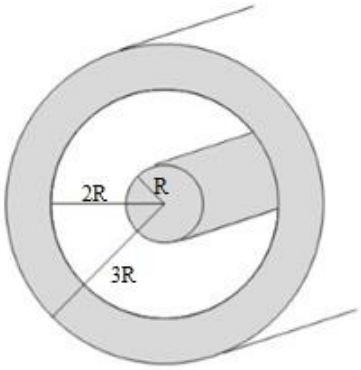
ii. Derive an expression for the **electric field** at P.

17. A parallel plate capacitor is connected to a battery, fully charged, and then isolated from the battery. The plates are given equal and opposite charge density σ, and the plate separation between the plates is d, as shown. The area of each plates is A.



a) Determine an expression for the voltage across the capacitor.

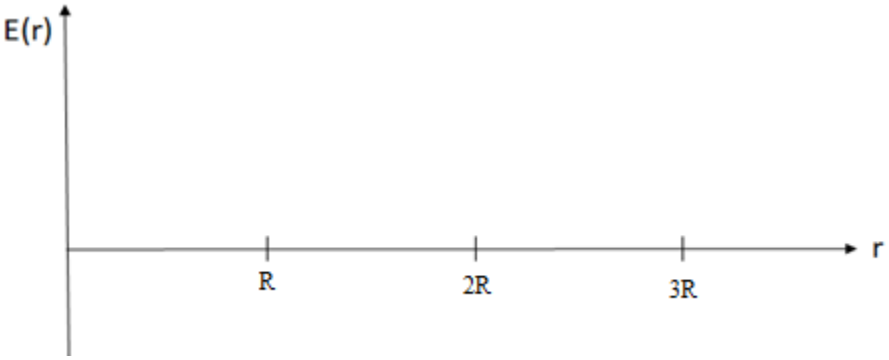
18. Consider a cylinder capactior of length L and linear charge density λ. The capacitor has a solid cylinder conductor inside with positive charge and radius R. The outer cylindrical shell has inner radius 2R, out radius 3R, and negative charge



a) Determine an expression for the charge density on the inner surface of the outside cylinder in terms of R and λ.

b) Use Gauss's law to derive an expression for the electric field as a function of distance r form the center for $R < r < 2R$.

c) Sketch the electric field as a function, r, the distance from the center of the cylindrical shell.



d) Derive an expression for the capacitance of the cylinder.