Unit 8 Test Review

Electric Potential and Capacitance: Chapters 24-25

*** In studying for your test, make sure to study this review sheet along with your quizzes and homework assignments.**

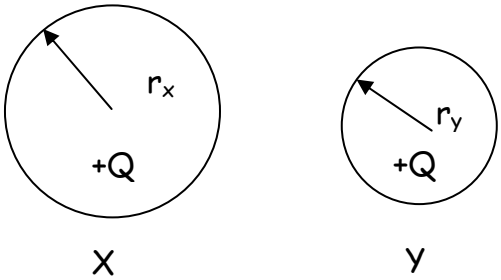
Multiple Choice Review: On this portion of the test, you will not be allowed to use your calculator or AP formula sheet. (You may, however, use your AP table of information.) Approximate $g=10m/s^2$ for simplicity of calculations. No partial credit will be given.

1. When two identical parallel-plate capacitors are connected in series, which of the following is true of the equivalent capacitance?
- **a.** It depends on the charge of each capacitor.
- **b.** It depends on the potential difference across both capacitors.
- **c.** It is larger than the capacitance of each capacitor.
- **d.** It is smaller than the capacitance of each capacitor.
- **e.** It is the same as the capacitance of each capacitor.

2. A charge distribution creates an electric potential that varies along the x-axis as $V(x) = 2x^2 - 5x$. What is the x-component of the electric field at x=1?

a. -3 V/m **b.** 3 V/m **c.** -1 V/m **d.** 1 V/m **e.** 0

3. Two conducting spheres, X and Y , have the same positive charge +Q, but different radii ($r_x > r_y$) as shown. The spheres are separated so that the distance between them is large compared with either radius. If a wire is connected between them, in which direction will current be directed in the wire?



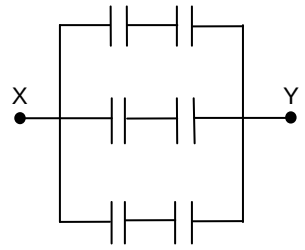
- **a.** From X to Y
- **b.** From Y to X
- **c.** There will be no current in the wire.
- **d.** It cannot be determined without knowing the magnitude of Q.
- **e.** It cannot be determined without knowing whether the spheres are solid or hollow.

4. An air-gap capacitor with capacitance of C is connected across a battery with potential difference V, setting up an electric field of strength E and causing the capacitor to store charge Q. Then the capacitor is disconnected from the battery and a substance with dielectric constant 3 is inserted to fill the space between the plates. What are the values for capacitance, potential difference, electric field magnitude, and charge stored, after the dielectric is in place?

	Capacitance	Pot. Diff.	E-Field	Charge Stored
a.	3C	3V	3E	3Q
b.	3C	V/3	E/3	3Q
c.	3C	V	E	3Q
d.	3C	V/3	E/3	Q
e.	C	V/3	E/3	Q

5. Each capacitor in the system shown below has a capacitance of 2μF. The equivalent capacitance of the system of capacitors is closest to which of the following?

a. 2/3 μF
b. 4/3 μF
c. 3 μF
d. 6 μF
e. 12 μF



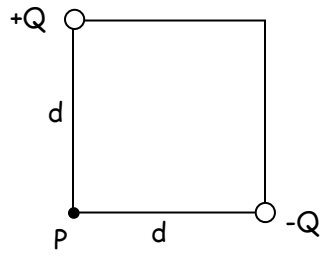
6. For the same system of capacitors as in the previous problem, what potential difference must be applied between points X and Y so that the charge on each plate of each capacitor will have magnitude 6 microcoulombs?

a. 1.5 V
b. 3 V
c. 6 V
d. 9 V
e. 18 V

7. Two parallel conducting plates, separated by a distance D, are connected to a battery of potential difference V. Which of the following is correct if the plate separation is doubled while the battery remains connected?

a. The electric charge on the plates is doubled.
b. The electric charge on the plates is halved.
c. The potential difference between the plates is doubled.
d. The potential difference between the plates is halved.
e. The capacitance is unchanged.

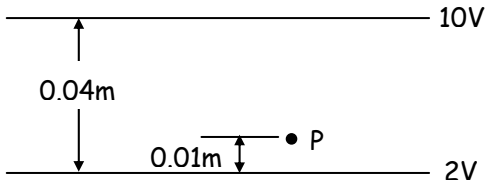
8. The given figure shows two charged particles, one of charge positive Q and the other of charge -Q, that are located at the opposite corners of a square with sides of length d. What is the magnitude of the electric potential at point P? (Assume potential to be zero at infinity.)



a. zero **b.** $\frac{kQ}{\sqrt{2}d}$ **c.** $\frac{kQ}{d}$ **d.** $\frac{\sqrt{2}kQ}{d}$ **e.** $\frac{2kQ}{d}$

9. Two large, flat, parallel, conducting plates are 0.04m apart, as shown in the diagram. The lower plate is at a potential of 2V with respect to ground, while the upper plate is at a potential of 10V with respect to ground. Point P is located 0.01m above the lower plate. What is the magnitude of the electric field at point P?

a. 800 V/m
b. 600 V/m
c. 400 V/m
d. 200 V/m
e. 100 V/m



10. For the same two plates and point P as used in the previous question, in which direction would an electron move, if released at point P?

a. To the right.
b. To the left.
c. Upward.
d. Downward.
e. Out of the plane of the page.

11. Which of the following statements about conductors under electrostatic conditions is true?

a. Positive work is required to move a positive charge over the surface of a conductor.
b. Charge that is placed on the surface of a conductor always spreads evenly over the surface.
c. The electric potential inside a conductor is always 0.
d. The electric field at the surface of a conductor is tangent to the surface.
e. The surface of a conductor is always an equipotential surface.

Problem Review: On this portion of the test, you may use your calculator, AP formula sheet, and AP table of information. Partial credit will be given on these problems.

12. A very large vertically-oriented sheet of charge has a surface charge density of $\sigma = -2.5 nC/m^2$.

a. What is the difference in potential between two points, one of which is 1cm away from the sheet, and another of which is 8cm from the sheet and 20cm directly above the first point?

b. How much work does the E-field do in moving a proton between the two points?

13. An electron starts from rest 41cm from a fixed point charge with $Q = -2.3 \mu C$.

a. How fast will the electron be moving when it reaches a point 2.5m from the charge Q?

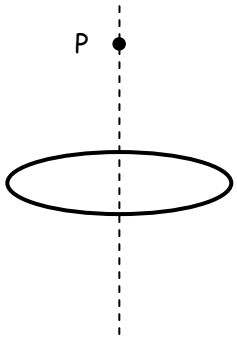
b. How fast will the electron be moving when it reaches a point very far away from Q?

14. A 124pF capacitor is fully charged by a 9V battery, and then disconnected from the battery. This capacitor is then connected to an uncharged 65pF capacitor. What is the charge eventually stored by this 65pF capacitor, once equilibrium is reached?

15. Calculate the work required to assemble three charges at the corners of an equilateral triangle with 25cm-long sides, if the charges have strengths of +3μC, -1.2μC, and 5μC.

16. Two parallel metal plates, each with an area of $42cm^2$, are separated by 3mm of glass (k=4.8), and connected across a 6V potential difference. Calculate the charge stored by the capacitor plates, and the charge induced on the surface of the glass.

17. A circular ring with a 5cm radius has a charge of +3nC spread uniformly along its length. Calculate the electric potential at a point P on the ring's central axis at a distance of 8cm above the plane of the ring.



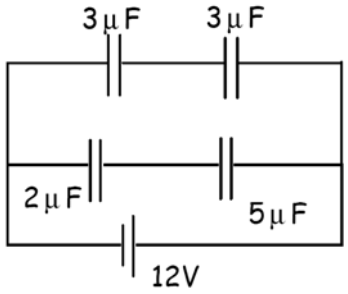
18. A charge of 37μC is distributed evenly on the surface of a 15cm-radius sphere. Calculate the electric potential at a location…

a. … 23 cm from the sphere's center.

b. … on the sphere's surface.

c. … 8cm from the sphere's center.

19. Calculate the equivalent capacitance of the group of capacitors, and also the charge stored by the 5μF capacitor.



20. The electric potential at points in a certain xy plane is given by $V=5xy^2+3x$, measured in volts. In unit-vector notation, what is the electric field at the point (2, -1)?

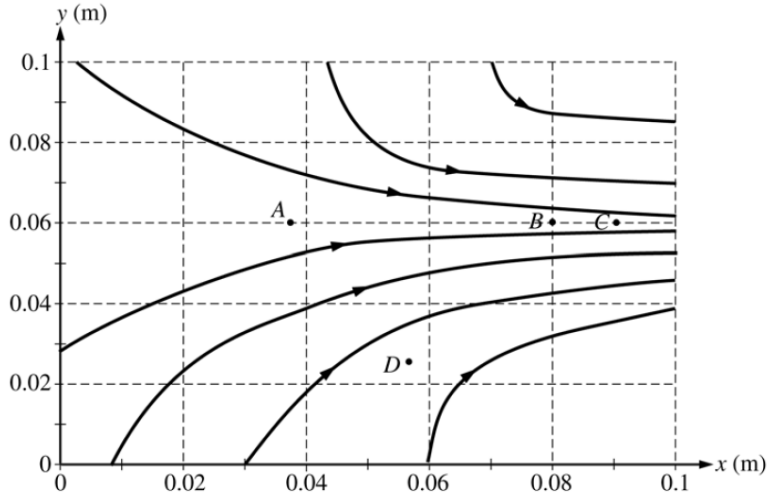
21. Use Gauss' law, the idea that $V=\int E \cdot ds$, and the definition of capacitance to derive expressions for the capacitance of…

a. two concentric metal spherical shells of radii A and B.

b. two coaxial metal cylindrical shells of radii A and B.

22. Actual A.P. Physics Free-Response Question (2005):

Consider the electric field diagram shown to the right.



a. Points A, B, and C are all located at y=0.06m.

i. At which of these three points is the magnitude of the electric field the greatest? Justify your answer.

ii. At which of these three points is the electric potential the greatest? Justify your answer.

b. An electron is released from rest at point B.

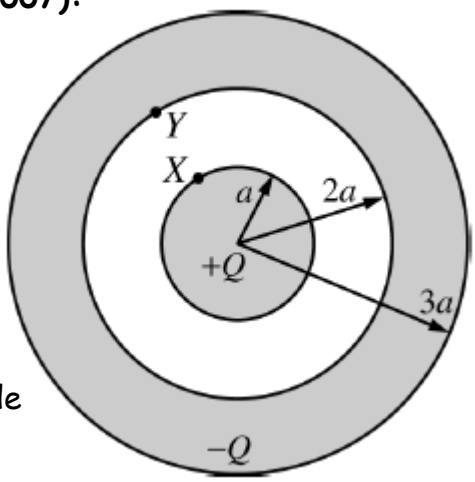
i. Qualitatively describe the electron's motion in terms of direction, speed, and acceleration.

ii. Calculate the electron's speed after it has moved through a potential difference of 10V.

c. Points B and C are separated by a potential difference of 20V. Estimate the magnitude of the electric field midway between them and state any assumptions you make.

d. On the diagram, draw an equipotential line that passes through point D and intersects at least three electric field lines.

23. Actual A.P. Physics C Free-Response Question (2007):



In the figure, a nonconducting solid sphere of radius *a* with charge +*Q* uniformly distributed throughout its volume is concentric with a nonconducting spherical shell of inner radius 2*a* and outer radius 3*a* that has a charge −*Q* uniformly distributed throughout its volume. Express all answers in terms of the given quantities and fundamental constants.

a. Using Gauss' law, derive expressions for the magnitude of the electric field as a function of radius *r* in the following regions.

i. Within the solid sphere ($r < a$)

ii. Between the solid sphere and spherical shell ($a < r < 2a$)

iii. Within the spherical shell ($2a < r < 3a$)

iv. Outside the spherical shell ($r > 3a$)

b. What is the electric potential at the outer surface of the spherical shell ($r = 3a$)? Explain your reasoning.

c. Derive an expression for the electric potential difference $V_X - V_Y$ between points X and Y shown in the figure.