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Assigned Seat Number

Dr. Gary Agin PH2200 0A

Exam I

Fall 2003
Serway, Chapters 23-26:2

Part I: Qualitative

Write the letter of the correct answer on the answer sheet.

NO PARTIAL CREDIT: SUBMIT ONE ANSWER ONLY.

Note that in qualitative multiple-choice questions, sometimes one answer is clearly correct, while the others are clearly incorrect. However, with some questions you must choose the best or most complete answer.

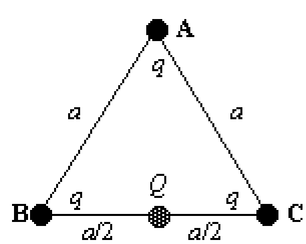
Note also that even though this section is qualitative, the formula sheet may prove useful for some questions.

20 questions at 3 points each = 50 % of test

1. Consider Coulomb's law for point charges. The statement that $\vec{F}_{12} = -\vec{F}_{21}$ is an example of which of the following facts?

(a) Coulomb's law obeys the principle of superposition.
(b) Coulomb's law obeys Newton's 3rd law of motion.
(c) Coulomb's law is an inverse-square law.
(d) Coulomb's law has a very large constant of proportionality.

2. Three identical charges, *q*, are placed at the corners of an equilateral triangle. A fourth charge, *Q*, is placed midway between two of the charges as shown. Is it possible to choose a value for the charge *Q* such that the force on it due to the three corner charges is ***zero***?



(a) Yes, because it is centered between identical charges at points *B* and *C*.
(b) No, because three force vectors can never add to zero.
(c) No, because the forces on *Q* due to the charges at points *B* and *C* are in the same direction
(d) No, because an additional charge would be needed to cancel the force on Q due to the charge at point *A*.

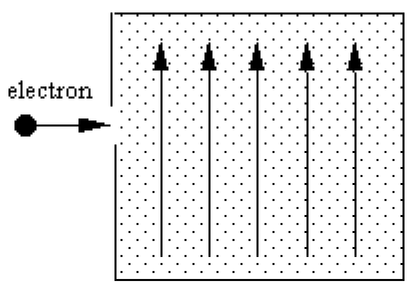
3. The magnitude of the electric field at a point in space is equal to

(a) the force that would be felt by a proton if placed at that point
(b) the force that would be felt by a electron if placed at that point
(c) the force that would be felt by a test charge if placed at that point
(d) the force per unit charge at that point

4. All of the following are properties of electric field lines ***EXCEPT***:

(a) A tangent to a field line gives the direction of the field at that point.
(b) The number of field lines per unit cross-sectional area is proportional to the magnitude of the field.
(c) Field lines can cross only at right angles.
(d) Field lines can never cross.

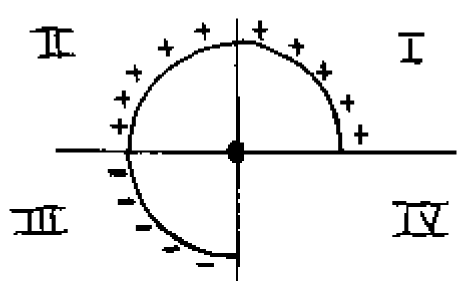
5. Suppose an electric field is constant in a certain region of space and directed upward as shown. An ***electron*** is fired to the right into the field. What is the direction of the force that the field exerts on the electron once it has entered the field?



(a) To the left
(b) To the right
(c) Upward
(d) Downward

6. Consider the linear, uniform charge distribution shown. Determine the direction of the electric field at the origin.

(a) A vector into quadrant I
(b) A vector into quadrant II
(c) A vector into quadrant III
(d) A vector into quadrant IV



7. State Gauss's law in words.

(a) the flux through a closed surface is always zero.
(b) the flux through a closed surface is proportional to the net enclosed charge.
(c) the flux for a closed surface cannot be calculated.
(d) the flux through a closed surface is infinite.

8. Suppose that a uniform electric field exists in a certain region of space. Now consider a mathematical plane surface of area *A*. To ***maximize*** the flux through this surface, the ***face*** of the plane (not its normal)

(a) must be placed parallel to the field.
(b) must be placed perpendicular to the field.
(c) must be placed at 45° with the field.
(d) The flux cannot be maximized because it is always zero for a plane surface.

9. Suppose a certain Gaussian surface has a positive flux. A second Gaussian surface completely ***within*** the first one has a smaller positive flux. What does this imply?

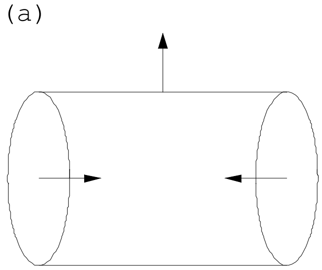
(a) There is positive charge outside both surfaces.
(b) There is negative charge outside both surfaces.
(c) There is positive charge between the two surfaces.
(d) There is negative charge between the two surfaces.

10. Consider the problem of applying Gauss's law to a cylindrical Gaussian surface.

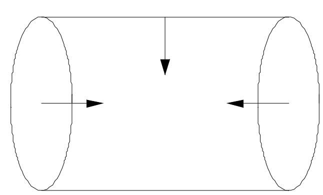
$$q_{enclosed} = \varepsilon_0 \oiint_S \vec{E} \bullet d\vec{A}$$

Which of the following pictures represents correct directions for all three $d\vec{A}$ vectors?

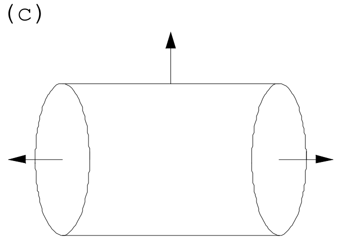
(a)



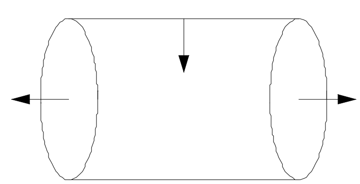
(b)



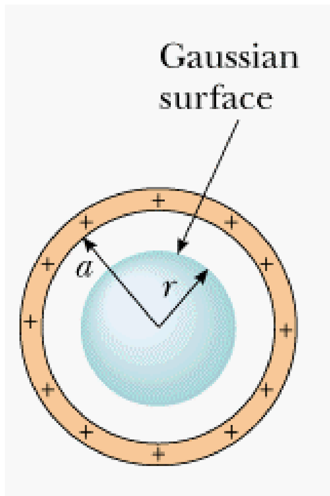
(c)



(d)



11. Consider a thin, spherical shell, radius *a*, of uniformly distributed ***positive*** charge $+2Q$. A ***negative*** point charge, $-Q$, is placed at the center of the sphere. What can you say about the electric flux through a concentric, spherical Gaussian surface of radius *r*, where $r < a$? See figure.



(a) It is negative.
(b) It is positive.
(c) It is zero.
(d) No conclusion is possible from the information given.

12. Consider a charged conductor in electrostatic equilibrium. Which of the following statements is ***FALSE***?

(a) The excess charge resides only on the surface of the conductor.
(b) The electric field is zero in the interior of the conductor.
(c) The direction of the electric field just outside the conductor is parallel to the surface of the conductor.
(d) The magnitude of the electric field just outside the conductor is σ / ε_0.

13. A system of two charges has a ***positive potential energy***. This ***necessarily*** implies that

(a) both charges are positive
(b) both charges are negative
(c) both charges have the same sign
(d) the two charges have opposite sign

14. Consider a uniform electric field in the positive *z*-direction. In which case would an ***external agent*** do positive work in moving a positive test charge without acceleration?

(a) If he moved it in the positive *z*-direction.
(b) If he moved it in the negative *z*-direction.
(c) If he moved it in the positive *x*-direction.
(d) If he moved it in the positive *y*-direction.

15. Two equal positive point charges are placed at the corners of an equilateral triangle. A negative point charge is then placed at the third corner. What can be said about the potential energy of the negative charge in the field of the two positive charges?

(a) It is positive.
(b) It is negative.
(c) It is zero.
(d) Any of the above, depending the magnitude of the negative charge.

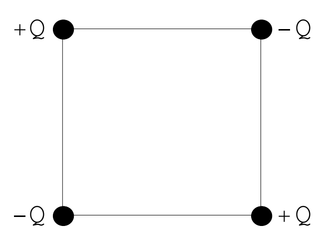
16. Electric ***potential***

(a) is essentially the same as electric potential energy.
(b) is unrelated to electric potential energy.
(c) is conceptually different from electric potential energy but measured in the same units.
(d) is the electric potential energy per unit charge.

17. Suppose an electric field exists in a certain region of space. A test charge moves from point *A* to point *B* in the field. The ***work done by the field*** during this process is equal to

(a) the potential difference between points *A* and *B*.
(b) the difference in the potential energy of the charge at point *A* and at point *B*.
(c) the difference between the value of the electric field at point *A* and at point *B*.
(d) zero if the electric field is uniform.

18. Consider the system below that consists of four charges identical in magnitude placed at the corners of a square. What can be said about the ***potential*** at the center of the square?



(a) It is positive.
(b) It is negative.
(c) It is zero.
(d) Nothing without knowing the length of the sides.

19. The ratio of charge to potential difference across a capacitor is

(a) always constant for a given capacitor
(b) constant only for parallel plate capacitors
(c) never constant for any capacitor
(d) infinite for any real capacitor

20. A parallel-plate capacitor consists of two identical conducting plates parallel to each other. A cylindrical capacitor consists of two concentric cylindrical conductors. Consider an "ideal" parallel-plate capacitor (infinite plates) and an "ideal" cylindrical capacitor (infinitely long cylinders), both of equal capacitance. Now charge each capacitor to the same potential difference.

(a) Both fields are uniform.
(b) Neither field is uniform.
(c) Only the field in the parallel-plate capacitor is uniform.
(d) Only the field in the cylindrical capacitor is uniform.

Part II: Quantitative

Write the letter of the correct answer on the answer sheet. Use the backs of these test pages for scratch work.

<u>PARTIAL CREDIT POSSIBLE</u>: Select one (1), two (2), or three (3) choices.

6 points for the single correct answer
4 points if correct answer is among two choices
2 points if correct answer is among three choices
0 if correct answer not present or of more than 3 answers are submitted

10 questions at 6 points each = 50 % of test

21. Consider a point charge of 2.50×10^{-6} C. Calculate the ***<u>force</u>*** on another point charge of 3.00×10^{-6} C placed 0.0200 m from the first charge.

(a) 1.69×10^{2} N
(b) 3.37 N
(c) 3.37×10^{2} N
(d) 7.34×10^{-2} N
(e) 7.34×10^{2} N

22. A charge of 16 nC is distributed uniformly along the x axis from $x = 0$ to $x = 4$ m. Which of the following integrals is correct for the magnitude of the electric field at $x = 10$ m?

(a) $\int_0^4 \frac{36dx}{(10-x)^2}$ (b) $\int_0^4 \frac{154dx}{(10-x)^2}$ (c) $\int_0^4 \frac{36dx}{x^2}$

(d) $\int_0^4 \frac{154dx}{x^2}$ (e) $\int_6^{10} \frac{154dx}{(10-x)^2}$

23. A uniform electric field of magnitude 2.00 N/C is established in a certain region of space. What is the flux through a plane surface of area 3.00 m^2 if the normal vector, $d\vec{a}$, makes a 30.0° angle with the field?

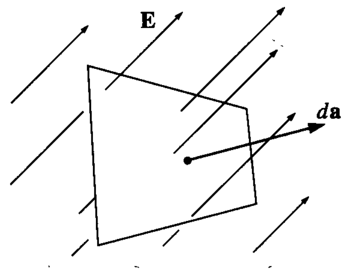


Figure 2.15

(a) 5.20 N•m^2/C
(b) 6.00 N•m^2/C
(c) 6.73 N•m^2/C
(d) 8.65 N•m^2/C
(e) 9.23 N•m^2/C

24. Eight identical point charges of 3.00 x 10^{-6} C are arranged to form a cube of length 0.500 m (one charge at each corner). Consider a spherical ***Gaussian surface*** of radius 6.00 m with the cube at its center. Calculate the ***flux*** through the sphere.

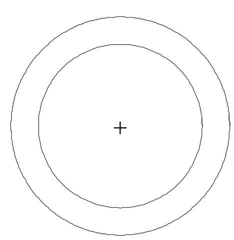
(a) 1.66 x 10^6 N•m^2/C
(b) 2.71 x 10^6 N•m^2/C
(c) 6.55 x 10^6 N•m^2/C
(d) 4.39 x 10^7 N•m^2/C
(e) 6.78 x 10^7 N•m^2/C

25. A ***nonconducting*** sphere of radius 3.0 cm has a charge of 2.0 μC distributed uniformly throughout its volume. What is the magnitude of the electric field within the sphere 1.5 cm from its center?

(a) 1.0 x 10^7 N/C
(b) 2.0 x 10^7 N/C
(c) 3.0 x 10^7 N/C
(d) 4.0 x 10^7 N/C
(e) 5.0 x 10^7 N/C

26. A ***conducting*** spherical shell has an inner radius of 2.5 cm, an outer radius of 5.0 cm, and carries a net, excess charge of +4.0 pC. A +4.0-pC ***point charge*** is placed at its center. What is the magnitude of the electric field 6.0 cm from the center?

(a) 10 N/C
(b) 20 N/C
(c) 25 N/C
(d) 30 N/C
(e) 35 N/C

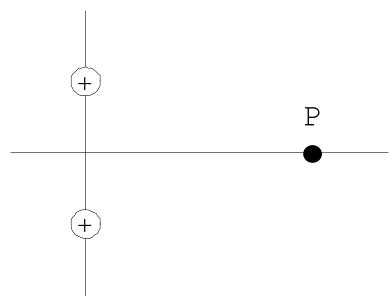


27. Three identical point charges of 2.00×10^{-6} C form an equilateral triangle whose side is 0.250 m. Calculate the ***potential energy*** of ***ONE*** of these charges in the electric field created by the other two charges.

(a) 6.74×10^{-3} J
(b) 0.144 J
(c) 0.288 J
(d) 0.432 J
(e) 0.575 J

28. Consider two identical point charges of 3.50×10^{-6} C on the y axis at y = 0.0100 m and y = -0.0100 m. Calculate the ***potential*** relative to infinity at a point P located at x = 0.0400 m.

(a) 3.71×10^{7} V
(b) 1.98×10^{7} V
(c) 6.43×10^{6} V
(d) 1.53×10^{6} V
(e) 7.78×10^{6} V



29. Suppose the potential, relative to some reference point, is given by $V = xy^2z^3$. Calculate the y-component of the electric field at (1, -3, 2).

(a) $72\hat{j}$ N/C
(b) $-72\hat{j}$ N/C
(c) $48\hat{j}$ N/C
(d) $-48\hat{j}$ N/C
(e) $9\hat{j}$ N/C

30. A potential difference of 120 V is established between parallel metal plates. The magnitude of the charge on each plate is 0.020 C. What is the capacitance of this capacitor?

(a) 170 μF
(b) 24 μF
(c) 7.2 μF
(d) 0.12 F
(e) 2.4 F