Physics 241 (Fall 2002) Midterm Exam #1 October 1, 2002

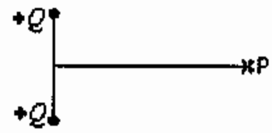
Instructions:

1) The problems are NOT given in the order of their degree of difficulty.
2) There are 17 problems. Each problem is worth 6 points.
3) Please find possibly useful formulae and constants in a separate page.
4) One 8.5"x11" crib sheet (both sides) is allowed; the use of any additional material (except for those provided) is considered cheating.

1. Two identical conducting spheres A and B carry equal charge. They are separated by a distance much larger than their diameters. A third identical conducting sphere C is uncharged. Sphere C is first touched to A, then to B, and finally removed. As a result, the electrostatic force between A and B, which was originally F, becomes:
   A) $F/2$
   B) $F/4$
   C) $3F/8$
   D) $F/16$
   E) 0

2. Charge is distributed uniformly on the surface of a spherical balloon (an insulator) with a point charge q inside. The electrical force on q is greatest when:
   A) it is near the inside surface of the balloon
   B) it is at the center of the balloon
   C) it is halfway between the balloon center and the inside surface
   D) it is anywhere inside (the force is same everywhere and is not zero)
   E) it is anywhere inside (the force is zero everywhere)

3. The diagram shows two identical positive charges Q. The electric field at point P on the perpendicular bisector of the line joining them:

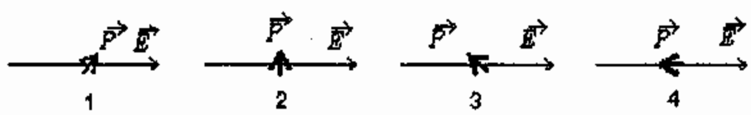


A) ↑
B) ↓
C) →
D) ←
E) zero

4. An electron traveling north enters a region where the electric field is uniform and points north. The electron:
A) speeds up
B) slows down
C) veers east
D) veers west
E) continues with the same speed in the same direction

5. An electric dipole is oriented parallel to a uniform electric field, as shown.

It is rotated to one of the five orientations shown below. Rank the final orientations according to the change in the potential energy of the dipole-field system, most negative to most positive.



A) 1, 2, 3, 4
B) 4, 3, 2, 1
C) 1, 2, 4, 3
D) 3, 2 and 4 tie, then 1
E) 1, 2 and 4 tie, then 3

6. A point charge is placed at the center of a spherical Gaussian surface. The electric flux Φ_E is changed if:
   A) the sphere is replaced by a cube of the same volume
   B) the sphere is replaced by a cube of one-tenth the volume
   C) the point charge is moved off center (but still inside the original sphere)
   D) the point charge is moved to just outside the sphere
   E) a second point charge is placed just outside the sphere

7. 10 C of charge are placed on a spherical conducting shell. A –3-C point charge is placed at the center of the cavity. The net charge in coulombs on the inner surface of the shell is:
   A) –7
   B) –3
   C) 0
   D) +3
   E) +7

8. Three charges lie on the x axis: 1×10^{-8} C at $x = 1$ cm, 2×10^{-8} C at $x = 2$ cm, and 3×10^{-8} C at $x = 3$ cm. The potential energy of this arrangement, relative to the potential energy for infinite separation, is:
   A) 7.9×10^{-2} J
   B) 8.5×10^{-4} J
   C) 1.7×10^{-3} J
   D) 0.16 J
   E) zero

9. The work in joules required to carry a 6.0-C charge from a 5.0-V equipotential surface to a 6.0-V equipotential surface and back again to the 5.0-V surface is:
   A) zero
   B) 1.2×10^{-5}
   C) 3.0×10^{-5}
   D) 6.0×10^{-5}
   E) 6.0×10^{-6}

10. A hollow metal sphere is charged to a potential V. The potential at its center is:
    A) V
    B) 0
    C) $-V$
    D) $2V$
    E) πV

11. A dielectric slab is slowly inserted between the plates of a parallel plate capacitor, while the potential difference between the plates is held constant by a battery. As it is being inserted:
    A) the capacitance, the potential difference between the plates, and the charge on the positive plate all increase
    B) the capacitance, the potential difference between the plates, the charge on the positive plate all decrease
    C) the potential difference between the plates increases, the charge on the positive plate decreases, and the capacitance remains the same
    D) the capacitance and the charge on the positive plate decrease but the potential difference between the plates remains the same
    E) the capacitance and the charge on the plate increase but the potential difference between the plates remains the same

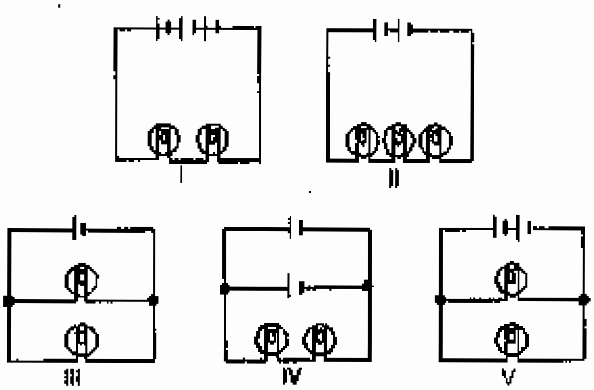
12. A 2-μF and a 1-μF capacitor are connected in series and charged by a battery. They store energies P and Q, respectively. When disconnected and charged separately using the same battery, they have energies R and S, respectively. Then:
    A) $R > P > S > Q$
    B) $P > Q > R > S$
    C) $R > P > Q > S$
    D) $P > R > S > Q$
    E) $R > S > Q > P$

13. An ordinary light bulb is marked "60 watt, 120 volt". Its (heated) resistance is:
    A) 60 Ω
    B) 120 Ω
    C) 180 Ω
    D) 240 Ω
    E) 15 Ω

14. Nine identical wires, each of diameter d and length L, are connected in series. The combination has the same resistance as a single similar wire of length L but whose diameter is:
A) $3d$
B) $9d$
C) $d/3$
D) $d/9$
E) $d/81$

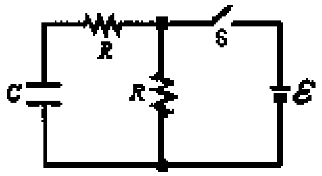
15. Two identical batteries, each with an emf of 18 V and an internal resistance of 1 Ω, are wired in parallel by connecting their positive terminals together and connecting their negative terminals together. The combination is then wired across a 4-Ω resistor. The current in each battery is:
A) 1.0 A
B) 2.0 A
C) 4.0 A
D) 3.6 A
E) 7.2 A

16. In the diagrams, all light bulbs are identical and all emf devices are identical. In which circuit (I, II, III, IV, V) will the bulbs be dimmest?



A) I
B) II
C) III
D) IV
E) V

17. In the circuit shown, both resistors have the same value R. Suppose switch S is initially closed. When it is then opened, the circuit has a time constant τ_a Conversely, suppose S is initially open. When it is then closed, the circuit has a time constant τ_b The ratio τ_a/τ_b is:



A) 1
B) 2
C) 0.5
D) 0.667
E) 1.5

$$\vec{F} = \frac{1}{4\pi\varepsilon_o}\frac{q_1 q_2}{r^2}\hat{r} \qquad \vec{E} = \frac{\vec{F}}{q_o} \qquad dE = \frac{1}{4\pi\varepsilon_o}\frac{dq}{r^2}$$

$$\Phi_E = \oint \vec{E} \bullet d\vec{A} \qquad \varepsilon_o \Phi_E = q \qquad \vec{\tau} = \vec{P} \times \vec{E}$$

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_o r}\hat{r} \qquad V_b - V_a = -\int_a^b \vec{E} \bullet d\vec{l} \qquad U = -\vec{P} \cdot \vec{E}$$

$$V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r} \qquad U = qV \qquad E = -\left(\frac{dV}{dl}\right)$$

$$q = CV \qquad C = \varepsilon_o \frac{A}{d} \qquad C = \kappa C_o$$

$$R = \rho \frac{L}{A} \qquad V = iR \qquad P = iV$$

$$U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{q^2}{C} \qquad V = \mathcal{E}\left(1 - e^{-t/RC}\right)$$

$$\frac{1}{4\pi\varepsilon_o} = 9x10^9\, Nm^2/C^2 \qquad \varepsilon_o = 8.85x10^{-12}\, F/m$$

$$e = 1.609x10^{-19}\, C \qquad E_z = \frac{qz}{4\pi\varepsilon_o (z^2 + R^2)^{3/2}}$$

$$E_z = \frac{\sigma}{2\varepsilon_o}\left[1 - \frac{z}{\sqrt{z^2 + r^2}}\right] \qquad E = \frac{\lambda}{2\pi\varepsilon_o r}$$

Exam 1 Fall 2002

1. C
2. E
3. C
4. B
5. A
6. D
7. D
8. B
9. A
10. A
11. E
12. E
13. D
14. C
15. B
16. D
17. B