University of the Philippines
College of Science

PHYSICS 72

1st Semester 2012-2013
First Long Problem Set

INSTRUCTIONS: Choose the **best** answer and shade the corresponding circle on your answer sheet. To change your answer, cross-out and sign your original answer and then shade your new answer. No computational devices allowed (e.g. calculators, mobile phones). **Following instructions is part of the exam.**

Useful formulas:

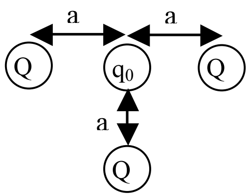
	Area	**Volume**
Sphere (radius = *r*)	$4\pi r^2$	$\frac{4}{3}\pi r^3$
Cylinder (radius =*r*, height = *h*)	$2\pi rh$	$\pi r^2 h$

Useful constants:

e	-1.60 x 10^{-19} C
m_e	9.1 x 10^{-31} kg
ε_o	8.854 x 10^{-12} C^2/Nm^2
k	8.988 x 10^9 Nm^2/C^2

1. **The Cube.** Cube A has initial charge 4Q and cube B has initial charge –2Q. Both cubes have the **same dimensions and are conducting**. They were made to momentarily touch each other. What are the **final charges** of each cube **a long time after touching**?
   A. Cube A: 0, cube B: 0
   B. Cube A: Q, cube B: Q
   C. Cube A: 4Q, cube B: -2Q
   D. Cube A: -2Q, cube B: 4Q
   E. Cube A: -4Q, cube B: 2Q

2. **T-square.** What is the **net electric force** on q_0 given the system at the right? Each point charge has charge Q.

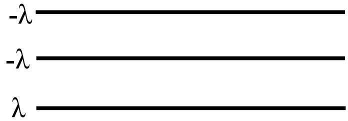


   A. kQq_o/a^2 **,** to the right
   B. kQq_o/a^2 , to the left
   C. kQq_o/a^2 , upward
   D. kQq_o/a^2 , downward
   E. Zero

3. **E-wan.** Which of the following statements about the **electric field** due to a **point charge** is **TRUE**?
   I. Its magnitude follows the inverse square law.
   II. It points towards a positive point charge.
   III. Its magnitude depends on the square of the charge magnitude.

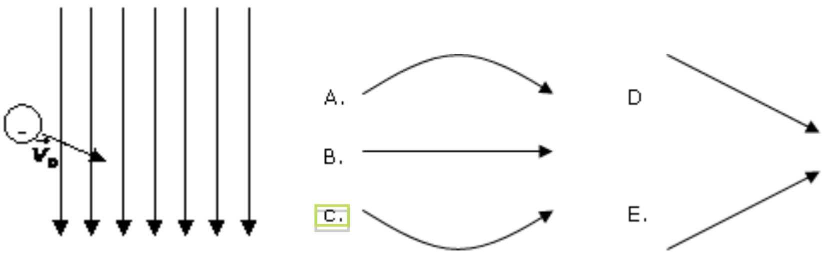
   A. I only
   B. II only
   C. III only
   D. I and II
   E. I, II and III

4. **Adidas.** Consider three **parallel infinitely long wires** with linear charge density as shown in the figure below. The wires are coplanar and separated by a distance *a,* from the next. What is the **electric field** at a point on the **bottom** wire?
   A. kλ/a, upward
   B. kλ/a, downward
   C. 3kλ/a, upward
   D. 3kλ/a, downward
   E. Zero

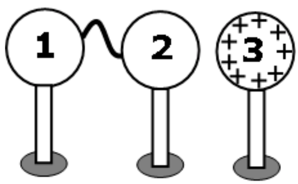


5. **Transfer**. Two **identical conductors** X and Y are separately charged with +15C and -25C, respectively. They are then brought into contact. What is the **amount of charge** on conductor X **at electrostatic equilibrium**?
   A. 0C
   B. -5C
   C. -10C
   D. -15C
   E. -25C

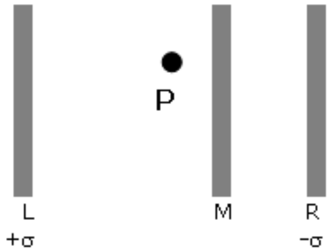
6. **Trajectory**. A **negative point charge** with initial velocity v_o enters a region of uniform electric field directed downward as shown. Which trajectory would the charge most likely follow as it traverses the electric field?



7. **Conduction**. Spheres 1 and 2, which are uncharged metals, are mounted on insulating support rods. Sphere 3, carrying a **positive charge**, is then placed near sphere 2. Now a conducting wire is momentarily connected between spheres 1 and 2 and then removed. Finally, sphere 3 is removed. What are the **final charges** of spheres 1 and 2?
   A. Sphere 1: +; sphere 2: +
   B. Sphere 1: -; sphere 2: +
   C. Sphere 1: 0; sphere 2: 0
   D. Sphere 1: +; sphere 2: -
   E. Sphere 1: -; sphere 2: -

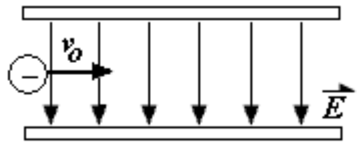


*Consider three **infinite (nonconducting) sheets of charge** placed side by side as with their cross-sections shown below. The left (L) and right (R) sheets have surface charge densities $+\sigma$ and $-\sigma$, respectively. The charge density of sheet M located in between L and R is not known. It was found that the **net force** on a **test charge** placed at **point P is zero**.*

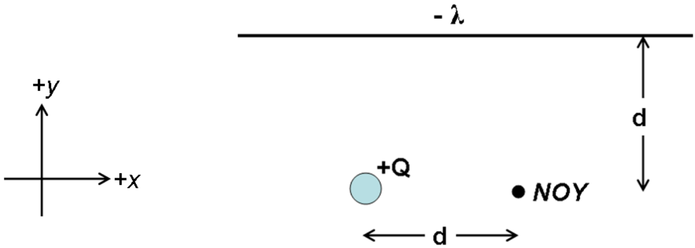


8. **Density**. What is the **charge density** of sheet M?
   A. $-\sigma$
   B. $+\sigma$
   C. -2σ
   D. $+2\sigma$
   E. Zero

9. **Force**. An **electron** is launched into the uniform electric field between two parallel plates with an initial horizontal velocity $v_o = 1.60\times10^{6}$ m/s. The magnitude of the electric field is 1.00×10^{5} N/C. What is the **force (magnitude and direction)** experienced by the electron?
   A. 1.60×10^{11} N, left
   B. 1.60×10^{11} N, right
   C. 1.60×10^{-14} N, up
   D. 1.60×10^{-14} N, down
   E. 1.00×10^{-5} N, down



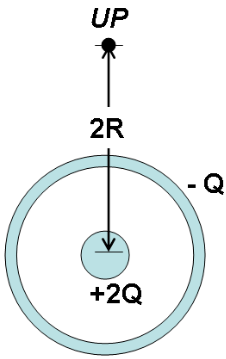
*For the next two numbers, consider an **infinite line** charge with charge $-\lambda$ that is at a distance d above point NOY and a **point charge** +Q placed at the left of point NOY.*



10. **Gaussian.** Which of the following **Gaussian surfaces** can be used to manually calculate the electric field at point *NOY*?
   A. One **sphere** centered at +Q with a radius d and another **sphere** centered at – λ with radius d
   B. One **cylinder** centered at +Q with radius d and has infinite length and another **cylinder** centered at –λ with radius d and has infinite length
   C. One **cylinder** centered at +Q with radius d and has infinite length and another **cylinder** centered at –λ with radius 2d and has infinite length
   D. A **sphere** centered at +Q with radius d and a **cylinder** centered at –λ with radius d and has infinite length
   E. A **sphere** centered at +Q with radius d and a **cylinder** centered at –λ with radius 2d and has infinite length

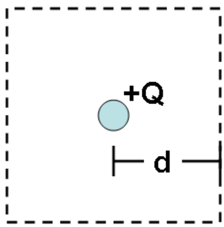
11. **Field.** What is the **net electric field** at point *NOY*? *Note:* $k = 1/(4\pi\varepsilon_o)$
   A. $\boldsymbol{E} = 2kQ/d^2\ \boldsymbol{i} + k\lambda/d\ \boldsymbol{j}$
   B. $\boldsymbol{E} = 2kQ/d^2\ \boldsymbol{i} - k\lambda/d\ \boldsymbol{j}$
   C. $\boldsymbol{E} = kQ/d^2\ \boldsymbol{i} + 2k\lambda/d\ \boldsymbol{j}$
   D. $\boldsymbol{E} = kQ/d^2\ \boldsymbol{i} - 2k\lambda/d\ \boldsymbol{j}$
   E. $\boldsymbol{E} = kQ/d^2\ \boldsymbol{i} + k\lambda/d\ \boldsymbol{j}$

12. **Force.** Consider a +2Q charge placed at the center of a **thin uniformly-charged spherical conducting** shell with net charge –Q and radius R. Point UP is at a distance 2R away from +2Q charge. If a +Q charge is placed at point *UP*, what will be the **electric force** acting on +Q? *Note:* $k = 1/(4\pi\varepsilon_o)$



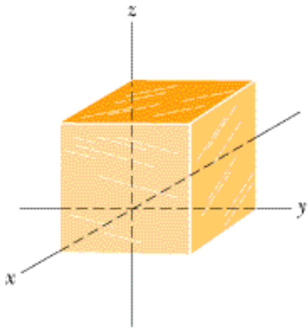
   A. zero
   B. $|F| = kQ^2/4R^2$, downward
   C. $|F| = kQ^2/4R^2$, upward
   D. $|F| = 2kQ^2/4R^2$, downward
   E. $|F| = 2kQ^2/4R^2$, upward

13. **Flux.** Consider a point charge +Q placed at the center of a cubic surface with side-length 2d. Determine the **net flux** through the cubic surface if the point charge is moved to the right **at a distance d/2 from the center**.

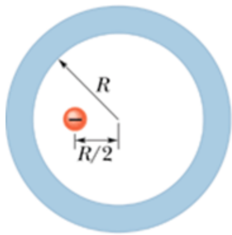


   A. $+Q/\varepsilon_0$
   B. $-Q/\varepsilon_0$
   C. $+Q/2\varepsilon_0$
   D. $-Q/2\varepsilon_0$
   E. zero

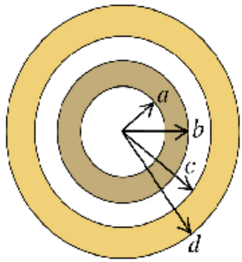
14. **Electric flux.** At each point on the surface of the cube shown in figure, the electric field is parallel to the z axis. The length of each edge of the cube is 1.0 m. On the top face of the cube **E** = -14 x 10^3 N/C **k**, and on the bottom face of the cube **E** = 7.0 x 10^3 N/C **k**. What is the net flux through the cube?
    - A. -2.1 x 10^4 Nm^2/C
    - B. 2.1 x 10^4 Nm^2/C
    - C. Zero
    - D. -7.1 x 10^4 Nm^2/C
    - E. 14.1 x 10^4 Nm^2/C



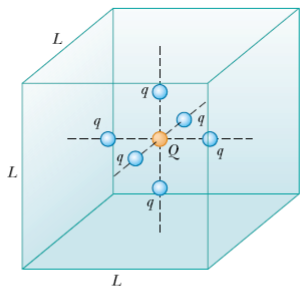
15. **Charges on Conductors.** The figure shows a cross section of a spherical metal shell of inner radius R. A point charge of -q is located at a distance R/2 from the center of the shell. If the shell has a net charge of 3q, what are the (induced) charges on its **inner** and **outer** surfaces?
    - A. zero, zero
    - B. +q, -2q
    - C. +q, +2q
    - D. +q, +3q
    - E. +q,-q



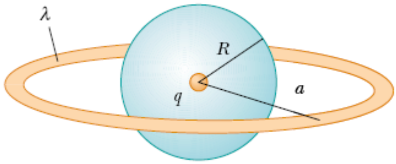
16. **Charges on Conductors.** Consider two concentric conducting spherical shells. If the **inner shell** has total charge +q, what is the **electric field magnitude** at a distance b<r<c?
    - A. zero
    - B. $3kq/r^2$
    - C. $2kq/r^2$
    - D. kq/r^2
    - E. kq/b^2



17. **Gauss Law.** A positive point charge *Q* is located at the center of a cube of side-length L. In addition, six other identical positive point charges *q* are positioned symmetrically around *Q*, as shown in the figure. What is the **electric flux through one face** of the cube?
    - A. q/ε_0
    - B. $6q/\varepsilon_0$
    - C. $(Q+6q)/\varepsilon_0$
    - D. $(Q+6q)/6\varepsilon_0$
    - E. Zero

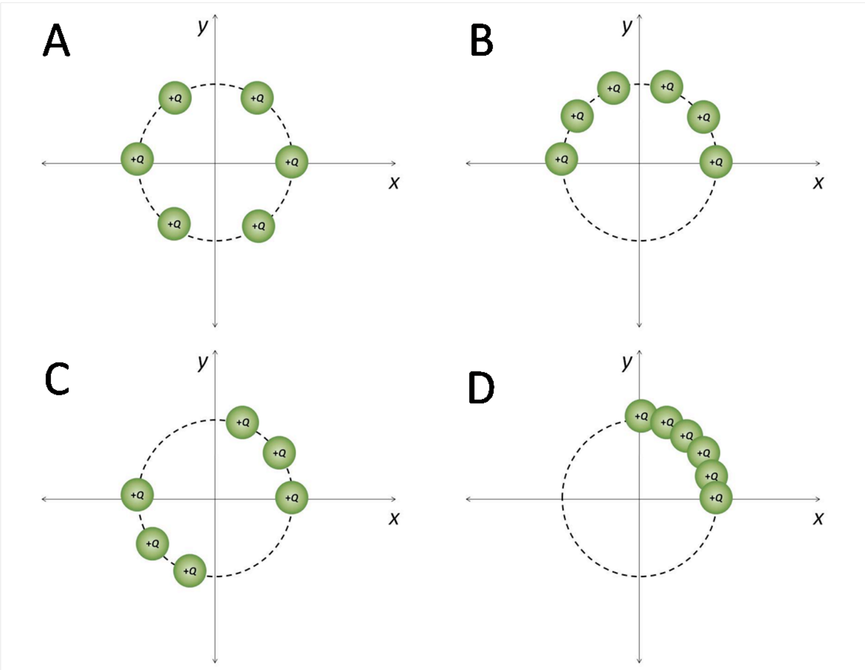


18. **Gauss Law.** A point charge q is located at the center of a uniform ring having linear charge density λ and radius a, as shown in the figure. What is the **total electric flux** through a Gaussian sphere centered at the point charge and having radius R, where R<a.



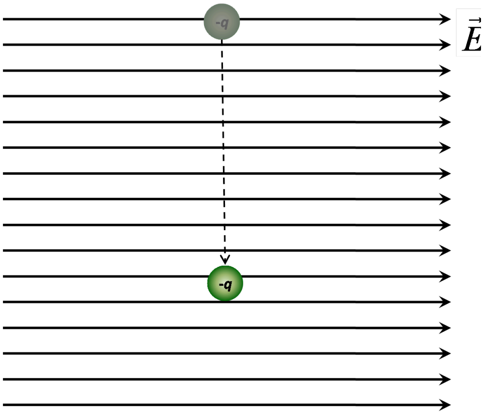
A. zero
B. q/ε_0
C. $\lambda R^2/2a\ \varepsilon_0$
D. $2\pi\lambda a/\varepsilon_0$
E. $(2\pi\lambda a + q)/\varepsilon_0$

19. **Circle.** Six **identical** point charges $+Q$ are placed along the circumference of a circle of radius R whose center coincides with the origin. Which of the following configurations will produce the **highest potential at the origin**?



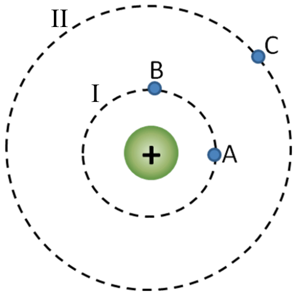
E. ALL will produce the same potential at the origin.

20. **Uniform field.** A negative point charge $-q$ is **moved downward** in a **uniform** electric field ***E* directed to the right**. Which of the following statements is **TRUE**?
   A. Potential energy is stored due to this motion of the point charge.
   B. Potential energy decreases due to the motion of the charge.
   C. The work done by the electrostatic force is positive.
   D. The work done by the electrostatic force is negative.
   E. The work done by the electrostatic force is zero.



21. **Working.** Two positive charges $+q$ are to be fixed along the x-axis at x=-a and x=a. How much **potential energy** is needed to **assemble** the system?
   A. 0
   B. kq^2/a
   C. $kq^2/(2a)$
   D. $kq^2/(4a)$
   E. $2kq^2/(a)$

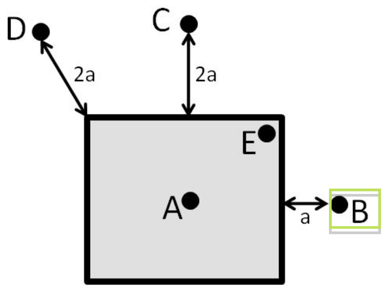
For the next two questions, consider spherical equipotential surfaces (whose cross sections are shown in the figure) surrounding a positive point charge. The ***potential difference between the surfaces I and II is measured to be 2.00 V****.*



22. **Surface.** A positive test charge q_0 is to be placed in one of the labeled points along the surfaces. At which location for the test charge will the **potential energy of the system be highest**?
   A. At point A
   B. At point B
   C. At point C
   D. Either point A or B
   E. Either A, B or C

23. **Test.** Another positive test charge q = 1.00 x 10^{-9} C is brought from A to C and then to B. What is the **total work done** by the electric field in moving the test charge?
   A. 0
   B. 1.00 x 10^{-9} J
   C. 2.00 x 10^{-9} J
   D. -1.00 x 10^{-9} J
   E. -2.00 x 10^{-9} J

24. **Electric Potential.** Consider an isolated square **conductor slab** with charge density **-ρ** as shown. Among the points A to E, which is **greatest** in terms of potentials? (a and 2a are distances of the given point from the slab.)



25. **Potential energy**. Consider two **small spheres A** and **B** initially separated by a distance of $\mathbf{r_0}$. Both have the same charge of **q**. Sphere B has mass **m**. Sphere A is held on a stationary position while sphere B is launched towards sphere A with a speed **v**. How close can sphere B get to sphere A? *Neglect the force of gravity.*

A. $\dfrac{2kq^2}{mv^2}$

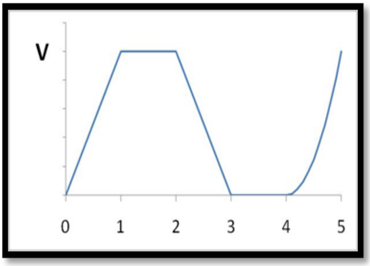
B. $\sqrt{\dfrac{2kq^2}{mv^2}}$

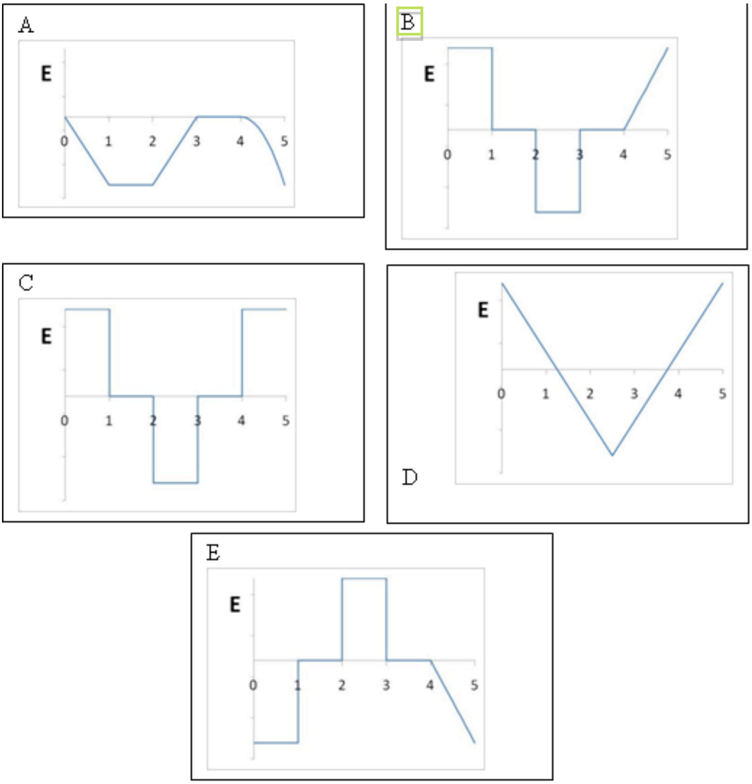
C. $\dfrac{kq^2}{\dfrac{mv^2}{2}+\dfrac{kq^2}{r_0}}$

D. $\dfrac{kq}{\dfrac{mv^2}{2}+\dfrac{kq^2}{r_0}}$

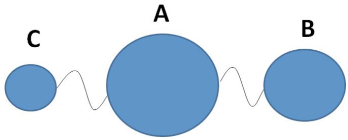
E. None of the above

26. **Electric Potential and Electric Field.** Consider an electric **potential-versus-position** (V vs. r) plot shown below. Which of the plots below best represent its corresponding **electric field-versus-position** (E vs. r) plot?





27. **Conductors and Electric Potential.** Conducting spheres C, A and B are connected to each other by conducting wires as shown in the figure. If the radius of A is twice of B, and the radius of A is three times the radius of C ($r_a = 2r_b = 3r_c$), which of the following statements is correct at electrostatic equilibrium?
    - A. $Q_A = Q_B = Q_C$; $V_A = V_B = V_C$
    - B. $Q_A = Q_B < Q_C$; $V_A < V_B = V_C$
    - C. $Q_A > Q_B > Q_C$; $V_A = V_B = V_C$
    - D. $Q_A > Q_C > Q_B$; $V_A = V_B = V_C$
    - E. $Q_A < Q_B < Q_C$; $V_A = V_B = V_C$



28. **Capacitance**. Consider a 10μF parallel plate capacitor initially connected to a 5-V DC power supply. The potential applied to the capacitor is then increased to 10V. What happens to the **capacitance** of the capacitor?
    - A. It will be doubled
    - B. It will be quadrupled
    - C. It will be halved
    - D. It will be quartered
    - E. It will remain the same

29. **Energy**. A **parallel plate capacitor** is connected to a battery. While connected to the battery, the area of each plate is **increased** by a **factor of 2**. What happens to the **energy stored** in the capacitor?
    - A. It will increase by a factor of 2
    - B. It will increase by a factor of 4
    - C. It will decrease by a factor of 2
    - D. It will decrease by a factor of 4
    - E. It will remain the same

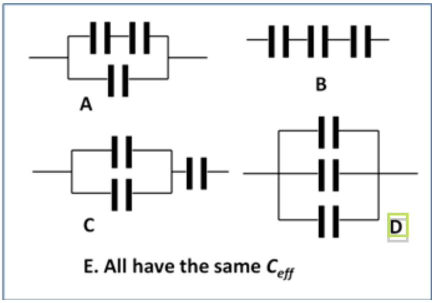
*For the next two numbers, consider an isolated parallel plate capacitor with an **initial charge 100μC**. A **dielectric κ** is then inserted into the capacitor. The **energy** of the capacitor becomes **500μJ**. The initial potential energy is 750μJ.*

30. **Charge**. What happens to the **charge** of the capacitor?
    - A. It will increase by a factor κ
    - B. It will increase by a factor κ^2
    - C. It will decrease by a factor κ
    - D. It will decrease by a factor κ^2
    - E. It will remain the same

31. **Dielectric**. What is the value of κ?
    - A. 1.0
    - B. 1.5
    - C. 2.0
    - D. 2.5
    - E. 3.0

32. **Capacitance.** Two capacitors C_1=C and C_2=4C are connected in parallel to a 3-V battery. Which of the following statements is always <u>**TRUE**</u> about the charge stored and voltage across each capacitor?
   A. $V_{C1} < V_{C2}$; $Q_{C1} < Q_{C2}$
   B. $V_{C1} < V_{C2}$; $Q_{C1} = Q_{C2}$
   C. $V_{C1} > V_{C2}$; $Q_{C1} = Q_{C2}$
   D. $V_{C1} = V_{C2}$; $Q_{C1} < Q_{C2}$
   E. $V_{C1} = V_{C2}$; $Q_{C1} > Q_{C2}$

33. **Effective capacitance.** Consider the following diagrams at the right. Assume that each of the capacitors has capacitance equal to C. Which has the highest **effective capacitance**?

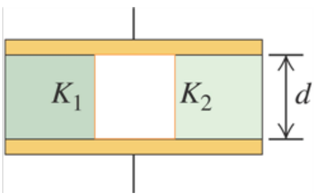


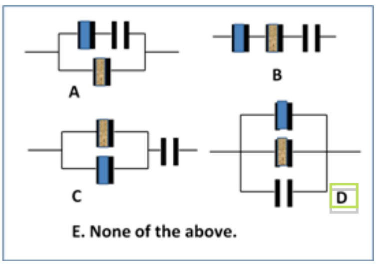
For the next two numbers, consider a parallel plate capacitor which consists of plates of area 1cm^2, separated by 2mm.

34. **Parallel plate capacitor.** The capacitor is connected to a 10-V battery. What is the electric field between the plates?
   A. 10 kV/m
   B. 5 kV/m
   C. 2 kV/m
   D. 1 kV/m
   E. 0

35. **Dielectric Slab.** If a dielectric slab (κ=2) is then placed in between the plates, what will be the new electric field due to the plates of the capacitor?
   A. 10 kV/m
   B. 5 kV/m
   C. 2 kV/m
   D. 1 kV/m
   E. 0

36. **Dielectrics.** Two dielectric slabs are placed inside a capacitor as shown in the figure. Which of the following circuit diagrams on its right corresponds to the capacitor combination?

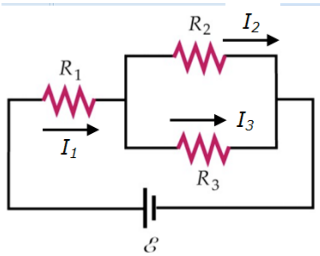




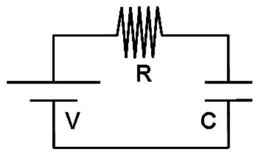
37. **Current Density.** The current density ***J*** in a wire is given by 50.0 A/m^2 **i**. If the drift velocity of the charge carriers (*q = -0.1 C*) is –2.0 x 10^{-4} m/s **i**, what is the concentration of the carriers?
   - A. – 2.5 x 10^6 m^{-3}
   - B. – 2.5 x 10^6 m^3
   - C. 2.5 x 10^5 m^{-3}
   - D. 2.5 x 10^6 m^3
   - E. 2.5 x 10^6 m^{-3}

38. **Ohm's Law.** Three different materials *A*, *B* and *C* each have resistivities $\rho_A > \rho_B > \rho_C$. Assuming that the **current densities** in all materials **are the same**, rank the three in order of **increasing electric field magnitude.**
   - A. A > B > C
   - B. B > A > C
   - C. C > A > B
   - D. C > B > A
   - E. A > C > B

39. **I've got the powah!** Consider **three identical resistors** connected to the battery as shown at the right. Arrange the three resistors in order of **increasing dissipated power**.
   - A. $R_1 < R_2 < R_3$
   - B. $R_1 < R_2 = R_3$
   - C. $R_1 = R_2 < R_3$
   - D. $R_1 > R_2 = R_3$
   - E. $R_1 = R_2 = R_3$



40. **RC circuit.** Consider the circuit below, composed of a battery *V* (internal resistance not shown), a resistor *R*, and a capacitor *C*. When the system is **at steady state**, which of the following statements is/are **true?**
   - A. Current through the resistor is at minimum
   - B. Power dissipated through the resistor is at minimum
   - C. Charge on the capacitor is at minimum
   - D. A and B
   - E. B and C

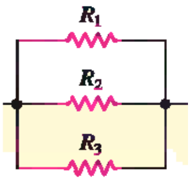


41. **Resistance**. A piece of cylindrical copper wire has diameter *d* and length *L*. If the diameter is **halved** while the length is **doubled**, what happens to its **resistance?**
   - A. 8 times the original
   - B. 4 times the original
   - C. Same as the original
   - D. 1/4 times the original
   - E. 1/8 times the original

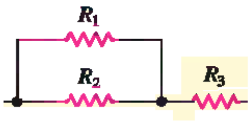
42. **Resistors.** Given a set of three identical resistors, which configuration would have the highest dissipated power for a constant voltage?

A.

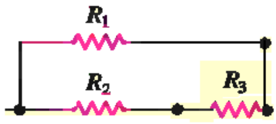
B.



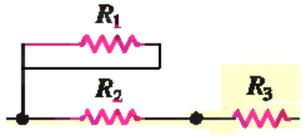
C.



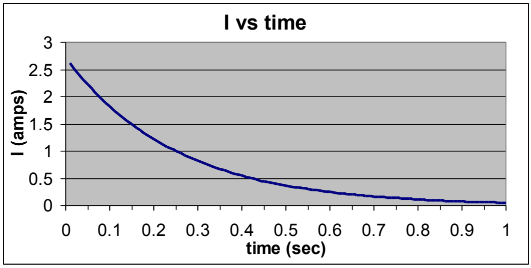
D.



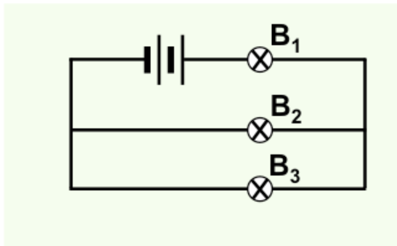
E.



43. **RC circuit.** From the current curve of a RC circuit shown on the right, what is the **time constant** of the circuit if the initial current I_o = 2.71 A? *Hint:* e = 2.71…
   A. 0.1s
   B. 0.25s
   C. 0.45s
   D. 0.8s
   E. 1.0s



44. **Power.** Three bulbs B1, B2, and B3 are connected to a voltage power supply. The resistance of B1 is **twice** that of B2 and B3 ($2R_2 = R_1 = 2R_3$), how much **power** is B1 getting compared to B2 and B3?
   A. ½ times
   B. Same
   C. 2 times
   D. 4 times
   E. 8 times



45. **Kirchhoff.** Using the circuit diagram on the right use junction rule to express the relationship of the **assumed current direction**.
   A. $I_1 + I_2 + I_3 = 0$
   B. $- I_1 - I_2 + I_3 = 0$
   C. $- I_1 + I_2 + I_3 = 0$
   D. $- I_1 + 2I_2 - I_3 = 0$
   E. $2I_1 - I_2 - I_3 = 0$