## Physics 102 Spring 2007: Final Exam —Multiple-Choice Questions

1. The circuit on the left in the figure below contains a battery of potential V and a variable resistor R_V. The circuit on the right in the figure below contains an ideal voltmeter connected in parallel across a resistor R. While the resistance of the variable resistor in the left circuit is *increased* linearly with respect to time , the voltmeter measures
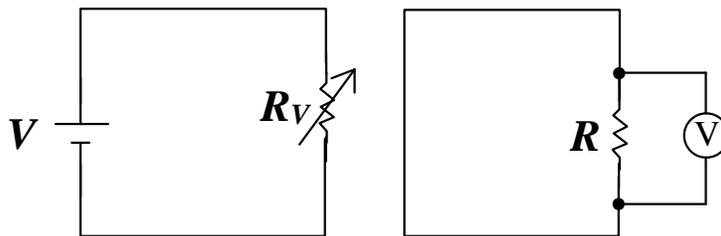

   (A) a non-zero and constant voltage.

   (B) a non-zero and increasing voltage.

   (C) a non-zero and decreasing voltage.

   (D) a zero voltage.

2. The frequency of an LC oscillator (a fully charged capacitor placed in series with an inductor) is ω_0. The plates of the parallel plate capacitor are pulled apart to twice the original distance, and a dielectric ($\kappa > 1$) is completely inserted into the capacitor. What is the new frequency of oscillation for the circuit?

   (A) $\frac{2}{\kappa} \omega_0$.

   (B) $\sqrt{\frac{2}{\kappa}} \omega_0$.

   (C) $\sqrt{\frac{\kappa}{2}} \omega_0$.

   (D) $\frac{\kappa}{2} \omega_0$.

3. Consider a solenoid with radius R and length L ($R \ll L$). The magnetic field at the center of the solenoid is B_0. A second solenoid is constructed that has twice the radius, twice the length, and carries twice the current as the original solenoid, but has the same number of turns per meter. The magnetic field at the center of the second solenoid is

   (A) $B_0/4$.

   (B) $B_0/2$.

   (C) B_0.

   (D) $2\,B_0$.

   (E) $4\,B_0$.

4. Two balls of equal mass m are hung from silk threads of equal length. If the sphere on the right has a charge $4q$ and the sphere on the left has charge q, then how are the angles α and β related.

(A) $\alpha = \frac{1}{4}\beta$.

(B) $\alpha = \frac{1}{2}\beta$.

(C) $\alpha = \beta$.

(D) $\alpha = 2\beta$.

(E) $\alpha = 4\beta$.
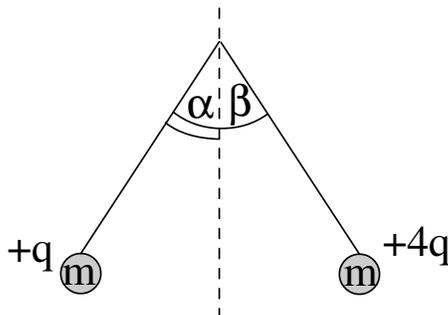
5. Three small spheres x, y, and z carry charges of equal magnitudes and with signs shown below. They are placed on the vertices of an isosceles triangle with the distance between x and y equal to the distance between x and z. Spheres y and z are held in place but sphere x is free to move on a frictionless surface. Which path labeled A through E will sphere x take upon release?
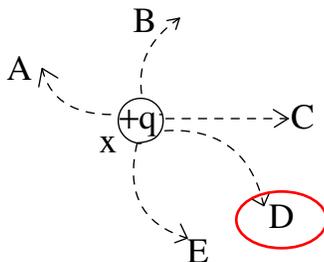
6. The current through an infinitely long solenoid is decreased linearly as a function of time. The figure below represents a cross section of the solenoid with the direction of the arrow indicating the current and the dots indicating the direction of the magnetic field. An electron is placed *initially at rest* outside the solenoid. The force the electron experiences at the instant it is released is best represented by which of the following arrows

(A) ←

(B) ↘

(C) ↖

(D) →

(E) 0
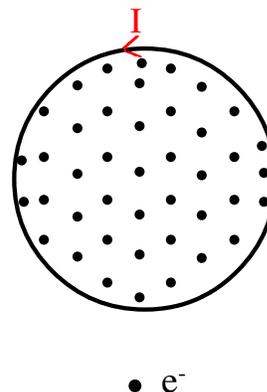
7. In figure (a) below, a solenoid produces a magnetic field whose strength increases into the plane of the page. An induced EMF is established in a conducting loop surrounding the solenoid, and this EMF lights bulbs A and B. In figure (b), points P and Q are shorted (that is a wire with negligible resistance is connected across points P and Q). After the short is inserted,

(A) bulb A turns off and bulb B gets brighter.

(B) bulb B turns off and bulb A gets brighter.

(C) bulb A turns off and bulb B gets dimmer.

(D) bulb B turns off and bulb A gets dimmer.

(E) both bulbs go out.
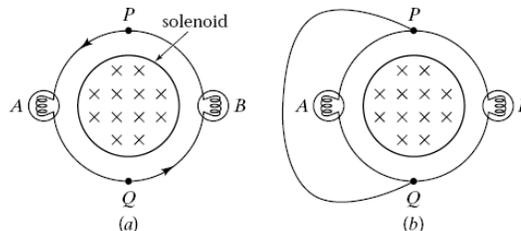
8. A battery and five resistors of **equal resistance** are arranged as shown in the figure below. Which resistor dissipates the most power?
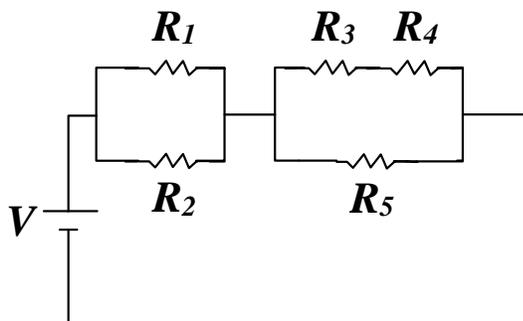
(A) R_1.

(B) R_2.

(C) R_3.

(D) R_5.

(E) The power dissipated by each resistor is the same for all resistors.

9. Consider a very long wire carrying a steady current I going into the page as indicated in the figure below. Three oriented loops are also shown in the figure below. Which statement(s) is (are) correct?

I. $\oint_A \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} = \mu_0\, I$.

II. $\oint_A \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} = -\, \mu_0\, I$.

III. The magnetic field at every point around loop B is $\frac{\mu_0\, I}{2\,\pi\, R_b}$.

IV. $\oint_A \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} > \oint_B \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} > \oint_C \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}}$.

V. An external agent would do negative work when moving a positive charge around loop B in the direction of loop B.

loop A

loop B

loop C

R_b
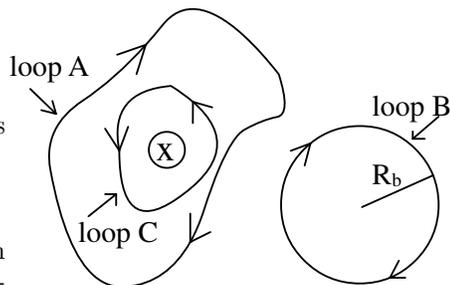
(A) Only I and IV are correct.

(B) Only II and IV are correct.

(C) Only III and V are correct.

(D) Only I, IV, and V are correct.

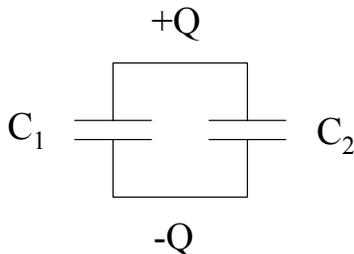(E) Only II, IV and V are correct.

10. When the switch is closed, the potential difference across R is

primary coil

secondary coil

V

N_1

$N_2 > N_1$

R
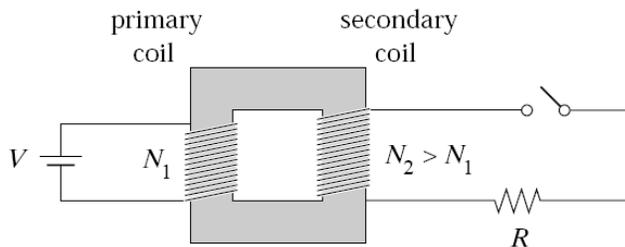
(A) $V\, N_2\, /N_1$.

(B) $V\, N_1\, /N_2$.

(C) V.

(D) 0.

(E) insufficient information.

11. Consider the arrangement of two capacitors connected by wires depicted below. A charge of $+Q$ is ripped from the bottom wire and added to the top. For the case $C_1 > C_2$, compare the charge on each capacitor's top plate (Q_1 and Q_2) and the voltage difference (V_1 and V_2) across each capacitor. Which of the statement(s) below is (are) true?

I. $Q_1 > Q_2$.

II. $Q_1 = Q_2$.

III. $Q_1 < Q_2$.

IV. $V_1 > V_2$.

V. $V_1 = V_2$.

VI. $V_1 < V_2$.

+Q

$C_1 \quad C_2$

-Q

(A) Only I and VI are correct.

(B) Only II and VI are correct.

(C) Only I and IV are correct.

(D) Only III and VI are correct.

(E) Only I and V are correct

12. Consider the circuit below. A resistor R, inductor L, and capacitor C are connected in *parallel* across an alternating voltage source. Which statement(s) is (are) correct?

I. The instantaneous current through each element must add up to the instantaneous current provided by the driving source.

II. The instantaneous voltages across each element must add up to the instantaneous voltage of the driving source.

III. The voltage across C is 90° out of phase with the voltage across R.

IV. The voltage across C is 180° out of phase with the voltage across L.

V. All energy is dissipated by the resistor.

$V_P \sin(\omega t)$ R L C
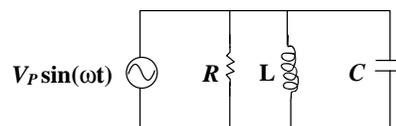
(A) Only I and V are correct.

(B) Only II and V are correct.

(C) Only I, III, and V are correct.

(D) Only I, IV, and V are correct.

(E) Only II, IV, and V are correct.

Refer to the circuit below for Questions 13 - 15. The circuit has been established for a very long time. At time $t = 0$, the switch is closed
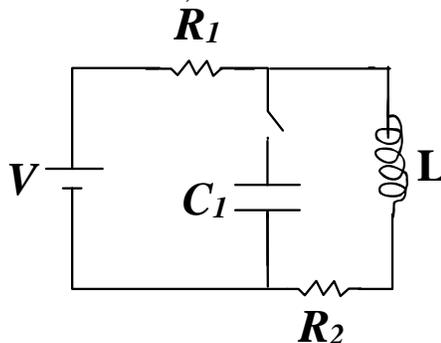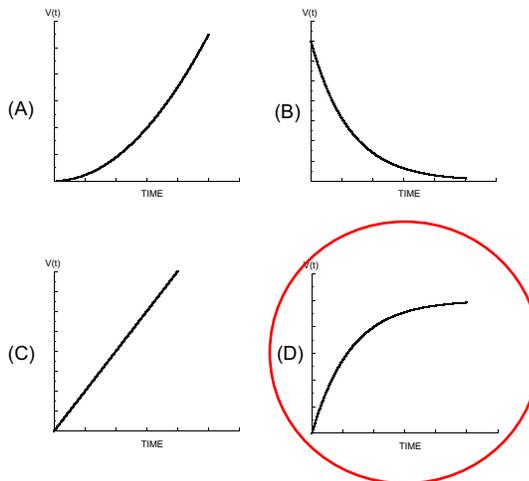

13. The current, I_0, through resistor R_2 at the instant $t = 0$ is

   (A) 0.
   (B) $I_0 = V/R_1$.
   (C) $I_0 = V/R_2$.
   (D) $I_0 = V/(R_1 + R_2)$.

14. After the switch has been closed for a very long time, the charge on the capacitor is

   (A) $Q = 0$.
   (B) $Q = V\,C_1$.
   (C) $Q = V\,C_1\,(R_2/R_1)$.
   (D) $Q = V\,C_1\,(\frac{R_1}{R_1+R_2})$.
   (E) $Q = V\,C_1\,(\frac{R_2}{R_1+R_2})$.

15. Which of the following graphs best represents the behavior of the potential difference across the capacitor as a function of time?

Refer to the figure below for questions 16 and 17. Two identical magnets are dropped at the same time from the same height above the ground. The first magnet (Case 1) is dropped in a region of space that contains no conducting loops. The second magnet (Case 2) is dropped and allowed to pass through the center of a small copper ring. The diameter of the copper ring is larger than the width of the bar magnet so that the bar magnet does not hit the copper ring.
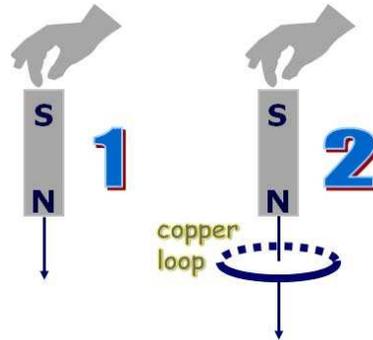
16. How does the kinetic energy of the magnet in Case 1 compare to the kinetic energy of the magnet in Case 2 right before the magnets hit the ground?

    (A) KE (Case 1) > KE (Case 2).

    (B) KE (Case 1) = KE (Case 2).

    (C) KE (Case 1) < KE (Case 2).

    (D) More information is needed.

17. Which magnet strikes the ground first?

    (A) The magnet in Case 1.

    (B) The magnet in Case 2.

    (C) Both magnets will hit the ground at the same time.

18. The leads of a sinusoidal AC-generator with angular frequency ω and peak voltage V_p are connected across a resistor with resistance R. What is the average power $<P>$ dissipated by the resistor?

    (A) $<P>= 0$.

    (B) $<P>= V^2/(\sqrt{2}\,R)$.

    (C) $<P>= V^2/(2\,R)$.

    (D) $<P>= V^2/(R)$.

    (E) $<P>= 2\,V^2/(R)$.

For questions 19 - 20 refer to the figure below. Two isolated, identical spherical drops of mercury (a good electrical conductor) each carry a net charge of $+q_0$ and an electric potential V_0 at the surface with respect to infinity. The two drops are pushed together to form a single drop of mercury with charge q_1 and electric potential V_1 at its surface as illustrated in the figure below.
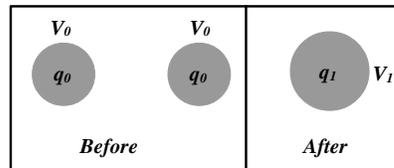
19. Which of the following statement(s) is (are) true?

    I. $V_1 = V_0$.
    II. $V_1 = 2\,V_0$.
    III. $q_1 = q_0$.
    IV. $q_1 = 2\,q_0$.

    (A) Only III is correct.
    (B) Only IV is correct.
    (C) Only I and III is correct.
    (D) Only I and IV is correct.
    (E) Only II and IV are correct.

20. What can be stated about the amount of work the *electric field* does on the system of the two mercury drops?

    (A) The work done by the electric field is positive.
    (B) The work done by the electric field is zero.
    (C) The work done by the electric field is negative.
    (D) Information about the displacement of the drops is needed to answer the question.

21. The charge on an originally neutral isolated conductor is separated by induction from a positively charged rod brought near the conductor. Rank the electric flux (Φ_E) through the gaussian surfaces labeled S_1 through S_5 in the figure below from greatest to least. NOTE: The electric flux through surface S_1 is denoted as $\Phi(S_1)$.
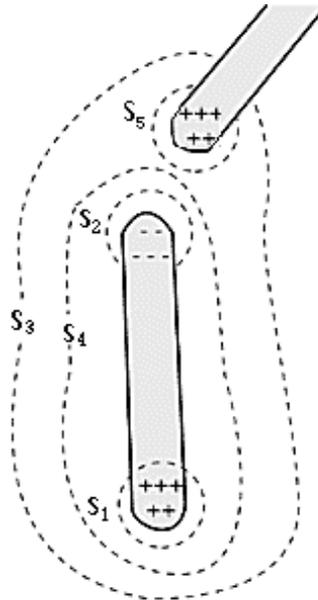
(A) $\Phi(S_3) > \Phi(S_4) > \Phi(S_1) = \Phi(S_5) > \Phi(S_2)$.

(B) $\Phi(S_2) > \Phi(S_5) > \Phi(S_4) = \Phi(S_3) > \Phi(S_1)$.

(C) $\Phi(S_1) = \Phi(S_5) > \Phi(S_4) = \Phi(S_3) > \Phi(S_2)$.

(D) $\Phi(S_1) = \Phi(S_3) = \Phi(S_5) > \Phi(S_4) > \Phi(S_2)$

(E) $\Phi(S_1) = \Phi(S_3) = \Phi(S_5) > \Phi(S_2) > \Phi(S_4)$

22. A new electronic device requires an AC - Voltage of 6V in order to operate. You wish to make an transformer that will connect into the 120 V house wiring. What must the ratio of the primary to the secondary turns be in the *ideal* transformer?

(A) 0.0025

(B) 0.05

(C) 20

(D) 400

23. Which charge distribution shown below will yield a **non-zero electric field**, and a **non-zero potential** at the origin of the coordinate system if the potential is defined to be zero infinitely far away from the origin? NOTE: All semi- and quarter-circles have the same radius as the complete circle in (A) and are all centered about the origin of the coordinate system.

(A) $+\lambda$

(B) $+\lambda$ $-\lambda$

(C) $+\lambda$ $-\lambda$

(D) $+\lambda$ $+\lambda$ $-\lambda$ $-\lambda$

(A) A.

(B) B.

(C) C.

(D) D.
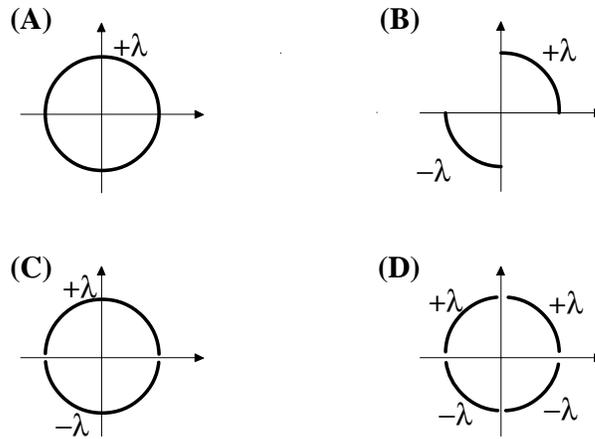
(E) None of the listed charge distributions meet the criteria.

24. Which charge distribution shown below will yield a **zero electric field**, and a **non-zero potential** at the origin of the coordinate system if the potential is defined to be zero infinitely far away from the origin? NOTE: All semi- and quarter-circles have the same radius as the complete circle in (A) and are all centered about the origin of the coordinate system.
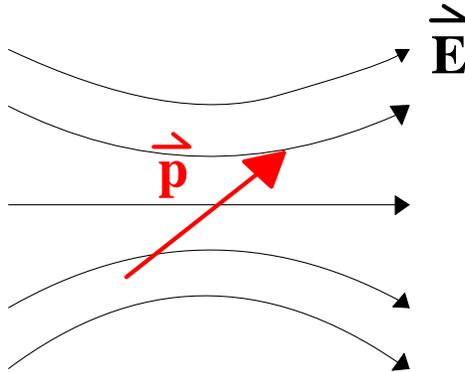
(A) $+\lambda$

(B) $+\lambda$ $-\lambda$

(C) $+\lambda$ $-\lambda$

(D) $+\lambda$ $+\lambda$ $-\lambda$ $-\lambda$

(A) A.

(B) B.

(C) C.

(D) D.
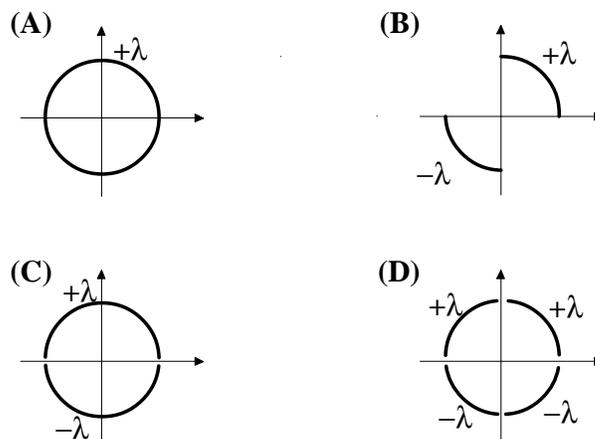
(E) None of the listed charge distributions meet the criteria.

25. An electric dipole $\vec{p}$ is placed in an external electric field $\vec{E}$ as shown in the figure below. What statement is correct about the subsequent behavior of the electric dipole?

    (A) The electric dipole experiences a net force but no net torque.

    (B) The electric dipole experiences a net torque but no net force.

    (C) The electric dipole experiences both a net torque and a net force.

    (D) The electric dipole experiences no net torque and no net force.

Physics 102 Spring 2007: Final Exam —Multiple-Choice Answers

	A	B	C	D	E
1	X				
2		X			
3				X	
4			X		
5				X	
6	X				
7	X				
8				X	
9	X				
10				X	
11					X
12	X				
13				X	
14					X
15				X	
16	X				
17	X				
18		X			
19		X			
20			X		
21				X	
22			X		
23					X
24	X				
25			X		