 77777

Instructor(s): *Profs. Korytov, Rinzler*

PHYSICS DEPARTMENT

PHY 2049, Spring 2015 — Midterm 2 — March 25, 2015

Name (print): ______________________ Signature: ______________________

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

DIRECTIONS

(1) **Code your test number on your answer sheet (use 76–80 for the 5-digit number)**. Code your name on your answer sheet. **Darken circles completely (errors can occur if too light)**. Code your student number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch work anywhere on this exam that you like. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout with scratch work.
(4) Work the questions in any order. Incorrect answers are not taken into account in any way; you may guess at answers you don't know.
(5) If you think that none of the answers is correct, please choose the answer given that is closest to your answer.
(6) **Blacken the circle of your intended answer completely, using a number 2 pencil**. Do not make any stray marks or the answer sheet may not read properly. Completely erase all incorrect answers, or take a new answer sheet.
(7) As an aid to the examiner (and yourself), in case of poorly marked answer sheets, please circle your selected answer on the examination sheet. Please remember, however, that in the case of a disagreement, the answers on the bubble sheet count, NOT what you circle here. Good luck!!!

>>>>>>>>**WHEN YOU FINISH** <<<<<<<<
Hand in the answer sheet separately.

Constants: $e = 1.6 \times 10^{-19}$ C $\quad m_p = 1.67 \times 10^{-27}$ kg $\quad m_e = 9.1 \times 10^{-31}$ kg $\quad \epsilon_o = 8.85 \times 10^{-12}$ C^2/N·m^2

$k = 1/(4\pi\epsilon_o) = 9 \times 10^9$ N·m^2/C^2 $\quad$ nano $= 10^{-9}$ $\quad$ micro $= 10^{-6}$ $\quad$ pico $= 10^{-12}$

Sphere: $A = 4\pi R^2$ $\quad V = \dfrac{4\pi}{3}R^3$ $\quad \mu_0 = 4\pi \times 10^{-7}$ T·m/A

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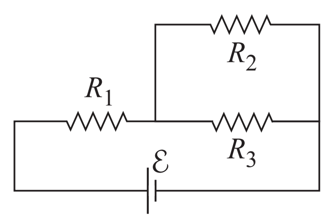
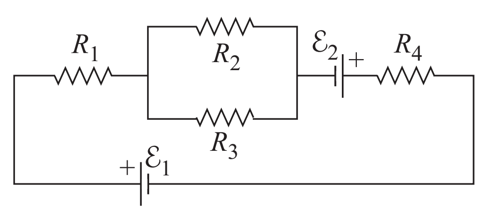
1. In the Figure $\mathcal{E} = 10.0$ V, $R_1 = 1.00$ kΩ, $R_2 = 4.00$ kΩ and $R_3 = 4.00$ kΩ. The current through R_3 (in mA) is?



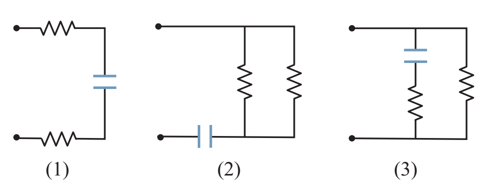
(1) 1.67
(2) 6.67
(3) 5.56
(4) 4.44
(5) 3.33

2. In the Figure $\mathcal{E}_1 = 1.00$ V, $\mathcal{E}_2 = 2.00$ V, $R_1 = R_4 = 10.0\,\Omega$, and $R_2 = R_3 = 20.00\,\Omega$. Power is dissipated in the resistors such that:



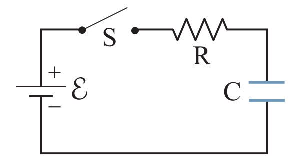
(1) $P_1 = P_4 > P_2 = P_3$
(2) $P_4 > P_1 > P_2 = P_3$
(3) $P_2 = P_3 > P_1 = P_4$
(4) $P_2 = P_3 > P_4 > P_1$
(5) $P_1 = P_2 = P_3 = P_4$

3. In the 3 circuits shown in the Figure, all resistances are the same and all capacitances are the same. The ends of each circuit are simultaneously connected to ideal DC power supplies of the same potential. The order in which the capacitors charge up to 70% of their full charge (first to last) is:



(1) 2, 3, 1 (2) 1, 2, 3 (3) 3, 2, 1 (4) 2, 1, 3 (5) 1, 3, 2

4. In the Figure $\mathcal{E} = 12.0$ V and $R = 2.00$ kΩ. The capacitor is initially fully discharged. After switch S is closed the potential difference between the plates of the capacitor rises to 9.00 V in 1.10 μs. The capacitance of the capacitor, in pF, is?



(1) 397 (2) 84.1 (3) 146 (4) 203 (5) 315

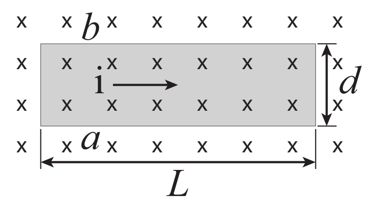
5. A proton having velocity $\vec{v} = 20.0\hat{j}$ km/s enters a region of space where the instantaneous magnetic field is given by $\vec{B} = (20.0\,\hat{i} + 20.0\,\hat{k})$ mT. The magnitude of the acceleration the proton experiences at that instant (in m/s^2) is?

(1) 5.42×10^{10} (2) 8.22×10^{9} (3) 2.92×10^{10} (4) 7.82×10^{10} (5) 9.62×10^{10}

6. A *negative* ion (possessing one extra electron) has a mass of 1.33×10^{-25} kg and moves along the x-axis with a velocity of 407 m/s in the $\hat{i}$ direction. The ion enters a region where a magnetic field of magnitude 5 mT directed in the $-\hat{k}$ direction is switched on. This causes the ion to execute a circular orbit. That orbit is in either the +y or the −y half plane and has period of motion (in ms) of?

(1) −y, 1.04 (2) +y, 1.04 (3) +y, 2.08 (4) −y, 2.08 (5) −y, 0.502

7. A new material is synthesized and found to be electrically conducting. To determine the sign of the charge carriers and drift velocity, it is shaped into a rectangular bar of length $L = 1.00$ cm, width $d = 1.00$ mm, thickness $h = 0.050$ mm. The bar carries a uniform current of 10 mA, in a uniform magnetic field of 1.2 T, oriented as shown in the Figure. Relative to side a at 0 volts, side b is measured to be +65.0 nV. Based on this information, you are to decide if the charge carriers are positive or negative and the value of the drift velocity (in m/s), in that order.

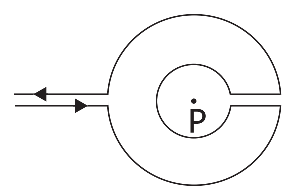


(1) positive, 5.40×10^{-5}
(2) negative, 5.40×10^{-5}
(3) positive, 1.10×10^{-3}
(4) negative, 1.10×10^{-3}
(5) charge cannot be determined, 1.10×10^{-3}

8. A 20 turn flat coil of wire of radius 50 cm carries a current of 1.5 A. The coil lies in a uniform magnetic field of magnitude $B = 55$ mT oriented in a direction such that no magnetic flux goes through the coil. The magnitude of the torque experienced by the coil is (in N·m)?

(1) 1.3 (2) 1.8 (3) 2.7 (4) 3.6 (5) 4.8

9. A single, very long (effectively infinite) wire comes in and is bent around point P in the shape shown in the Figure (all in one plane) where the outer circular segments have radius 24.0 cm, concentric with point P, and the inner loop having radius 12 cm, is also concentric with point P. The separation between the parallel segments of the wire is exaggerated for clarity (they lie virtually on top of each other, in line with point P, while being electrically isolated). A current of 4.50 A flows in the direction indicated by the arrows. With the positive direction being out of the page, the net magnetic field at point P (in μT) is?

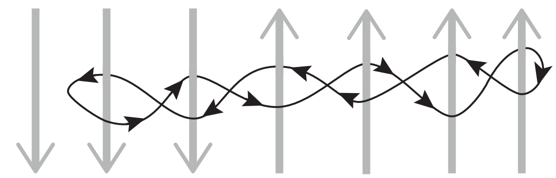


(1) −11.8 (2) +11.8 (3) −1.88 (4) +1.88 (5) −6.33

10. A 1.40 m long solenoid possessing 5000 turns has a current of 1.60 A running through the wire making up its windings. In the center of the solenoid lies a small, flat circular coil consisting of 5 turns of wire around a 2.00 cm diameter with 200 mA of current running through the wire of that coil. The vector magnetic dipole moment of the small coil is originally parallel to the $\vec{B}$ field of the solenoid. The work that must be done to rotate the small coil such that its vector dipole moment is anti-parallel to the $\vec{B}$ field of the solenoid is (in μJ)?

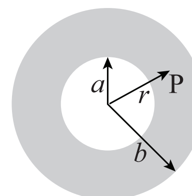
(1) 4.51 (2) 153 (3) 107 (4) 64.3 (5) 27.2

11. In the Figure each vertical gray arrow represents a current: i flowing in the direction indicated by the arrow. The integral of $\oint \vec{B} \cdot d\vec{s}$ along the black Amperian loop in the direction indicated by the arrows along the loop is?



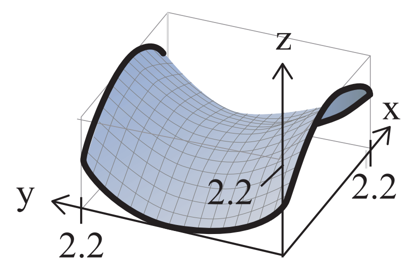
(1) 0 (2) $2i\mu_o$ (3) $i\mu_o$ (4) $-i\mu_o$ (5) $-2i\mu_o$

12. A cylindrical conductor has an inner hollow of radius $a = 1.00$ cm and outer radius $b = 2.00$ cm (the Figure shows a cross-section). It carries a uniform current density of 3.00 A/cm^2 into the page. The magnitude of the magnetic field at the point P at $r = 1.50$ cm from the central axis due to this current is (in μT)? (Hint — use Ampere's law.)



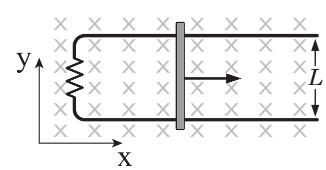
(1) 157 (2) 43.0 (3) 76.3 (4) 122 (5) 209

13. In the Figure the thick black line is a conductor that bounds the surface satisfying the equation, $z = (y - 1.1)^2 - (x - 1.1)^2 + 1.1$ where dimensions are in meters and the loop edges touch the sides of the rectangular box indicated. A uniform magnetic field permeates the area given by $\vec{B} = 312$ mT $\hat{k}$. The magnetic flux through the surface is (in T·m^2)?



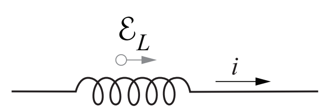
(1) 1.5 (2) 3.0 (3) 0.91 (4) 4.4 (5) 6.0

14. Two parallel conducting rails of negligible resistance are separated by distance $L = 15$ cm and electrically connected through a resistor of resistance 36 Ω (see Figure). A conducting bar, also of negligible resistance, is electrically coupled to the rails and free to slide along them. A uniform magnetic field of magnitude $B = 400$ mT that points into the page permeates the entire area. The bar is pulled to the right with a constant speed of $v = 1.7$ m/s. The resulting current that flows through the resistor is along the +y or −y direction and has value (in mA)?



(1) −y, 2.83 (2) +y, 2.83 (3) −y, 0.289 (4) +y, 0.289 (5) +y, 0.00801

15. At a particular instant an inductor of inductance $L = 12$ H has current of 2.0 A flowing through it and a self induced EMF: $\mathcal{E}_L = 60$ V. The EMF and the current through it at that instant are in the direction shown in the Figure. With what rate must the current be changing (in A/s) to create this EMF and is it increasing or decreasing?



(1) 5.0, decreasing (2) 5.0, increasing (3) 30, increasing (4) 30, decreasing (5) 24, decreasing

16. At one instant in time an LR circuit has a current flowing through it of 44 mA. At a time $3.3\,\mu$s later the current is 22 mA. The resistor is 1.0 kΩ. The inductance of the inductor must be (in mH)?

(1) 4.8 (2) 3.9 (3) 2.7 (4) 1.4 (5) 0.88

17. A series RLC circuit has $R = 9\,\Omega$, $C = 16\,\mu$F and $L = 4$ H. At one instant in time the capacitor has a charge of $12\,\mu$C and the current is zero. The natural *angular* frequency of the oscillations is (in rad/s)?

(1) 125 (2) 41.6 (3) 103 (4) 56.9 (5) 147

18. In a driven, series RLC circuit the current oscillates in-phase with the drive EMF of $\mathcal{E}_{max} = 14$ V. The average power is 2.4 W. The resistance in the circuit must be close to (hint: careful, some pitfall wrong answers are here)?

(1) 41 Ω (2) 82 Ω (3) 20 Ω (4) 110 Ω (5) 196 Ω

19. A series RLC circuit is to be operated at 1.20 kHz. The inductance $L = 300$ mH and the resistance $R = 12\,\Omega$. How much capacitance (in nF) should be introduced to minimize the power reflected to the power supply?

(1) 58.6 (2) 42.2 (3) 36.8 (4) 29.1 (5) 16.3

20. A generator supplies 6.00 V at 60.0 Hz to the primary coil of an ideal transformer having 50 turns. The secondary has 540 turns. The frequency and voltage of the secondary is?

(1) 60 Hz, 64.8 V (2) 60 Hz, 0.556 V (3) 648 Hz, 6 V (4) 5.56 Hz, 6 V (5) 648 Hz, 64.8 V