Instructor(s): Mueller/Woodard

PHYSICS DEPARTMENT

PHY 2049, Fall 2017 Exam 2 November 3, 2017

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

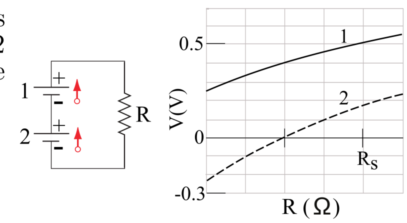
(1) **Code your test number on your answer sheet (use 76–80 for the 5-digit number)**. Code your name on your answer sheet. **Darken circles completely (errors can occur if too light)**. Code your student number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch 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		
$\mu_B = 9.27 \times 10^{-24}$ J/T	$m_p = 1.67 \times 10^{-27}$ kg	$m_e = 9.11 \times 10^{-31}$ kg
$e = 1.6 \times 10^{-19}$ C	$k = 9 \times 10^9$ N m^2/C^2	$\epsilon_0 = 8.85 \times 10^{-12}$ F/m
$\mu_0 = 4\pi \times 10^{-7}\ T \cdot A/m$	$c = 3 \times 10^8$ m/s	$g = 9.8$ m/s^2
f = femto = 10^{-15}	p = pico = 10^{-12}	n = nano = 10^{-9}
μ = micro = 10^{-6}	M = Mega = 10^6	G = Giga = 10^9

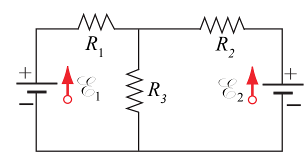
 77777

1. In figure a, both batteries have emf $\mathcal{E} = 1.2$ V and the external resistance R is a variable resistor. Figure b gives the electric potentials V between the terminals of each battery as functions of R; Curve 1 corresponds to battery 1, and curve 2 corresponds to battery 2. The horizontal scale is set by $R_s = 0.20\ \Omega$. What is the internal resistance of battery 1?



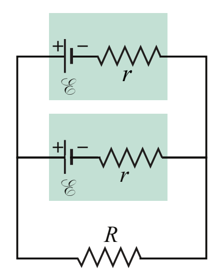
(1) 0.20 Ω (2) 0.35 Ω (3) 0.25 Ω (4) 0.15 Ω (5) 0.10 Ω

2. In the figure, the ideal batteries have emfs $\mathcal{E}_1 = 10$ V and $\mathcal{E}_2 = 5$ V, and the resistances are each 4 Ω. What is the current in R_2?



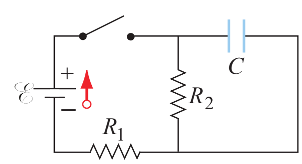
(1) 0 A (2) 0.50 A (3) 0.75 A (4) 1.00 A (5) 1.25 A

3. In the figure, two batteries each with emf $\mathcal{E} = 12$ V and an internal resistance $r = 0.30\ \Omega$ are connected in parallel across a resistance R. For what value of R is the dissipation rate in the resistor a maximum?



(1) 0.15 Ω (2) 0.30 Ω (3) 0.60 Ω (4) 0.45 Ω (5) 0.75 Ω

4. In the figure, $R_1 = 10$ kΩ, $R_2 = 15$ kΩ, $C = 0.4\ \mu$F, and the ideal battery has emf $\mathcal{E} = 20$ V. First, the switch is closed a long time so that the steady state is reached. Then the switch is opened at time $t = 0$. What is the magnitude of the current in R_2 at time $t = 4$ ms?

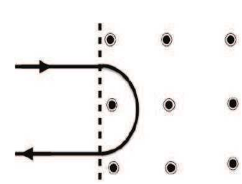


(1) 0.41 mA (2) 1.3 mA (3) 2.0 mA (4) 0.74 mA (5) 0.51 mA

5. A beam of protons with a velocity of $v = 1.5\times10^6\,\hat{j}$ m/s is sent into a region of uniform magnetic field of $B = 2.0\times10^{-3}\hat{\imath}$ T. What electric field in N/C is necessary (in magnitude and direction) such that the protons continue in a straight line without deflection by the magnetic field?

(1) $3000\,\hat{k}$ (2) $3000\,\hat{j}$ (3) $-3000\,\hat{\imath}$ (4) $-3000\,\hat{k}$ (5) $-3000\,\hat{j}$

6. An ion of charge +4e is sent into a region with constant magnetic field of magnitude B=0.25 T perpendicular to the plane of motion of the ion. The charge makes a U-turn. What is its mass in kg if it exits the region after a time $t = 7.8 \times 10^{-6}$s?

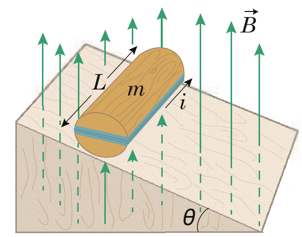


(1) 4×10^{-25} (2) 1×10^{-27} (3) 9×10^{-26} (4) 6×10^{-25} (5) 7×10^{-24}

7. A particle with a negative charge propagates through a uniform magnetic field. At time t=0 it has a velocity of $\vec{v} = 3.0\hat{i} + 2.0\hat{j}$ and experiences a force into the positive $\hat{k}$-direction. Which of the following directions could be correct for the magnetic field?

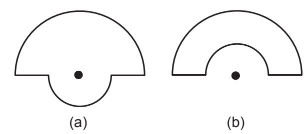
(1) $-\hat{j}$ (2) $+\hat{j}$ (3) $+\hat{k}$ (4) $-\hat{k}$ (5) $-\hat{i}$

8. The figure shows a wood cylinder of mass $m = 0.25$ kg and length $L = 0.10$ m, with $N = 10$ turns of wire wrapped around it longitudinally, so that the wire coil contains the long central axis of the cylinder. The cylinder is released on a plane inclined at an angle θ to the horizontal, with the plane of the coil parallel to the incline plane. If there is a vertical magnetic field of magnitude 0.50 T, what is the least current i through the coil that keeps the cylinder from rolling down the plane? Note that the friction between the wood and the plane keeps the cylinder from sliding.



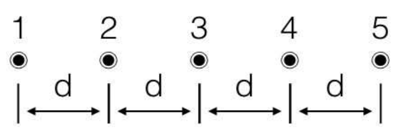
(1) 2.5 A (2) 4.9 A (3) 1.2 A (4) 7.4 A (5) Must know θ

9. A current is set up in a wire loop consisting of a semicircle of radius 4.0 cm, a smaller concentric semicircle, and two radial straight lengths, all in the same plane. Figure a shows the arrangement but is not drawn to scale. The magnitude of the magnetic field produced at the center of curvature is 47.25 μT. The smaller semicircle is then flipped over (rotated) until the loop is again entirely in the same plane (figure b). The magnetic field produced at the (same) center now has magnitude 15.75μT. What is the radius of the smaller semicircle?



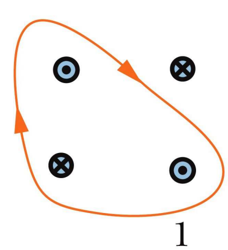
(1) 2.0 cm (2) 1.0 cm (3) 1.5 cm (4) 2.5 cm (5) 3.0 cm

10. In the figure, five long parallel wires in an xy plane are separated by distance $d = 50$ cm. The currents into the page are $i_1 = 2.0$ A, $i_3 = 0.25$ A, $i_4 = 4.0$ A, and $i_5 = 2.0$ A; the current out of the page is $i_2 = 4.0$ A. What is the magnitude of the net force *per unit length* acting on wire 3 due to the currents in the other wires?



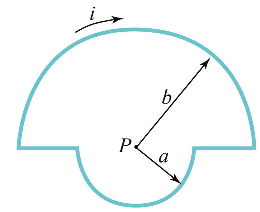
(1) 8×10^{-7} N/m (2) 10×10^{-7} N/m (3) 6×10^{-7} N/m (4) 4×10^{-7} N/m (5) 2×10^{-7} N/m

11. Each of the four wires in the figure carries a current of magnitude i either into or out of the page. What is the value of the line integral $\oint \vec{B} \cdot d\vec{s}$ along the line and in the direction shown in the figure?



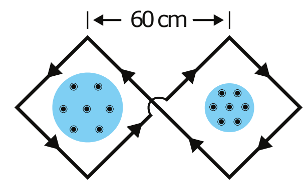
(1) $-\mu_0 i$ (2) $+\mu_0 i$ (3) $-2\mu_0 i$ (4) $+2\mu_0 i$ (5) 0

12. In the figure, current $i = 56$ A is set up in a loop having two radial lengths and two semicircles of radii $a = 5.7$ cm and $b = 9.4$ cm with a common center P. What is the magnitude and direction (into or out of the page) of the loop's magnetic dipole moment in units of 10^{-3} Am^2?



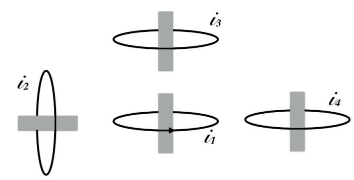
(1) 1.1 into (2) 1.1 out of (3) 2.1 into (4) 2.1 out of (5) 0

13. The figure shows two circular regions; region 1 of radius $r_1 = 15$ cm and region 2 of radius $r_2 = 10$ cm. separated by 60 cm. The magnetic field in region 1 is 50mT coming out of the plane of the page, and that in region 2 is 30mT coming also out of the plane of the page. The magnitudes of both fields are decreasing at a rate of 5mT/s. Calculate the path integral $\oint \vec{E} \cdot d\vec{s}$ in mV along the path drawn in the figure; ignore the bending of the path at the crossing. Note: The direction of the path integral matters.



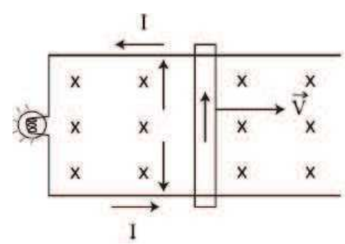
(1) 0.2 (2) 34 (3) 6.2 (4) 0.9 (5) 11.6

14. Current i_1 flows through the circular loop of wire in the center, as shown in the figure. The direction of the current is counterclockwise, when viewed from above. (The grey bars, which indicate the central axes of the loops, have been added to help you visualize the geometry of the problem.) If this current increases with time, what are the directions of the currents i_2, i_3, i_4 induced in the three adjacent circular loops of wire? Loop 3, whose current is i_3, is located above loop 1, whose current is i_1. In the answers, cw stands for clockwise, and ccw for counterclockwise, both when viewed from above or from the right, and 0 means no induced current.



(1) 0, cw, ccw (2) 0, cw, 0 (3) ccw, cw, ccw (4) cw, cw, ccw (5) 0, ccw, cw

15. The rod in the figure is moving at a constant speed in a direction perpendicular to a 0.60 T magnetic field, which is directed into the paper. The rod has a length of 1.6 m and has negligible electrical resistance. The rails also have negligible resistance. If the power dissipated by the light bulb is 4 W and its resistance is 100 Ω, what is the speed of the rod in m/s?



(1) 21 (2) 7 (3) 3 (4) 12 (5) 17

16. Suppose the emf of the battery in a serial RL circuit varies with time so that the current is given by $i(t) = 0.5 \cdot t$ where i is in A and t is in seconds. Assume $R = 1.0\,\Omega$ and $L = 6\,$H. What is the emf at $t = 10\,$s?

(1) 8V (2) 2V (3) 3V (4) 5V (5) 4V

17. An LC circuit has a capacitance of $10\,\mu$F and an inductance of 20 mH. At time $t_0 = 0$ the charge on the capacitor is $20\,\mu$C and the current is 80 mA. The maximum possible current in mA is.

(1) 92 (2) 135 (3) 8.3 (4) 56 (5) 70

18. The amplitude of oscillations at frequency 10^6 Hz in an RLC-circuit decreases by a factor of two in 1 ms. If one doubles the resistance R, while keeping L and C the same, how long does it take now for the amplitude of oscillations to decrease by a factor of two?

(1) 0.5 ms (2) 2 ms (3) 0.25 ms (4) 4 ms (5) 1 ms

19. A 1.5 mH inductor in an oscillating LC circuit stores a maximum energy of $10\,\mu$J. If the resonance frequency of the circuit is 1 kHz, what is the maximum voltage in V across the capacitor?

(1) 1.1 (2) 6.2 (3) 0.35 (4) 3.7 (5) 21.1

20. Consider an serial RLC circuit with $R = 10\,\Omega$, $L = 1.0\,\mathrm{H}$, and $C = 1.0\ \mu\mathrm{F}$. It is connected to a voltage source which produces $V_0 = 10\,\mathrm{V}\sin\omega_0 t$ where ω_0 is the angular resonance frequency of the circuit. Find the amplitude of the voltage across the inductor.

(1) 1000 V (2) 2 V (3) 70 V (4) 10 V (5) 400 V