Instructor(s): *Profs. Mueller, Takano*

PHYSICS DEPARTMENT

PHY 2049, Spring 2017 Midterm 2 March 24, 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

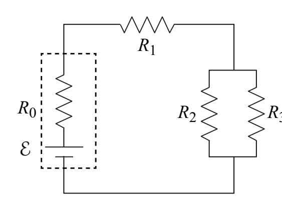
(1) **Code your test number on your answer sheet (use 76–80 for the 5-digit number)**. Code your name on your answer sheet. **Darken circles completely (errors can occur if too light)**. Code your student number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch 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.

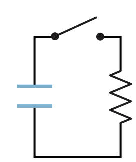
Constants			
$e = 1.6 \times 10^{-19}$ C	$m_p = 1.67 \times 10^{-27}$ kg	$m_e = 9.1 \times 10^{-31}$ kg	$\epsilon_o = 8.85 \times 10^{-12}$ C^2/N·m^2
milli (m) $= 10^{-3}$	micro (μ) $= 10^{-6}$	nano (n) $= 10^{-9}$	pico (p) $= 10^{-12}$
$k = 1/(4\pi\epsilon_o) = 9 \times 10^9$ N·m^2/C^2		$\mu_0 = 4\pi \times 10^{-7}$ T·m/A	
Sphere: $A = 4\pi R^2$ $V = \frac{4\pi}{3}R^3$			

1. A battery, which has an emf of $\mathcal{E} = 10$ V and an internal resistance of $R_0 = 50\,\Omega$, is connected to three resistors, as shown in the figure. The resistors have the resistances of $R_1 = 25\,\Omega$, $R_2 = 50\,\Omega = R_3$. What is the current through R_3, in mA?



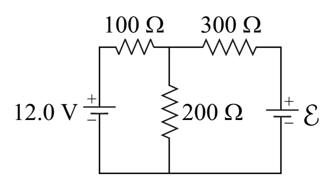
(1) 50 (2) 80 (3) 125 (4) 10 (5) 180

2. Consider an RC circuit with $R = 100\,\Omega$ and $C = 10\,\mu$F, shown in the figure. The initial charge on the capacitor is $Q = 1\,\mu$C. At time $t = 0$, the switch is closed. What is the magnitude of the current (in mA) through the resistor at $t = 500\,\mu$s?



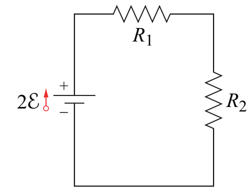
(1) 0.61 (2) 1.35 (3) 1.04 (4) 0.25 (5) 2.2

3. In the circuit shown, find the emf $\mathcal{E}$ that makes the current through the 300 Ω resistor zero.



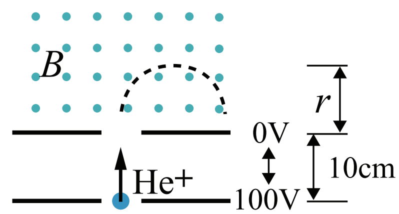
(1) 8.0 V (2) 12.0 V (3) 4.0 V (4) 10.0 V (5) 6.0 V

4. When resistors R_1 and R_2 are connected separately, one at a time, to a battery whose emf is $\mathcal{E}$, R_1 dissipates twice as much power as R_2. When the resistors are connected in series to another battery whose emf is $2\mathcal{E}$, as shown, R_1 dissipates a power P_1, and R_2 dissipates a power P_2. What is the ratio P_1/P_2? Assume that the batteries have no internal resistance.



(1) 1/2 (2) 2 (3) 1 (4) 4 (5) $\sqrt{2}$

5. A helium ion He^+ is first accelerated by a potential difference of 100 V over a distance of 10 cm before it enters a region of uniform magnetic field pointing perpendicular to the path of the ion. There is no electric field in that region. The magnetic field causes the ion to undergo a circular motion with radius $r = 10$ cm. What is the magnitude of the magnetic field in mT? The mass of the helium ion is 6.64×10^{-27} kg.

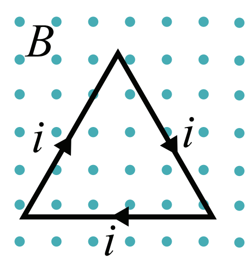


(1) 28.8 (2) 127 (3) 54.3 (4) 92.7 (5) 4.7

6. A 10-turn circular loop of wire of area 200 cm^2 carries a current of 10 A. The magnetic dipole moment of the loop is oriented at an angle 50° to a uniform magnetic field of 4 T. How much work was required to rotate the loop from its lowest energy position to this orientation?

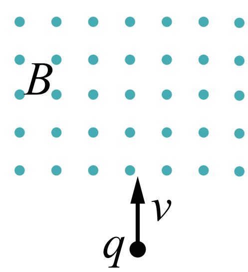
(1) 2.9 J (2) 35.1 J (3) 4.3 J (4) 1.28 J (5) 17.4 J

7. A wire loop, which has the shape of an equilateral triangle, is placed in a uniform magnetic field, with the plane of the triangle perpendicular to the field such that the field points out of the plane, as shown in the figure. The loop carries a current i in the direction indicated by arrows. There is no gravity, and the loop is free to move. Which of the following statements is correct about the magnitude of the torque, τ, on the loop and the potential energy U of the loop?



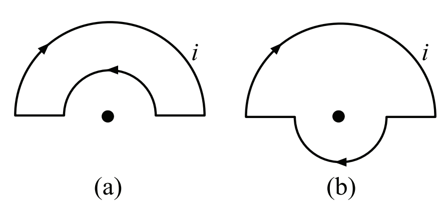
(1) τ is zero, and U is maximum.
(2) τ is zero, and U is minimum.
(3) τ is maximum, and U is minimum.
(4) τ is maximum, and U is maximum.
(5) τ is maximum, and U is zero.

8. Travelling upward in the plane of the page at speed v, a particle enters a region of uniform magnetic field B, which points out of the plane of the page, as shown in the figure. The particle has mass m and positive charge q. What is the uniform electric field E that is required to make the particle travel on a straight trajectory in this region?



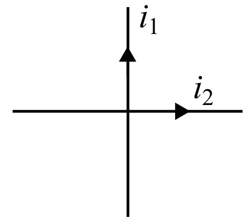
(1) $E = vB$ pointing to the left.
(2) $E = vB$ pointing to the right.
(3) $E = qvB/m$ pointing to the left.
(4) $E = qvB/m$ pointing to the right.
(5) There is no such E.

9. The figure shows two configurations of loops with identical currents. Each loop consists of a larger semicircle of radius 20 cm, a smaller concentric semicircle of radius 13.3 cm, and two straight segments, all in the same plane. The magnitude of the magnetic field produced at the center marked by the dot is 25 μT in configuration (b). What is the magnitude of the magnetic field at the center marked by the dot in configuration (a)?



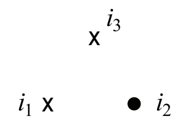
(1) 5.0 μT (2) 10.0 μT (3) 2.0 μT (4) 25 μT (5) 50 μT

10. Two long straight current-carrying wires cross each other at an angle of 90°, as shown in the figure. The arrows indicate the directions of the currents. What are the directions of the forces on the upper and lower sections of wire 1, which carries a current i_1? The answers are given for the upper section first, the lower section second after a semicolon.



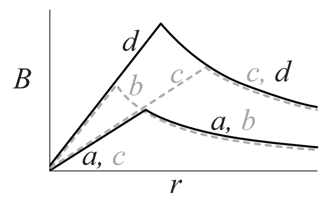
(1) to the right; to the left
(2) to the right; to the right
(3) There is no force on the wire.
(4) to the left; to the right
(5) to the left; to the left

11. Three long straight current-carrying wires pierce the plane of the page at vertices of an equilateral triangle, as shown in the figure, with a 5 cm separation between the wires. Currents i_1 and i_3 in wires 1 and 3 go into the plane, whereas current i_2 in wire 2 comes out of the plane. Each current is 1 A. What is the direction of the force on wire 3, which lies above wires 1 and 2?



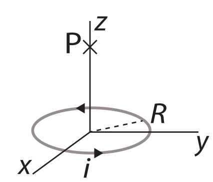
(1) to the left (2) up (3) There is no force on the wire. (4) down (5) to the right

12. The figure gives, as a function of radial distance r, the magnitude B of the magnetic field inside and outside four long straight wires (a, b, c, and d), each of which carries a current that is uniformly distributed across the wire's cross section. Overlapping portions of the plots are indicated by double labels. Rank the wires according to the value of the current, greatest first.



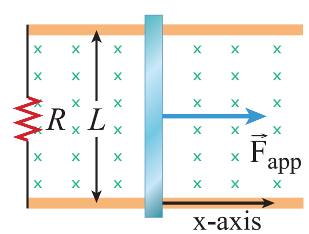
(1) $c = d > a = b$ (2) $d > c > b > a$ (3) $b = d > a = c$ (4) $c > d > a > b$ (5) $c > d = b > a$

13. A circular loop of radius R, carrying a current i, lies flat on the xy plane, as shown. The z axis runs through the center of the loop. Consider a point P on the z axis, at distance z from the center. At this point, what is the magnitude of the z component of the infinitesimal magnetic field due to the current in a very short segment of the loop of length ds?



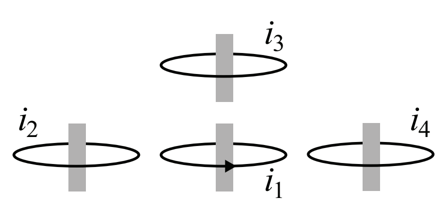
(1) $\frac{\mu_0}{4\pi}\frac{iR}{(R^2+z^2)^{3/2}}ds$ (2) 0 (3) $\frac{\mu_0}{4\pi}\frac{iz}{(R^2+z^2)^{3/2}}ds$ (4) $\frac{\mu_0}{4\pi}\frac{iR}{R^2+z^2}ds$ (5) $\frac{\mu_0}{4\pi}\frac{iRz}{(R^2+z^2)^2}ds$

14. As shown in the figure, a sliding bar is pulled at constant speed v along two conducting rails, which are separated by distance $\ell = 20$ cm. A uniform magnetic field of 2.0 T is directed into the page, as indicated by crosses. What is the work (in mJ) required to pull the bar over a distance of 40 cm at $v = 25$ cm/s, if the resistance R of the load that connects the two rails is 50 Ω?



(1) 0.32 (2) 0.11 (3) 2.7 (4) 12 (5) 7.4

15. 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, and "0" means no induced current.

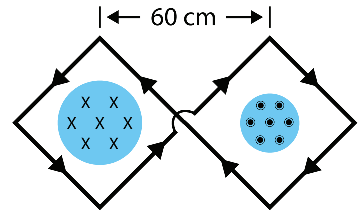


(1) ccw, cw, ccw (2) 0, cw, 0 (3) cw, cw, cw (4) cw, 0, ccw (5) cw, ccw, cw

16. A 2.5 mH inductor is connected in series with a resistor and a 10 V battery. After the current reaches its maximum value, the energy stored in the magnetic field of the inductor is 0.8 mJ. What is the resistance of the circuit (in ohms)?

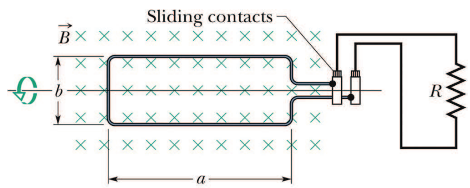
(1) 12.5 (2) 10.7 (3) 2.83 (4) 5.1 (5) 7.3

17. 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 50 mT going into the plane of the page, and that in region 2 is 30 mT coming out of the plane of the page. The magnitudes of both fields are decreasing at a rate of 5 mT/s. Calculate the path integral $\oint \vec{E} \cdot d\vec{s}$ along the path drawn in the figure; ignore the bending of the path at the crossing. Note: The direction of the path integral matters.



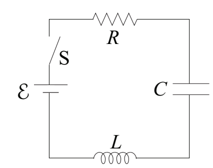
(1) −0.51 mV (2) 0.13 mV (3) 2.3 mV (4) −8.5 mV (5) 0

18. A rectangular coil of 10 turns and of length $a = 10$ cm and width $b = 5$ cm is rotated 60 times per second in a uniform magnetic field $\vec{B}$ as indicated in the figure. The coil is connected to co-rotating cylinders, against which metal brushes slide to make electrical contact. If the amplitude of the resulting AC current through the resistor $R = 1\,\mathrm{k}\Omega$ is 1 mA, what is the magnitude of the magnetic field $\vec{B}$? The resistance of the coil is negligible.



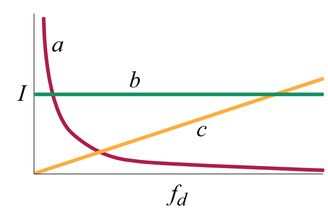
(1) 530 mT (2) 120 mT (3) 200 mT (4) 870 mT (5) 62 mT

19. A constant emf of 10 V is connected through switch S to a series RLC circuit with $R = 10\,\Omega$, $L = 20$ mH, and $C = 500\,\mu$F. Across which of the three elements will the potential difference be the largest (a) immediately after the switch is closed, and (b) a long time later?



(1) L, C (2) C, R (3) R, L (4) L, R (5) R, C

20. An alternating emf source with a certain emf amplitude is connected, in turn, to a resistor R, a capacitor C, and then an inductor L. Once connected to one of these three elements, the driving frequency f_d is varied and the amplitude I of the resulting current through the element is measured and plotted. Which of the three plots — labeled a, b, c — in the figure corresponds to which of the three elements? (In the answers, the label for a plot is followed by an equal sign, then by the symbol — R, C, or L — for the corresponding element.)



(1) $a = L$, $b = R$, $c = C$
(2) $a = C$, $b = R$, $c = L$
(3) $a = C$, $b = L$, $c = R$
(4) $a = L$, $b = C$, $c = R$
(5) $a = R$, $b = L$, $c = C$