Instructor: Prof. Paul Avery, Prof. Zongan Qiu

PHY 2049

Exam 2

November 4, 2014

Name (print, last first): ___________________________ 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. 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 most questions demand.

(4) Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink. Do not make any stray marks or the answer sheet may not read properly.

(5) The answers are rounded off. Choose the closest to exact. There is no penalty for guessing.

1. The positive terminals of two batteries with emf’s of \( \epsilon_1 \) and \( \epsilon_2 \), respectively, are connected together. Here \( \epsilon_2 > \epsilon_1 \). The circuit is completed by connecting the negative terminals. If each battery has an internal resistance of \( r \), the rate in watts at which electrical energy is converted to chemical energy in the smaller battery is:

- (1) \( (\epsilon_2 - \epsilon_1)\epsilon_1/2r \)
- (2) \( \epsilon_2^2/2r \)
- (3) \( (\epsilon_2 - \epsilon_1)\epsilon_1/r \)
- (4) \( \epsilon_1^2/r \)
- (5) \( \epsilon_2^2/2r \)

2. The current in the 12.0-\( \Omega \) resistor in the circuit shown is:

- (1) 0.5 A
- (2) 0.22 A
- (3) 0.14 A
- (4) 0.8 A
- (5) 1.0 A

3. In the diagrams, all light bulbs are identical and all emf devices are identical. In which circuit will each of the bulbs glow with the same brightness as in circuit X?

- (1) 
- (2) 
- (3) 
- (4) 
- (5) 

4. A certain capacitor, in series with a 720-\( \Omega \) resistor, is being charged. At the end of 10 ms, its charge is half the final value. The capacitance is about:

- (1) 20 \( \mu \)F
- (2) 14 \( \mu \)F
- (3) 9.6 \( \mu \)F
- (4) 7.2 F
- (5) 10 F
5. If \( R_1 = 6\,\Omega \), \( R_2 = 8\,\Omega \), \( R_3 = 2\,\Omega \), \( \mathcal{E}_1 = 8\,V \), and \( \mathcal{E}_2 = 28\,V \), what is the current in \( R_2 \)?

(1) 2 A
(2) 1 A
(3) 3 A
(4) 4 A
(5) 5 A

\[ \frac{\mathcal{E}_1}{R_1} = \frac{\mathcal{E}_2}{R_2} + \frac{\mathcal{E}_1}{R_3} \]

6. An electron is moving at \( 3 \times 10^5 \, m/s \) in the positive \( x \) direction. A magnetic field of 0.8 T is in the positive \( z \) direction. The magnetic force on the electron is:

(1) \( 4 \times 10^{-14} \, N \) in the positive \( y \) direction
(2) \( 4 \times 10^{-14} \, N \) in the positive \( z \) direction
(3) \( 4 \times 10^{-14} \, N \) in the negative \( z \) direction
(4) 0
(5) \( 4 \times 10^{-14} \, N \) in the negative \( y \) direction

7. An electron is launched with velocity \( \vec{v} \) in a uniform magnetic field \( \vec{B} \). The angle \( \theta \) between \( \vec{v} \) and \( \vec{B} \) is between 0 and 90°. As a result, the electron follows a helix, its velocity vector \( \vec{v} \) returning to its initial value in a time interval of:

(1) \( \frac{2\pi m}{eB} \)
(2) \( \frac{2\pi mv}{eB} \)
(3) \( 2\pi mv \sin \theta /eB \)
(4) \( 2\pi mv \cos \theta /eB \)
(5) none of these

8. In a certain mass spectrograph, an ion beam passes through a velocity filter consisting of mutually perpendicular fields \( \vec{E} \) and \( \vec{B} \). The beam then enters a region of another magnetic field \( \vec{B}' \) perpendicular to the beam. The radius of curvature of the resulting ion beam is proportional to:

(1) \( E/BB' \)
(2) \( EB/B' \)
(3) \( BB'/E \)
(4) \( B/EB' \)
(5) \( EB'/B \)

9. A square loop of wire measured 2 cm \( \times \) 2 cm carries a current of 1.25 A. The loop’s magnetic dipole moment initially is aligned with a 0.5-T magnetic field. To rotate the loop so its dipole moment is perpendicular to the field and hold it in that orientation, you must do work of:

(1) \( 2.5 \times 10^{-4} \, J \)
(2) 0
(3) \( -2.5 \times 10^{-4} \, J \)
(4) \( 1.0 \times 10^{-3} \, J \)
(5) \( -1.0 \times 10^{-3} \, J \)

10. A long wire is bent into the form of three-quarter concentric loops as shown in the figure. The loops have radii 4 cm and 8 cm and carry a common current of 2.0 A. What is the magnitude of the magnetic field at the center of the loops?

(1) 11.8 \( \mu \)T
(2) 23.6 \( \mu \)T
(3) 31.4 \( \mu \)T
(4) 7.85 \( \mu \)T
(5) 5.9 \( \mu \)T

11. In the figure, four long parallel wires of equal length are carrying identical currents in the directions shown. If the force per unit length on wire B is \( F \) what is the force per unit length on B if the currents in wires B and C reverse their directions?

(1) \( F/3 \)
(2) \( F \)
(3) \( 4F \)
(4) \( 2F/3 \)
(5) \( 3F/2 \)
12. A toroid is like a solenoid that has been bent around in a circle until its ends meet, as shown in the figure (inner radius 4 cm, outer radius 8 cm). What is the magnitude of the magnetic field inside a toroid of 1000 turns carrying a current 0.5 A at a distance 6 cm from the center of the toroid?

(1) 1.67 mT  (2) 0.172 mT  (3) 2.53 mT  (4) 4.92 mT  (5) 0.876 mT

13. As shown in the figure, a long wire carries a current of 12 A in the direction shown. What is the net force acting on the rectangular wire loop having dimensions 4 cm $\times$ 8 cm, current 2A, and whose closest distance to the wire is 4 cm (in $\mu$N)?

(1) 4.8  (2) 2.4  (3) 14.4  (4) 7.2  (5) 0

14. A 14.0 g conducting rod of length 1.30 m and resistance 8.0 $\Omega$ slides freely downward between two vertical conducting rails without friction. The entire apparatus is placed in a 0.43 T uniform magnetic field. Ignore the electrical resistance of the rails. What is the terminal velocity of the rod? ($g = 9.8$ m/s$^2$)

(1) 3.51 m/s  (2) 5.22 m/s  (3) 1.96 m/s  (4) 3.22 m/s  (5) 4.34 m/s

15. The number of turns is tripled for an ideal solenoid, and its length is doubled while holding its cross-sectional area constant. If the old inductance is $L$, what is the new inductance?

(1) $9L/2$  (2) $3L/2$  (3) $2L/3$  (4) $9L/4$  (5) $3L/4$

16. In the circuit shown in the figure, the switch is in position 1 for a long time. It is then moved to position 2. How long will it take for the current in the inductor to reach 0.25 A after the switch is moved to its new position? The values are $L = 12$ mH, $R_1 = 48$ $\Omega$ and $R_2 = 16$ $\Omega$. The battery has a voltage of 96 V.

(1) 1.56 ms  (2) 0.56 ms  (3) 2.84 ms  (4) 7.12 ms  (5) 4.23 ms

17. What resistance $R$ should be connected in series with an inductance $L = 500$ mH and capacitance $C = 120\mu$F for the maximum charge on the capacitor to decay to 25% of its initial value in 25 cycles? (Assume $\omega' \simeq \omega_0$.)

(1) 1.14 $\Omega$  (2) 0.28 $\Omega$  (3) 2.84 $\Omega$  (4) 7.16 $\Omega$  (5) 4.23 $\Omega$

18. A hollow cylindrical conductor (inner radius = $a$, outer radius = $b$) carries a current $i$ uniformly spread over its cross section. Which graph below correctly gives $B$ as a function of the distance $r$ from the center of the cylinder?

(1)  (2)  (3)  (4)  (5)
19. An LC circuit has a capacitance of 30 \( \mu \text{F} \) and inductance of 15 mH. At time \( t = 0 \) the charge on the capacitor is 10 \( \mu \text{C} \) and the current is 20 mA. The maximum charge on the capacitor is:

(1) 17 \( \mu \text{C} \)  
(2) 10 \( \mu \text{C} \)  
(3) 12 \( \mu \text{C} \)  
(4) 8.9 \( \mu \text{C} \)  
(5) 24 \( \mu \text{C} \)

20. An ac generator producing 10 V (rms) at 200 rad/s is connected in series with a 50-\( \Omega \) resistor, a 400-mH inductor, and a 200-\( \mu \text{F} \) capacitor. The rms voltage (in volts) across the inductor is:

(1) 10.8  
(2) 3.4  
(3) 6.7  
(4) 10.0  
(5) 2.5