Exam III, vers. 0001 - Physics 1120 - Fall, 2011

NAME (print please)______________________________________________

Student ID #____________________________________________________

TA’s Name(Circle one!): Jorge Hernandez-Charpak, Jack Houlton, Scott Johnson, Zhao Kang, Andrew Koller, Vasily Kravtsov, Galan Moody, Brian Neyenhuis

Starting time of your Tues recitation (write time in box: 9am, noon, 1pm, etc) □

Please do not open the exam until you are told to.

Your exam should have 9 pages, numbered 1 thru 9.
This exam consists of 21 multiple-choice questions. We will drop one wrong answer, so you will be graded on 20 questions, at 5 points each, for a total of 100 points. Fill in the bubble sheet with a #2 pencil.

PLEASE follow all directions carefully – if you don’t, we may not be able to identify your exam (which would be a disaster for you!) Place a check in each box on the left as you complete the instructions.

☐ Circle your TA’s name.

☐ Print and bubble in your name on the bubble sheet.

☐ Print and bubble in your student Identification Number.

☐ Print and bubble in your Exam version, 0001 or 0002, in the upper left of your bubble sheet in the area marked 1234.

☐ Please leave the areas labeled Code and Date blank

☐ Erase mistakes as thoroughly as possible. Ask for a fresh bubble sheet if you fear you cannot thoroughly erase mistakes.

☐ As you take the exam, circle the correct answers on your exam as well as mark them on the bubble sheet, so we can grade the exam, if your bubble sheet is lost.

☐ At the end of the exam, check that you have filled in the first 21 questions on the bubble sheet, with only one bubble filled in for each question.

I have read and followed the instructions above.
Signature_____________________________________________________

Possibly useful information:
\[ e = 1.6 \times 10^{-19} \text{ C}, \quad \varepsilon_0 = 8.85 \times 10^{-12} \text{ (SI units)}, \quad \mu_0 = 4\pi \times 10^{-7} \text{ (SI units)} \]

Vers.0001
1. Two particles, labeled 1 and 2, are observed to travel through a constant, uniform magnetic field along the paths shown. The B-field is everywhere into the page, and the trajectories of both particles are in the plane of the page. The only force acting on the particles is from the uniform B-field. What can you say about the charges of the two particles?

A) Nothing. The particles’ charges cannot be determined from this information.
B) Both particles are negative.
C) Both particles are positive.
D) Particle 1 is positive and 2 is negative.
E) Particle 1 is negative and 2 is positive.

The next two questions refer to the following situation. A uniform magnetic field with magnitude \( B \) points in the positive y direction, \( \vec{B} = B\hat{y} \). The field is constant in time. A square conducting loop with area A is oriented at an angle \( \theta \) with respect to the x-axis as in the diagram below.

2. What is the magnitude of the magnetic flux through the loop?

A) \( BA \)  
B) \( BA \cos \theta \)  
C) \( BA \sin \theta \)  
D) \( \mu_0 BA \)  
E) \( \mu_0 B / A \)

\[ \Phi_{\vec{B}} = \vec{B} \cdot \vec{A} = BA \cos \theta \]

angle between \( \vec{B} + \vec{A} \)

3. Suppose the entire conducting loop now moves with a constant velocity \( v \) in the positive y direction. What is the direction of the current induced in the loop as observed by the “observer” marked in the figure?

A) clockwise  
B) counter-clockwise  
C) none because there is zero induced current  
D) can’t determine unless the value of \( \theta \) is given

\[ \theta \text{ constant} \rightarrow \Phi_{\vec{B}} \text{ constant} \rightarrow \text{no induced } I \]
4. A single wire lies above a set of rectangular wires arranged in a line. The current in the single, circular wire points into the page. The current in each of the rectangular wires points out of the page (and hence this configuration looks like a sheet of current). Which direction best describes the direction of the force on the single wire?

(A) Up  
(B) Right  
(C) Down  
(D) Left  
(E) Into the page

5. A proton (charge +e) enters a region with uniform electric and magnetic fields perpendicular to each other as shown in the figure. The initial velocity of the proton is v, and the magnitude of the electric field is E. What magnitude of the magnetic field B is required so that the proton is not deflected.

(A) eE²/v  
(B) 0  
(C) eEv  
(D) E/v  
(E) Ev

6. Note carefully the polarities of the batteries in this circuit. A student chooses the directions of the currents in the three resistors as shown. Given this choice of current directions, which one of the following equations is correct? (Only one is correct.)

A) V₁ - V₂ - I₁R₁ - I₂R₂ = 0  
B) V₁ + V₂ - I₁R₁ - I₂R₂ = 0  
C) V₁ - I₁R₁ - I₂R₂ = 0  
D) V₂ + I₁R₂ + I₃R₃ = 0  
(E) V₁ + I₂R₂ - I₁R₁ = 0

Vers.0001
The next two questions refer to the following situation. Two identical light bulbs and a capacitor are connected to an ideal battery of voltage $V$, as shown. Initially, the switch is open and the capacitor is uncharged. The switch is closed.

7. A long time after the switch is closed, the voltage across the capacitor is.

(A) zero  (B) $V$  (C) $2V$  (D) $V/2$  

(E) None of these

8. Which of the statements about the brightness of the bulbs is true.

I. Immediately after the switch is closed Bulb A is bright.
II. Bulb B gets dimmer as time increases after the switch is closed.
III. The brightness of Bulb A a long time after the switch is closed depends on the value of the capacitance $C$.

A) Only I and II are true  B) Only II and III are true  C) I, II, and III are true

D) None are true  (E) Only II is true

9. What is the voltage at point (a) in the diagram? Let $V=0$ at the negative terminal of the battery.

A) 8 V  B) 10 V  C) 0 V  D) 2 V  E) 5 V

$$I = \frac{10V}{(10+40)\Omega} = 0.2A$$

$$V_a = 0V + 0.2A \times 10\Omega = 2V$$
The next two questions refer to the bar magnet shown below (shaded in gray). Assume there are no other magnetic fields present except that provided by the bar magnet.

10. What is the direction that a compass will point when placed at the position labeled by P (below the magnet). The arrow in the choices refers to the North end of the compass magnet.

11. Rank the magnitude of the magnetic field at points P, Q, and T.

A) P > Q = T  B) Q > T > P  C) Q = T > P  D) T > P > Q  E) T > P > Q

12. A triangular loop of wire is placed in a uniform magnetic field B, which points to the right. The loop is in the shape of a 60-60-60 equilateral triangle and the bottom side is parallel to the B-field, as shown. The loop carries a constant current I in the clockwise direction. Consider the following two statements about the net force on the wire loop due to the B-field and the net torque on the loop due to the B-field.

I) there is zero net force on the wire loop
II) there is zero net torque on the wire loop

(A) both statements are true  (B) both are false  
(C) I is true and II is false  (D) I is false and II is true  
(E) impossible to answer without more information
13. A solid wire of square cross-section with side length L carries a total current I. The current density J is uniform throughout the wire and is directed out of the page. Consider the (imaginary) circular dashed loop of diameter D within the wire and oriented with its plane perpendicular to the current flow, as shown. What is the magnitude of the line integral of the magnetic field around the circular dashed loop, \( \oint \mathbf{B} \cdot d\mathbf{l} = ? \)

(A) \( \mu_0 I \left( \frac{D^2}{L^2} \right) \)  
(B) \( \mu_0 I \left( \frac{\pi D^2}{4L^2} \right) \)  
(C) \( \mu_0 I \left( \frac{4L^2}{\pi D^2} \right) \)  
(D) \( \mu_0 I \)  
(E) None of these.

14. A coil of wire with \( N = 100 \) turns and area \( A = 0.010 \, \text{m}^2 \) is oriented so that its plane is perpendicular to a uniform magnetic field \( \mathbf{B} \) which is increasing at a rate of \( 0.010 \, \text{T/s} \). The coil is connected to a resistor \( R = 10 \Omega \). What is the power dissipated in the resistor?

A) 0.1 W  
B) \( 10^{-2} \) W  
C) \( 10^{-4} \) W  
D) \( 10^{-5} \) W  
E) None of these.

Faraday's Law
\[ \mathcal{E} = \frac{d\Phi_B}{dt} = NA \frac{d\mathbf{B}}{dt} = \frac{(100 \times 0.01 \, \text{m}^3 \times 0.01 \, \text{T/s})^2}{10 \, \Omega} = 10^{-5} \, \text{W} \]

15. The diagram shows two concentric wire loops. The outer loop is connected to a battery and a switch, as shown. The switch has been open for a long time and then is closed. When the switch closes, the induced current in the inner loop is

A) counter-clockwise  
B) clockwise  
C) zero
16. I want to calculate the field of an infinitely long wire using the Biot-Savart law.

\[ \vec{B} = \int d\vec{B} = \frac{\mu_0}{4\pi} \int \frac{I \, d\vec{l} \times \hat{r}}{r^2} \]

I start by calculating the contribution \( d\vec{B} \) at point P due to the segment \( d\vec{l} \). What is the correct expression for the magnitude of \( d\vec{l} \times \hat{r} \)?

A) \( d\vec{l} \, \frac{y}{r} \)
B) \( d\vec{l} \, \frac{x}{r} \)
C) \( d\vec{l} \, \frac{xy}{r^2} \)
D) \( d\vec{l} \, \frac{(x + y)}{r} \)
E) \( d\vec{l} \, \frac{1}{r} \)

17. A long straight wire has a constant current \( I \) flowing to the right. A loop of wire in the shape of a circle is situated above the long wire and has current \( i \) flowing through it in the direction shown.

What is the direction of the net magnetic force on the circular current loop?

(A) up, along \(+y\) direction
(B) right, along \(+x\) direction
(C) down, along \(-y\).
(D) left, along \(-x\)
(E) the net magnetic force on the loop is exactly zero
18. A charged particle with charge $q$ circles in a uniform magnetic field pointing out of the page (represented by black dots). The diameter of the circular path is $D$, and the particle moves with velocity $v$. What is the work done by the magnetic field as the particle moves from point P to point T?

A) $0$  B) $qvBD$  C) $qvB\frac{\pi D}{2}$  D) $-qvB\frac{\pi D}{2}$  E) Not enough information

\[ \oint \mathbf{F}_B \cdot d\mathbf{r} = 0 \]

Direction is changed, but not speed $\rightarrow \Delta KE = 0$

19. Two long straight wires each carry a current $I$ (same magnitude current for both wires). One wire carries current into the page, the other carries current out of the page, as shown. Each wire is a distance $r$ from point $x$ (same distance $r$ for both wires). The point $x$ is located as shown in the figure. What is the direction of the B-field at point $x$?

(A) No direction, $B = 0$  (B) right $\rightarrow$  (C) left $\leftarrow$

(D) up $\uparrow$  (E) down $\downarrow$

20. A long solenoid consists of 1000 turns and has a length of 10 m. The current in the wire is 100 A. What is the magnitude of the magnetic field inside the solenoid in gauss (G)?

$[1 \text{ G} = 10^{-4} \text{ T}]$ (Assume all magnetic fields present are created by the solenoid, and choose the closest answer.)

A) 1260 G  B) 126 G  C) 1.26 G  D) 1.26 X $10^{-6}$ G

\[
B_{\text{solenoid}} = \mu_0 n I
\]

\[
B = 4\pi \times 10^{-7} \frac{N}{A^2} \times (1000/10m) \times 100A
\]

\[
= 1.26 \times 10^{-6} \times 10^2 \times 10^2 \times 10^{-7} \text{T} = 1.26 \times 10^{-3} \text{T}
\]
21. Two identical solenoids are placed end-to-end as shown in the diagram below, with a small but finite gap between them. What you see is a cross section through the solenoids. A large current I flows in each solenoid. What best characterizes the forces between the solenoids?

(A) They are attracted
(B) They repel
(C) There are no forces here

\[\text{Solenoid 1: } \rightarrow \text{Solenoid 2: } \leftarrow \]

Currents in the same direction attract

or

\[N\quad S\quad N\quad S\]

Like two bar magnets that attract