Physics 126: Practice
Midterm #2

This practice midterm was the second midterm exam given during Winter 2006. The median score on this exam was 14/20.

This is a closed-book exam lasting 90 minutes. You may use a calculator and a 3” x 5” “crib sheet.” The exam contains 20 multiple-choice questions.

Before you begin:
1. Fill in your name and section number on your Scantron sheet. Fill in your 8-digit UM ID (not your SSN) in the space indicated.
2. Fill in the version number of your exam in the area of the Scantron marked “Form.” Your exam version number is 1.
3. Sign and date your Scantron.

Useful Physical Constants:
proton charge $e = 1.602 \times 10^{-19}$ C
Electron mass $m_e = 9.1 \times 10^{-31}$ kg
Proton mass $m_p = 1.7 \times 10^{-27}$ kg
Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2$/N·m$^2$
Coulomb’s law constant $k = 1/(4\pi\varepsilon_0) = 8.99 \times 10^9$ N·m$^2$/C$^2$
Permeability of free space $\mu_0 = 4\pi \times 10^{-7}$ T·m/A
Speed of light in vacuum $c = 3.00 \times 10^8$ m/s
Acceleration of gravity $g = 9.8$ m/s$^2$
1. A static magnetic field cannot
   A) exert a force on a charge
   B) accelerate a charge
   C) change the momentum of a charge
   D) change the kinetic energy of a charge
   E) be uniform in a region of space

2. A beam consisting of five types of ions labeled A, B, C, D, E enters a region that contains a uniform magnetic field as shown in the figure below. The field is perpendicular to the plane of the paper but its precise direction is not given. All ions in the beam travel at the same speed. The table below gives the masses and charges of the ions. Which ion falls at position 2?

<table>
<thead>
<tr>
<th>Ion</th>
<th>Mass</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4 units</td>
<td>+2e</td>
</tr>
<tr>
<td>B</td>
<td>4 units</td>
<td>+e</td>
</tr>
<tr>
<td>C</td>
<td>6 units</td>
<td>+e</td>
</tr>
<tr>
<td>D</td>
<td>2 units</td>
<td>-e</td>
</tr>
<tr>
<td>E</td>
<td>4 units</td>
<td>-e</td>
</tr>
</tbody>
</table>

   A) A  R =mv/qB ∝ m/q
   B) B  3 + charges to left, 2 –
   C) C  charges to right. Location 2
   D) D  has intermediate m/q = 2,4,6
   E) E  for A,B,C.

3. The diagram shows a straight wire carrying a flow of electrons into the page. The wire is between the poles of a permanent magnet. The direction of the magnetic force exerted on the wire is:

   A) ↑
   B) ↓
   C) ←
   D) →
   E) into the page

   B to right. I out of page. Force is up. RHR-I
4. Electrons are going around a circle in a counterclockwise direction as shown. At the center of the circle they produce a magnetic field that is:

Electrons (-) CCW, 
Current is CW. RHR-III 
(or RHR-II) gives B into 
the page

(A) into the page
B) out of the page
C) to the left
D) to the right
E) zero

5. Two long straight current-carrying parallel wires cross the $x$ axis and carry currents $I$ and $3I$ in the same direction, as shown. At what value of $x$ is the net magnetic field zero?

\[
B = \frac{\mu_0 I}{2\pi |x - 2|} - \frac{\mu_0 3I}{2\pi |x - 6|} = 0
\]

\[
\frac{1}{|x - 2|} = \frac{3}{|x - 6|}
\]

\[
x = 3
\]
6. A long coaxial cable carries a current of 20 A to the right through the outer conducting shield (radius = 2 cm) and a current of 20 A to the left through the central conductor (radius = 0.5 cm). What is the magnitude and direction of the magnetic field 1 cm above the centerline of the cable? This point is inside the shield but outside of the central conductor. Hint: Use Ampere’s Law.

\[ B(2\pi r) = \frac{\mu_0 I}{2\pi} \]

A) zero
B) 1000 \( \mu_0 / \pi \) Tesla into the page
C) 1000 \( \mu_0 / \pi \) Tesla out of the page
D) 2000 \( \mu_0 / \pi \) Tesla into of the page
E) 2000 \( \mu_0 / \pi \) Tesla out of the page

7. A generator is running at 500 revolutions per minute. If this rate is doubled, by how much will the emf change?

A) It will increase by a factor of 2
B) It will increase by a factor of 4
C) It will decrease by a factor of 2
D) It will decrease by a factor of 4
E) It will remain the same. The emf does not depend on the rate of rotation.

\[ \text{emf} \propto \omega \]

8. A long straight wire is carrying a current in the direction shown. A rectangular wire loop lies in the plane of the paper as shown. The current is decreasing. While the current is decreasing, what will be the direction of the force on the rectangular wire loop?

\[ \text{B into page at loop RHR-II} \]
\[ \text{Flux at loop into page and decreasing} \]
\[ \text{Induced current CW to create B into page to oppose decrease} \]
\[ \text{Force on current larger at top (B is higher here)} \]
\[ \text{Net force on loop is up} \]
9. In the diagram below we see a 200 turn square loop of wire, 0.1 meters on an edge. The loop is immersed in a homogeneous magnetic field of 0.2 Tesla, directed as shown. An external battery (not shown) drives a current of 2 amperes through the wire.

A) At this instant, the torque on the loop will be 0.4 meter-Newton and would cause the loop to rotate in the CW direction as shown
B) At this instant, the torque on the loop will be 0.4 meter-Newton and would cause the loop to rotate in the CCW direction as shown
C) At this instant, the torque on the loop will be 0.8 meter-Newton and would cause the loop to rotate in the CW direction as shown
D) At this instant, the torque on the loop will be 0.8 meter-Newton and would cause the loop to rotate in the CCW direction as shown
E) At this instant, the torque on the loop will be zero.

10. An **unpolarized** beam of light has intensity $I_0$. It is incident on two ideal polarizing sheets. The angle between the axes of polarization of these sheets is $\theta$. Find $\theta$ if the emerging light has intensity $I_0/4$:

A) 30°
B) 26.6°
C) 60°
D) 45°
E) 75.5°

After 1st polarizer $I = I_0/2$

$1/2 = \cos^2(\theta)$

$\theta = 45°$
11. You are approaching a red ($\lambda = 6.395 \times 10^{-7}$ m) traffic light at such a high speed that it appears green ($\lambda = 5.397 \times 10^{-7}$ m)! How fast are you going relative to the traffic light?

A) $4.4 \times 10^8$ m/s
B) $2.2 \times 10^8$ m/s
C) $8.4 \times 10^7$ m/s
D) $5.5 \times 10^7$ m/s
E) $2.9 \times 10^6$ m/s

$$f_0 = f_s \left(1 + \frac{v}{c}\right)$$

$$\frac{1}{5.397 \times 10^{-7}} = \frac{1}{6.395 \times 10^{-7}} \left(1 + \frac{v}{3 \times 10^8}\right)$$

$$v = 5.5 \times 10^7 \text{ m/s}$$

12. Five balls labeled A, B, C, D, and E are placed in front of a plane mirror as shown in the figure. Which ball(s) will the observer see reflected in the mirror? Hint: Use the edge of your note card as a straight edge.

A) A only
B) C only
C) A and B
D) A, B, D and E
E) A, B, C, D and E

[Diagram of a plane mirror with balls A, B, C, D, and E labeled.]  
No other image can be seen in the mirror.

13. An object 0.50 cm high is 5.0 cm from a concave spherical mirror of focal length 20 cm. How high is the image and is it erect or inverted?

A) 0.40 cm, inverted
B) 0.67 cm, erect
C) 0.50 cm, inverted
D) 0.67 cm, inverted
E) 0.40 cm, erect

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$$

$$\frac{1}{20} = \frac{1}{5} + \frac{1}{d_o}$$

$$\frac{1}{d_o} = \frac{1}{20} - \frac{4}{20} = -\frac{3}{20}$$

$$d_o = \frac{-20}{3}$$

$$m = \frac{d_o}{d_i} = \frac{20}{3(5)} = \frac{4}{3}$$

$$h_i = h_o \left(\frac{4}{3}\right) = 0.5 \left(\frac{4}{3}\right) = 0.67$$
14. The main reason that alternating current replaced direct current for general use is:

A) ac generators do not need slip rings
B) ac voltages may be conveniently transformed
C) electric clocks do not work on dc
D) a given ac current does not heat a power line as much as the same dc current
E) ac minimizes magnetic effects

15. The peak value of the magnetic field component of an electromagnetic wave is $B$. At a particular instant, the intensity of the wave is 0.020 W/m$^2$. If the peak value of the magnetic field were increased to $5B$, what would be the intensity of the wave?

A) 0.020 W/m$^2$
B) 0.10 W/m$^2$
C) 0.25 W/m$^2$
D) 0.50 W/m$^2$
E) 1.0 W/m$^2$

\[ S \propto B^2 \]

\[ 5^2(0.020) = 0.50 \text{W/m}^2 \]

16. A circular coil of wire has 25 turns and has a radius of 0.075 m. The coil is located in a variable magnetic field whose behavior is shown on the graph. At all times, the magnetic field is directed at an angle of 75° relative to the normal to the plane of a loop. What is the average emf induced in the coil in the time interval from $t = 5.00$ s to 7.50 s?

\[ \varepsilon = -\Delta \Phi / \Delta t = -NA(\Delta B / \Delta t)\sin(\theta) \]

\[ = -(25)(\pi 0.075^2)(0.4/2.5)\sin(75) \]

\[ = -0.018 \text{ V} \]

A) −18 mV
B) −49 mV
C) −92 mV
D) −140 mV
E) −180 mV
17. A metal ring is dropped from rest below a bar magnet that is fixed in position as suggested in the figure. An observer views the ring from below. Which one of the following statements concerning this situation is true?

- **A)** As the ring falls, an induced current will flow counterclockwise as viewed by the observer.
- **B)** As the ring falls, an induced current will flow clockwise as viewed by the observer.
- **C)** As the ring falls, there will be an induced magnetic field around the ring that appears counterclockwise as viewed by the observer.
- **D)** As the ring falls, there will be an induced magnetic field around the ring that appears clockwise as viewed by the observer.
- **E)** Since the magnet is stationary, there will be no induced current in the ring.

**Flux points down through loop and is decreasing**
**Current flows CCW in loop to produce B field pointing down to oppose decrease**

18. A 60-W light bulb emits spherical electromagnetic waves uniformly in all directions. If 50% of the power input to such a light bulb is emitted as electromagnetic radiation, what is the maximum value of the magnetic field at a distance of 2.0 m from the light bulb?

- **A)** 71 nT
- **B)** 0.35 µT
- **C)** 0.14 µT
- **D)** 0.20 µT
- **E)** 0.10 µT

\[
S = \frac{30 W}{(4\pi r^2)} = \frac{30}{4\pi(2.0)^2} = 0.597 \text{ W/m}^2
\]

\[
= c \varepsilon_0 \frac{E_0^2}{2} = (3.00 \times 10^8)(8.85 \times 10^{-12}) \left(\frac{E_0^2}{2}\right)
\]

\[
E_0 = 21.2
\]

\[
B_0 = \frac{E_0}{c} = 7.08 \times 10^{-8} \text{ T}
\]
19. The angular speed of a motor is 262 rad/s. The back emf generated by the motor is 89.4 V. Assuming all other factors remain the same, determine the back emf if the angular speed of the motor is reduced to 154 rad/s.

\[ \varepsilon \propto \omega, \quad \varepsilon = 89.4 \left( \frac{154}{262} \right) = 52.5 \]

A) 32.3 V  
B) 44.7 V  
C) 52.5 V  
D) 89.4 V  
E) 152 V

20. A 0.10 m long solenoid has a radius of 0.05 m and \( 1.5 \times 10^4 \) turns. The current in the solenoid changes at a rate of 6.0 A/s. A conducting loop of radius 0.02 m is placed in the center of the solenoid with its axis the same as the solenoid as shown. Determine the induced emf in the loop.

\[ \varepsilon = (\Delta B/\Delta t)A = \mu_0 n (\Delta I/\Delta t)A \]

\[ = 4\pi \times 10^{-7} (1.5 \times 10^4/0.1)(6.0)(\pi 0.02^2) \]

\[ = 1.4 \times 10^{-3} \text{ V} \]

A) \( 0.7 \times 10^{-3} \) V  
B) \( 1.4 \times 10^{-3} \) V  
C) \( 2.8 \times 10^{-3} \) V  
D) \( 5.6 \times 10^{-3} \) V  
E) zero volts