Name: ................................................  Student ID: ........................
Section: ..............................

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Instructions:
1. Don’t forget to write down your name, student ID#, and section number. You need to do
this on (this page of) your test book AND on your Scantron sheet.

2. Answer all multiple choice questions in this test book by indicating the best answer
among choices. You must do this both on your test book and on your Scantron sheet.
Follow instructions on the Scantron sheet on how to mark valid answers.

3. When you finish, you need to turn in both this test book and the Scantron sheet.

4. Use the blank side of question pages as additional draft spaces. An extra blank sheet
is provided at the end of the test book.

5. Only one answer is allowed per problem/question. All problems have equal weight.

Constants:  \( \mu_0 = 4\pi \times 10^{-7} \, \text{Tm/A} \)
charge of an electron = \( 1.6 \times 10^{-19} \, \text{C} \)
mass of an electron = \( 9.1 \times 10^{-31} \, \text{kg} \)
1G = \( 10^{-4} \, \text{T} \)

Please be very careful with the first question even though the answer will not count
towards your grade:

1. ENTER THE ID CODE ABOVE IN THE UPPER RIGHT CORNER OF THE PAGE
A. ID Code A
B. ID Code B
C. ID Code C
D. ID Code D
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Physics 202 Midterm 2, Spring 2011

Multiple Choice
Identify the choice that best completes the statement or answers the question.

2. A light bulb is rated at 30 W when operated at 120 V. How much charge enters (and leaves) the light bulb in 1.0 min?
   A) 17 C
   B) 14 C
   C) 60 C
   D) 13 C
   E) 15 C

   \[ P = 30 \text{ W} \]
   \[ V = 120 \text{ V} \]
   \[ I = \frac{30 \text{ W}}{120 \text{ V}} = 0.25 \text{ A} \]
   \[ \frac{\Delta Q}{\Delta t} = I \]
   \[ \Delta Q = (0.25 \text{ A})(60 \text{ s}) = 15 \text{ C} \]

3. In a loop in a closed circuit, the sum of the currents entering a junction equals the sum of the currents leaving a junction because
   A) the potential of the nearest battery is the potential at the junction.
   B) there are no transformations of energy from one type to another in a circuit loop.
   C) capacitors tend to maintain current through them at a constant value.
   D) current is used up after it leaves a junction.
   E) charge is neither created nor destroyed at a junction.

4. If \( R_1 = 10 \Omega, R_2 = 15 \Omega, R_3 = 20 \Omega, \) and \( I = 0.50 \text{ A}, \) at what rate is heat being generated in these resistors?

   \[ P = I^2 R = (0.50 \text{ A})^2 (45 \text{ J}) = 11.25 \text{ W} \]

   A) 29 W
   B) 16 W
   C) 22 W
   D) 11 W
   E) 1.1 W
5. What is the total resistance in the circuit below?

\[ R = \left( \frac{1}{30} + \frac{1}{20} \right) + 5 = 12 + 5 = 17 \]

A) 55 \, \Omega
B) 32 \, \Omega
C) 7.9 \, \Omega
D) 17 \, \Omega
E) 25 \, \Omega

6. Continuing with the circuit in question 5, what is the current through the 5-\,\Omega resistor?

\[ V = IR \]
\[ 1V = I (17 \, \Omega) \]
\[ I = 0.65 \, A \]

A) 0.31 \, A
B) 0.22 \, A
C) 0.2 \, A
D) 0.44 \, A
E) 0.65 \, A

7. Continuing with the same circuit as above, what is the magnitude of the potential difference across the 20-\,\Omega resistor?

\[ V = IR \]
\[ = (0.65)(5) = 7.75 \, V \]

A) 3.2 \, V
B) 7.8 \, V
C) 11 \, V
D) 5.0 \, V
E) 8.6 \, V
8. In an RC circuit, how many time constants must elapse if an initially uncharged capacitor is to reach 80% of its final potential difference?

A) 2.2
B) 1.9
C) 1.6
D) 3.0
E) 5.0

\[
\frac{Q}{Q_{\text{final}}} = 0.8 = 1 - e^{-t/RC}
\]

\[e^{-t/RC} = 0.2\]

\[t/RC = -\ln(0.2) = 1.6\]

9. A magnetic field is directed out of the page. Two charged particles enter from the top and take the paths shown in the figure. Which statement is correct?

A) Particle 1 has a positive charge and particle 2 has a negative charge.
B) Both particles are positively charged.
C) Both particles are negatively charged.
D) Particle one has a negative charge and particle 2 has a positive charge.
E) The direction of the paths depends on the magnitude of the velocity, not on the sign of the charge.

10. An electron follows a circular path (radius = 15 cm) in a uniform magnetic field (magnitude = 3.0 G). What is the period of this motion?

\[r = 15 \text{ cm} \quad B = 3.0 \text{ G} \quad B = \frac{\hbar}{m_e} \quad r = \frac{m_e}{eB}\]

\[T = \frac{2\pi m}{eB} = \frac{2\pi (9.1 \times 10^{-31} \text{ kg})}{(1.6 \times 10^{-19} \text{ C})(3 \text{ G})} = 12 \times 10^{-12} \text{ s} \times (10^4 \text{ G/T}) = 0.12 \mu\text{s}\]
11. What is the magnetic force on a 2.0-m length of (straight) wire carrying a current of 30 A in a region where a uniform magnetic field has a magnitude of 55 mT and is directed at an angle of 20° away from the wire?

\[ F = I \cdot L \times B \]

A) 1.5 N  
B) 1.3 N  
C) 1.1 N  
D) 1.7 N  
E) 3.1 N

\[ |F| = (30 \text{ A})(2 \text{ m})(55 \text{ mT})(\sin 20°) = 1.1 \]

12. A bar magnet is to be cut at the dash-line as shown. (note the cut is not at the center).

Which of the following 4 cases represents the resulting configuration after cut?

A)  
B)  
C)  
D)  

---

4
13. As shown, a charged particle of mass $m$ is moving counter-clockwise along a circular (and planar) path inside a uniform magnetic field $\mathbf{B}$ pointed into the page. The magnitude of the particle’s charge is $Q$. The particle has a linear speed of $v$.

Is the charge of the particle positive or negative?

A) positive  
B) negative  
C) cannot be determined with given information.

14. In the same setting as the previous question, during the period that the particle completes 10 full circles, what is the work done by the magnetic field to the particle?

A) 0  
B) $10 \left( \frac{mv^2}{2} \right)$  
C) $10 QvB (2\pi r)$ where $r = \frac{mv}{QB}$ is the radius of the circle  
D) $10 \; mv^3$
15. The point P lies along the perpendicular bisector of the line connecting two long straight wires S and T that are perpendicular to the page. A set of directions A through H is shown next to the diagram. When the two equal currents in the wires are directed up out of the page, the direction of the magnetic field at P is closest to the direction of

\[ B = \mu_0 n I \]

A) E.  
B) F.  
C) G.  
D) H.  
E) A

16. A solenoid 4.0 cm in radius and 4.0 m in length has 8000 uniformly spaced turns and carries a current of 5.0 A. What is the magnitude of the magnetic field in the center of the solenoid?

A) 13 mT  
B) 13 T  
C) 1.3 mT  
D) 50 mT  
E) 0.5 T

\[ B = \frac{\mu_0 n I}{4\pi} \times \frac{800}{4m} \times 5A = 0.013 T \]

17. Which of the following type(s) of materials is(are) repelled when a magnet is brought near by?

A) paramagnetic  
B) diamagnetic  
C) ferromagnetic  
D) paramagnetic and ferromagnetic  
E) paramagnetic, ferromagnetic, and diamagnetic
18. Consider a current loop with radius \( a \) with center at point \( P \), carrying current \( I \). What is the magnitude of the magnetic field at point \( P \) in the figure (center) if \( a = 2.0 \text{ cm} \) and \( I = 5.0 \text{ A} \)?

\[
B_1 = \frac{\mu_0 I}{2\pi r} = \frac{(4\pi \times 10^{-7})(5\text{ A})}{2\pi (0.02)} = 1.57 \times 10^{-4} \text{ T}
\]

A) 10 \( \mu \text{T} \), into the paper
B) 10 \( \mu \text{T} \), out of the paper
C) 0.23 mT, out of the paper
D) 157 \( \mu \text{T} \), into the paper
E) 157 \( \mu \text{T} \), out of the paper

19. We add another circular loop concentric with the loop to the previous problem. What is the magnitude of the magnetic field at point \( P \) in the figure if \( a = 2.0 \text{ cm}, b = 4.5 \text{ cm}, \) and \( I_1 = I_2 = 5.0 \text{ A} \)?

\[
B_2 = \frac{\mu_0 I_2}{2\pi (0.045)} = \frac{(4\pi \times 10^{-7})(5\text{ A})}{2\pi (0.045)} = 70 \mu \text{T} \text{ out of paper}
\]

\[
B_{\text{tot}} = B_1 + B_2 = (157 - 70) \mu \text{T} = 87 \mu \text{T}
\]

A) 87 \( \mu \text{T} \), into the paper
B) 87 \( \mu \text{T} \), out of the paper
C) 0.23 mT, out of the paper
D) 0.23 mT, into the paper
E) 23 \( \mu \text{T} \), into the paper
20. The figure shows the orientation of a rectangular loop consisting of 80 closely wrapped turns each carrying a current $I$. The magnetic field in the region is $(40 \, \text{i}) \, \text{mT}$. The loop can turn about the $y$ axis. If $\theta = 30^\circ$, $a = 0.40 \, \text{m}$, $b = 0.30 \, \text{m}$, and $I = 8.0 \, \text{A}$, what is the magnitude of the magnetic dipole moment?

\[
N = 80, \quad I = 8 \, \text{A}
\]

\[
\mu = I A = 80 \times 0.4 \times 0.3 = 7.68 \, \text{A} \cdot \text{m}^2
\]

A) 39 A · m²
B) 77 A · m²
C) 67 A · m²
D) 0.96 A · m²
E) 0.48 A · m²

21. In the setting in the previous question, what is the magnitude of the torque exerted on the loop? (hint: be aware of which angles you use)

A) 2.5 N · m
B) 1.7 N · m
C) 3.1 N · m
D) 2.7 N · m
E) 0.34 N · m

\[
\tau = \vec{\mu} \times \vec{B} = (7.68 \, \text{A} \cdot \text{m}^2 \times 0.3 \, \text{m}) \sin (90^\circ - 30^\circ)
\]

\[
\tau = 2.7 \, \text{N} \cdot \text{m}
\]