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

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:  \( k_e = 9 \times 10^9 \text{Nm}^2/\text{C}^2 = 1/(4\pi \varepsilon_0) \),  \( \varepsilon_0 = 8.85 \times 10^{-12} \text{C}^2/(\text{Nm}^2) \)

\( \mu_0 = 4\pi \times 10^{-7} \text{Tm/A} \)

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
A. ID Code A
B. ID Code B
C. ID Code C
D. ID Code D
E. ID Code E
2. The figure below represents a section of a circular conductor of nonuniform diameter carrying a current of I = 4.10 A. The radius of cross-section A\(_1\) is \(r_1 = 0.450\) cm.

![Circular conductor diagram]

What is the magnitude of the current density across A\(_1\)?

A. 6.5 A/m\(^2\)
B. 64.5 \times 10^3 A/m\(^2\)
C. 145 A/m\(^2\)
D. 290 A/m\(^2\)
E. None of above is within 10% of correct answer.

3. In the above figure, consider the cross-section A\(_2\), which has twice as much radius compared to A\(_1\), which of the following statement is true?

A. The current density at A\(_2\) is the same as that at A\(_1\).
B. The current density at A\(_2\) is twice as much as that at A\(_1\).
C. The current density at A\(_2\) is 4 times as much as that at A\(_1\).
D. The current density at A\(_2\) is half as much as that at A\(_1\).
E. None of above is true.

4. Light bulb A is rated 80W at 120V and light bulb B is rated 40W at 120V. If the brightness is proportional to the power a light bulb consumes, which of the following statements is true when the two bulbs are connected in series in a circuit. (Assuming both light bulbs are incandescent).

A. Light bulb A is twice as bright as B
B. Light bulb A is half as bright as B
C. Light bulb A is 4 times as brighter
D. Light bulb A is 1/4 as brighter
E. None of above.
5. 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 cases represents the resulting configuration after cut?

E: None of above. The magnet will be destroyed if cut into two pieces.
Answer: D

6. The figure below shows the magnetic field lines near a bar magnet.

Which end is magnetic “North”?
A. Left end
B. Right end
C. Can not be determined

7. A current carrying solenoid coil is placed near a bar magnet as shown. Consider the magnetic forces in between them, which of the following statements is true?

A. The coil is subject to a force to the left, the magnet is subject a force to the right
B. The coil is subject to a force to the right, the magnet is subject a force to the left
C. Both are subject forces to the left
D. Both are subject forces to the right
E. None of above.
8. In the circuit shown below, $R_1=200\,\Omega$, $R_2=80\,\Omega$, $R_3=40\,\Omega$

The current through $R_1$, $R_2$, are found to be $I_1=1\,A$ and $I_2=3\,A$ respectively in the directions indicated.

What is the current flown through $R_3$?

A. $2\,A$ up  
B. $2\,A$ down  
C. $4\,A$ up  
D. $4\,A$ down  
E. None of above is within $0.2\,A$ from the correct answer.

9. In the above circuit, what is the $\varepsilon_2$?

A. $10\,V$  
B. $20\,V$  
C. $30\,V$  
D. $40\,V$  
E. None of above is within $1.0\,V$ from the correct answer.

10. Still in the above circuit, what is the power consumed on $R_2$?

D. $720\,W$  
B. $240\,W$  
C. $80\,W$  
D. $800\,W$  
E. None of above is within $1\,W$ from the correct answer.

11. Yet Still in the above circuit, what is the total power consumed?

(hint: batteries do not consume power)

A. $1200\,W$  
B. $1360\,W$  
C. $920\,W$  
D. $840\,W$  
E. None of above is within $10\,W$ from the correct answer.
12. The figure below is a cross-sectional view of a coaxial cable. The center conductor is surrounded by a rubber layer, an outer conductor, and another rubber layer. In a particular application, the current in the inner conductor is \( I_1 = 1.04 \, \text{A} \) out of the page and the current in the outer conductor is \( I_2 = 2.98 \, \text{A} \) into the page. Assuming the distance \( d = 1.00 \, \text{mm} \), how much is the magnetic field at point b?

![Coaxial Cable Diagram]

A. \( 117 \, \mu\text{T} \) upwards
B. \( 65 \, \mu\text{T} \) downwards
C. \( 129 \, \mu\text{T} \) downwards
D. 147 upwards
E. None of above is within \( 1 \, \mu\text{T} \) of the correct answer (and have correct direction)

13. As shown in figure below, two straight (infinite) currents, \( I_1 \) and \( I_2 \), are placed at location \((y,x) = (0,0)\) and \((0,a)\) respectively. Current \( I_1 \) is pointing normally into the page and current \( I_2 \) is pointing normally out of page.

![Diagram of Currents]

At location \((0,2a)\), the magnetic field \( B \) must satisfy which of the following conditions?

A. \( 4\pi a B = \mu_0 (I_1 + I_2) \)
B. \( 4\pi a B = \mu_0 (-I_1 + I_2) \)
C. \( B = \frac{\mu_0 I_2}{2\pi a} - \frac{\mu_0 I_1}{4\pi a} \)
D. \( 2\pi a + 2a B = \mu_0 (-I_1 + I_2) \)
E. None of above.

14. In the circuit below, the three resistors are of 10kΩ, 10kΩ, and 20 kΩ respectively.

What is the time constant when the switch S is closed?

A. 4 x10^2 s
B. 4 x10^3 s
C. 2 x10^{-1} s
D. 2 x10^{-2} s
E. None of above is within 10% from the correct answer

15. In the above setting, initially, the switch S is open and there is no charge on the capacitor. At t=0, S is closed. How long does it take to charge the capacitor to 60% of full charge? (represent your answer in terms of time constant $\tau$)

A. 0.92$\tau$
B. 0.51$\tau$
C. 0.40$\tau$
D. 0.22$\tau$
E. None of above is within 10% of the correct answer.

16. Still in the above setting, what is the charge on the capacitor long ($t=\infty$) after the switch is closed?

A. 5x10^6 C
B. 25x10^6 C
C. 0
D. 5x10^{-6} C
E. None of above or not enough information to determine.

17. Two long, parallel conductors, separated by 11.0 cm, carry currents in the same direction. The first wire carries a current $I_1 = 6.00$ A, and the second carries $I_2 = 8.00$ A.

What is the force (per unit length) between the two conductors?

A. 0
B. 8.7x10^{-5} N/m, repulsive.
C. 8.7x10^{-5} N/m, attractive.
D. 5.5x10^{-4} N/m, repulsive.
E. 5.5x10^{-4} N/m, attractive.
18. As shown, a charged particle of mass \( m \) is moving clockwise along a circular (and planar) path inside a uniform magnetic field \( B \). 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. Not enough information to determine.

19. In the above setting, what is magnetic force on this particle?
A. 0
B. \( QvB \)
C. \( QvB \sin \theta \), where \( \theta \) changes as the particle moves along the circle.
D. not enough information to determine
E. None of above.

20. Still in the above setting, what is the period of the particle’s circular motion?
A. \( \frac{2\pi m}{QB} \)
B. \( \frac{m}{QB} \)
C. \( \frac{mv}{QB} \)
D. not enough information to determine
E. None of above.

21. Yet still in the above setting, the total work done by the magnetic field in 10 circles is
A. 0
B. \( 10mv^2 \)
C. \( 10(\frac{1}{2} mv^2) \)
D. \( 10QvB(2\pi r) \), where \( r=mv/(QB) \) is the radius of the circle
E. None of above