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 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: \( k_e = 9 \times 10^9 \text{Nm}^2/\text{C}^2 = 1/(4\pi \varepsilon_0), \quad \varepsilon_0 = 8.85 \times 10^{-12} \text{C}^2/(\text{Nm}^2) \)
\[ \mu_0 = 4\pi \times 10^{-7} \text{Tm/A} \]

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. In the configuration below, initially the switch S is closed (i.e. connected). At t=0, the switch is opened (disconnected). When the switch S is being opened, what is the direction of the current passing through R?

- A. Left to right
- B. Right to left

3. In the configuration above, when the switch is being opened, what is the force on the coil at the right side?
- A. towards right
- B. towards left
- C. the coil at right would not subject a force as it is not powered.

4. As shown below, an aluminum ring of radius $r_1$ is placed around the top of a long air-core solenoid of smaller radius $r_2$. When current I is decreasing, what is the direction of the induced current in the aluminum ring?

- A. clockwise (viewing from the top)
- B. counter clockwise (viewing from the top)
5. A flexible conducting loop as shown in the figure below has a radius of 10.0 cm and is in a magnetic field of magnitude 0.120 T. The loop is grasped at points A and B and stretched until its area is nearly zero.

During the process, is the induced current running
A. clockwise
B. counter clockwise
C. No, the will be no induced current since the magnetic field is unchanged.

6. In the above setting, if it takes 0.190 s to close the loop, what is the magnitude of the average induced emf in it during this time interval?
A. zero
B. 20 mV
C. 40 mV
D. 60 mV
E. None of above is within 20% from the correct answer.

7. Two solenoids A and B, spaced close to each other and sharing the same cylindrical axis, have 430 and 610 turns, respectively. A current of 3.80 A in solenoid A produces an average flux of 300 µWb through each turn of A and a flux of 90.0 µWb through each turn of B. Calculate the mutual inductance between the two solenoids.
A. 2.4 mH
B. 3.6 mH
C. 4.8 mH
D. 14.4 mH
E. None of above is within 0.2mH from the correct answer.
8. The figure below shows a top view of a conducting bar sliding on two frictionless rails inside a magnetic field $B=2.5\, \text{T}$ that is pointing into the page. The bar, two rails, and a resistor $R$ form a closed circuit. Let $\ell = 1.20\, \text{m}$.

![Image of a conducting bar and magnetic field](image)

A constant force of $2.39\, \text{N}$ is required to drag the bar to the right at a constant speed of $1.7\, \text{m/s}$. What is the current through $R$?

A. $0.6\, \text{A}$  
B. $0.8\, \text{A}$  
C. $0.7\, \text{A}$  
D. None of above is within $0.1\, \text{A}$ from the correct answer.  
E. The current can not be determined as the resistance $R$ is not given.

9. In the above setting, what is the direction of the current through $R$?

A. downwards  
B. upwards  
C. not enough information to determine.

10. Figure below shows a purely inductive AC circuit. The AC power source is $40\, \text{Hz}$ and with $\Delta V_{\text{max}} = 100\, \text{V}$. The maximum current is $I_{\text{max}} = 7.0\, \text{A}$.

![Image of an AC circuit](image)

What is the inductance $L$?

A. $0.057\, \text{H}$  
B. $0.0091\, \text{H}$  
C. $0.36\, \text{H}$  
D. $0.023\, \text{H}$  
E. None of above is within $5\%$ from the correct answer.

11. The average power consumed in the circuit above can be calculated by

A. $P_{\text{av}} = \Delta V_{\text{max}} \, I_{\text{max}}$.  
B. $P_{\text{av}} = \frac{1}{2} \Delta V_{\text{max}} \, I_{\text{max}}$.  
C. $P_{\text{av}} = \frac{1}{4} \Delta V_{\text{max}} \, I_{\text{max}}$.  
D. $P_{\text{av}} = 0$  
E. None of above is correct.
12. A series RCL circuit as shown is driven by an AC power source. An AC source with \( \Delta V_{\text{max}} = 160 \text{ V} \) and \( f = 40.0 \text{ Hz} \) is connected between points \( a \) and \( d \) in the figure.

What is the maximum \( \Delta V \) between \( a \) and \( b \)?

A. 72V
B. 150 V
C. 175 V
D. 350 V
E. None of above is within 5% from the correct answer.

13. In the circuit above, what is the \( \Delta V_{\text{max}} \) between \( b \) and \( d \)?

A. 230 V
B. 350 V
C. 170 V
D. 55 V
E. None of above is within 5% from the correct answer.

14. Still in the above setting, what is the peak power consumed in the circuit?

A. 76.5W
B. 55.6W
C. 27.7W
D. 38.2 W
E. None of above is within 5% from the correct answer.

15. Yet still in the above circuit, if the frequency and maximum voltage of the power source can be programmed. In order to increase the average power consumption in the whole circuit (from the current level), which of the power functions shall be used for the AC source? (SI implied)

A. \( \Delta V = 160\sin(45t) \)
B. \( \Delta V = 160\sin(180t) \)
C. \( \Delta V = 160\sin(270t) \)
D. Not enough information to determine.
16. The intensity of sunlight at the Earth's surface is about 1370 W/m². The distance between the Sun and Earth is 1.5x10¹¹ m. What is the total power emitted by the Sun?

**A.** 8x10²⁶ W
**B.** 4x10²⁶ W
**C.** 1x10²⁶ W
**D.** none of above is within 20% of the correct answer.
**E.** Not enough information to determine, as the radius of the Sun is not given.

17. The electric component of an electromagnetic wave can be described as:

\[ E_x(z,t) = 2.5 \times 10^{-3} \sin(6.28 \times 10^{-3} z + 1.884 \times 10^6 t) \text{ V/m} \]

Which of the following describes the magnetic component of the same wave?

\( B_{\text{max}} \) to be determined

**A.** \( B_x(z,t) = -B_{\text{max}} \sin(6.28 \times 10^{-3} z + 1.884 \times 10^6 t) \text{ T} \)
**B.** \( B_y(y,t) = -B_{\text{max}} \sin(6.28 \times 10^{-3} y + 1.884 \times 10^6 t) \text{ T} \)
**C.** \( B_z(z,t) = -B_{\text{max}} \sin(6.28 \times 10^{-3} z + 1.884 \times 10^6 t) \text{ T} \)
**D.** \( B_z(x,t) = -B_{\text{max}} \sin(6.28 \times 10^{-3} x + 1.884 \times 10^6 t) \text{ T} \)
**E.** None of above is correct.

18. What is the \( B_{\text{max}} \) of the EM wave above?

**A.** 8.3x10⁻¹² T
**B.** 1.2x10⁻¹¹ T
**C.** 2.5x10⁻¹¹ T
**D.** 4.6x10⁻¹² T
**E.** None of above is within 5% of the correct answer.

19. What is the wavelength of the above EM wave?

**A.** 628 m
**B.** 1000 m
**C.** 1256 m
**D.** 1500 m
**E.** None of above is within 5% of the correct answer.
20. A WIFI access point transmits a 2.4GHz signal isotropically. Its average transmission power is 20 mW. How much energy it emits in 1 second?

A. 15 mJ  
B. 10 mJ  
C. 33 mJ  
D. 45 mJ  
E. None of above is within 10% from the correct answer

21. If the power of the above access point doubles, what can we expect for its effective range?

A. the range will increase by about 40%  
B. the range will also double  
C. the range will more than double  
D. the range will not change.