YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

DIRECTIONS

(1) Code your test number on your green answer sheet (use 76–80 for the 5-digit number). Code your name on your answer sheet. Darken circles completely (errors can occur if too light). Code your student number on your answer sheet.

(2) Print your name on this sheet and sign it also.

(3) Do all scratch work anywhere on this exam that you like or on paper provided. At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout.

(4) Blacken the circle of your intended answer completely, using a number 2 pencil or blue or black ink. Do not make any stray marks or the answer sheet may not read properly. If you believe there is no correct answer listed, leave the answer spaces blank.

(5) The answers are rounded off. Choose the closest to exact. There is no penalty for guessing.

>>>>>>>>>BEFORE YOU FINISH <<<<<<<<<<<

Hand in the answer sheet separately.

Useful (??) Constants:

<table>
<thead>
<tr>
<th>μ₀ = 4π × 10⁻⁷ Tm/A</th>
<th>ε₀ = 8.85 × 10⁻¹² F/m</th>
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</table>

<table>
<thead>
<tr>
<th>electron charge = -1.6 × 10⁻¹⁹ C</th>
<th>electron mass = 0.911 × 10⁻³¹ kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>V = volt</td>
<td>N = newton</td>
</tr>
<tr>
<td>A = ampere</td>
<td>“pico” = 10⁻¹²</td>
</tr>
<tr>
<td>c = 3 × 10⁸ m/s</td>
<td></td>
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</tbody>
</table>

1. Immediately after switch S in the circuit shown is closed, the current through the battery shown is:

\[ \text{Initially, the battery EMF} \]

\[ \text{IN} \ L \ \text{OPPOSES ANY CURRENT IN} \ L; \ \text{Thus I flows ONLY} \]

\[ \begin{align*}
(1) & \ V_a/(R_1 + R_2) \\
(2) & \ V_a/R_1 \\
(3) & \ V_a/R_2 \\
(4) & \ 0
\end{align*} \]

2. In the diagram, the current in the 3-Ω resistor is 4 A. The potential difference between points A and B is:

\[ \begin{align*}
(1) & \ 20 \ V \\
(2) & \ 0.8 \ V \\
(3) & \ 1.25 \ V \\
(4) & \ 12 \ V \\
(5) & \ 0.75 \ V
\end{align*} \]

\[ \text{QA THROUGH 5 Ω } \Rightarrow AV = 4Α(5Ω) = 20 V \]

3. In the diagrams, all light bulbs are identical and all emf devices are identical. In which circuit (I, II, III, IV, V) will the bulbs be dimmest?

(1) IV

(2) I

(3) II

(4) III

(5) V

\[ \text{IV: HAS THE HIGHEST RESISTANCE (2 LAMPS} \]

\[ \text{IN SERIES} \ \text{ACROSS THE LEAST BATTERY VOLTAGE (1 CELL). SO THESE ARE DIMMEST} \]
4. When switch $S$ is open, the ammeter in the circuit shown reads 2.0 A. When $S$ is closed, the ammeter reading will:

**CLOSING $S$ ADDS ANOTHER PATH FOR THE CURRENT, SO IT INCREASES**

(1) increase slightly  (2) remain the same  (3) decrease slightly  (4) double  (5) halve

5. In the circuit shown, the capacitor is initially uncharged and $V = 9.0$ volts. At time $t = 0$, switch $S$ is closed. If $\tau$ denotes the time constant, the approximate current through the 3Ω resistor when $t = \tau/100$ is:

$$i \approx \frac{q}{R} e^{-100}$$

If $t = \frac{\tau}{100}$, we have $i \approx \frac{9.0}{3} e^{-100} = (0.99) \approx 1$ A

(1) 1 A  (2) 1/2 A  (3) 3/4 A  (4) 3/8 A  (5) 3/2 A

6. An electron is moving north in a region where the magnetic field is south. The magnetic force exerted on the electron is:

(1) zero  (2) up  (3) down  (4) east  (5) west

**RHR: IF $\vec{v} \parallel \vec{B}$, $F = 0$**

7. A beam of electrons is sent horizontally down the axis of a tube to strike a fluorescent screen at the end of the tube. On the way, the electrons encounter a magnetic field directed vertically downward. The spot on the screen will therefore be deflected:

(1) to the right as seen from the electron source
(2) upward
(3) downward
(4) to the left as seen from the electron source
(5) not at all

**RHR: $F$ FOR (-) PARTICLES IS AS SHOWN**

8. The figure shows the motion of electrons in a wire which is near the N pole of a magnet. The wire will be pushed:

(1) upwards  (2) toward the magnet  (3) away from the magnet  (4) downwards  (5) along its length
9. A square loop of wire lies in the plane of the page and carries a current I as shown. There is a uniform magnetic field \( B \) parallel to the side MK as indicated. The loop will tend to rotate:

- (1) about PQ with KL coming out of the page
- (2) about PQ with KL going into the page
- (3) about RS with MK coming out of the page
- (4) about RS with MK going into the page
- (5) about an axis perpendicular to the page

10. The magnitude of the magnetic field at point \( P \), at the center of the semicircle shown, is given by:

\[
\text{THIS IS HALF A CIRCULAR LOOP, \( B = \frac{1}{2} \left( \frac{N_0 I}{2R} \right) \)}
\]

- (1) \( I_0/4R \)
- (2) \( I_0/R^2 \)
- (3) \( I_0/2\pi R \)
- (4) \( I_0/4\pi R \)
- (5) \( I_0/2R \)

11. Two long straight wires pierce the plane of the paper at vertices of an equilateral triangle as shown below. They each carry 2 A, out of the paper. The magnetic field at the third vertex \( (P) \) has magnitude (in T):

\[
\text{\( B = 2 \left( \frac{I}{2R} \right) \cos 60^\circ \)}
\]

- (1) \( 1.7 \times 10^{-4} \)
- (2) \( 1.0 \times 10^{-5} \)
- (3) \( 2.0 \times 10^{-5} \)
- (4) \( 5.0 \times 10^{-6} \)
- (5) \( 8.7 \times 10^{-6} \)

12. Magnetic field lines inside the solenoid shown are:

- (1) toward the top of the page
- (2) clockwise circles as one looks down the axis from the top of the page
- (3) counterclockwise circles as one looks down the axis from the top of the page
- (4) toward the bottom of the page
- (5) in no direction since \( B = 0 \)

13. Four long straight wires carry equal currents into the page as shown. The magnetic force exerted on wire \( F \) is:

\[ \text{ALL FORCES ARE ATTRACTIVE, AS SHOWN.} \]

- (1) east
- (2) north
- (3) south
- (4) west
- (5) zero

14. An 8.0-\( \text{mH} \) inductor and a 2.0-\( \Omega \) resistor are wired in series to a 20-V ideal battery. A switch in the circuit is closed at time 0, at which time the current is 0. A long time after the switch is thrown the potential differences across the inductor and resistor are:

- (1) 0, 20 V
- (2) 20 V, 0
- (3) 10 V, 10 V
- (4) 16 V, 4 V
- (5) unknown since the rate of change of the current is not given

\[ \text{AFTER A LONG TIME, THERE'S NO BACK EMF IN L, SO} \Delta V_\text{L} \text{=} 0. \text{ \"ALL POTENTIAL DIFFERENCE IS ACROSS R.\} }\]
15. An LC circuit has an oscillation frequency of $10^7$ Hz. If $C = 0.1 \mu F$, then $L$ must be about:

(1) 25 $\mu H$  
(2) 10 $mH$  
(3) 1 $mH$  
(4) 2.5 $\mu H$  
(5) 1 $pH$

16. The primary of a 3:1 step-up transformer is connected to a source and the secondary is connected to a resistor $R$. The power dissipated by $R$ in this situation is $P$. If $R$ is connected directly to the source it will dissipate a power of:

(1) $P/9$  
(2) $P/3$  
(3) $P$  
(4) $3P$  
(5) $9P$

17. A long straight wire is in the plane of a rectangular conducting loop. The straight wire carries a constant current $I$, as shown. While the wire is being moved toward the rectangle the current in the rectangle is:

(1) counterclockwise  
(2) clockwise  
(3) clockwise in the left side and counterclockwise in the right side  
(4) clockwise in the left side and clockwise in the right side  
(5) inside the loop, induced

18. The circuit shown is in a uniform magnetic field that is into the page and is decreasing in magnitude at the rate 150 T/s. The current in the circuit (in amperes) is:

$I_{\text{battery}} = -4V$  
$I_{\text{C}} = 0.4A$  
The induced emf must produce a downward current which produces $I_B$ in opposite direction. Thus $e = \frac{\Delta B}{\Delta t} = 1.44 \times 10^{-2} (150 T/s)$ + $v$

(1) 0.18  
(2) 0.22  
(3) 0.40  
(4) 0.62  
(5) none of these

19. A rod with a resistance $R$ lies across frictionless conducting rails in a uniform magnetic field $B$, as shown. Assume the rails have negligible resistance. The force that must be applied by a person to pull the rod to the right at constant speed $v$ is:

$E = BLv$ and $P = \frac{E^2}{R}$ (electrical)

The mechanical $P = Fv$, so $Fv = \frac{B^2L^2v^2}{R}$

(1) $B^2L^2v^2/R$  
(2) 0  
(3) $BLv$  
(4) $BLv/R$  
(5) $B^2L^2v^2/R$

20. When the switch $S$ in the circuit shown is closed, the time constant for the growth of current in $R_2$ is:

$I$ in the "L-Leg" is determined only by $L$ and $R_2$. Hence

(1) $L/R_2$  
(2) $L/R_1$  
(3) $L/(R_1 + R_2)$  
(4) $L(R_1 + R_2)/(R_1R_2)$  
(5) $(L/R_1 + L/R_2)/2$