

1. (5 points) A resistance R and a 3.9 H inductance are in series across a 60 Hz AC voltage. The voltage across the resistor is 23 V and the voltage across the inductor is 35 V . Assume that all voltages in this problem are rms voltages. What is the resistance R (in ohms)?

- A. 2.56
- B. 154
- C. 966
- D. 356
- E. 2237

For Questions 2-4:

A $4.5 \mu\text{F}$ capacitor is charged to 27 V and is then connected across a 12 mH inductor.

2. (4 points) How much energy is stored in the system?

- A. 0
- B. 1.64 mJ
- C. $60.8 \mu\text{J}$
- D. 3.28 J
- E. 9.4 nJ

3. (3 points) What is the frequency (in Hz) of oscillation?

- A. 4300
- B. 2.32×10^{-4}
- C. 2.7×10^4
- D. 56
- E. 685

4. (3 points) What is the maximum current (in Amperes)?

- A. 57
- B. 1.4
- C. 0.52
- D. 0.10
- E. 0.083

5. (5 points) At one instant an electron is moving in the xy plane, the components of its velocity being $v_x = 5 \times 10^5$ m/s and $v_y = 3 \times 10^5$ m/s. A magnetic field of 0.8 T is in the positive x direction. At that instant, the magnitude of the magnetic force (in Newtons) on the electron is:

- A. 0
- B. 6.4×10^{-14}
- C. 4.7×10^{-14}
- D. 1.0×10^{-13}
- E. 3.8×10^{-14}

6. (5 points) A loop of wire carrying current of 2.0 A is in the shape of a right triangle with two equal sides, each 15 cm long. A 0.7 T uniform magnetic field is in the plane of the triangle and is perpendicular to the hypotenuse. The magnitude of the magnetic force (in Newtons) on either of the two equal sides has is:

- A. 0
- B. 0.105
- C. 0.15
- D. 0.21
- E. 0.25

7. (5 points) Electrons are accelerated from rest through a potential difference V and are deflected by a magnetic field B that is perpendicular to their velocity. The radius of the resulting electron trajectory is:

- (A) $B\sqrt{\frac{2mV}{e}}$ (B) $\frac{1}{B}\sqrt{\frac{2mV}{e}}$ (C) $\frac{mV}{eB}$ (D) $\frac{B}{e}\sqrt{2mV}$ (E) None of these

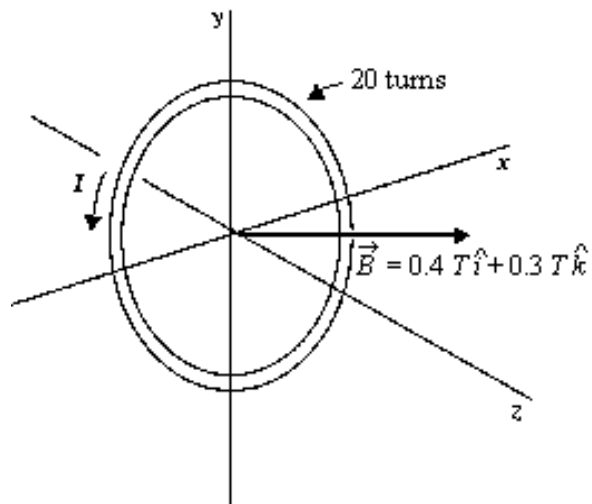
8. (5 points) An electron passes through a region where there is an electric field $E = 4.0 \times 10^5 \text{ V/m}$ and the magnetic field $B = 0.090 \text{ T}$. The directions of the electric field, the magnetic field, and the electron velocity are mutually perpendicular. If the electron is not deflected from its straight-line path through these fields, its velocity (in m/s) must be

- A) 3.6×10^4
- B) 1.2×10^4
- C) 5.0×10^5
- D) 4.4×10^6
- E) 2.2×10^{-7}

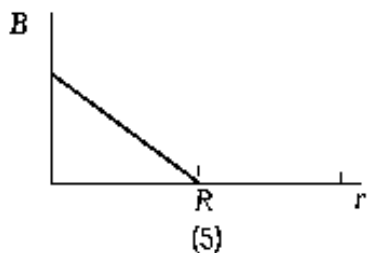
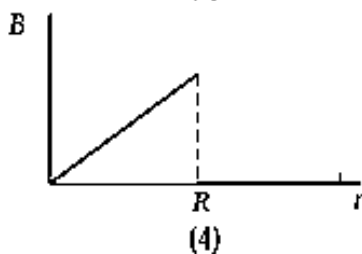
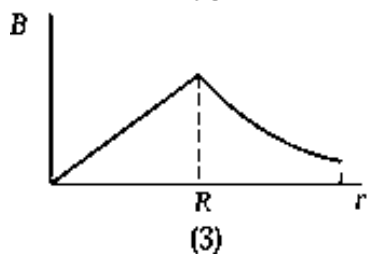
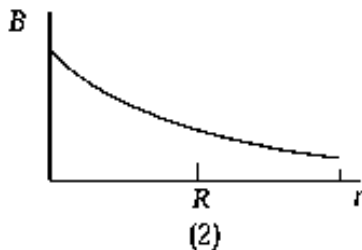
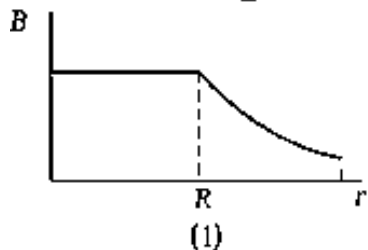
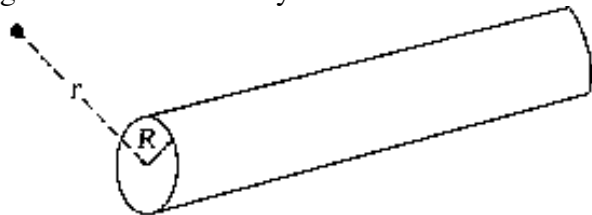
9. (5 points) A circular 20-turn coil with a radius of 10 cm carries a current of 3 A. It lies in the xy plane in a uniform magnetic field

$\vec{B} = 0.4 \text{ T } \hat{i} + 0.3 \text{ T } \hat{k}$. The potential energy (in Joules) of the system is

- A. -0.263
- B. -0.461
- C. 0.461
- D. -0.564
- E. 0.564



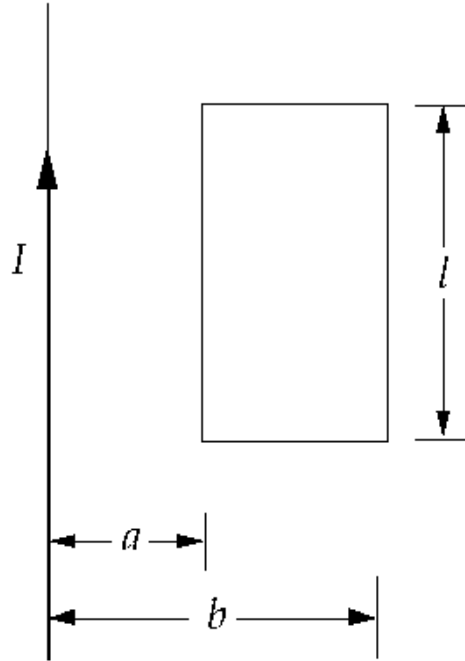
10. (5 points) The graph that best represents B as a function of r for a wire of radius R carrying a current I uniformly distributed over its cross-sectional area is



- A. 1
- B. 2
- C. 3
- D. 4
- E. 5

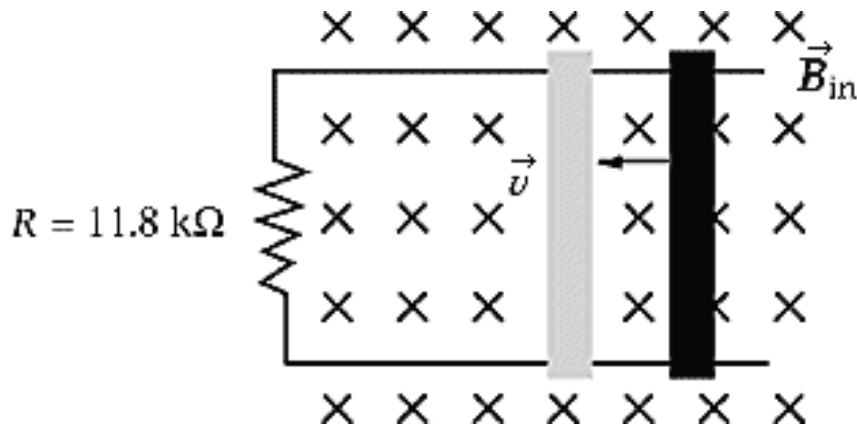
11. (5 points) A long straight wire carries a constant current I . The magnitude of the magnetic flux through the illustrated rectangular loop of wire is

- (A) $\frac{\mu_o I l}{\pi} \ln(b/a)$
 (B) $\frac{\mu_o I l}{4\pi} \ln\left(\frac{a+b}{b-a}\right)$
 (C) $\frac{\mu_o I l}{\pi} \ln\left(\frac{b-a}{b+a}\right)$
 (D) $\frac{\mu_o I l}{2\pi} \ln(b/a)$
 (E) $\frac{\mu_o I l}{2\pi} \ln\left(\frac{b-a}{b+a}\right)$



12. (5 points) A 100-turn coil has a radius of 7.50 cm and a resistance of 50.0 Ω . At what rate (in T/s) must a perpendicular magnetic field change to produce a current of 5.00 A in the coil?

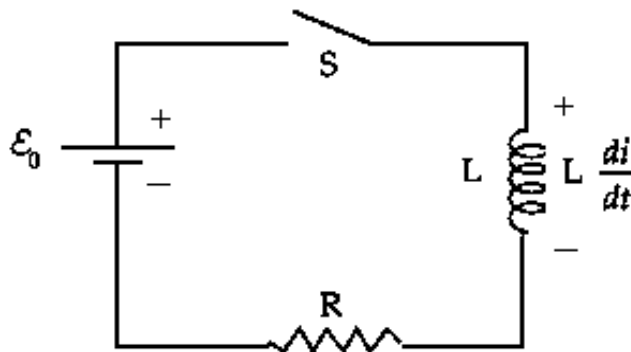
- (A) 275
 (B) 106
 (C) 141
 (D) 134
 (E) 329



13. (5 points) A wire rod rolls to the left with a speed of 20 m/s on two metallic rails, 1.0 m apart, that form a closed loop. If the magnetic field is 1.5 T into the page, the power (in mW) dissipated in the resistor $R=11.8 \text{ k}\Omega$ and the current direction are, respectively

- A) 33, clockwise
- B) 33, counterclockwise
- C) 76, counterclockwise
- D) 76, clockwise
- E) 50, clockwise

14. (5 points) In this circuit, $\epsilon_0 = 12 \text{ V}$, $R = 6.0 \Omega$, and $L = 0.48 \text{ H}$. The switch is closed at time $t = 0$. At time $t = 0.25 \text{ s}$, the rate (in W) of Joule heating is approximately



- A) 22
- B) 546
- C) 37
- D) 273
- E) 51

15. (5 points) A cross section of a long conductor of a type called a coaxial cable is shown in the figure and gives the radii (a, b, c). Equal but opposite currents i are uniformly distributed in the two conductors. The expression for the magnetic field $B(r)$ in the ranges of $b < r < a$ is

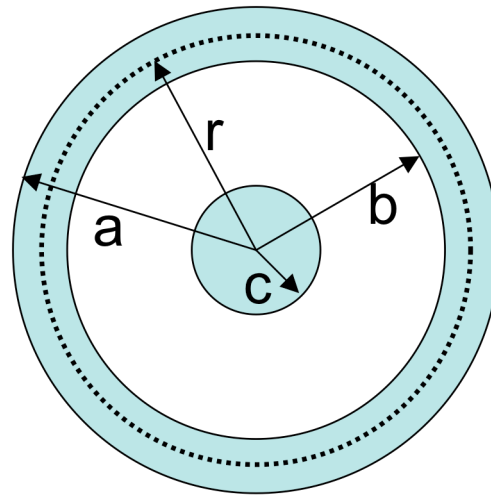
(A) $\frac{\mu_0 i (a^2 - r^2)}{2\pi r (a^2 + b^2)}$

(B) $\frac{\mu_0 i}{2\pi a}$

(C) $\frac{\mu_0 i (a^2 - r^2)}{2\pi r (a^2 - b^2)}$

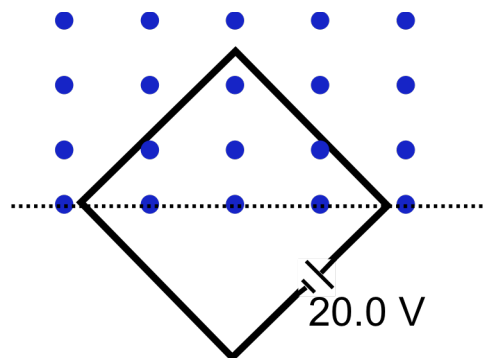
(D) $\frac{\mu_0 i r}{2\pi b^2}$

(E) $\frac{\mu_0 i (a^2 - r^2)}{2\pi (a^2 - b^2)}$



16. (5 points)

A square wire loop with 2.00 m sides is perpendicular to a uniform magnetic field, with half the area of the loop in the field. The loop contains a 20.0 V battery with negligible internal resistance. If the magnitude of the field varies with time according to $B = 0.0420 - 0.870t$, with B in Teslas and t in seconds, what is the net emf (in Volts) in the circuit?



- A) 1.74 B) 12.3 C) 18.3 D) 20.0 E) 21.7

17. (5 points) A generator is to be connected in series with an inductor of $L = 2.00 \text{ mH}$ and a capacitance C . You are given two capacitors, $C_1 = 4.00 \mu\text{F}$ and $C_2 = 6.00 \mu\text{F}$. To achieve the highest resonant frequency, you must

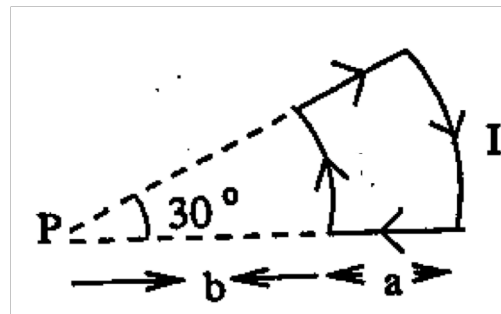
- A) use only C_1
 B) use only C_2
 C) connect C_1 & C_2 in parallel
 D) connect C_1 & C_2 in series
 E) No capacitors are needed.

18. (5 points) What is the kinetic energy (in eV) of an electron that passes undeviated through a perpendicular electric and magnetic fields if $E = 4.0 \text{ kV/m}$ and $B = 8.0 \text{ mT}$? (Hint: $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$)

- A) 1.4
 B) 0.54
 C) 0.71
 D) 0.65
 E) 0.84

19. (5 points) In the figure shown, if $a=2.0 \text{ cm}$, $b=5.0 \text{ cm}$ and $I = 20 \text{ A}$, what is the magnitude of the magnetic field (in μT) at point P?

- A) 4.5
 B) 7.5
 C) 9.0
 D) 6.0
 E) 3.0



For Questions 20 & 21

The voltage $8 \sin(400t)$ is applied to a series RLC circuit, with $R = 200 \Omega$, $L = 0.1 \text{ H}$, and $C = 1.0 \mu\text{F}$.

20. (5 points) What is the phase angle ϕ in degrees?

- A) -15
- B) +89
- C) -63
- D) -85
- E) -37

21. (5 points) What is the impedance (in Ohms)?

- A) 393
- B) 2468
- C) 2540
- D) 566
- E) 200