1. A wire carrying a current I runs vertically upward in the accompanying figure. Off to the side is a loop oriented so that it and the wire lie in the plane of the page. The wire is moved towards the loop. If a current is induced in the loop, in which direction is it, and what is the direction of the force on the loop?
(a) counterclockwise, loop is repelled from wire.
(b) No current is induced.
(c) clockwise, loop is repelled from wire.
(d) counterclockwise, loop is attracted to wire.
(e) clockwise, loop is attracted to wire.

solution: (a) You'll have to consult your test for the figure – note that only the relative motion counts. The field due to the wire is found from a right hand rule. It makes a field that goes down into the plane of the loop, so if we call up out of the paper positive, there is a flux through the loop that is becoming more and more negative. Lenz' law will want to produce a field that keeps the flux from getting more negative, and a right-hand rule will show you that that means a counter clockwise current induced in the loop. Finally you can then use the rule that antiparallel currents repel or just the conservation of energy implicit in Lenz to show that the loop is repelled from the wire.

2. The emf induced in an inductor during a period when the current is changing by 0.2 A/s has magnitude 12 mV. This same inductor is later used in series with a resistance of 150 Ω. What is the time constant for the LR circuit?
(a) not enough information to answer.
(b) 1.67 ms
(c) 2.5 s
(d) 9 s
(e) 0.4 ms

solution (e). The first sentence tells us L: we use emf $\xi = -L\, dI/dt$ to find (magnitude)

$$L = \xi/(dI/dt) = (12\text{ mV})/(0.2\text{ A/s}) = 60\text{ mH}.$$

Then for second part use the time const $\tau = L/R = (60\text{ mH})/(150\ \Omega) = 0.4\text{ ms}$

3. Consider the material with the hysteresis loop shown. You have a sample of this material, initially unmagnetized, and you expose it to an external magnetic field of $+3 \times 10^{-4}$ T. (All vector quantities are aligned with the z-axis, with the + sign indicating the positive z-direction.) You then decrease the external field to a value of -3×10^{-4} T and then increase it to $+2 \times 10^{-4}$ T. What is the magnetic field within the material at the end of the process?
(a) +1.1 T
(b) −0.2 T
(c) −1.1 T
(d) 0
(e) +0.5 T

solution. (a) Again, refer to your test for the figure. You must follow the hysteresis curve, which describes how the magnetic field in the material (vertical axis) depends on the external field (horizontal axis). By starting at external field = $+3 \times 10^{-4}$ T, you are at the upper right part of the curve. As the external field decreases, you follow the upper curve (sensible – the material "remembers" the applied field), and if the external field goes to -3×10^{-4} T you are at the lower left corner. As the external field increases you follow the lower curve, and end up at +1.1 T.

4. True or false: Iron filings are attracted to the N-pole of a bar magnet but repelled from the S-pole.
(a) True
(b) False

Answer. (b). The filings are attracted to each pole because they are little dipoles that can be oriented so that the lowest energy is such that they are attracted to each pole.

5. An AC circuit contains a parallel-plate capacitor and a long, cylindrical solenoid. Suppose that all the linear dimensions of the apparatus, including the wire radii, are scaled down by a factor of 2. (Note that the turn density doubles.) How would the resonant frequency of the circuit change?
(a) It doubles.
(b) It increases by a factor of 4.
(c) It decreases by a factor of 4.
(d) It decreases by a factor of 2.
(e) none of the above

answer (a). The resonant frequency is $(LC)^{-1/2}$. With C = ε_0 A/d, we have A $\rightarrow$ A/4, d $\rightarrow$ d/2, so that C $\rightarrow$ C/2, while for the inductor use A $\rightarrow$ A/4, length $\rightarrow$ length/2, $n \rightarrow 2n$ so that L = μ0 A × length × $n^2 \rightarrow L/2$. Thus the frequency $\rightarrow$ frequency × $(2 \times 2)^{+1/2}$ = frequency × 2.

6. The primary coil of a step-down transformer is connected to house current, which is AC with an amplitude of 160 V at a frequency f = 60 Hz. If the secondary coil of the transformer delivers a current with an amplitude of 2.0 A at a voltage amplitude of 24 V, what is the amplitude of the current drawn by the primary coil? Ignore losses in the transformer.
(a) 3 mA
(b) cannot be determined from the information given
(c) 13 A
(d) 3.3 A
(e) 0.30 A

answer (e). By comparing the expressions for V_2/V_1 and I_2/I_1 as a function of the turn ratios, we have $V_2/V_1 = I_1/I_2$, or $I_2 = I_2 \times (V_2/V_1)$ = (2.0 A) × [(24 V)/(160 V)] = 0.3 A.

7. An electron (mass m) with nonrelativistic kinetic energy K moves in a region of constant magnetic field of magnitude B; the motion is perpendicular to the magnetic field. The electron consequently moves in a circle of radius

(a) $\dfrac{q\sqrt{K}}{mB}$

(b) $\dfrac{\sqrt{2mK}}{qB}$

(c) $\dfrac{m}{qBK}$

(d) $\dfrac{qB}{mK}$

(e) $\dfrac{mK}{qB}$

answer (b). The motion is circular with the force equation reading $qvB = mv^2/r$ or $r = mv^2/(qvB) = mv/qB$. But the kinetic energy is K = ½ mv^2, i.e. $v = (2K/m)^{1/2}$. Hence $r = m(2K/m)^{1/2}/qB = (2mK)^{1/2}/(qB)$. Dimensional analysis can also limit things here.

8. Assume that the current a wire carries in this problem is proportional to the area of the wire. A solenoid is tightly wound with a single layer of wire. How should we change the diameter of the wire to double the magnetic field inside?

(a) decrease it by a factor of 4
(b) increase it by a factor of 4
(c) halve it
(d) double it.
(e) there is no way to double the field inside in this way.

answer (d). The magnetic field inside is $B = \mu_0 nI$. Let the diam of the wire change according to $d \rightarrow f\,d$, where f is a factor. Then the winding density, which is inversely proportional to the diam for tight winding (smaller diam implies larger density) changes by $n \rightarrow (1/f)\,n$ and with the current proportional to area which is proportional to d^2, I changes by $I \rightarrow f^2 I$. The $B \rightarrow B \times (1/f) \times f^2 = B \times f$. To double B, $f = 2$, hence we should double the wire diam.

9. You can use Ampere's law to find the magnetic field of a toroidal solenoid. Consider one that is formed from a tube of circular cross section of radius 1 cm that is bent into a circle—the center line of the tube forms a circle of radius 50 cm. The solenoid is wound with n turns per unit length. What approximate turn density is needed to give a field of strength 3×10^{-4} T down the center line of the tube when the wires carry 0.25 A?
(a) 10 turns per m
(b) 100 turns per m
(c) 10 turns per cm
(d) 50 turns per cm
(e) 0.5 turns per cm

answer. (c) Let R be the radius of the large circle made by the torus. Make an Ampere's law circle down the center of this circle. The current enclosed is $I \times N = I \times 2\pi R\,n$, where N is the total number of turns and n is the turn density. μ_0 times this current equals $B \times$ path length $= B \times 2\pi R$, because B is parallel to the path and is constant in value over the path, so that it comes out of the integral. Thus the $2\pi R$ cancels and $B = \mu_0 I n$, or $n = B/\mu_0 I = (3 \times 10^{-4}\text{ T})/[(4\pi \times 10^{-7}\text{ SI units}) \times (0.25\text{ A})] = 10^3$ turns per meter = 10 turns per cm.

10. The term "power factor" refers to
(a) the way that the impedance comes into power loss in an *RLC* circuit.
(b) the relation between the power delivered in an AC *RLC* circuit and the relative phase of the driving emf and the current.
(c) the way that the impedance comes into the power loss in an AC *RLC* circuit.
(d) the magnification of the power in a transformer.
(e) How the frequency of an *LC* circuit depends on *L* and *C*.

answer (b)