Name:

Physics 122-02 Test 4

Instructions:

There are 105 points on the test, but it is graded on the usual 100 point scale. Use 3x5 index card and calculator only. We will provide scratch paper. *Index card and all paper used must be submitted before you leave.* Problems 1-4 require *only* an answer. However, you *may* provide an explanation for 1-4 for possible partial credit. Problems 5-10 require work to be shown. The later answers for multipart problems often build on the answers to earlier parts. However, if you can answer a later part but not an earlier part, make an assumption about the earlier part, state what your assumptions was, and answer the rest of the question. Likewise if you cannot answer the problem as written but you can do a similar problem, *state what alternate problem you are solving* and you may get part credit.

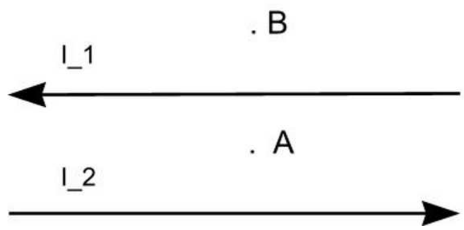

Figure 1: For questions 1-3, two wires carry current of equal magnitude in opposite directions. Point A is exactly midway between the two wires. You may assume the wires are infinitely long and perfectly parallel.

1. *(6 pts.)* At point A, the total magnetic field is:

- **(a)** Directed downward (toward wire 2).
- **(b)** Directed upward (toward wire 1).
- **(c)** Directed into the page.
- **(d)** Directed out of the page.
- **(e)** Zero.

2. *(7 pts.)* At point B, the total magnetic field is:

- **(a)** Directed downward.
- **(b)** Directed upward.
- **(c)** Directed into the page.
- **(d)** Directed out of the page.
- **(e)** Zero.

3. *(7 pts.)* The magnetic force on wire 1 is:

- **(a)** Directed downward (toward wire 2).
- **(b)** Directed upward (away from wire 2).
- **(c)** Directed into the page.
- **(d)** Directed out of the page.
- **(e)** Zero.

4. *(5 pts.)* The SI units for magnetic field (B), inductance (L) and magnetic flux (Φ_B) are, respectively:

- **(a)** Gauss, Henry, and Tesla
- **(b)** Gauss, Louis, and Pauling
- **(c)** Curie, electron-volt, Angelina
- **(d)** Tesla, Volt, and Farad
- **(e)** Tesla, Henry, and Volt m
- **(f)** Tesla, Henry, and Tesla m^2

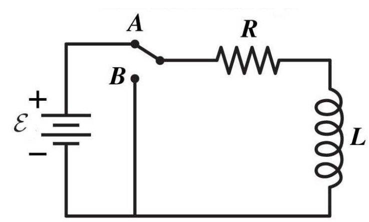

Figure 2: In this circuit, $L = 0.1\ H$, $R = 100\ \Omega$, and $\varepsilon = 9\ V$

5. *(15 pts.)* You build the circuit shown in Figure 2. The switch is set to position B and left there for several seconds so that the current dies away to zero. After that, at $t = 0$, you throw the switch back to position A.

- **(a)** What is the voltage across the inductor for $t \simeq 0$?
- **(b)** What is the rate of change of the current at $t \simeq 0$?
- **(c)** What is the current through the circuit a very long time after you have thrown the switch?
- **(d)** What is the current at $t = 0.001\ sec$?
- **(e)** What is the rate of change of the current at $t = 0.001\ sec$?

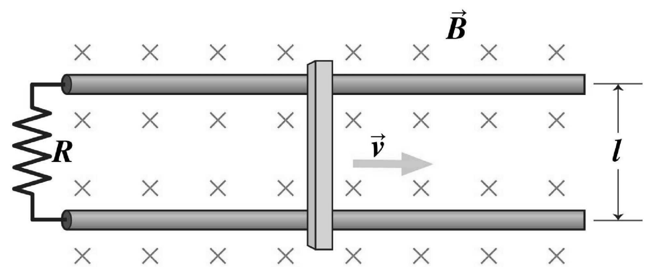

Figure 3: In the figure above, $l = 2$ m, $v = 10$ m/s, $B = 50$ mT and $R = 4\,\Omega$.

6. *(15 pts.)* A bar is pulled to the right at constant speed as shown in Figure 3. The bar remains in electrical contact with the rails.

- **(a)** What is the voltage across the resistor and the current through the circuit?
- **(b)** What force must be exerted on the moving bar to keep it moving at constant speed?
- **(c)** How much power is the agent moving the bar expending?

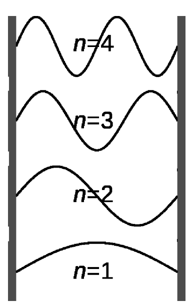

Figure 4: The first four wavefunctions for a particle in a box with infinitely high walls. The left side of the box is at $x = 0$. The right side of the box is at $x = 0.95\ nm$.

7. *(10 pts.)* What is the ground state energy for an electron in this box? What wavelength of electromagnetic radiation is emitted by an electron falling from the n=3 to n=2 state in this box? What type of radiation is this closest to? (Check table at end of exam).

8. *(10 pts.)* For each of the first four quantum states of the particle in the box, rank (highest to lowest, indicating ties) the probability of finding the particle in a tiny interval around $x = 0.475\ nm$ (the middle of the box). (e.g.

P_2, P_3, P_4, P_1 means the probability of n=2 state being in the middle of the box is highest, followed by n=3, n=4, n=1).

9. *(15 pts.)* You have a job in a lab. You are given a giant spool of wire and asked to build a solenoid 3 m long and 10 cm in radius by winding a single layer of wire around a cylindrical form. When a current of 80 Amps is passed through it, it is desired to have a magnetic field of 100 mT inside. In answering the questions that follow, you can neglect the diameter of the wire itself.

(a) What total length of wire do you need to build the solenoid?
(b) What total magnetic flux is enclosed in the 3 m length of the final solenoid?
(c) What is the self-inductance of your hand-built solenoid?

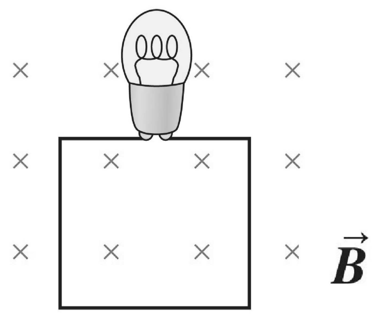

Figure 5: The light bulb in the picture has a resistance of 0.5 Ω. It is attached to a square wire loop of side 20 cm.

10. *(15 pts.)* The magnitude of the magnetic field in figure 5 above varies as $B = 7 + 4t - 4t^3$ Tesla and is directed into the page as shown.

(a) What direction does the induced current flow?
(b) How much power does the light-bulb consume at $t = 1$ sec?
(c) If the loop were turned (before t=0) so that it pointed out of the page at 45 degrees, what power would it consume at $t = 1$ sec?

Useful Constants

Electric permeability of vacuum (and air) ϵ_0**:** $8.86 \times 10^{-12}\ \frac{A^2 \cdot s^4}{kg \cdot m^3}$
Magnetic permeability of vacuum (and air) μ_0**:** $1.26 \times 10^{-6}\ \frac{T \cdot m}{A}$
Charge of an electron or proton (magnitude): 1.60×10^{-19} C
Speed of light in vacuum (and air) (c): 3.00×10^8 m/s
Planck's constant (h): 6.63×10^{-34} J s
Mass of an electron (m_e)**:** 9.11×10^{-31} kg

Electromagnetic Spectrum

Type	Wavelength (nm)	Comments
FM Radio	3 m	
Microwave	1 mm	
Infrared	10 μm	
Visible	400 nm	violet
Visible	500 nm	blue
Visible	590 nm	yellow
Visible	700 nm	red
Xray	1 nm	
Gamma ray	1 pm	