THE UNIVERSITY OF BRITISH COLUMBIA

Physics 108

Second Midterm Examination

Friday 11 March 2005

TIME: 50 MINUTES

FULL NAME: ____________________ STUDENT # : ____________

SIGNATURE: ____________________

This Examination paper consists of 9 pages (including this one). Make sure you have all 9.

INSTRUCTIONS:

Write your name on every sheet.

Calculator and 1-page Summary Sheet allowed.

Try every question — *easy ones first!* A *diagram* is usually a good start.

Read carefully!

Your answers may be expressed in terms of irrational numbers like π or $\sqrt{2}$.

MARKING:

Q1	/50
Q2	/50
TOTAL	/100

NAME OF INSTRUCTOR: Jess H. Brewer

Q1 QUICKIES [10 marks each — 50 total]

(*a*) Show with sketches how to combine

i) two identical capacitors to give an equivalent capacitance half as big as either;

ii) two identical resistors to give an equivalent resistance half as big as either;

iii) two identical coils to give an equivalent inductance half as big as either;

iv) two identical batteries to give an equivalent voltage half as big as either.

(*b*) Explain why a static magnetic field can't change the kinetic energy of a charged particle.

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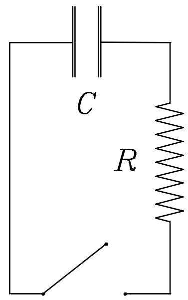
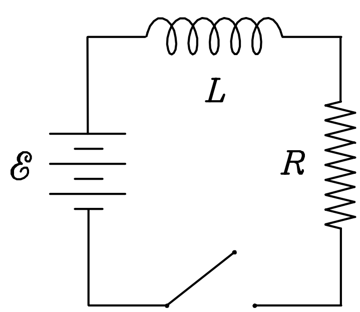
Describe in *quantitative* detail what happens after the switch is closed at $t = 0$ in each of the following circuits, where $C = 0.1$ F, $R = 10\ \Omega$, $L = 0.01$ H and $\mathcal{E} = 10$ V.
(Graphs are fine as long as the axes are labeled *quantitatively*.)

(*c*) The capacitor is initially charged to $Q = 1$ C.



(*d*)



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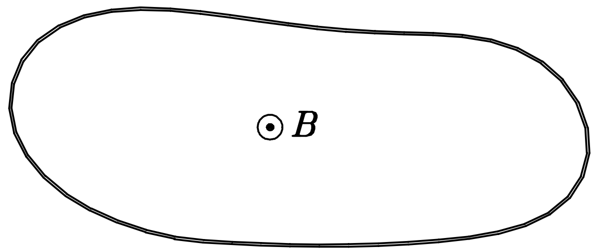
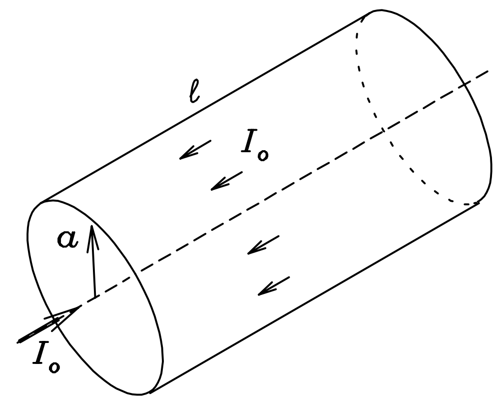
(*e*) A loop of limp braided wire lies flat on a frictionless table in an elongated oval shape. Suddenly a uniform magnetic field is turned on normal to the table's surface. What happens to the loop? Why?



Q2 Ideal Coaxial Cable [50 marks]



An idealized coaxial cable consists of a solid cylindrical wire of length ℓ and radius a coated with a thin layer of insulating paint and a second thin layer of metal (outside the paint, so that it does not make electrical contact with the inner wire). The thickness of the paint and that of the outer conductor are both negligible compared with a, and we shall treat the wire as "long" ($\ell \gg a$) so that "end effects" can be neglected.

A net current I_0 flows down the solid central conductor and back (in the opposite direction) along the thin outer conductor. The current density $\vec{\boldsymbol{J}}$ is uniform over the cross-sectional area of the central conductor and the returning current is uniformly distributed over the surface of the outer conducting shell.

(*a*) [10 marks] In what *direction* is the vector magnetic field $\vec{\boldsymbol{B}}$ inside and outside the cable? (Indicate on the sketch and/or in words.)

(*b*) [10 marks] Calculate the magnetic field strength B as a function of r (the distance from the central axis), I_0, a and any fundamental constants, both inside and outside the cable.

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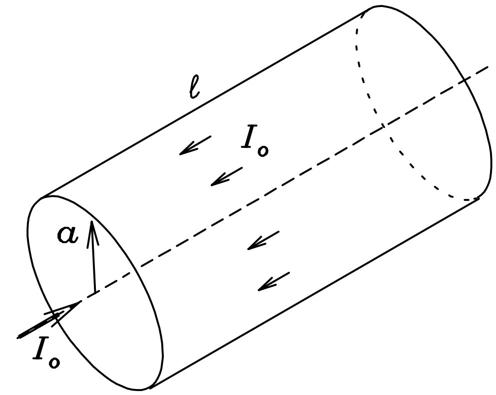
(*c*) [10 marks] Calculate the cable's *inductance* in terms of a and ℓ.



(*d*) [10 marks] Describe what would happen in the cable if the battery driving the current were suddenly "shorted out" by a superconducting switch.

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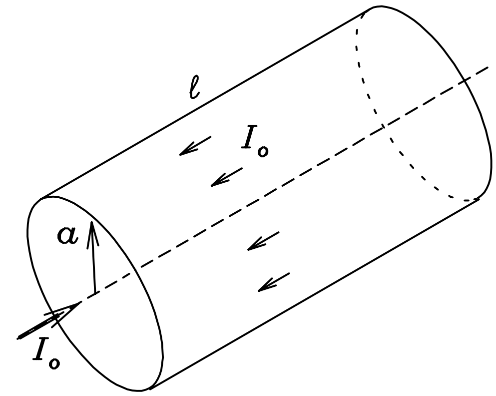
(*e*) [5 marks] Now assume that the thin outer conductor has *no* resistance but the solid inner conductor has a resistivity $\rho = 10^{-6}$ Ωm. If $a = 1$ mm and $\ell = 2$ m, what is the *resistance* of the cable?



(*f*) [5 marks] If $I_0 = 0.5$ A, what is the *electric field* $\vec{\boldsymbol{E}}$ in the inner conductor?

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(extra work space)

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Constants and Conversion Factors. (You may not need all of these!)

Exchange Rate (10 Mar 2005)	\$1.00 USD	=	\$1.20412 CAD
Universal Gravitational Constant	G	=	6.672×10^{-11} m^3 kg^{-1} s^{-2}
Mass of the Earth	M_E	=	5.974×10^{24} kg
Mean radius of the Earth	R_E	=	6367 km
Planck's constant	h	=	6.6262×10^{-34} J-s
Permittivity of free space	$\epsilon_\circ$	=	0.8854×10^{-11} C^2/N-m^2 [or F/m]
constant in Coulomb's Law	$k_E = \frac{1}{4\pi\epsilon_0}$	=	8.988×10^9 N-m^2/C^2
Permeability of free space	μ_0	=	1.2566×10^{-6} N/A^2 [or H/m]
constant in Biot-Savart Law	$k_M = \frac{\mu_0}{4\pi}$	=	10^{-7} T-m/A
Electric charge of a proton	e	=	1.602×10^{-19} C
Speed of light in vacuum	c	=	2.99792458×10^8 m/s
Avogadro's number	N_0	=	6.022×10^{23} molecules per mole
Proton rest mass	M_p	=	1.673×10^{-27} kg
Neutron rest mass	M_n	=	1.675×10^{-27} kg
Electron rest mass	m_e	=	9.11×10^{-31} kg
Boltzmann constant	k_B	=	1.3807×10^{-23} J/K
electron volt	1 eV	=	1.602×10^{-19} J $= k_B \times 11,600$ K
Atmospheric pressure:	1 atm	=	760 torr $=$ 1.013×10^5 pascal [N/m^2]

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