THE UNIVERSITY OF BRITISH COLUMBIA

Physics 108

Midterm Examination

Friday 7 March 2003

TIME: 50 MINUTES

FULL NAME: ______________________ STUDENT # : ______________

SIGNATURE: ______________________

This Examination paper consists of 8 pages (including this one). Make sure you have all 8.

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!

MARKING:

Q1	/60
Q2	/20
Q3	/20
TOTAL	/100

NAME OF INSTRUCTOR: Jess H. Brewer

Q1 QUICKIES [10 marks each — 60 total]

(a) Under what circumstances would the *entropy* of a system *decrease* with the *addition of energy*, and what could you say about the *temperature* of such a system?

(b) Charges of $+Q$ and $-2Q$ are located as shown:

$$+Q \bullet \qquad\qquad\qquad \bullet -2Q$$

A point where the electric field could equal zero is located (encircle your choice)

(i) to the left of the $+Q$ charge (ii) between the two charges

(iii) to the right of the $-2Q$ charge (iv) nowhere

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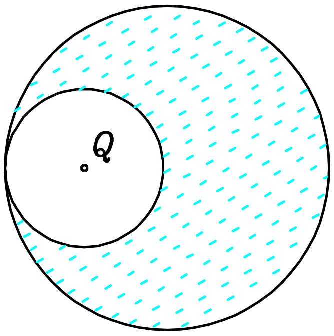
(*c*) A solid *conducting* sphere of radius R has a spherical cavity of radius $R/2$ just touching one side, as shown. In the exact centre of the *cavity* is a point charge Q. Describe in detail the *electric field as a function of position*

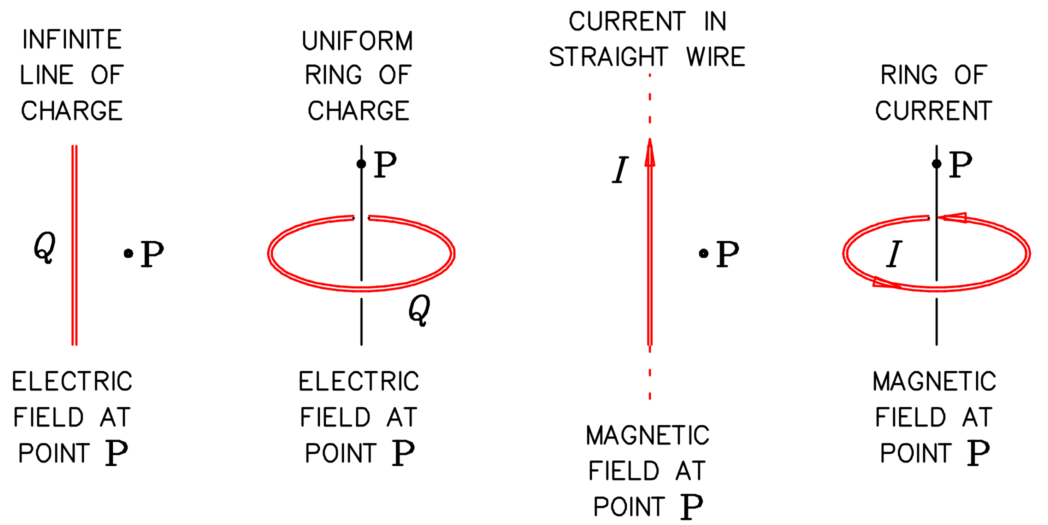


i) in the cavity

ii) in the conductor

iii) outside the big sphere

(*d*) Shown below are four types of calculation problems and four "Laws" of Electricity and Magnetism. Match up (with connecting lines) each problem with the Law you should use to solve it with.



Coulomb's Law | Gauss' Law | Law of Biot & Savart | Ampère's Law

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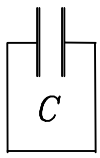
(*e*) The charge Q on any *shorted* capacitor will exhibit thermal fluctuations. If a 1 F capacitor is in thermal equilibrium at a temperature of 300 K, what is its *root mean square charge* $Q_{rms} = \sqrt{\langle Q^2 \rangle}$?



(*f*) A proton is *initially at rest* in a uniform magnetic field out of the page. A uniform electric field is then applied in the $+y$ direction, perpendicular to the magnetic field. Describe the subsequent motion of the proton *qualitatively*, using a simple *sketch* and a few words.

Does the proton ever move into or out of the page? *Explain.*

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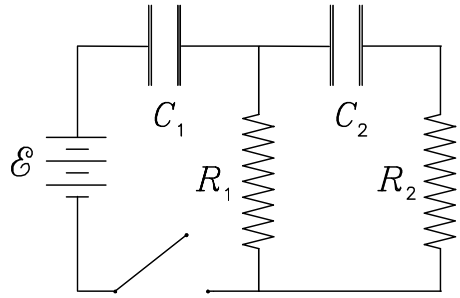
Q2 Not a Simple Circuit [20 marks]

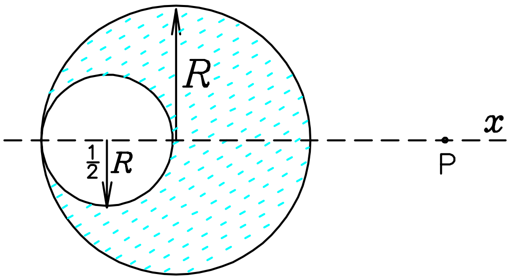


Two identical 0.01 F capacitors and two identical 100 Ω resistors are used with a 1 V battery $\mathcal{E}$ to make the circuit shown. The capacitors are initially uncharged.

Describe what happens after the switch is closed at $t = 0$. (You need not solve equations. Sketches are nice.)

Q3 Composite Conductor [20 marks]

A long cylindrical conductor (a wire), viewed in cross-section at right, carries a uniform current density out of the page except in the off-centre cylindrical hole where the metal has been removed. The radius of the hole is half the radius R of the wire and the hole's central axis is located its $R/2$ to the left of the central axis of the wire, as shown. If $R = 1$ cm and the wire carries a net current of 1 A, calculate the resultant magnetic field at a position P on the x axis 1 cm to the right of the wire's right edge.



(a) [5 marks] Explain how you plan to solve this problem.

(b) [15 marks] Do it.

(extra work space)

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

Exchange Rate (05 Mar 2003)	\$1.00 CAD	=	0.619965 EUR (Euro)
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 $= 4.1357 \times 10^{-15}$ eV-s
Permittivity of free space	ϵ_0	=	0.8854×10^{-11} C^2/N-m^2 [or F/m]
constant in Coulomb's Law	$k_E = \dfrac{1}{4\pi\epsilon_0}$	=	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	$k_M = \dfrac{\mu_0}{4\pi}$	=	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	$k_{\rm B}$	=	1.3807×10^{-23} J/K
electron volt			1 eV $= 1.602 \times 10^{-19}$ J $= k_{\rm B} \times 11,600$ K
Atmospheric pressure:			1 atm = 760 torr $= 1.013 \times 10^5$ pascal (N/m^2)

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