$$|E(r)| = \frac{q}{4\pi\epsilon_0 r^2}$$
$$|E(r)| = \frac{\lambda}{2\pi\epsilon_0 r}$$
$$|E| = \frac{\sigma}{2\epsilon_0}$$

$$V(r) = \frac{q}{4\pi\epsilon_0 r}$$
$$V(r) = -\frac{\lambda}{2\pi\epsilon_0}\ln r$$
$$V(x) = C - \frac{\sigma}{2\epsilon_0}\,x$$

$$\oint_S \mathbf{E}\cdot\hat{n}dA = \frac{Q_{inS}}{\epsilon_0}$$
$$\Delta V = \frac{Q}{C}$$
$$\mathbf{E} = -\boldsymbol{\nabla}V - \frac{\partial\mathbf{A}}{\partial t}$$

$$|J| = \frac{I}{A}$$
$$U = \frac{Q^2}{2C}$$
$$RC = \epsilon_0\rho$$

$$\mathbf{F} = q\mathbf{v}\times\mathbf{B}$$
$$R = \frac{mv}{qB}$$
$$d\mathbf{B} = \frac{\mu_0}{4\pi}Id\ell\frac{\mathbf{t}\times\mathbf{r}}{r^3}$$

$$V(b) - V(a) = -\int_a^b \mathbf{E}\cdot\mathbf{d}r$$
$$R = \frac{\rho L}{A}$$
$$C = \frac{\kappa\epsilon_0 A}{d}$$

$$\frac{d\mathbf{F}}{d\ell} = I\mathbf{t}\times\mathbf{B}$$
$$\oint_C \mathbf{B}\cdot d\mathbf{r} = \mu_0 I_C$$
$$\mathbf{B} = \frac{\mu_0 q}{4\pi}\frac{\mathbf{v}\times\mathbf{r}}{r^3}$$

$$C_{parallel} = C_1 + C_2$$
$$\frac{1}{C_{series}} = \frac{1}{C_1} + \frac{1}{C_2}$$
$$\tan\theta = \frac{\sin\theta}{\cos\theta}$$

$$\mathbf{B} = \nabla\times\mathbf{A}$$
$$\mathbf{A}(r) = \frac{\mu_0}{4\pi}\int\frac{Id\ell\mathbf{t}}{r}$$
$$U = -\mathbf{m}\cdot\mathbf{B}$$

$$(x-x_c)^2 + (y-y_c)^2 = R^2$$
$$E_x = -\frac{\partial V}{\partial x}$$
$$E_y = -\frac{\partial V}{\partial y}$$

$$Q = \rho\cdot Vol$$
$$Q = \sigma A$$
$$\sigma(x) = \epsilon_0\mathbf{E}(x)\cdot\mathbf{n}$$

$$F_x = -\frac{\partial U}{\partial x}$$
$$\mathbf{N} = \mathbf{p}\times\mathbf{E}$$
$$\mathbf{p} = \sum_{i=1}^2 q_i\mathbf{r}_i$$

$$\frac{d}{du}\tan^{-1}u = \frac{1}{1+u^2},$$
$$\frac{d}{dx}\frac{u}{v} = \frac{u'v-v'u}{v^2}$$
$$\frac{d}{dx}\ln x = \frac{1}{x}$$

$$\int_a^b\frac{dr}{r^2} = \frac{1}{a} - \frac{1}{b}$$
$$\int_a^b\frac{dr}{r} = \ln\frac{b}{a}$$
$$\tan(\tan^{-1}(x)) = x = \tan^{-1}(\tan(x))$$

$$\Delta W = \Delta(qV)$$
$$\frac{dW}{dVol} = \frac{1}{2}\epsilon_0\kappa E^2$$
$$W = \frac{Q^2}{2C} = \frac{CV^2}{2}$$

$$\ln(e^x) = -\ln(e^{-x}) = x$$
$$V = IR$$
$$ma = -kx$$

$$Vol = \pi r^2 h$$
$$Vol = \frac{4\pi}{3}r^3$$
$$Vol = LWH$$

$$Area = 2\pi rh$$
$$Area = 4\pi r^2$$
$$Area = L^2$$

$$C = \frac{4\pi\epsilon_0 ab}{b-a}$$
$$C = \frac{2\pi\epsilon_0\ell}{\ln\frac{b}{a}}$$
$$C = \frac{\epsilon_0 A}{d}$$

$$|E_{total}| = \frac{|E_{ext}|}{\kappa}$$
$$\mathbf{J} = \frac{I}{A}\hat{n}$$
$$\frac{dy}{dx} = \frac{E_y}{E_x}$$

$$\frac{d}{dx}\tan^{-1}f(x) = \frac{f'(x)}{1+f^2(x)}$$
$$\tan(a-b) = \frac{\tan a - \tan b}{1+\tan a\,\tan b}$$
$$|\mathbf{B}| = \frac{\mu_0 I}{2\pi R},\ \frac{\mu_0 I}{2R},\ \mu_0 nI,$$

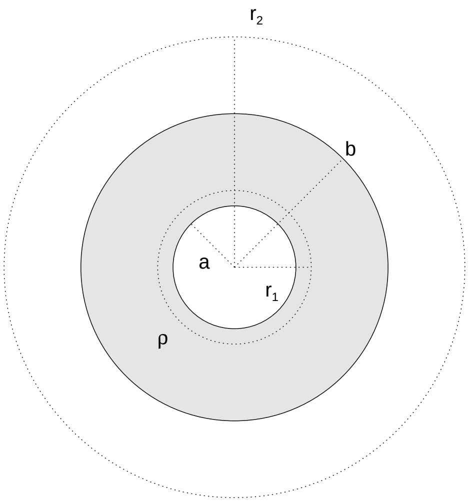
$$\int_a^b\frac{dx}{(c-x)^2} = \frac{a-b}{(c-a)(c-b)}$$
$$U = \frac{1}{2}CV^2$$
$$Q = \lambda\ell$$

$$\frac{1}{4\pi\epsilon_0} = 9.0\times10^9\frac{Nm^2}{C^2}$$
$$\mu_0 = 4\pi\times10^{-7}\frac{T\,m}{A}$$
$$c = 3.0\times10^8\frac{m}{s}$$

$$|\mathbf{B}| = \frac{\mu_0 I}{2\pi r}, \frac{\mu_0 I}{2R}, \mu_0 In$$
$$\mathcal{E} = -L\frac{dI}{dt}$$
$$|Z| = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$$

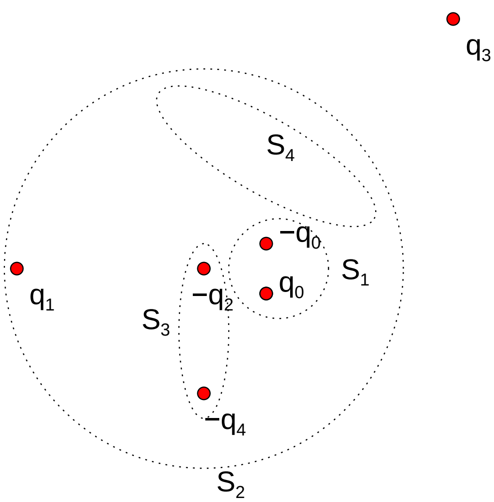
$$\omega = 2\pi f$$
$$\phi = \tan^{-1}\frac{\omega L - \frac{1}{\omega C}}{R}$$
$$\wp = I^2 R$$

Physics 202 Exam 2, Name:______________________________



Problem 1a. $(4+4$, E-52)

A hollow ball of inner radius a and outer radius b is made of charged dust of density ρ. **Compute the electric field strength $|\mathbf{E}(r)|$ for $r < a$, and for $a \le r \le b$**

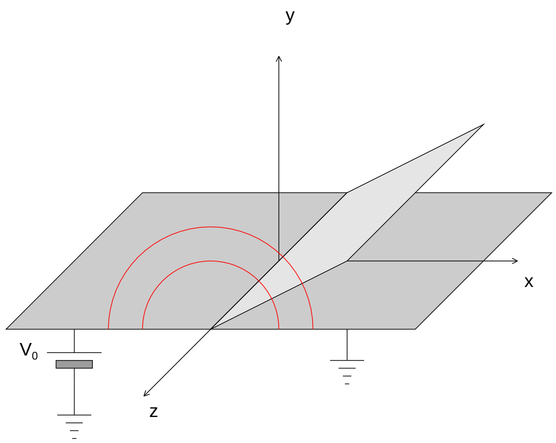


Problem 1b. (4, P-74)

Each dotted curve in the figure to the left is a closed surface in cross section. Compute the electric flux through S_1, S_2, S_3, S_4.

Problem 1c. (4, P-81)

A region of space around the origin contains an electric field $\mathbf{E} = 2.0\frac{N}{m\cdot C}x\mathbf{i} - 3.0\frac{N}{m\cdot C}y\mathbf{j}$. Such a field cannot exist in empty space. Find the total charge within a cube of side $a = 0.5\,m$ centered on the origin, with its six faces possessing normals in the six cardinal directions $\pm\mathbf{i}, \pm\mathbf{j}, \pm\mathbf{k}$.

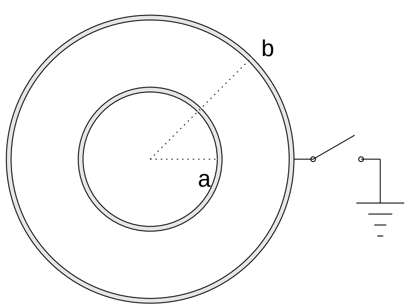


Problem 2a. (2+2+2, P-80)

Two semi-infinite conducting planes meet along the z-axis. The right plane is grounded and the left is maintained at voltage V_0 by a battery. The voltage function is $V(x, y) = \frac{V_0}{\pi}\tan^{-1}(\frac{y}{x})$. Find $\mathbf{E}$ at $(a, 0, a)$. This point is on a $V = 0$ equipotential. Find the charge density σ at that point.

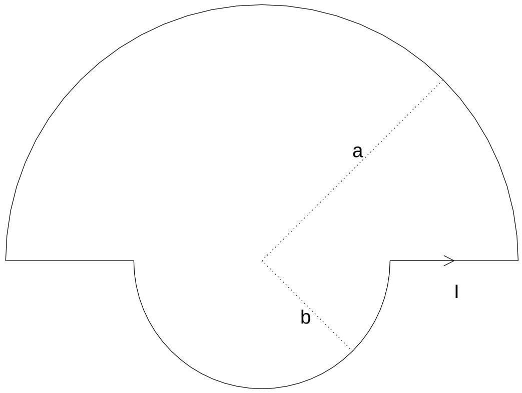
Problem 2b. (4, E-116)

A vector potential for a time-varying magnetic field is $\mathbf{A} = (4.0\frac{T}{s})\, t\, (-y\mathbf{i} + x\mathbf{j})$. **Find** both $\mathbf{B}$ and $\mathbf{E}$.



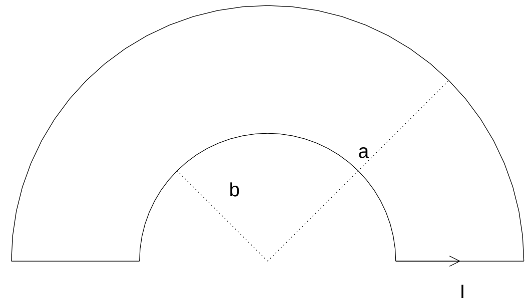
Problem 2c. (4+4, P-102)

Compute the capacitance for a coaxial cylindrical capacitor, with inner cylinder radius $a = 1.0\,cm$ and outer cylinder radius $b = 2.0\,cm$ of length $\ell = 1.0\,m$. A cross-section would look like the figure to the left. **Compute the charge** that would be pushed onto the inner conductor if a battery $V_0 = 100\,V$ were connected to it while the outer conductor is grounded.



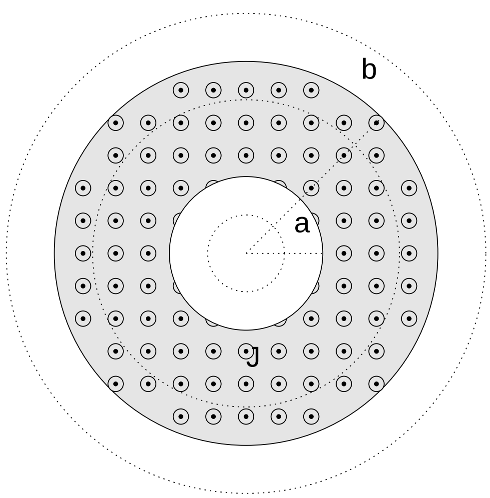
Problem 3a. (4, P-160)

Use the Biot-Savart law to find the magnetic field at the center of the loop shown.



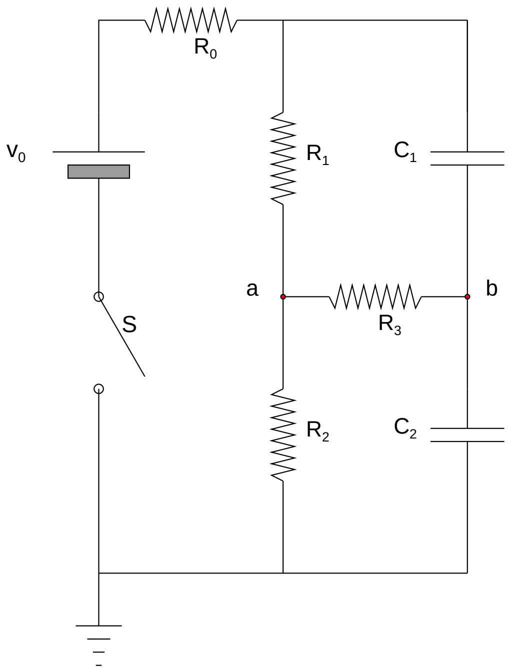
Problem 3b. (4, P-161)

Use the Biot-Savart law to find the magnetic field at the center of the loop shown.



Problem 3c. (4+4, P-181)

The left figure shows a long conducting hollow tube carrying a uniform current I out of the page, distributed evenly over the cross sectional conducting area $\pi(b^2 - a^2)$. **Determine from Ampere's law** $|\mathbf{B}(\mathbf{r})|$ for $a < r < b$, **and** $r > b$. I have drawn suitable Amperian loops. **draw a magnetic field vector on each loop that you use**.

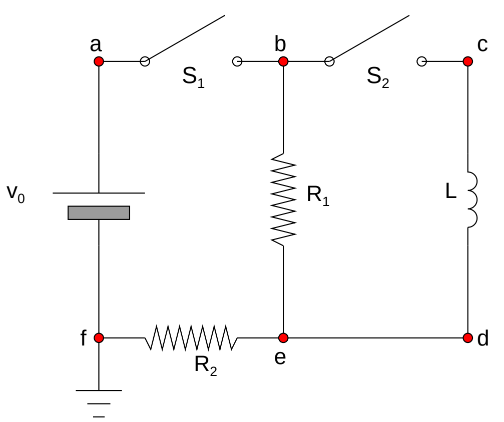


Problem 4 (4+4, p-133)

$V_0 = 100V$, $R_0 = 100\Omega$, $R_1 = 200\Omega$, $R_2 = 300\Omega$, $R_3 = 400\Omega$, $C_1 = 1 \times 10^{-8}F$, $C_2 = 2 \times 10^{-8}F$.

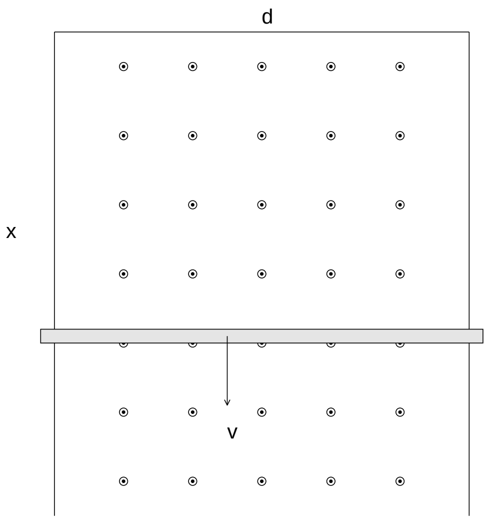
a. Instantly after closing the switch S at $t = 0$, find the currents through the resistors I_0, I_1, I_3, I_2 **(all down or to the right)** and the charges on the capacitors q_1, q_2 **(top plates positive)**.

b. Very long after closing the switch S at $t = 0$, the currents will have reached steady (constant) values, as will the charges on the capacitors. Find these steady values.



c. (2+2).The electric starter. An inductor can be used to generate a huge voltage with only a modest battery, such as the large voltage needed to start up a car engine. Let $V_0 = 10.0\,V$, $R_2 = 1000\,\Omega$, $L = 0.75\,H$ and $R_1 = 1.0 \times 10^6\,\Omega$. Suppose that S_1 and S_2 have been closed for a long time, **find the currents through R_1, and R_2.**

d. (4) Set the clock to $t = 0$ and open S_1. Find the currents through R_1, L and R_2 and the voltage drop $V_e - V_b$. This voltage would be applied to the electric starter to turn over the engine.

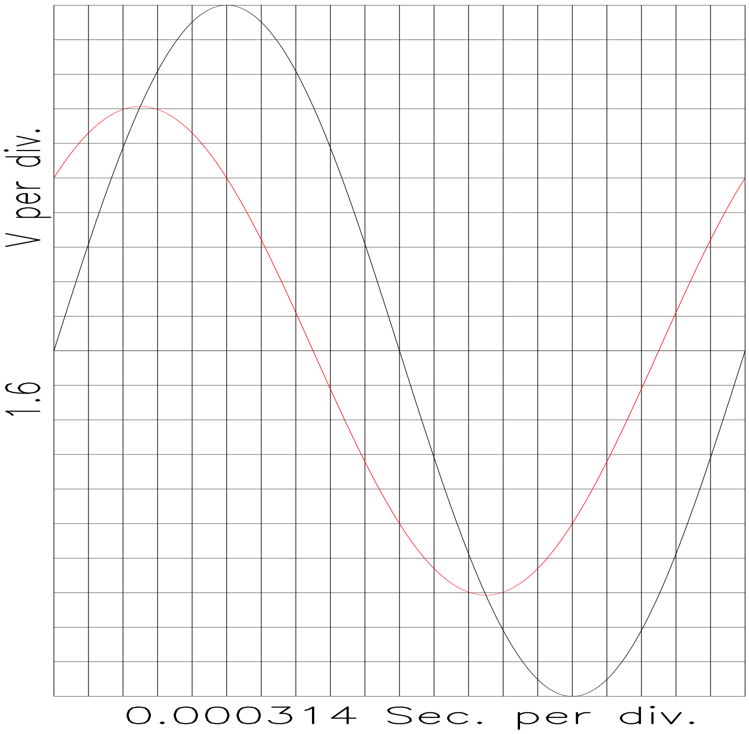


Problem 5a . (2+4+4, P-194)

A sliding rod is forced to move at speed $v = 5.0\frac{m}{s}$ along wire tracks a distance $d = 1.0m$ apart, threaded by a magnetic field **B** normal to the paper, of strength $0.08T$. The rod has resistance $R = 100\Omega$. **Determine the direction of the induced current through the bar, the force required to move the rod at constant speed, and the power expended to do so**.

Problem 5b. (2+4+4, P-194)

Suppose that instead of moving the bar, we let the magnetic field increase in strength according to $|\mathbf{B}| = 0.01T\ \cos(100\pi\frac{rad}{s}t)$. **Determine the induced current through the bar (including direction) and force required to hold the bar in place at position** $x = 1.0\,m$ at $t = \frac{1}{200}s$.



Problem 6. (16, P-218)

Here is a much more realistic scenario; illustrated is a dual-input oscilloscope trace of a generator (full scale) and the voltage across a resistor in an AC-RC circuit. If $C = 5.0 \times 10^{-5} F$, find Find $\mathcal{E}_0$, R, ϕ, Z, ω.