Complex

a) $Z = 3 - j4$, find e^z in complex $a + jb$ form

b) write $v(t) = 12 \sin(\omega t + \theta_0)$ as a phasor

a)

$$e^z = e^3 e^{-j4} = e^3(\cos 4 - j \sin 4)$$

$$e^3 = 20.09 \qquad 4 \text{ rad} = 229.18^\circ$$

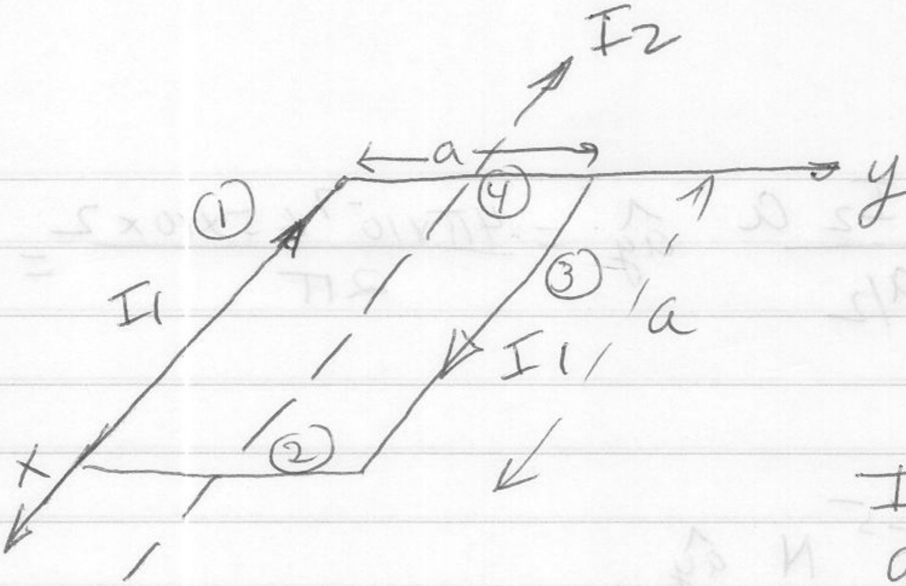
$$e^z = 20.08(\cos 229.18 - j \sin 229.18)$$

$$= -13.13 + j15.20$$

b) $v(t) = 12 \sin(\omega t + \theta_0) = 12 \cos(\pi/2 - (\omega t + \theta_0))$

$$= 12 \cos(\omega t + \theta_0 - \pi/2)$$

$$\tilde{V} = 12 e^{+j(\theta_0 - \pi/2)} = -j12 e^{+j\theta_0}$$



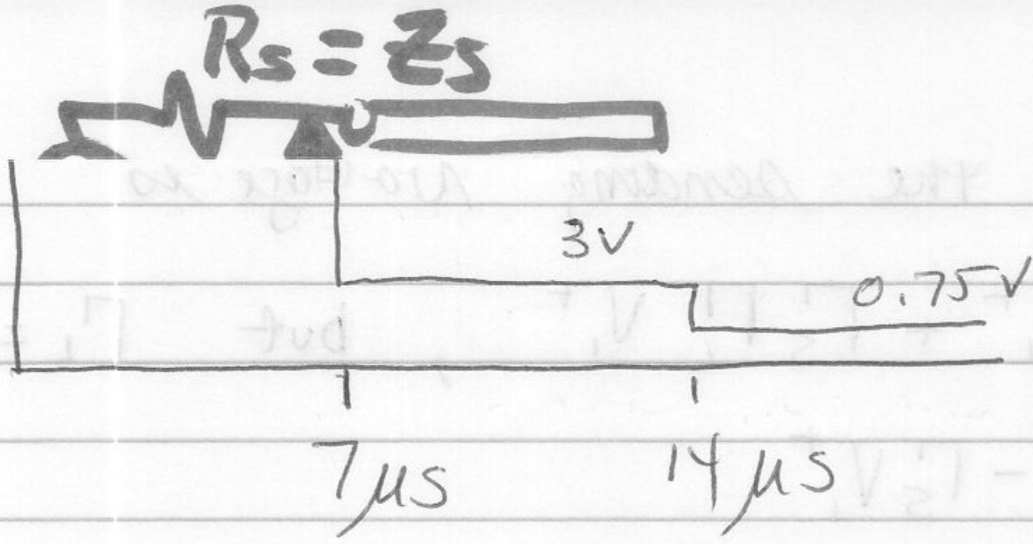
$I_1 = 5A$, $I_2 = 10A$
$a = 2$

a square (2x2) loop has current I_1 just ~~about~~ above it at the midpoints of the sides current $I_2 = 10A$ flows as indicated. Find the force on the loop.

$$F_1 = \frac{\mu_0 I_1 I_2 a}{2\pi\, a/2}\,\hat{a}_y = \frac{4\pi \times 10^{-7} \times 5 \times 10 \times 2}{2\pi} = 2 \times 10^{-5}\,\hat{a}_y$$

$$F_3 = F_1$$

$$F = 4 \times 10^{-5}\ N\ \hat{a}_y$$



Find V_s, Z_s, and ℓ

$$v_p = \frac{c}{\sqrt{\epsilon_r}} = 1.5 \times 10^{8} \ m/s$$

$$\frac{2l}{v_p} = 7 \times 10^{-6} \ \text{sec.} \Rightarrow l = 525 \, m$$

at $7 \mu s$ the sending voltage is

$$V_1^+ + \Gamma_L V_1^+ + \Gamma_S \Gamma_L V_1^+ \ , \quad \text{but} \quad \Gamma_L = -1$$

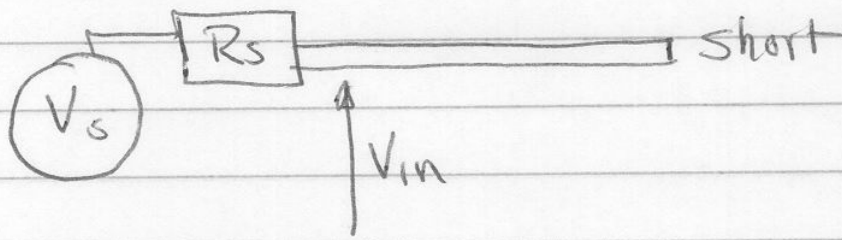
so $V = -\Gamma_S V_1^+$

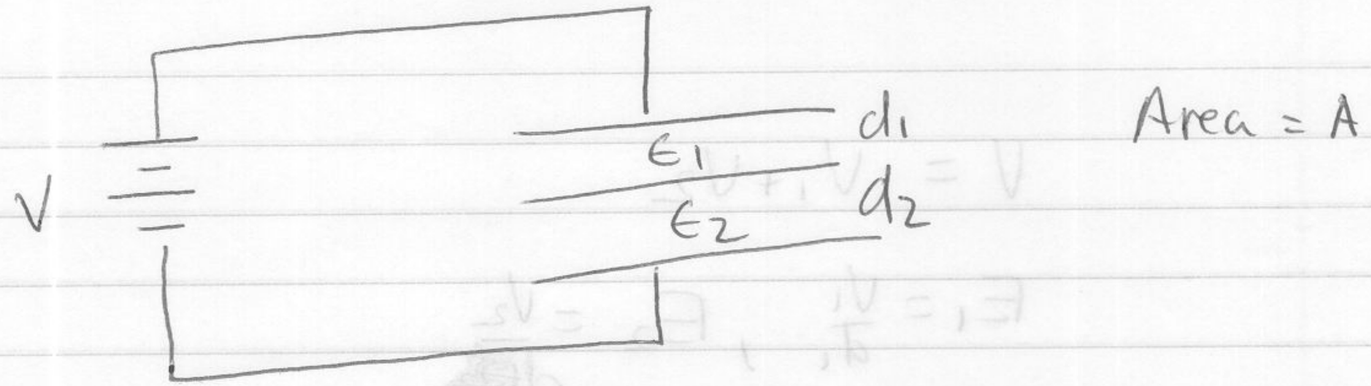
$$\Gamma_S = -0.25$$

$$Z_S = Z_0 \left(\frac{1 + \Gamma_S}{1 - \Gamma_S} \right) = 50 \left(\frac{1 - 0.25}{1 + 0.25} \right) = 30 \Omega$$

$$V_1^+ = \frac{V_S Z_0}{R_S + Z_0} \doteq 12 = \frac{V_S \, 50}{80}$$

$$V_S = 19.2 \ V$$





Find the Electric field in the capacitor(s)

$$V = V_1 + V_2$$

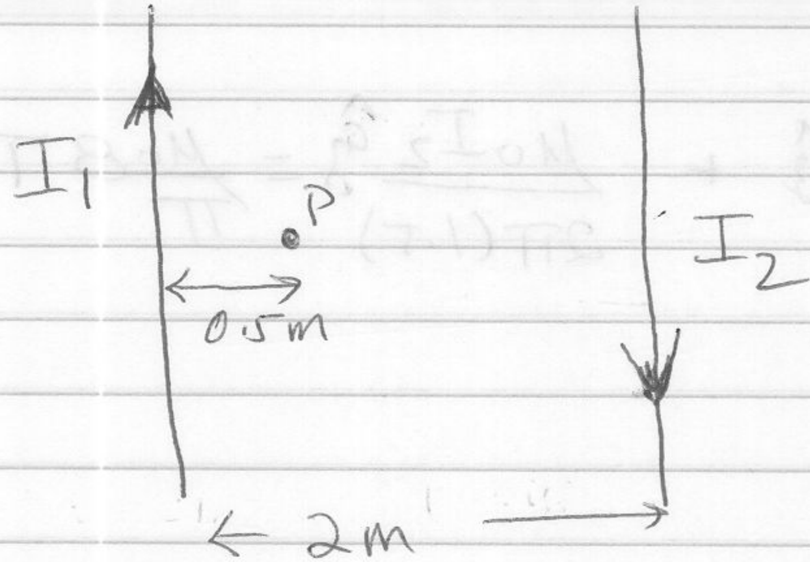
$$E_1 = \frac{V_1}{d_1}, \quad E_2 = \frac{V_2}{d_2}$$

$D_1 = D_2$ (why?)

$$\epsilon_1 E_1 = \epsilon_2 E_2$$

$$V = E_1 d_1 + E_2 d_2 = E_1 d_1 + \frac{\epsilon_1}{\epsilon_2} E_1 d_2$$

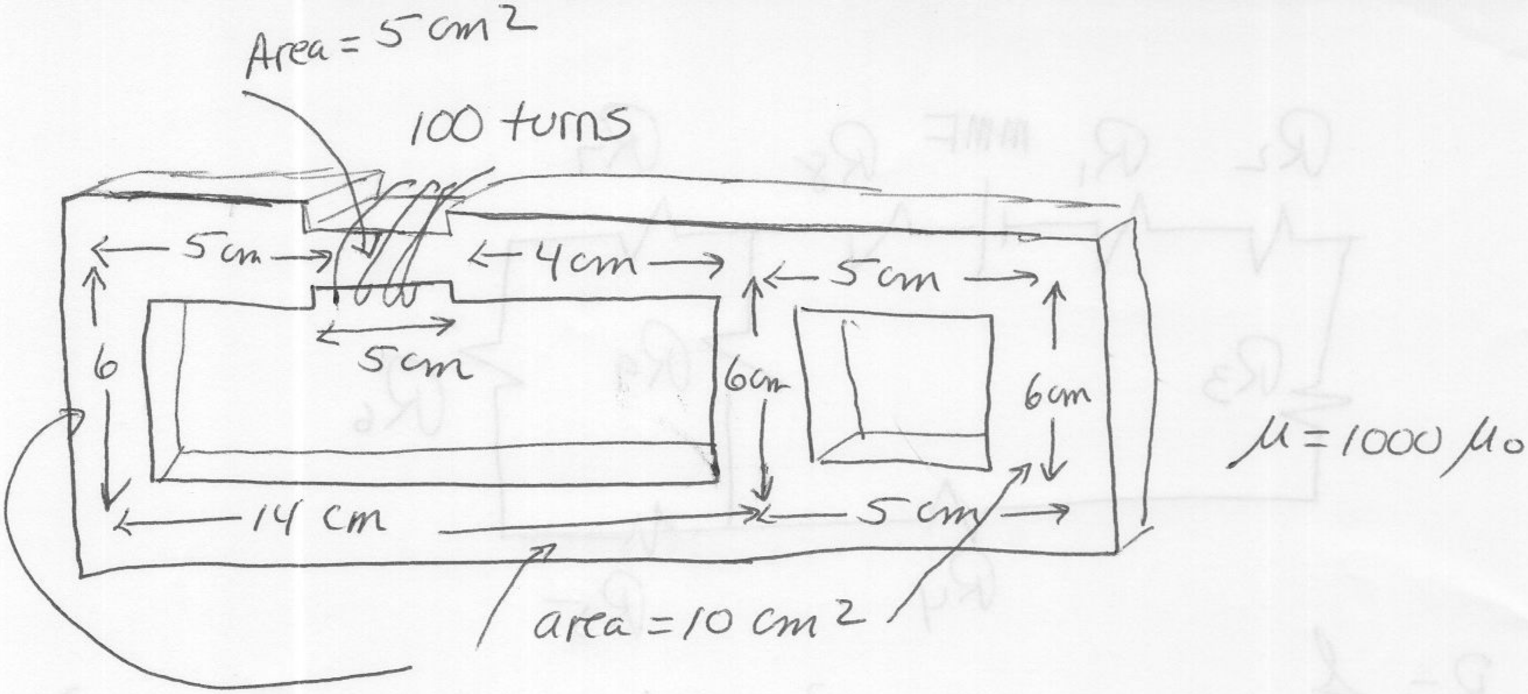
$$E_1 = \frac{V}{d_1 + \frac{\epsilon_1}{\epsilon_2} d_2} \qquad E_2 = \frac{V}{d_2 + \frac{\epsilon_2}{\epsilon_1} d_1}$$



$I_1 = 6$ A
$I_2 = 6$ A

Find B at point P

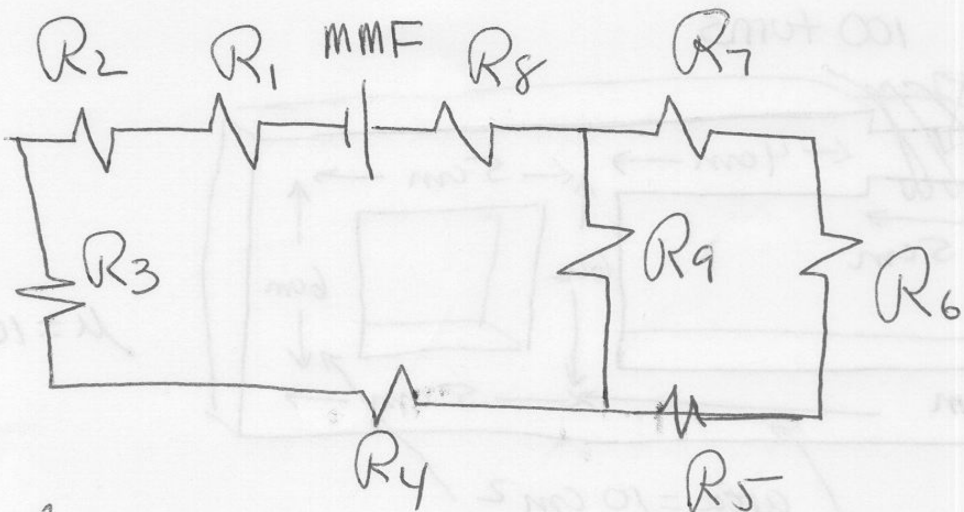
$$B = \frac{\mu_0 I_1}{2\pi(0.5)}\hat{a}_z + \frac{\mu_0 I_2}{2\pi(1.5)}\hat{a}_z = \frac{\mu_0 8}{\pi}\ T$$



a) draw equivalent circuit

b) reduce to single reluctance

c) Find Inductance.



$$R = \frac{l}{\mu A}$$

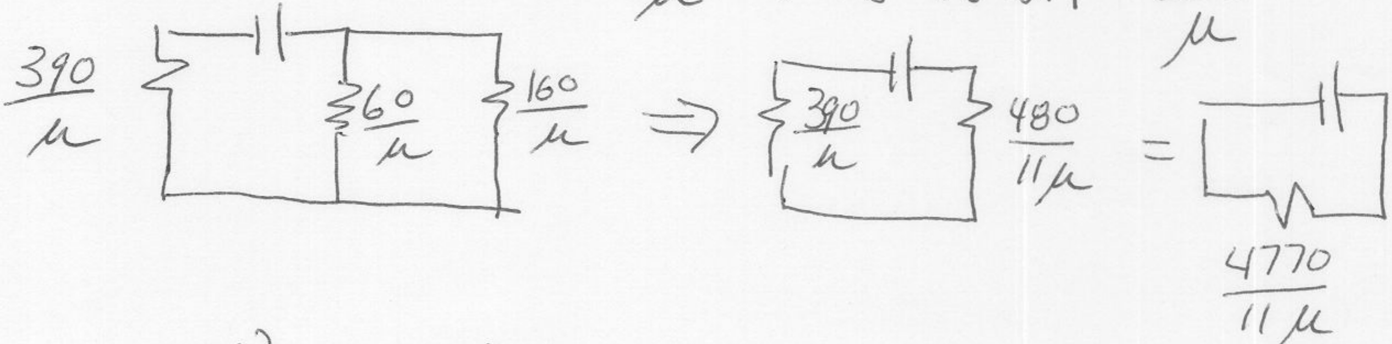
$$R_1 = \frac{5\times10^{-2}}{\mu\, 5\times10^{-4}}, \quad R_2 = R_5 = R_7 = \frac{5\times10^{-2}}{\mu\times10\times10^{-4}}$$

$$R_1 = \frac{100}{\mu} \qquad R_2 = \frac{50}{\mu}$$

$$R_3 = R_6 = R_9 = \frac{6\times10^{-2}}{\mu(10\times10^{-4})} = \frac{60}{\mu}$$

$$R_4 = \frac{14\times10^{-2}}{\mu\times10\times10^{-4}} = \frac{140}{\mu}, \quad R_8 = \frac{4\times10^{-2}}{\mu\times10\times10^{-4}} = \frac{40}{\mu_0}$$

$$R_1 + R_2 + R_3 + R_4 + R_8 = \frac{390}{\mu}, \quad R_5 + R_6 + R_7 = \frac{160}{\mu}$$



$$R = 3.45\times10^5$$

$$L = \frac{N^2}{R} = \frac{100^2}{R} = 28.98\ \text{mH}$$

In which cases should we use transmission line theory. Assume $v_p = c$.

a) $l = 20\ cm$ $f = 10\ KHz$

b) $l = 50\ Km$ $f = 60\ Hz$

c) $l = 20\ cm$ $f = 300\ MHz$

d) $l = 1\ mm$ $f = 100\ GHz$

We want to find l/λ

a) $\frac{l}{\lambda} = \frac{lf}{c} = \frac{20 \times 10^{-2} \times 10 \times 10^{3}}{3 \times 10^{8}} = 6.67 \times 10^{-6}$ (NO)

b) $l/\lambda = 0.01$ maybe

c) $l/\lambda = 0.2$ yes

d) $l/\lambda = 0.33$ yes.

Write the following in the time domain (phasor → time)

$\hat{V} = -3 + j2 \ V$

$\underline{I} = j \ A$

$V = -3 + j2 = 3.61 e^{j146.3^\circ}$

$V(t) = Re\{3.61 e^{j146.3^\circ} e^{j\omega t}\}$

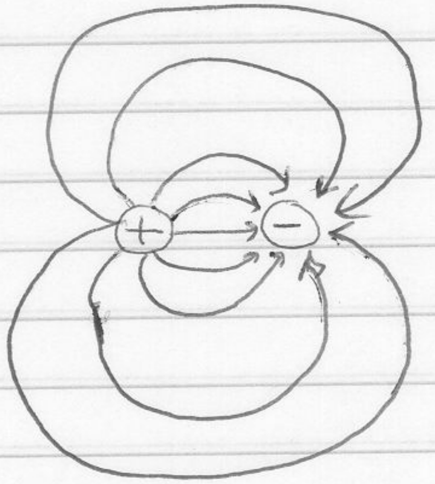
$= 3.61 \cos(\omega t + 146.3^\circ) \ V$

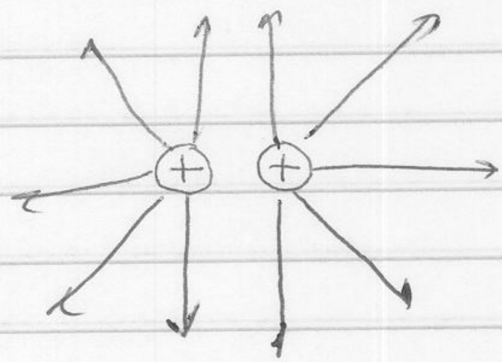
$I = j = e^{j\pi/2}$

$i(t) = Re\{e^{j\pi/2} e^{j\omega t}\} = \cos(\omega t + \pi/2) = -\sin(\omega t)$

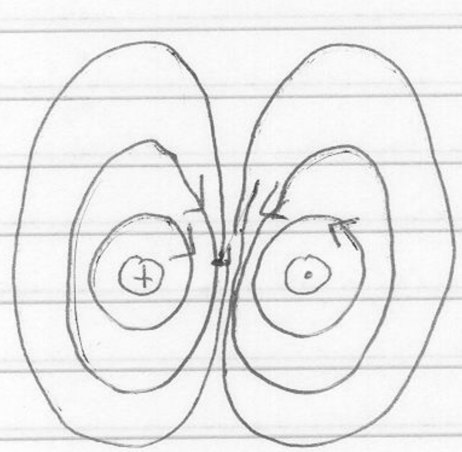
SKETCH THE FLUX LINES

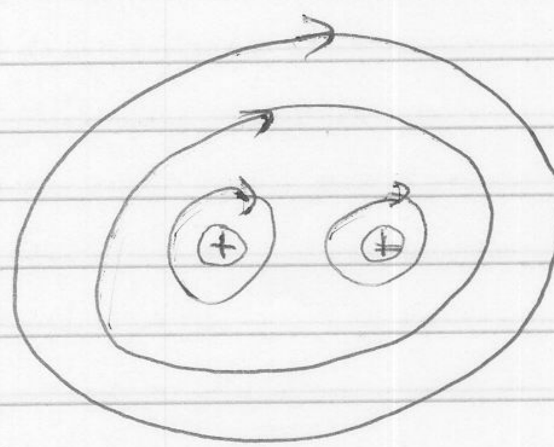
a) Electric all charges are $+q$ or $-q$

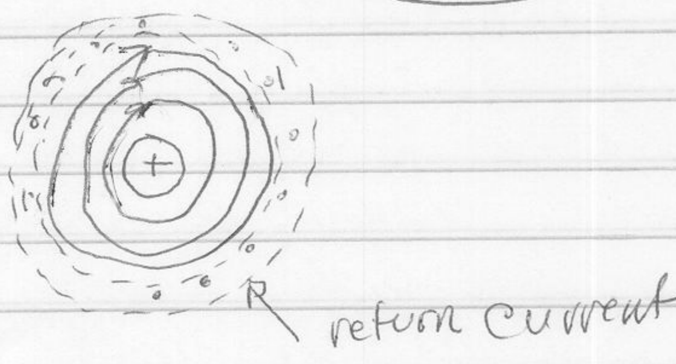


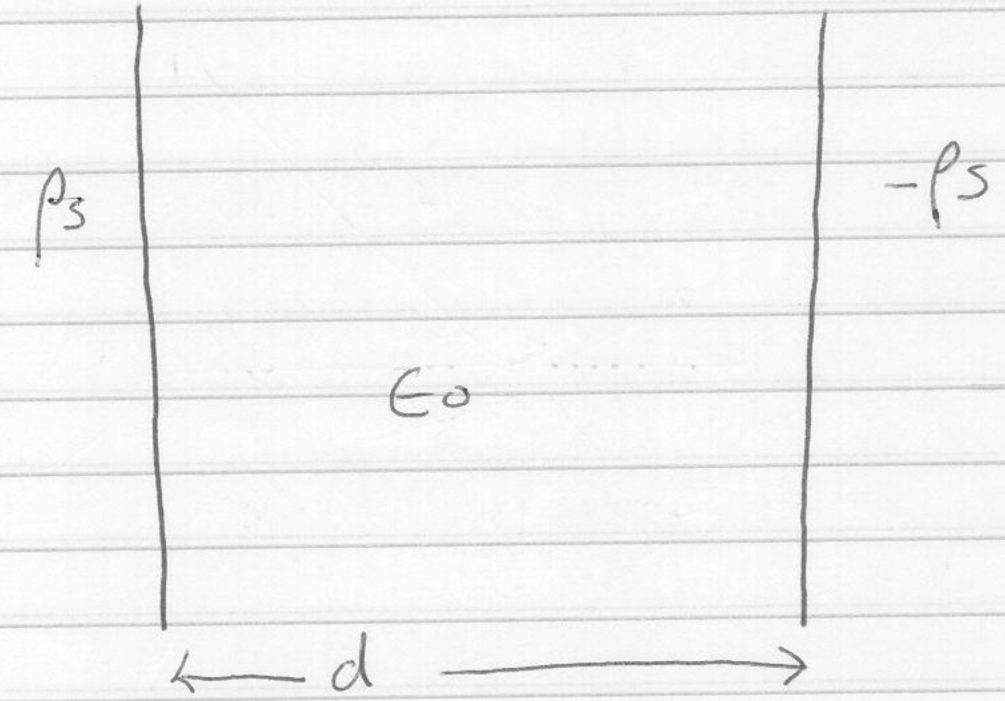


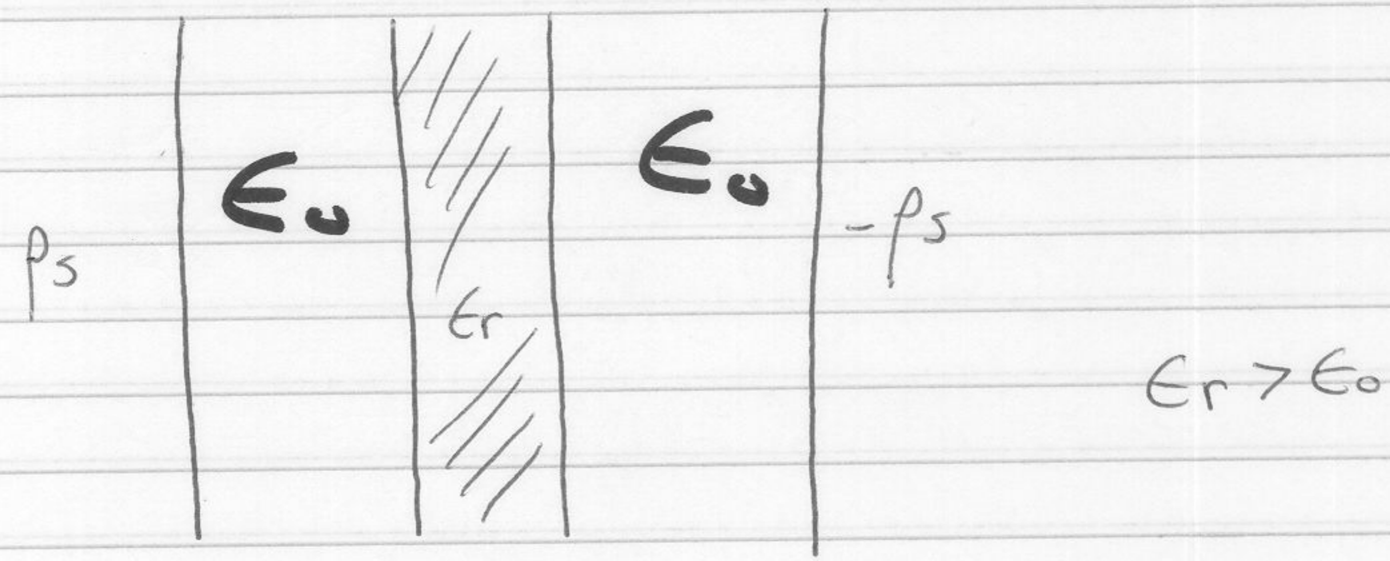
b) Magnetic all currents are I or $-I$





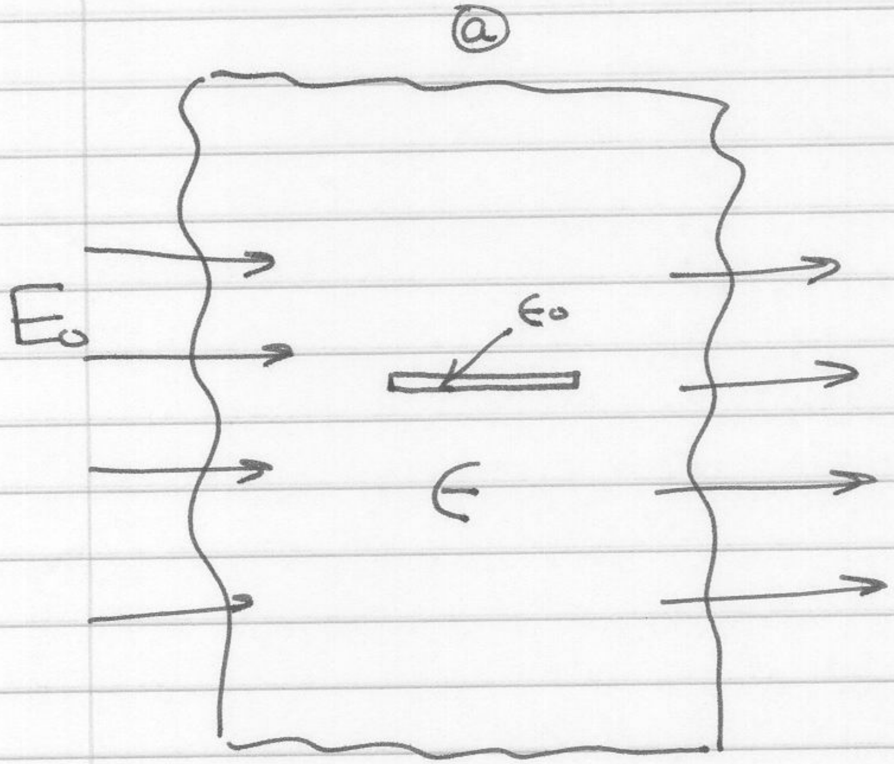


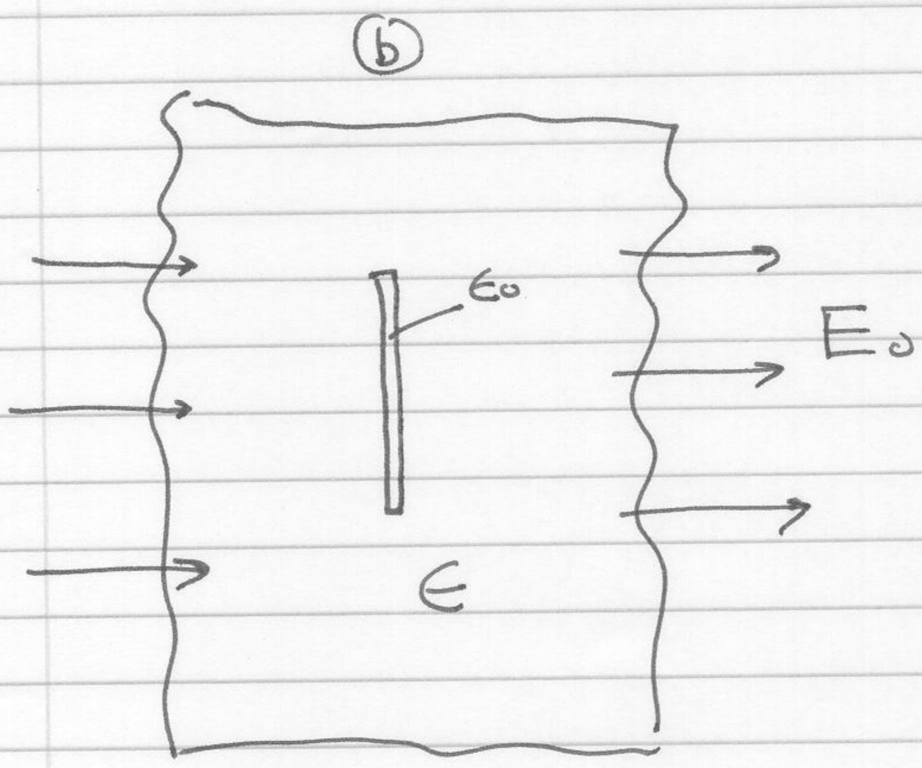


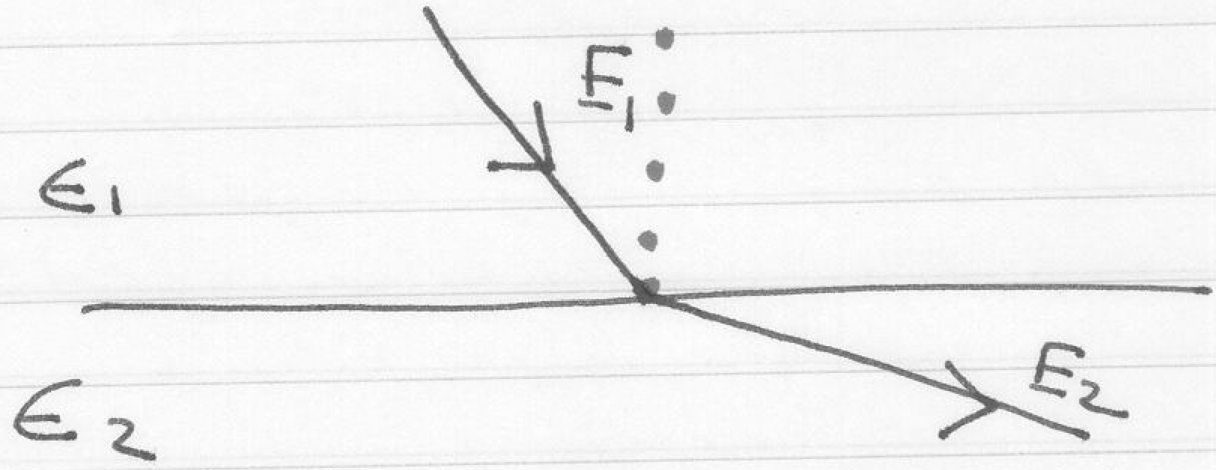


Plot D, E, V for the 2 cases.

a dielectric slab of ϵ has a very thin air cavity. we apply E_0, an electric field. what is the electric field in the cavity for the 2 cases







which is true?

$\epsilon_1 > \epsilon_2$

$\epsilon_1 < \epsilon_2$