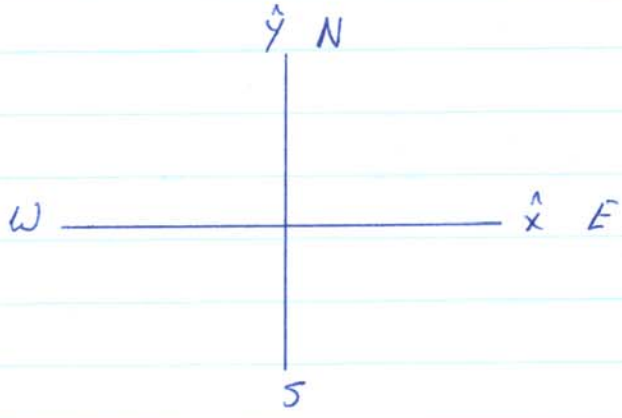
PHYS 2020 Assignment 8

4.1)



Ions.

$n_i = 5 \times 10^{10}\ cm^{-3}$

$q_i = +2 \times 4.8 \times 10^{-10}\ esu$

$\vec{v}_i = 10^7\ cm/sec\ (-\hat{x})$

Electrons

$n_e = 10^{11}\ cm^{-3}$

$q_e = -1 \times 4.8 \times 10^{-10}\ esu$

$\vec{v}_e = 10^8 \left(\frac{\hat{x}}{\sqrt{2}} + \frac{\hat{y}}{\sqrt{2}}\right)\ cm/sec.$

$$\vec{J} = n_i q_i \vec{v}_i + n_e q_e \vec{v}_e$$

$$= 5 \times 10^{10}\ cm^{-3} \times 2 \times 4.8 \times 10^{-10}\ esu \times 10^7\ cm/sec\ (-\hat{x})$$

$$+ 10^{11}\ cm^{-3} \times (-1) \times 4.8 \times 10^{-10}\ esu \times 10^8 \left(\frac{\hat{x}}{\sqrt{2}} + \frac{\hat{y}}{\sqrt{2}}\right) cm/sec$$

$$= -4.8 \times 10^8\ \hat{x} - 3.39 \times 10^9\ \hat{x} - 3.39 \times 10^9\ \hat{y}\quad esu/sec/cm^2$$

$$\vec{J} = -3.87 \times 10^9\ \hat{x} - 3.39 \times 10^9\ \hat{y}\quad esu/sec/cm^2.$$

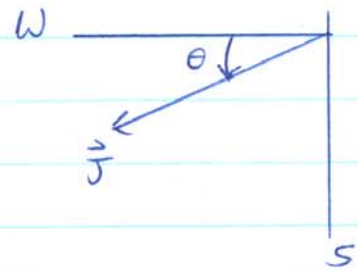
$$|\vec{J}| = 5.14 \times 10^9\ \frac{esu}{sec\ cm^2}$$

$$|\vec{J}| = 5.14 \times 10^9 \frac{esu}{sec\ cm^2} \times \frac{1.6 \times 10^{-19}\ Coul}{4.8 \times 10^{-10}\ esu} \times \frac{10^4}{1}\ \frac{cm^2}{m^2}$$

$$= 1.71 \times 10^4\ \frac{Coul}{sec\ m^2}$$

$\therefore |\vec{J}| = 1.71 \times 10^4$ amp/meter^2

$$\tan\theta = \frac{J_y}{J_x}$$



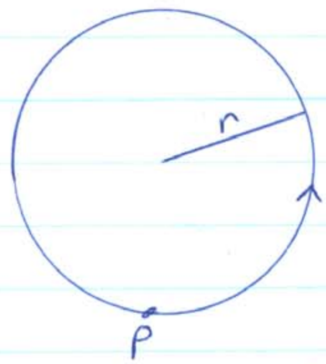
$$= \frac{3.39 \times 10^9}{3.87 \times 10^9}$$

$$= .88$$

$$\theta = 41.2°.$$

$\therefore \vec{J}$ points 41.2° south of west.

4.2)



$2\pi r = 240$ meters

$n = 10^{11}$ electrons

In 1 sec, electron travels $c = 3 \times 10^{10}$ cm.

revolutions made by electron in 1 sec $= \frac{c}{2\pi r}$

Current passing P = Amount of charge passing point P in 1 sec

= # electrons × electron charge × # revs. of elect. in 1 sec

$= n \times q_e \times \frac{c}{2\pi r}$

$= 10^{11} \times 4.8 \times 10^{-10}$ esu $\times \frac{3 \times 10^{10} \text{ cm}}{240 \times 100 \text{ cm sec}}$

$= 6 \times 10^{7}$ esu/sec

= .020 amp.

4.4 a) Cable = 7 Cu Wires

Wire: diameter = .73 mm

length = 3000 km. = 3×10^8 cm.

$\rho_{Cu} = 3 \times 10^{-6}$ ohm cm

Cross sectional area of wire = $\pi \left(\frac{.073}{2} \right)^2$

$= 4.19 \times 10^{-3}$ cm^2

Resistance of 1 wire $R = \frac{\rho L}{A}$

$$= \frac{3 \times 10^{-6} \text{ ohm cm} \times 3 \times 10^{8} \text{ cm}}{4.19 \times 10^{-3} \text{ cm}^2}$$

$= 2.15 \times 10^5$ ohm.

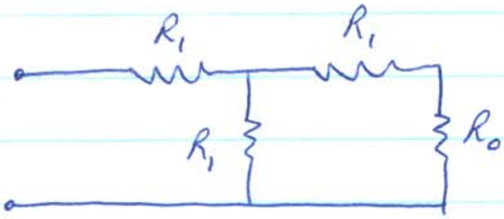
∴ Resistance of Cable = resistance of 7 wires in parallel

$$= \frac{R}{7}$$

$$= \frac{2.15 \times 10^5}{7}$$

$= 3.07 \times 10^4$ ohms.

4.16)



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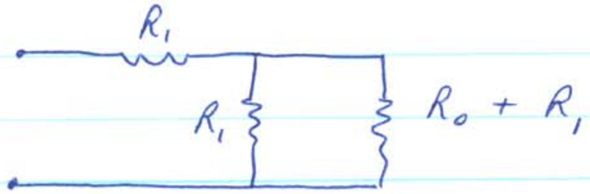

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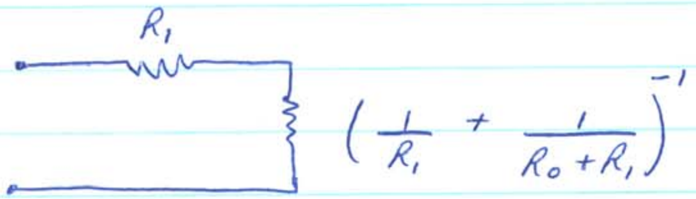

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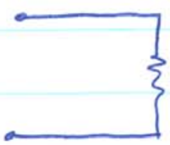


$$R_1 + \left(\frac{1}{R_1} + \frac{1}{R_0+R_1}\right)^{-1} = R_0$$

$$\left(\frac{1}{R_1} + \frac{1}{R_0+R_1}\right)^{-1} = R_0 - R_1$$

$$\frac{1}{R_1} + \frac{1}{R_0+R_1} = \frac{1}{R_0-R_1}$$

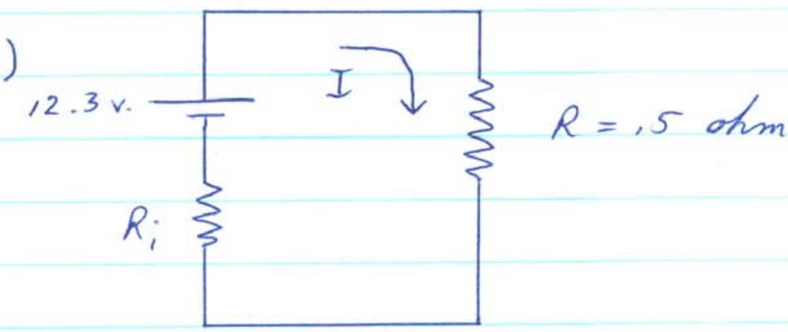
$$(R_0-R_1)(R_0+R_1) + R_1(R_0-R_1) = R_1(R_0+R_1)$$

$$R_0^2 - R_1^2 + R_1R_0 - R_1^2 = R_1R_0 + R_1^2$$

$$R_0^2 = 3R_1^2$$

$$\therefore R_1 = \frac{R_0}{\sqrt{3}}.$$

4.17)



Voltage across R is 9.8 volts.

Current $I = \frac{9.8 \text{ volts}}{R} = \frac{9.8 \text{ volt}}{.5 \text{ ohm}} = 19.6 \text{ amp.}$

Voltage drop across $R + R_i$ is:

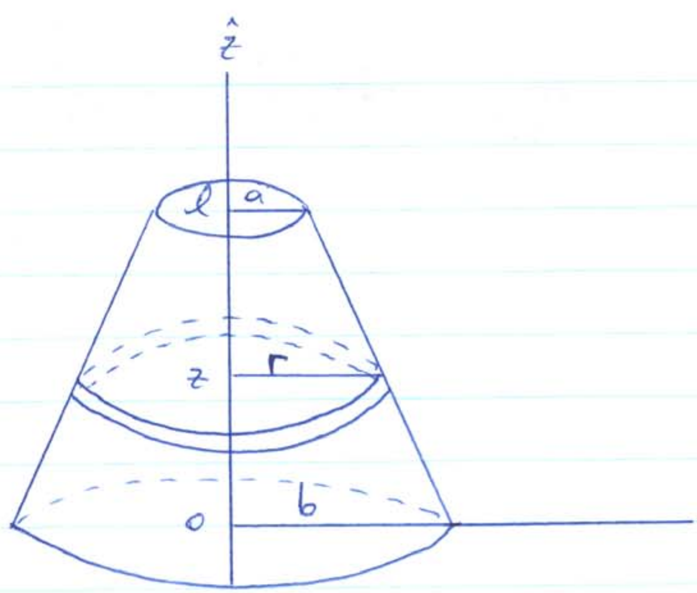
$$12.3 \text{ volts} = I(R + R_i)$$

$$R_i = \frac{12.3}{I} - R$$

$$= \frac{12.3 \text{ volt}}{19.6 \text{ amp}} - .5 \text{ ohm}$$

$\therefore$ R_i = .13 ohm is internal battery resistance.

4.26)



Divide cylinder into infinitesimally narrow disks.

Consider a disk at height z having length dz.

Radius of disk at z is $r(z) = b + \frac{(a-b)z}{l}$

Area of disk is πr^2

Resistance of disk is $dR = \frac{\rho\, dz}{\pi r^2}$

Resistance of cone = Resistance of all disks in series

$$R = \int_0^l dR$$

$$= \int_0^l \frac{\rho\, dz}{\pi \left[b + \frac{(a-b)}{l} z \right]^2}$$

$$= \frac{\rho}{\pi} \; (-1) \frac{l}{a-b} \left[b + \frac{(a-b)z}{l} \right]_0^{-1 \; l}$$

$$R = \frac{\rho}{\pi} \frac{-l}{a-b} \left[\frac{1}{a} - \frac{1}{b} \right]$$

$$= \frac{\rho}{\pi} \frac{l}{b-a} \frac{b-a}{ab}$$

$$= \frac{\rho l}{\pi a b}$$

$$= \frac{a}{b} \frac{\rho l}{\pi a^2}$$

$\therefore R = \frac{a}{b}$ R (cylinder of radius a & length l)