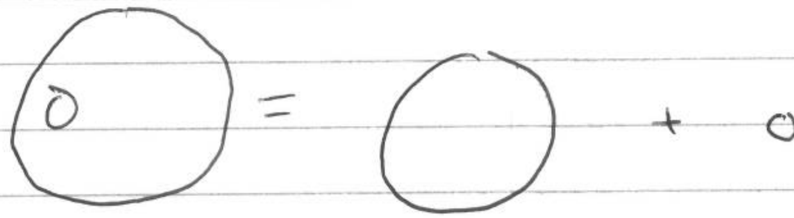
#1. USE SUPERPOSITION. NET CURRENT EQUALS VECTOR SUM OF CURRENTS. VOID CAN BE THOUGHT OF AS BEING PRODUCED BY THE SUPERIMPOSING OF TWO CURRENT DENSITIES OF EQUAL MAGNITUDE BUT OPPOSITE DIRECTIONS.



FORCE OF BIG WIRE ON LITTLE ONE.

$$f = \frac{\mu_0 I_1 I_2}{2\pi d} \quad w/ \quad I_1 = J\pi R^2, \quad I_2 = I, \quad d = D$$

REPULSIVE

$f =$ FORCE/UNIT LENGTH

DUE TO CURRENT IN VOID:

$$f = -\frac{\mu_0 J\pi b^2 I}{2\pi (D+A)}$$

$$\boxed{f = \frac{\mu_0 J R^2 I}{2D} - \frac{\mu_0 J b^2 I}{2(D+A)}}$$

$f =$ REPULSIVE

#2. $\nabla \times \mathbf{B} = \mu_0 \mathbf{J}$

$\oint \mathbf{B}\cdot d\mathbf{l} = \mu_0 I_{enc}$ (INSIDE & OUTSIDE THE WIRE).

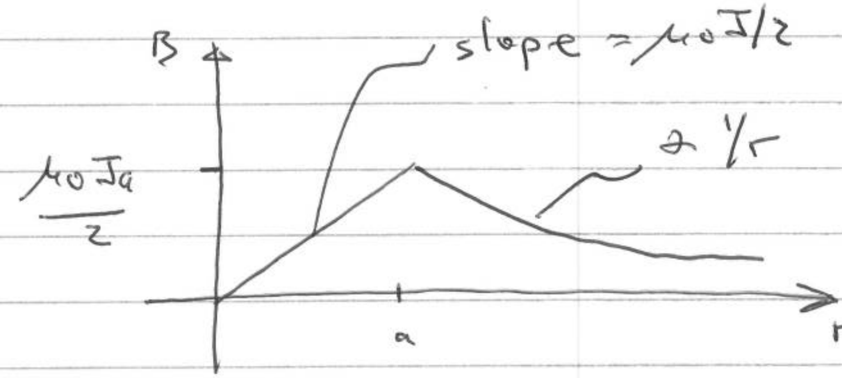
$B \cdot 2\pi r = \mu_0 \pi r^2 J \qquad r \le d.$

$$\boxed{B = \frac{\mu_0 J}{2} r \qquad r \le d}$$

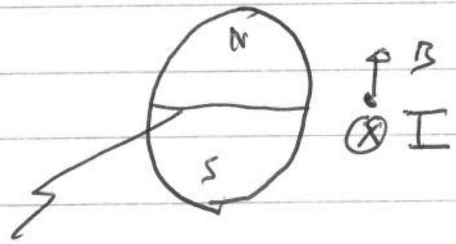
$r > d$

$B\, 2\pi r = \mu_0 J \pi a^2$

$$\boxed{B = \frac{\mu_0 a^2 J}{2r} \qquad r > d}$$



#3



EQUATOR

$F_B = F_G$ FLOATING

$$F_B = I l B = J \pi a^2 l B$$

$$F_G = mg = \rho \pi a^2 l g$$

$$F_B = F_G \Rightarrow J = \rho g / B = 8.7 \times 10^8 \ A/m^2$$

MUST USE MKSA UNITS!

INDEPENDENT OF a

TAKE WIRE DIAMETER = 1 mm

CORRESPONDS TO $I = 6.8 \times 10^2$ Amps.

POWER DISSIPATED IN 1 m OF WIRE

$$P = I^2 R = I^2 \rho L/A$$

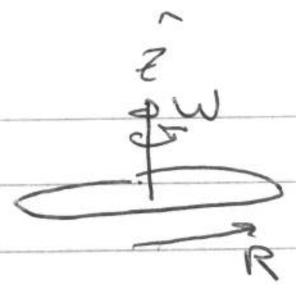
ρ: resistivity of Cu.

$$P = (JA)^2 \rho L/A = J^2 A \rho L$$

$\boxed{P(1m) = 10 kW}$ TRÈS HOT

WIRE WILL MELT

#4.



$\underset{\sim}{m} = \int I \, d\underset{\sim}{S}$

I IS FUNCTION OF r

$I = dQ/dt$

$dQ = \sigma \, dr \cdot \omega r \, dt$ CHARGE CONTAINED IN ANNULUS WEDGE OF WIDTH dr & AZIMUTHAL LENGTH $\omega r \, dt$

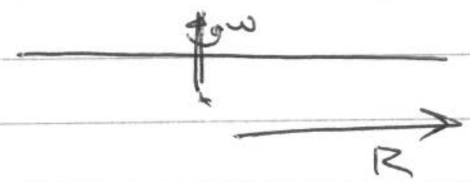
$\Rightarrow I = \sigma \omega r \, dr$ IN ANNULUS OF WIDTH dr

$$\underset{\sim}{m} = \int I \, d\underset{\sim}{S} = \int_0^R \sigma \omega r \pi r^2 \, dr \, \hat{z}$$

$$\boxed{\underset{\sim}{m} = \frac{\sigma \omega \pi R^4}{4} \hat{z}}$$

#5

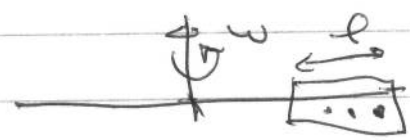
THIN DISK. CONSIDER IT AS A KIND OF INFINITE CURRENT SHEET. CURRENT FLOWS AZIMUTHALLY, GREATEST CURRENT DENSITY K AT DISK EDGES.



CURRENT IS IN PLANE OF DISK, BUT RUNS AZIMUTHALLY. FROM PROBLEM #4,

$$K = dI/dr = \sigma \omega r$$

DRAW AMPERIAN LOOP NEAR DISK EDGE, WHERE SURFACE CURRENT IS LARGEST.



$$\oint \underset{\sim}{B} \cdot d\underset{\sim}{\ell} = \mu_0 I_{enc}$$

$$2B\ell = \mu_0 K \ell$$

$$B = \frac{\mu_0 \sigma \omega r}{2}$$

$$\boxed{\Rightarrow \sigma = \frac{2B}{\mu_0 \omega R}} \quad \boxed{= 2.1\ C/m^2 = 1.3 \times 10^{19}\ e^-/m^2}$$

#5 (b)

FROM PROBLEM #4, CURRENT ΔI IN ANNULUS OF WIDTH Δr IS

$$\Delta I = \sigma \omega r dr$$

$$I = \int_{r=0}^{R} \sigma \omega r dr$$

$$\boxed{I = \sigma \omega R^2/2}$$

$$I \simeq \frac{2 \times 3 \times 10^{-2} \times 10^{14}}{2} \text{ A}$$

$$\boxed{I \simeq 3 \times 10^{12} \text{ Amps}}$$

#5 (c) THINK OF NET CHARGE. PLENTY OF PROTONS AROUND. DISK CAN BE NEUTRAL IN A SENSE: e^-'s MOVING BUT MIXED IN W/ STATIONARY PROTONS.