1. \[ R_{11} \text{ is parallel equivalent resistance for } R_2 + R_3 \]
\[ \frac{1}{R_{11}} = \frac{1}{R_2} + \frac{1}{R_3} = \frac{R_2 + R_3}{R_2 R_3} \]
\[ R_{11} = \frac{R_2 R_3}{R_2 + R_3} \]
\[ V_{eq} = R_{11} + R_4 = \frac{R_2 R_3}{R_2 + R_3} + R_4 \]

b) Current at node a: \[ I_1 = I_4 + I_5 \]

Loop 1: \[ E_1 + V_2 - I_4 V_{eq} - I_1 R_1 = 0 \]
Loop 2: \[ -E_2 + V_3 - I_5 R_5 + I_4 V_{eq} = 0 \]
Loop 3: \[ E_1 + V_3 - I_5 R_5 - I_1 R_1 = 0 \]

Any 3 of the above 4 equations is acceptable.

c) If \( I_4 \) is known, \( V_{eq} = \) voltage across \( R_{eq} = I_4 R_{eq} \)
\[ V_4 = \text{voltage across } R_4 = I_4 R_4 \]
Let \( V_2 = \text{voltage across } R_2 \)
Let \( V_3 = \text{voltage across } R_3 \)
Since \( R_2 \) is in parallel with \( R_3 \), \[ V_2 = V_3 = V_{eq} - V_4 \]
\[ I_2 = \frac{V_2}{R_2} = \frac{V_{eq} - V_4}{R_2} = \frac{I_4 (R_{eq} - R_4)}{R_2} \]
\[ I_3 = \frac{V_3}{R_3} = \frac{V_{eq} - V_4}{R_3} = \frac{I_4 (R_{eq} - R_4)}{R_3} \]
2. \( \vec{F} = q \frac{\vec{V} \times \vec{B}}{c} \)

\( \vec{B} = 5000 \text{ Gauss} \) \( \vec{F} = (4.8 \times 10^{-10} \text{ cm})(3 \times 10^8 \text{ cm/sec}) \)

\( \vec{F} = \frac{5000 \text{ Gauss}}{3 \times 10^8 \text{ cm/sec}} \)

\( \vec{F} = 1.2 \times 10^{-8} \text{ dyne} \)

\( \vec{V} \times \vec{B} \) is into paper, since \( e^- \) is negative. \( \vec{F} \) points out of paper if \( \vec{V} + \vec{B} \) are as shown. 

Motion is a helix. \( \vec{V} \) along direction of \( \vec{B} \) is unchanged.

Redraw diagram with \( \vec{B} \) out of paper, \( \vec{V} \), out of paper. So helix spirals out of paper counter-clockwise as \( \vec{B} \) points out of paper.

\( m \frac{\Delta \vec{V}}{\Delta t} = B \frac{\vec{q} \times \vec{E}}{c} \)

\( \frac{\Delta \vec{V}}{\Delta t} = \frac{Bq}{mc} \left( \frac{5000 \text{ Gauss}}{7.1 \times 10^{-28} \text{ g}} \right)(3 \times 10^8 \text{ cm/sec}) \)

\( \frac{\Delta \vec{V}}{\Delta t} = 8.7 \times 10^{10} \text{ cm/sec} \)

3. \( F = \frac{2 \pi I J_2 L}{c^2 r} \)

Since \( e = 4.8 \times 10^{-10} \text{ cm} = 1.6 \times 10^{-19} \text{ coul} \), \( I \times 4.8 \times 10^{-10} \text{ cm} \) \( \frac{4.8 \times 10^{-10} \text{ cm}}{1.6 \times 10^{-19} \text{ cm}} = 3 \times 10^9 \text{ cm} \)

\( F = 2 \left( \frac{5A \times 10A \times 3 \times 10^9 \text{ cm}}{3 \times 10^8 \text{ cm/sec}} \right)^2 (200 \text{ cm}) = 100 \text{ dyne} \)

Wire attract if the currents go in the same direction.

Prove this by thinking about \( \vec{B} \) field directions & forces.

By right-hand rule, \( \vec{B} \), at position of wire 2 goes into paper.

\( \vec{F} = I \frac{\vec{V} \times \vec{B}}{c} \) points to left, i.e. force between 2 wires is attractive, with currents in the same direction as shown.

4. \( \frac{dB}{dr} = \frac{I \delta x}{c r^2} \) Suppose the wire extends from \(-a \) to \( a \) along x-axis.

\( \vec{B} = \frac{I}{c} \int_{-a}^{a} \frac{y \hat{z}}{r^2} = \frac{I}{c} \int_{-a}^{a} \frac{y \hat{z}}{r^2} = \frac{I}{c} \left[ \frac{x}{\sqrt{x^2 + y^2}} \right]_{-a}^{a} \)

\( \vec{B} = \frac{I}{c} \left( 2a \right) = \frac{I}{c} (2a) = \frac{2I \hat{z}}{c} \)

From Ampere's law:

\( \int \vec{B} \cdot d\vec{S} = 4\pi I \) \( \Rightarrow \vec{B} (2\pi r) = \frac{4\pi I}{c} \)

\( c \hat{r} \times \vec{B} \) is around wire.

\( \vec{B} = \frac{2I}{c} \hat{r} \) if \( I \) is along +x axis, \( \vec{B} \) is in \( \hat{\phi} \) direction.
5. \[ J = \frac{A r^2}{c} \quad 0 \leq r \leq a \]

Ampere's law, \( \oint_C \mathbf{B} \cdot d\mathbf{s} = \frac{4\pi}{c} \int_S \mathbf{J} \cdot d\mathbf{a} \), where \( C \) is curve bounding surfaces.

\( 0 \leq r \leq a \), take \( C \) to be circle of radius \( r \Rightarrow B(2\pi r) = \frac{4\pi}{c} \int_0^a A r^2 (2\pi r')dr' \)

\[ B(2\pi r) = \frac{8\pi^2 A}{c} \int_0^r r^3 dr' = \frac{8\pi^2 A r^4}{c} \]

\( 0 \leq r \leq a \), 
\[ B = \frac{\pi A r^3}{c} \]

\( r \geq a \), C is circle of radius \( r \), 
\[ B(2\pi r) = \frac{4\pi}{c} \int_0^a A r^2 (2\pi r'dr') \]

\( r \geq a \), 
\[ B = \frac{\pi A a^4}{c} \]

6. \( 100 \text{ V} \) a) Capaetor charged to \( 100 \text{ V} = \frac{1}{2} \text{ statvolt} \)

\[ E_0 = \frac{1}{3} \text{ statvolt} \text{ cm} = \frac{1}{2} \text{ statvolt} \text{ cm} = \frac{4\pi}{c} \text{ statvolt} \text{ cm} = \frac{1}{2} \text{ statvolt} \text{ cm} \]

\[ E' = E_0 - (0.33 \text{ statvolt/cm}) = 4.13 \times 10^{-1} \text{ statvolt/cm} = 0.41 \text{ statvolt/cm} \]

\[ \sigma_0 = \frac{E'}{4\pi} = 3.28 \times 10^{-2} \text{ statau/cm}^2 \]

b) If capacitor plates are parallel to \( xy \) plane, there is no length contraction \( \sqrt{1 - \beta^2} = \sqrt{1 - (0.8)^2} = 1.25 \)

\[ E' = E_0 = 0.33 \text{ statvolt/cm}, \quad \sigma = \sigma_0 = 0.026 \text{ statau/cm}^2 \]

7. \[ E_{\text{max}} \text{ in left occurs when } e^- \text{ is at origin in left frame.} \]

\[ E_{\text{max}} = e \frac{1}{8\gamma^2(1 - \beta^2)^{3/2}} \frac{y}{\sqrt{c^2 - v^2}} \]

\( \beta = 0.8, \gamma = \frac{1}{\sqrt{1 - \beta^2}} = \frac{1}{\sqrt{1 - 0.8^2}} = 1.67 \)

\[ E_{\text{max}} = \left(1.67 \right) \left( 4.8 \times 10^{-10} \text{ cm} \right) = 8.0 \times 10^{-7} \text{ statvolt/cm} \]

\[ \overrightarrow{F}_{\text{max}} = \left( 8.0 \times 10^{-7} \text{ statvolt/cm} \right) \left( 0.01 \text{ cm} \right) = 3.84 \times 10^{-15} \text{ dyna} \]

\[ \overrightarrow{F}_{\text{max}} = \left( 3.84 \times 10^{-15} \text{ dyna} \right) \]

Field lines of traveling \( e^- \), as viewed from left frame, look like whiskeehom (a pancake, according to Pincell).