HW1: a. $W > 0$ since final
$U = -\vec{\mu} \cdot \vec{B}$ higher

b. $2 \to 1 = 2 \to 4 > 2 \to 3 = 0$

HW2: $B_{arc} = \frac{\mu_0 I \Delta\varphi}{4\pi R}$

so $c > a > b$

HW3: $B = \frac{\mu_0 I}{2\pi R}$ into page
$F = q\vec{v} \times \vec{B}$

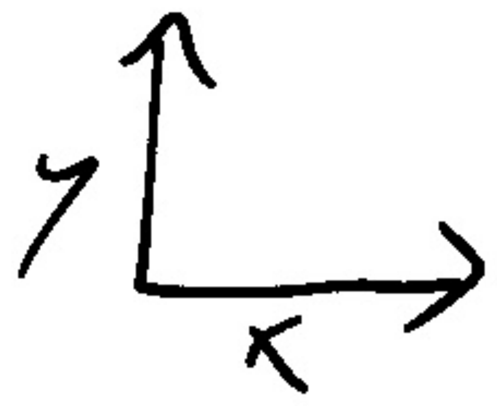
$|\vec{F}_1| > |\vec{F}_3| = |\vec{F}_4| > |\vec{F}_2| = 0$

HW4: $\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{enc}$

a. $+4$
b. $+4 - 9 = -5$
c. $+4 - 9 + 5 = 0$
d $+4 - 9 + 5 - 3 = -3$
$\Rightarrow$ $b > a > d > c$

HW5: a. $F = 0$
b. $F = F_0/L + F_0/2L + F_0/L + F_0/2L = 3F_0$
c. $F = F_0/L - F_0/2L + F_0/L - F_0/2L$
$= F_0/L$
d. $F = F_0/L + F_0/L = 2F_0/L$
$\Rightarrow$ $b > d > c > a$

HW6: Need $I\vec{L}\times\vec{B} - mg\hat{y} = 0$



$\vec{B} = -B\hat{k}$

so want $I\vec{L}\times(-B\hat{k}) = mg\hat{y}$

$\Rightarrow \vec{L} = L\hat{i}$

$ILB = mg$

or $I = mg/BL$ to right

HW7: $\vec{F} = i\vec{L}\times\vec{B}$

$= i\vec{d}\times\vec{B}$

$= -idB$ to left

$= m\,dv/dt$

$dv/dt = idB/m$

$\Rightarrow V = -idB/m \cdot t$

HW8: Equivalent to:

$\vec{\mu}_{ABCD} = i\cdot A_{ABCD}\cdot(-\hat{k})$

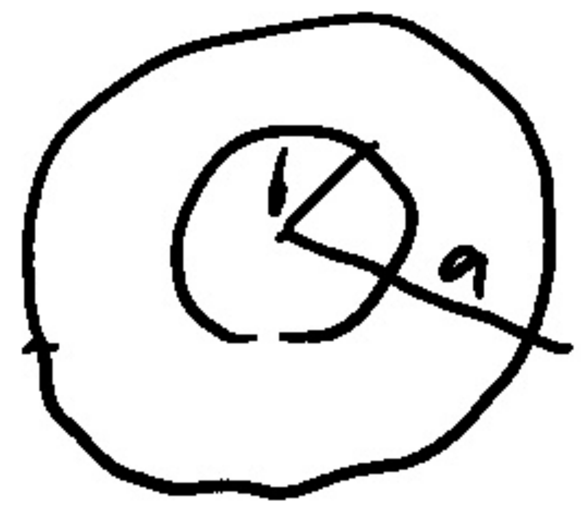
$= -i\cdot 600\hat{k}$ A cm^2

$\vec{\mu}_{ADEF} = i\cdot A_{ADEF}\cdot\hat{j}$

$= i\cdot 240\hat{j}$ A cm^2

$\vec{\mu} = \vec{\mu}_{ABCD}+\vec{\mu}_{ADEF} = i(240\hat{j}-600\hat{k})$ A cm^2

HW9:



$$\oint \vec{B}\cdot d\vec{l} = B\cdot 2\pi r = \mu_0 I_{enc}$$

$$I_{enc} = \oint \vec{J}\cdot d\vec{A} = J\cdot A = J(\pi r^2 - \pi b^2)$$

$$J = i/(\pi a^2 - \pi b^2)$$

a. $$B(r) = \frac{\mu_0 i}{2\pi r}\left(\frac{\pi r^2 - \pi b^2}{\pi a^2 - \pi b^2}\right) \quad b<r<a$$

b. $$B(r) = \mu_0 i/2\pi r \quad @ \quad r = a$$

c. $$B(r) = \frac{\mu_0 i\cdot \pi r^2}{2\pi r\cdot \pi a^2} = \frac{\mu_0 i r}{2\pi a^2}$$

HW10: $$F = \frac{\mu_0 I_1 I_2 L}{2\pi r} = \frac{\mu_0 I^2 L}{2\pi r}$$

$$F_1 = \frac{\mu_0 I^2 L}{2\pi}\left(1/d + 1/2d + 1/3d + 1/4d\right)$$
$$= \frac{\mu_0 I^2 L}{2\pi d}\cdot\frac{25}{12}$$

$$F_2 = \frac{\mu_0 I^2 L}{2\pi}\left(-1/d + 1/d + 1/2d + 1/3d\right)$$
$$= \frac{\mu_0 I^2 L}{2\pi d}\cdot 5/6$$

$$F_3 = 0$$
$$F_4 = F_2$$
$$F_5 = F_1$$

Sample 1: Increase $A \to$ more charge
decrease $d \to$ less voltage
increase $\varepsilon \to$ less voltage

Sample 2: $U = \frac{1}{2} Q^2/C$
w/ $C = \varepsilon_0 A/d$
so $U = \frac{1}{2} Q^2 d/\varepsilon_0 A$

a. $\Delta U = \frac{1}{2} Q^2 dx/\varepsilon_0 A$

b. $F = -dU/dx$
$= -\frac{1}{2} Q^2/\varepsilon_0 A$

c. $E = V/d = Q/Cd = Q/\varepsilon_0 A$
$\Rightarrow F/A = -\frac{1}{2}\varepsilon_0 E^2 = -U_E$

d. $\varepsilon_0 \to \kappa\varepsilon_0 = \varepsilon$

Sample 3: $P = VI = I^2 R = V^2/R$
$R = \rho L/A \Rightarrow P = V^2 A/\rho L$
$\text{Vol} = Z = AL = \text{const.}$
$P = V^2 A/\rho L = V^2 A/\rho Z/A = V^2 A^2/\rho Z$

so $P \propto A^2$
want $P' = 9 P_0$
so want $A' = 3 A_0$ lowers R by $1/9$
$L' = 1/3 A_0$ increases P by 9

Sample 4: $R_1 = \rho L/A$

$R_2 = \rho L/(A/2) = 2\rho L/A$

$I = V_0/R_{tot} = V_0/(3\rho L/A) = V_0 A/(3\rho L)$

same in both

$J = I/A = V_0/(3\rho L)\ ,\ 2V_0/(3\rho L)$

$E = \rho J = V_0/3L\ ,\ 2V_0/3L$

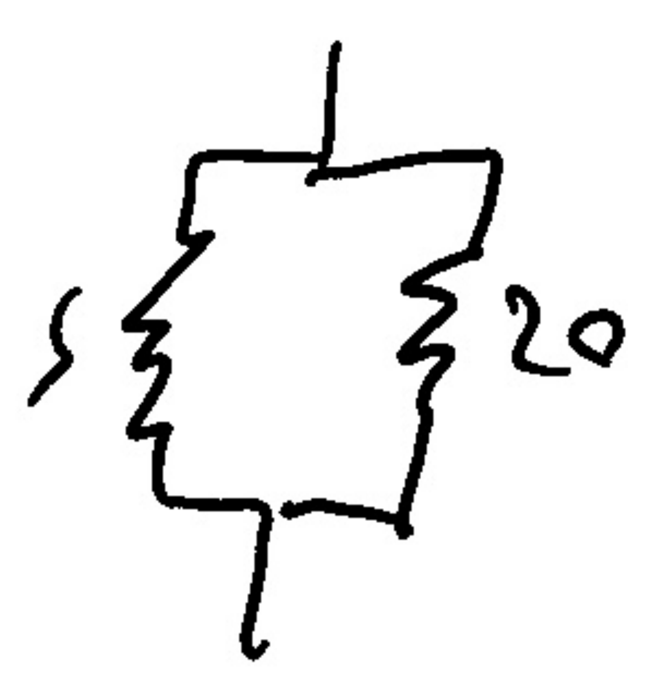
$\Delta V = -\int E\cdot dx = -V_0/3\ ,\ -2V_0/3$

Sample 5: $R_I = R_0/2\ ,\ R_{II} = 2R_0$

$P = V^2/R$

so $P_I = 4P_{II}$

Sample 6:



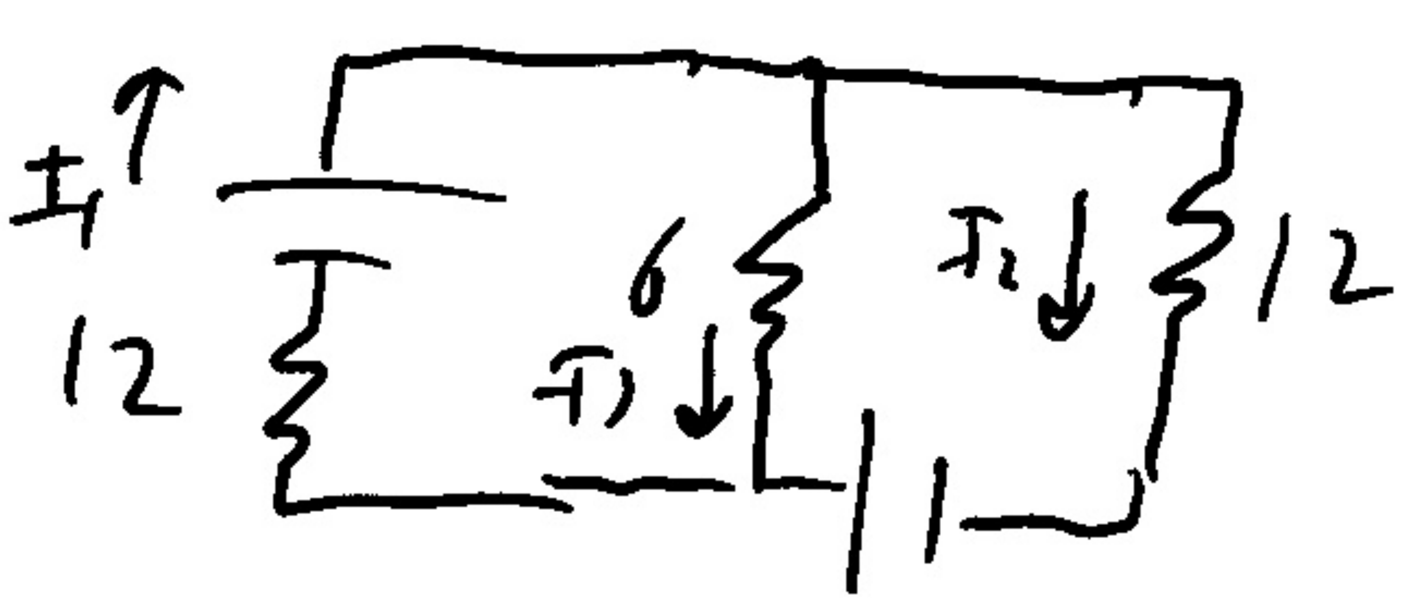
$1/R_{eq} = 1/5 + 1/20$

$\Rightarrow R_{eq} = 4$

$R_{eq} = 8 + 4 = 12$

a. new circuit

b.



c. $9 - 6I_3 - 12I_1 = 0$

$9 + 6I_3 - 12I_2 = 0$

d. $I_1 = I_2 + I_3$

plug $I_1 = I_2 + I_3$
into first

$$9 - 6I_3 - 12(I_2 + I_3) = 0$$

or $9 - 18I_3 - 12I_2 = 0$

subtract $9 + 6I_3 - 12I_2 = 9$

$\Rightarrow -24I_3 = 0$

or $I_3 = 0$

$I_1 = 9/(12K) = 3/(4K)$

$I_2 = I_1 = 3/(4K)$

Sample 7: initially

$R_{eq} = R_0 + R_0/2 = 3R_0/2$

$I = V/R_{eq} = 2V/3R_0$

$P_{10} = I^2R = (2V/3R_0)^2 \cdot R_0 = 4/9\, V^2/R_0$

$P_{20} = \left(\frac{I}{2}\right)^2 R = (V/3R_0)^2 \cdot R_0 = 1/9\, V^2/R_0$

after $R_3 \to \infty$

$R_{eq} = 2R_0$

$I = V/2R_0$

$P_{11} = P_{21} = 1/4\, V^2/R_0$

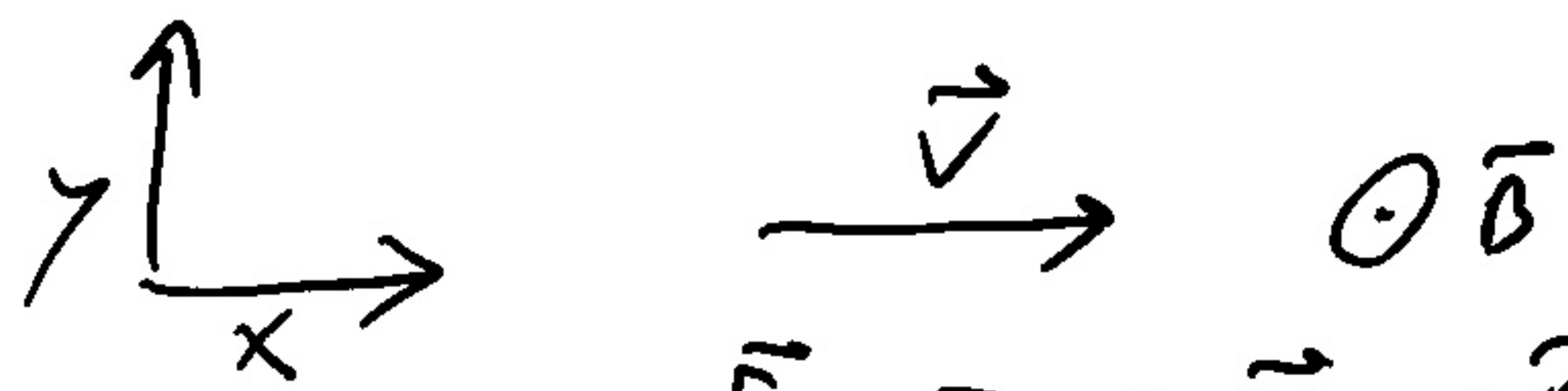
so P_1 goes from $4/9$ to $1/4$ $V^2/2R_0$

P_2 goes from $1/9$ to $1/4$ $V^2/2R_0$

$P_{11}/P_{10} = 9/16$

$P_{21}/P_{20} = 9/4$

Sample 8:



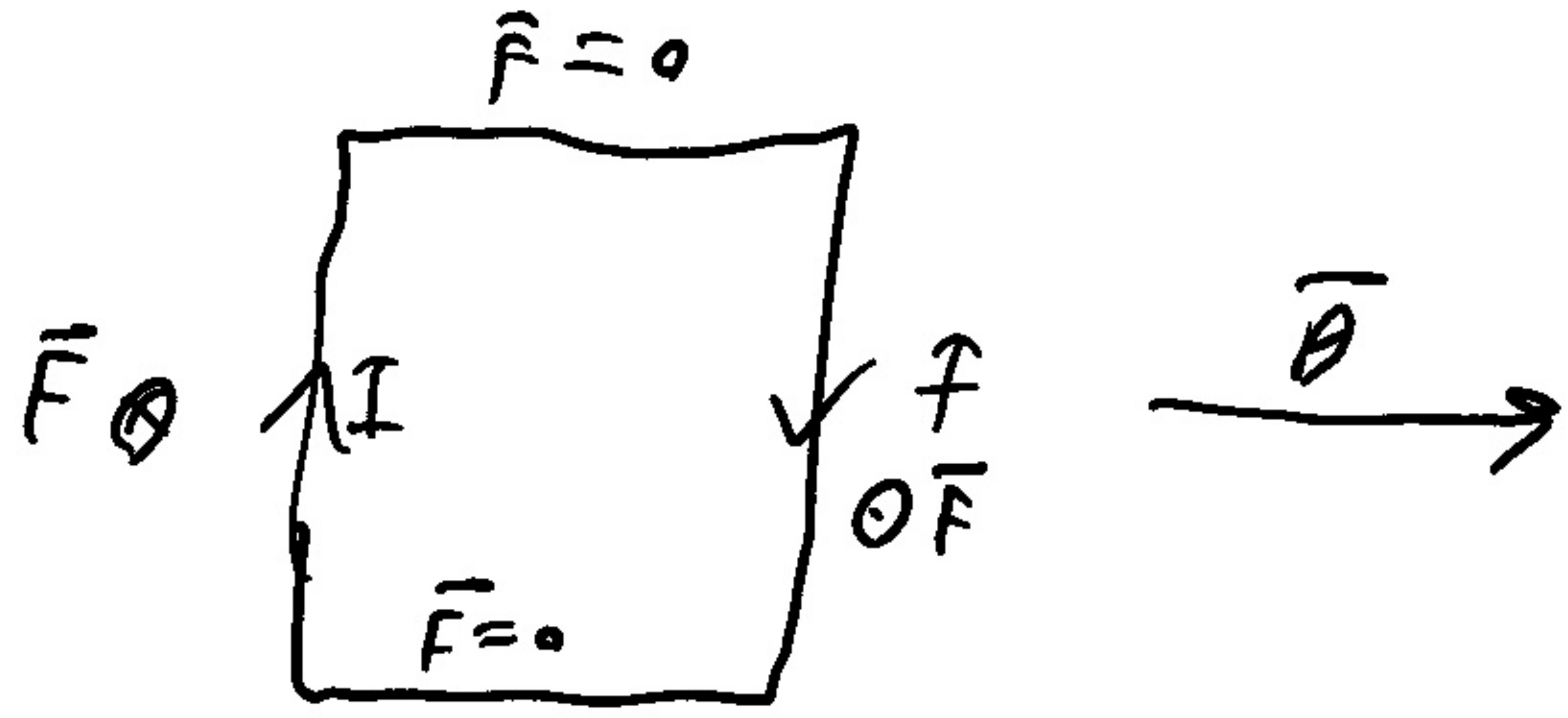
$\vec{F}_B = q\vec{v} \times \vec{B}$ ↓

So need $\vec{F}_E$ in +y

$|F_E| = qE = qvB$

$\Rightarrow \boxed{E = vB}$

Sample 9:

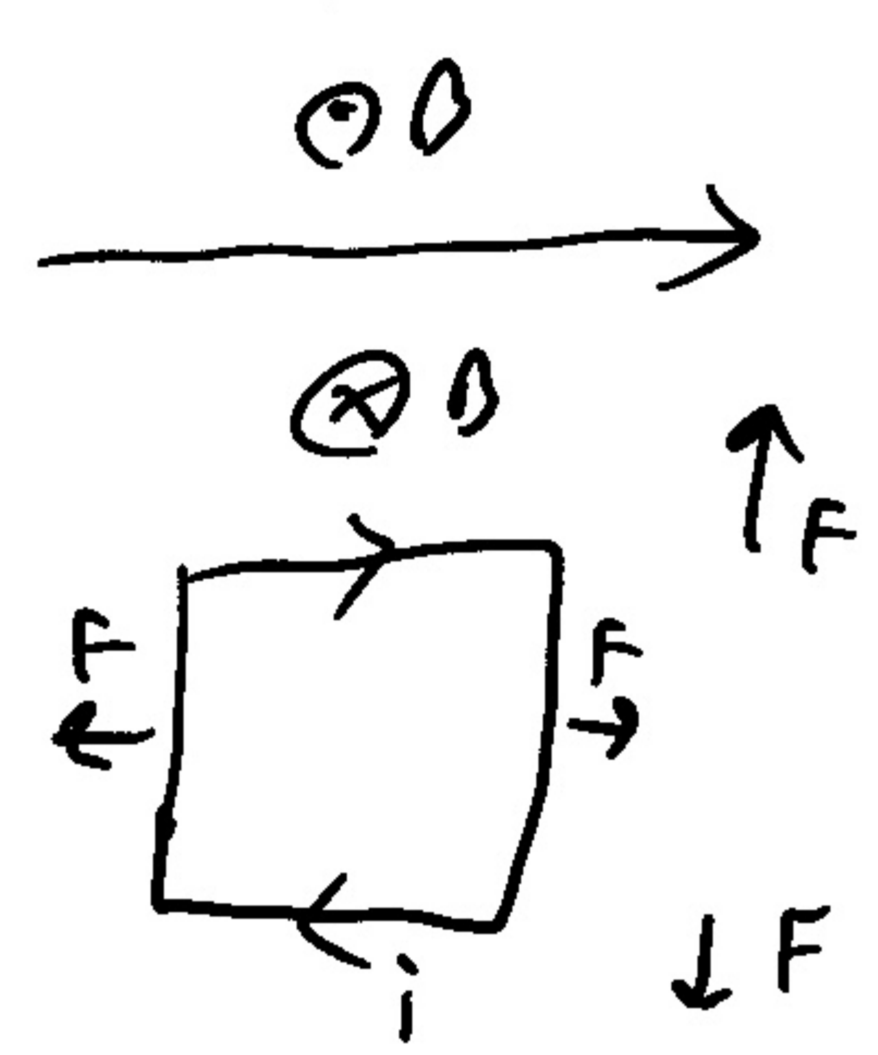


Page rotates to align $\vec{\mu}$

Right side up, left side down

Sample 10:

A.



F_{tot} ↑

B. $F = \frac{\mu_0 I}{2\pi} \cdot \left(\frac{Li}{d} - \frac{Li}{d+L}\right) = \frac{\mu_0 I i L}{2\pi}\left(\frac{1}{d} - \frac{1}{d+L}\right)$

C. $\vec{\mu} \cdot \vec{B} = 0$ so $\vec{\tau} = 0$

d. $\vec{F} = \nabla(\mu \cdot \vec{B})$

$= \nabla \left(i L^2 - \frac{\mu_0 I}{2\pi r} \right) \Big|_d$

$= -i L^2 \mu_0 I / 2\pi r^2 \Big|_d$

$= -i L^2 \mu_0 I / 2\pi d^2$

e. $1/d - 1/d+L = \frac{d+L \; -d}{d(d+L)} = \frac{L}{d(d+L)}$

for $d \gg L \Rightarrow L/d2$

and $F \to \frac{\mu_0 i I L^2}{2\pi d^2}$ same as ideal moment

Sample 11: $1 > 2 > 3$

Sample 12: done on homework