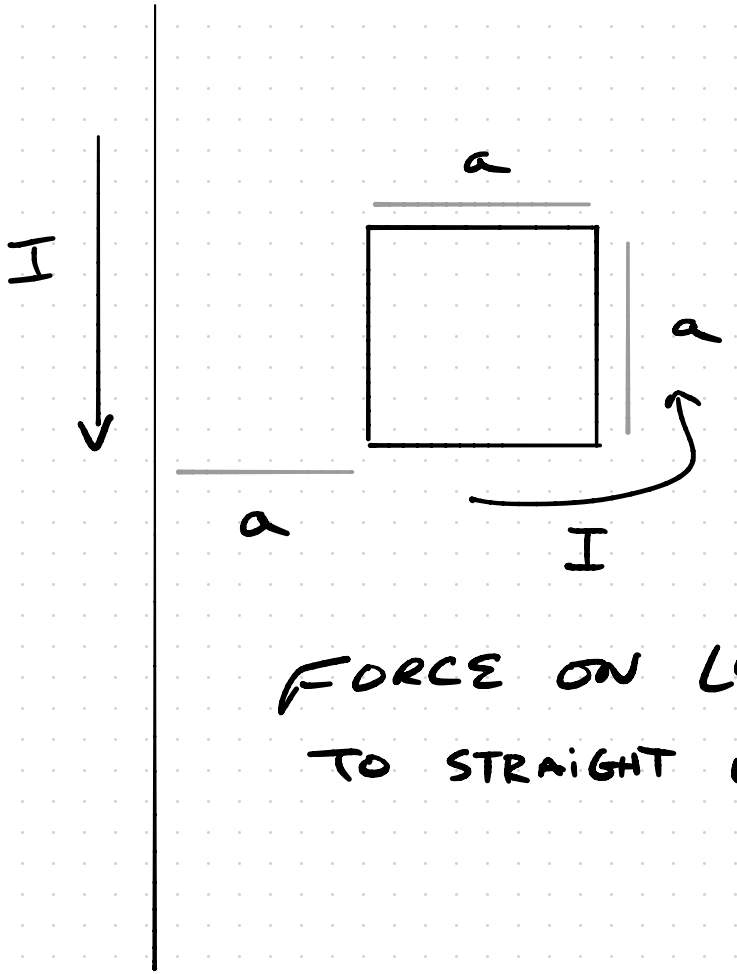
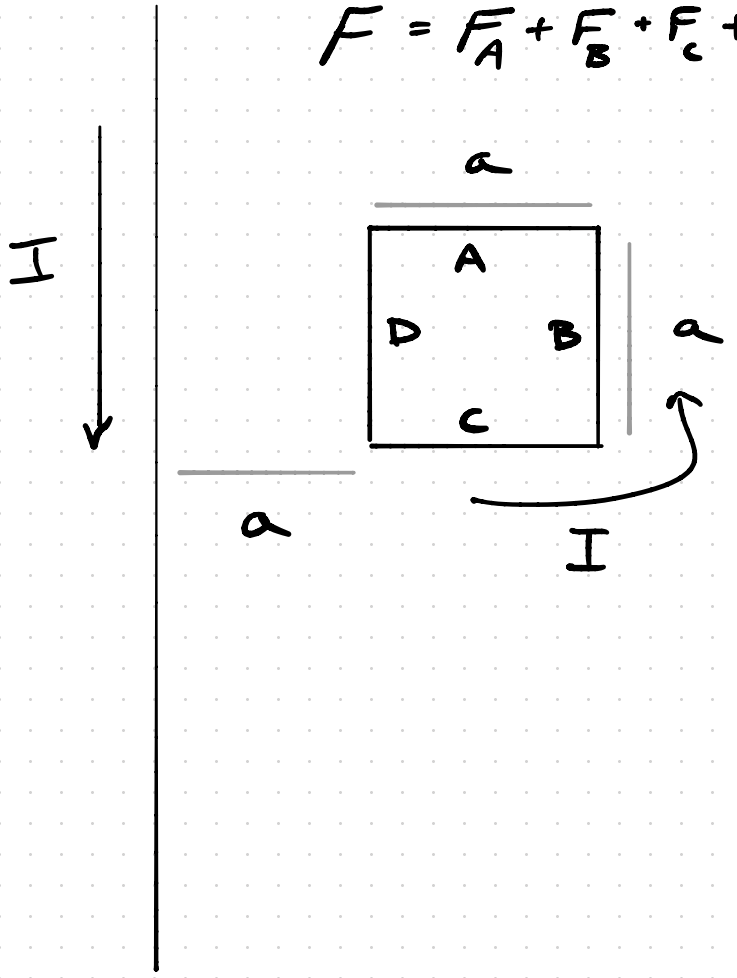
HW#9 Q21 HINT



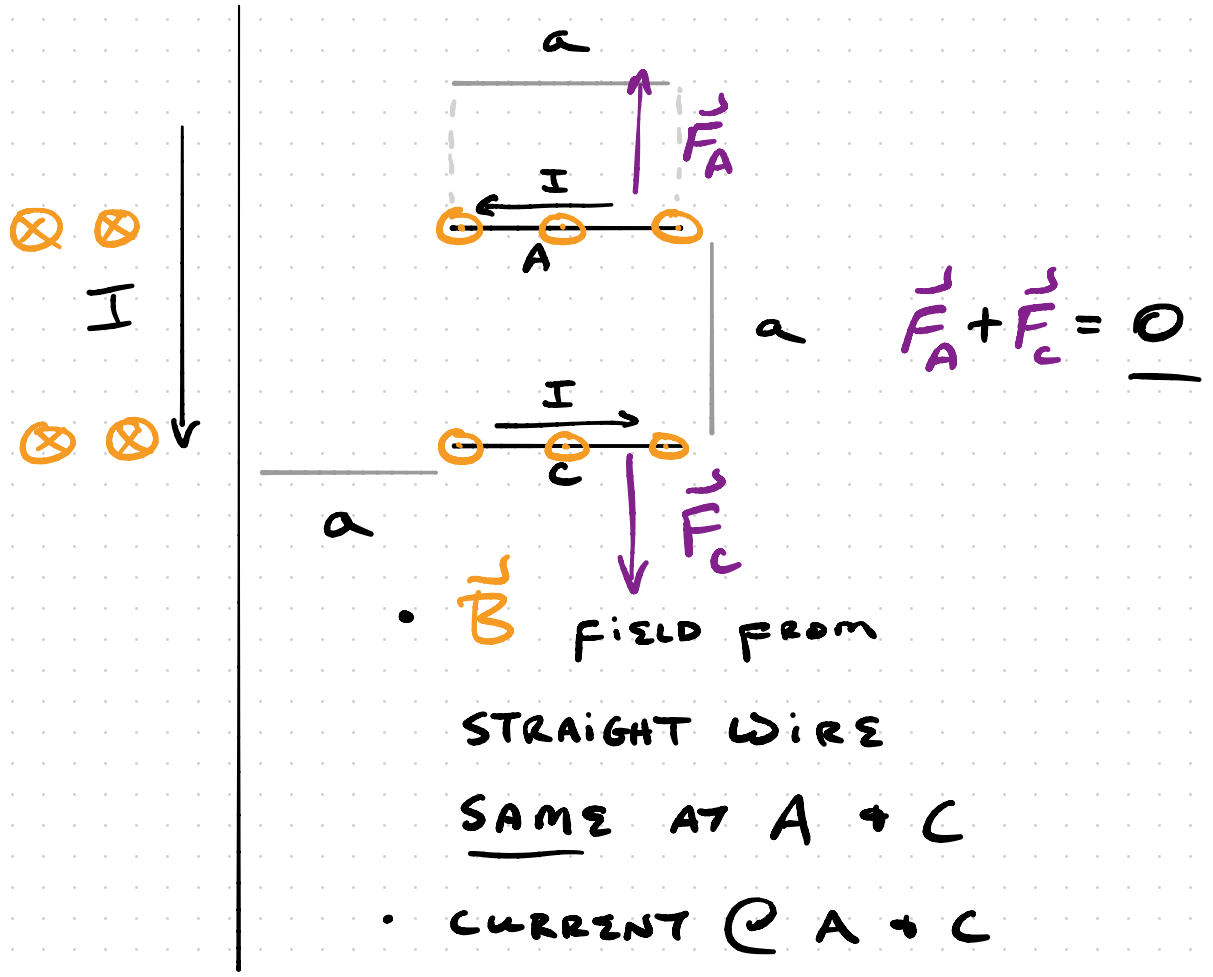
FORCE ON LOOP DUE TO STRAIGHT WIRE?

- Sum up forces from each segment (A, B, C, D):

$$\vec{F} = \vec{F}_A + \vec{F}_B + \vec{F}_C + \vec{F}_D$$

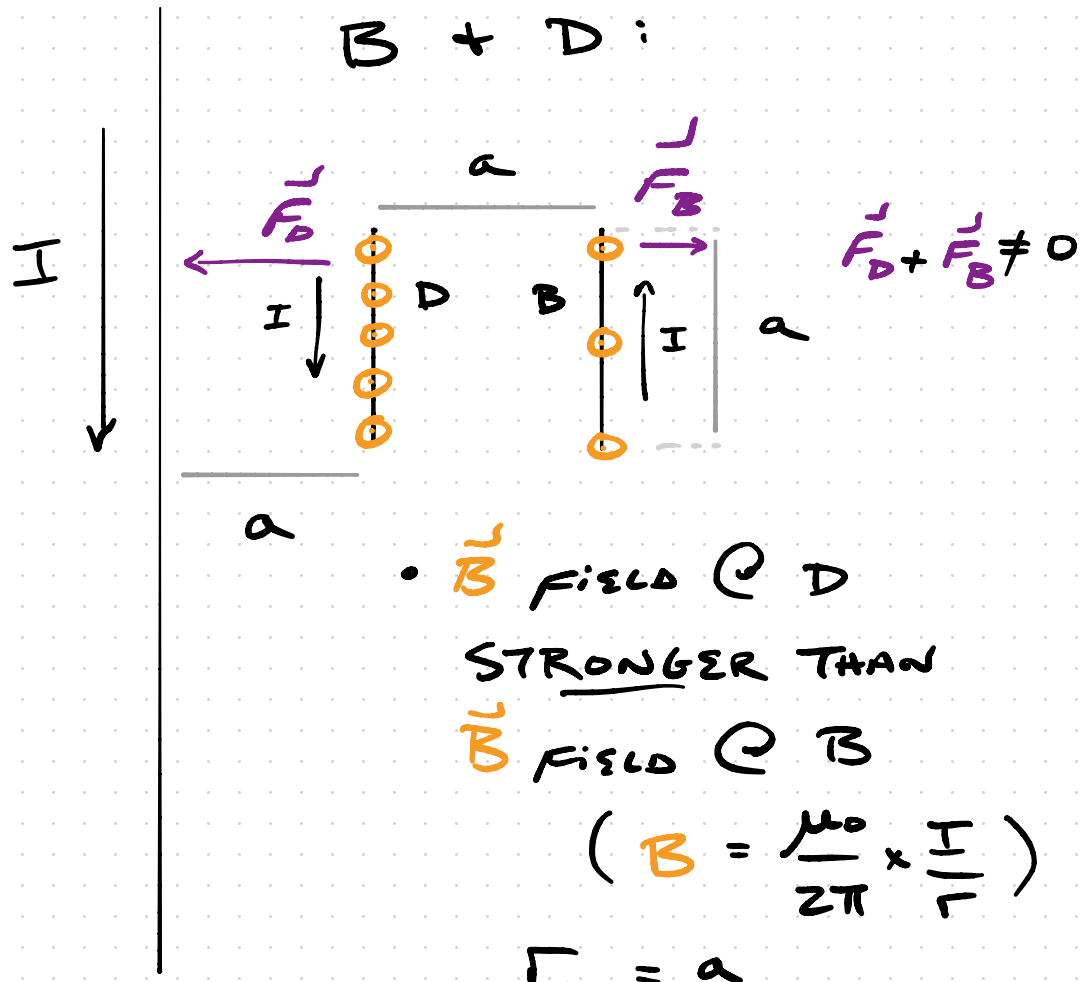


FORCE ON SEGMENTS A & C:



- $\vec{B}$ FIELD FROM STRAIGHT WIRE SAME AT A & C
- CURRENT @ A & C ARE OPPOSITE.
- FORCES CANCEL. (RHR #1)

FORCES ON SEGMENTS B + D:



- $\vec{B}$ FIELD @ D STRONGER THAN $\vec{B}$ FIELD @ B

$$\left(B = \frac{\mu_0}{2\pi} \times \frac{I}{r} \right)$$

$r_D = a$

$r_B = a + a = 2a$

- FORCES DO NOT CANCEL!

IN GENERAL,

FORCE ON WIRE of LENGTH ℓ DUE TO $\vec{B}$ FIELD IS:

$$F = IB\ell \sin\theta$$

FOR SEGMENTS B + D:

- $\theta = 90^\circ \quad (\vec{B} \perp \vec{I})$
- $\ell = a$
- $B = \frac{\mu_0}{2\pi} \times \frac{I}{r}$ $\begin{cases} B: r \rightarrow r_B = 2a \\ D: r \rightarrow r_D = a \end{cases}$

$$\longrightarrow F_B = I \times \frac{\mu_0}{2\pi} \times \frac{I}{2a} \times a = \frac{\mu_0}{4\pi} I^2$$

$$\longrightarrow F_D = \frac{\mu_0}{2\pi} I^2 = 2F_B$$

- $\vec{F}_D$ points LEFT
- $\vec{F}_B$ points RIGHT

$$F = F_D - F_B \quad \text{(To the Left)}$$

$$= 2F_B - F_B$$

$$= F_B = \boxed{\frac{\mu_0}{4\pi} \times I^2}$$