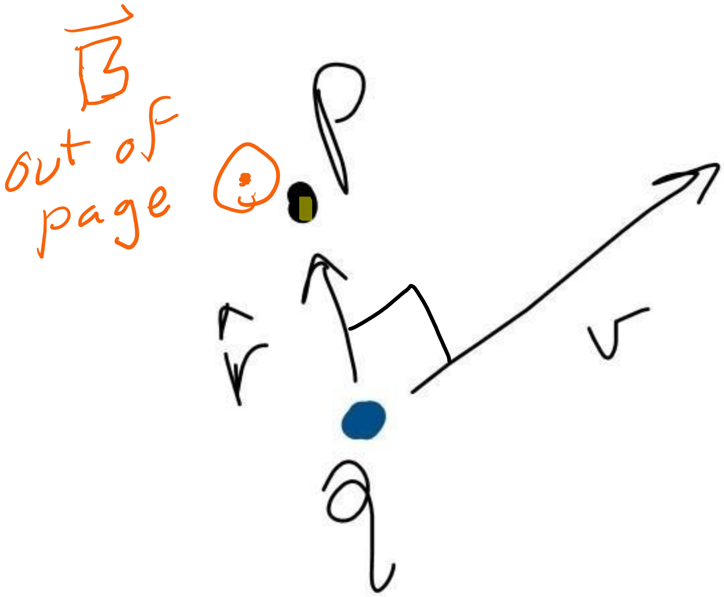
1) Draw the direction of the magnetic field at point P caused by the particle shown below. How far away is point P from the particle q if the magnitude of the B-field at this point is $B = 1\ mT$? Here the velocity is $v = 0.5\ m/s$ and the charge is $q = 1.7\ \mu C$. (Hint: Use the Biot-Savart Law)



$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

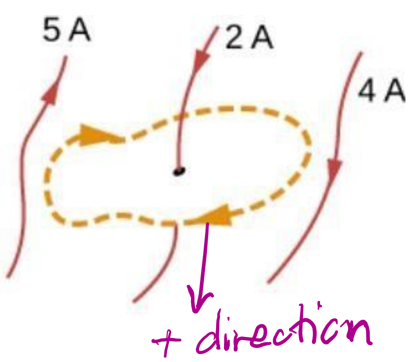
$$B = \frac{\mu_0}{4\pi}\frac{qv}{r^2}$$

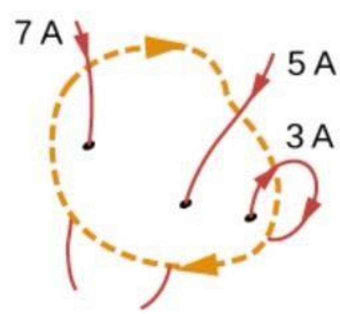
$$r = \sqrt{\frac{\mu_0}{4\pi}\frac{qv}{B}}$$

$$= \sqrt{\frac{(4\pi\times10^{-7})}{4\pi}\frac{(1.7\times10^{-6})(0.5)}{(1\times10^{-3})}}$$

$$= 9.2\times10^{-6}\ m = \boxed{9.2\ \mu m}$$

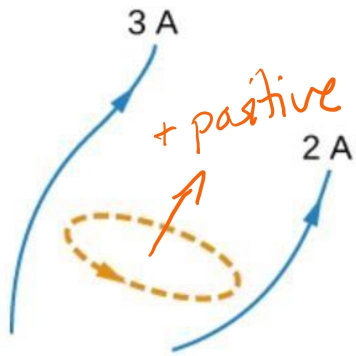
2) What is the total enclosed current in each of the following Amperian Loops?





$$\boxed{I_{enc} = 2A}$$

$$I_{enc} = 7A + 5A - 3A = \boxed{9A}$$

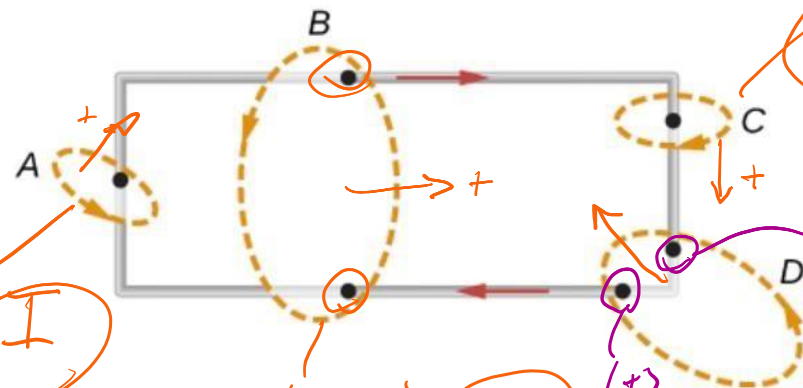


+ positive

$\boxed{I_{enc} = 0}$

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

3) Calculate $\oint B \cdot dl$ for the loops A, B, C, and D. This wire that has current I is flowing through it. (Hint: Loop D is in the same plane as the wire.)



$\mu_0 I$

$\oint B\cdot dl = \mu_0 I$

(-)

(+)

$= \mu_0(I-I) = 0$

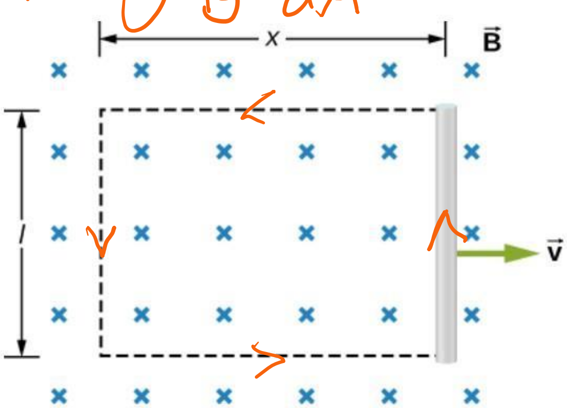
$= \mu_0(I-I) = 0$

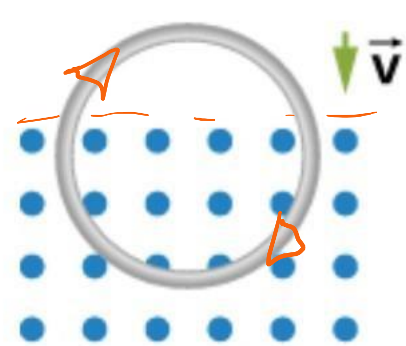
4) What is the direction of the induced current in the following loops of wire? Is the magnetic flux increasing or decreasing?

$\phi_B = \vec{B}\cdot\vec{A} = \int \vec{B}\cdot d\vec{A}$

ϕ_B increasing (more out of page)

I clockwise

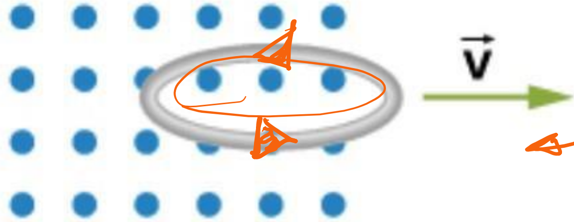




ϕ_B increasing (more into page)

I counter-clockwise

Lenz's law
- opposes change in flux



ϕ_B decreasing

I counter-clockwise

5) Suppose we have a wire in a uniform magnetic field with magnitude $B = 6\ \mu T$. What is the force on this wire per unit length? What is the direction of the force? The current is $I = 2.9\ A$.

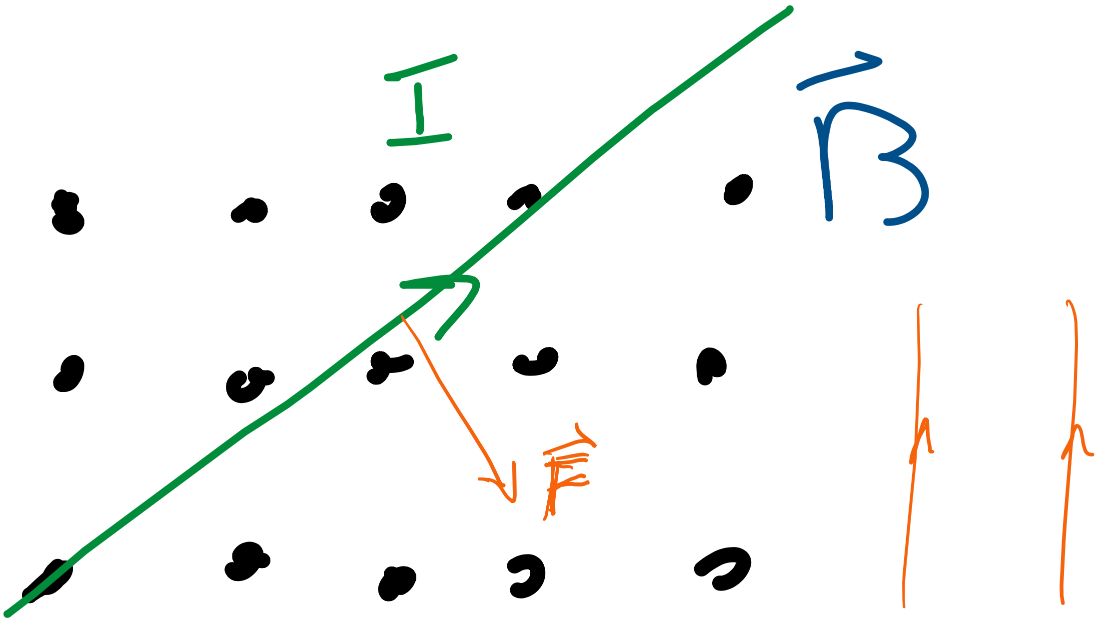
$$\boxed{\vec{F} = I\vec{l} \times \vec{B}}$$

$$\frac{F}{l} = IB$$

$$= (2.9)(6\times10^{-6})$$

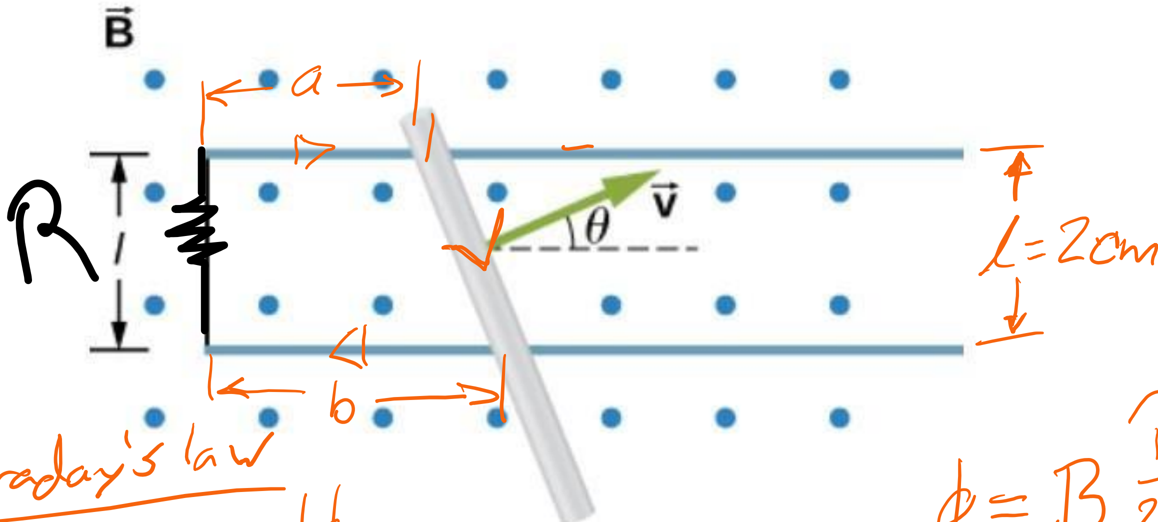
$$= 17.4\times10^{-6}\ N$$

$$= \boxed{17.4\ \mu N}$$



$$B = \frac{\mu_0 I}{2\pi r}$$

6) The rod shown below moves to the right on an essentially zero-resistance rails at a speed of $v = 3\ m/s$ and tilted to an angle of $\theta = 30°$. What is the current induced through this resistor shown below when $R = 8\ \Omega$? The magnetic field is constant everywhere and equal to $B = 0.4\ T$ and the height of the rectangular loop is $l = 2\ cm$.



Faraday's law

$$\mathcal{E} = -\frac{d\phi}{dt}$$

emf (voltage)

$$= -Bl v\cos\theta$$

$$= -(0.4)(0.02)(3)\cos 30°$$

$$= -0.02\,V$$

area of trapezoid

$$\phi = B\,\tfrac{1}{2}(a+b)\,l$$

$$\frac{da}{dt} = \frac{db}{dt} = v\cos\theta$$

$$\frac{d\phi}{dt} = Bl v\cos\theta$$

$$\mathcal{E} = IR \rightarrow I = \frac{\mathcal{E}}{R} = \frac{0.02\,V}{8\,\Omega} = \boxed{0.0025\,A}$$

$$= \boxed{25\,mA}$$

clockwise