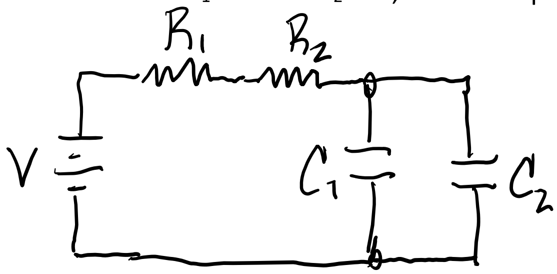
Practice Quizzam 5

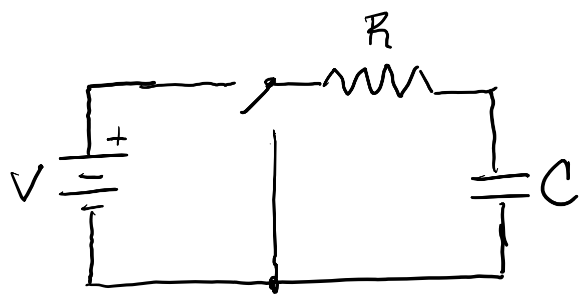
Solutions

1. What is the time constant of the RC circuit drawn below? The battery voltage is V=12V, the resistances are R_1=3Ω and R_2=7Ω, and the capacitances are C_1=6F and C_2=3F.



$$R_{eq} = R_1 + R_2 = 10\,\Omega$$
$$C_{eq} = C_1 + C_2 = 9F$$
$$\tau = R_{eq} C_{eq} = \boxed{90s}$$

2. In the circuit below, the switch can close either of the two circuits. When switched to the upper position, the capacitator is charging, and when in the lower position, the capacitator is discharging. The battery voltage is V=5V, the resistance is R=3Ω, and the capacitance is C=4F.



   a. What is the charge on the capacitator after the switch has been in the upper position for a long time?

In upper position, capacitator is charging. After a long time, no more current flows, so ΔV on capacitor is V of battery

$$Q = C\Delta V = (4F)(5V) = \boxed{20C}$$

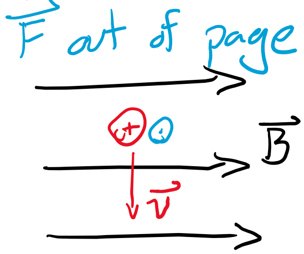
   b. The switch is then moved to the lower position. What is the current through the resistor immediately after this is done (at time t = 0)?

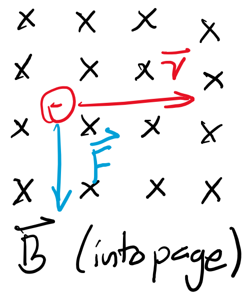
Immediately after moving switch, discharging through resistor. $\Delta V_C = 5V$ is still voltage of capacitator.

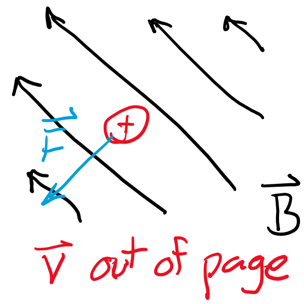
$$I = \frac{\Delta V}{R} = \frac{5V}{3\Omega} = \boxed{1.667A}$$

0

3. For each of the following moving charges in a magnetic field, sketch the resulting magnetic force vector or state that F=0. (Recall we represent a vector into the page as an 'x', and one out of the page as a dot).



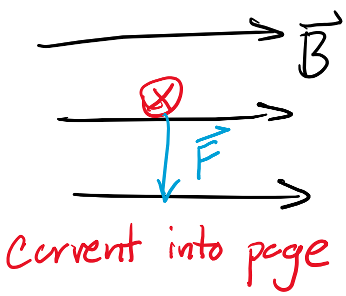


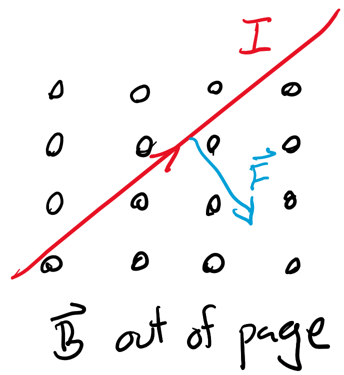


Right-hand rule, $\vec{F} = q\vec{v} \times \vec{B}$

For middle problem, note charge is (-), so $q\vec{v}$ points left.

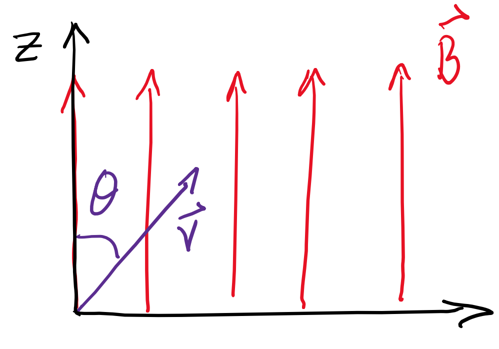
4. For each of the following currents in a magnetic field, sketch the resulting magnetic force vector or state that F=0.





Right-hand rule, $\vec{F} = I\vec{L} \times \vec{B}$

5. A proton is moving in the xz-plane with a velocity of 10m/s, at an angle of θ=30° with respect to a constant magnetic field with strength B=5T in the positive z-direction, as shown below. What is the resulting magnetic force? (Note: the positive y-direction is into the screen)

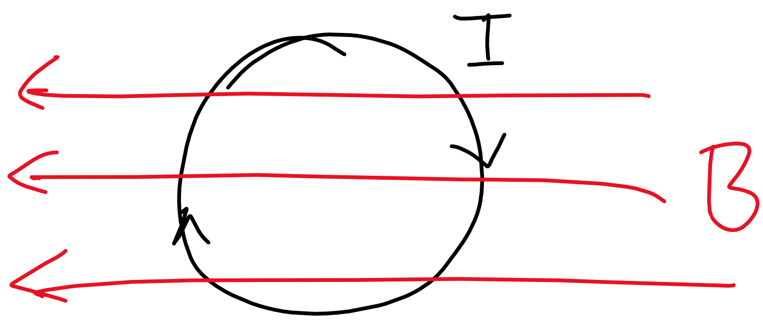


$\vec{F} = q\vec{v}\times\vec{B}$
right-hand rule
⇒ out of screen.

$|F| = qvB\sin\theta = (1.602\times10^{-19}C)(10m/s)(5T)\sin 30° = 4\times10^{-18}$ N

∴ $\boxed{\vec{F} = -4\times10^{-18} N\,\hat{j}}$

6. The circular current loop shown below, with radius r=5cm carries a current of I=4A in the clockwise direction. What is the magnitude and direction of its magnetic moment?



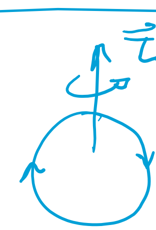
$\vec{\mu} = I\vec{A} = (4A)\cdot\pi(0.05m)^2 = \boxed{0.0314\ \frac{Nm}{T}}$

area vector, and thus $\vec{\mu}$ into screen by right hand rule.

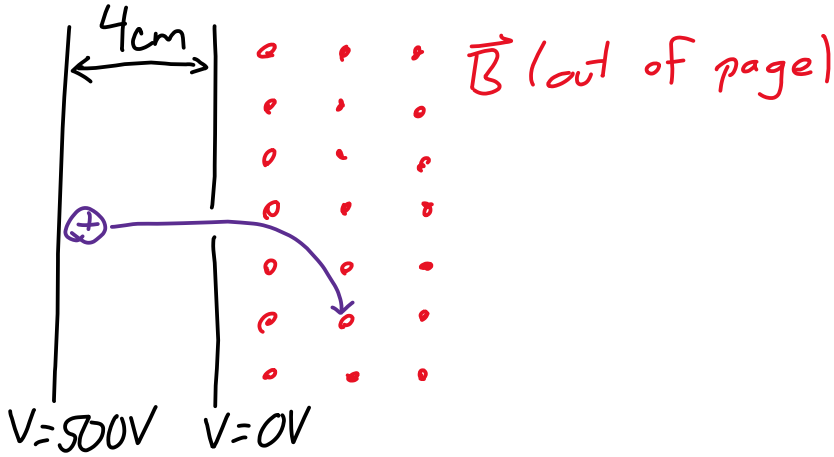
7. The current loop in the previous problem is placed in a magnetic field with strength of 5T pointing to the left. What is the torque this field exerts on the current loop?

$\vec{\tau} = \vec{\mu}\times\vec{B} = (0.0314\frac{Nm}{T})(5T) = \boxed{0.157\ Nm}$

direction is up, by right hand rule



8. Two parallel plates are placed a distance of 4cm apart from each other, with a potential difference of 500V between them. There is a small hole in the negative plate across from it. On the other side of this plate, there is a magnetic field of strength B=1T with field lines parallel to the plates. If a proton is released from rest at the positive plate, it will accelerate out of the hole and then move in a circular path in the magnetic field, as shown below. What is the radius of this circular path?



First, find speed at which it enters the B-field using conservation of energy:

$$U_i + \underbrace{\cancel{K_i}}_{=0} = \underbrace{\cancel{U_f}}_{=0} + K_f, \qquad U = qV, \quad K = \frac{1}{2}mv^2$$

$$qV_i = \frac{1}{2}mv_f^2$$

$$v_f = \sqrt{\frac{2qV_i}{m}} = \sqrt{\frac{2(1.602\times10^{-19}\,C)(500V)}{1.672\times10^{-27}\,kg}} = 310{,}000\,\frac{m}{s}$$

Now, magnetic force causes uniform circular motion.

$$|q\vec{v}\times\vec{B}| = |F| = mv^2/r \qquad \vec{a} = v^2/r\,(-\hat{r})$$

$$qvB = mv^2/r$$

$$\Rightarrow r = \frac{mv}{qB} = \frac{(1.672\times10^{-27}\,kg)(310{,}000\,m/s)}{(1.602\times10^{-19}\,C)\,(1T)} = \boxed{0.323cm}$$