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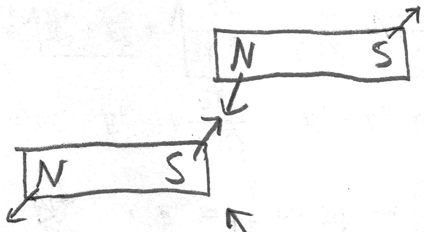
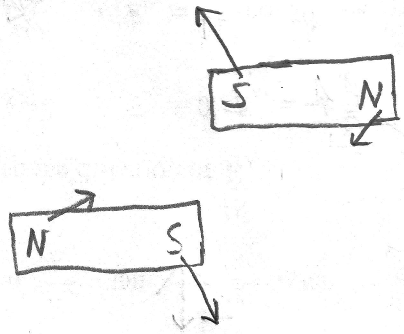
Exam 2 Solutions

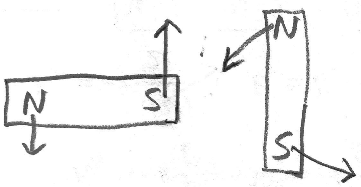
1. a. i)



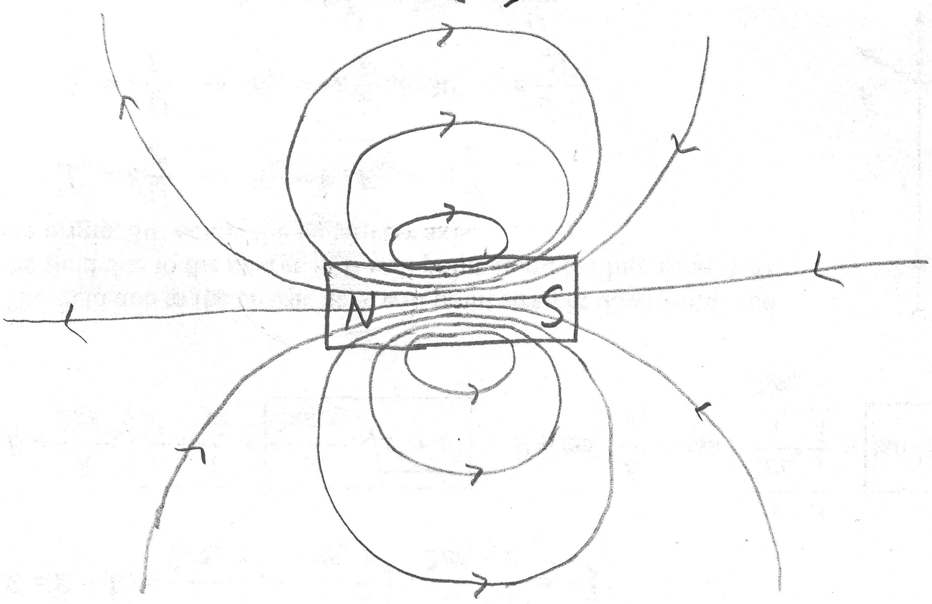
ii)



iii)



b.

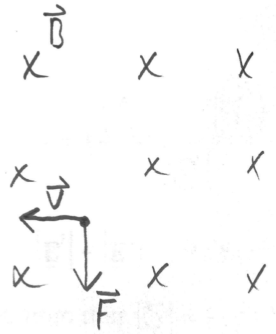


c. Magnetic field lines are loops, they don't start or end. Electric field lines are anchored at their ends on charges.

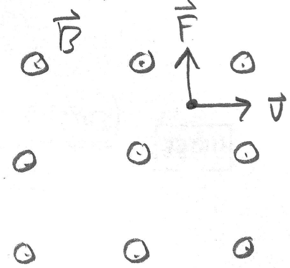
Both types of field lines try to spread out and keep apart. Both represent the field in the same way.

d. No monopoles. This is why magnetic field lines have no ends.

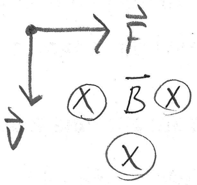
(2) a.



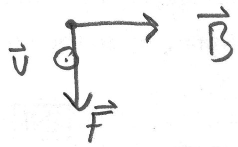
b.



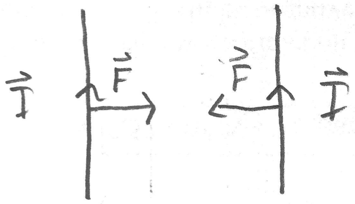
c.



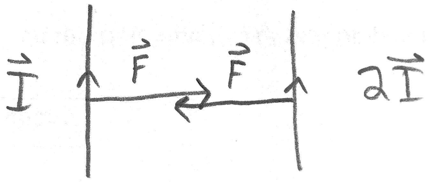
d.



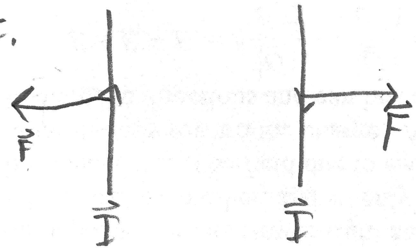
(3) a.



b.

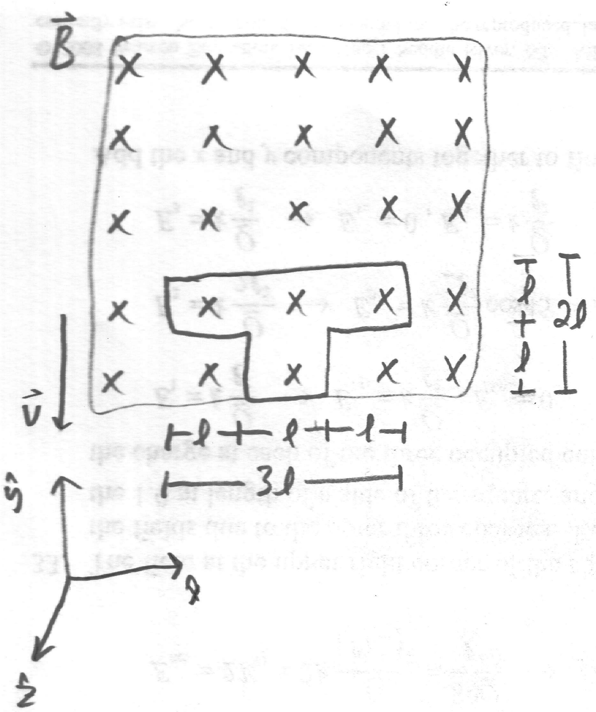


c.



Note that these forces must be equal and opposite: Newton's Laws of motion still hold.

(4)



$\vec{B} = B(-\hat{z})$

$\vec{v} = v(-\hat{y})$

a) $\boxed{\vec{A} = 4l^2(-\hat{z})}$

b) $\Phi_B = \int \vec{B}\cdot d\vec{A}$

$\boxed{\Phi_B = 4l^2 B}$

c) The flux is 0 once the loop has left the field. With $|\vec{v}| = v$ and distance $2l$ to travel, $\boxed{t_2 = \frac{2l}{v}}$.

d) At $t_1 = \frac{1}{2}t_2$, only the top half of the loop is still in the field. This has area $3l^2$

$\boxed{\Phi_B = 3l^2 B}$

e) $\frac{\Delta\Phi_B}{\Delta t} = \frac{4l^2B}{2l/v}$

$\boxed{\frac{\Delta\Phi_B}{\Delta t} = -2vlB}$

$\boxed{\mathcal{E}_{ind} = 2vlB}$

f) $\frac{\Delta\Phi_B}{\Delta t} = \frac{3l^2B - 4l^2B}{l/v} = \frac{-l^2vB}{l}$

$\boxed{\frac{\Delta\Phi_B}{\Delta t} = -vlB}$ $\boxed{\mathcal{E} = vlB}$

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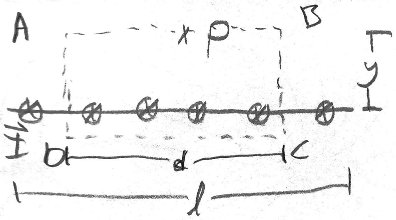
g) $\frac{\Delta \Phi_B}{\Delta t} = \frac{0 - 3\ell^2 B}{\ell/v}$

$\boxed{\frac{\Delta \Phi_B}{\Delta t} = -3v\ell B}$ $\boxed{\mathcal{E} = 3v\ell B}$

8.



$y \ll \ell$

a) $\boxed{I/\ell}$

b) If y is not much smaller than ℓ, the field won't be uniform so we can't use an amperian loop effectively.

c) $\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{enc}$

$$\int_A^B \vec{B} \cdot d\vec{l} + \int_B^C \vec{B} \cdot d\vec{\ell} + \int_C^D \vec{B} \cdot d\vec{\ell} + \int_D^A \vec{B} \cdot d\vec{\ell} = \mu_0 I_{enc}$$

$$Bd + 0 + Bd + 0 = \mu_0 I \left(\frac{d}{\ell}\right)$$

$$2B\cancel{d} = \mu_0 I \frac{\cancel{d}}{\ell}$$

$$B = \mu_0 \frac{I}{2\ell}$$

$\boxed{\vec{B} = \mu_0 \frac{I}{2\ell} \quad \begin{matrix} \hat{x} \text{ above sheet} \\ -\hat{x} \text{ below sheet} \end{matrix}}$

d) $\vec{F} = q\vec{v} \times \vec{B}$

$= 0$ at rest

$\vec{F} = qvB\,\hat{z} \times \hat{x}$

$\boxed{\vec{F} = qvB\,\hat{y}}$

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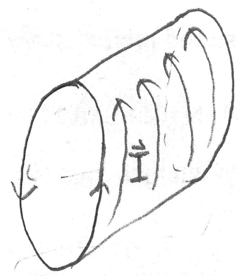
Didn't ask this part.

e. i)

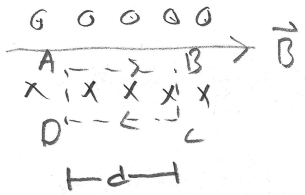


Circumference is $2\pi r = 2l$

$r = l/\pi$

ii) This is like a solonoid but without individual wires.

(7) a)



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

$B_1 \cancel{d} = \mu_0 \frac{N_1}{L_1} \cancel{d} I$ $\qquad n_1 = N/L_1$

$\boxed{B_1 = \mu_0 n_1 I_1}$

b) $\Phi_B = A B_1$

$\Phi_B = l^2 B_1$

I accepted anything for Φ_{tot} b.c. the question was unclear.

c) $M = \frac{N_2}{I_1} \Phi$

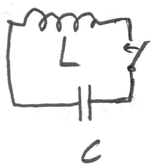
$= \frac{N_2}{\cancel{I_1}} l^2 \mu_0 \frac{N_1}{L_1} \cancel{I_1}$

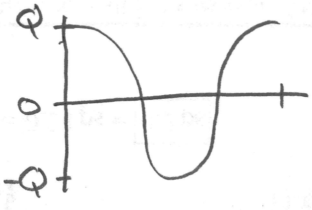
$\boxed{M = \mu_0 l^2 \frac{N_1 N_2}{L_1}}$

d) $\mathcal{E}_2 = -M \frac{dI_1}{dt}$

$\boxed{\mathcal{E}_2 = \mu_0 l^2 \frac{N_1 N_2}{L_1} \frac{dI_1}{dt}}$

(5)

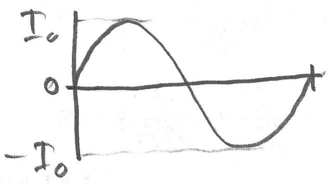




charge on capacitor

Initially, the capacitor is fully charged. When the switch is closed, the charge has a route to equalize and starts flowing through the circuit, resulting in a current. This burst of current results in an opposing $\mathcal{E}$ in the inductor, such that the capacitor takes a finite amount of time to discharge. Once the capacitor is fully discharged, however, the inductor now has a large current flowing through it. As the current driven by the discharging capacitor dies down, the inductor tries to keep the current going. The result is that the capacitor gets re-charged with the opposite charge. This starts the same process in reverse, so the charge keeps oscillating.

The current starts at 0 and climbs



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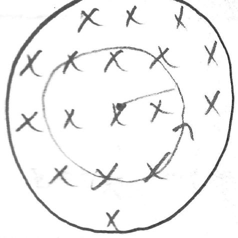
⑥



a) $A(r) = \pi r^2$

$\Phi_E = E \cdot A(r)$

$$\boxed{\Phi_E = E_0 t \pi r^2}$$

b) $\frac{d\Phi_E}{dt} = \frac{d}{dt}(E_0 \pi r^2 t)$

$$\boxed{\frac{d\Phi_E}{dt} = \pi r^2 E_0}$$

c) $\oint \vec{B} \cdot d\vec{l} = \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$

$B\, 2\cancel{\pi}\cancel{r} = \mu_0 \epsilon_0 \cancel{\pi} r^{\cancel{2}} E_0$

$B = \frac{\mu_0}{2} r \epsilon_0 E_0$

$$\boxed{\vec{B} = \frac{\mu_0}{2} r \epsilon_0 E_0 \,\widehat{RHR}}$$

$\widehat{RHR}$ = clockwise.

d) The $\vec{B}$ field results from Maxwell's correction to Ampère's Law. w/o this correction, we can get 2 different results for $\vec{B}$ around a current.

This not given

⑨ a) $P = \frac{\bar{S}}{c} = \frac{16 \cdot 10^5 \, W/m^2}{3 \cdot 10^8 \, m/s} = 2 \cdot 10^{-2} \frac{W \cdot s}{m^3} = \boxed{2 \cdot 10^{-2} \frac{N}{m^2}}$

$F = P \cdot A = 2 \cdot 10^{-2} \frac{N}{m^2} \cdot (.005m)^2$

$= 2 \cdot 10^{-2} \cdot 25 \cdot 10^{-6} \, N$

$= 50 \cdot 10^{-8} \, N$

$$\boxed{F = 5 \cdot 10^{-7} \, N}$$

b) $\boxed{P = 4 \cdot 10^{-2} \frac{N}{m^2} \quad F = 1 \cdot 10^{-6} \, N}$

Not Given

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c) $\vec{F}_g = -G \dfrac{m_1 m_2}{r^2} \hat{r}$

$= -7 \cdot 10^{-11} \cdot \cancel{100} \cdot 100{,}000 \; \cancel{\dfrac{1}{10^2}} \; \dfrac{N\,m^2}{\cancel{kg^2}} \; \cancel{kg \cdot kg} \; \cancel{\dfrac{1}{r^2}} \; \hat{r}$

$= -7 \cdot 10^{-11} \cdot 1 \cdot 10^{5} \; N \; \hat{r}$

$\boxed{|\vec{F}_g| = -7 \cdot 10^{-6} \; N}$

d) She still gets pulled in by the shuttle, tho both forces are extremely weak.