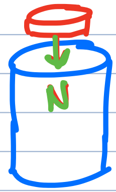
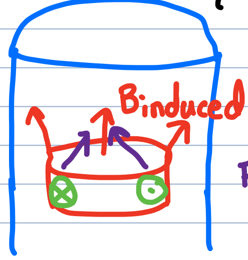
ch 13 Electromagnetic Induction

Faraday's Law $\mathcal{E} = -\dfrac{d\Phi_B}{dt}$ where $\Phi_B = \oint \vec{B}\cdot d\vec{A}$

→ an induced current will create its own $\vec{B}$ field, one which opposes the changing external B flux

Demo where magnet fell slowly down copper tube





F_B up and in and that's why the magnet falls slowly

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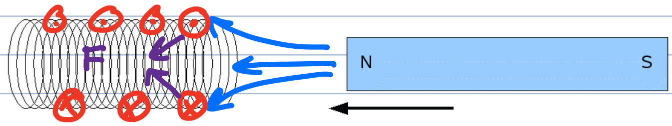


induced current in metal slinky

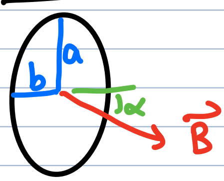
If the north end of a bar magnet is brought near a *non-magnetic* but metallic slinky, the slinky will

a) not move.
b) move towards the magnet.
c) move away from the magnet.

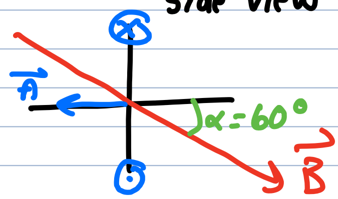
And doesn't matter which way the bar magnet is oriented - slinky moves away in both cases

Magnetic flux example

$B = 2\cdot10^{-4}\,T$ $\alpha = 60^\circ$
$a = 0.20\,m$ $b = 0.15\,m$
$I = 6.0\,A$ $N_{turns} = 1$



side view

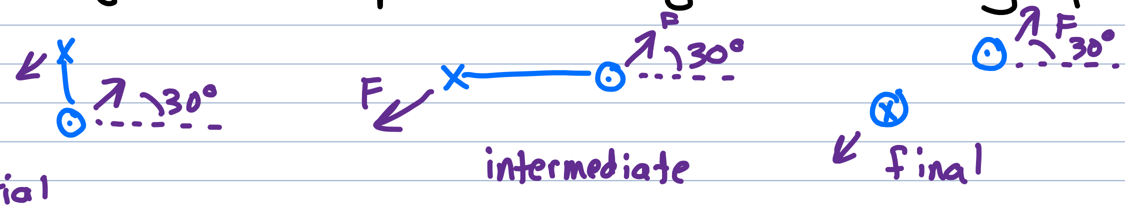


a) what is B flux through the current loop?

$$\Phi_B = \oint \vec{B}\cdot d\vec{A} = B\int dA \cos 120^\circ = BA\cos 120^\circ = -9.4\cdot10^{-6}\,Wb$$

b) what is the net B force? zero, but it does spin

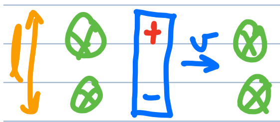
c) what angle will the loop rotate through before reaching equilibr.



loop rotates by $90° + 30° = 120°$

motional electromotive force

consider a neutral conducting bar moving through a $\vec{B}$ field



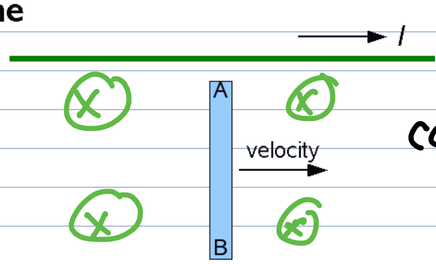
$\vec{F} = q\vec{v} \times \vec{B}$ → upward force on + charges

what is $\mathcal{E}$ potential difference?

$q\vec{v} \times \vec{B} = q\vec{E} \Rightarrow E = vB$

→ potential difference $\mathcal{E} = El$
$= vBl$

A metal rod is moving along a nearby long wire. If the wire has current *I*, then the potential at *A* and the potential at *B* are related by



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a) $V_A = V_B$
b) $V_A > V_B$
c) $V_A < V_B$

A square metal loop is moving along a nearby long wire. If the wire has current *I*, then the induced current in the loop will be

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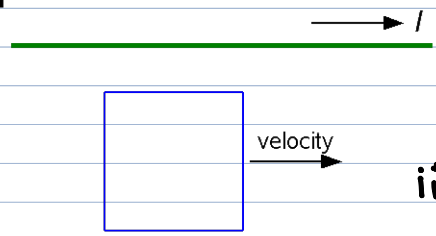
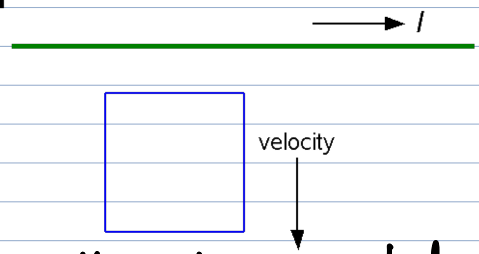


a) counterclockwise
b) zero
c) clockwise

i) no change in Φ_B

ii) all + charges move up – no net current

A square metal loop is moving away from a long wire. If the wire has current *I*, then the induced current in the loop will be



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a) counterclockwise
b) zero
c) clockwise

Let's compute how much voltage is generated in the loop

$v = v(-\hat{y})$ $\quad y = y_0 - vt$ $\quad \vec{B}(y) = \frac{\mu_0 I}{2\pi y}(-\hat{z}) = \frac{\mu_0 I}{2\pi(y_0 - vt)}(-\hat{z})$

$\Phi_B = \oint \vec{B} \cdot d\vec{A}$

$\mathcal{E} = -d\Phi_B/dt = -\oint \frac{d\vec{B}}{dt} \cdot d\vec{A} = -\int -\frac{\mu_0 I}{2\pi} \frac{-v}{(y_0 - vt)^2} dA \cos 0^\circ$

$= \frac{\mu_0 I}{2\pi} \frac{v}{(y_0 - vt)^2} \ell^2$