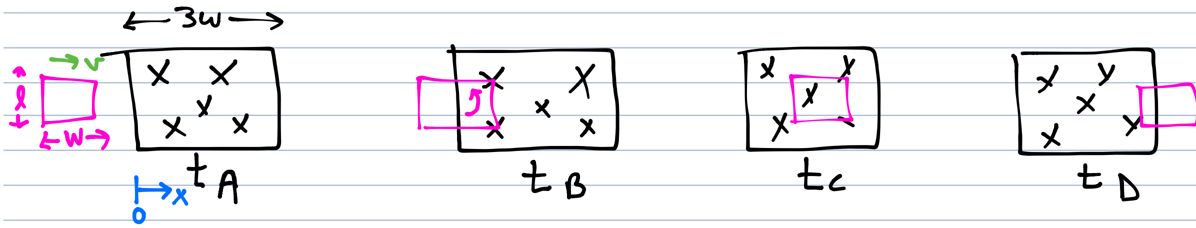
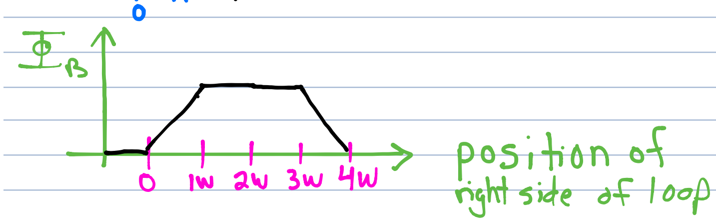
Eddy currents

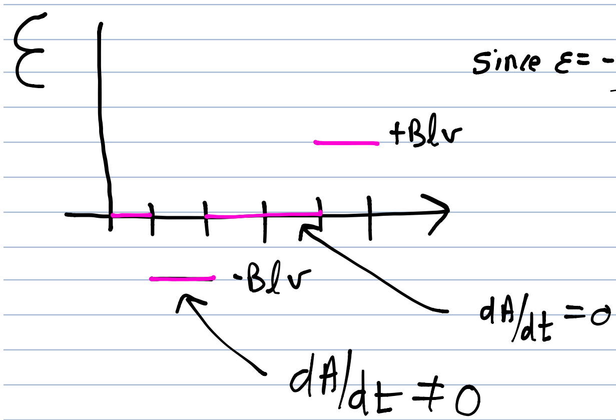
Small current loops created when there is a changing $\Phi_B = \int \vec{B} \cdot d\vec{A}$

Basic picture (similar to p. 128 of tutorials)





$A(t) = l\,x(t)$



Since $\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}(BA(t)) = -B\frac{dA}{dt} = -B\,l\,\frac{dx(t)}{dt}$

$= -Bl v$

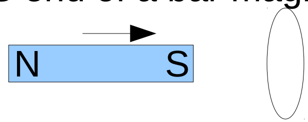
numbers: $l = 0.05\,m$ $v = 1\,m/s$ $B = 1T$

$R = 1\,\Omega$, $I = \mathcal{E}/R = \frac{Blv}{R} = 50\,mA$

Approach a circular wire loop with the S end of a bar magnet. You observe a ______ induced curren

a) clockwise

b) counterclockwise

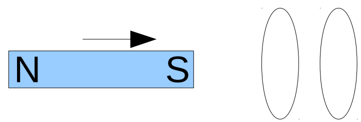


Suppose the maximum current in the above example is 5 mA. If I repeat the above with an additional wire loop (#2) just behind the first (#1), what is the maximum current in #1?

a) <5 mA

b) 5 mA

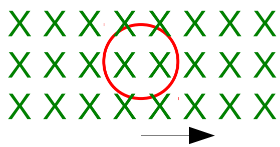
c) >5 mA



A wire loop moves through a uniform B field. What is the induced current in the loop if *v* is constant (and thus *a* is zero)?

a) zero

b) non-zero

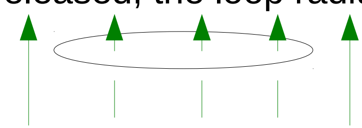


What if *v* is not constant (and thus *a* is non-zero)?

a) zero

b) non-zero

Consider a conducting, elastic loop stretched to a radius r = 12 cm. When released, the loop radius shrinks at a rate of 75 cm/s. An external B field is 0.80 T.



a) What is the induced emf? $\mathcal{E} = -\frac{d}{dt}\int \vec{B}\cdot d\vec{A} = -\frac{d}{dt}\int B\,dA = -B\frac{d}{dt}\int dA = -B\frac{d}{dt}A(t)$

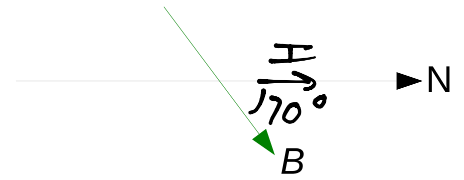
b) If the resistance is R=9.0 Ω, what is the induced current? $= -\pi B\frac{d}{dt}r^2(t) = -\pi B\,2r\frac{dr}{dt}$

c) If viewed from above, in which direction does the induced current flow?

ccw

$\frac{d}{dx}x^2 = 2x \quad \frac{d}{dx}y^2 = 2y\frac{dy}{dx}$

The Earth's B field points into the ground at Laramie, at an angle of 70° to the horizontal, towards the North (with amplitude ~60 μT).



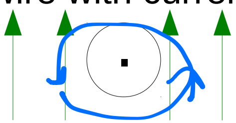
a) Suppose a long conductor carrying 500 A is lying on the ground, in a N-S orientation. What is F_B on a 100 m segment?

$\vec{F} = I\vec{L} \times \vec{B} \quad = ILB \sin 70°$ to the west

b) If I climb the classroom building and drop a metal loop down, in which direction is the induced current, as viewed from above?

no current since Φ_B constant. But there will be an AC current if I spin the hoop

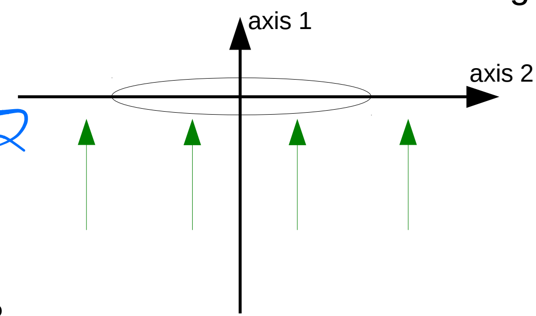
A long wire with current 100 A is held perpendicular to a 5 mT B field. Where is the net B zero?



2 B fields cancel to the wire's left

$B_{\text{due to wire}} = \frac{\mu_0 I}{2\pi r} \rightarrow r = \frac{\mu_0 I}{2\pi B}$

A wire loop is perpendicular to a uniform B field. In which direction is the induced current flowing if I spin the loop about axis #1? about axis #2?



a) no current → for axis #1

b) clockwise as viewed from above

c) counter-clockwise as viewed from above

} for axis #2

An electron zooms into a uniform B field. Which way will it turn?

a) to “its” left

b) to “its” right ← it's an e^- !