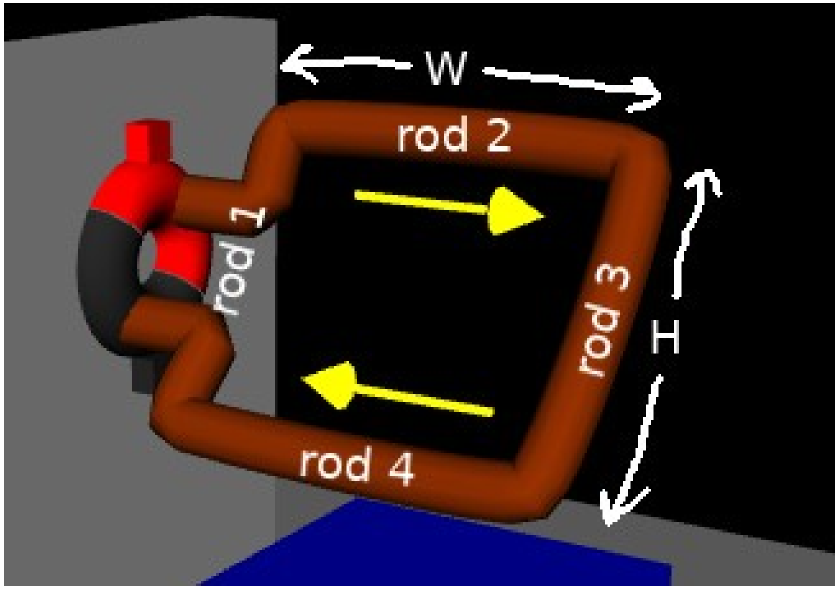
# Moment of inertia




$$m_r = \frac{M}{4}$$

$$Rod\,1,3 = \frac{1}{12} m_r H^2$$

$$Rod\,2,4 = m\left(\frac{H}{2}\right)^2$$

$$Total = \frac{1}{6} MH^2$$

# Force and torque

$$I_{current} = \frac{\varepsilon}{R}$$

$$\vec{F} = I_{current}\,\vec{\ell} \times \vec{B}$$

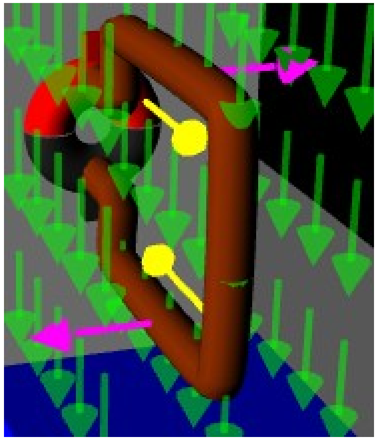
$$\vec{\tau} = \vec{r} \times \vec{F} = I_{inertia}\,\alpha$$

- Gets repeated for top and bottom wire
- Code runs about 60 times per second
- When the acceleration is found, it is multiplied by the time elapsed in order to calculate angular velocity
- Then angular velocity is used to update rotation

# Back EMF

$$\Phi_B = \oiint \vec{B} \cdot \vec{dS} = B \times A \times \sin(\theta) \qquad \varepsilon = \frac{-d\Phi_B}{dt} = -B \times A \times \omega \times \cos(\theta)$$

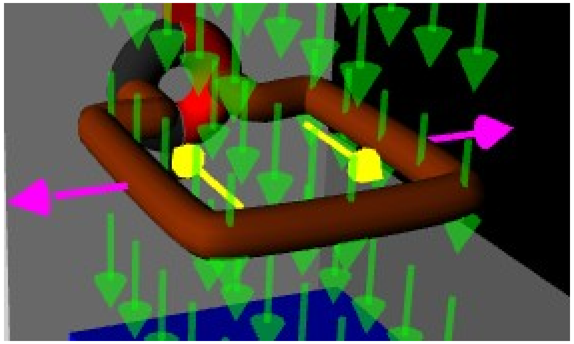
- As armature spins, magnetic flux changes – so by Faraday's Law, there's an induced EMF
- This counteracts the supplied voltage from the battery
- It increases linearly with ω
- θ is angle of rotation, not angle between B and A vectors!
- What happens when you disconnect the battery?



$\theta = 0$

$\Phi_B = 0$

**minimum flux**



$\theta = 90°$

$\Phi_B = BA$

**maximum flux**

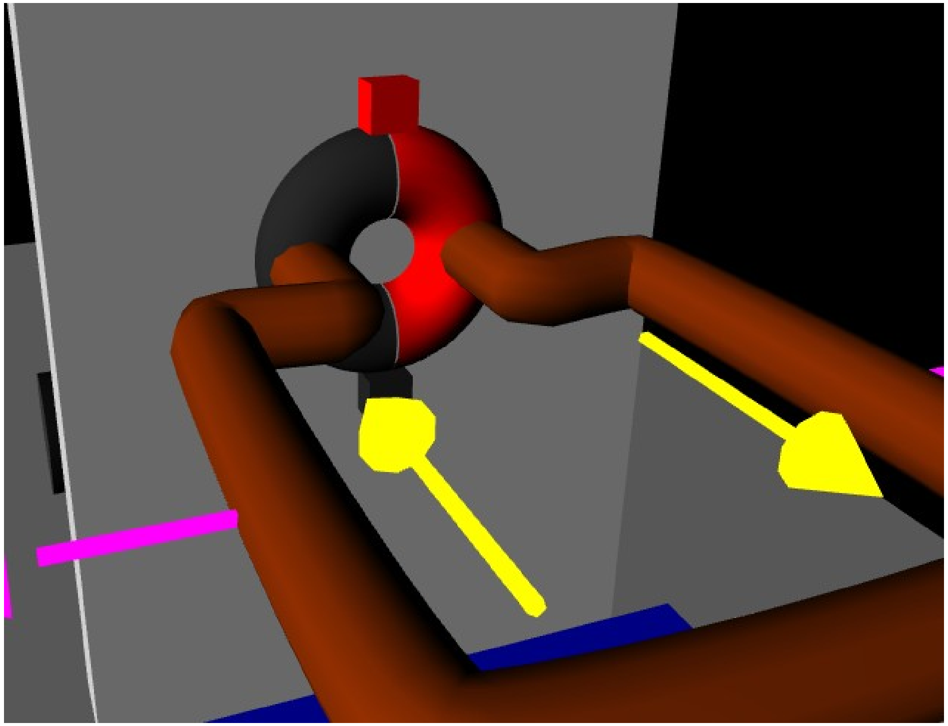
# Limitations

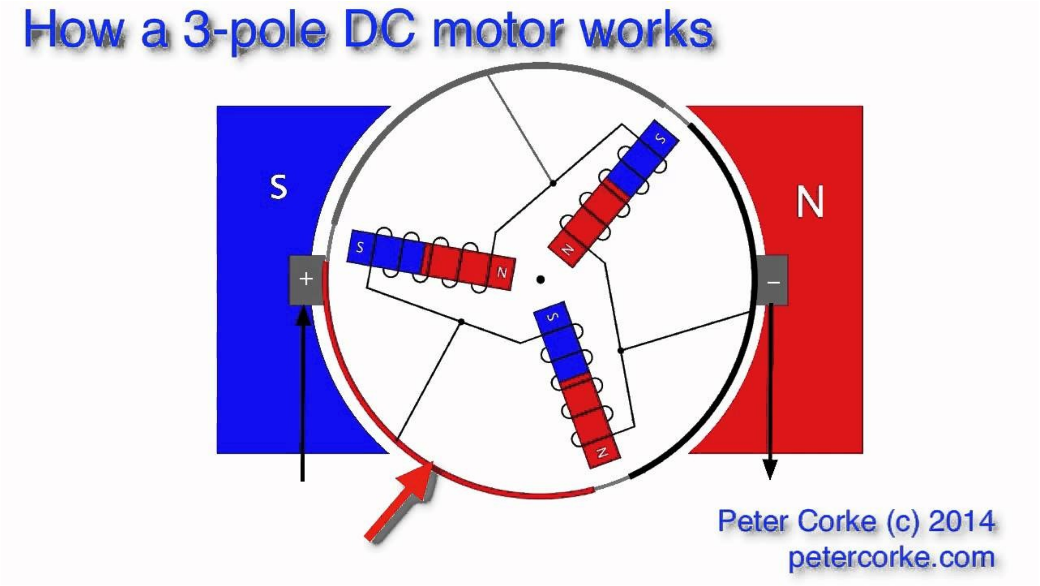
- **Simulation isn't complete**
  - Missing inductive term
    - Armature is a coil → an inductor!
    - Therefore it should be resisting the change in current
    - Simulation does not account for this

$$\varepsilon = -L\frac{dI}{dt}$$

  - Would also be nice to graph different parameters over time
- **Motor design has some problems**
  - "Torque ripple" – the torque is not constant for all angles
  - Most DC motors have more than two poles to avoid shorts

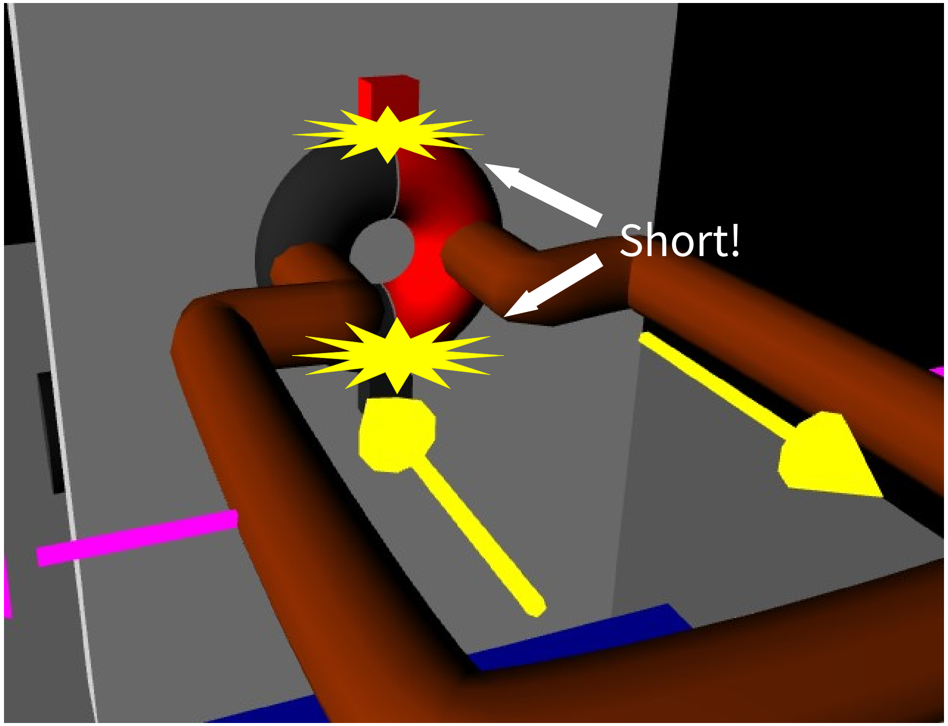
# Better motor designs

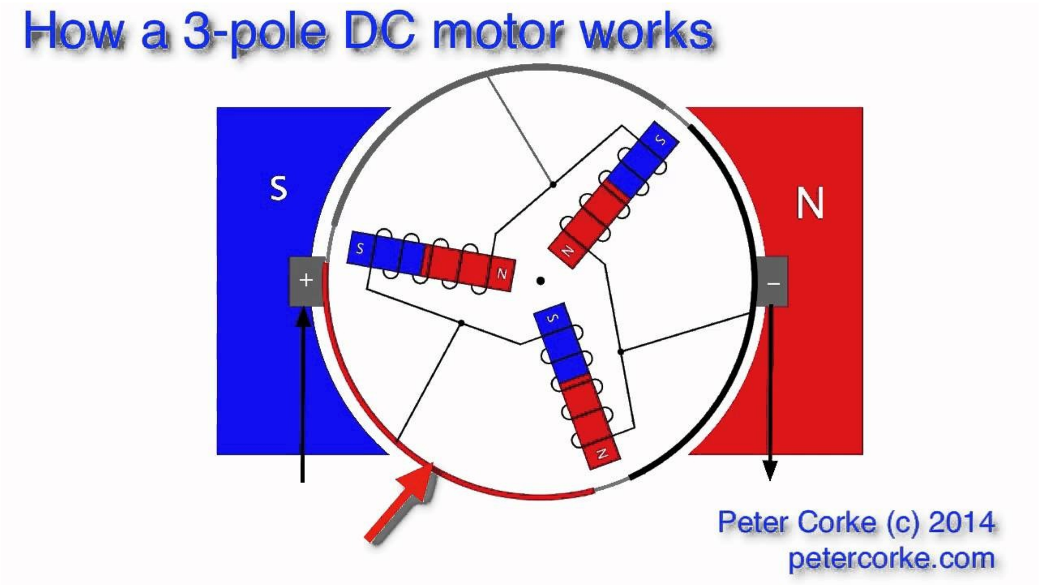





https://www.youtube.com/watch?v=1673-0Y3fFQ

# Better motor designs

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# Website

- https://web.mit.edu/astuder/www/motorsim/