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# Maxwell's Equations:

## *Gauss' Law for Magnetic Fields*

EE-3321

Electromagnetic Field Theory



## Outline

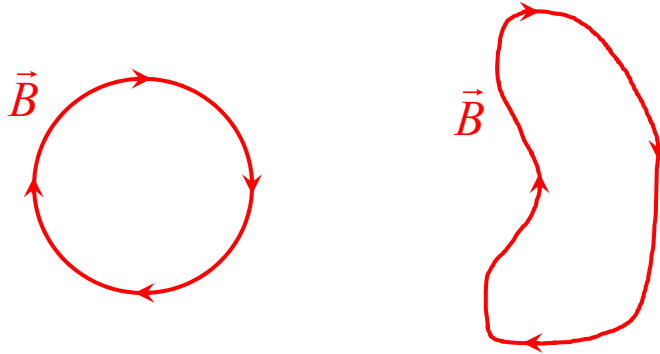


- No Magnetic Charge
- Gauss' Law for Magnetic Fields in Integral Form
- Gauss' Law for Magnetic Fields in Differential Form

# No Magnetic Charge



Since there exists no isolated magnetic charge, the magnetic field cannot have a beginning or an end. The magnetic field can only form loops.



# Prove Zero Magnetic Charge



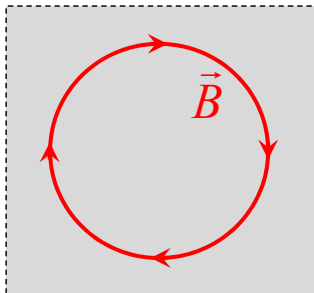
## Surface integral of magnetic flux

Following what we did for electric fields, we calculate total magnetic charge enclosed within a surface  $S$  by integrating the flux of the magnetic field lines at the surface.

$$0 = \oiint_S \vec{B} \cdot d\vec{s}$$

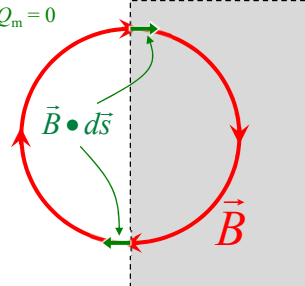
No flux lines through surface.

$$Q_m = 0$$



Flux adds to zero.

$$Q_m = 0$$



## Gauss' Law for Magnetic Fields in Integral Form



The result from last slide is Gauss' law for magnetic fields.

$$\oiint_S \vec{B} \cdot d\vec{s} = 0$$

Maxwell's Equations -- Gauss' Law for Magnetic Fields

Slide 5

## Apply Divergence Theorem



The *divergence theorem* allows us to write a closed-contour surface integral as a volume integral.

$$\oiint_S \vec{A} \cdot d\vec{s} = \iiint_V (\nabla \cdot \vec{A}) dv$$

Applying this to Gauss' law for magnetic fields gives us

$$Q_m = \oiint_S \vec{B} \cdot d\vec{s} = \iiint_V \rho_m dv$$

↓

$$Q_m = \iiint_V (\nabla \cdot \vec{B}) dv = \iiint_V \rho_m dv$$

Maxwell's Equations -- Gauss' Law for Magnetic Fields

Slide 6

## Gauss' Law for Magnetic Fields in Differential Form



If the surface  $S$  and volume  $V$  describe the same space, the argument of both integrals must be equal. Setting these arguments equal gives Gauss' law for magnetic fields in differential form.

$$Q_m = \iiint_V (\nabla \cdot \vec{B}) dv = \iiint_V \rho_m dv$$

$$\nabla \cdot \vec{B} = \rho_m$$

However, there is no magnetic charge so  $\rho_m = 0$ .

$$\boxed{\nabla \cdot \vec{B} = 0}$$