# April 4, Week 11

Today: Chapter 9, Rotation

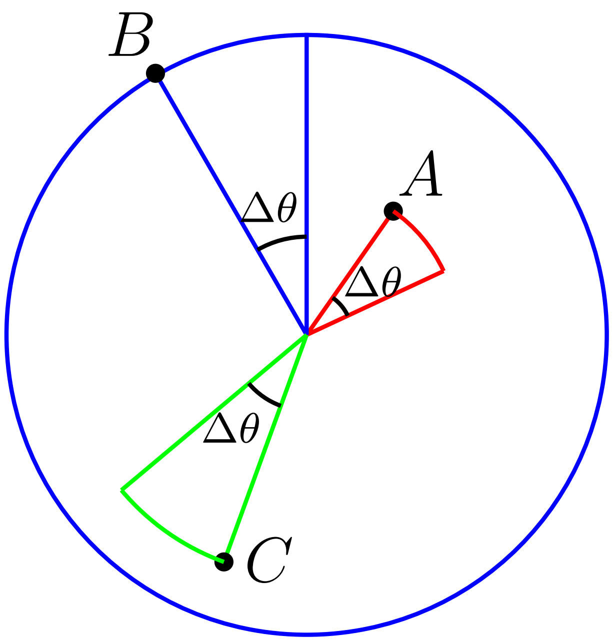
Exam #4: Friday, April 6

Review Session: Thursday, April 5, 7:30PM in Regener 114

Practice Problems for chapters 5, 6, 7, and 8 available on Mastering Physics

Practice Exam on Website.

# Review



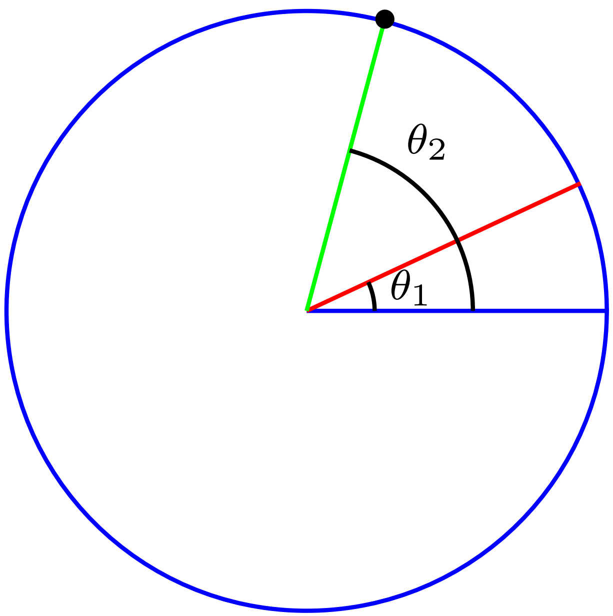

*All* points rotate through the same angle

We must distinguish
linear motion = distance/time
from angular motion = angle/time

A rotating object has infinitely many linear speeds but only one angular speed

# Angular Velocity

The rate at which an objects spins is given by its angular velocity, $\vec{\omega}$.




$$\omega_{av} = \frac{\theta_2 - \theta_1}{t_2 - t_1} = \frac{\Delta\theta}{\Delta t}$$

Unit: $rad/s$

$$\omega = \lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t} = \frac{d\theta}{dt}$$

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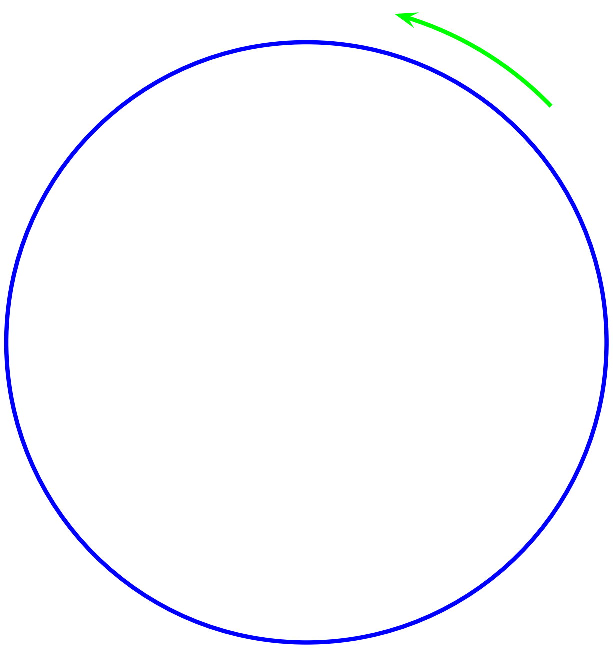

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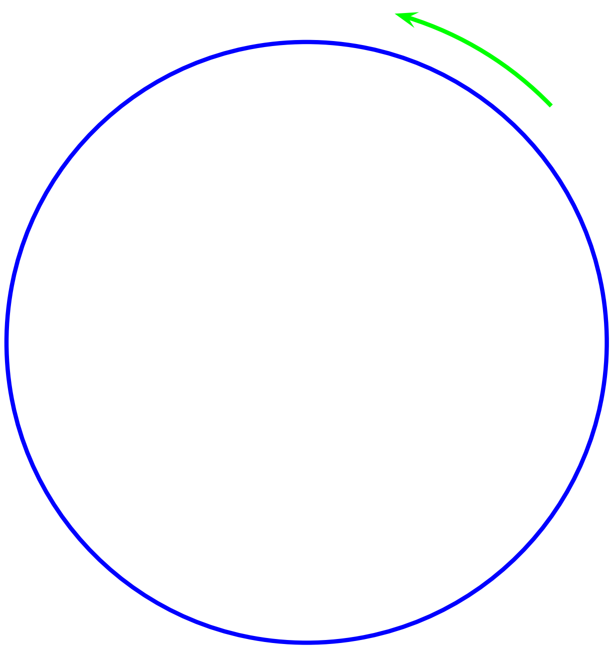

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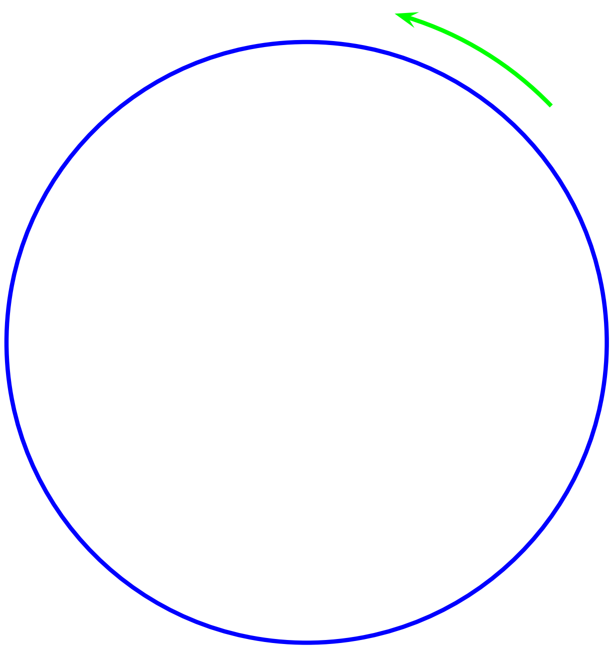

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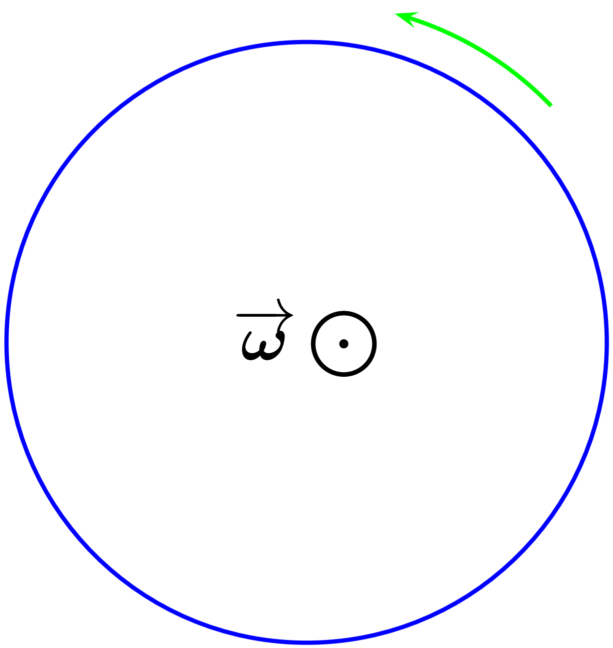


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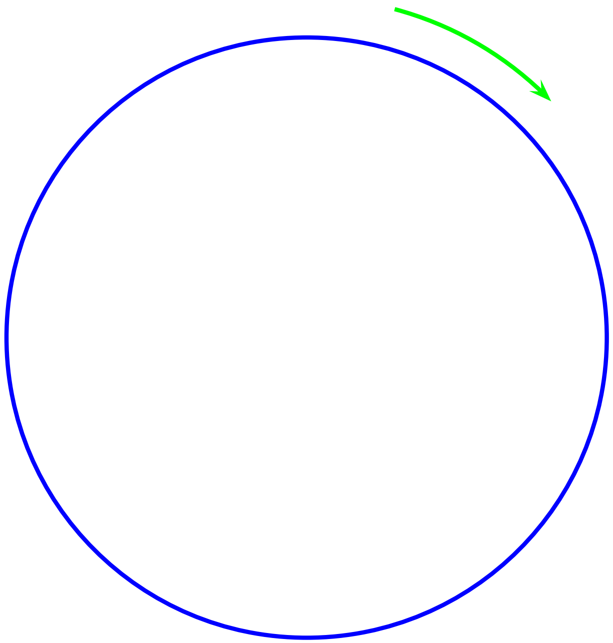

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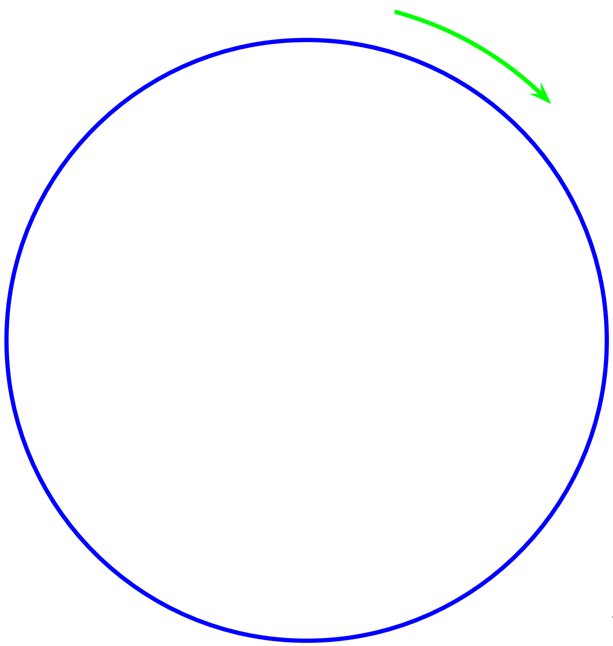

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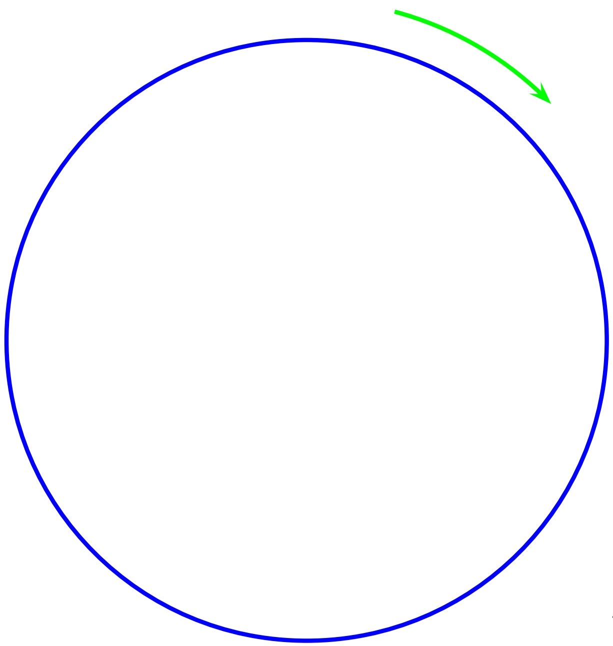

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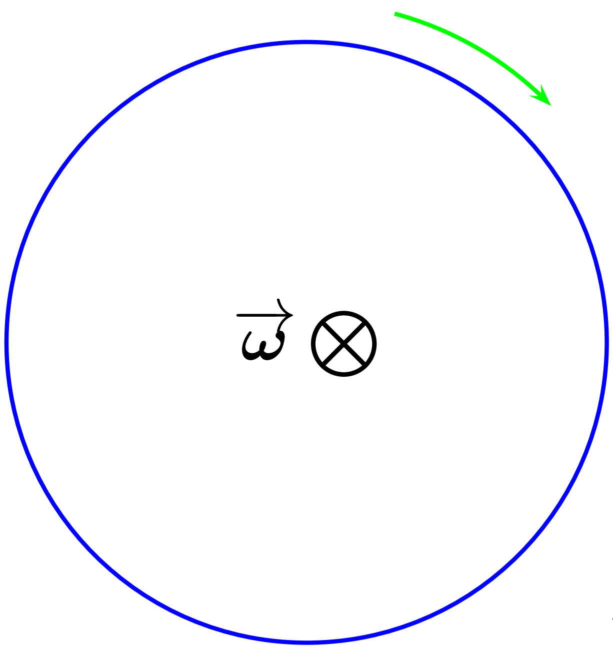


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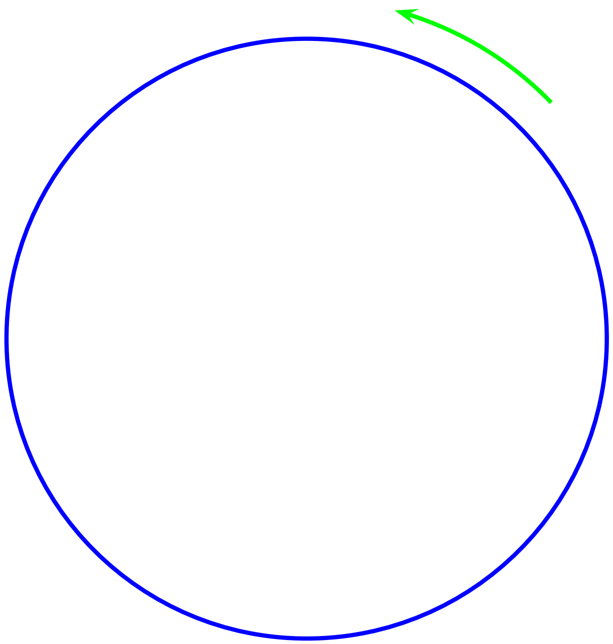
# Clicker Quiz

A wheel, rotating counter-clockwise, has a decreasing angular speed. What direction is its angular acceleration vector, $\vec{\alpha}$?



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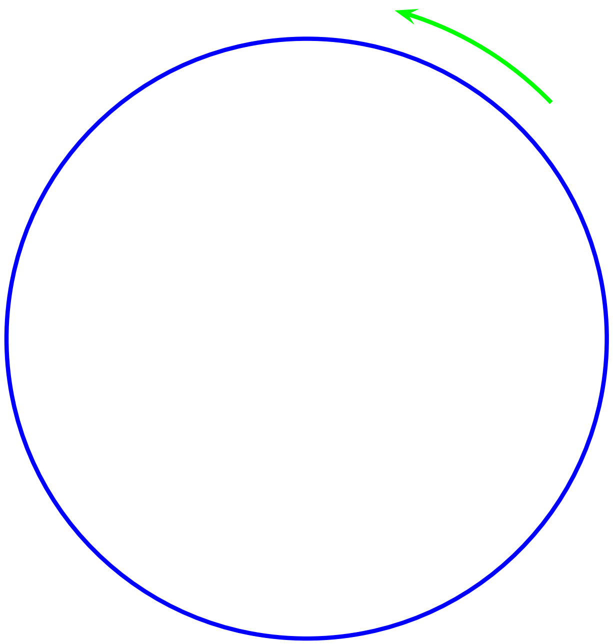

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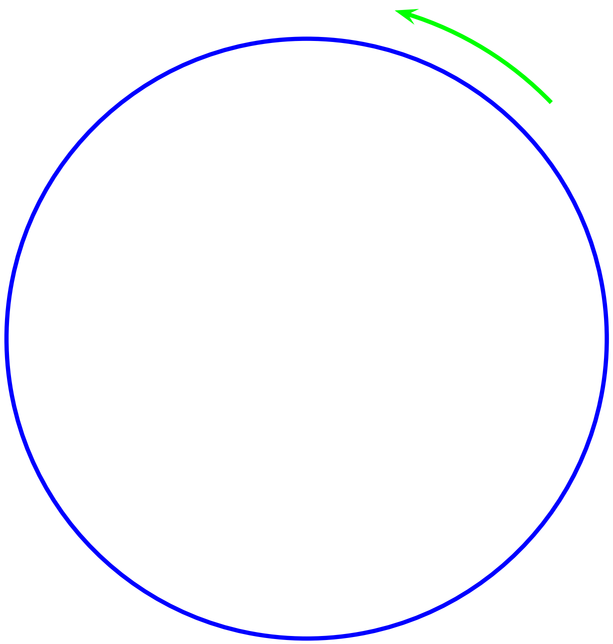

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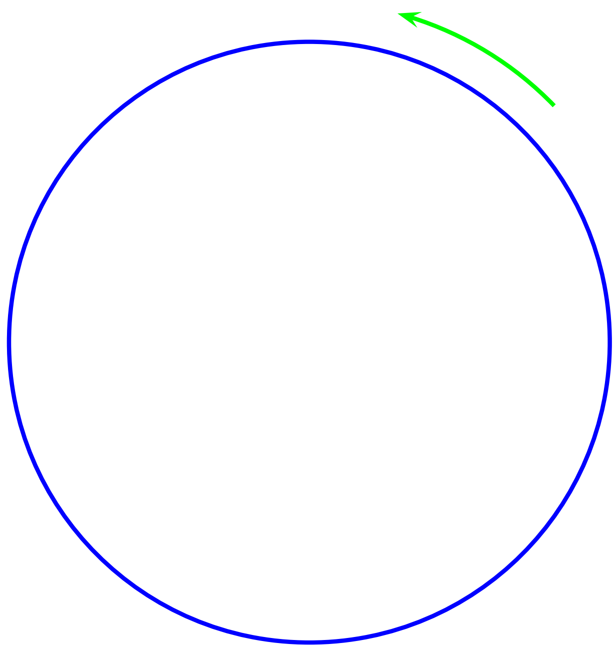

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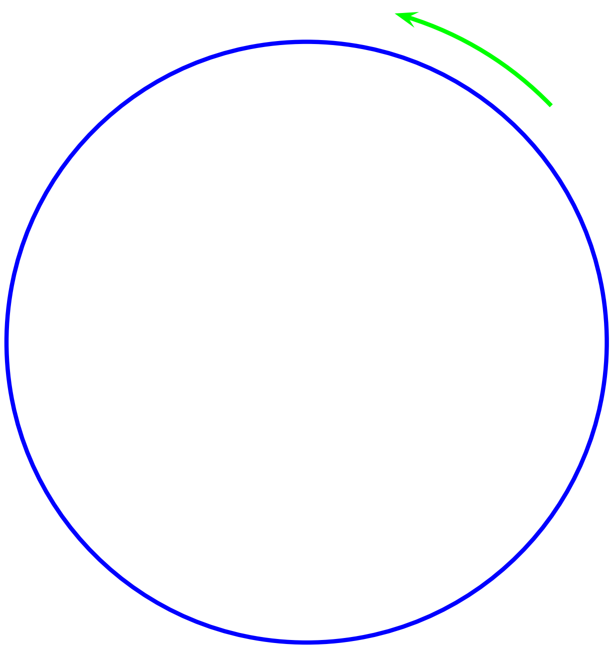

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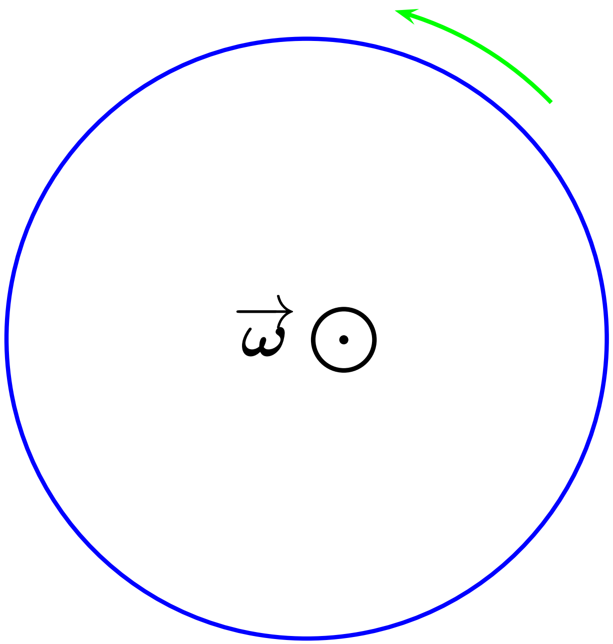

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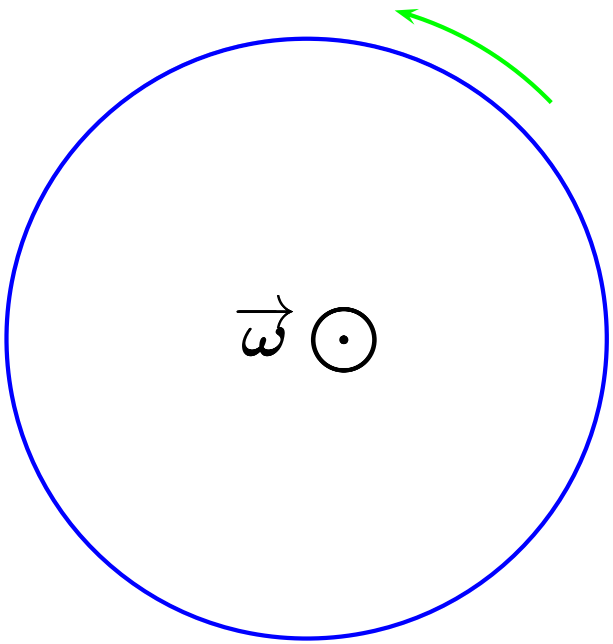


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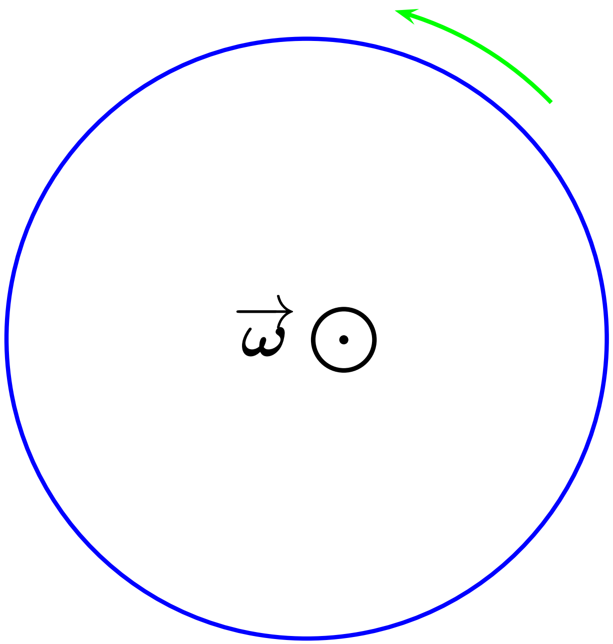


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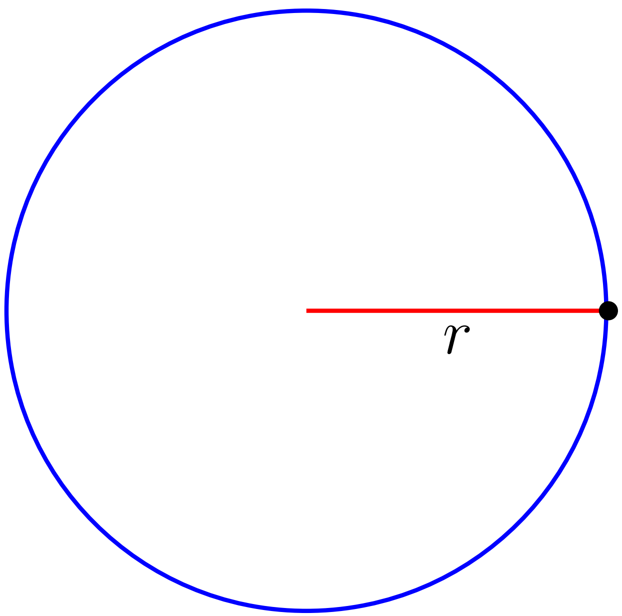

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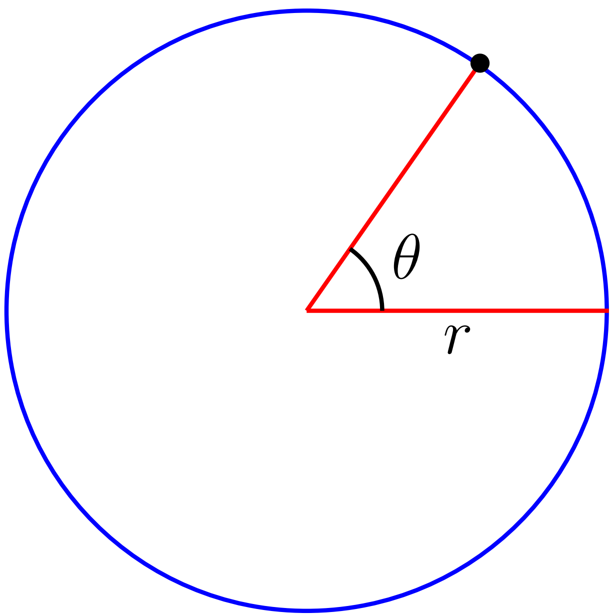

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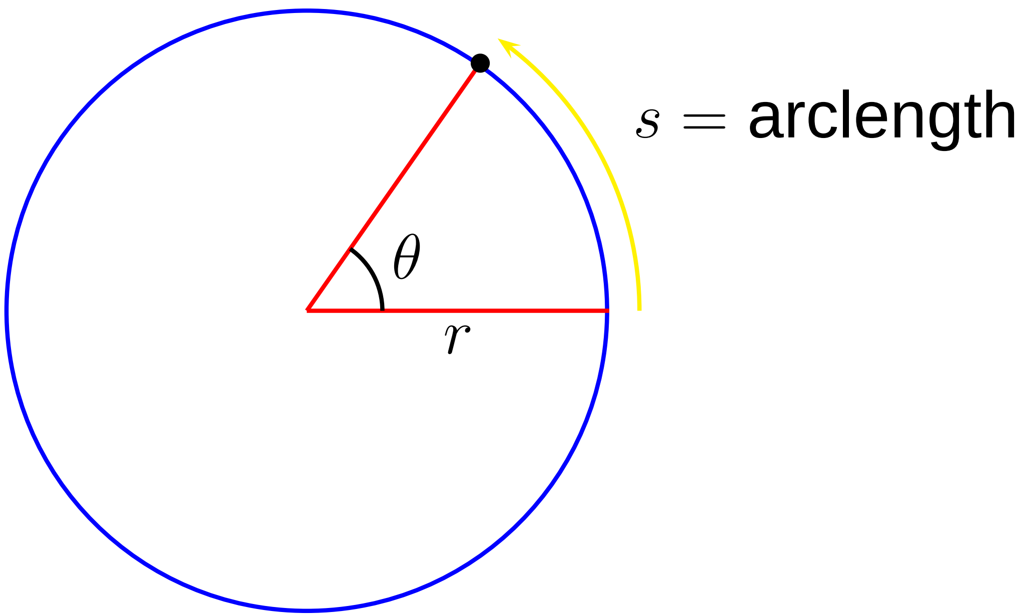

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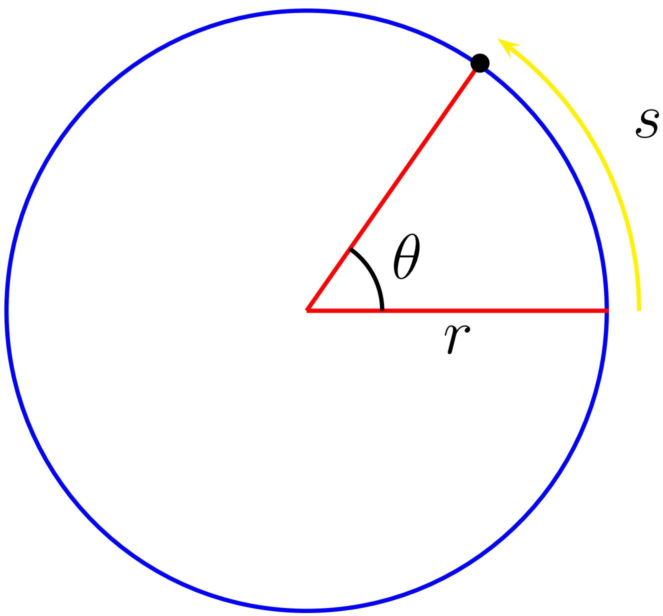


$s =$ arclength

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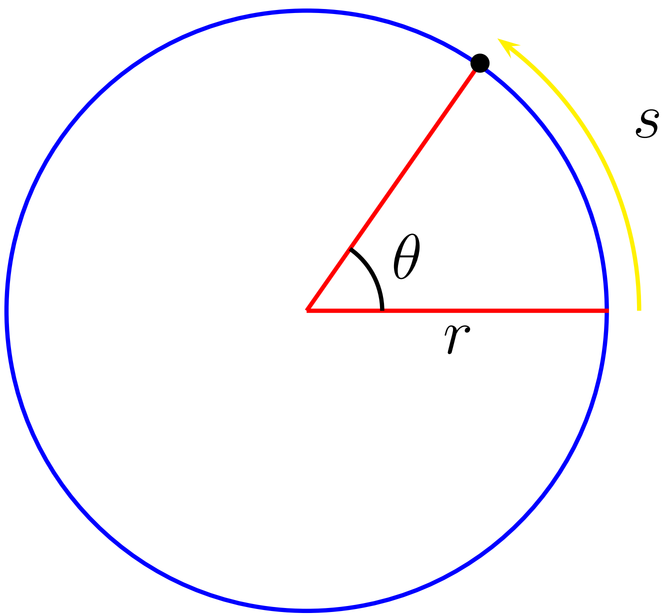


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$v = \frac{ds}{dt}$

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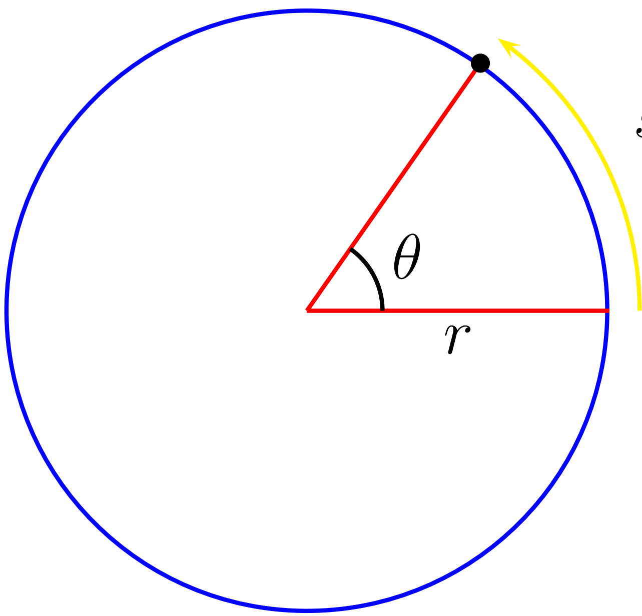


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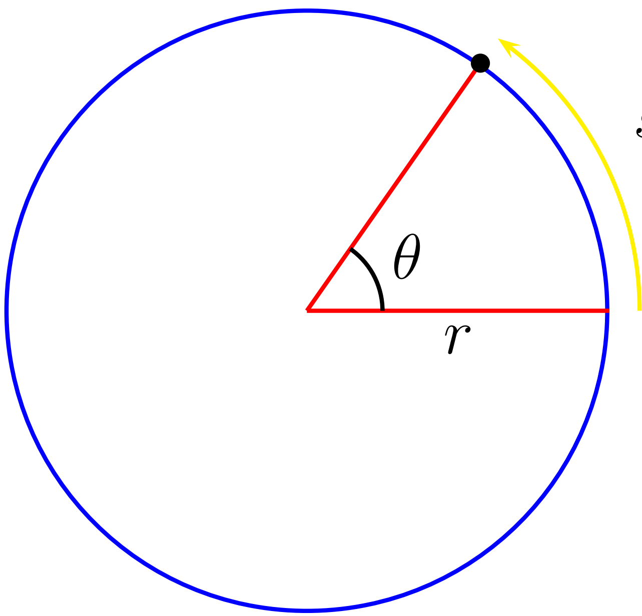


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$\frac{d}{dt}\left(s = r\theta\right)$

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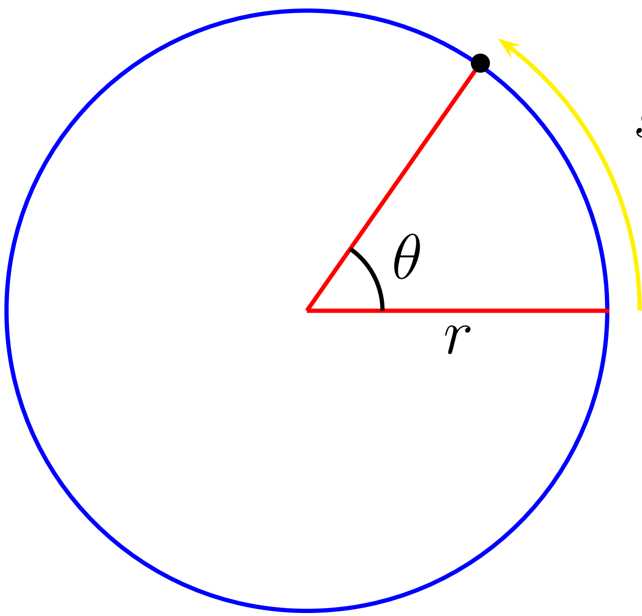


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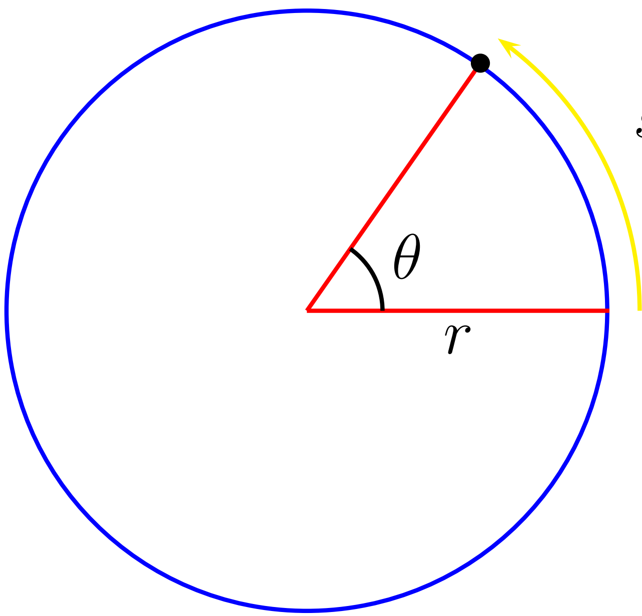


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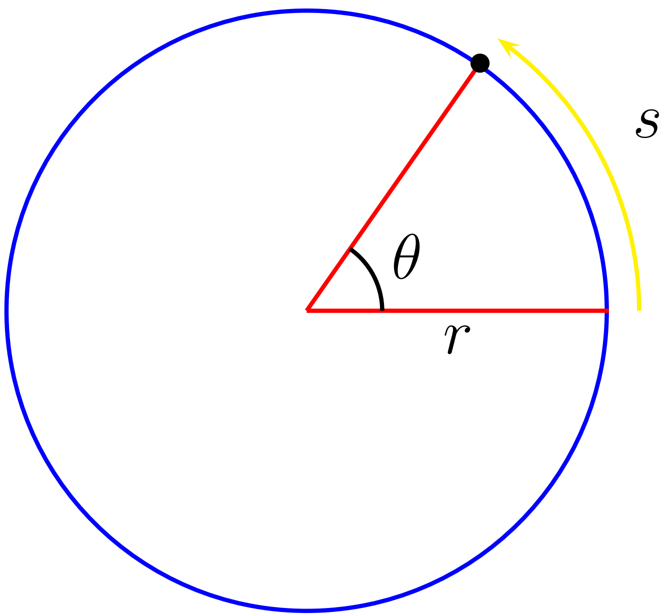


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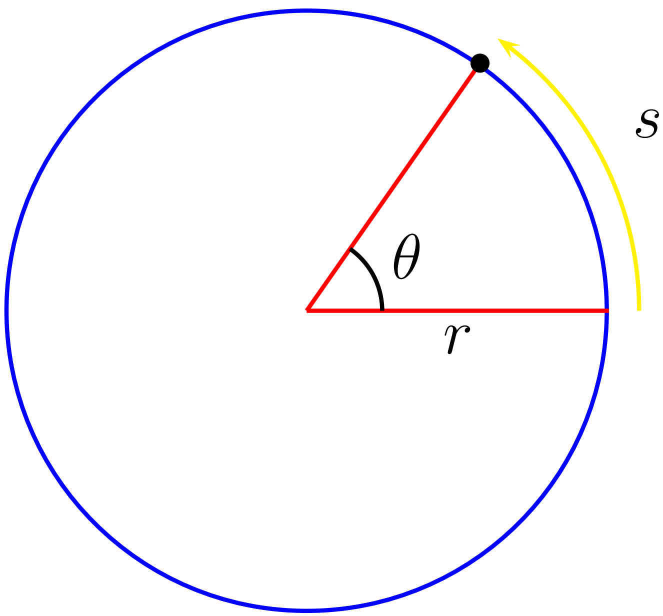


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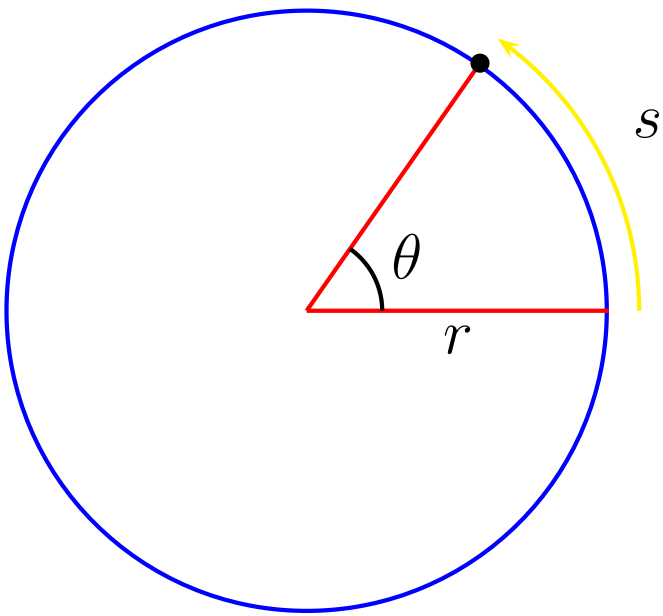


$s =$ arclength

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Units:

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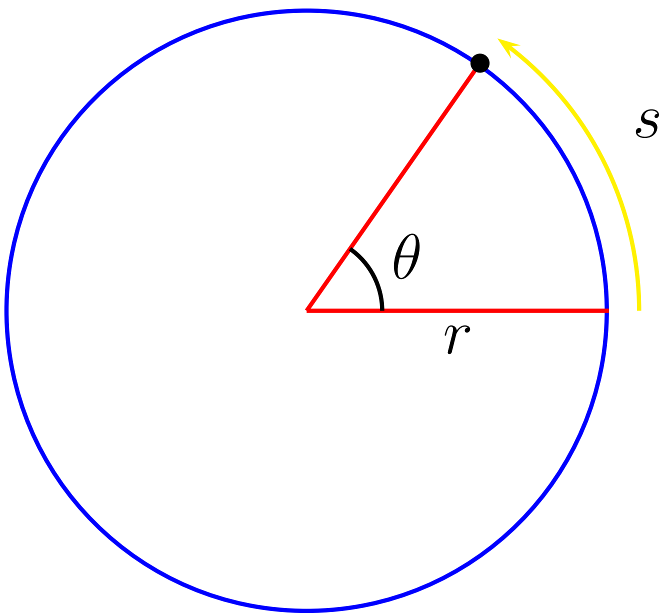


$s =$ arclength

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Units: $\frac{m \cdot rad}{s}$

# Relating Linear and Angular Velocity II

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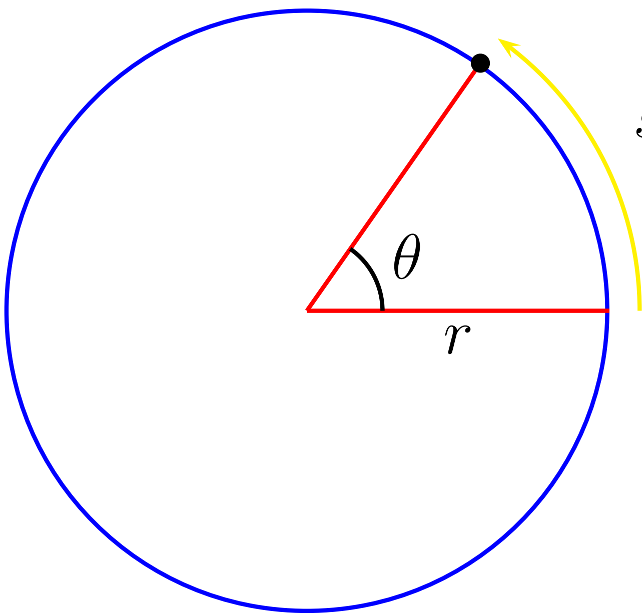


$s =$ arclength

$$\boxed{v = r\omega}$$

Units: $\frac{m \cdot rad}{s} = \frac{m \cdot r\not{a}d}{s}$

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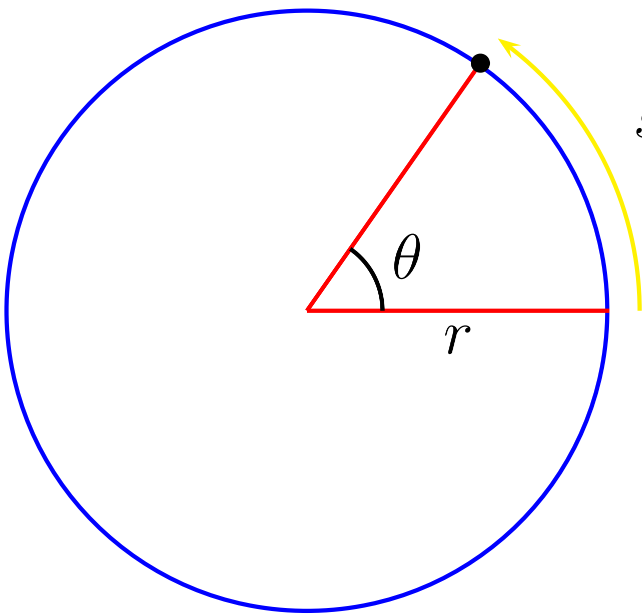


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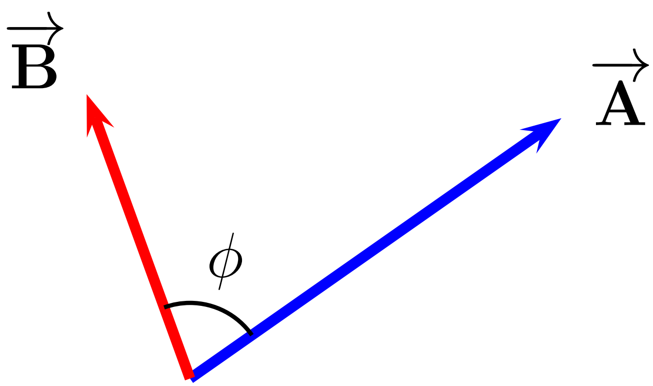

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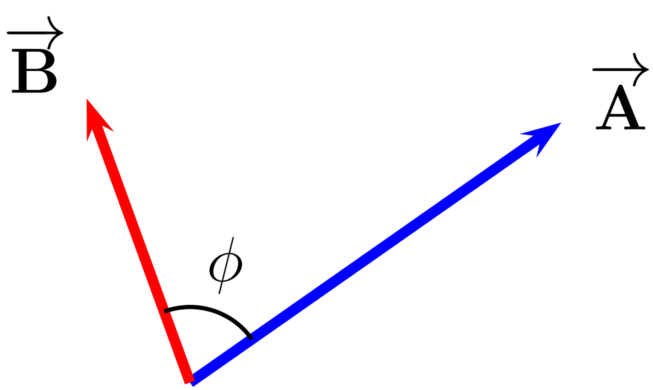


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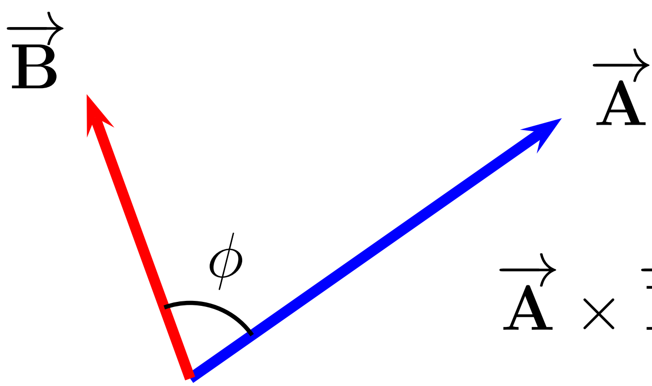


$$\left|\overrightarrow{\mathbf{A}} \times \overrightarrow{\mathbf{B}}\right| = AB\sin\phi$$

$\overrightarrow{\mathbf{A}} \times \overrightarrow{\mathbf{B}}$ is perpendicular to both $\overrightarrow{\mathbf{A}}$ and $\overrightarrow{\mathbf{B}}$

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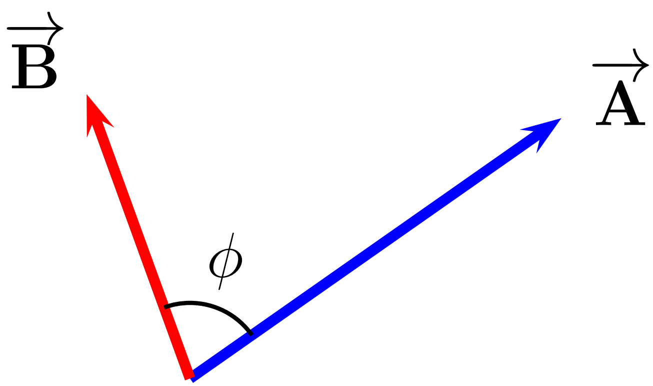
Another Right-Hand-Rule (RHR) gives direction:



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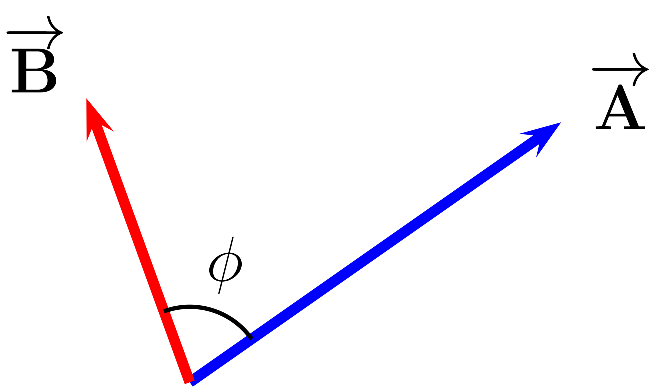


Take the fingers of the right hand and “sweep" $\overrightarrow{\mathbf{A}}$ into $\overrightarrow{\mathbf{B}}$, *i.e*, curl fingers from $\overrightarrow{\mathbf{A}}$ toward $\overrightarrow{\mathbf{B}}$ (using smaller angle). Extended thumb points in direction of cross product

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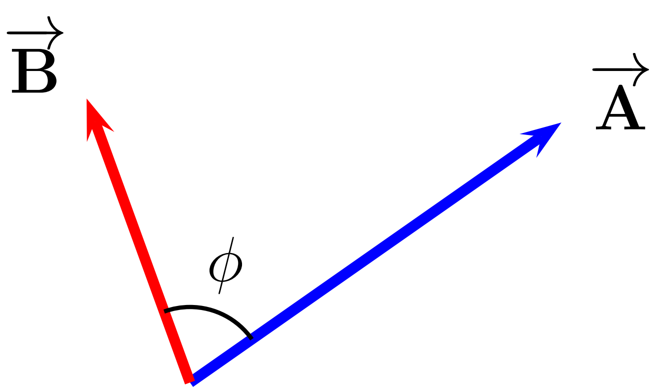


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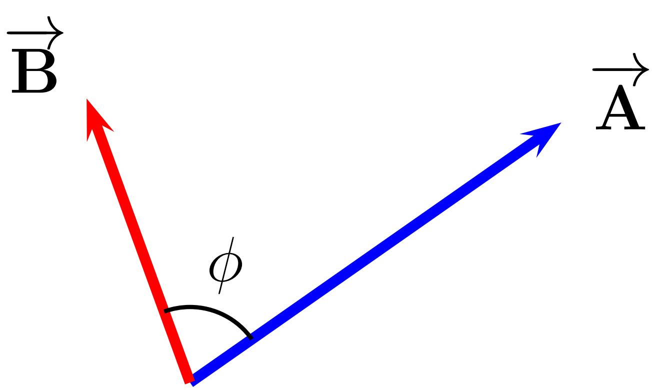


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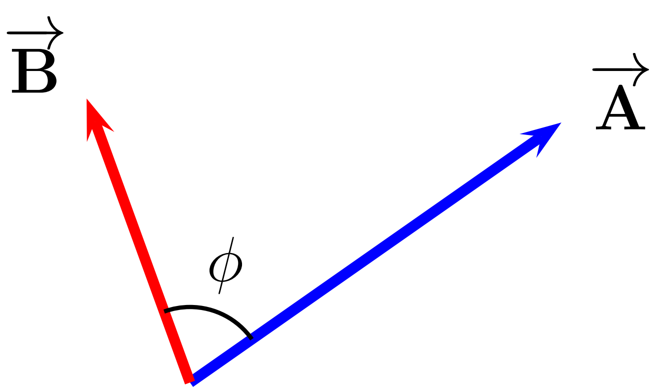


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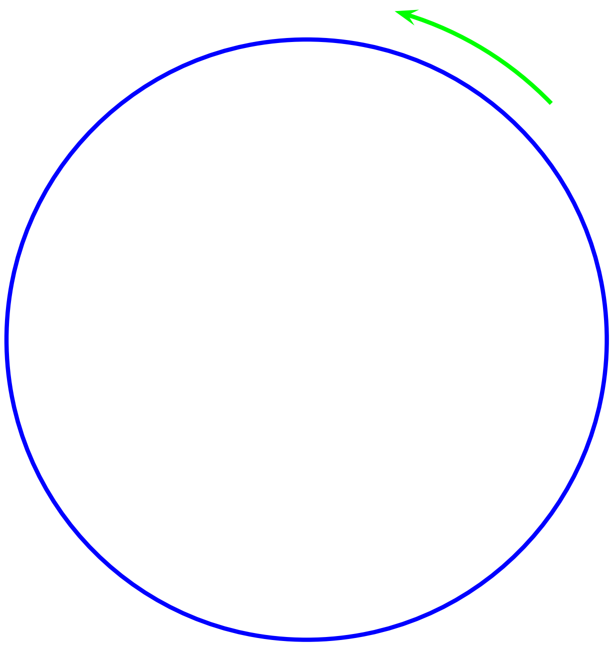
# Linear and Angular Velocities



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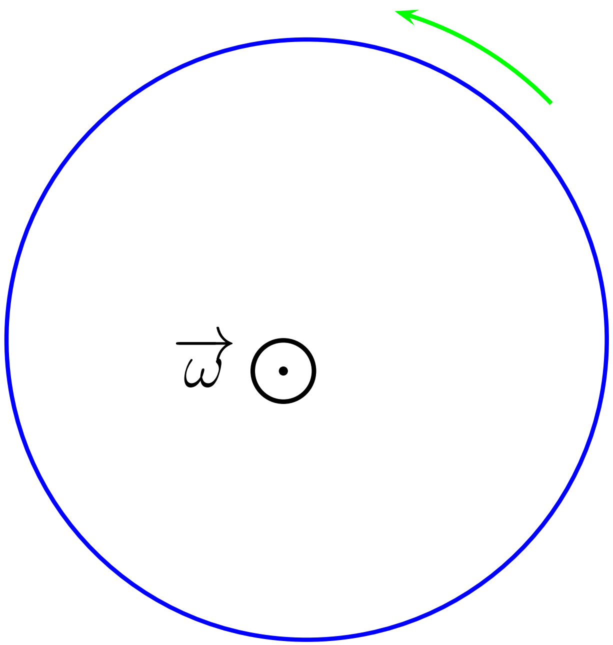

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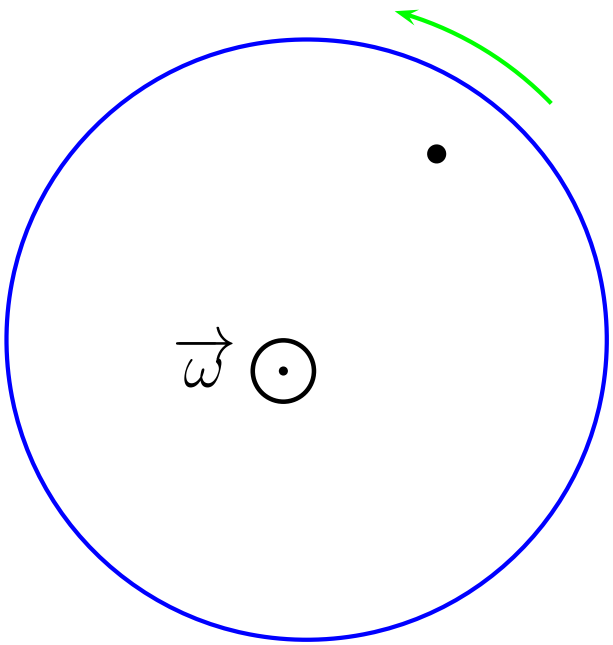

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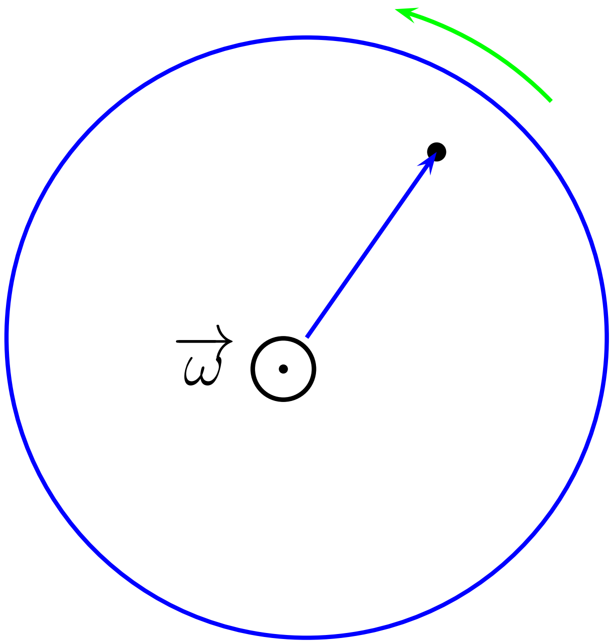

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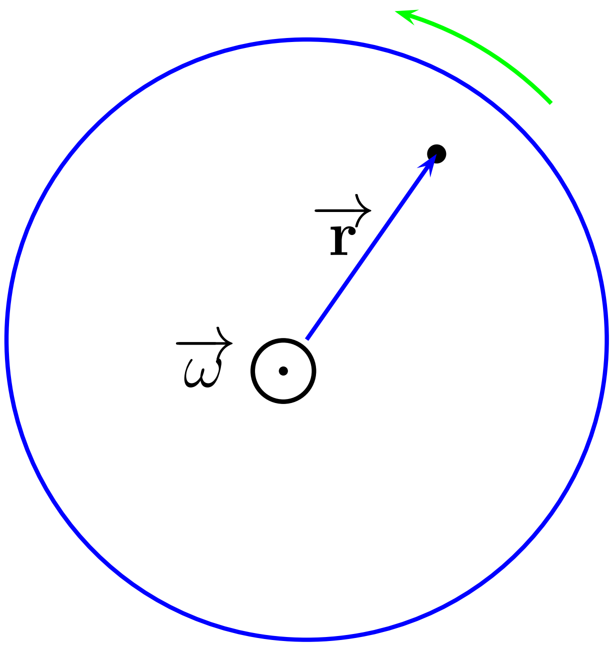

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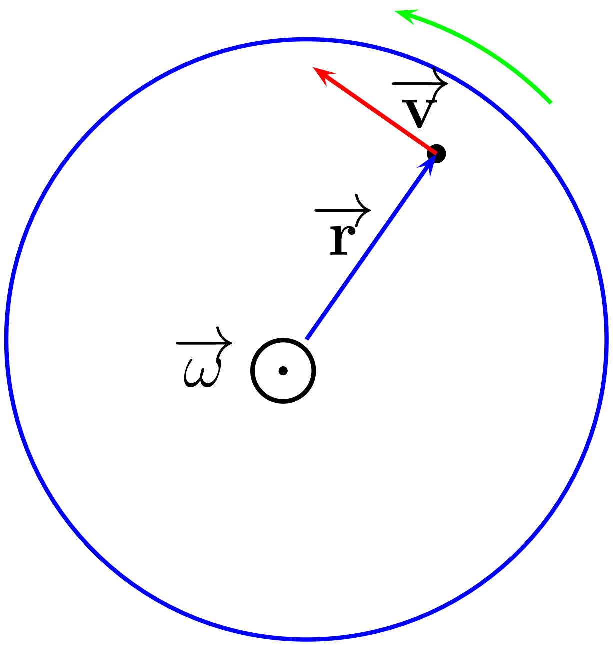

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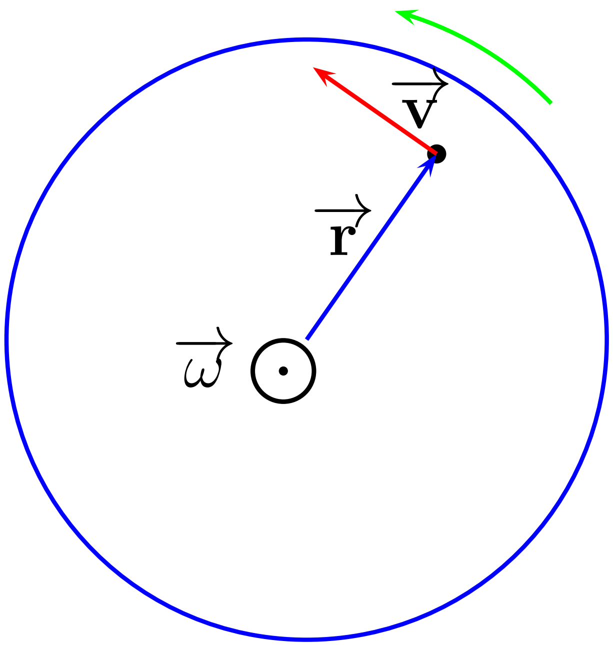
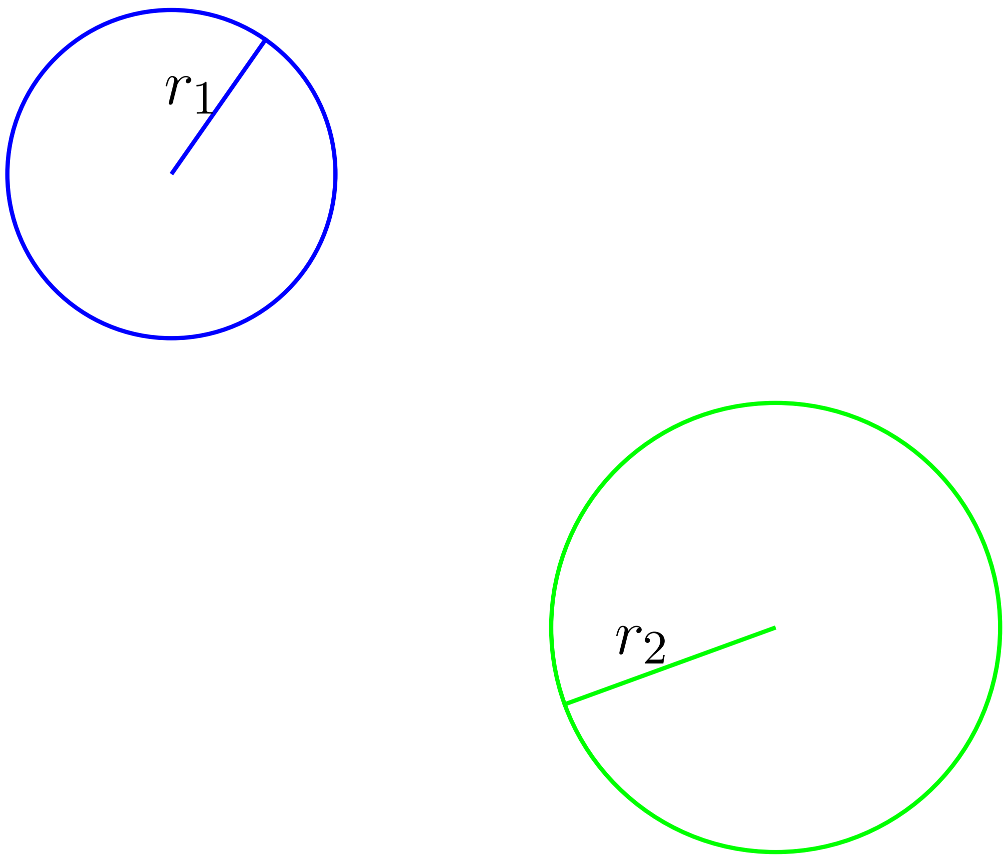



$$\vec{\mathbf{v}} = \vec{\omega} \times \vec{\mathbf{r}}$$

# Connected Rotating Objects



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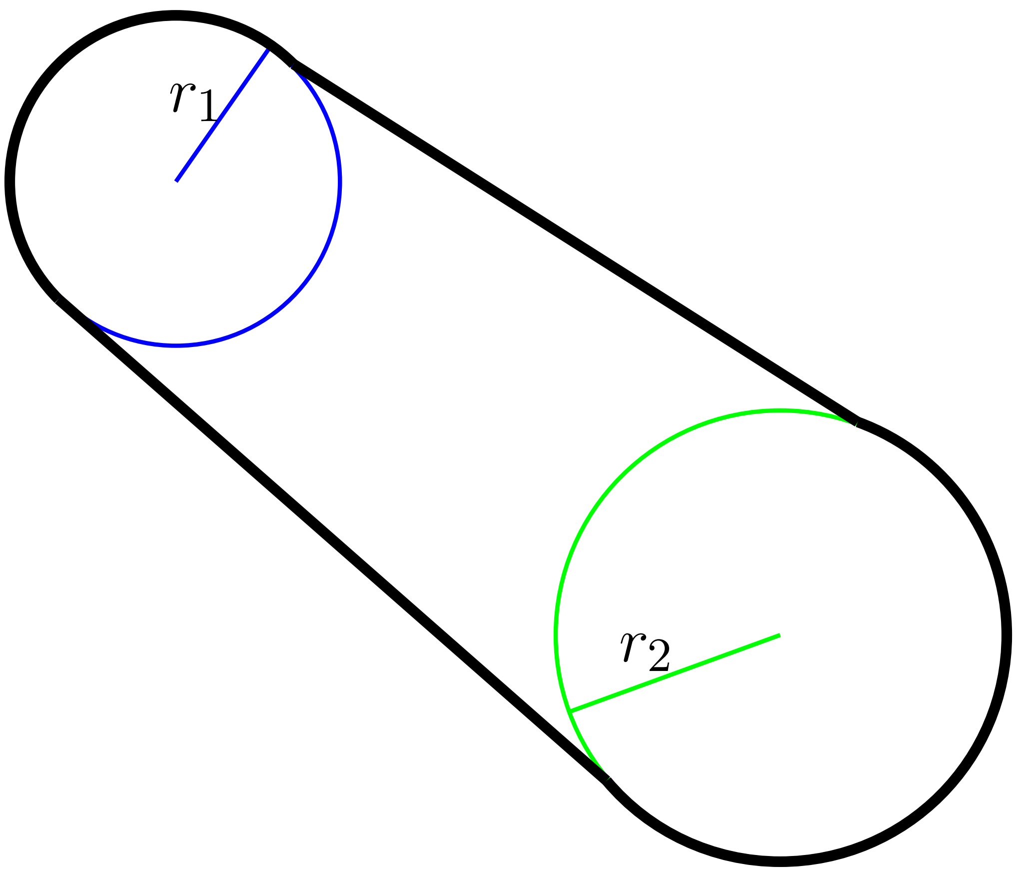

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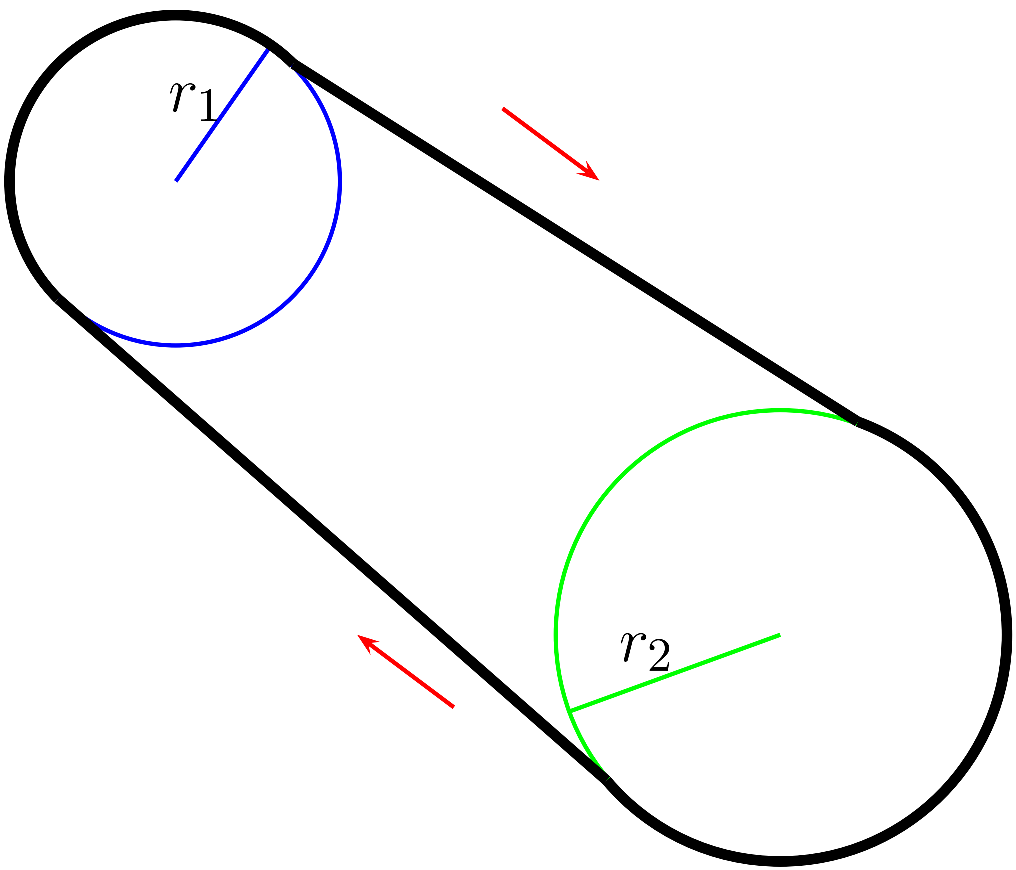

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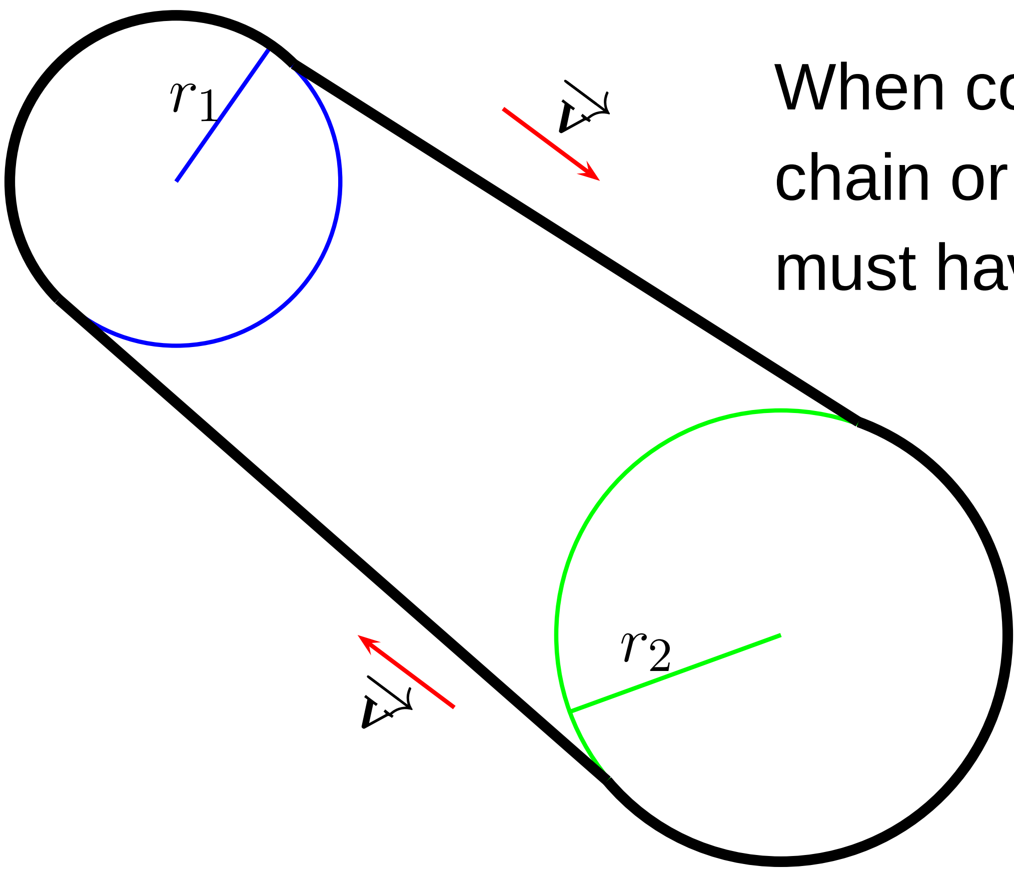


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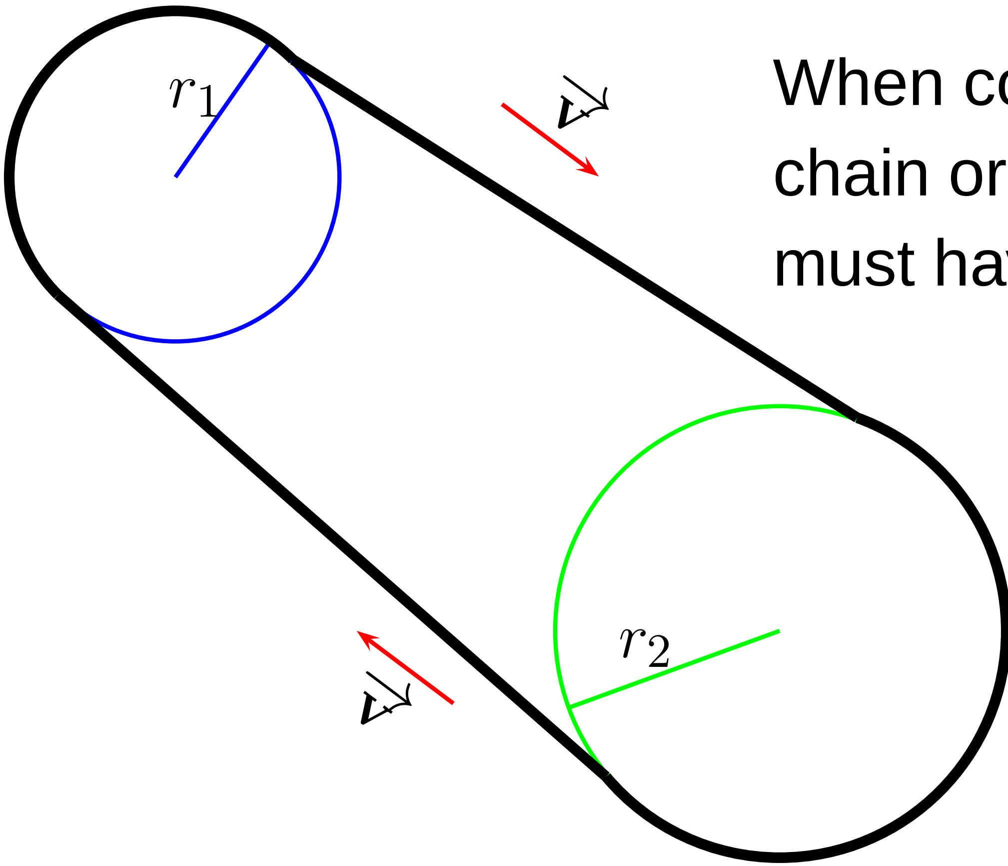


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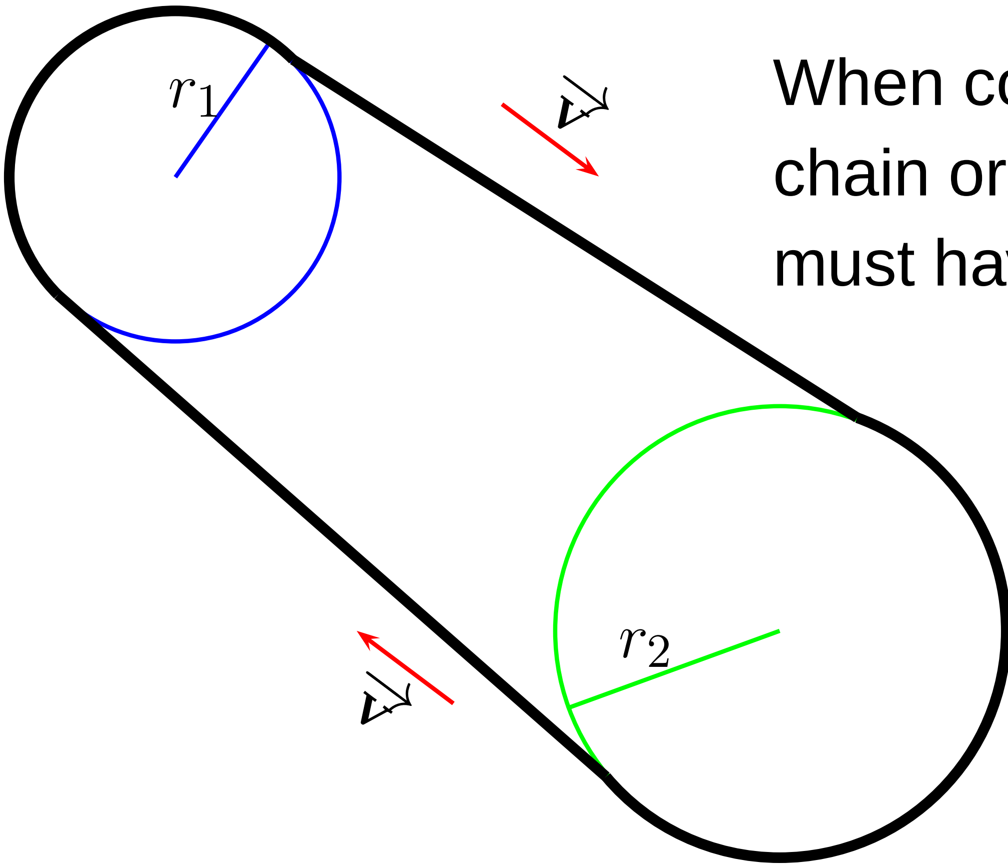


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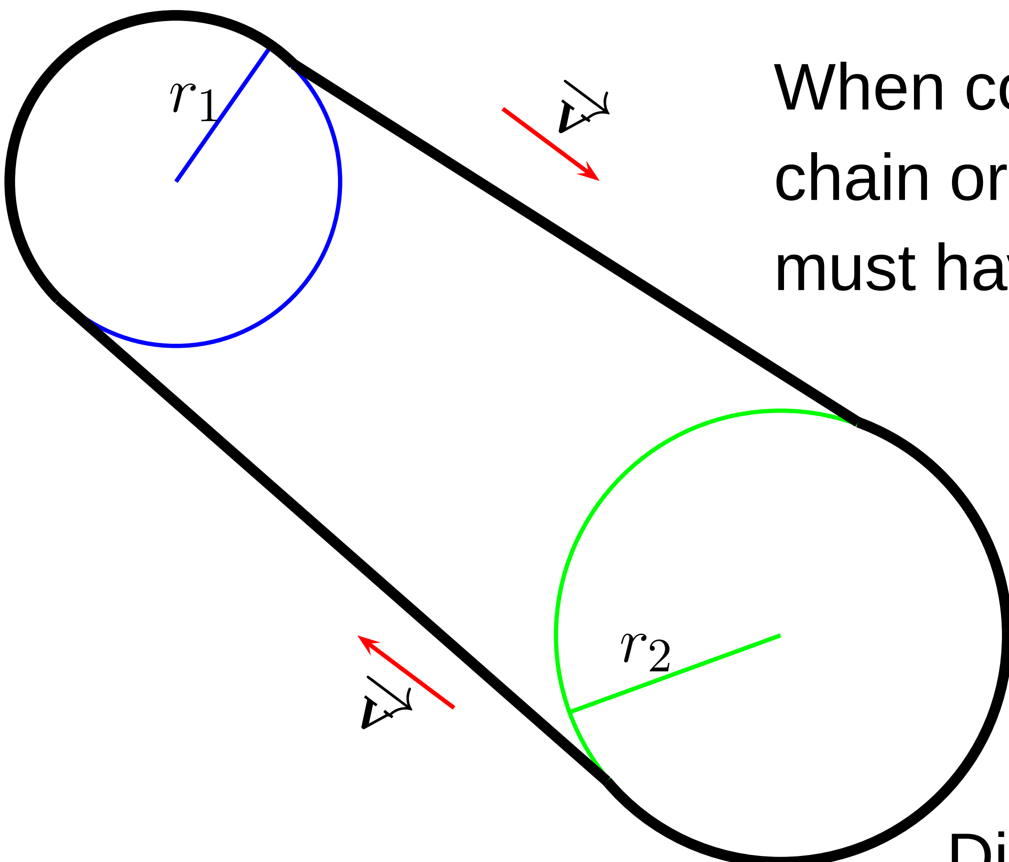


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Different Angular Velocities