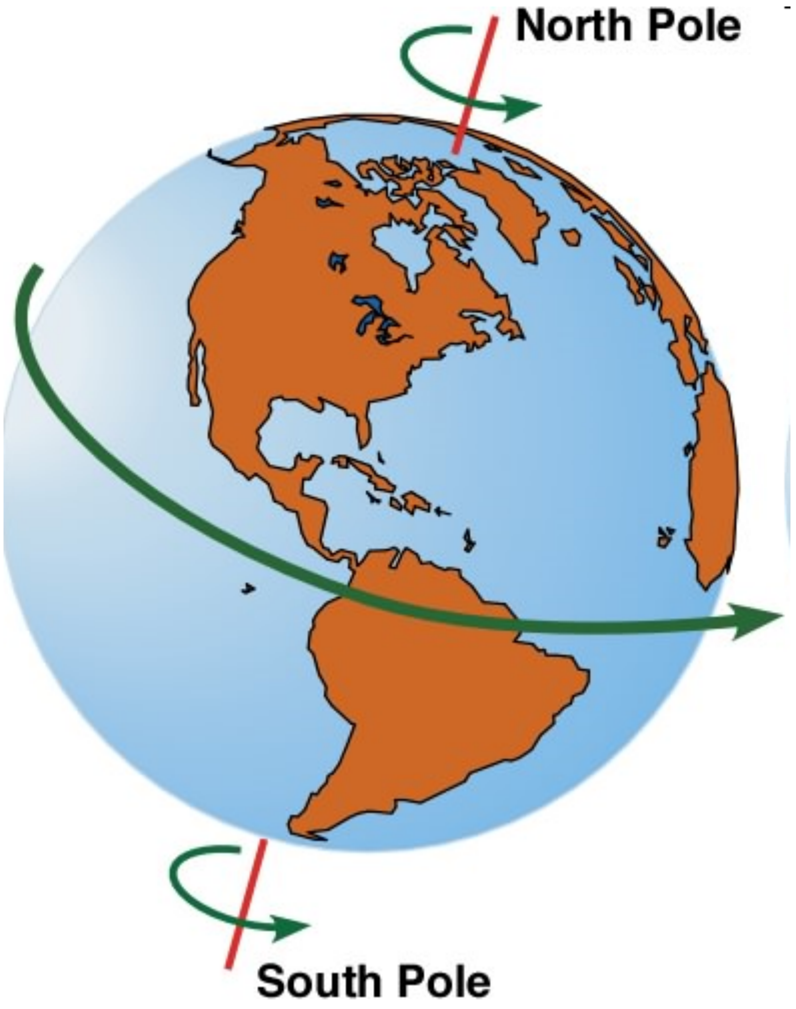
For the fastest ride on a merry-go-round, you should ride on the:

A. Inside
B. Middle
C. Outside
D. You’ll go the same speed everywhere

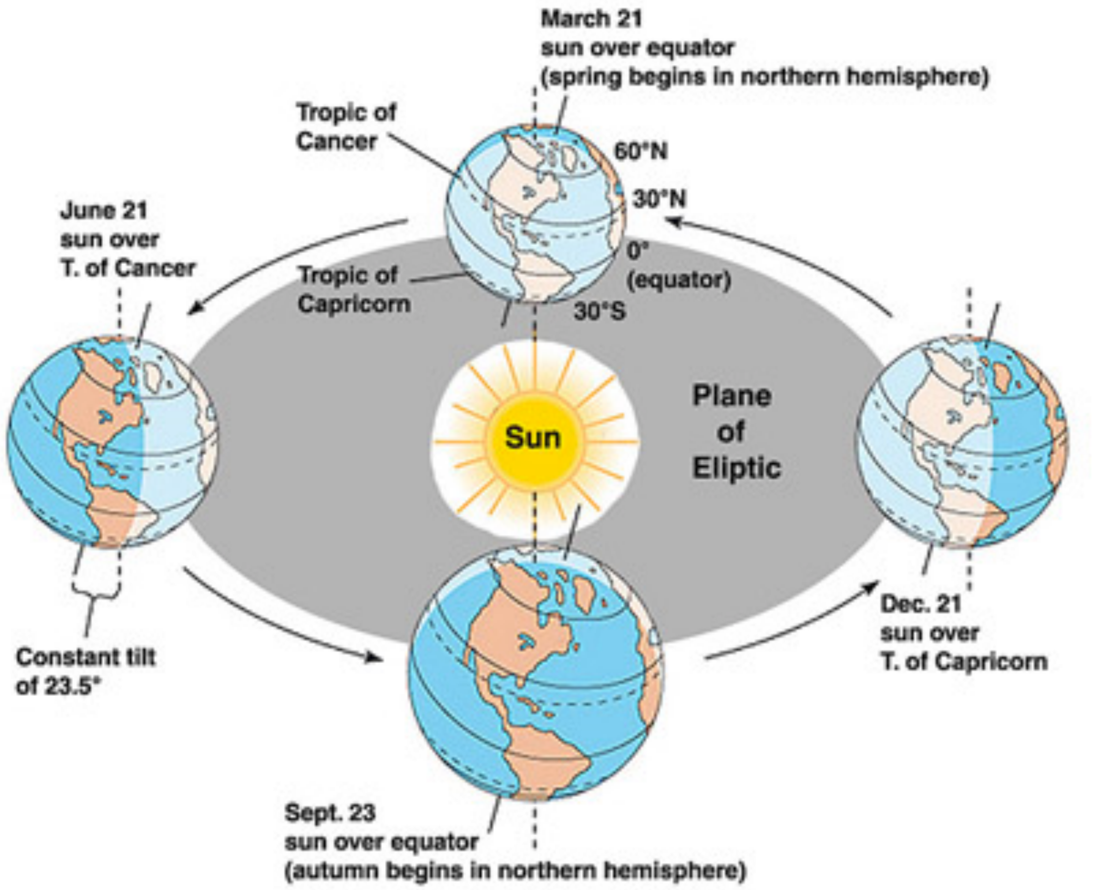
Circular Motion

pc: Ken Christison

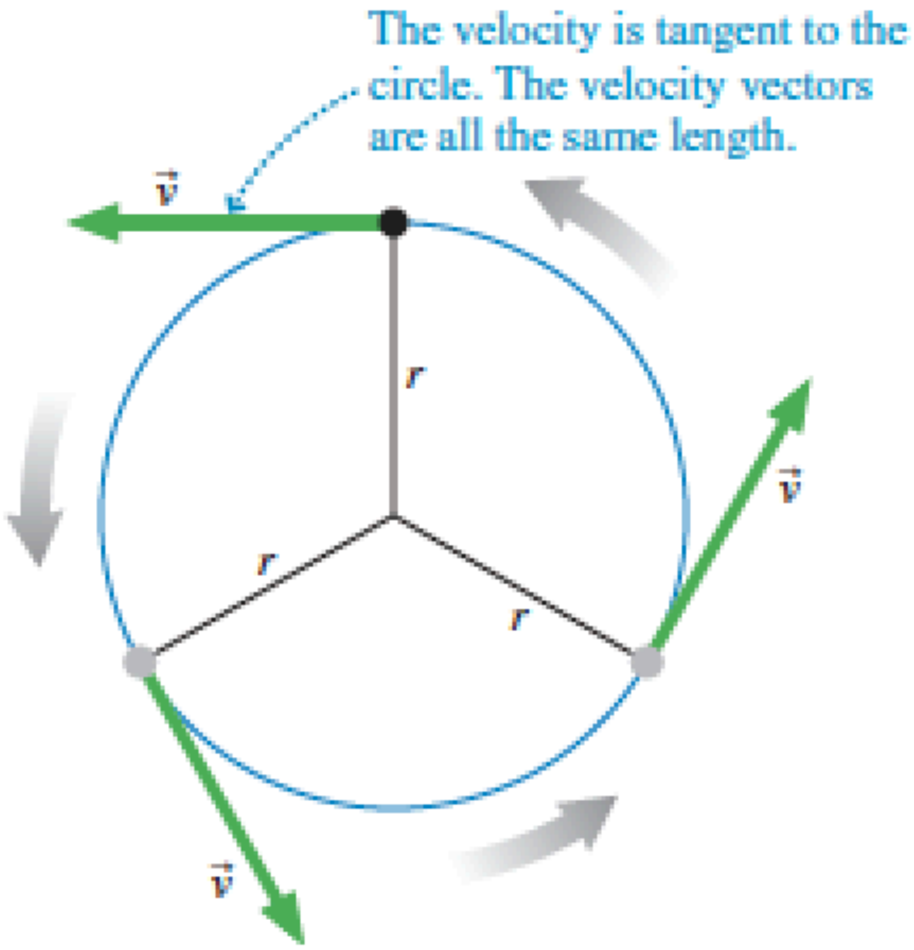
Rotation: motion or spin on an *internal* axis



Revolution: motion or spin on an *external* axis

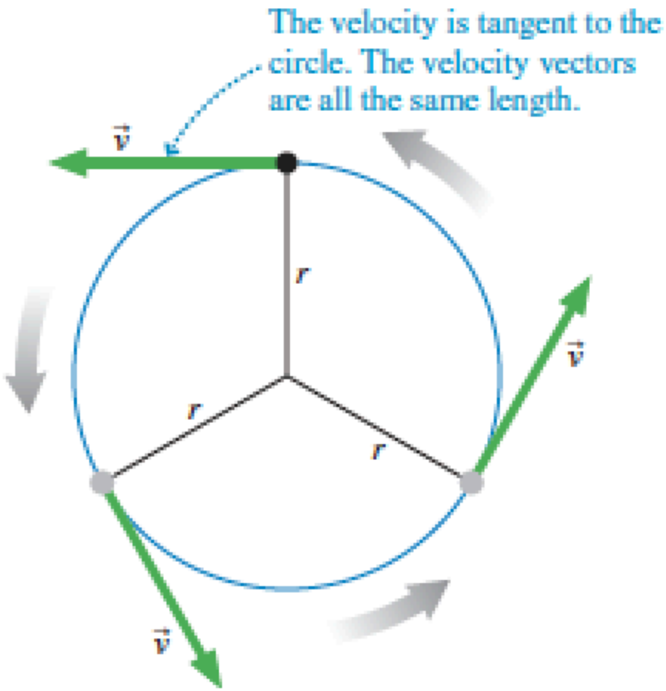


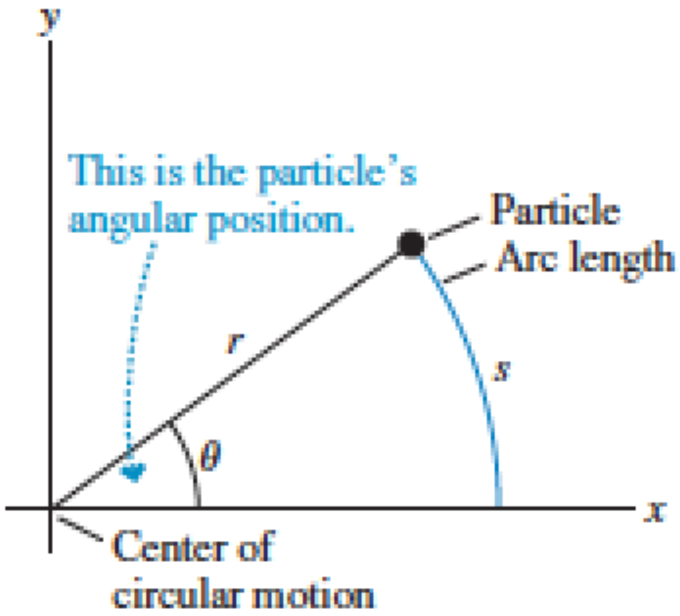
- Consider a particle moving at constant speed in a circle.
  - I.e. a satellite in orbit, a ball at the end of a string, an object on the side of a rotating wheel.
- This particle is in **uniform circular motion**: *v* is the same magnitude and always *tangent* to the edge of the circle, so *direction* is always changing



Some vocab:

- **Radial** – behavior toward and away from the center of the circle
- **Angular/rotational** – behavior measured in reference to the axis of revolution/rotation.
- **Tangential** – behavior along the edge of the circle
  - *v* is the tangential velocity (v_t)
  - May also see "**linear**"

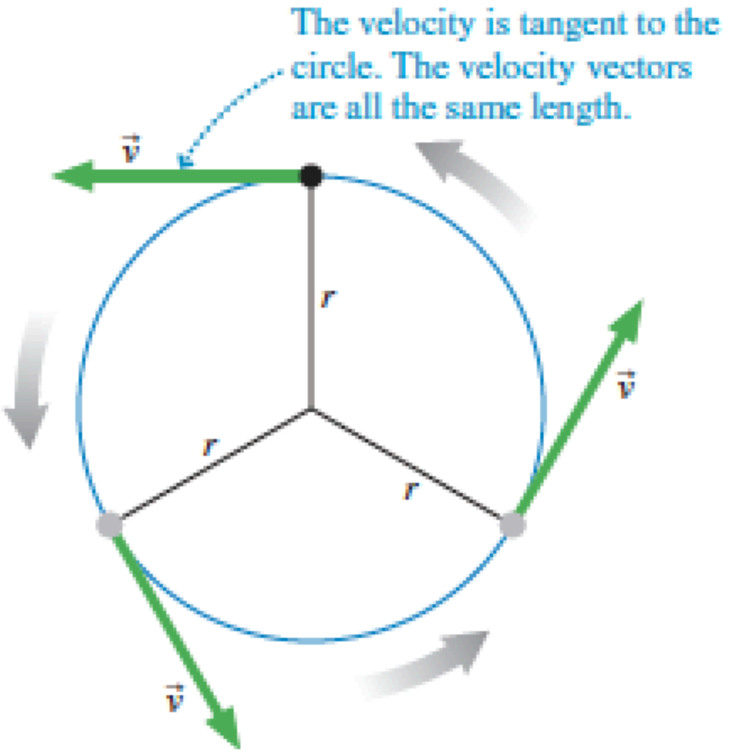




How do we figure out tangential speed (*v*)?

Method 1:

- Time to go once around the circle is called **period (T).**
- ***v* = distance traveled / time**
- $v = 2 \pi r / T$
  - 1 circumference /1 period

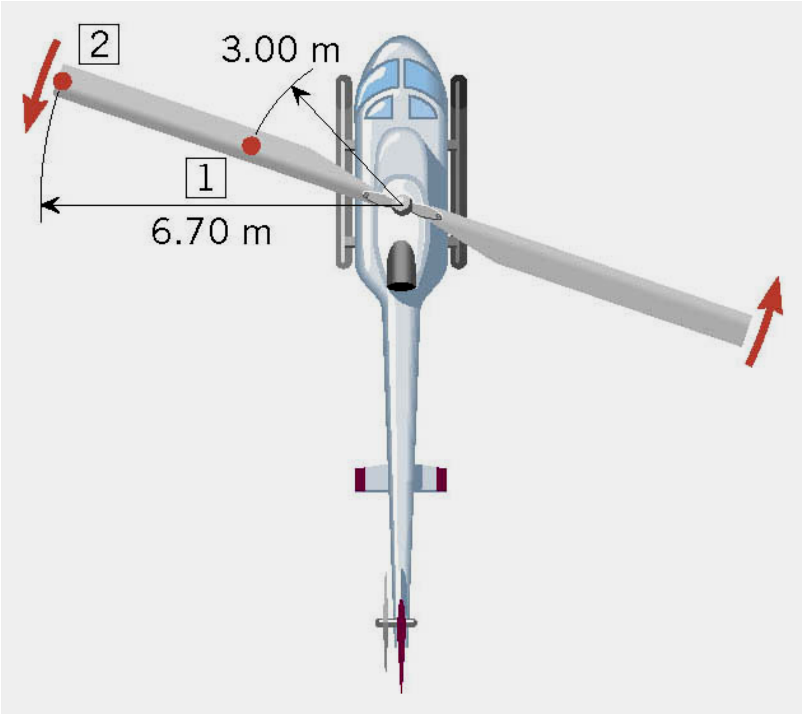


How do we figure out tangential speed (*v*)?

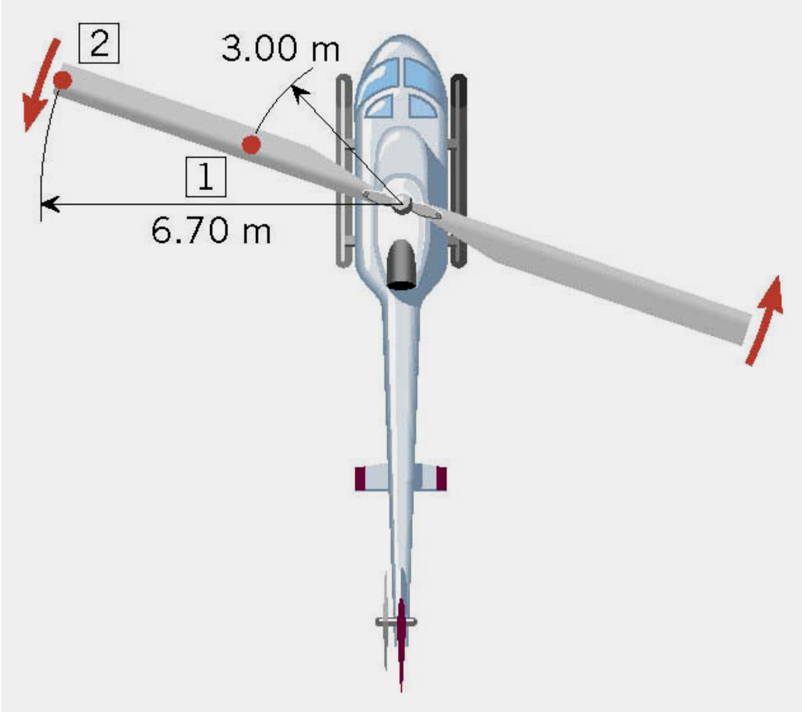
Method 2:

- Rotational or angular speed
- **Frequency *(f)*:** # revolutions/rotations per second
  - In your car, this is measured as rpm (rotations per minute)
  - Standard units: Hertz (Hz), 1 Hz = 1 rev/s
  - $f = 1/T$
  - $v = 2\pi r f$

All parts of a rigid merry-go-round rotate about their axes in the same amount of time, so they have the same rotational speed



A helicopter blade takes 0.154 seconds for one rotation (cycle). For point 2 on the blade, find the rotational/angular speed



Given: t = 0.154 s & 1 rotation (cycle)

Find the average rotational speed (in rps)

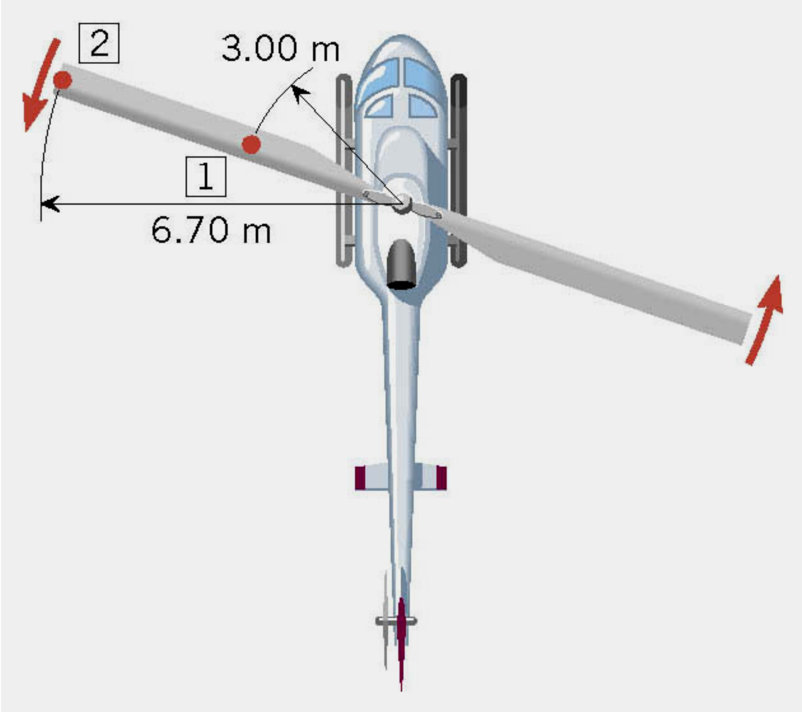
$$f = \frac{\text{rotations}}{\text{second}}$$

$$= \frac{1 \text{ rotation}}{0.154 \text{ seconds}}$$

= 6.49 rps = 6.49 cycles/second = 6.49 Hz

Would this be different at point 1? Why or why not?

No! All the points on the blade are spinning together. They all cover 1 rotation in 0.154 seconds. Angular/rotational speed isn't dependent on the radius

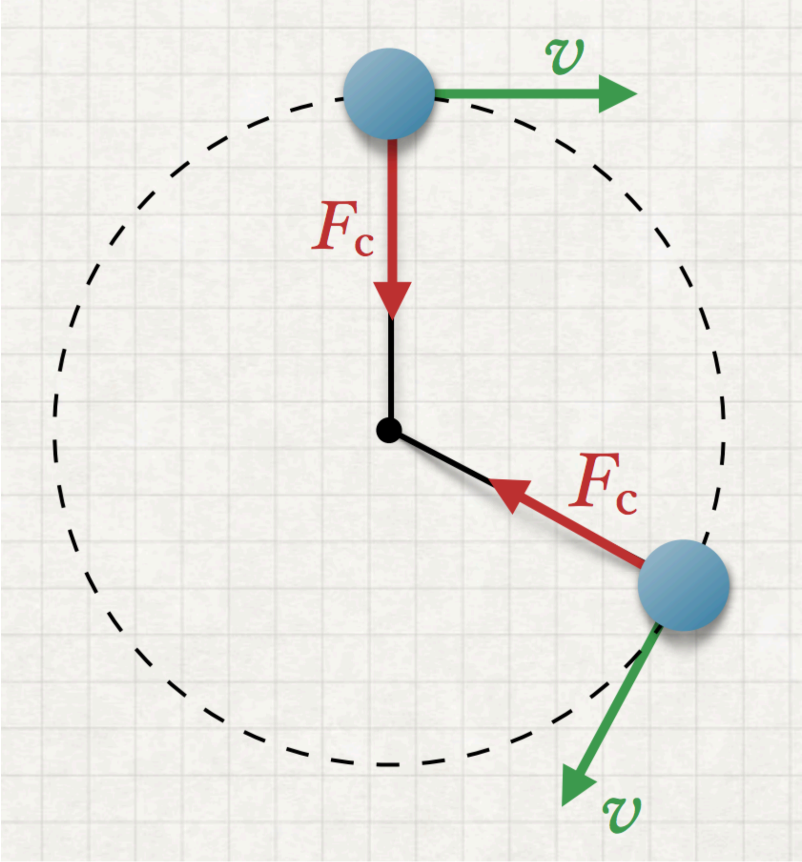


Now that you know the frequency is 6.5 Hz and the period is 0.154 seconds, calculate the tangential velocity at points 1 and 2 with your neighbors. Which is moving faster?

$v = 2\pi r f = 2\pi r/T$

2: 273 m/s vs. 122 m/s

Explain to your neighbor why Darth Vader has the fastest **tangential speed** at the outer edge of the merry-go-round, but his **angular speed** is the same no matter where he sits.

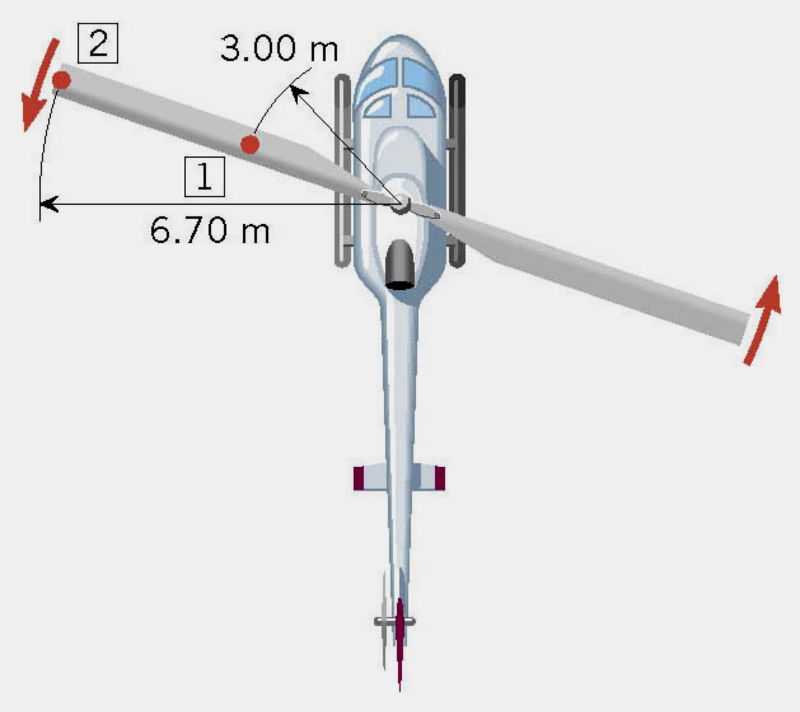


A spinning object's velocity is constantly changing direction. So it must be accelerating. How do we find that acceleration?

$$a_c = \frac{v_T^2}{r}$$

We call this acceleration "centripetal" meaning "center-seeking".

Proof: https://www.youtube.com/watch?v=TNX-Z6XR3gA



Point 2 on the helicopter blade has a tangential speed of 273 m/s. Find the centripetal acceleration at this point.

$$a_c = \frac{v_T^2}{r} = \frac{(273\ \text{m/s})^2}{6.70\ \text{m}} = 1.12 \times 10^4\ \text{m/s}^2$$