

# Rotationsmekanik

Jun 12, 2026, 2 min read

#fysik

#rotation

#kinematik

Kurs: F0006T Förkunskaper: Kinematik, Rotation

## 🔗 Påminnelse av Elfgren

Rita alltid bild när du använder **Arbete och kinetisk energi**.

En stel kropp är odeformerbar – den töjer eller böjer sig inte.

## 1. Vinkelhastighet och vinkelacceleration

Vinkeln definieras utifrån ett fixt koordinatsystem; kroppen roterar kring  $z$ -axeln.

Definition, vinkelhastighet:

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

Jämför med linjär hastighet:  $v = \frac{dx}{dt} = \dot{x}$ .

Definition, vinkelacceleration:

$$\alpha = \lim_{\Delta t \rightarrow 0} \frac{\Delta \omega}{\Delta t} = \frac{d\omega}{dt} = \dot{\omega} = \ddot{\theta}$$

Jämför med linjär acceleration:  $a = \frac{dv}{dt} = \dot{v} = \ddot{x}$ .

$$\alpha d\theta = \omega d\omega \quad (\text{Fysika FB2})$$

## 2. Konstant vinkelacceleration

$$\omega = \omega_0 + \alpha t \quad \theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2 \quad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$$

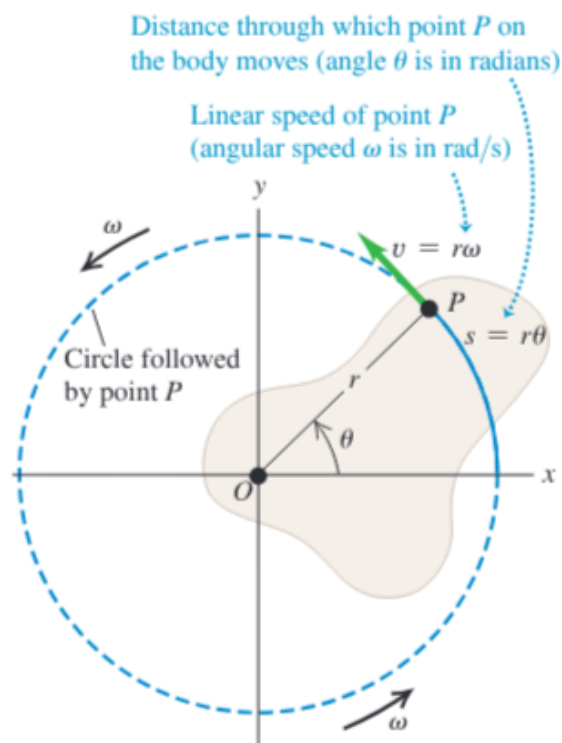
### ⚠ Förutsättningar

- Vinklar i radianer.
- $\alpha = \text{konstant}$  – annars fungerar inte formlerna.

## 3. Förhållande linjär-rotationskinematik

Varje punkt i en roterande stel kropp går i en cirkelbana runt rotationsaxeln. Elfgren kallar vinkeln  $\Delta\theta$ , båglängden  $\Delta S$  och radien  $r$ .

Figure 9.9 A rigid body rotating about a fixed axis through point  $O$ .



### EXAMPLE 9.4 Throwing a discus

WITH **VARIATION** PROBLEMS

An athlete whirls a discus in a circle of radius 80.0 cm. At a certain instant, the athlete is rotating at 10.0 rad/s and the angular speed is increasing at 50.0 rad/s<sup>2</sup>. For this instant, find the tangential and centripetal components of the acceleration of the discus and the magnitude of the acceleration.

**IDENTIFY and SET UP** We treat the discus as a particle traveling in a circular path (Fig. 9.12a), so we can use the ideas developed in this section. We are given  $r = 0.800$  m,  $\omega = 10.0$  rad/s, and  $\alpha = 50.0$  rad/s<sup>2</sup> (Fig. 9.12b). We'll use Eqs. (9.14) and (9.15) to find the acceleration components  $a_{\text{tan}}$  and  $a_{\text{rad}}$ , respectively; we'll then find the magnitude  $a$  by using the Pythagorean theorem.

**EXECUTE** From Eqs. (9.14) and (9.15),

$$a_{\text{tan}} = r\alpha = (0.800 \text{ m})(50.0 \text{ rad/s}^2) = 40.0 \text{ m/s}^2$$

$$a_{\text{rad}} = \omega^2 r = (10.0 \text{ rad/s})^2(0.800 \text{ m}) = 80.0 \text{ m/s}^2$$

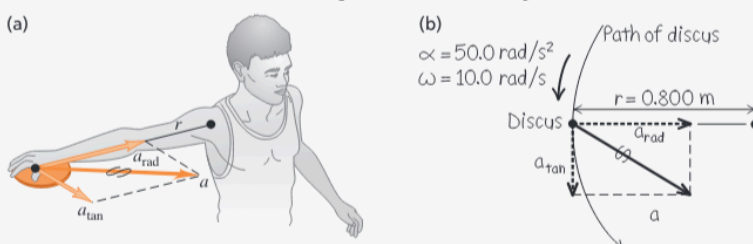
Then

$$a = \sqrt{a_{\text{tan}}^2 + a_{\text{rad}}^2} = 89.4 \text{ m/s}^2$$

**EVALUATE** Note that we dropped the unit "radian" from our results for  $a_{\text{tan}}$ ,  $a_{\text{rad}}$ , and  $a$ . We can do this because "radian" is a dimensionless quantity. Can you show that if the angular speed doubles to 20.0 rad/s while  $\alpha$  remains the same, the acceleration magnitude  $a$  increases to 322 m/s<sup>2</sup>?

**KEYCONCEPT** Points on a rigid body have a *centripetal* (radial) acceleration component  $a_{\text{rad}} = \omega^2 r$  whenever the rigid body is rotating; they have a *tangential* acceleration component  $a_{\text{tan}} = r\alpha$  only if the angular speed  $\omega$  is changing. These two acceleration components are perpendicular, so you can use the Pythagorean theorem to relate them to the magnitude of the acceleration.

Figure 9.12 (a) Whirling a discus in a circle. (b) Our sketch showing the acceleration components for the discus.



Formelblad **FB2** (Fysika):

	Allmänt		Konstant vinkelacceleration			Båglängd:	
<b>Rotation</b>	$\omega = \frac{d\theta}{dt}$	$\alpha = \frac{d\omega}{dt}$	$\alpha \, d\theta = \omega \, d\omega$	$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$	$\omega = \omega_0 + \alpha t$	$\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$	$s = r \cdot \theta$

[FB2 – beteckningar >](#)

## Läsning

- Chapter 9 Rotation of Rigid Bodies
- Chapter 10 Dynamics of Rotational Motion

## Se även

- Rotation
- Newtons lagar

- Momentekvationen
  - Masströghetsmoment
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