Baseball Physics

curve balls video: https://www.youtube.com/watch?v=IkHN04M8-sQ


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video: YouTube by "Made the Cut" https://www.youtube.com/watch?v=IkHN04M8-sQ

Baseball Physics

1. projectile with **drag** (air resistance)
2. baseball (**drag** and **spin**)

Drag

$$\mathbf{F}_{\mathbf{drag}} = -b_1 v \hat{\mathbf{v}} - b_2 v^2 \hat{\mathbf{v}} + \ldots$$

$$\mathbf{F}_1 = -b_1 \mathbf{v}$$

$$\mathbf{F}_2 = -b_2 v \mathbf{v}$$

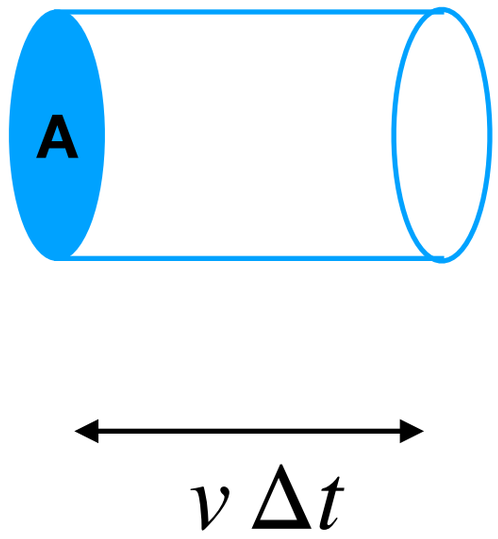
Quadratic drag

Drag

$$\mathbf{F}_{\text{drag}} = -b_1 v\hat{\mathbf{v}} - b_2 v^2\hat{\mathbf{v}} + \ldots$$

$$\mathbf{F}_1 = -b_1\mathbf{v}$$

$$\mathbf{F}_2 = -b_2 v\mathbf{v}$$



$$\Delta V = AL = Av\Delta t$$

$$\Delta m = \rho \Delta V$$ **displaced air mass**

$$\Delta p = \Delta m v = \rho A v^2 \Delta t$$ **accelerated to *v*
momentum change**

$$F_{\text{air}} = \dot{p} \approx \frac{\Delta p}{\Delta t} = \rho A v^2$$ **force (Newton's 2nd law)**

$$F_2 = -\rho A v^2$$ **force on disk
(Newton's 3rd law)**

$$b_2 \approx \rho A$$

Drag

$$\mathbf{F}_{\text{drag}} = -b_1 v\hat{\mathbf{v}} - b_2 v^2 \hat{\mathbf{v}} + \ldots$$

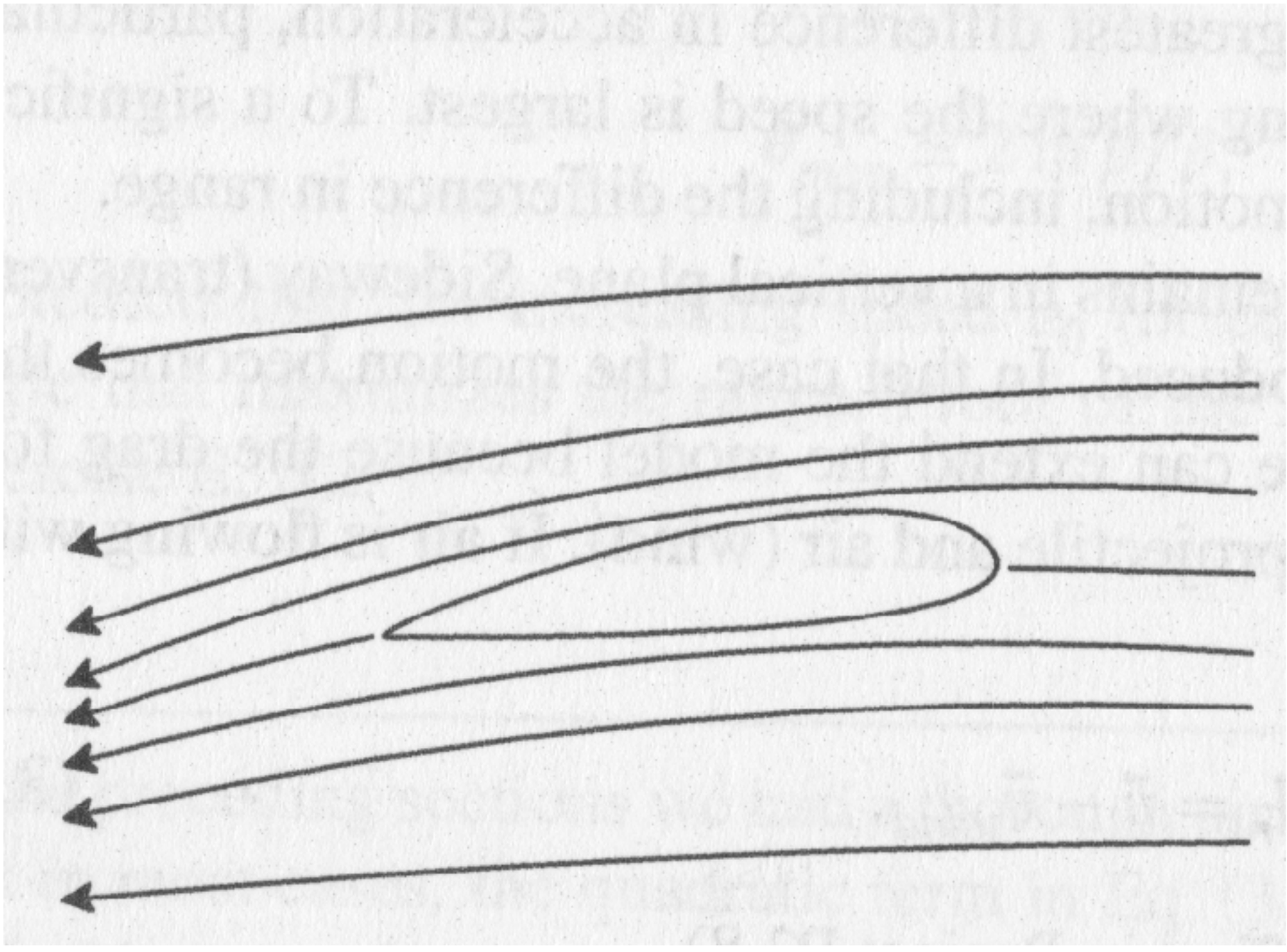
$$\mathbf{F}_2 = -b_2 v\mathbf{v}$$

$$b_2 \approx \rho A$$

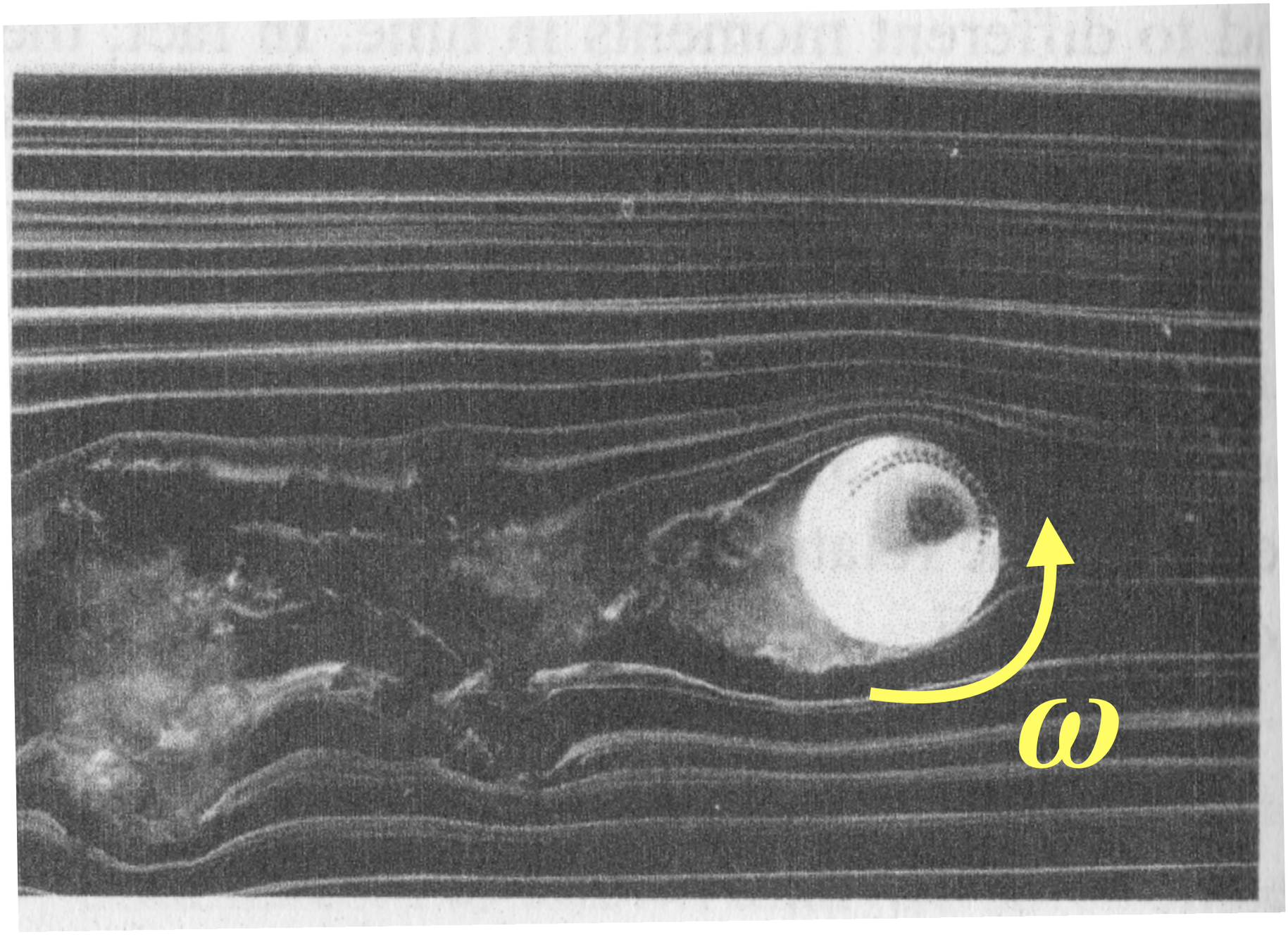
drag coefficient

$$b_2 = \frac{1}{2} C_d \rho A$$

Spin: Magnus force

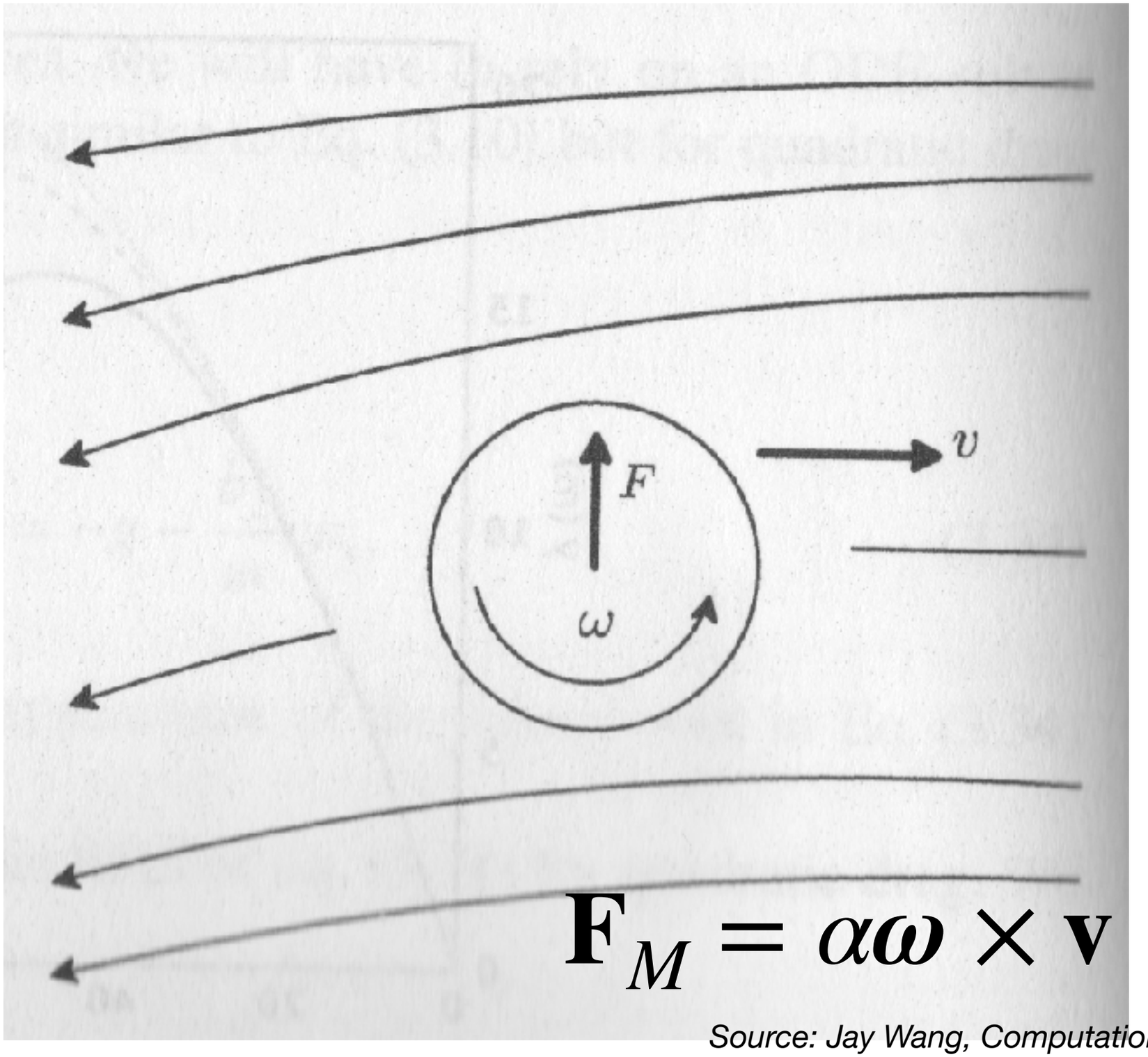


Source: Jay Wang, Computational Modelling, Wiley



Source: Jay Wang, Computational Modelling, Wiley

Magnus Effect



$$\mathbf{F}_M = \alpha\boldsymbol{\omega} \times \mathbf{v}$$

Source: Jay Wang, Computational Modelling, Wiley

Magnus force

$$\mathbf{F}_M = \alpha\ \boldsymbol{\omega} \times \mathbf{v}$$

$$v = \sqrt{\mathbf{v} \cdot \mathbf{v}}$$

$$S = \frac{r\omega}{v}$$ **spin parameter**

$$C_L = 0.62 \times S^{0.7}$$ **lift coefficient**

$$\alpha = \frac{1}{2} C_L \frac{\rho A r}{S}$$