Centrifugation

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Separation Processes

Sedimentation is driven by gravity and follows Stoke's law at low velocity

- Sedimentation separates solid particles dispersed in liquid
- **Stoke's law** describes flow around a sphere at low velocity (Re < 1)
  - $\boxed{v_\infty = \frac{(\rho_p - \rho_f)}{18\mu} D_p^2 g}$ for $\mathrm{Re} = \frac{D_p v_\infty \rho_f}{\mu} < 1$
    - v_∞ - terminal velocity
    - ρ_p - particle density
    - ρ_f - fluid density
    - μ - fluid viscosity
    - D_p - particle diameter
- Sedimentation is slow... How can we speed it up?

Centrifugation is driven by centrifugal force and also follows Stoke's law

- Centrifugation separates solid particles dispersed in liquid *faster*
- **Stoke's law** describes flow around a sphere at low velocity (Re < 1)
  - $\boxed{v_\infty = \frac{(\rho_p - \rho_f)}{18\mu} D_p^2 \omega^2 r}$ for $\mathrm{Re} = \frac{D_p v_\infty \rho_f}{\mu} < 1$
    - ω - angular velocity of centrifuge bowl
    - r - centrifuge bowl radius
- **G-force** normalizes centrifugal driving force by gravitational driving force
  - $\boxed{Z = \frac{\omega^2 r}{g}}$

Sigma factor compares performance of continuous centrifuges of the same type

- **Sigma factor** - effective area of a continuous centrifuge
  - $\boxed{\Sigma = \frac{\dot{V}}{2v_\infty}}$

- **Ex**. At small scale, cells can be centrifuged at $\Sigma_1 = 200$ and $\dot{V}_1 = 15\ \mathrm{mL/min}$. At large scale, cells can be centrifuged at $\Sigma_2 = 9000$ and $\dot{V}_2 = 700\ \mathrm{mL/min}$ at the same speed. The densities and viscosity are unchanged. Quantify the changed physical property.