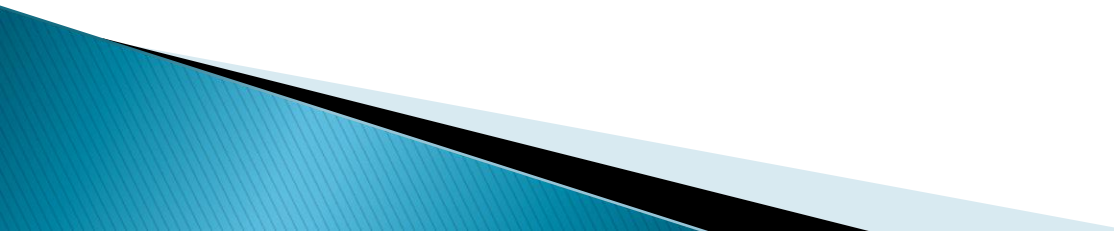


# Aerodynamický tunel

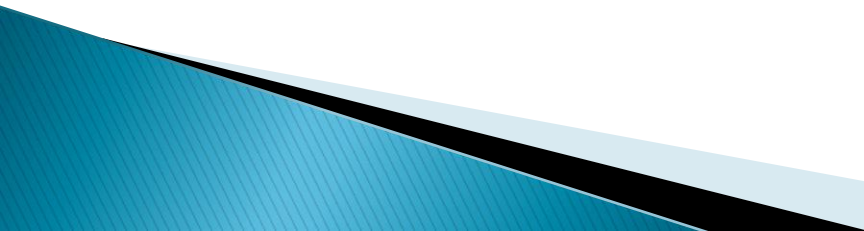
Vypracovali: Otta Hartvich  
Michal Farník  
Filip Širc

# Teorie

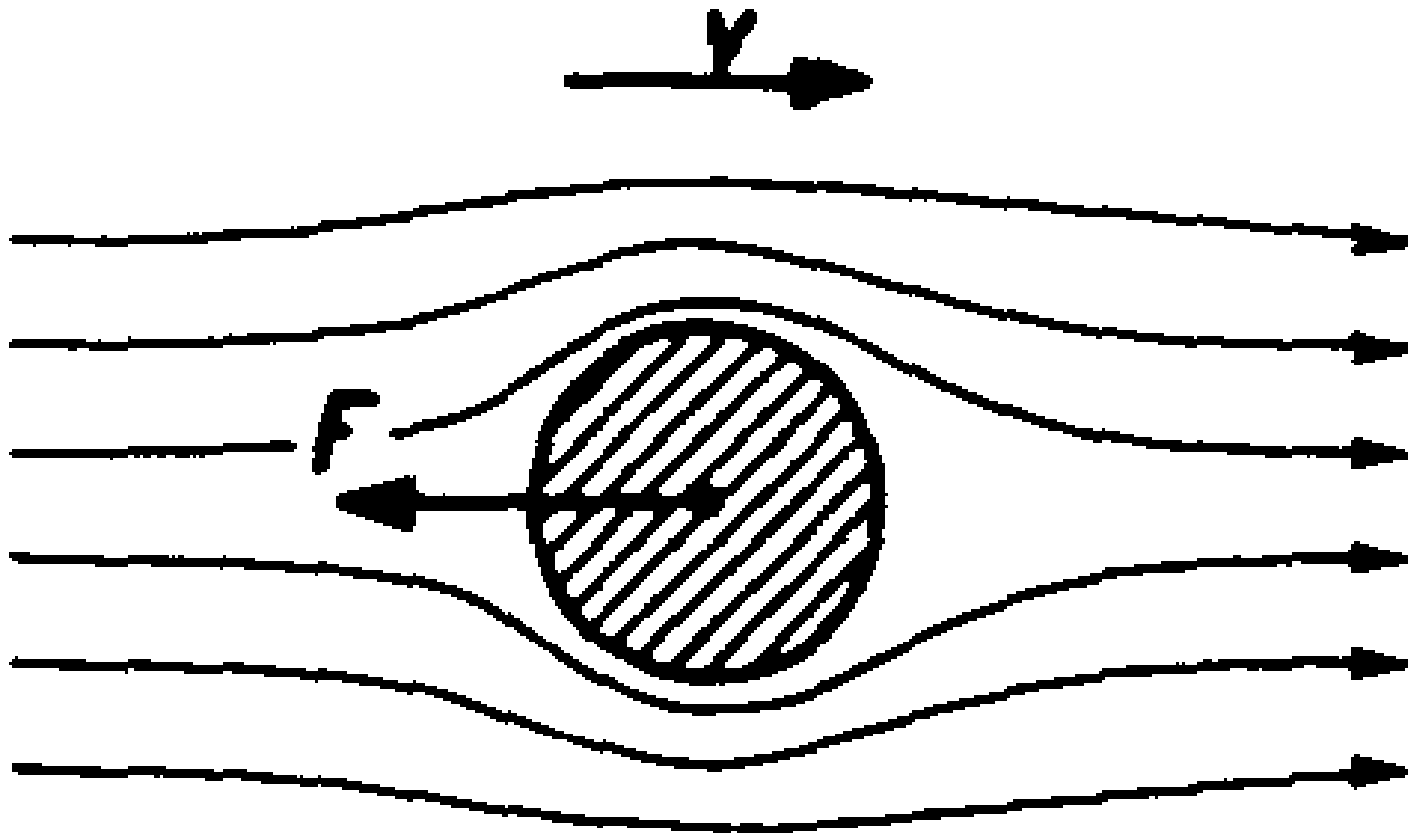
- ▶ Zařízení umožňující kontrolovat proudění vzduchu a zkoumat aerodynamiku těles.
  - ▶ V praxi těleso pevně uchyceno, a vzduch proudí.
  - ▶ Do vzduchu často vypouštěny barevné plyny, umožňující sledovat proudění vzduchu okem.
- 



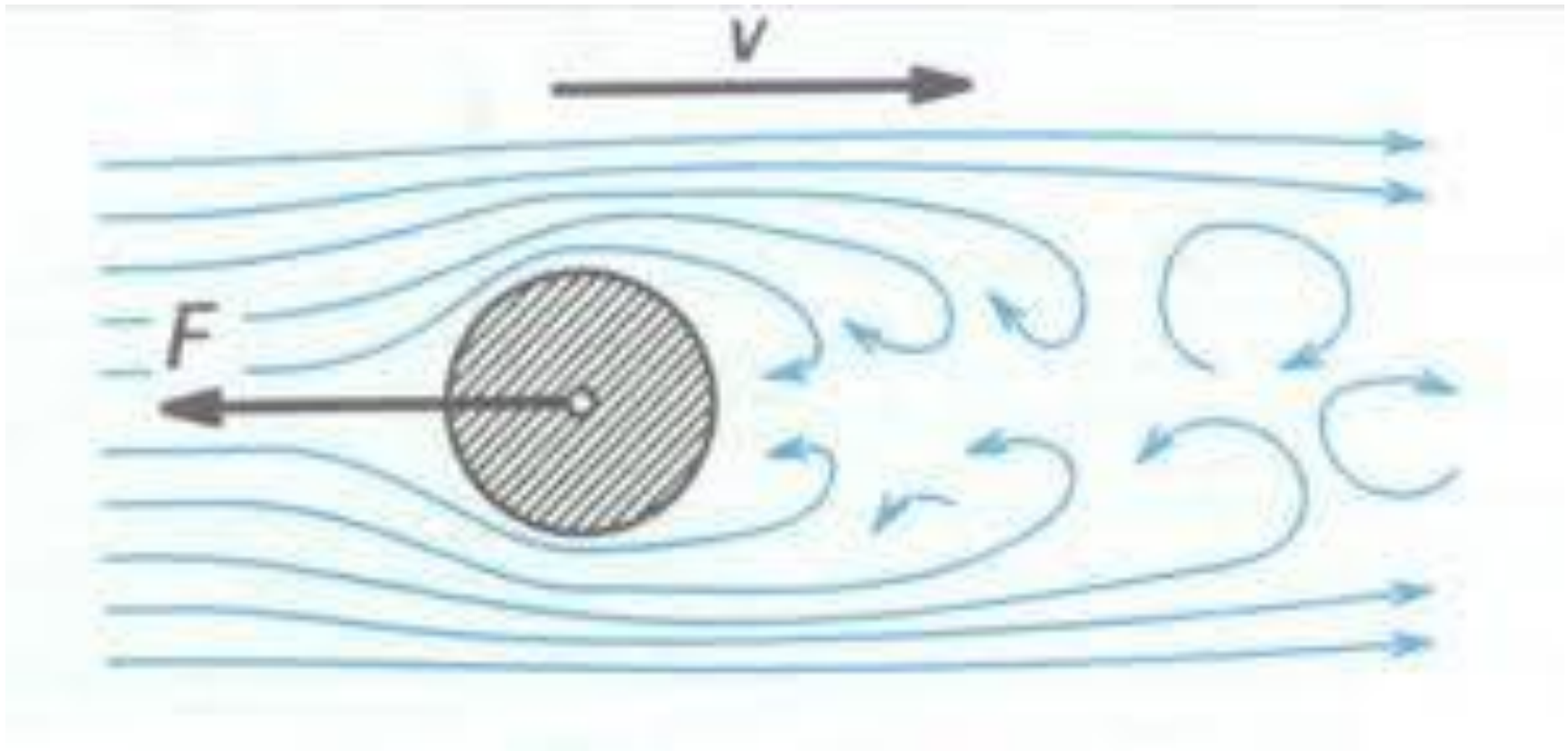
# Proudění

- ▶ Závisí na rychlosti a tvaru tělesa
  - ▶ *Laminární*
  - ▶ Při nižších rychlostech
  - ▶ *Turbulentní*
  - ▶ Při vyšších rychlostech a u méně aerodynamických tvarů
- 

- *Laminární*



# - *Turbulentní*







# Navier–Stokes Equations

## 3 – dimensional – unsteady

Glenn  
Research  
Center

Coordinates: (x,y,z)

Time : t      Pressure: p

Heat Flux: q

Density: ρ      Stress: τ

Reynolds Number: Re

Velocity Components: (u,v,w)

Total Energy: Et

Prandtl Number: Pr

**Continuity:** 
$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0$$

**X – Momentum:** 
$$\frac{\partial(\rho u)}{\partial t} + \frac{\partial(\rho u^2)}{\partial x} + \frac{\partial(\rho uv)}{\partial y} + \frac{\partial(\rho uw)}{\partial z} = -\frac{\partial p}{\partial x} + \frac{1}{Re_r} \left[ \frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} \right]$$

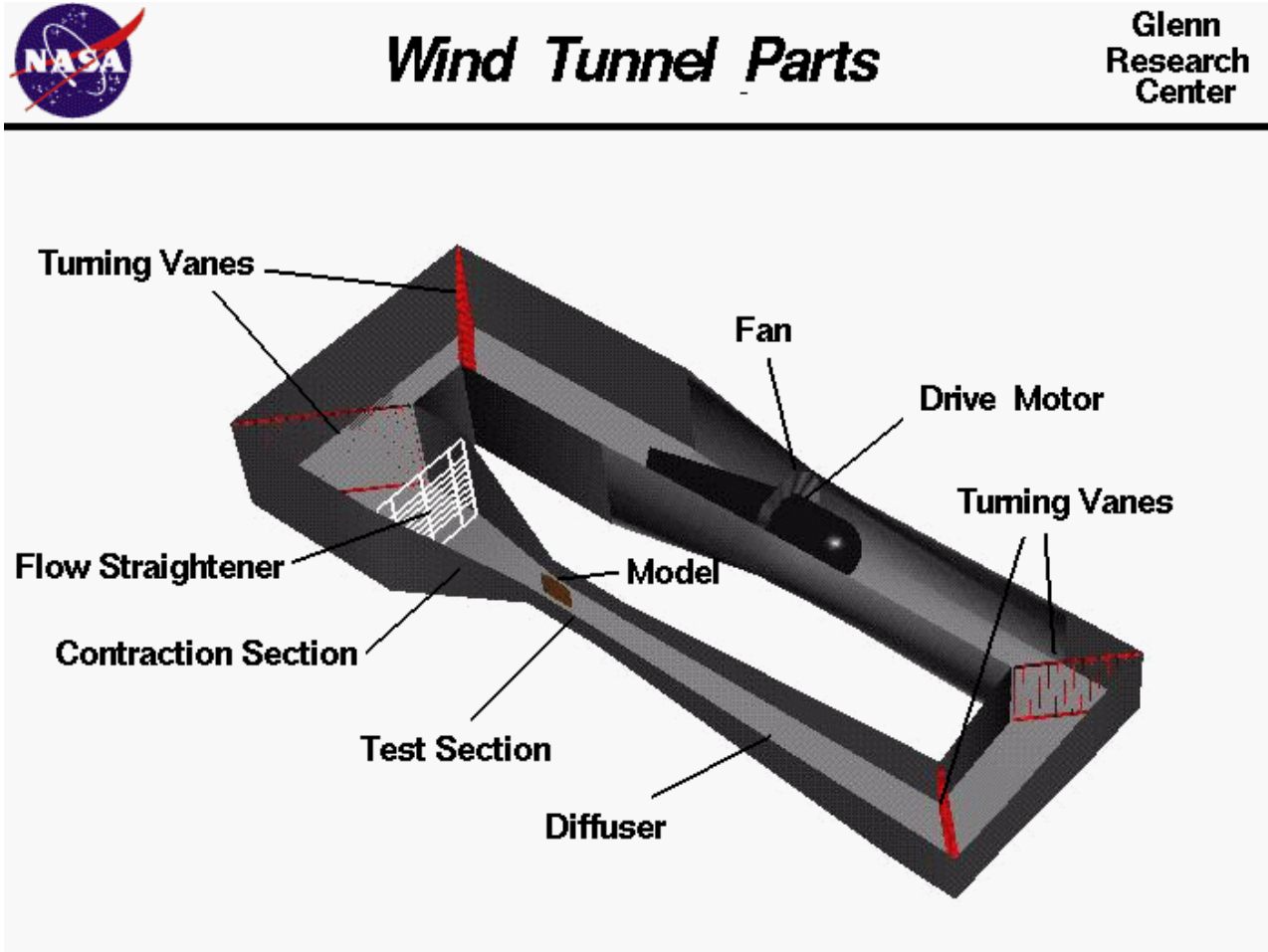
**Y – Momentum:** 
$$\frac{\partial(\rho v)}{\partial t} + \frac{\partial(\rho uv)}{\partial x} + \frac{\partial(\rho v^2)}{\partial y} + \frac{\partial(\rho vw)}{\partial z} = -\frac{\partial p}{\partial y} + \frac{1}{Re_r} \left[ \frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} \right]$$

**Z – Momentum:** 
$$\frac{\partial(\rho w)}{\partial t} + \frac{\partial(\rho uw)}{\partial x} + \frac{\partial(\rho vw)}{\partial y} + \frac{\partial(\rho w^2)}{\partial z} = -\frac{\partial p}{\partial z} + \frac{1}{Re_r} \left[ \frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} \right]$$

**Energy:**

$$\frac{\partial(E_T)}{\partial t} + \frac{\partial(uE_T)}{\partial x} + \frac{\partial(vE_T)}{\partial y} + \frac{\partial(wE_T)}{\partial z} = -\frac{\partial(up)}{\partial x} - \frac{\partial(vp)}{\partial y} - \frac{\partial(wp)}{\partial z} - \frac{1}{Re_r Pr_r} \left[ \frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + \frac{\partial q_z}{\partial z} \right] + \frac{1}{Re_r} \left[ \frac{\partial}{\partial x} (u \tau_{xx} + v \tau_{xy} + w \tau_{xz}) + \frac{\partial}{\partial y} (u \tau_{xy} + v \tau_{yy} + w \tau_{yz}) + \frac{\partial}{\partial z} (u \tau_{xz} + v \tau_{yz} + w \tau_{zz}) \right]$$

# Aerodynamický tunel NASA





# Experiment PAK

- ▶ (PAK = podolská aerodynamická komora)
- ▶ Potřebné: Karton, PET, větráček, brčka, spousta trpělivosti.



# Zajímavost: Aerodynamika golfového míčku

