Chapter 6
Fan and Duct systems

Pressure drop in straight ducts (Frictional losses)

$$\Delta P = 1000 f \frac{L}{D} \frac{V^2}{2} \rho$$

ΔP: Pa; L: m; V: m/s; ρ: Kg/m^3; D: inside Diameter mm

To find friction coefficient f we need to find Reynolds number

$$f' = 0.11\left(\frac{\varepsilon}{D_h} + \frac{68}{Re}\right)^{0.25}$$

Where $Re = \frac{D_h V}{1000\, \upsilon}$, υ → m^2/s Kinematic Viscosity

If $f' \geq 0.018$: $f = f'$

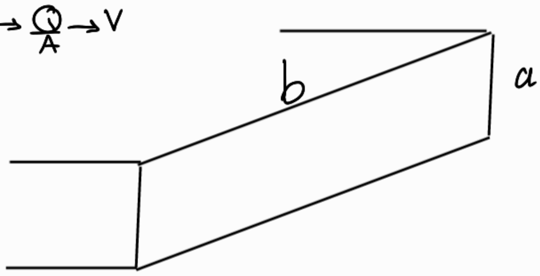
If $f' \leq 0.018$: $f = 0.85 f' + 0.0028$

Pressure drop in rectangular straight ducts

$$\Delta P = f \frac{L}{D_h} \frac{V^2}{2} \rho$$

D_h: Equivalent Diameter

V: De → A → $\frac{Q}{A}$ → V



$$D_h = \frac{4 \times \text{Cross sectional area}}{\text{perimeter}} = \frac{2ab}{a+b}$$

To find pressure drop using figure 6-2 when you have flow rate and velocity a new diameter should be used which is the equivalent diameter Deq

$$D_{eq} = \frac{1.3\,(ab)^{0.625}}{(a+b)^{0.25}}$$

$V = \frac{Q}{A}$ → area calculated from $(De)^2 \frac{\pi}{4}$

Use De in this equation

Pressure Drop in fittings (Dynamic losses)

- Fittings can be:
  - Enlargements
  - Contractions
  - elbows
  - branches
  - dampers
  - filters
  - registers

Note

If you have an unequal area fittings:

$$C_i = \frac{C_o}{(V_i/V_o)^2}$$

(C_i: At section i; C_o: at section o)

$$C = \frac{\Delta P_j}{(\rho V^2/2)}$$

For fittings with equal velocity and Re

(ΔP_j: Total pressure loss; $\rho V^2/2$: velocity pressure)

Total losses: $\Delta P = \left(\frac{1000 f L}{D_h} + \Sigma C\right)\left(\frac{\rho V^2}{2}\right)$

- To find ε

Table 1 Duct Roughness Factors

Duct Material	Roughness Category	Absolute Roughness ε, mm
Uncoated carbon steel, clean (Moody 1944) (0.05 mm) PVC plastic pipe (Swim 1982) (0.01 to 0.05 mm) Aluminum (Hutchinson 1953) (0.04 to 0.06 mm)	Smooth	0.03
Galvanized steel, longitudinal seams, 1200 mm joints (Griggs et al. 1987) (0.05 to 0.10 mm) Galvanized steel, continuously rolled, spiral seams, 3000 mm joints (Jones 1979) (0.06 to 0.12 mm) Galvanized steel, spiral seam with 1, 2, and 3 ribs, 3600 mm joints (Griggs et al. 1987) (0.09 to 0.12 mm)	Medium smooth	0.09
Galvanized steel, longitudinal seams, 760 mm joints (Wright 1945) (0.15 mm)	Average	0.15
Fibrous glass duct, rigid Fibrous glass duct liner, air side with facing material (Swim 1978) (1.5 mm)	Medium rough	0.9
Fibrous glass duct liner, air side spray coated (Swim 1978) (4.5 mm) Flexible duct, metallic (1.2 to 2.1 mm when fully extended) Flexible duct, all types of fabric and wire (1.0 to 4.6 mm when fully extended) Concrete (Moody 1944) (1.3 to 3.0 mm)	Rough	3.0

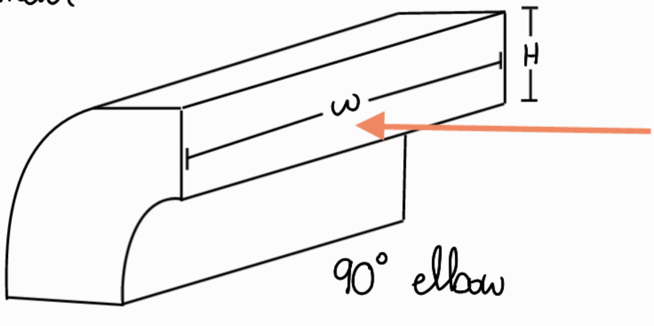
From Book, not mentioned in lecture

For sudden enlargment:

$$P_{loss} = \frac{V_1^2 \rho}{2}\left(1 - \frac{A_1}{A_2}\right)^2$$

For turns in a rectangular duct

1. Find ratio of inner to outer diameter
2. Find ratio $\frac{W}{H}$
3. Use these in figure 6-8



Branch takeoffs

$$P_{loss} = \frac{V_d^2}{2}\rho\,(0.4)\left(1 - \frac{V_d^2}{V_u}\right)^2$$