Stethoscope

- Chest piece Diaphragm
  - Mechanical Amplifier
  - High-Pass Filter
Stethoscope

Early

Standard Acoustic
- LF Bell
- HF Diaphragm

Electronic
- Filter
- Amplifier

Peak Flow Meter
Bernoulli’s Equation

\[ \frac{V_1^2}{2} + \frac{P_1}{\rho} + gh_1 = \frac{V_2^2}{2} + \frac{P_2}{\rho} + gh_2 \]

$V = \text{velocity}$  
$P = \text{pressure}$  
$\rho = \text{fluid density}$  
$g = \text{gravity (9.81)}$  
$h = \text{height}$

Bernoulli’s Equation (orifice)

\[ h_1 = h_2 \]

\[ \frac{V_1^2}{2} + \frac{P_1}{\rho} = \frac{V_2^2}{2} + \frac{P_2}{\rho} \]
Orifice = Virtual Chamber

\[ \frac{V_1^2}{2} + \frac{P_1}{\rho} = \frac{V_2^2}{2} + \frac{P_2}{\rho} \]

Recall: \( P = \frac{F}{\text{unit area}} \)

\[ 1\text{Pa} = 1\text{N} / \text{m}^2 \]

Reference pressure

Peak Flow Meter

Bougiulli’s Eqn.

\[ \frac{V_1^2}{2} + \frac{\Delta P}{\rho} = \frac{V_2^2}{2} \]

Assume Incompressible

\[ V_1 A_1 = V_2 A_2 \]

Rearrange

\[ V_1 = \sqrt{\frac{2\Delta P A_2^2}{\rho (A_1^2 - A_2^2)}} \]

Variable Orifice Size (note: \( A_1 = \text{constant} \))

\[ A_2 = w l \]

\[ \Delta P = \frac{F}{A_1} = \frac{K l}{A_1} \]

\[ V_1 = \sqrt{\frac{2K w^2 l^3}{\rho A_1 (A_1^2 - w^2 l^2)}} \]
Limb Plethysmography

Boyle’s Law: \( pV = K \) (constant)

\[ \Delta p \rightarrow \Delta V \]

Assume human is incompressible

- \( V_c \) = Volume of chamber (known)
- \( V_h \) = Volume of human (computed)
- \( \Delta V \) = Volume change of chamber (known)
- \( p_1 \) = Chamber pressure before volume change (1 ATM)
- \( p_2 \) = Chamber pressure after volume change (measured)

\[
(V_c - V_h)p_1 = (V_c - V_h - \Delta V)p_2 \quad V_h = V_c - \frac{\Delta Vp_2}{p_2 - p_1}
\]
End-Tidal CO₂ & Beer’s Law

\[ P_i = P_0 e^{-\alpha c} \]

\[ P_i = \text{Power / unit area (transmitted)} \]
\[ P_0 = P_i \text{ for air (c=0)} \]
\[ c = \text{concentration of absorbing gas} \]
\[ a(\lambda) = \text{absorption coeff of gas (func of } \lambda) \]
\[ l = \text{length (transmission path)} \]

or \( P_0 \) if no gas present

ET CO₂ Meter
End-Tidal CO$_2$

Absorption Peak

Noise Compensation (Ivy Monitor)

- Source light intensity
- Condensation
- Temperature
- Beam splitter
- Reference filter