Measurement of Flow

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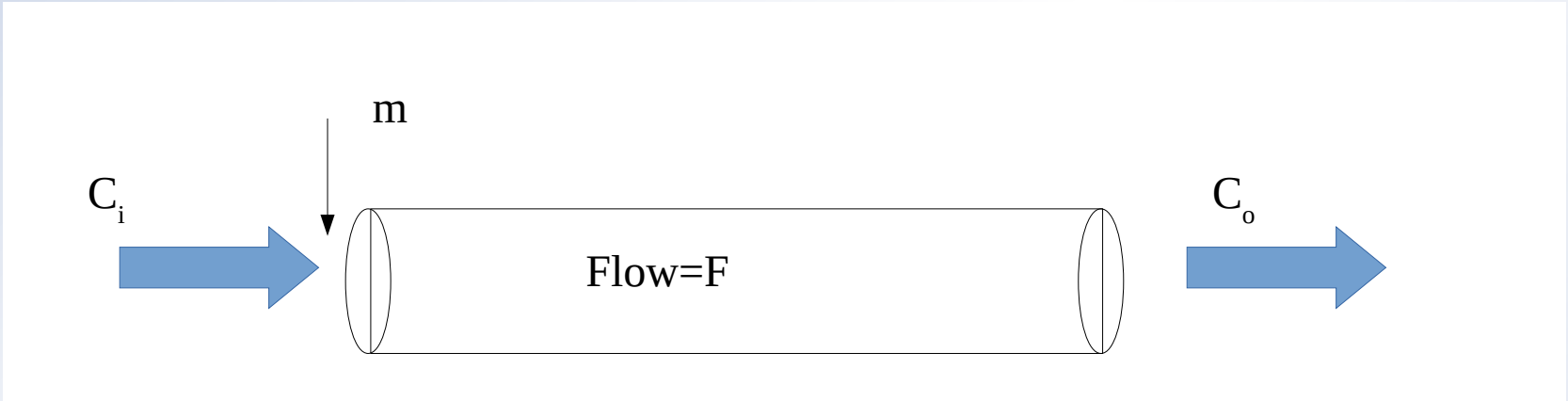
Lecture - Outline

- Fluid flow – liquid and gas
- Dilution methods
- Doppler and transit time
- Pressure drop method
- Electromagnetic
- Plethysmographic
  - Electrical
  - Optical

Flow in tubes

- Fluid flow is similar for liquids and gases
- Flow in tubes – most biomedical applications
- Flow in open spaces – e.g., respiration

Dilution methods

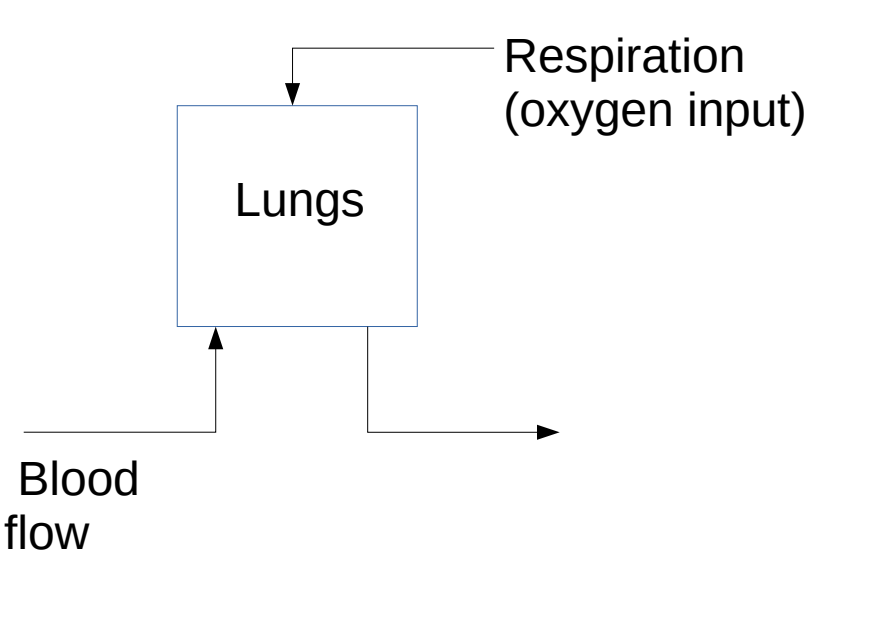


$$C_i F + \frac{dm}{dt} = C_o F$$

$$F = \frac{dm/dt}{C_o - C_i}$$

Example of dilution method – cardiac output

- Respiratory Gas Oxygen consumption: 0.25 litres/min
- Arterial Oxygen concentration: 0.2litre/litre
- Venous Oxygen concentration: 0.15 litre/litre



$$F = \frac{dm/dt}{C_o - C_i} = \frac{0.25\,l/min}{0.2\,l/l - 0.15\,l/l} = 5\,l/min$$

Thermodilution

- Apply heat at one point and measure heat downstream
- Depends on density of blood and specific heat of blood
- Assumes that there is no loss of heat by conduction across the vessel wall

$$F = \frac{injected\ heat}{change\ of\ temperature}$$

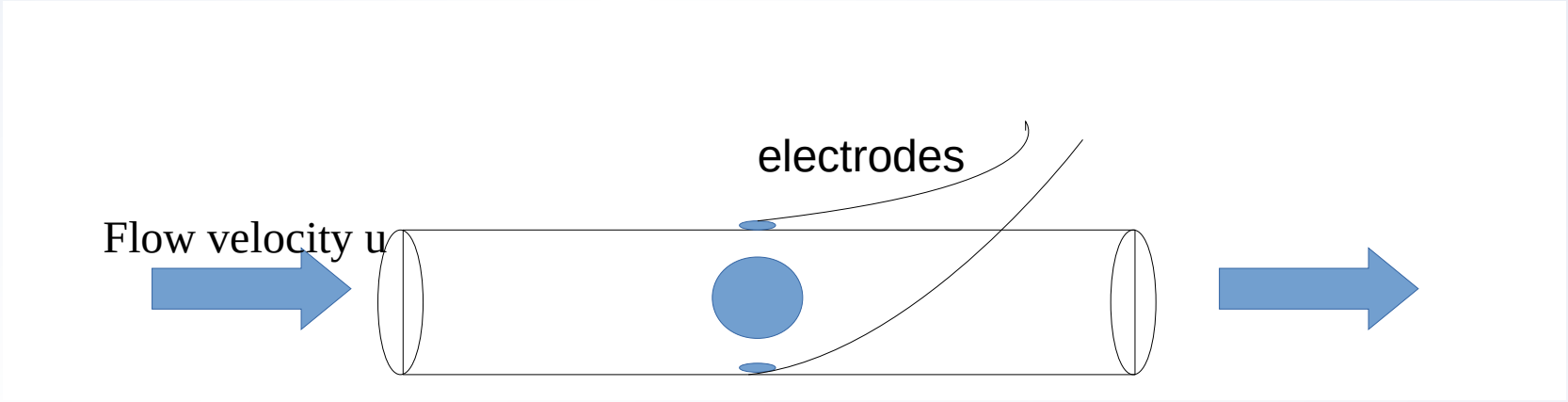
$$F = \frac{Q}{\rho c_b \int \Delta T\, dt}$$

Doppler and Transit time flow measurement

- Ultrasound transmitter+Receiver
- Doppler shift = $f_o u/c$
- Transit time = d/u

Electromagnetic flowmeter

- Blood is a moving conductor
- In a magnetic field:
  - EMF=(velocity)(Mag Flux density)(conductor length)



Plethysmographic methods

- Measurement of volume change
- Electrical resistance method
- Optical absorption method

Other methods of flow measurement

- Turbine
- Thermistor Heat dissipation

End of Lecture