BME 386
Prelab 6 Solns

Total = 30 pts

(1) Air enters the mouth and nose and passes through the pharynx to reach the trachea. The trachea divides into two bronchi that enter the lungs. The bronchi subdivide many times into smaller bronchioles. The bronchioles end at alveolar ducts, where oxygen diffuses from alveoli into capillaries.

(2) Tidal Volume (TV) : volume change during relaxed breathing

Vital Capacity (VC) : Max volume change of lungs. It is the maximum amount of air that is exhaled after the fullest possible inhalation.

Forced vital capacity (FVC) : Similar to VC, but air is exhaled with maximal effort.

(3) Spirometry is a test that measures breathing and lung function. The subject is asked to take a deep breath and exhale as forcefully as possible ← forced expiratory maneuver (FEM)

(4) Two spirometer types: (1) Volume spirometers directly measure the volume of exhaled air. They usually involve some type of inflatable chamber (e.g. bellows).

(2) Flow spirometers measure air flow. Volume is obtained by integration with time.

The Vernier spirometer is a flow spirometer.

⑤ Spirometry typically measures:

① Forced Vital Capacity (FVC): Amount of exhaled air (with max force) after a forced expiratory maneuver (FEM)

② Forced Expiratory Volume at one second (FEV_1): the amount of air that a person exhales during the first second of a FEM.

③ Ratio of FEV_1 to FVC

Low FVC → restrictive disease such as asbestosis

Low $\frac{FEV_1}{FVC}$ → obstructive disease such as emphysema

⑥ According to data sheet:

$$\boxed{\begin{aligned} \text{sensitivity} &= 2.5\ mV/kPa \\ V_{supply} &= 10V \end{aligned}}$$

⑦

$$V_{MEAS} = A_d \times \overbrace{S \times F \times R}^{\Delta V_{SENSOR}} + 2.5$$

limited by ADC

$$A_d \left(\frac{2.5\times10^{-3}\,V}{kPa}\right)\left(16\,\tfrac{L}{s}\right)(.036\,kPa) + 2.5 < 5V$$

$$A_d < \frac{2.5}{\left(2.5\times10^{-3}\,\frac{V}{kPa}\right)\left(16\,\frac{L}{s}\right)(.036\,kPa)} = \boxed{1736.1}$$

⑧

$$A_d = 1 + \frac{49400}{R_G} < 1736.1 \rightarrow R_G > \frac{49400}{1736.1 - 1} = \underline{\underline{28.5\,\Omega}}$$

Choose $\boxed{R_G = 30\,\Omega}$

Actual gain $= 1 + \frac{49400}{30} = \boxed{1647.7}$

(9) $V_{MEAS} = A_d S R F + V_{Ref}$

$$F = \frac{1}{A_d S R}\left(V_{MEAS} - V_{Ref}\right)$$

Include calibration factor:

$$\boxed{F = \frac{\text{calibration}}{A_d S R}\left(V_{meas} - V_{Ref}\right)}$$

(10)

$$\Delta F_{MIN} = \frac{\Delta V_{MIN}}{\frac{\partial V_{MEAS}}{\partial F}} \leftarrow \left[\begin{array}{l} \Delta V_{ADC} = \frac{5-0V}{2^{10}-1} = \underline{\underline{4.9mV}} \\ V_N = 2mV \end{array} \right.$$

$$\Delta F_{MIN} = \frac{\Delta V_{ADC}}{A_d S R} = \frac{.0049V}{(1647.7)(.0025\frac{V}{kPa})(.036\ kPa \cdot s/L)}$$

$$= \boxed{0.033\ L/s}$$