SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

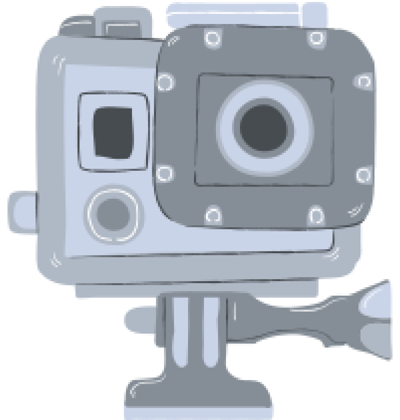
DEPARTMENT OF BIOMEDICAL ENGINEERING

COURSE NAME: 19BMT301/ BIOCONTROL SYSTEM

III YEAR / V SEMESTER

Unit 4 – Modelling of Biological System

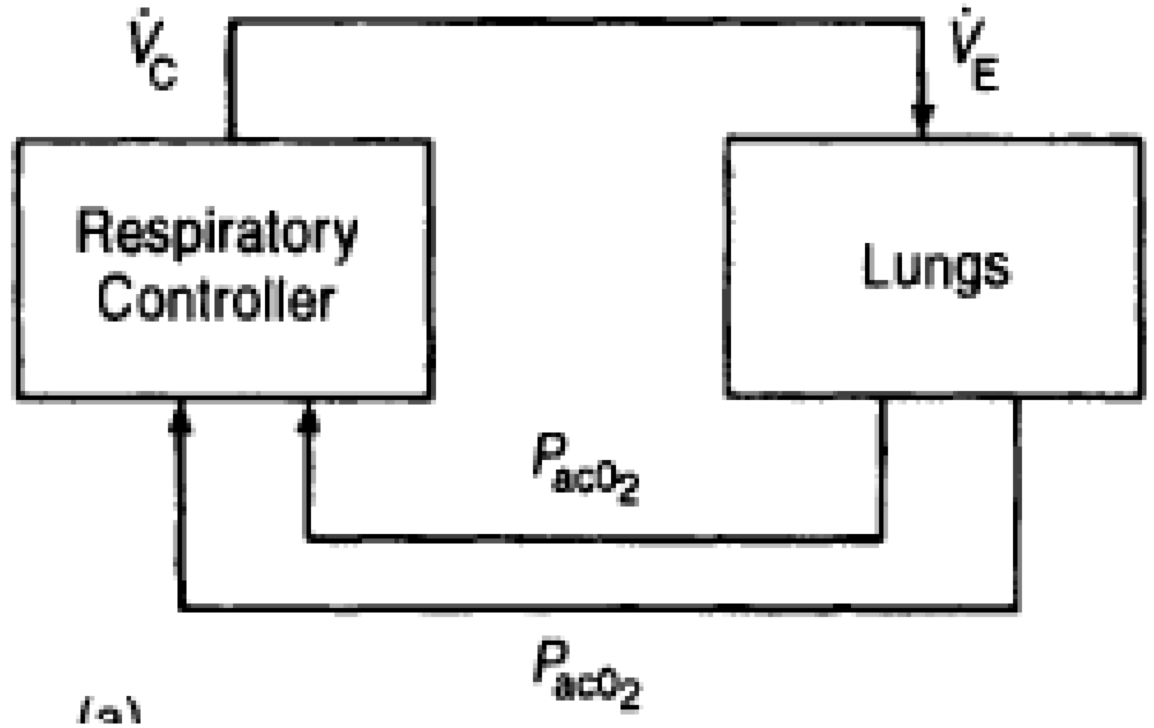
Topic 2: Regulation of Ventilation

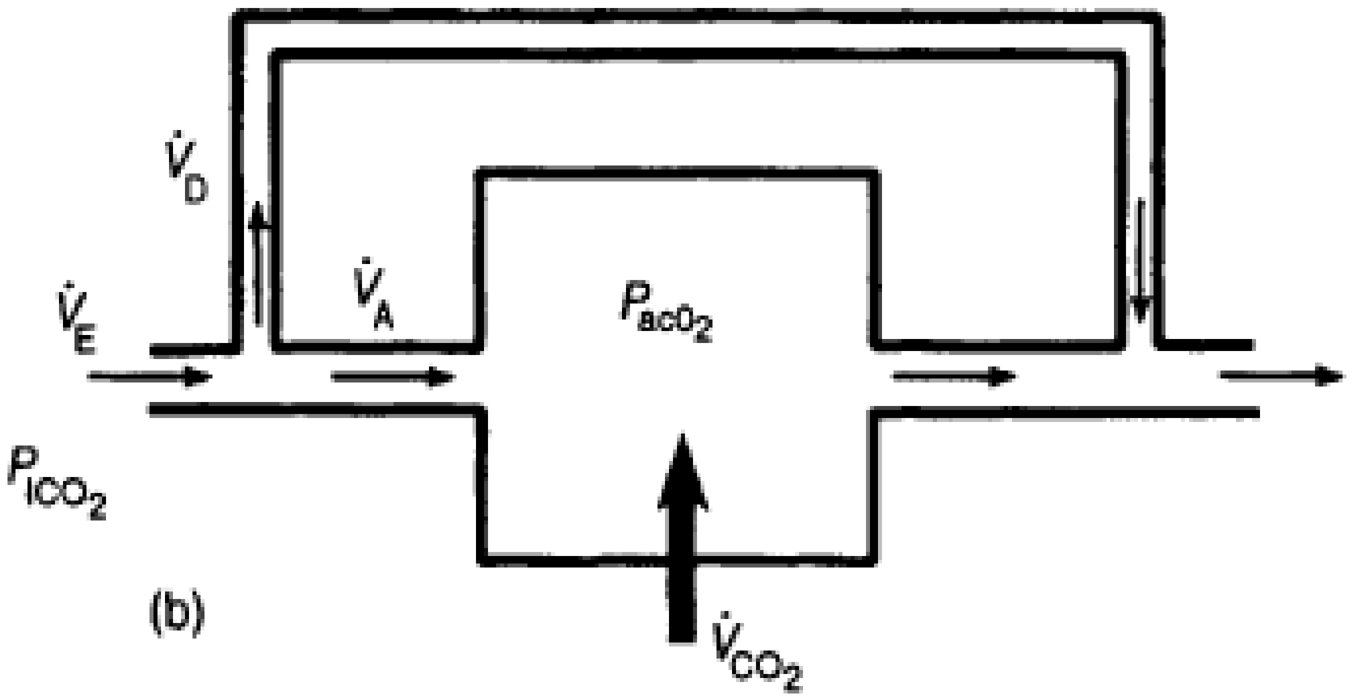


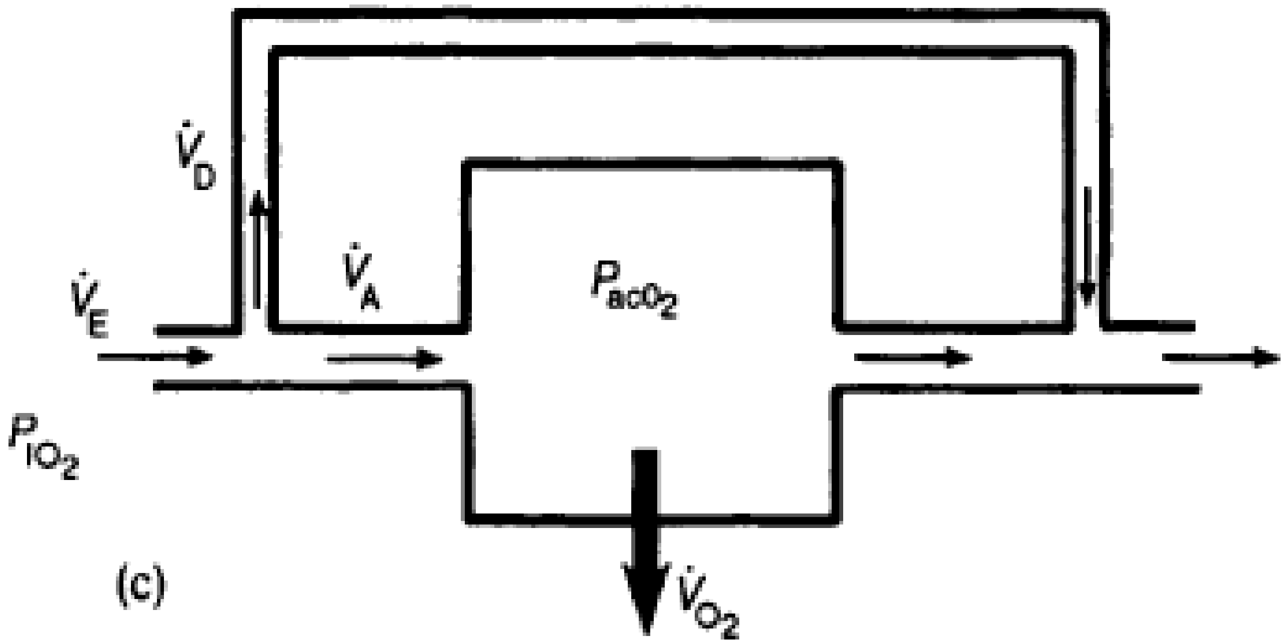
REGULATION OF VENTILATION

- In normoxic conditions, breathing is controlled almost exclusively by the level of CO_2 in the arterial blood.
- Ventilation is highly sensitive to $PaC0_2$, the partial pressure of CO_2 in arterial blood. A rise in $PaC0_2$ by 1mmHg from its normal level of approximately 40 nun Hg may increase the ventilatory output by a third of its resting level.
- However, upon ascent to altitude or during inhalation of a gas mixture containing low O_2 content, there is an additional drive to breathe due to hypoxia. This hypoxic drive becomes noticeable when the partial pressure of O_2 in arterial blood, $Pa0_2$, drops below 70mmHg.
- Since the metabolic consumption rate of O_2 and the metabolic elimination rate of CO_2 are relatively constant in the steady state, a higher level of ventilation would lead to an increase in $Pa0_2$ and a decrease in $PaC0_2$, which in turn would lower ventilation.

REGULATION OF VENTILATION







REGULATION OF VENTILATION

- The operating characteristics of the gas exchanger are obtained by deriving the mass balance equations for CO_2 and O_2.
- We assume the metabolic CO_2 production rate to be $\dot{V}_{CO2}$; this is the rate at which CO_2 is delivered to the lungs from the blood hat is perfusing the pulmonary circulation. In the steady state, this must equal the net flow of CO_2 exiting the lungs in gas phase.
- The latter is equal to the difference in volumetric fraction (or concentration) of CO_2 in the air entering (F_{ICO2}) and leaving (F_{AC02}) the alveoli multiplied by the alveolar ventilation, V_A. The alveolar ventilation represents that portion of the total ventilation, V_E, that actually participates in the gas exchange process.

REGULATION OF VENTILATION

$$\dot{V}_A = \dot{V}_E - \dot{V}_D$$

And the CO2 mass balance

$$\dot{V}_{CO_2} = k\dot{V}_A(F_{ACO_2} - F_{ICO_2})$$

The constant k allows volumes and flows measured in BTPS units to be converted into STPD units. This conversion is achieved by using the ideal gas equation:

$$\frac{V_{STPD}760}{273} = \frac{V_{BTPS}(P_B - 47)}{310}$$

The above equation assumes body temperature to be 37°C or 310 K and a saturated water vapour partial pressure of 47 mmHg at that temperature. PB represents the barometric pressure under which the gas exchange process is taking place; at sea level, this is 760 mmHg.

REGULATION OF VENTILATION

$$k = \frac{V_{STPD}}{V_{BTPS}} = \frac{P_B - 47}{863}$$

•The volumetric fractions, $F_{ICO\ 2}$ and F_{ACO2} , can be converted into their corresponding partial pressures, P_{ICO2} and $P_{\ ACO2}$, using Dalton's law:

$$P_{ICO_2} = F_{ICO_2}(P_B - 47), \qquad P_{ACO_2} = F_{ACO_2}(P_B - 47)$$

$$P_{ACO_2} = P_{ICO_2} + \frac{863\dot{V}_{CO_2}}{\dot{V}_A}$$

$$P_{AO_2} = P_{IO_2} - \frac{863\dot{V}_{O_2}}{\dot{V}_A}$$

Respiratory Controller

- The controller part of the system includes the chemoreceptors, the neuronal circuits in the lower brain involved in the generation of the respiratory rhythm as well as the neural drive to breathe, and the respiratory muscles.
- The controller response to CO_2 has been shown to be linear over the physiological range. In the absence of vigilance, such as during sleep, the controller output falls rapidly to zero (i.e., central apnea occurs)whenPaC0 2 decreases slightly below normal awake resting levels. Exposure to hypoxia (i.e., when Pa0 2 decreases below 100mmHg) leads to an increase in the CO_2 response slope as well as the ventilatory controller output.

Respiratory Controller

- Ventilator Controller output is given by,

$$\dot{V}_C = \left(1.46 + \frac{32}{P_{aO_2} - 38.6}\right)(P_{aCO_2} - 37), \qquad P_{aCO_2} > 37$$

$$= 0, \qquad P_{aCO_2} \leq 37$$

SUMMARY

Definition, Macro and Micro Economics, Nature and Scope of Economics

ASSESMENT

Dear student,

Quiz is posted in your Google class room

Allotted time for quiz is 5 min

No of Questions is 10

KEEP LEARNING..

Thank u

SEE YOU IN NEXT CLASS