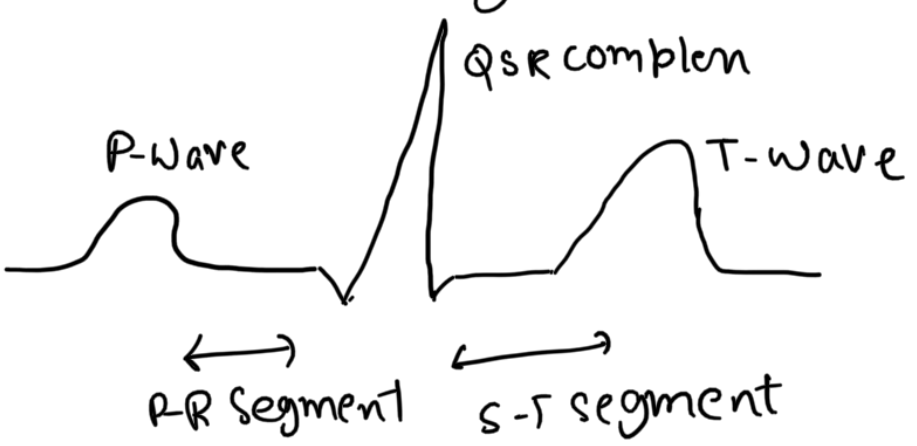
BT1010 - Module-2 | Arabhi Subhash - CS17B005

Biosignals and Physiological Modelling

1) Biosignal is a description of a physiological phenomenon of any nature. It is any signal in living beings that can be measured and monitored (Bio - Living, Signal - Function that carries information). Biosignals can be electrical in nature - ECG, EEG, EOG etc or images - X-ray, MR, Ultrasound etc or mechanical - displacement, velocity, volume etc. All biomedical systems either generate the signals to influence body or analyze them to understand underlying physiological mechanisms.

2) Electric signals are formed by field generated in cells and organs because of intra and extra cellular ionic currents. cells control the flow of specific charged elements through its membrane with the help of proteins. These proteins are called ion channels. The potential of these signals is very low (10-100 milli Volts) but they are very important in simulating movements (voluntary and involuntary), thoughts and behaviors etc. Typically in nerve cells these currents are triggered by chemicals released by other neurons.

3) Electrocardiogram (ECG) is a simple test that can be used to check one's heart rhythm and electrical activity. It is recorded by sensors attached to the skin to detect electrical signals produced by the heart muscles each time it beats. these signals are amplified and presented as a waves. A typical wave in a single ECG -



→ P wave - first electrical signals catched from atria

→ P-R segment - short period of no electrical activity due to slowed down depolarisation by AV Node

→ QRS - The down-up-down parts of ventrical depolarisation respectively

→ S-T, T - Repolarisation.

The height, width and time span of different parts of the wave is used to diagnose and monitor conditions of heart. It can be used to investigate symptoms of heart problem - chest pain, palpitations, dizzines and shortnes of breathe. It can help to detect arrhythmias, coronary

heart diseases, heart attacks, cardiomyopathy etc. It is also used to keep a check on medication that potentially affects the heart.

4) Electroencephalogram (EEG) is a method that records brain wave patterns. It is a non invasive method that is done by placing metal discs with thin wires on the scalp that sends the signals to computer. The EEG captures the activation dynamics of pyramidal cells of cerebral cortex (grey matter). It has an advantage of temporal resolution over other similar methods. It is widely used as a diagnostic test fo epilepsy. It helps in treating brain tumor, brain damage, dysfunction stroke, sleeping disoders etc. It is also useful in monitering alertness, coma, testing afferent pathways, locating seizure and checking physiology.

5) Muscle is one of four primary tissue types in homan body. We have 3 types of muscle tissue - skeletal, cardiac & smooth. The primary function of muscle is movement. Muscles get excited when their plasma

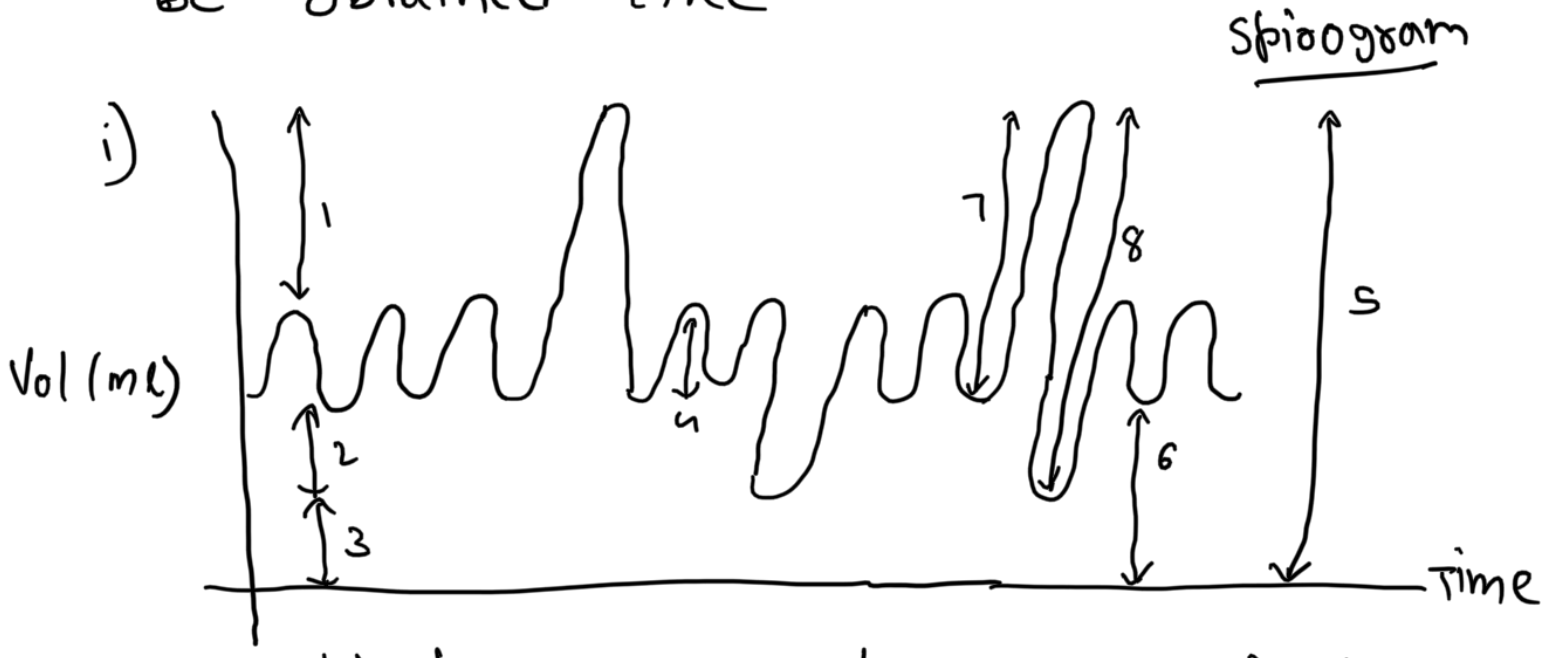
membrane changes their electrical state (polarized to depolarized). Nervous system can influence the excitability by signalling and help in different organs to work properly. Muscle fibres are cylindrical cells with many nuclei, their membrane is called sarcolemma and the cytoplasm is called sarcoplasm. The sarcoplasm has parallel thread like myofibrils. These myfibrils have 2 kind of protin filaments - thin: composed of myosin, thick: composed of Actin, troponin & tropomyosin. Muscle striations are produced by these altering dark & light filaments.

Muscle Force generation

i) Motor neuron activity & secretion of neurotransmitter - acetycholine (Ach)
ii) This ach binds to sarcolemm and opens gated channels
iii) Nat enters the cell and initiates AP which in turn causes depolarisation and triggers Ca^{+2} release
iv) Ca^{+2} initiates contraction cycle. This produces the molecular force.
v) After contraction, Ca^{+2} is reabsorbed by sarcoplasmic reticulum.

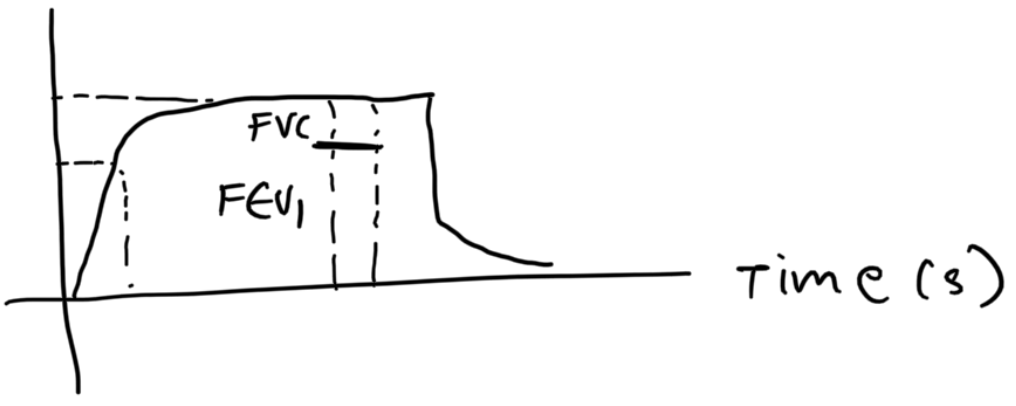
6) Spirometry is one of the pulmonary function tests that aid diagnosis and help monitor respiratory weaknesses, chronic pulmonary obstructions, air flow, asthama etc. In this procedure one will be asked to breath deep in to a mask which is connected to a small device. It can measure all the lung volumes except residual volume. It provides different graphical displays from which various volumes can be obtained like

i)



1: Inspiratory reserve volume, 2: expiratory RV
3: Residual volume, 4: Tidal volume, 5: total lung capacity, 6: Functional redual capacity
7: Inspiratory capacity, 8: vital capacity

ii)



FVC: forced vital capacity
- total air enhaled forcefully

after quick deep inhale

FEV$_1$: forced expiratory flow
- avg. rate of flow during middle half of FVC

7) A lot of biological systems that we are interested in are very difficult to study for veriety of reasons like complenity, lack of resources etc. A model of a system is an imitation of it, which captures most of the properties that we hope to evaluate by doing experiments.

Physical Model :

A model that resmeble physical characteristics of a system like movement, force, reaction etc.

EX: Mechanical model of skelatal muscle

Physiological Model :

It is a mathematical model characterized by a physiologically consistant mathematical structure (defined by set of equations) and a set of parameters to be estimated with accuracy

EX: The Hodgkin-Huxley model,
circuit model for Axon membrane