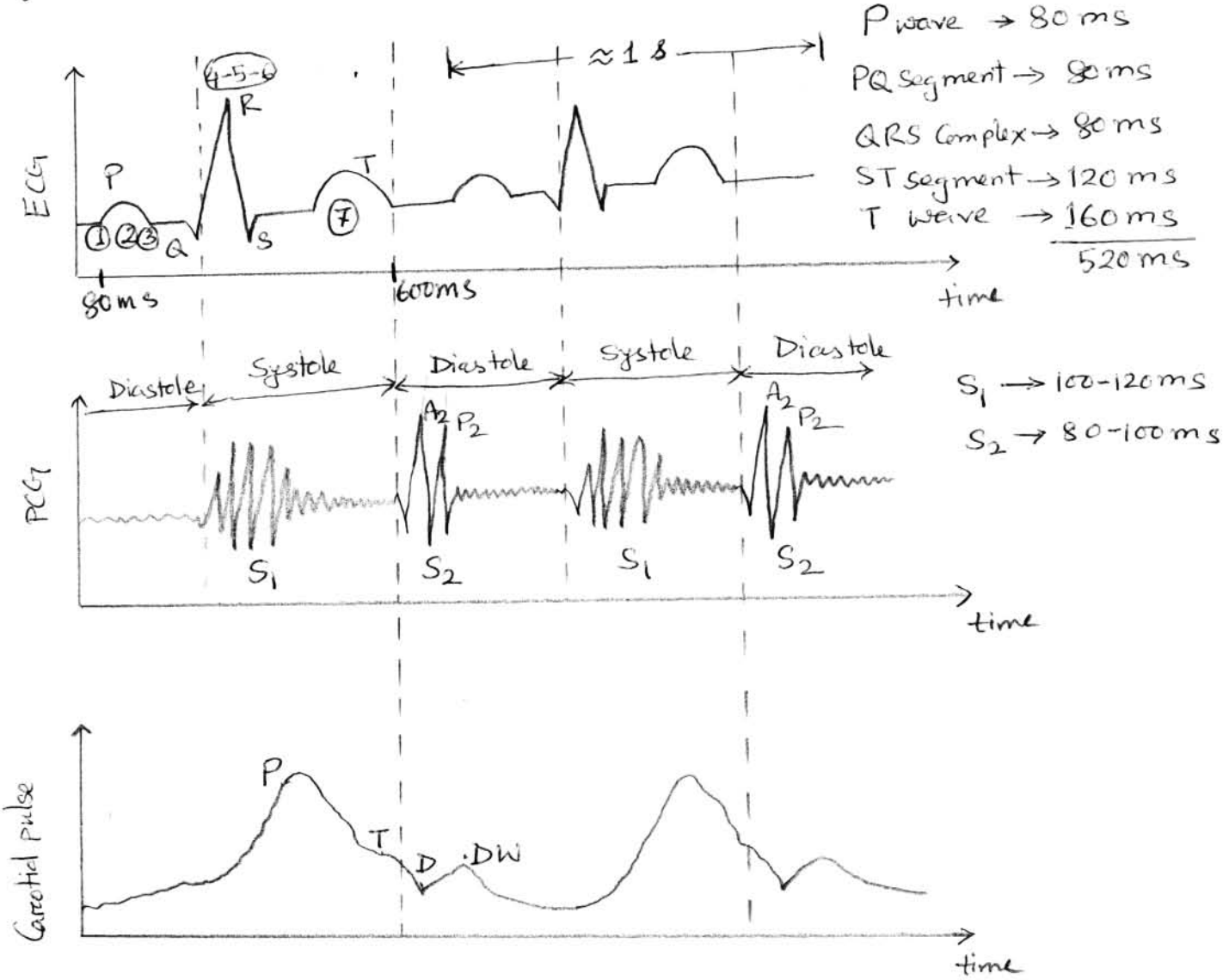
Assignment 1

Solution by: Shantanu Banik

Q1 A 3-channel schematic plot of simultaneous recordings of the ECG, PCG, and Carotid pulse signals:-



ECG

1. Starting of P wave → SA node fires
2. P wave → atrial contraction
3. Isoelectric PQ segment → AV node delay
4. Beginning of Q wave → AV node fires
5. Bundle branches, Purkinje fibers conduct stimulus
6. Ventricles contract → systole
7. T wave → ventricular relaxation.

(4), (5), (6) → QRS Complex → ventricular contraction + atrial relaxation

ST segment : normally isoelectric.

PCG

S1: ⇒ 1st heart sound,

⇒ AV valves close (mitral & tricuspid); isovolumetric Contraction.

⇒ Aortic and Pulmonary valves open,

⇒ Blood ejected out of ventricles

~~⇒ Systolic segment~~

S2: ⇒ 2nd heart sound,

⇒ It has 2 Components - (i) A2 → Aortic valve closes
(ii) P2 → Pulmonary valve closes

~~⇒ Diastolic segment~~
⇒ Indicates the end of systole.

Carotid Pulse

P wave ⇒ Percussion wave; the carotid pulse rises abruptly with the ejection of blood from the left ventricle to the aorta

T wave ⇒ Tidal wave; just after P wave. A plateau or a secondary wave caused by a reflected pulse returning from the upper body.

D ⇒ Dicrotic notch; closure of aortic valve.

DW ⇒ Dicrotic wave; Caused by the reflected pulse from the lower body.

Common or interrelated waves or markers

- S_1 starts during the QRS complex and represents the starting point of systole (ventricular contraction).
- Dicrotic notch is ~~associated to first~~ related to the starting point of S_2 and beginning of diastole. Usually, it 52ms is subtracted from the location of D, the corresponding position gives the starting point of diastole or S_2.
- S_2 occurs after the end of T wave (ventricular relaxation) because of the closure of aortic and pulmonary valves. 'D' is the consequence of aortic valve closure.

Q2

Two potential clinical applications of the analysis of EMG Signals:—

① An EMG signal indicates the level of activity of a muscle, and may be used to diagnose neuromuscular diseases such as neuropathy and myopathy. Neuropathy causes slow conduction and/or desynchronized activation of muscle fibers and a polyphasic SMUAP with an amplitude larger than normal. The same motor unit may be observed to fire at higher rates than normal before more motor units are recruited. Myopathy involves the loss of muscle fibers in motor units, with the neurons presumably intact.

② EMG signal may be useful in studies related to neuromuscular control, muscle contraction, athletic training, and biofeedback.

Q3 Three main objectives of biomedical signal analysis:—

① Information gathering: measurement of phenomena to interpret a system.

Clinical application — Blood pressure measurement (pressure signal), heart rate measurement using the ECG which is associated with the electrical activity of the heart.

② Diagnosis: detection of abnormal or pathological (disease) processes.

Clinical application — Analysis of the ECG signal of critically ill patients for the detection of arrhythmia or analysis of the EEG for the detection of epileptic seizures. The EEG and ECG both are electrical signals and are associated with brain activity and heart activity, respectively.

③ Monitoring: Obtaining continuous or periodic information about a system.

Clinical application — Heart rate monitoring using ECG signals, EEG analysis in sleep research etc. Both are electrical signals.

Q4

Voiced: * Involve the participation of the glottis: air is forced through the vocal cords held at a certain tension.

* The signal is a series of quasi-periodic pulses of air which is passed through the vocal tract and filtered. ~~* vowels are voiced sounds~~

Unvoiced: * These sounds are produced by forcing a steady stream of air through a narrow opening or constriction formed at a specific position along the vocal tract.

* The signal is turbulent ~~that~~ and appears almost like random noise.

* Do not involve any activity (vibration) of the vocal cords.

Plosives: * Involved complete closure of the vocal tract, followed by an abrupt release of built-up pressure.

* ~~Hard~~ Difficult to characterize as they are transients, and are affected by the preceding phoneme.

Q5

EEG rhythms are associated with various physiological and mental processes.

The alpha (α) rhythm is the ~~principal~~ principal resting rhythm of the brain, and is common in wakeful, resting adults. Auditory and mental arithmetic tasks with the eyes closed lead to strong alpha waves, which are suppressed when the eyes are opened.

The theta (θ) waves appear at the beginning stages of sleep. The delta (δ) waves appear at deep sleep stages. High-frequency beta (β) waves appear as background activity in tense and anxious subjects.

The frequency ranges of the related EEG waves are listed below:

* delta (δ): $0.5 \leq f < 4$ Hz;
* Theta (θ): $4 \leq f < 8$ Hz;
* Alpha (α): $8 \leq f \leq 13$ Hz; and
* Beta (β): $f > 13$ Hz.

As a person begins to fall asleep and enters deep stages of sleep, the α rhythm is replaced by slower and slower θ and δ waves; the EEG shifts to lower frequencies