Experiment on T wave

1) Experiment :

1) Find T peak, T wave width and T wave area in a given ECG.
2) Find the distribution of above parameters in a set of ECGs, which can be used to distinguish between Normal and Abnormal ECGs.

2) Understanding what is an ECG:

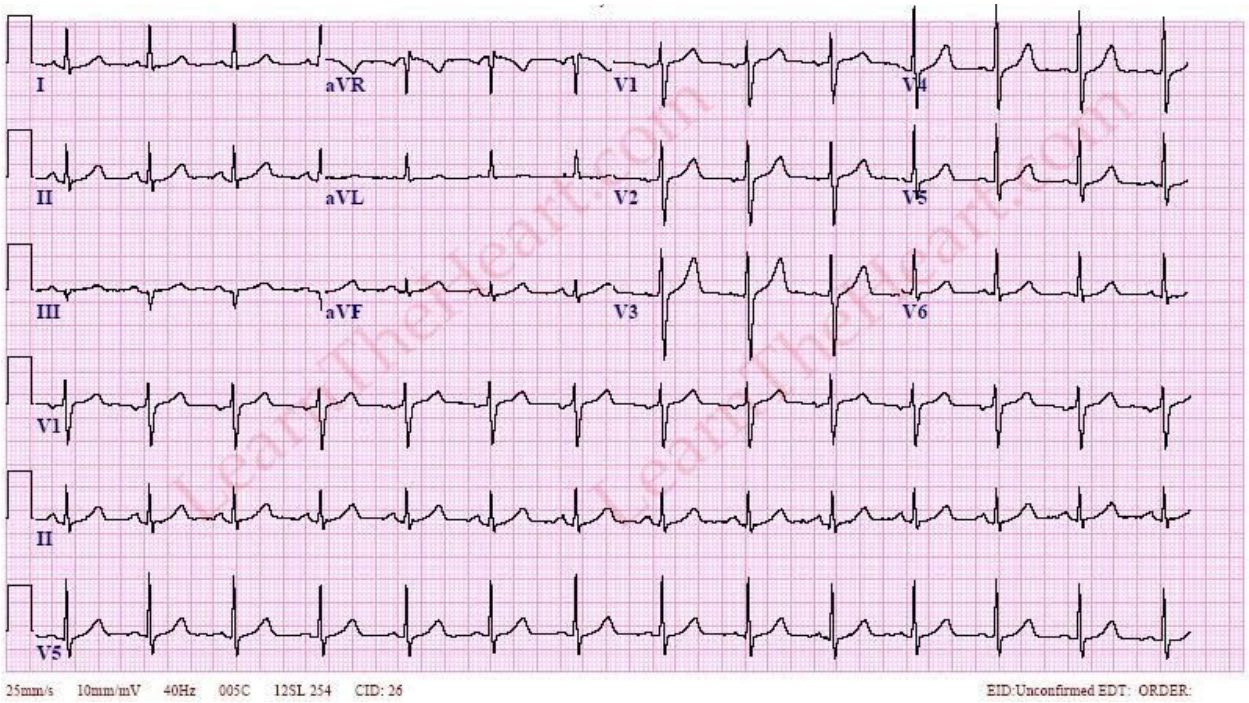
An electrocardiogram is a picture of the electrical conduction of the heart. By examining changes from normal on the ECG, clinicians can identify a multitude of cardiac disease processes.

The standard ECG has 12 leads. Six of the leads are considered “limb leads” because they are placed on the arms and/or legs of the individual. The other six leads are considered “precordial leads” because they are placed on the torso (precordium).

The six limb leads are called lead I, II, III, aVL, aVR and aVF. The letter “a” stands for “augmented,” as these leads are calculated as a combination of leads I, II and III.

The six precordial leads are called leads V1, V2, V3, V4, V5 and V6.

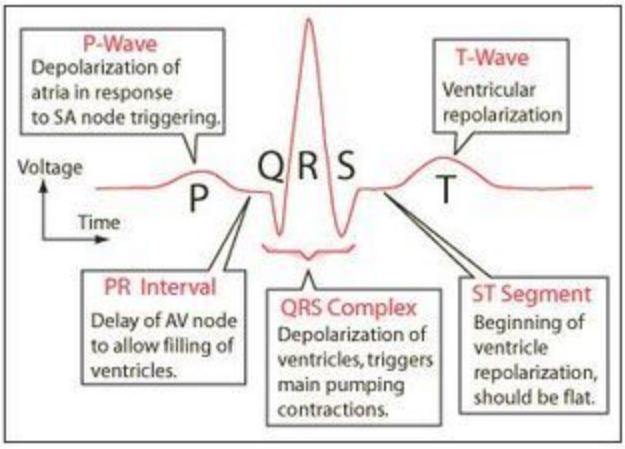
Below is a normal 12-lead ECG tracing. The different parts of the ECG will be described in the following sections.



3) **ECG Waves and intervals :**

Interval: The time between two specific ECG events. The intervals commonly measured on an ECG include the PR interval, QRS interval (also called QRS duration), QT interval and RR interval.

Wave: A positive or negative deflection from baseline that indicates a specific electrical event. The waves on an ECG include the P wave, Q wave, R wave, S wave, T wave and U wave.



4) **Basic Parameters/knowledges needed for this experiment :**

1) RR interval:
    a) Easiest method to find RR intervals is either use Pantomkin's algorithm or use manual annotation information.
    b) RR interval is nothing but the mean distance of all pairs of two consecutive r peaks in a signal.
2) Understanding of **Sliding Window Area** (A method we need to follow)

Explanation for SWA:

SWA is an algorithm for detecting *T* wave onset and offset (T_{on} and T_{end}, respectively) by analyzing the waveform area of ECG within a sliding window . Onset/offset is detected when the area of the sliding window reaches its maximum in a prefixed searching range

Steps:

1) Find the RR interval for all the pair and its denoted as RR_i for i^{th} pair.
2) Find t_1 & t_2 using eq 1.
3) Find the Area of the On set for all the t in the range of $[t_1,t_2]$, check equation eq 2 for calculating A_o

4) Similarly, find t_3 & t_4 and calculate A_e.
5) The j at which maximum area calculated is the $T_{on\text{-}set}$ and $T_{off\text{-}set}$

$$\begin{cases} t_1 = \left(\lceil 0.5 \times \sqrt{\mathrm{RR}_i} \rceil + R_i + 0.08\right) \mathrm{s}, & \\ t_2 = \left(\lfloor 0.15 \times (\mathrm{RR}_i) \rfloor + R_i + 0.12\right) \mathrm{s}, & \text{if } \mathrm{RR}_i < 0.88\ \mathrm{s}, \\ t_1 = \left(\lceil 0.5 \times \sqrt{\mathrm{RR}_i} \rceil + R_i + 0.1\right) \mathrm{s}, & \\ t_2 = \left(R_i + 0.32\right) \mathrm{s}, & \text{if } \mathrm{RR}_i \geq 0.88\ \mathrm{s}, \end{cases} \tag{1}$$

$$\mathrm{Ao} = \sum_{j=t}^{t+w} \left(s_j - \bar{s}_k\right), \tag{2}$$

$$\bar{S}_k = \frac{1}{2p+1} \sum_{j=t-p}^{t+p} S_j. \tag{3}$$

Constants for onset: w = 0.12s , p = 0.016s

$$\begin{cases} t_3 = \left(\lfloor 0.15 \times \mathrm{RR}_i \rfloor + R_i + 0.148\right) \mathrm{s}, & \\ t_4 = \left(\lceil 0.7 \times \mathrm{RR}_i \rceil + R_i - 0.036\right) \mathrm{s}, & \text{if } \mathrm{RR}_i < 0.88\ \mathrm{s}, \\ t_3 = \left(R_i + 0.28\right) \mathrm{s}, & \\ t_4 = \left(\lceil 0.2 \times \mathrm{RR}_i \rceil + R_i + 0.404\right) \mathrm{s}, & \text{if } \mathrm{RR}_i \geq 0.88\ \mathrm{s}. \end{cases} \tag{4}$$

$$\mathrm{Ae} = \sum_{j=t-w}^{t} \left(s_j - \bar{s}_k\right), \tag{5}$$

Constants for offset: w = 0.128s , p = 0.016s

Figure 1 and Figure 2 state examples for finding optimum A_o and A_e

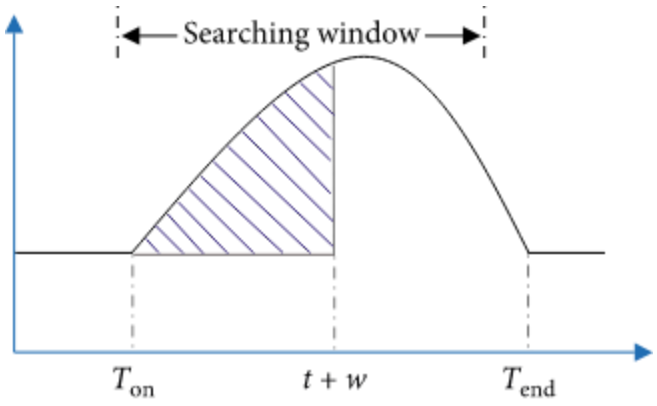


Fig.1 Eg of Max window area for T_{on} calculation

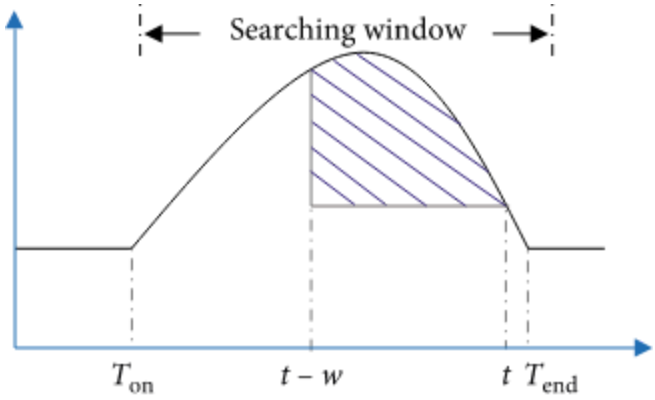


Fig.2 Example of window operation for T_{off} or T_{end}.

5) Dataset link: Use the following data for T wave analysis.

1) https://physionet.org/content/edb/1.0.0/
2) https://physionet.org/content/svdb/1.0.0/