

1. (10 points) *Plot the electrocardiogram for one heart beat. Denote the PQSRT waves and indicate typical temporal durations for the P-wave, the QRS complex and the T-wave.*
2. (10 points) *The electrocardiogram arises from the flow of depolarization in the heart. Provide a schematic diagram of the depolarization flow in a normal heart, labeling all anatomic components. Indicate the correspondence between the sequential depolarization of the cardiac muscle and the electrocardiogram.*
3. (10 points) *Human EEG often exhibits some rhythms that appear as oscillatory signals confined to specific frequency bands. The occurrence of such rhythms largely depends on behavioral and mental states (e.g. sleep and wakefulness). List the common brain rhythms and their respective frequency ranges.*
4. (20 points) *Human EEG recordings contain signals generated by the brain as well as some artifacts that originate from interfering physiological processes unrelated to brain activity. A common strategy to remove physiological artifacts from EEG recordings requires the acquisition of reference signals that purely characterize the interfering physiological processes of no interest to the study of brain activity. Such reference signals can be used to estimate and then remove the physiological artifacts. Briefly provide a general description (or design) of one or more artifact processing method(s) that would serve this purpose. State the underlying assumptions made in the method(s).*
5. (20 points) *Evoked potentials (EPs) constitute an event-related activity which occurs as the electrical response from the brain to various types of sensory stimulation. Individual EPs have very low amplitudes and are hidden in the ongoing EEG background activity. Suppose that in an experiment, a human subject receives 1000 impulse-like visual stimuli delivered at known and well-separated times. The background EEG is assumed to be stationary random Gaussian process with the average amplitude of $100\mu\text{V}$. Individual electrical responses to separated stimuli are assumed to have fixed waveforms, durations and amplitudes, which are known to be $5\mu\text{V}$ on average. In this case, (a) describe the method to extract the evoked potential from the recorded EEG and (b) estimate the signal-to-noise ratio of the to-be-extracted evoked potential.*
6. (30 points) *A typical application of signal processing to the ECG is the detection of QRS complexes. For the purpose of this problem, we will assume that the QRS complex has a constant, known shape, $s(n)$, of duration, D , and that it occurs at unknown times, $\{\theta_i\}$, such that it is contained completely within the observation window of length N . Consider the noise to be a stationary, white, Gaussian process with variance, σ^2 . Indicate the model for the observation, $x(n)$, and define an appropriate algorithm for detecting the presence of a QRS complex. Include relevant equations for your method.*