Electrocardiography

1. (10 pts) Plot (for one heart beat) the electrocardiogram. Denote the PQRST waves and indicate typical wave amplitudes (in mV). Label your time axis and justify the temporal durations you have assigned to the signal.

2. (20 pts) The electrocardiogram arises from the flow of depolarization in the heart. Provide a schematic diagram of the depolarization flow in a normal heart, labelling all anatomic components. Indicate the correspondence between the sequential depolarization of the cardiac muscle and the electrocardiogram.

3. (10 pts) A key mechanism for automatic processing of cardiac signals is knowledge of the underlying power spectrum. Plot an approximate power spectrum for the ECG wave components (P, QRS and T) and label your axes.

4. (30 pts) For each of the following ECG artifacts, indicate (1) the typical mechanism by which the artifact is introduced to the measured signal, (2) how the artifact is evidenced in the ECG signal (include a drawing), and (3) propose how (when possible) the artifact may be differentiated and removed from the underlying ECG signal.
   - Baseline wander
   - Powerline interference
   - Respiratory activity

5. (30 pts) A typical application of signal processing to the ECG is the detection of QRS complexes. For the purposes 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 an unknown time, \( \theta \), 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 \( \sigma^2 \). Indicate the model for the observation, \( x(t) \), and define an appropriate algorithm for detecting the presence of a QRS complex. Include relevant equations for your method.