You have received a letter from your friend Dr Gert, who is a famous cardiologist.

Dear Linus/ Linnea (general nickname for LiTH students)!

How are you doing? I have just recently started using my new MATLAB version. You can achieve a lot with the new data acquisition toolbox! I have recorded a couple of ECGs and need some help analyzing them. Some of the signals come from healthy subjects, while others have some type of arrhythmia or an ST-shift. Occasionally the signal contains some noise and baseline drift (unstable amplifier). Could you please help me by developing an analysis tool for detection and classification of the two different types of irregular arrhythmias that are present in the ECG signals you’ve received from me?

I also need the algorithm to automatically detect and visualize the gradual change in ST-level (i.e. ST-elevation/suppression) that I think is present in one or more of the ECGs. The ECGs are stored in the data file ECG.mat, which can be retrieved from the homepage. You can also find some plots of the ECGs on the web site. The variable ECGinfo contains the sampling frequency of the signal according to:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fs [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG1</td>
<td>250</td>
</tr>
<tr>
<td>ECG2</td>
<td>250</td>
</tr>
<tr>
<td>ECG3</td>
<td>360</td>
</tr>
<tr>
<td>ECG4</td>
<td>360</td>
</tr>
<tr>
<td>ECG5</td>
<td>250</td>
</tr>
</tbody>
</table>

It would also be great if you have the possibility to acquire and analyze additional ECG:s from a healthy population as a reference group.

Best regards, Gert, MD, PhD
Since you are famous engineers with a great interest in developing software algorithms you accept the challenge. Here you have a chance to show Dr Gert that your education provides you with generally applicable knowledge so that you can deal even with issues in cardiology.

**Requirement specification of the algorithm:** The algorithm should be able to handle both slow baseline variations and measurement noise. It is important to note that the amplitude of the ECG varies with the setting of the amplifier and the degree of contact between the electrodes and the skin. Hence, any amplitude thresholds need to be adaptive. If possible, implement thresholds that are adaptive not only between files but also within a single measurement. Further, the algorithm should be able to detect the occurrence of arrhythmic heart beats (when in time) and to classify each arrhythmia as either of the two types found in the ECG signals you have received. The algorithm should also return how many arrhythmias in total (per type) that are found in each ECG file. Finally, your algorithm should be able to detect and visualize how the ST level changes over time in the provided ECG files, to facilitate any further diagnosis related to a suppressed or elevated ST level.

The data files containing the ECGs can be downloaded from the course file archive. However, before starting designing and implementing your algorithm we recommend that you consider:

- What is the appearance of an ECG?
- How can you differ between healthy and abnormal ECG?
- How does an irregular arrhythmia look?
- Which types of irregular arrhythmia are present in your ECG?
- Which signal processing blocks/steps are needed in an algorithm for detection and differentiation of the two irregular arrhythmias?
- What is an ST-elevation suppression and how can it be quantified in an algorithm?

This task should be solved in groups of 3-6 students (two groups per PBL-group) and documented in a group report where you present and discuss the results of your solution, describe the important steps in the implementation and the pros and cons of the solutions. The report should briefly describe how your algorithm design relates to the medical background of healthy and arrhythmic ECG:s according to relevant parts of the point list above. The report should contain results from ECG 1-5, both visual and numerical, that shows that the requirement specification is fulfilled. The software should be included as an appendix in the report, and the maximal length of the report is 2000 words, excluding figure captions and code. Please also note that you are not allowed to share your algorithm with anyone outside your group except your teachers.

The report shall be presented at a seminar where other groups and the course teachers will discuss your solution and report in a peer-review process. For further details on the examination, please consult the document *Examination and report*

**Good Luck!**