ECEN220 Signals and Systems

(Lec 0 Introduction)

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with

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The journey, not the arrival (yet), that matters...

Format of classes (per week):

- 4 periods of lectures,
- 2 periods of Labs,
- There will be homework, tutorials to help you learn.
- Assessments are individually submitted and marked.

Signals and Systems Course Overview

- This is a 1 semester undergraduate course, covering the basics of Signals and Systems:

First half:

- ☐ Signals (properties, transformations etc)
- ☐ Linear Time Invariant (LTI) Systems
- ☐ Fourier Series
- ☐ Fourier Transform

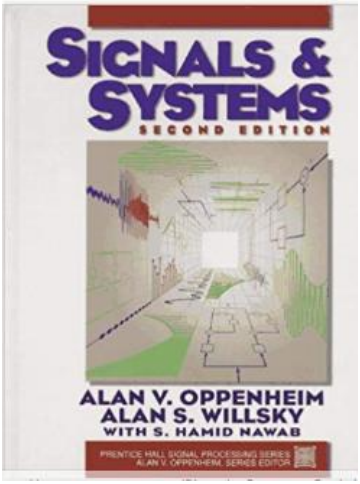
- ☐ Time & Frequency Domain Signal Analysis
- ☐ Sampling Theorem
- ☐ Z-Transform

All LABS will be conducted by Li Yiwei

Textbook

- ☐ Any book on Signals and Systems is equally good.
- ☐ But we will refer to this book:

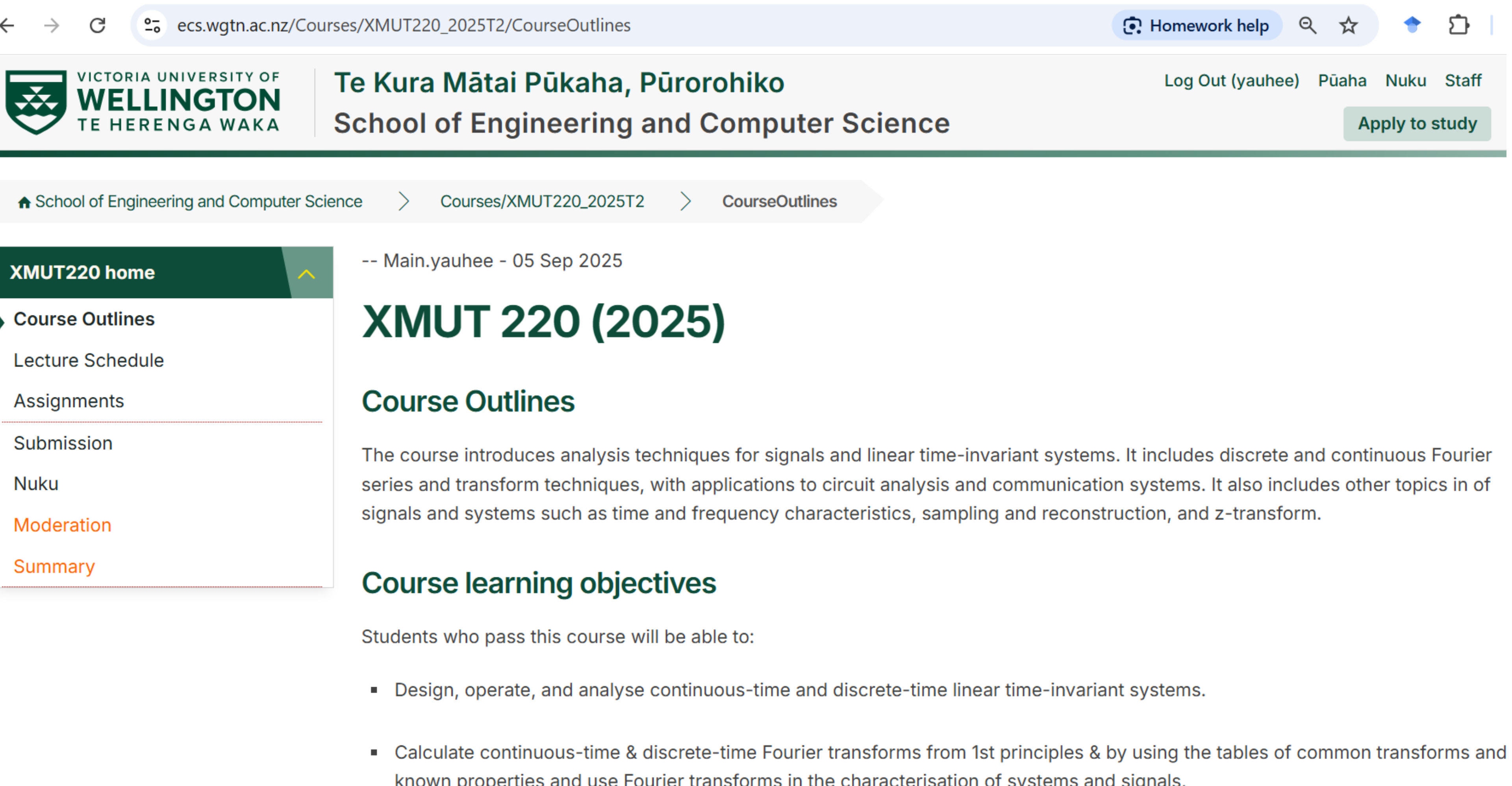
"Signals and Systems" by Alan V. Oppenhium, Alan S. Willsky, published by Pearson, 2nd edition.



Although you will want to read Chinese textbooks, that is okay, but remember that all assessments are in English!

Course Website

- https://ecs.wgtn.ac.nz/Courses/XMUT220_2026T2/220COURSEOUTLINE



Assessment Criteria (subject to confirmation)

- 1 end-of-semester final exam 30%.
- 1 mid-semester Tests at 30%.
- 6 Labs to be done. Only 2 Labs will be marked (10% each, giving a total of 20%).
- 4 Homework Assignments. (2.5% each, with a total 10%).
- Participation in classes and labs (10%)

On top of the above, you need to manage on your own:

- Tutorials
- Reading

Teaching Schedule

Teaching schedule

Week	Lecture	Tutorial	Homework	Lab	Due for Marking
1	Introduction on Signals and Systems	Tutorial 1		Lab 0 Introduction to Matlab	
2	Signals		HW 1	Lab 0	
3	LTI Systems	Tutorial 2		Lab 1 Signals and Systems	
4	LTI Systems			Lab 1	HW 1 (5%)
5	Fourier Series	Tutorial 3	HW 2	Lab 1	
6	Fourier Series			Lab 2 Fourier Series (to be marked)	
7	Fourier Transform	Tutorial 4		Lab 2	
8	Fourier Transform			Lab 2	Lab 2 (10%) **Mid Term TEST (30%)**

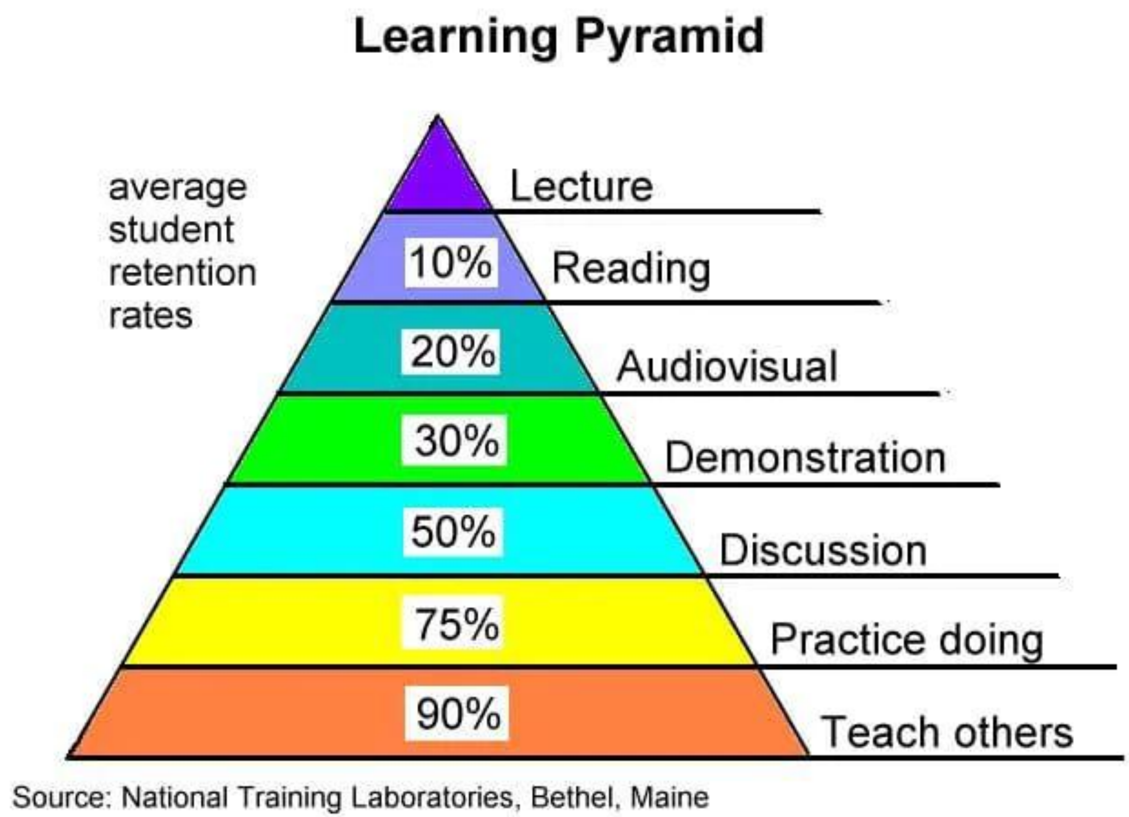
(Note: schedule for second half of semester will appear closer to the start)

How to study Signals and Systems?

Tell me and I forget,

Show me and I remember,

Involve me and I learn.



Expected hours of study

- 4 periods of Lectures per week ,
- 2 periods of Labs per week ,
- You also need self-directed study; how many hours per week will be required?
- At VUW this is a 15-point course; 1 point ~ 10 hours, so this means a total of 150 total hours for whole course.
- We have 16 weeks, minus one week of National Day holidays, there are 15 weeks, so ~ **10 hours per week**!
- These include class/lab times, doing homeworks, assignments, write lab reports, reading etc

General Information

- Difference between the style of teaching and learning at VUW and XMUT
- Plagiarism – do not copy from your classmates
- Attendance – make sure you have enough attendance to sit final exam.
- Mark scaling between VUW and XMUT
- Resit exam – course marks will be calculated.

Different systems and teaching styles

- “Easy in Difficult out” vs “Difficult in Easy out”,
- Students treated as mature adults, not higher secondary students,
- Training you to be an independent professional with critical thinking and problem solving skills,
- More hands-off => you explore and teach yourself,
- Open ended questions, reports etc,
- Tests and Exams are usually not the repeat of homeworks.

Plagiarism **(also known as copying/cheating)**

- Meaning to copy others' works and submit as your own. This is NOT OK.
- You can discuss and seek help from classmates, BUT
- DO NOT just COPY => you must work on your own.
- This includes NOT just copy and translate words from webpages/textbooks => you must re-write in your own words.
- This includes diagrams and figures!
- In group lab work, indicate all members' names and IDs.
- Please do not disclose your VUW login passwords.
- Penalty: verbal warning, followed by 0 marks in assessment, then report to School.

Attendance

- By XMUT’s rules, you need to have a minimum level of attendance rate in classes. I think it is 70%?
- Otherwise, you will not be allowed to take the final exam => you will fail the course.

Mark scaling

- Different pass marks: 50 marks in VUW and 60 marks in XMUT.
- Does this mean it is easier to pass in VUW?
- NO, due to an inverse relationship => a lower pass mark means assessments are usually more difficult.
- As long as you get 50 marks in VUW’s courses, you would have passed!
- When reporting to XMUT, we will apply a piecewise linear scaling so that 50 in VUW becomes 60 in XMUT.

Resit exams

- There is NO resit exams in VUW!
- BUT we have adapted to XMUT’s system, by offering resit exams BUT with a major difference: your normal assessments and tests marks will still be included.
- This is different from XMUT where only the resit exam marks will be considered.
- This means, if your normal assessment marks are too low, you will still not pass the resit exam => in some cases even if you get 100% in the resit exam!
- Please take note!

If you need help on the course…

- I am willing to answer your queries, but please bear in mind that NZ is 4 hours ahead of Xiamen (5 hours from October onwards).
- You can message me using WeChat.
- Please refrain from posting unrelated stuff/comments in our WeChat Group. Also, if you need help, message me privately instead.
- I encourage you to communicate in English

Introduction

- Myself https://people.wgtn.ac.nz/YauHee.Kho
- Jimmi Rosa
- Li Yiwei
- Ye Yishan
- Our class…

ECEN220: What is a Signal?

- A signal is a physical quantity which is measurable and normally expressed as a function of some independent variable, either space or time.
- Example:
  - Weight Data of this class in kg:
    - W(n) = {56,40,101,70,72,…,90}
  - Temperature in this room at different time:
    - Temp(t)
  - Speech Signal
    - V(t)

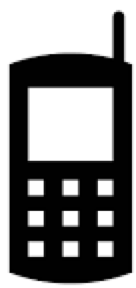
What is a Signal?

- We aim, ultimately, to extract information from the variation of a physical quantity or at least at transforming it in ways that make it easier for the information to be perceived.
- E.g. The average weight of the class:
  - $E(W) = 1/N \Sigma W(n)$

  tells us what is expected weight given any student.
- Variance then tells us how much variation from the expected value we are to anticipate.

What is a System?

- A system will take in an input signal, process it, then produce an output signal.
- Example, your handphone receive the wireless signals from the antenna, then process it, and give you the voice and multimedia.

Wireless signals in the air →  → voice and multimedia

Input signal, x(t)　　System, h(t)　　Output signal, y(t)

Example Applications of Signals and Systems

There are many applications, and we will have a look at 4 examples:

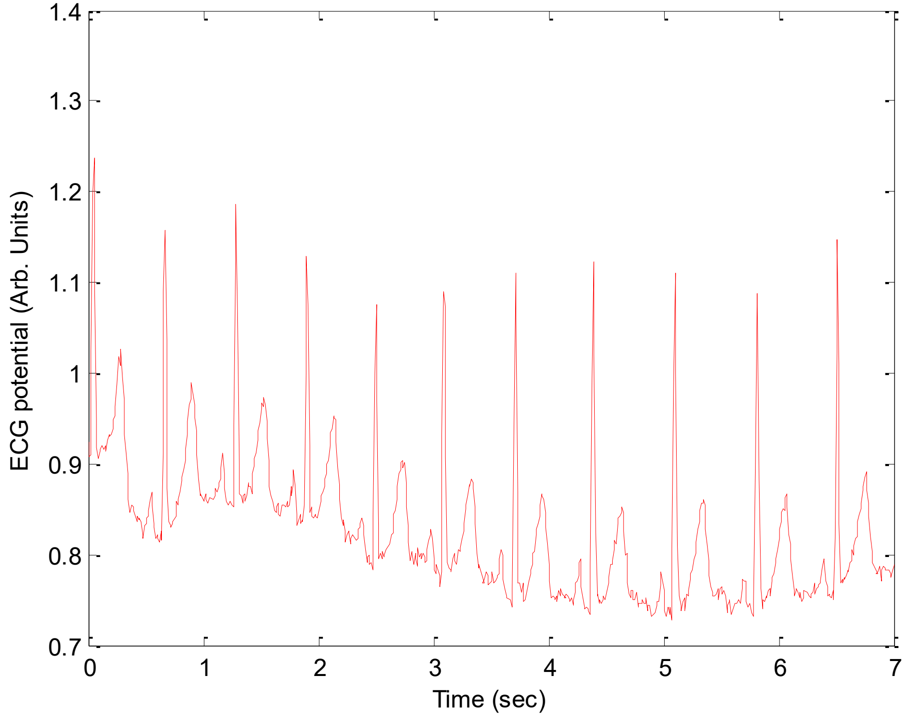
- Data Extraction or Reduction
- Spectral Analysis
- Signal Estimation
- Signal Detection

Example applications

- **Data Extraction or Reduction**
- Spectral Analysis
- Signal Estimation
- Signal Detection

Data extraction or reduction

- A typical example is the analysis of Electrocardiographic (ECG) signals: signals typically recorded on the outside of the chest which reflect the electrical activity of the heart

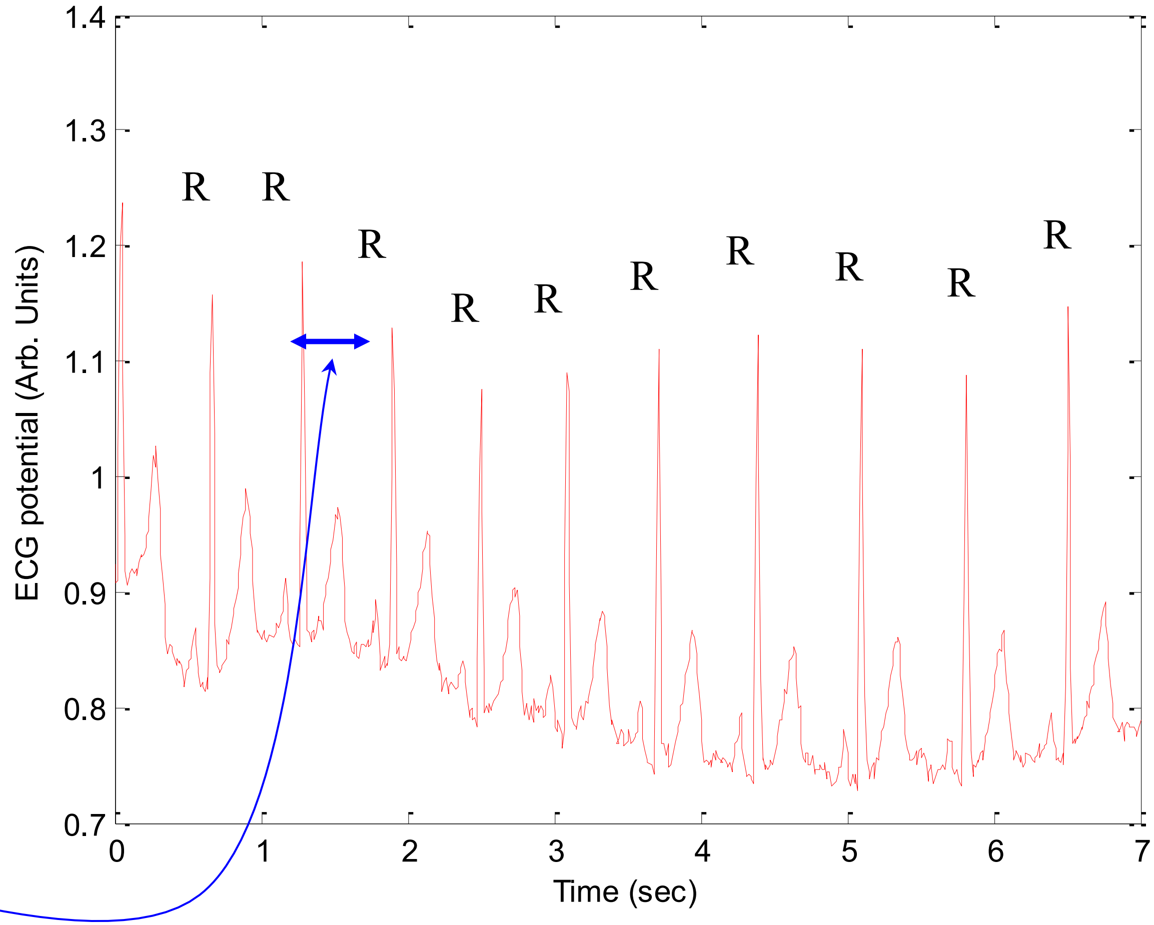


Data Extraction (ECG 1/4)

Example of ECG signal sampled at about 100 Hz .

The recorded signal suffers from an obvious base-line drift, probably due to patient motion.

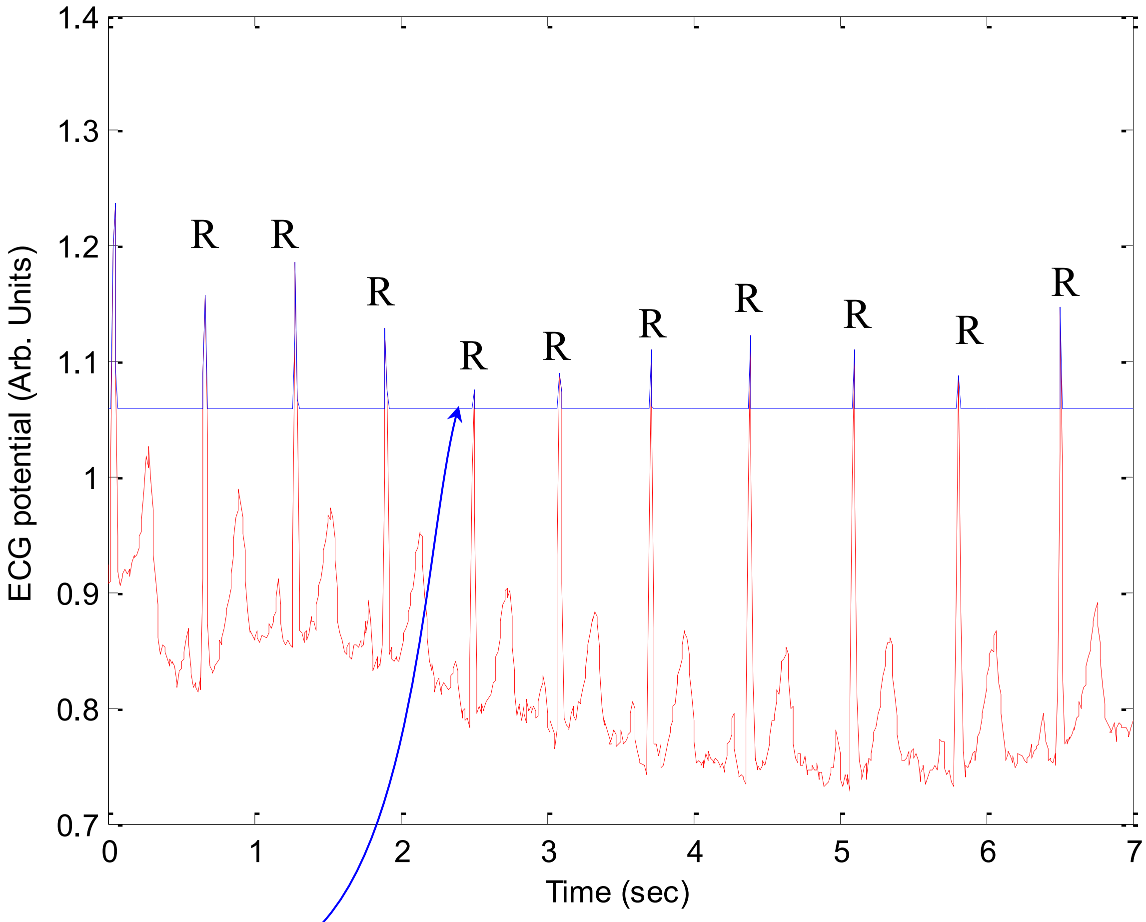
One piece of information usually required is the heart rate or equivalently R-R interval.



Data Extraction (ECG 2/4)

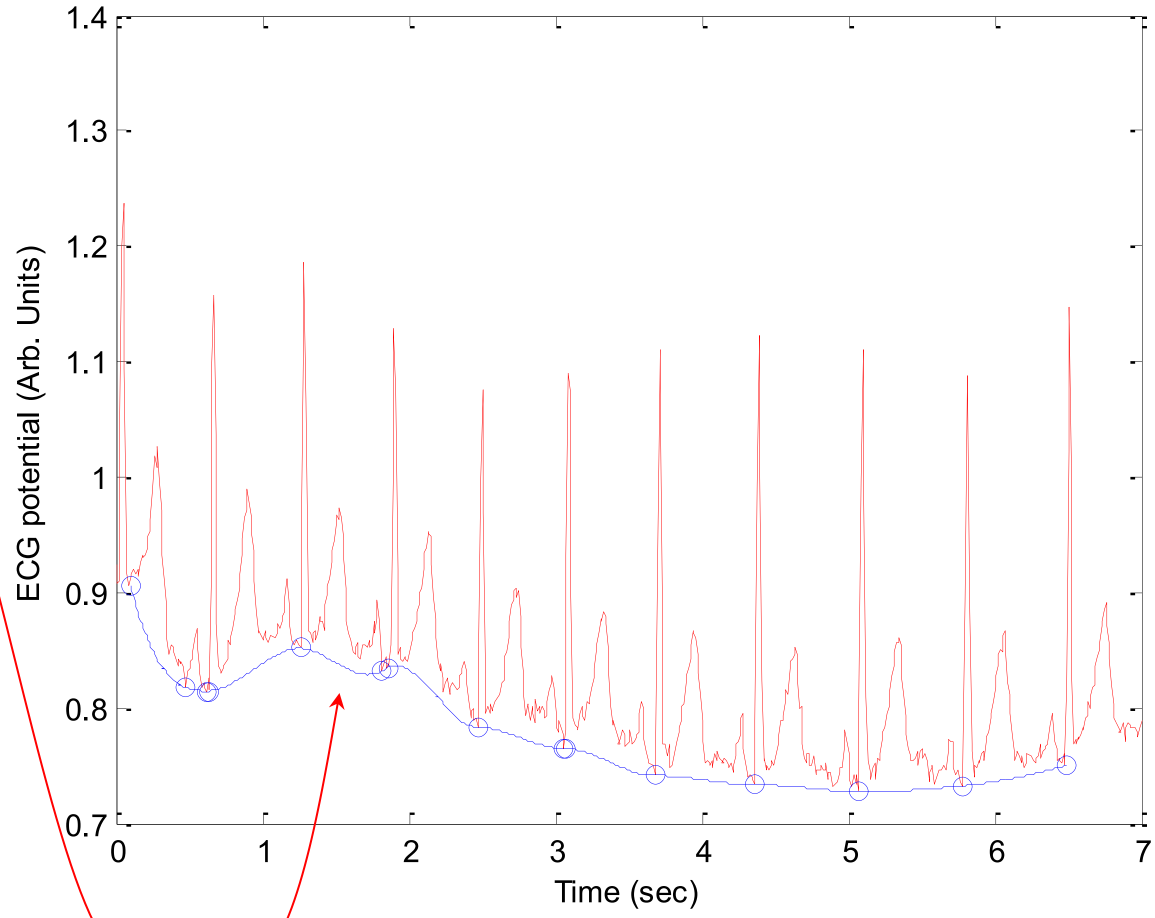
The obvious approach is to use a threshold (either an algorithm in DSP or a circuit that responds only to signals above a certain level).

One problem is that the baseline drift may cause genuine peaks to fall close to or even below the threshold level.



Data Extraction (ECG 3/4)

If more information is required, say about the actual shape of the pulse, it may be necessary to estimate the baseline drift before any measurements can be taken.

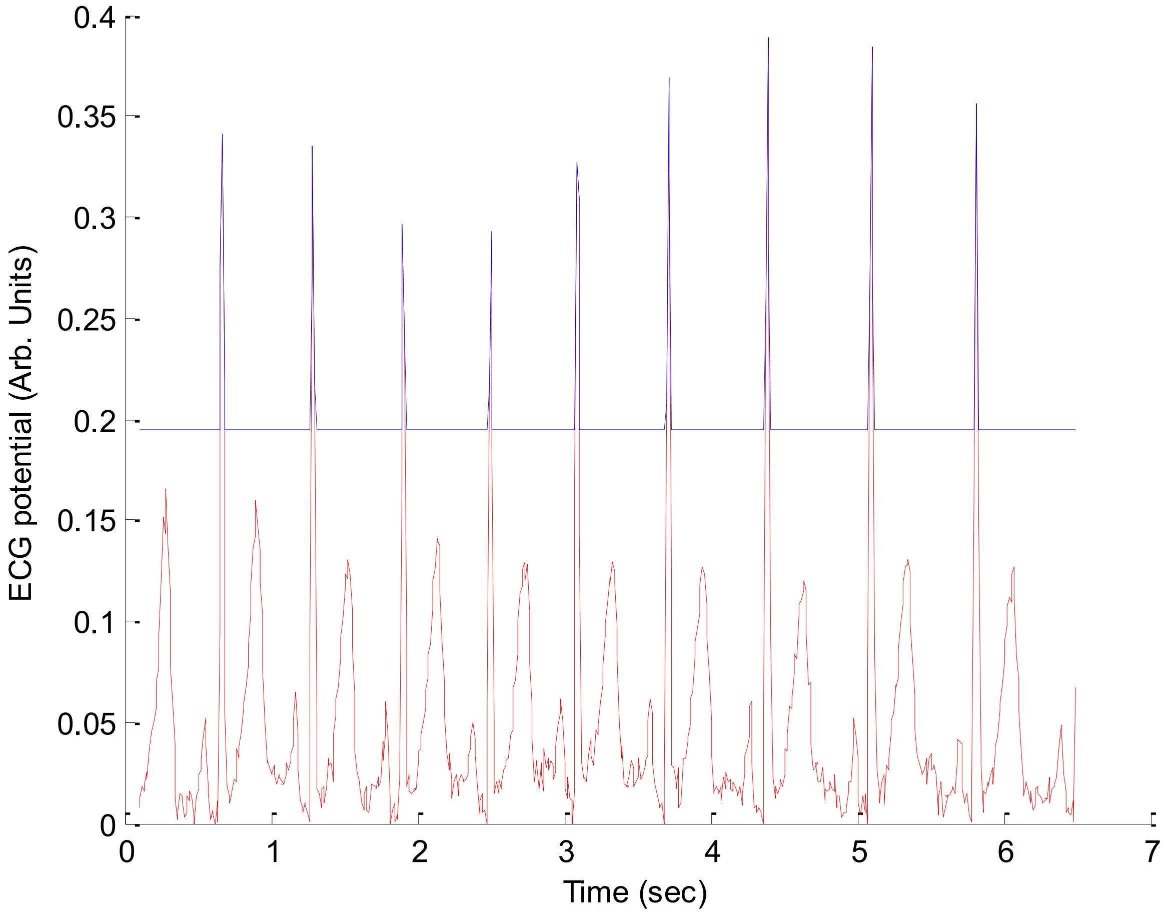


Data Extraction (ECG 4/4)

The drift can then be removed to make it easier to apply a uniform threshold over the full sweep.

This allows the R-R interval to be more reliably estimated.

Clinically, the R-R interval is used to measure the instantaneous heart rate.



Example applications

- Data Extraction or Reduction
- **Spectral Analysis**
- Signal Estimation
- Signal Detection

Spectral Analysis (Audio 1 of 3)

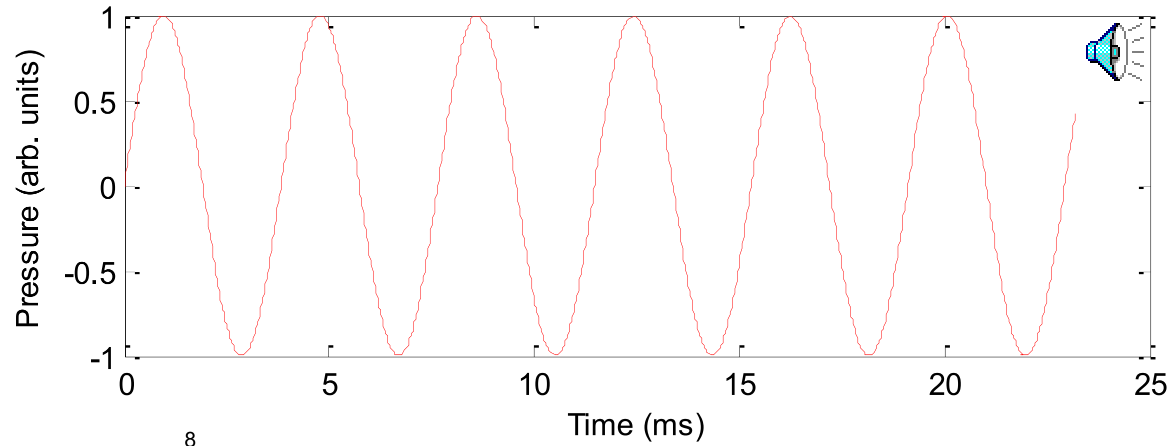
- Many signals arise from oscillatory processes and the information in the signals is often more easily determined if the signal is transformed in such a way as to highlight the different oscillations contributing to the signal.

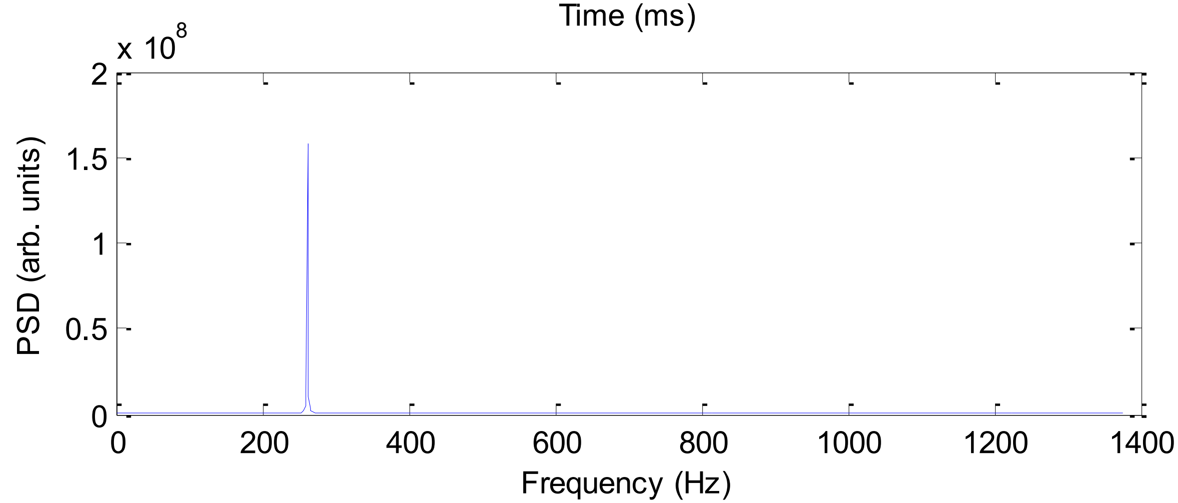
- As with data reduction, the field of spectral analysis is vast, and a number of different "spectra" are used. Many of these are closely related to the Fourier transform. Let’s look at the audio example.

Spectral Analysis (Audio 2 of 3)

In the time domain the signal shows a pure sinusoidal variation with time.

In the frequency domain the tone is recognisable as a colourless middle c (about 261Hz).

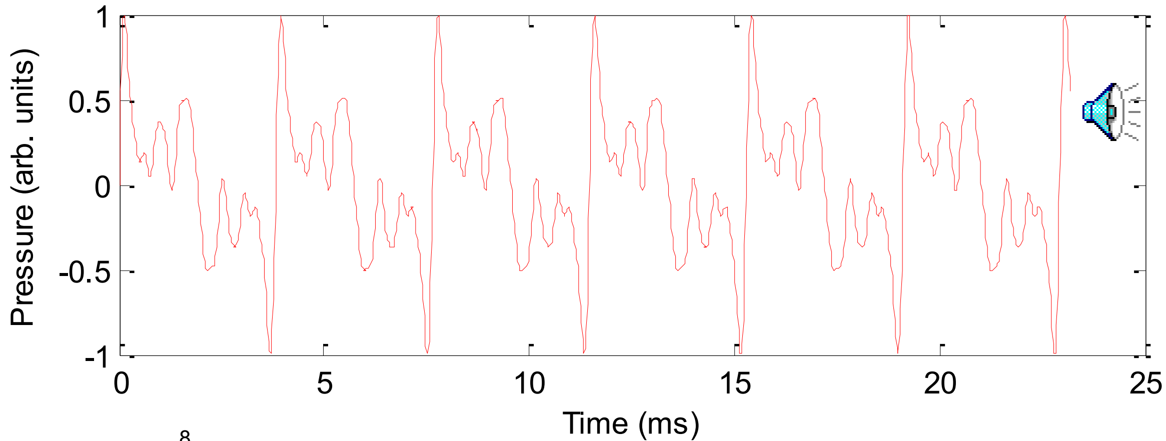


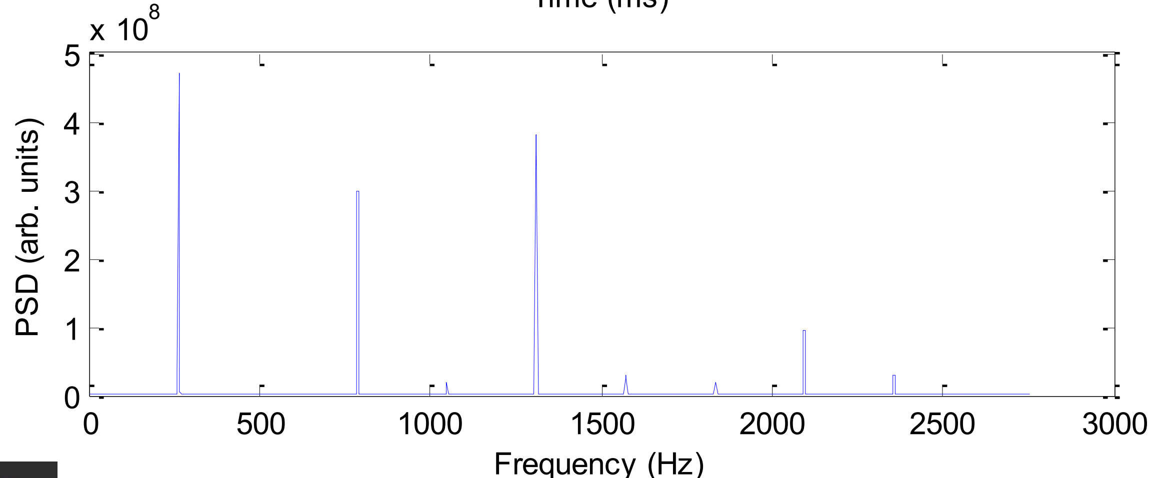


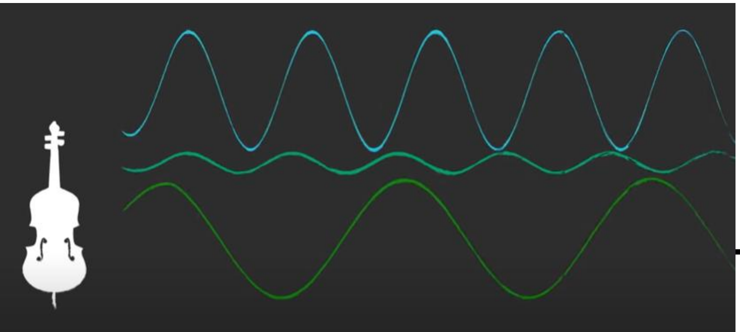
Spectral Analysis (Audio 3 of 3)

The audible character ('timbre ') of a tone is determined to a large extent by the harmonic content of the signal

In the frequency domain the tone appears as a sequence of *spectral lines* characteristic of the instrument on which the note is played.







Example applications

- Data Extraction or Reduction
- Spectral Analysis
- **Signal Estimation**
- Signal Detection

Signal Estimation

- When information is transmitted or when data are taken, the signal is often corrupted by noise and distorted by the process of transmission and recording.

- Signal estimation is the problem of recovering the "best" estimate of the ideal information bearing signal from the received signal.

Signal Estimation

It is possible to take advantage of the difference between the spectrum of the true signal and the noise to reduce (if not entirely remove) the noise at the expense of some degradation of the signal.

Signals usually have structured spectra, whereas noise is typically a broad-band, unstructured, essentially random signal.

Better models of the signal and noise can generally provide a better estimate of the signal starting from the noisy version.

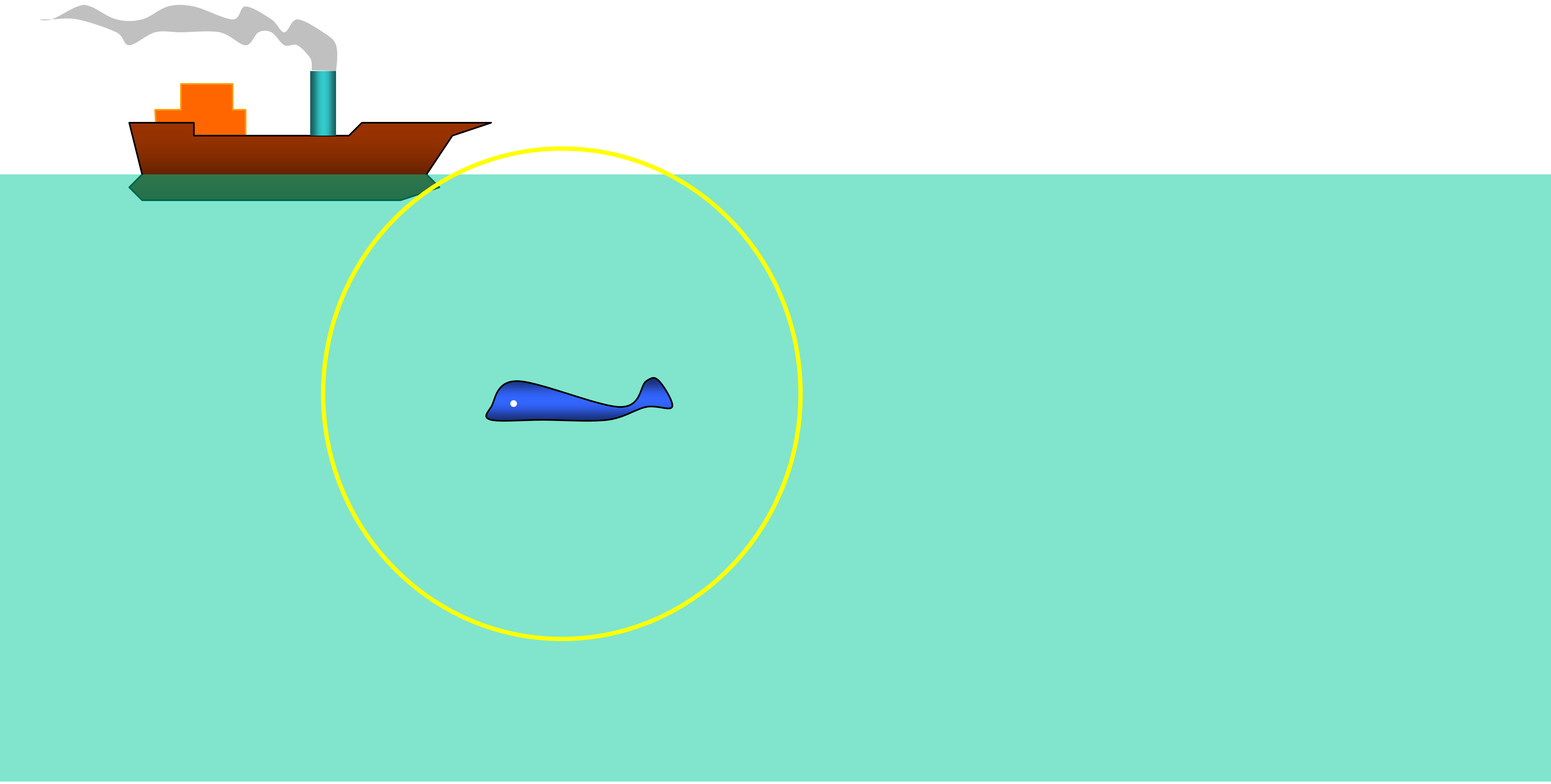
Example applications

- Data Extraction or Reduction
- Spectral Analysis
- Signal Estimation
- **Signal Detection**

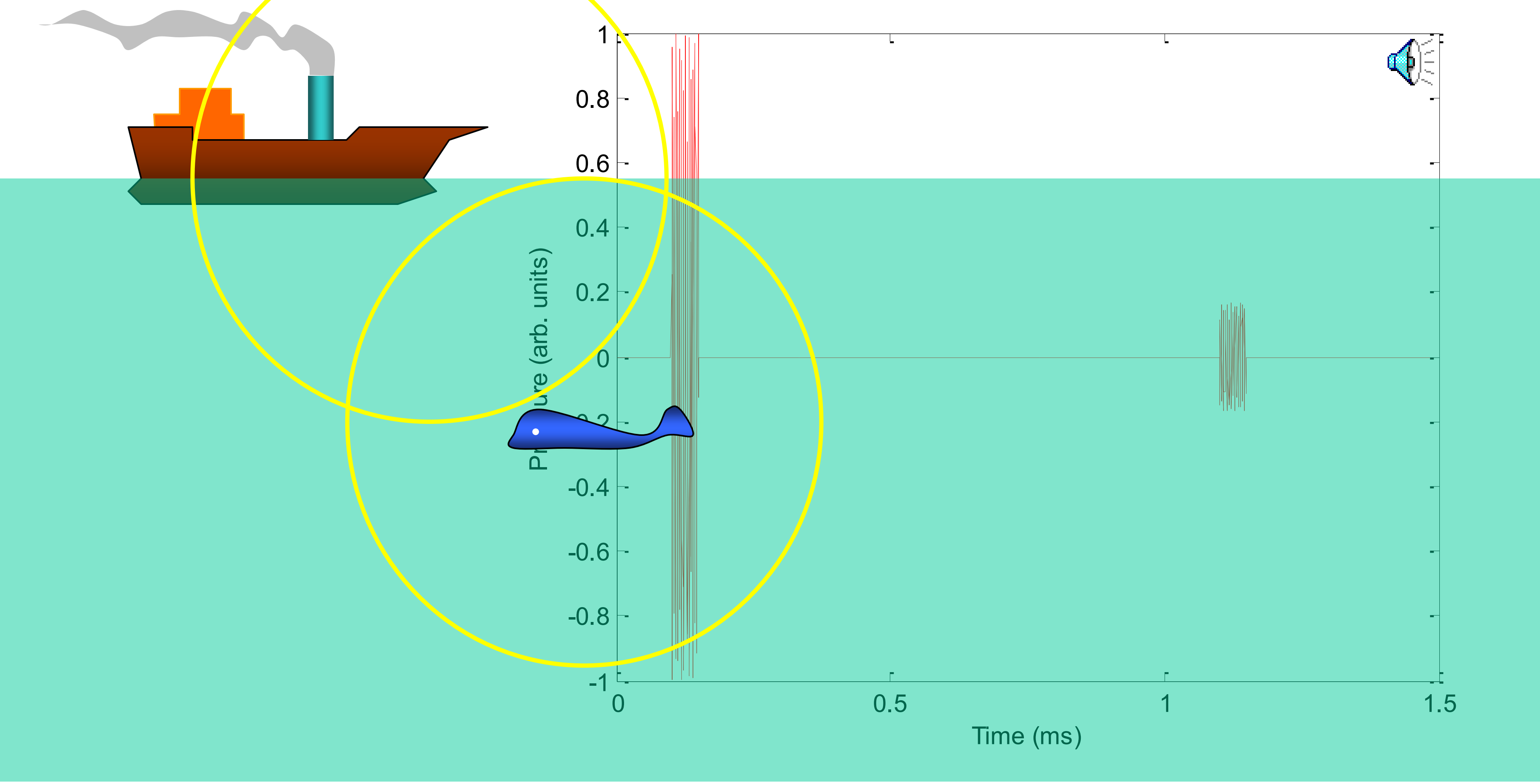
Signal Detection

- It may happen that all that is required in some application is detection of the presence of a genuine signal in an often severely degraded version of the signal, and estimation of some of its parameters.
- If the form of the signal is known in advance then a filter based on this known form can be used to detect the target signal in quite noisy backgrounds.
- This approach is called *matched filtering*, or, for special cases of the noise spectrum, *cross correlation*.

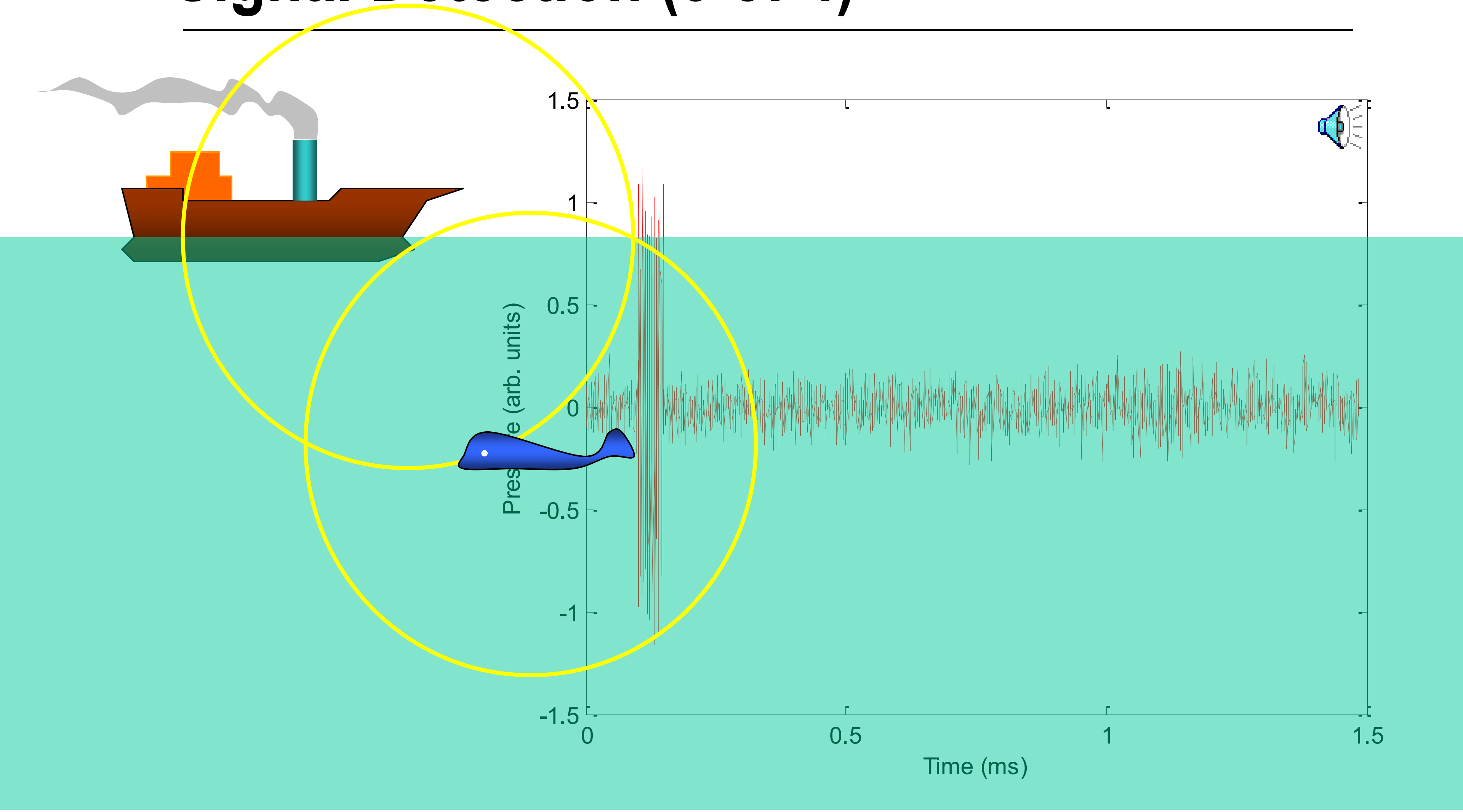
Signal Detection (Sonar 1 of 4)



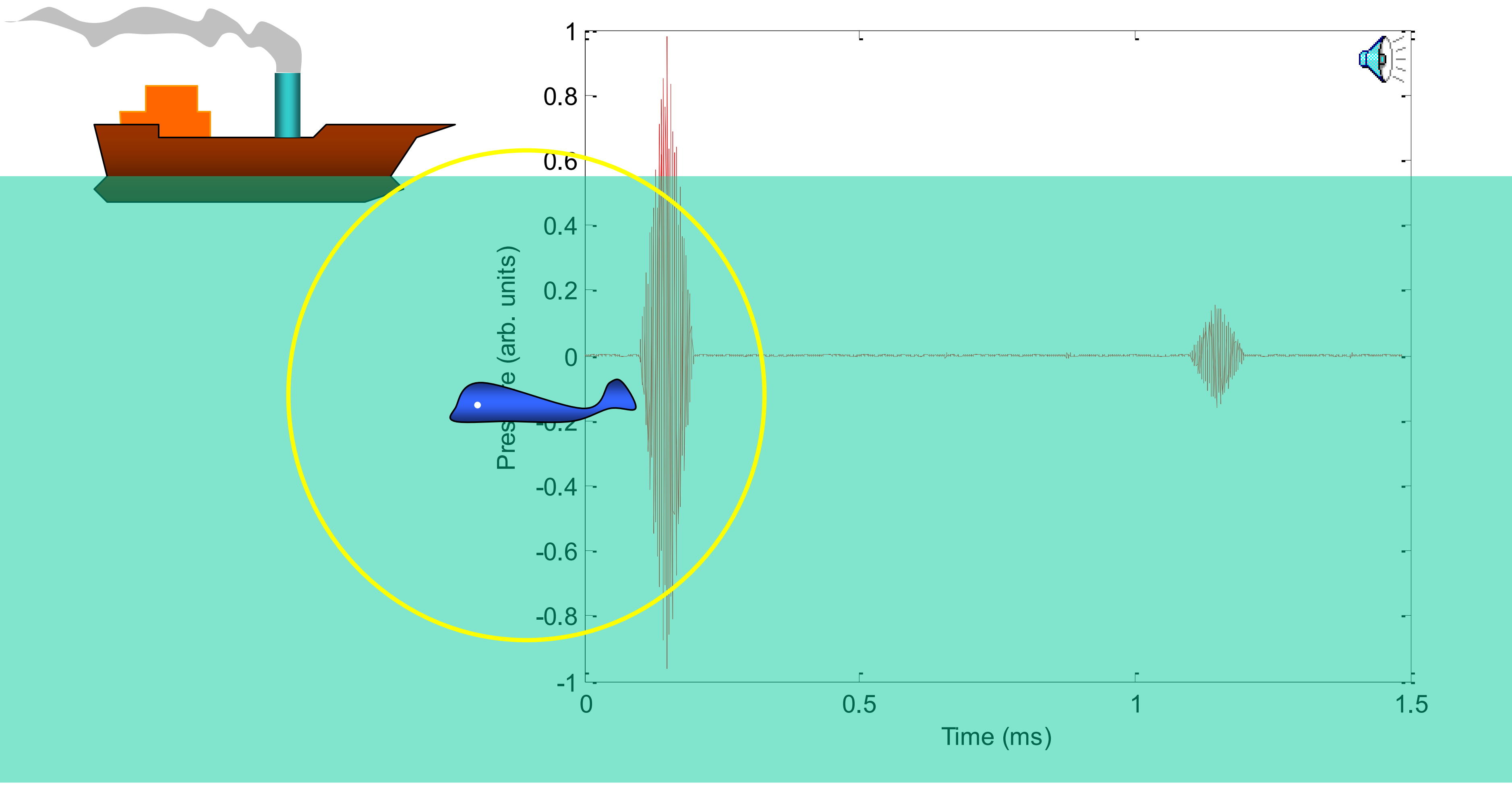
Signal Detection (Sonar 2 of 4)



Signal Detection (3 of 4)



Signal Detection (4 of 4)



Course syllabus

- Continuous Time Signals (CT)
- Discrete Time Signals (DT)
- Linear Time Invariant (LTI) Systems
- Fourier Series (CT & DT)
- Fourier Transform (CT & DT)
- Time and Frequency Characteristics
- Sampling
- Z-Transform

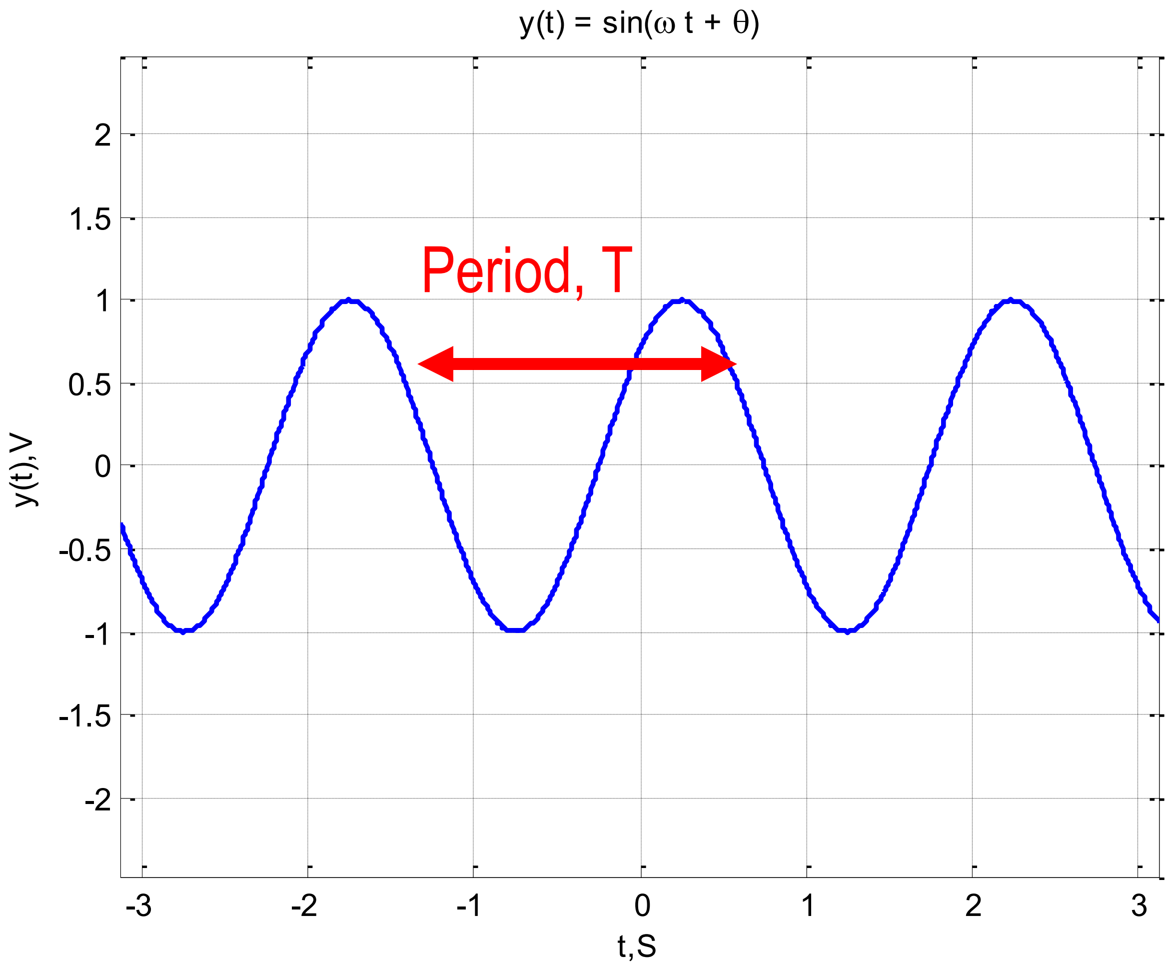
Quick Revisions:

- Definitions:

Frequency, f = 1/T (Hz or Cycle per Second)

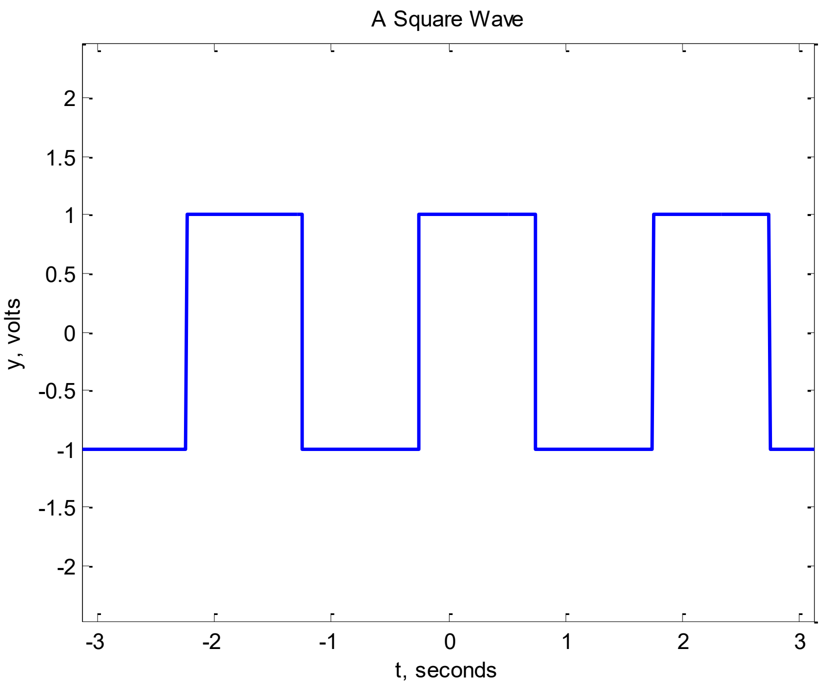
Radian Frequency, ω = 2πf

Phase Lag, θ



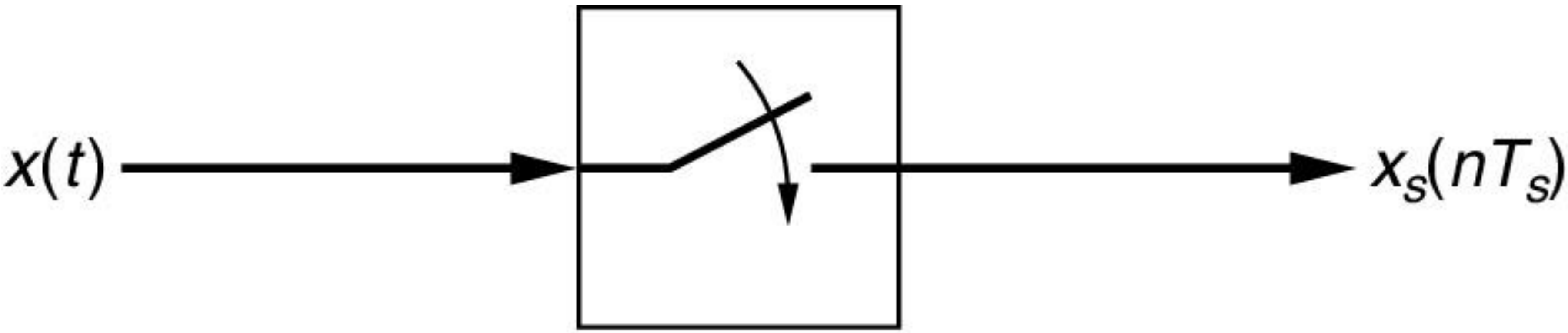
Continuous-time **Signal**

- A *continuous-time* (CT) signal is a function of time that is defined for every time instar within a given range of time
- Note that a CT signal need to be continuous in the mathematical sense.
- Example: A square is a CT time but not a *continuous function*.

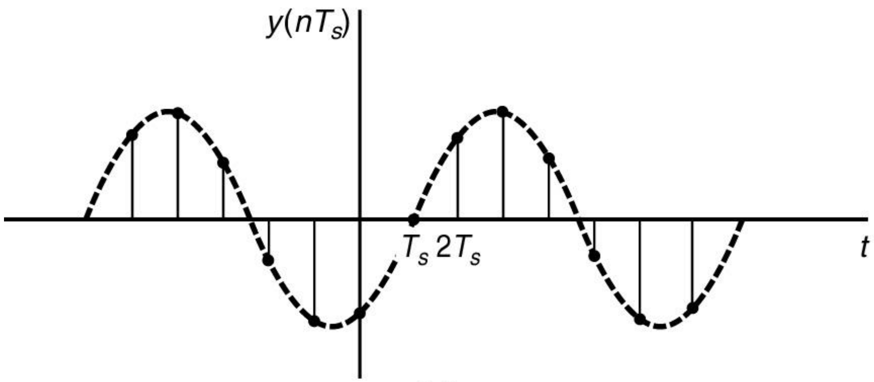


Discrete-time Signal & Sequence

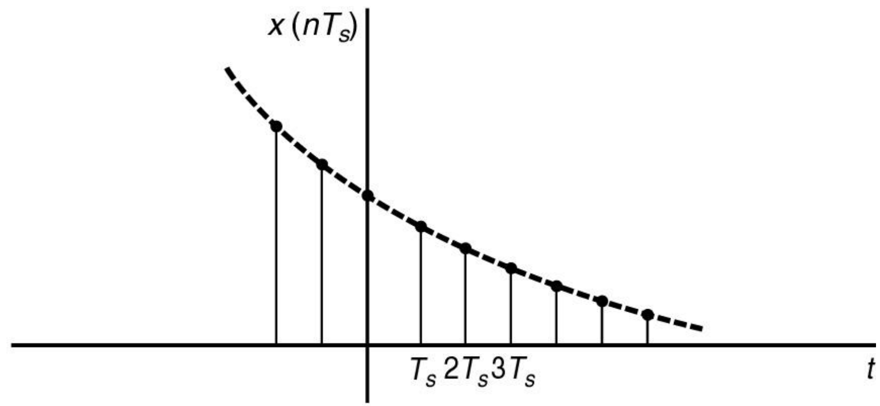
- A discrete-time signal contains only value at a constant time interval. In other words, the signal is *quantized* in time.
- i.e. x(t) = x(nTs)



Examples:

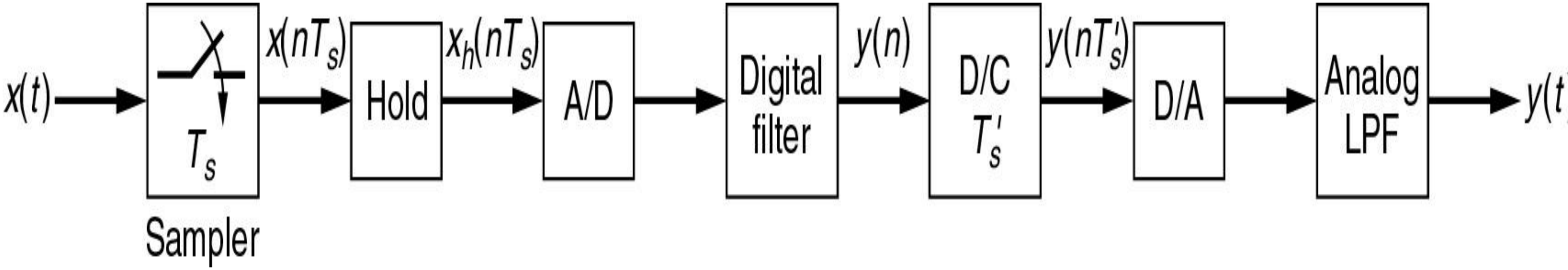


(a)

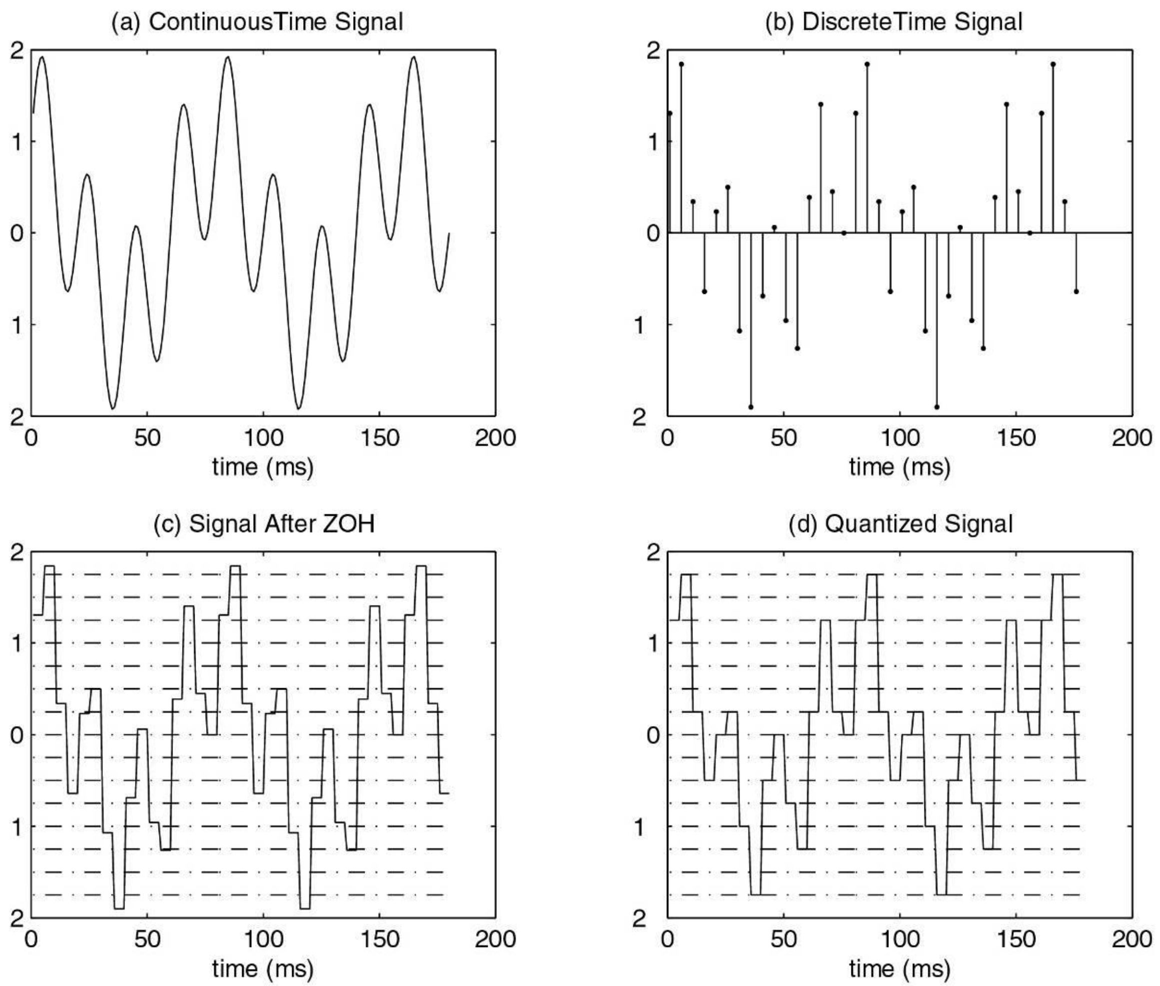


(b)

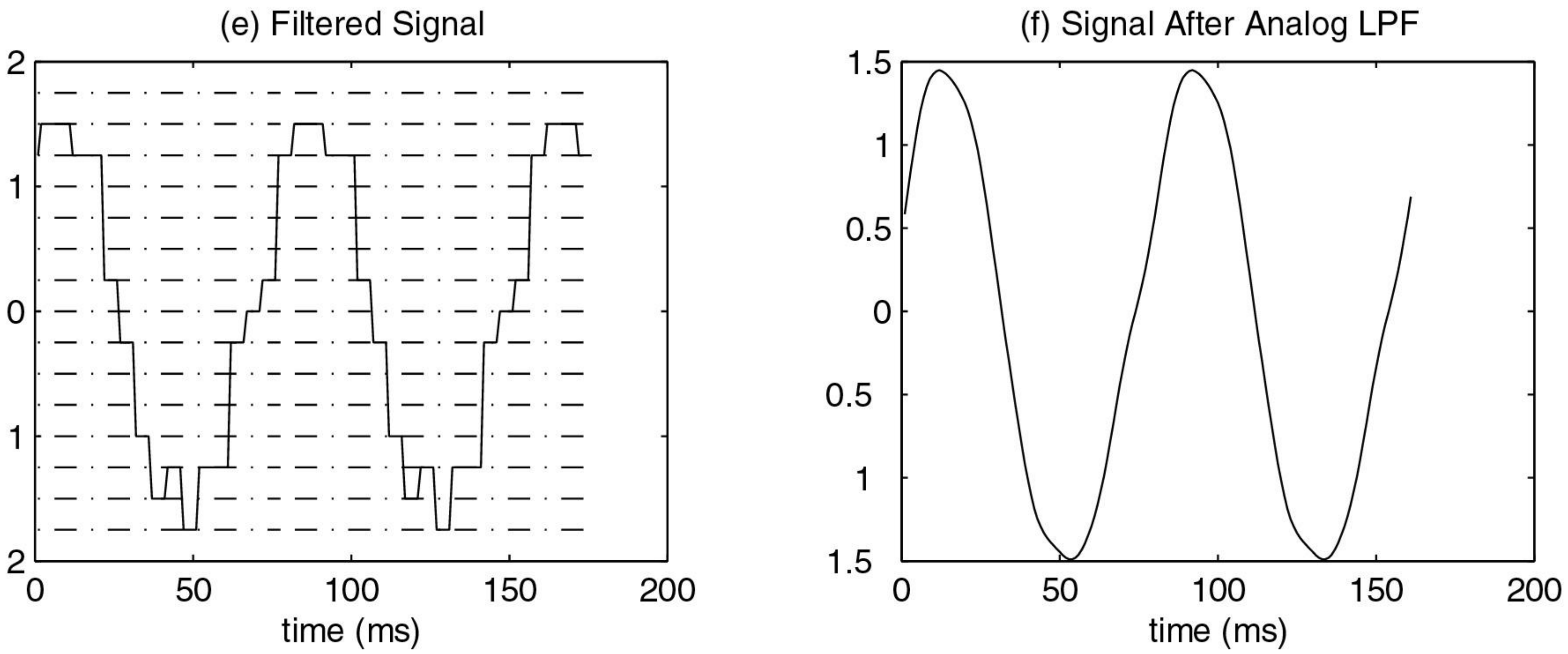
A typical Digital Signal Processing (DSP) system



A Typical DSP System



A Typical DSP System



Notes:

- There is a fundamental distinction between the words: digital and discrete time.
  - e.g. digital: 010 100 010 111
  - E.g. discrete time { … 2.15 4.33 2.10 7.22 …}
- Most of the topics requires a good understanding of linear algebra and trigonometry.
- For advanced DSP, we normally requires a good hand in vector and matrix calculus.