Introduction to Physiological Measurement

Transducers and Instrumentation for Physiological Measurement

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30th August, 2014

Outline

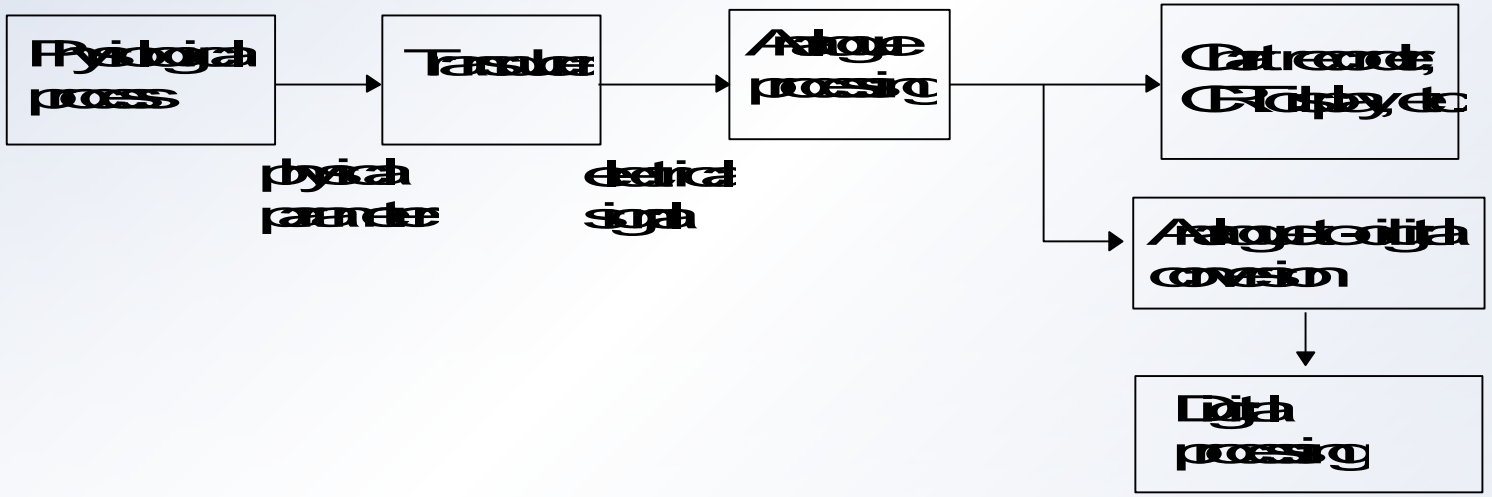
- General Principles of measurement
- Examples of measurement
- Sensors for measurement
- Unobtrusive measurement: non-invasive

Why Measure?

- To define normal physiology
- To classify deviations from normal physiology – i.e., pathophysiology
- To understand processes and systems

N.B. Physiology is the study of processes and systems that enable homeostasis

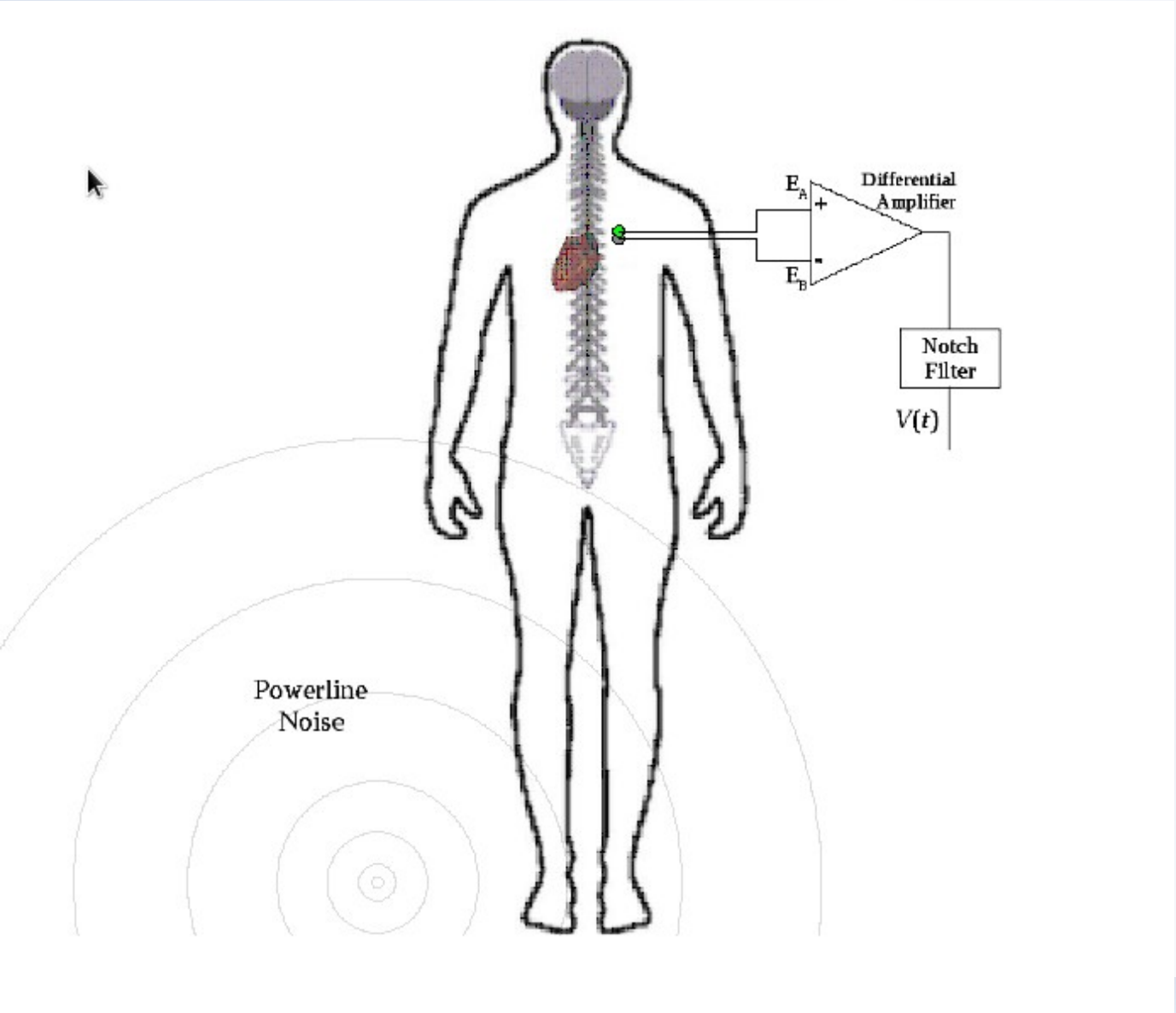
The Measurement Process



Examples of Measurement

- Measurement of chemical and gas concentrations
- Measurement of structure - imaging
- Electrophysiological Measurement
- Cardiovascular Fluid Mechanics Measurement
- Musculoskeletal Mechanical Measurement

Biopotential Measurement – ECG and Nerve Activity



Concepts for Measurement

- A signal is a physical quantity – typically it varies with time (but it can vary with length, space, etc.)
- A system is a process that can modify a signal

Transduction of Signals

- Transducer converts one kind of physical energy into another form
  - e.g., pressure to resistance, temperature to voltage
- Therefore, a transducer is also a system that modifies the signal

Characteristics of signals

- Steady state value – single value measurement, slow measurement
- Transient measurement – time-varying measurement

Characteristics of Systems

- Predictable behaviour – i.e., stationary over time
- Linear – acts the same way on small signals and as well as larger signals

Review Questions

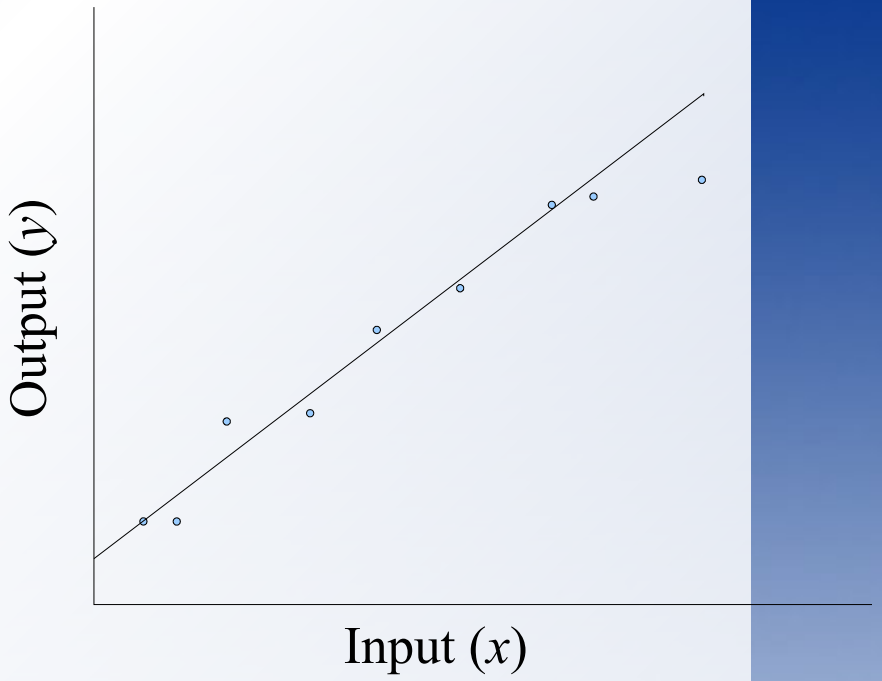
1. In each of the following transducers, what is the input and output?
    a) Manometer
    b) Weighing scale
    c) Load cell
    d) Accelerometer
2. A piston in a cylinder (like a syringe), and a displacement sensor, can be used as a pressure sensor. What are the potential difficulties with this arrangement? Is any additional element to be added? What is the zero reading of such a transducer?
3. When is an electrical pressure transducer better than a mercury manometer?

Characterization of measurement systems

- Static calibration
- Dynamic calibration

Static calibration of transducers

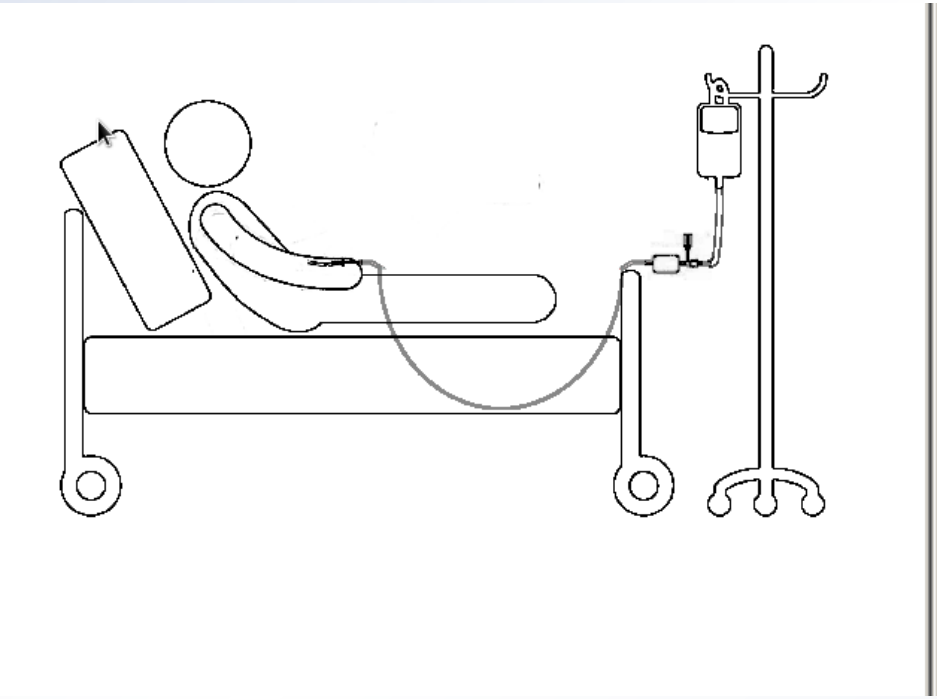
- Input-output relationship
- Linearity
  - Linear: $y = m\,x + c$
  - Compensating for non-linearity
- Offset
- Calibration and curve fitting

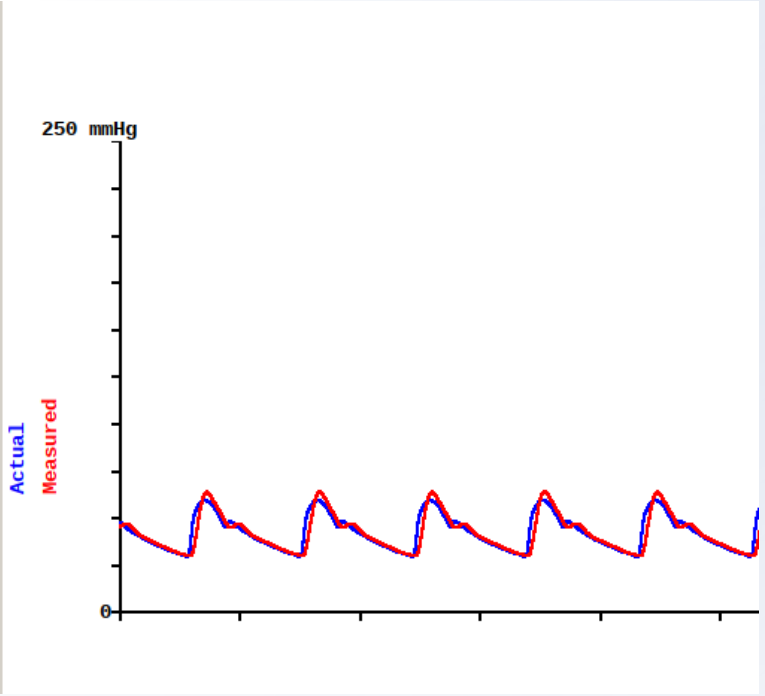


Dynamic calibration

- Transient behaviour of physiological systems
  - Changes in system output with time
- Dynamic response = response of a transducer or recording system to a changing signal
- Dynamic characterization
  - Time constant
  - Step response
  - Frequency response
  - Transfer function

Dynamic Measurement – Intra Arterial Blood Pressure





Digitization of Signals

- Sampling and Quantization
- Analog-to-Digital Converters
- The Sampling Theorem
  - If the signal is sampled at a rate which is at least twice the highest frequency contained in the signal, then the original signal can always be recovered

Characterizing signals

- Decomposing signals
- Identifying contamination of signals

- ---> Next lecture