Lecture 1

# Measurement (1)

*Mohamad Fathi GHANAMEH*

# Course Organization

**Lecture**

Tuesday 14:00 - 16:00 PM

**Laboratory**

Gr A1: Wednesday 14:00 - 16:00 PM
Gr B1: Wednesday 16:00 - 18:00 PM
Gr A2: Thursday 14:00 - 16:00 PM
Gr B2: Thursday 16:00 - 18:00 PM
Gr A3: Friday 08:30 - 10:30 AM
Gr B3: Friday 10:30 - 12:30 AM

# Course Organization

**Instructor**
GHANAMEH Mohamad Fathi
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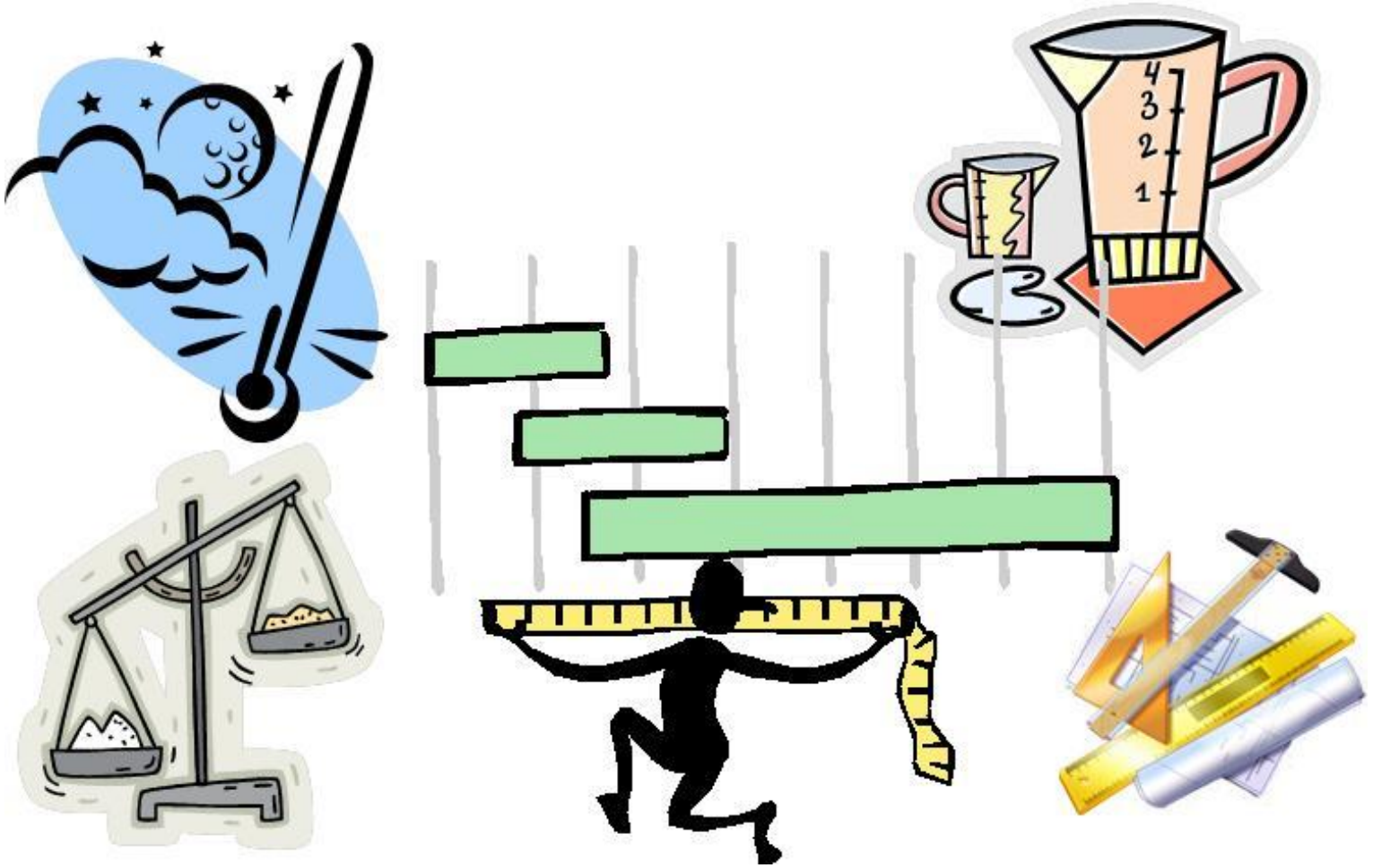
**Course Documentation and Support**
https://www.dropbox.com/sh/tdksh48vlryqael/AADlyqUYr_tGmzWmPNKDnW7na?dl=0

**Office Hours**

Monday 08:30 - 10:30 AM
Monday 16:00 - 18:00 PM

# Measurement



# Measurement

Every measurement is a comparison between a quantity we want to know about and a standard amount of that quantity

# Measurement in practice

How could you do the following everyday activities without measurement?

Measurement is everywhere, playing a vital role in our lives. Metrology is the science of measurement and National Metrology Institutes around the world make sure that the measurements we use are fit for purpose.

- catch a train
- buy petrol
- have an x-ray
- eat safe foods
- travel by aeroplane
- use your mobile






# Measurement in practice

People make measurements for many reasons:

1. To make sure an item will fit for a specific purpose,
2. To determine the correct price to pay for something,
3. To check that a manufactured item is within specification.

# Measurement

The action of measuring something where ‘measuring’ ascertains the size, amount or degree (of something) by using an instrument or device marked in standard units.

**Measurement in Mechanical Engineering**

The branch of engineering dealing with the:
design, construction and use of machines.


Parameters measured by mechanical engineers.

# Measurement

Improvements in measurement can have far-reaching consequences. For example, aero engines are built to a very high accuracy and require about 200,000 separate measurements during production. Some measurements are simple, and others more complicated. Some are made on a factory floor, others in specialist measurement laboratories. But by having confidence in each individual measurement, manufacturers save time and money, and improve the quality of their products.

# Measurement

## 23 July 1983

**The ‘Gimli Glider’.** An Air Canada Boeing 767-233 jet was refuelled in Montreal using 22 300 pounds of fuel instead of 22 300 kilograms. The pilot calculated how much fuel he needed thinking he was getting his fuel in pounds per litre.

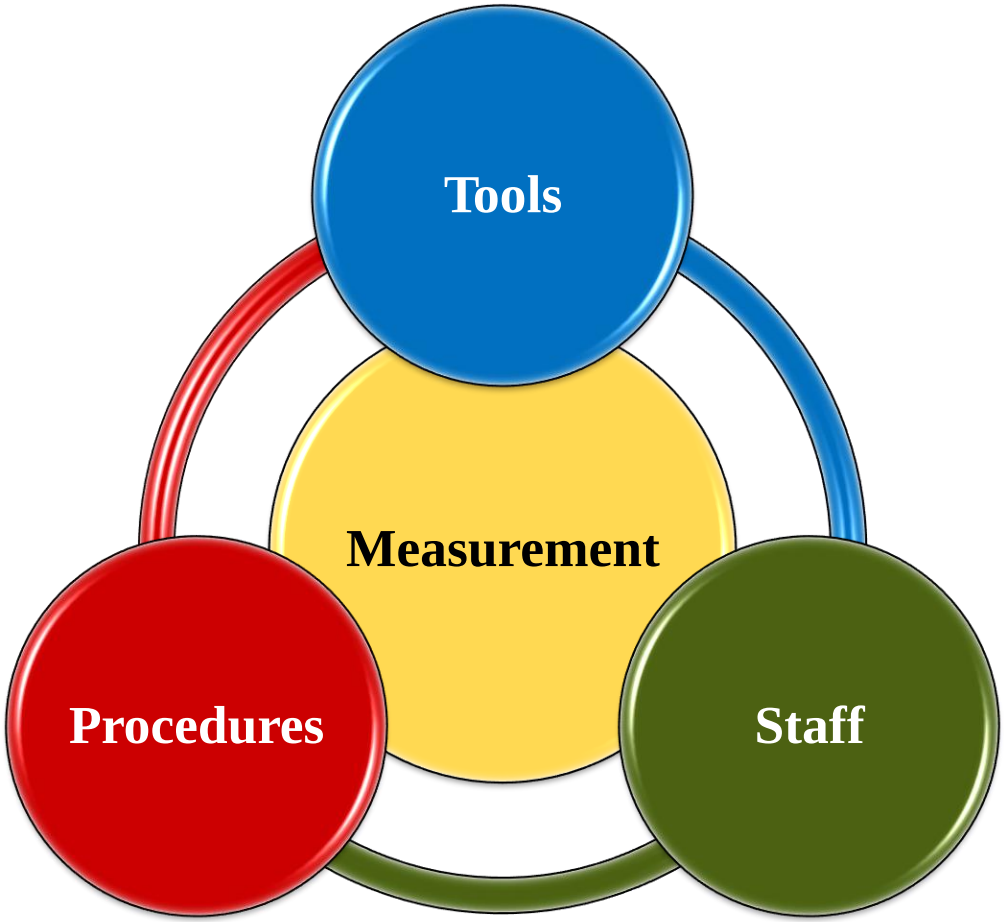
When the plane ran out of fuel mid-flight, the pilot had to make an emergency 'gliding' landing at Gimli Canadian Air Force Base.

# Measurement

All engineers measure things, but try asking yourself the following questions:

- Are the measurement results accurate enough?
- Is the measurement device working correctly?
- How critical is this measurement? If it is wrong, will someone lose money? Or could someone lose their life?

# Measurement



# Good measurement practice

| Six guiding principles for good measurement results | |
|---|---|
| 1. The Right Measurements | Measurements should only be made to satisfy agreed and well specified requirements |
| 2. The Right Tools | Measurements should be made using equipment and methods that have been demonstrated to be fit for purpose |
| 3. The Right People | Measurement staff should be competent, properly qualified and well informed |
| 4. Regular Review | There should be both internal and independent assessment of the technical performance of all measurement facilities and procedures |
| 5. Demonstrable Consistency | Measurements made in one location should be consistent with those made elsewhere and across time |
| 6. The Right Procedures | Well-defined procedures consistent with national or international standards should be in place for all measurements |

# Good measurement practice

**Make better measurements by:**

- **Using the International System of Units (SI)**
- **Ensuring the measurements are valid**
- **Understanding the concepts:**
  - **Precision, accuracy and uncertainty**
  - **Repeatability and reproducibility**
  - **Acceptance criteria (tolerance)**
  - **Traceability and calibration**
- **Estimating the overall uncertainty of the measurements**
- **Applying geometrical tolerances**

# International system of units (SI)

## Base SI units

There are seven base units of the SI, in terms of which all physical quantities can be expressed

| Quantity | SI unit | Symbol |
|---|---|---|
| Length | Metre | m |
| Mass | Kilogram | kg |
| Time | Second | s |
| Electric current | Ampere | A |
| Temperature | kelvin or degree Celsius | K or °C |
| Luminous intensity | candela | cd |
| Amount of substance | mole | mol |

# International system of units (SI)

## Derived SI units

All measurements can be expressed using combinations of the seven base

| Quantity | Unit | Symbol |
|---|---|---|
| Area | square metre | $m^2$ |
| Volume | cubic metre | $m^3$ |
| Speed | metre per second | $m\ s^{-1}$ or m/s |
| Acceleration | metre per second per second | $m\ s^{-2}$ or $m/s^2$ |
| Force | newton | N |
| Energy | joule | J |
| Power | watt | W |

# Prefixes used for multiples of units

| SI prefixes | | | |
|---|---|---|---|
| Prefix | Symbol | Decimal | Power of 10 |
| Yotta | Y | 1 000 000 000 000 000 000 000 000 | $10^{24}$ |
| Zetta | Z | 1 000 000 000 000 000 000 000 | $10^{21}$ |
| Exa | E | 1 000 000 000 000 000 000 | $10^{18}$ |
| Peta | P | 1 000 000 000 000 000 | $10^{15}$ |
| Tera | T | 1 000 000 000 000 | $10^{12}$ |
| Giga | G | 1 000 000 000 | $10^{9}$ |
| Mega | M | 1 000 000 | $10^{6}$ |
| Kilo | k | 1 000 | $10^{3}$ |
| Hector | h | 100 | $10^{2}$ |
| Deca | da | 10 | $10^{1}$ |

# Prefixes used for multiples of units

| SI prefixes | | | |
|---|---|---|---|
| Deci | d | 0.1 | $10^{-1}$ |
| Centi | c | 0.01 | $10^{-2}$ |
| Milli | m | 0.001 | $10^{-3}$ |
| Micro | µ | 0.000 001 | $10^{-6}$ |
| Nano | n | 0.000 000 001 | $10^{-9}$ |
| Pico | p | 0.000 000 000 001 | $10^{-12}$ |
| Femto | f | 0.000 000 000 000 001 | $10^{-15}$ |
| Atto | a | 0.000 000 000 000 000 001 | $10^{-18}$ |
| Zepto | z | 0.000 000 000 000 000 000 001 | $10^{-21}$ |
| Yocto | y | 0.000 000 000 000 000 000 000 001 | $10^{-24}$ |

# Prefixes used for multiples of units

It might seem that some of these prefixes are somewhat extreme, but they can be useful. For example:

- The Sun delivers 5.6 YJ (yottajoules) of energy to the Earth every year

- A proton is 1.6 fm (femtometres) in diameter

There is one exception to the system of prefixes. For historical reasons we do not apply the prefixes to the kilogram, but instead to the gram. This is to avoid the need to refer to a gram as a millikilogram!

# Internationally agreed SI exceptions

There are a small number of agreed SI exceptions which you will be familiar with and are shown in the table below.

| Name | Symbol | Quantity | Equivalent SI unit |
|---|---|---|---|
| minute | min | time | 1 min = 60 s |
| hour | h | time | 1 h = 3600 s |
| day | d | time | 1 d = 86400 s |
| degree of arc | ° | angle | 1° = (π/180) rad |
| minute of arc | ‘ | angle | 1’ = (π/10800) rad |
| second of arc | “ | angle | 1” = (π/648000) rad |
| hectare | ha | area | 1 ha = 10000 $m^2$ |
| litre | l or L | volume | 1 l = 0.001 $m^3$ |
| tonne | t | mass | 1 t = 1000 kg |

# Expressing measurement results

Measurement results need to be written down clearly. The good news is that the SI system has guidelines to help you.

# Expressing measurement results

Measurement results need to be written down clearly. The good news is that the SI system has guidelines to help you.

**A correct version would be:**

**A ship 60.96 m long weighing 200 219 kg travels at 0.1 m/s.**