Scale

- principles of operation
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13.3.6 Maintain a scale

Unit B 13.3 Maintaining General Bedside Nursing Equipment

Module 279 18 B Medical Instrumentation I

Function: measure Weight

What is a scale ?

A scale is an ***accurate*** and ***precise*** instrument used to measure the weight of a material. The ability to measure material as large as 100 kilogram (**Kg**) and as small as 10 microgram (**µg**) makes them quite common.

Engineering Notation	
Name/Symbol	Multiplier
pico (p)	10^{-12}
nano (n)	10^{-9}
micro (μ)	10^{-6}
milli (m)	10^{-3}
1	10^{0}
Kilo (K)	10^{3}
Mega (M)	10^{6}
Giga (G)	10^{9}
Tera (T)	10^{12}

Function: measure weight

Why is it important ?

In the hospital, many materials have to be measured, incl. patients, new-born babies, pharmaceutical drugs, …. to track the health situation (diagnosis) or apply therapies.

In what units do we measure mass and weight ?

The unit of the **Mass** is the kilogram [Kg]. It is equal to the mass of the international prototype kilogram and therefore fixed.

The unit of **Weight** is the Newton, the force with which gravity exerts on a kg mass.
Weight = Mass x Gravity Constant.
The Gravity Constant varies by up to 0.5% at different locations on Earth.

Use: many applications

Scientific principles

The **balance** (or **scale**) was the first mass measuring instrument invented. Traditionally, it consists of a pivoted horizontal lever with arms of equal length – the beam – and a weighing pan suspended from each arm. The unknown mass is placed in one pan and standard masses of known weight are added to the other pan until the beam is as close to equilibrium as possible.

Scientific principles

Spring balances (or **spring scales**)
measure force or weight by balancing the force due to gravity against the force on a spring

To eliminate the effect of gravity variations, **a spring scale must be calibrated** where it is used.

name giving:

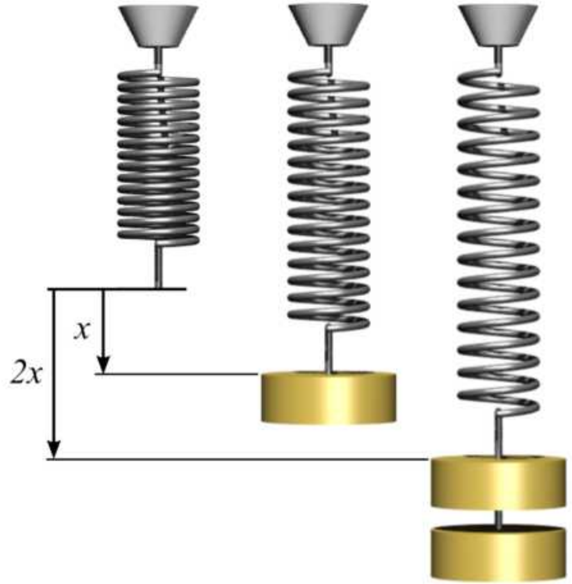
scales is mostly used for weighing larger masses like a bathroom scale or baby scale;
balances is mostly used for precise weighing of substances, as such are used in laboratories.

Hooke’s Law on springs

The extension of a spring is described by (Hooke's Law):

$$F = kx$$

F is the force
k is the spring constant
x is the distance the spring is extended



When you put an object on a spring scale, the object experiences a certain force (gravity pulling it toward the earth). Every spring has its own unique spring constant (k) which depends on its manufacture and material. Therefore the spring is the most important element of a commercial scale.

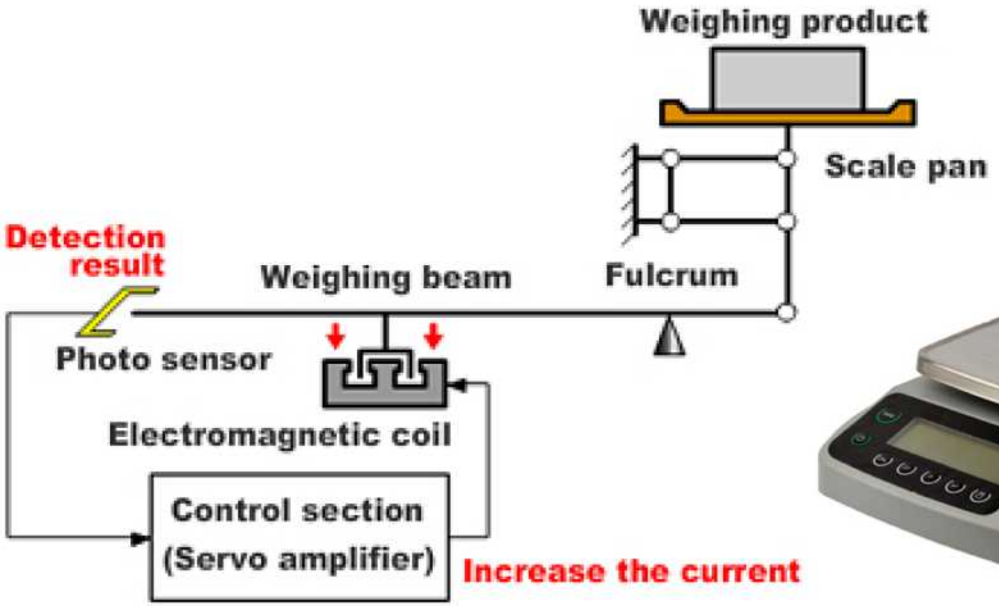
A spring scale can be damaged if the spring is pulled too far.

Scientific principles mechanical and electromagnetic scales

There are two main categories of (spring) scales, mechanical and electromagnetic

Mechanical scales (as on the previous pages) are the simpler of the two. They generally consist of springs or lever arms, and use either a known force or mass to determine the unknown measurement.

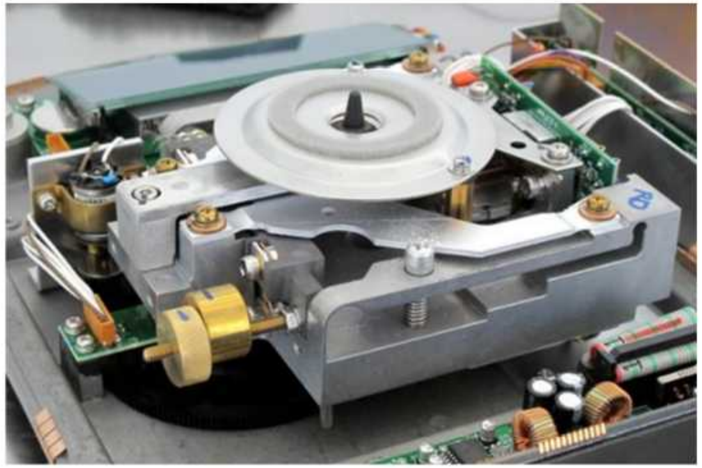
Electromagnetic scales / balances are more complex, but generally more **user friendly**. They are often based on measuring the current needed to levitate the pan and mass.



Construction

large varieties

Type	Readability			
Precision balance	1 mg	0.001 g	or	3 digit
Analytical balance	0.1 mg	0.0001 g	or	4 digit
Semi-micro balance	0.01 mg	0.00001 g	or	5 digit
Micro balance	1 µg	0.000001 g	or	6 digit



Precision balances

Precision balances are used to measure mass with a precision of up to **1 milligram (mg).** They are widely used because their accuracy is high enough for common measurements. Precision balances are nowadays all microprocessor controlled. That makes the usage easy and brings more functionality.
In principle all balances run on low-voltage or battery which is important for laboratories with unreliable power supply.

Construction

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Precision balance	1 mg	0.001 g	or	3 digit
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Analytical balances

Analytical balances are found in **laboratories** for the manufacture of pharmaceutical products, analysis, quality assurance, etc.. They are more precise, sensitive and more expensive. With a readability of **0.1 mg** they are ten times more precise than precision balances.

The electronic control units of precision and analytical balances are in principle identical so that the application possibilities are the same. The only difference is an additional function: **the automated calibration function.** That means, that no external calibration weights are needed to calibrate the balance before the measurement. A simple press of the calibration button is enough and a built-in motor-driven adjusting weight will do the calibration.

Due to their high resolution analytical balances are also more sensitive to outside influences like dust and air flow. To avoid these factors, the weighing pan of analytical balances is protected by a **transparent enclosure** with sliding doors.

Using a scale

Using laboratory balances

The user manual should be read by both the operator and the technician. The usage varies from manufacturer to manufacturer.

Preparations

- Is the balance exactly levelled?
- Was the balance connected to the mains for at least 4 hours?
- Do you know the maximum load? Never overload a balance.

Using procedures

- Do a calibration if needed
- Press the tare key to zero the display
- Never touch samples or samples containers with your bare fingers.
- Close the enclosure before starting the measurement
- Wait until the stability indicator is displayed.

Tare-Function

When a load is already on the balance, pressing the tare-button sets the display to zero. It is used when a samples comes in a container. First the empty container is measured, the tare-button is pressed and then the filled container is placed back. The result is the net weight.

Warm-up time

A laboratory balance should always be connected to the power. Switch off the balance only with the key of the keypad. Even when it is switched off and the balance is in standby mode, the measurement unit is still powered and has the necessary operating temperature. The balance then can be used immediately after switching on. If the balance was disconnected from the mains the balance has to warm up for at least 4 hours before the first weighing. Only then is the measurement accurate and reproducible.

Cleaning

After every usage and at the end of the day the balance has to be cleaned carefully. If possible remove the weighing pan for cleaning. Use an absorbent cloth to remove spilled liquids. If there is stain use a damp cloth and a mild soap solution for cleaning. Do not make the cloth too wet. Make sure that no moisture enters the balance. Wipe the balance with a soft and dry cloth afterwards. The glass of the weighing chamber can be cleaned with a common window cleaner.

Trouble shooting

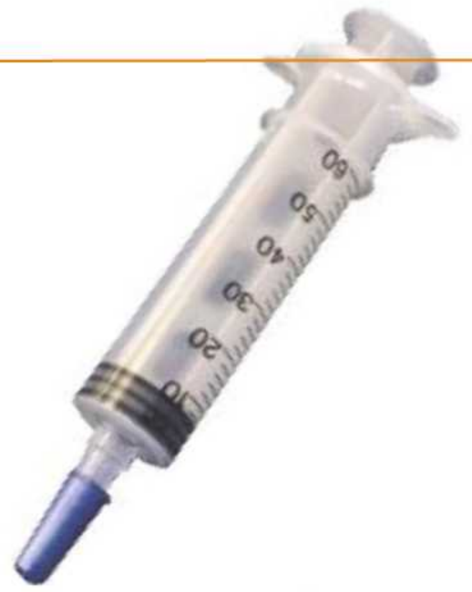
Mechanical balances are very reliable and rarely need major repairs. The most common problem with mechanical balances is **environmental factors** and **maintenance**. The movements of the mechanical balance must be free of dirt and other residue. If a mechanical balance is yielding erratic readings, **clean** and **lubricate** all moving parts before attempting any other diagnosis or repair.

Internal problems with an **electromagnetic balance** cannot usually be repaired in the field. The most common problems associated with an electromagnetic balance are the result of **environmental factors** and **user error**. The primary environmental factors leading to poor results from the balance are **temperature, static electricity, vibration, out of level (tilted) and wind.**

If the readings are inaccurate or erratic it can be remedied by:

- **Shielding** the balance from vibration, static electricity and air currents
- **Levelling** the scale
- **Controlling the temperature** may be problematic. You may have to restrict use to periods with low and stable room temperature.

Safety and Testing



A crude **calibration** is very straightforward. First, place a clean container in the center of the weighing pan. If the balance has a case, close the door.

Zero the balance by pushing the TARE button (a long rectangular bar, a twist of a dial, or, if the TARE is absent, write down the reading of the balance with the container).

Place a **known volume of water** on the scale. In most cases, the most accurate way to add the desired amount of water is to use a syringe.

Now read the balance. If there was no TARE, subtract your original measurement.

Compare the reading to the actual weight of the water (water weighs **one gram per milli-liter**).

The precision of the balance will probably exceed the precision of your water volume measurement, so **repeat** the measurement four or five times.

END

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