L1&2. Terminology ,Modeling, Measurement

Objectives:

At the end of the lecture the student will be learning

- **What the term medical physics refers to.**
- **Concepts of physical modeling.**
- **Physical measurements.**

Terminology

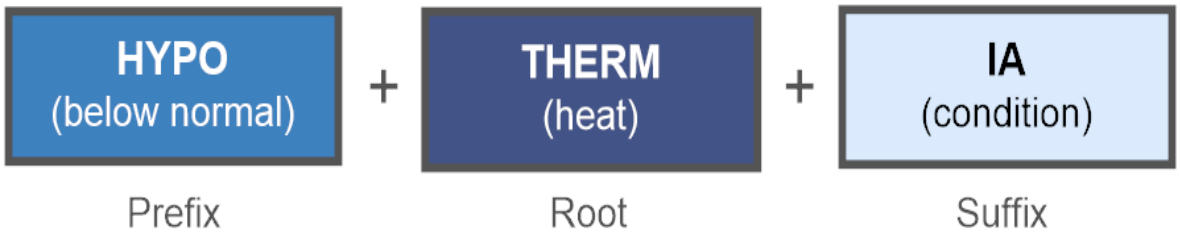
- **Terminology is a general word for the group of specialized words or meanings relating to a particular field, and also the study of such terms and their use.**
- **Concepts of Medical Terminology**
  Medical terminology is language that is used to describe anatomical structures, processes, conditions, medical procedures, and treatments.
  Most medical terms adhere to a fixed structure of a prefix, a root, and a suffix. These word components are assembled like building blocks to create a vast vocabulary.

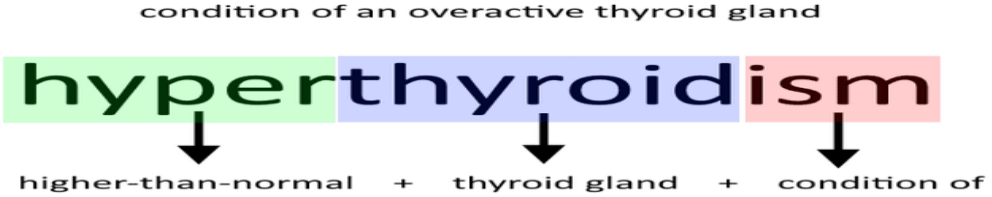
Basic Term Structure

Medical terms are composed of these standard word parts:

- **Prefix: When included, the prefix appears at the beginning of a medical term and usually indicates a location, direction, type, quality, or quantity.**
- **Root: The root gives a term its essential meaning. Nearly all medical terms contain at least one root. When a prefix is absent, the term begins with a root.**
- **Suffix: The suffix appears at the end of a term and may indicate a specialty, test, procedure, function, disorder, or status. Otherwise, it may simply define whether the word is a noun, verb, or adjective.**
- **Combining vowel: A combining vowel (usually the letter "o") may be added between word parts to aid in pronunciation.**

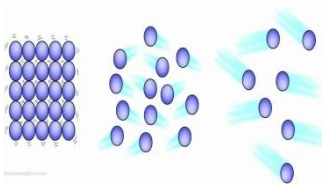
Breaking a word down into its component parts should help readers ascertain the meaning of an unfamiliar term. For example, hypothermia has the prefix hypo- (meaning below normal), the root therm (heat or warmth), and the suffix -ia (condition).

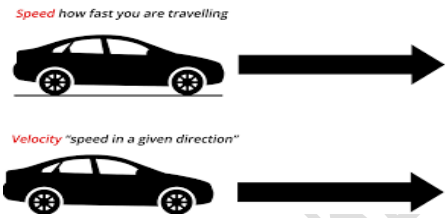


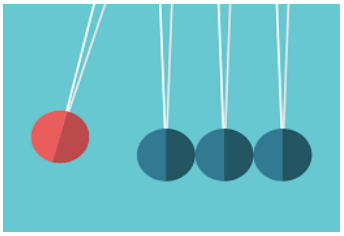


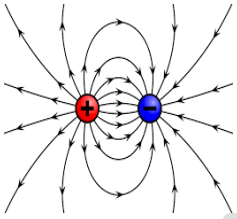
What is physics

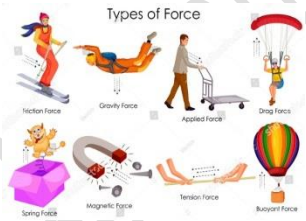
- **Is the natural science that studies matter, its motion and behavior through space and time, and the related entities of energy and force.**
- **Physics is the study of matter and energy, Physics has many subcategories: Mechanics- the study of motion, Dynamics- the study of causes of motion, Thermodynamics- heat behaviors Waves, Sound, Light, Optics Modern Physics- nuclear physics, relativity, astrophysics, etc. Physics is a science → an exploration into how things work and why, and find relationships between those fundamental measured quantities (e.g., Newton's Laws, conservation of energy)**

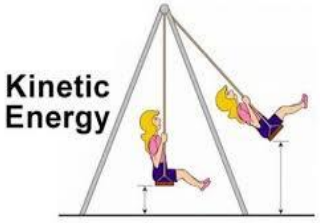












Medical physics

The term medical physics refers to: the application of physics principles to medicine, by using our physics knowledge to develop tools and treatments that helps humans to be healthy.
There are many branches of medical physics

- **Diagnostic radiology ;which includes X-ray, computed tomography ,(CT scan), ultrasound US and magnetic resonance image (MRI).**
- **Nuclear medicine: which deals with the use of radioactive substances in diagnosis, treatment and research.**
- **Radiation oncology (radiation therapy) : its medical specialty that involve treating cancer by radiation .**
- **Health physics (Radiation protection) : is the application of scientific principles to the protection of worker and public from the hazards of radiation.**

Physics can be found in various area of medicine too,
Examples :

- **In Physiology : where law of physics can be applied to the function of the human body in health and disease .**
- **In Practice of medicine : the application of the physics of stethoscope, percussion and the application of sphygmomanometer, pacemaker, defibrillators and so forth .**
- **Biophysics : is the study of biological process using the theories and tools of physics .**
- **Biomedical engineering : they develop mechanical and electrical solutions to medical problems ,such as develop diagnostic and imaging equipment and designing artificial organs .**
- **Treatment equipment includes infusion pumps, medical lasers and laser vision correction.**
- **Life support equipment is used to *maintain* a patient's bodily function. This includes medical ventilators, anesthetic machines, heart-lung machines, and dialysis machines.**

- **Physical Medicine and Rehabilitation ,enhance and restore functional ability and quality of life to those with physical impairments or disabilities affecting the brain, spinal cord, nerves, bones, joints, ligaments, muscles, and tendons.**
- **Physical therapy is one of the Medical health professions that, by using evidence based kinesiology, exercise prescription, health education, mobilization, and electrical or physical agents, treats acute or chronic pain, movement and physical impairments resulting from injury, trauma or illness typically of musculoskeletal, cardiovascular, respiratory, neurological and endocrinological origins. Physical therapy is used to improve a patient's physical functions through physical examination, diagnosis, prognosis, patient education, physical intervention, rehabilitation, disease prevention and health promotion.**

The field of medical physics has several subdivisions:

Radiological physics

This involves the applications of physics to:

- **Radiological problems and includes the use of radiation in the diagnosis and treatment of disease as well as the use of radionuclides in medicine (nuclear medicine).**
- **Radiation protection (Health physics): (of patients, workers, and the general public). In the United States this field is often called health physics. Is the application of scientific principles to the protection of worker and public from the hazards of radiation.Health physics also includes radiation protection outside of the hospital such as around nuclear power plants and in industry.**

Medical physics could be called medical engineering. or biomedical engineering is likely to be working on medical instrumentation, usually of an electronic nature ,they develop mechanical and electrical solutions to medical problems ,such as develop diagnostic and imaging equipment and designing artificial organs .

Modeling

In general it's the process of representing phenomenon as set of mathematical equation, to study the effect of changes on it.

Modeling often resort to different ways to understand the phenomena, for example:

To understand physical phenomena use ;

o Simplification by selection of main features

o Analysis

o Qualitative or quantitative expression and verification

Some models involve physical phenomena that appear to be completely unrelated to the subject being studied.

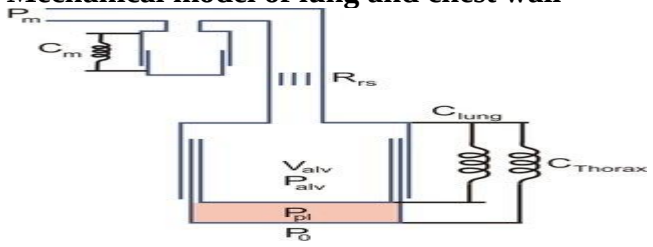
Analogies

Analogies is used to understand the physical aspects of the body.

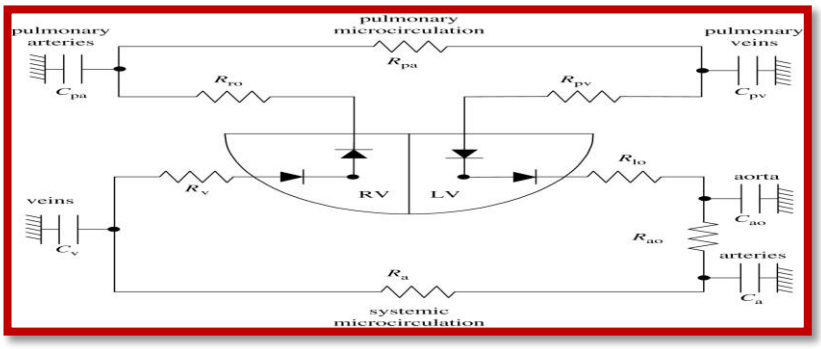
To describe and explain phenomena that can't experience directly physicists employ models, using different types for different aims.

Example:

- ✓ **Mechanical model of lung and chest wall**

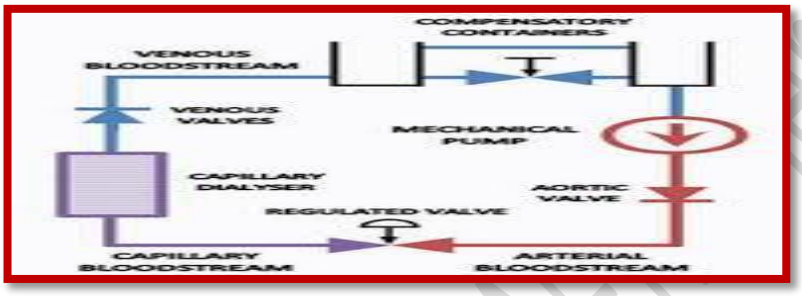


- ✓ **A model in which the flow of blood is represented by the flow of electricity is often used in the study of the body's circulatory system.**



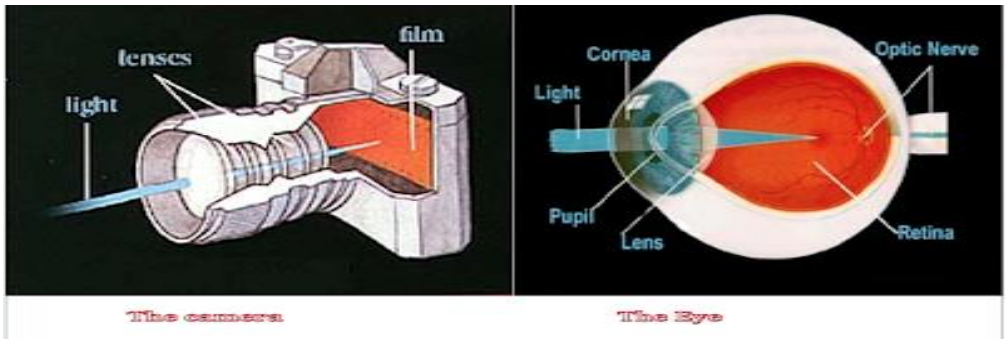
This electrical model can simulate very well many phenomena of the cardiovascular system. Of course, if you do not understand electrical phenomena the model does not help much. Also, as mentioned before, all analogies have their limitations.

- ✓ **Mechanical model for the cardiovascular system**



The eye can be compared to a camera.

- **The cornea is the transparent, curved front layer of the eye. The pupil, behind the cornea, is a hole in the colored membrane called the iris.**
- **Tiny muscles in the iris change the size of the pupil – like the aperture of a camera – to control the amount of light getting into the eye.**
- **There is a small, powerful lens behind the pupil which changes shape based on the pull of muscles in the eye. Like a camera lens,**
- **The retina is a thin membrane which covers the inside back of the eye. Like film in a camera, the retina**



Mathematical modeling:

consist of Equation and Function .

Equation such as QA (t) =QA1 (t) + QM (t)

Where QA(t) flow through aortic valve , QA1(t) initial flow through aortic valve QM(t) initial flow through pulmonary valve

Newton second law { F = ma } Where : F : is the force M : is the mass , a : is acceleration

- ➢ **Function model such as { R =f (p) } to indicate the heart rate R is the function of the power produce by the body .**
- ➢ **Feedback control (homeostasis): it is a control mechanism that uses information from measurement to manipulate a variable to achieve the desired result.**

There are two type of feedback control

- Negative feedback and Positive feedback

- ❖ **Negative feedback helps the system toward equilibrium state.**

- **Home thermostat that maintain specified temperature, by increase or decrease the temperature to reach the setting temperature.**
- **Regulation of blood sugar level, by insulin secretion into the blood, when blood sugar levels reach homeostasis the pancreas stops releasing insulin.**

❖ **Positive feedback is mechanisms enhance the original stimulus**

- **Blood clotting, once the vessel is damage the platelets start cling to the injured site and release chemicals that attract more platelets, the platelets continue to pile up until the clot is formed.**

Measurements

- **Measurements: is the numerical quantitation of the attributes of an object or event, which can be used to compare with other objects or events.**
- **Are values which made meaningful into specific units ,its act as labels which make those value more useful in term of details, for example instead of saying that someone tall , we can say that the individual length is (6 feet) .**

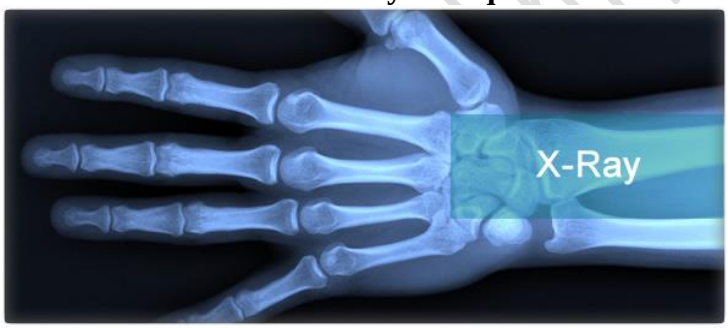
Practice medical measurements can be divided into: quantitative and qualitative measurements.

Quantitative measurement includes:

1. Thermometer: which measure the temperature.
2. A weighing machine to measure the weight.
3. Sphygmomanometer to measure blood pressure.
4. Syringes of different sizes for injection and aspiration of blood and fluid from the body.

Qualitative measurement

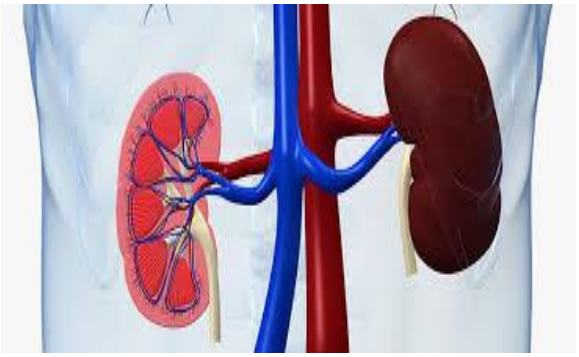
Gives information about the inside of the body, such as x-ray image, computed tomography (CT scan) , ultrasound (US) image , magnetic resonance image (MRI) ...
Ex. An X-ray gives only qualitative information about the inside of the body . A repeat X-ray taken with a different machine may look quite different to the ordinary observer.



- **There are many other physical measurements involving the body and time. We can divide them into two groups: -**
  1. **Measurements of repetitive processes, such as pulse. Involve the number of repetitions per second, minute, hour, and so forth.**

  For Example: -
- **The pulse rate is about 70/min.**
- **The breathing rate is about 15/min.**
  2. **Measurements of nonrepetitive processes, such as how long it takes the kidneys to remove a foreign substance from the blood.**

Nonrepetitive time processes in the body range from the action potential of a nerve cell (1msec) to the lifespan of an individual.



Units

There are several system of units

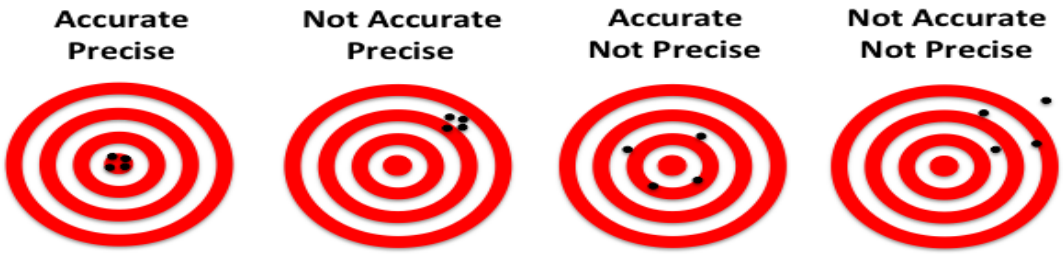
- International system SI unit: it measures quantity such as length (meter),Mass (kilogram), time (second), current (ampere).

- Nonstandard unit: which is used in medicine such as blood pressure which is measured in millimeter of mercury (mmHg).

Static characteristics that include accuracy and precision it is used in science and has different meanings.

- **Accuracy: refers to the degree of correctness of measurement when compared to true or absolute value.**
- **Precision: refers to the degree of refinement of measurement.**

After taking a lot of measurements , you notice that they are all close to each other this is precision , if they are degree with the true value this is accuracy .



Sources of error in medical measurements

Errors can be either random or systematic depending on how they affect the results.

1. **Psychological effects(carelessness or limitations of human ability)**
2. **Human factors such as environmental, individual characteristic which influence behavior.**
3. **Procedural error occurs when different procedures are used to answer the same question**
4. **Instrumental error happens when the instruments being used are inaccurate,**

Errors or uncertainties from measurements can be reduced by: -

1. **Being Careful in taking the measurement.**
2. **Repeating measurements.**
3. **Using reliable instruments.**
4. **Properly calibrating the instruments.**