Dentistry College *Medical Physics*

Terminology, Modeling, And Measurement

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Terminology

The field of medical physics overlaps the two very large fields of **medicine** and **physics**. The term **medical physics** refers to **two** major areas: -

1. The applications of physics to the function of the human body in health and disease.
2. The applications of physics in the practice of medicine.

The **first** of these could be called the physics of physiology; the **second** includes such things as the physics of the stethoscope, the tapping of the chest (**percussion**), and the medical applications of lasers, ultrasound, radiation, and so forth.

The branch of medicine referred to as **physical medicine** deals with the diagnosis and treatment of disease and injury by means of physical agents such as **manipulation**, **massage**, **exercise**, **heat**, and **water**.

Physical therapy is the treatment of disease or bodily weakness by physical means such as **massage** and **gymnastic** rather than by **drugs**.

The field of medical physics has several subdivisions: -

1. **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**), a person who refers to himself as a medical physicist it is highly probable that he is working in the area of radiological physics.
2. R**adiation protection**: - Radiation protection of patients, workers, and the general public. In the United States this field is often called **health physics**. Health physics also includes radiation protection outside of the hospital such as around nuclear power plants and in industry.
3. Medical physics could be called **medical engineering**. a person who refers to himself as a medical engineer or biomedical engineer is likely to be working on medical instrumentation, usually of an electronic nature.
4. In some areas, such as the applications of ultrasound in medicine and the use of computers in medicine, you are likely to find medical physicists and medical engineers in nearly equal numbers. (The word **medical** is sometimes replaced with the word **clinical** if the job is closely connected with patient problems in hospitals, i.e., clinical engineering or clinical physics).

Modeling

Even though physicists believe that the physical world obeys the laws of physics, they are also aware that the mathematical descriptions of some physical situations are too complex to permit solutions.

For Example: -

If you tore a small corner off this page and let it fall to the floor, it would go through various gyrations. Its path would be determined by the laws of physics, but it would be almost impossible to write the equation describing this path. Physicists would agree that the force of gravity would cause it to go in the general direction of the floor if some other force did not interfere. Air currents and static electricity would affect its path.

In trying to understand the physical aspects of the body, we often resort to analogies; physicists often teach and think by analogy. Keep in mind that analogies are never perfect.

For Example: - In many ways the eye is analogous to a camera; however, the analogy is poor when the film, which must be developed and replaced, is compared to the retina, the light detector of the eye.

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

For Example: -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.

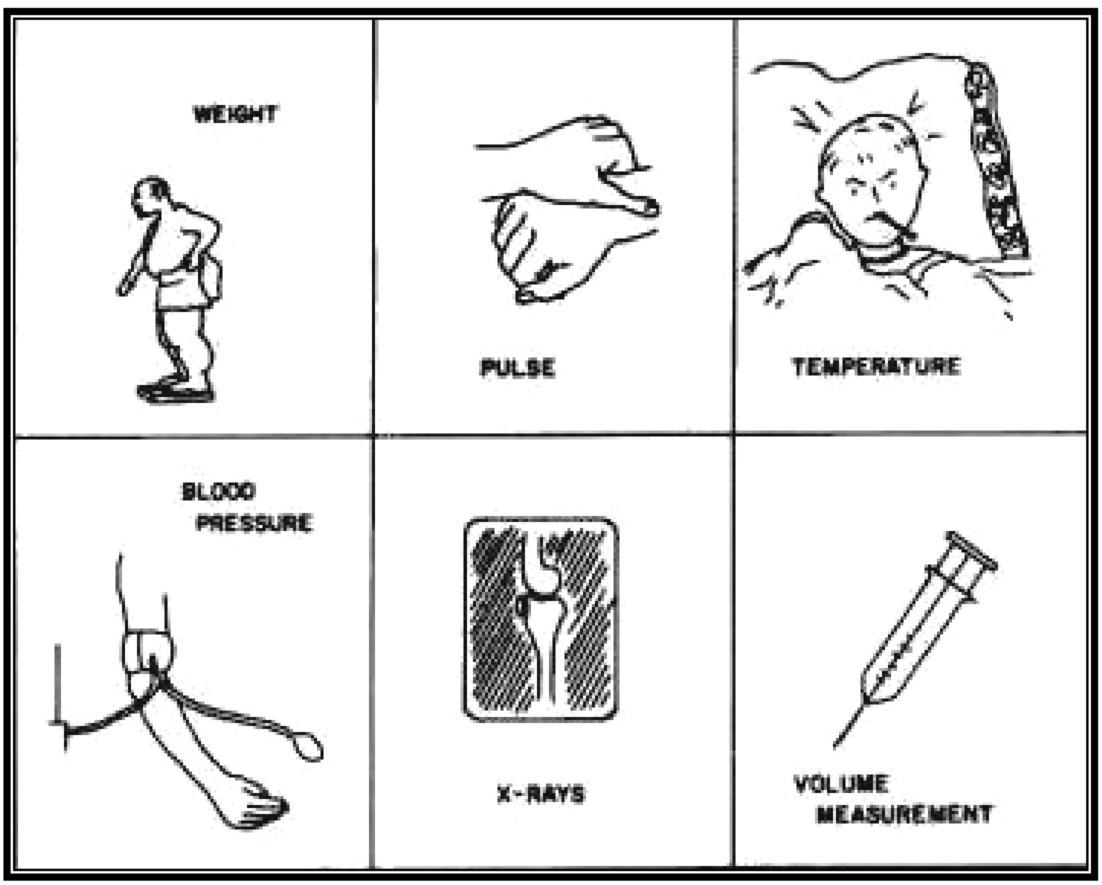
Blood is made up of red blood cells and plasma, and the percentage of the blood occupied by the red blood cells (**the hematocrit**) changes as the blood flows toward the extremities. This phenomenon is difficult to simulate with the electrical model.

Measurement

One of the main characteristics of science is its ability to reproducibly measure quantities of interest. The growth of science is closely related to the growth of the ability to measure. In the practice of medicine, early efforts to measure quantities of clinical interest were often scorned as detracting from the skill of the physician.

For Example: -Even though body temperature and pulse rate could be measured during the seventeenth century, these measurements were not routinely made until the nineteenth century. In this century there has been a steady growth of science in medicine as the number and accuracy of quantitative measurements used in clinical practice have increased.

The following figure illustrates a few of the common measurements used in the practice of medicine. Some of these measurements are more reproducible than others.



For Example: -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.
2. Measurements of nonrepetitive processes, such as how long it takes the kidneys to remove a foreign substance from the blood.

Measurements of the repetitive processes usually 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.

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

When a physician must decide if the patient is ill or not, and what the illness is?

After a physician has reviewed a patient's: -

1. Medical history.
2. The findings of the physical examination.
3. The results of the clinical laboratory measurements.

The decisions are two types: -

1. Right decisions.
2. Wrong decisions.

It is not surprising that sometimes wrong decisions are made. These wrong decisions are of **two** types: -

1. False Positives.
2. False Negatives.

*A **false positive*** error occurs when a patient is diagnosed to have a particular disease when he or she does not have it.

*A **false negative*** error occurs when a patient is diagnosed to be free of a particular disease when he or she does have it.

Note: -In some situations a diagnostic error can have a great impact on a patient's life.

For Example: -

A young woman was thought to have a rheumatic heart condition and spent several years in complete bed rest before it was discovered that a ***false positive diagnosis*** had been made-she really had arthritis, a disease in which activity should be maintained to avoid joint stiffening.

In the early stages of many types of cancer it is easy to make a false negative diagnostic error because the tumor is small. Since the probability of cure depends on early detection of the cancer, a ***false negative diagnosis*** can greatly reduce the patient's chance of survival.

Diagznostic errors (false positives and false negatives) can be reduced by: -

1. Research into the causes of misleading laboratory test values.
2. Development of new clinical tests and better instrumentation.

Errors or uncertainties from measurements can be reduced by: -

1. Using care in taking the measurement.
2. Repeating measurements.
3. Using reliable instruments.

4. Properly calibrating the instruments.