University of Al-Qadisiyah

College of Dentistry

Branch of Basic sciences

First lecture

Terminology

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CONTENTS

REFERENCE BOOKS

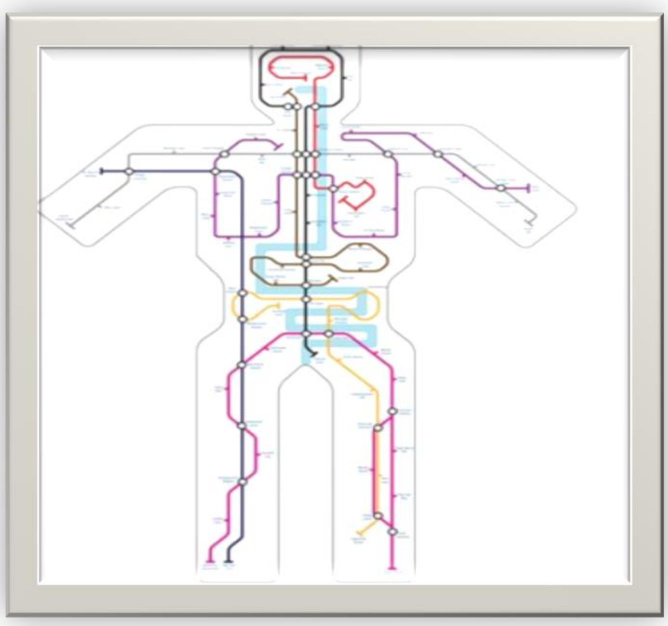
1- Medical Physics by John R. Cameron

2- Physics of the Human Body by Irving Herman

1- Medical Physics

Medical physics is the application of the concept of physics concepts in medicine, healthcare, and medical sciences. We study physics concept in medical faculties to understanding physical aspect of the body such as ; forces on and in the body, work, energy, power of the body, heat ,blood flow, respiration, electricity, circulation and hearing. Medical physics has many branches, namely, Ultrasound, Magnetic Resonance, Computed Tomography, Nuclear Medicine, X-rays, Radiation Therapy. These branches where continued research is being conducted by a very large group of dedicated researchers consisting of highly qualified physicists, engineers and radiologists.

Medical Physics is defined as the application of physics to the needs of medicine Aims of the Medical physics Application of the concepts and methods of physics to understanding the function of human body in health and disease.



A- Application of physics in medicine

Medical physics Techniques are used for Diagnostic:

1- **Stethoscope**

2- **Manometer (blood pressure)**

3- **Electrocardiograph(ECG)**

4- **X- Ray**

5- Electroencephalograph(EEG)

6- Electromyography (EMG)

7- thyroid function using I^{131}

8- Computer tomography (CT scan)

9- Ultrasound

10- tuning Fork

11- **Magnetic Resonance Imaging (MRI)**

12- **Flow meter**

13- **Spirometer to study the function lungs**

14- **Audiometer**

15- Optics

16- Laser

17- Gamma camera to study the function of kidney, liver, and lungs.

Medical Physics separate to

1- **Radiological Physics is a branch of physics focused on the theoretical and experimental study of certain kinds of radiation, its emission, propagation and interaction with matter.**

The term is used in the following major meanings:

A- study of radio waves

B- study of radiation used in radiology

C- study of other ranges of the spectrum of electromagnetic radiation in some specific applications, Among the main applications of radio physics

are radio communications, radiolocation, radio astronomy and radiology.

2- Health Physics (Radiation Protection)

also referred to as the science of radiation protection, is the profession devoted to protecting people and their environment from potential radiation hazards, while making it possible to enjoy the beneficial uses of radiation.

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 Engineering (Medical Instrumentation)

Biomedical engineering (BME) or medical engineering is the application of engineering principles and design concepts to medicine and biology for healthcare purposes (e.g., diagnostic or therapeutic). BME is also traditionally logical sciences to advance health care treatment, including diagnosis, monitoring, and therapy. Also included under the scope of a biomedical engineer is the management of current medical equipment in hospitals while adhering to relevant industry standards. This involves procurement, routine testing, preventive maintenance, and making equipment recommendations, a role also known as a Biomedical Equipment Technician (BMET) or as clinical engineering.

Biomedical engineering has recently emerged as its own study, as compared to many other engineering fields. Such an evolution is common as a new field transition from being an interdisciplinary specialization among already-established fields to being considered a field in itself. Much of the work in biomedical engineering consists of research and development, spanning a broad array of subfields Prominent biomedical engineering applications include the development of biocompatible prostheses, various diagnostic and therapeutic medical devices ranging from clinical equipment to micro-implants, common imaging equipment such as MRIs and EKG/ECGs, regenerative tissue growth, pharmaceutical and therapeutic biological.

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.

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

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.

measurement

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 non-repetitive 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. Non repetitive 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. Diagnostic 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.

Accuracy

The ability of an instrument to measure the accurate value is known as accuracy. In other words, it is the the closeness of the measured value to a standard or true value. Accuracy is obtained by taking small readings. The small reading reduces the error of the calculation. The accuracy of the system is classified into three types as follows:

1- Point Accuracy

The accuracy of the instrument only at a particular point on its scale is known as point accuracy. It is important to note that this accuracy does not give any information about the general accuracy of the instrument.

2- Accuracy as Percentage of Scale Range

The uniform scale range determines the accuracy of a measurement. This can be better understood with the help of the following example: Consider a thermometer having the scale range up to 500ºC. The thermometer has an accuracy of ±0.5 percent of scale range i.e. 0.005 x 500 = ± 2.5 ºC. Therefore, the reading will have a maximum error of ± 2.5 ºC.

3- Accuracy as Percentage of True Value

Such type of accuracy of the instruments is determined by identifying the measured value regarding their true value. The accuracy of the instruments is neglected up to ±0.5 percent from the true value.

Precision

The closeness of two or more measurements to each other is known as the precision of a substance. If you weigh a given substance five times and get 3.2 kg each time, then your measurement is very precise but not necessarily accurate. Precision is independent of accuracy. The below examples will tell you about how you can be precise but not accurate and vice versa. Precision is sometimes separated into:

1. **Repeatability**

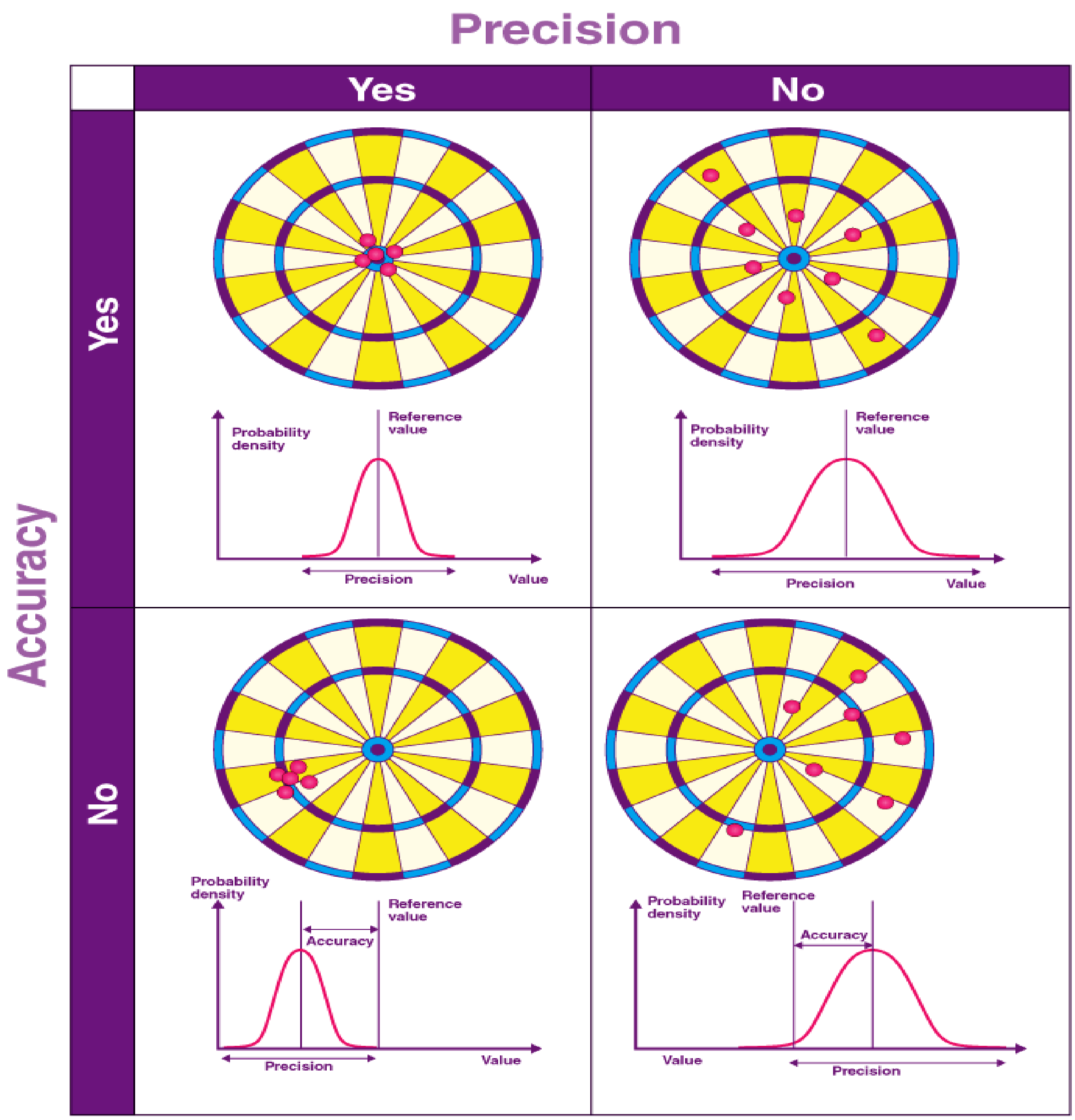
The variation arising when the conditions are kept identical and repeated measurements are taken during a short time period.

2. **Reproducibility**

The variation arises using the same measurement process among different instruments and operators, and over longer time periods.

Accuracy and Precision Examples

A good analogy for understanding accuracy and precision is to imagine a football player shooting at the goal. If the player shoots into the goal, he is said to be accurate. A football player who keeps striking the same goalpost is precise but not accurate. Therefore, a football player can be accurate without being precise if he hits the ball all over the place but still scores. A precise player will hit the ball to the same spot repeatedly, irrespective of whether he scores or not. A precise and accurate football player will not only aim at a single spot but also score the goal ,as shown in the figure below.



The top left image shows the target hit at high precision and accuracy.
The top right image shows the target hit at a high accuracy but low precision.
The bottom left image shows the target hit at a high precision but low accuracy.
The bottom right image shows the target hit at low accuracy and low precision.

Difference Between Accuracy and Precision

In the previous few sections having discussed what each term means, let us now look at their differences.

Accuracy	Precision
Accuracy refers to the level of agreement between the actual measurement and the absolute measurement.	Precision implies the level of variation that lies in the values of several measurements of the same factor.
Represents how closely the results agree with the standard value.	Represents how closely results agree with one another.
Single-factor or measurement are needed.	Multiple measurements or factors are needed to comment about precision.
It is possible for a measurement to be accurate on occasion as a fluke. For a measurement to be consistently accurate, it should also be precise.	Results can be precise without being accurate. Alternatively, the results can be precise and accurate.