Terminology, Modeling, and Measurement

Introduction

Physics is the natural science that studies matter. Physics is one of the most fundamental scientific disciplines, with its main goal being to understand how the universe behaves.

Broadly, physics involves the study of everything in physical existence, from the smallest subatomic particles to the entire universe. Physics is divided into several types:

1. Motor mechanics.
2. Physics of waves and sound.
3. Nuclear physics.
4. Physics of the universe and astronomy.
5. Physics of high energies.
6. Physics of electronics.
7. Physics of engineering optics.
8. Quantum mechanics.
9. Theory of relativity.
10. Thermodynamics.
11. Nano science.
12. Medical and Biological Physics.
13. Laser Physics.
14. Elementary Particle Physics.
15. Atomic Physics.
16. Plasma Physics.
17. Electromagnetic Theory.
18. Statistical Physics.
19. Solid State Physics.
20. Chemical Physics

Terminology:

Medical physics: is the term of a science that overlaps with the two fields of medicine and physics, and it refers to the applications of physics to the function of the human body in health and disease, is the application of the concept of physics in medicine.

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Aims of the Medical physics Application of the concepts and methods of physics to understanding the function of human body in health and disease.

1. Physics of the body is 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

2. Application of physics in medicine Medical physics Techniques are used for

A. Diagnostic: Stethoscope, Manometer (blood pressure),Sphygmomanometer ,Electrocardiograph(ECG),X-Ray,Electroencephalograph(EEG),Electromyography (EMG),thyroid function using I131 ,Computer tomography (CT scan) , Ultrasound , tuning Fork, Imaging Magnetic Resonance (IMR), Flow meter , Spirometer to study the function lungs, Audiometer, Optics, Laser, Gamma camera to study the function of kidney ,liver ,and lungs .

B. Therapy (Radiotherapy): Cobalt sixty(Co sixty), High voltage ,Ultrasound ,infrared ,Radio frequency ,Heating ,Laser

C. Patient monitoring: ECG, spirometer, blood pressure, and thermometer physics of physiology**.**

The branch of medicine referred to 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 gymnastics rather than by drugs.

The field of medical physics has several subdivisions.

Most medical physicists work in the field of *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).

Another major subdivision of medical physics involves radiation protection of patients, workers, and the general public. This field is often called (*health physics*).

Very often an applied field of physics is called *engineering*. This field is working on medical instrumentation, usually of an electronic nature.

The word medical is sometimes replaced with the word clinical if the job is closely connected with patient problems in hospitals.

○ Modeling

In trying to understand the physical aspects of the body, we often resort to analogies. For example, in many ways the eye is analogous to a camera; however, the analogy is poor when the film 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 representing by the flow of electricity is often used in the study of the body's circulatory system. This electrical model can simulate many phenomena of the cardiovascular system.

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.

Other models are mathematical; equations are mathematical models than can be used to describe and predict the physical behavior of some systems. Some are of such general use that they are referred to as laws.

For example, the relationship between force F, mass m, and acceleration a, usually written as $F = ma$, is known as newton's second law.

One of the physicist's favorite words is *function*. The equation $W = f(H)$ means the weight W is a function of the height H. It does not tell you how weight and height are related or what other factors are involved. It is sort of mathematical shorthand.

In the medical field we could write $R = f(P)$ to indicate that the heart rate R is a function of the power produced by the body P.

- *Modeling*

1. Simplification: selection of main features 2. Qualitative or quantitative expression

3. Analysis 4. Verification 5. Interpretation 6. Application

- *Analogy*

1. Mechanical model 2. Electrical circuit model

- *Mathematics*

1. Equation 2. Function

- *Feedback control*

1. Negative feedback: homeostasis 2. Positive feedback

○ Measurement

One of the main characteristics of science is its ability to measure quantities. 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 poor and related to the skill of the physician. For example, even though body temperature and pulse rate could be measure during the seventeenth century, these measurements were not routinely made until the nineteenth century.

Table 1 illustrates The SI is constructed from seven base units, which are adequate to describe most of the measurements used in science, industry and commerce.

Quantity	Unit Name	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Table 1. The SI Basic Units.

The units that used in measurements are divided into two quantities; fundamental quantities, which have internationally accepted, and derived quantities, which are all other quantities are expressed in terms of the fundamental quantities.

All other physical quantities and units can be expressed in terms of these six units.

Some derived quantities and units are given in Table 2.

Name of Derived Quantity	**Symbol**	**Formula**	**SI Unit**
1. Area	A	A = P x L	m^2, cm^2, mm^2
2. Volume	V	V = P x L x T	m^3, cm^3, mm^3
3. Velocity	v	v = s / t	ms^{-1}, kmj^{-1}
4. Acceleration	a	a = Δv / t	ms^{-2}
5. Density	ρ	ρ = m / V	kgm^{-3}, gcm^{-3}
6. Pressure	p	p = F / A	Nm^{-2}, pascal (Pa)
7. Work	W	W = F x s	Nm, joule(J)
8. Power	P	P = W / t	Js^{-1}, watt(W)
9. Energy	E	$E = mc^2$	J

Table 2. Some of The Derived Units.

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The SI system has not been accepted throughout the world. In addition, the various branches of medicine use some unique units.

Physiological unit : In medicine it is often convenient to measure quantities in nonstandard units.For example :the physical units of pressure is newtons per square meter

,blood pressure is expressed in millimeter of mercury (Hg)

Non Standard Unit (Pressure = mm Hg ,Time = minute,Energy = calorie ,Heart rate = pulse / minute).Another example ; pulse rate measure in pulse per min.

There are two groups of physics measurement in the body which are repetitive and nonrepetitive, the repetitive is the number of repetition per second, minute e.g. pulse rate (70/minute) breathing rate (16/minute men and 20/minute women) and frequencies in the electrical signals from the brain.

The nonrepetitive means Such as the time of the function of the kid eyes remove a foreign substance from the blood, food digestion in the body, time intervals of nerve signal.

The measurement in medicine should be very accurate and the percentage of error should be as low as possible.

The diagnostic error is not result of measuring instruments only, because the error can happened due to a cycological reasons e.g. the blood and pressure pusse rate can be affected during the measurement by several rejoins the diagnostic errors can lead to wrong dictions which are of two types which are:

i. *A false negative* error occurred when a point is diagnosed to be free of disease when he does have it.

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

i) V=6V olt (true or theoretical value) This instrument is accurate

ii) V=6V olt (true or theoretical value) This instrument is not accurate

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V=5.8V olt (measured or practical value) V=4.8V olt (measured or practical value) V=5.8V olt (measured or practical value)

iii) V=6V olt (true or theoretical value)

When we try to check the reading, we measured it again and again, and get the following results: second measure for the same reading equal V=5.8Volt, third measured V=5.8Volt, forth measured V=5.8Volt and so on.

This instrument is accurate and precise

iv) V=6Volt (true or theoretical value) V=4.8Volt (measured or practical value)

We try to check the reading, we measured it again and again, and get the following results: second measure for the same reading equal V=5Volt, third measured V=4.6Volt, forth measured V=5.2Volt and so on. This instrument is not accurate and not precise.

(H.W)// The following systolic blood pressures (in millimeters of mercury)were recorded for one individual over a period of several days.

112	128	127	118	123
110	117	133	117	124
127	132	133	123	119
112	114	115	125	132
126	136	132	134	131

a. Find the mean pressure

b. Find the standard deviation.

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