Lecture One

Introduction to medical physics

- ***Medical Physics:*** 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 human body in health and disease, called the ***physics of physiology***.

2) The application of physics in the ***practice of medicine*** includes such things as: Stethoscope, tapping of the chest (percussion), x-ray, ultrasound, radiation, nuclear medicine, and laser.

- ***Physical medicine:*** Is the branch of medicine deals with the diagnosis and treatment of disease and injury by means of physical such as massage, exercise, heat, water, cold.
- ***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:*** 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 radiation nuclides in medicine ***(nuclear medicine)***.

2) ***Health Physics:*** Involves ***radiation protection*** of patients, workers, and the general public, this name was given to it during world war second by members of the Manhattan project (the group responsible for the development of the atomic bomb).

3) ***Medical electronics (medical engineering):*** Deal with instrument used in monitoring body functions and diagnosis or as aids or as surgical, such as uses of the computers in medicine.
4) In some areas, such as the applications of x-ray and ultrasound in medicine.

- The word ***medical*** is sometime replaced with the word ***clinical*** if the job is closely connected with patient problem in hospitals, i.e. clinical engineering or clinical physics.

- ***Medical physics Techniques are used for:***

1) ***Diagnostic:*** Such as; tethoscope, Manometer (blood pressure), Sphygmomanometer, Electrocardiograph (ECG), X-Ray, Electroencephalograph (EEG), Electromyography (EMG), thyroid function using I^{131}, Computer tomography (CT scan), Ultrasound, tuning Fork, Magnetic Resonance Imaging (MRI), Flow meter, Spirometer to study the function lungs, Audiometer, Optics, Laser, Gamma camera to study the function of kidney, liver, and lungs.
2) ***Therapy:*** Such as; Radiotherapy, High voltage, Ultrasound, infrared, Radio frequency, Heating, and Laser.
3) ***Patient monitoring:*** Such as; ECG, spirometer, blood pressure, and thermometer.

- ***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 chemical interest were often scorned as detracting from skill of physician, for example: Weight, pulse, temperature of the body, blood pressure, x- rays, exposure

dose of radiation, and volume measurements some of the common measurement used in the practice of medicine.

Table 1: Quantities and Their Units

Quantity	SI Unit (symbol)
Length	**Meter (m)**
Mass	**Kilogram (Kg)**
Time	**Second (s)**
Temperature	**Kelvin (K)**
Electric Current	**Ampere (A)**
Luminous Intensity	**Candela (Cd)**
Amount of Substance	**Mole (mol)**

Table-2: Some quantity with non (SI) unit

Quantity	Unit	Abbreviation
Length	Foot	Ft
Volume	Liter	Li
Energy	Joule Calorie	1 joule=$2.39x10^{-4}$ Cal
Pressure	Pounds/square inch	PSi
Temperature	Celsius, Kelvin	°C, K=C+273 F=9/5 * C +32
Force	pound	Lb

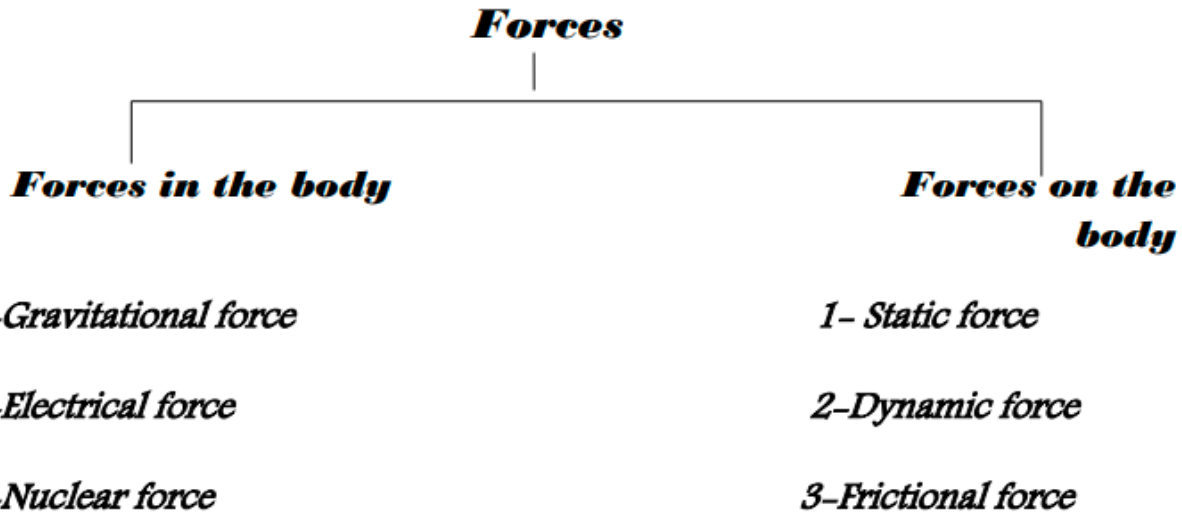
- There are many other physical measurements involving the body and time we can divide them in to two groups:

1) ***Measurements of repetitive processes,*** such as the pulse, this measurement usually involves the number of repetitions per time, minuets, hour, for example the pulse heart rate is about 70/min. And the breathing rate is about 15/min.

2) ***Measurements of non-repetitive processes***, such as how long it takes the kidneys to remove a foreign substance from the blood. Non repetitive time processes in the body range from the action potential of a nerve cell (1 m sec) to the lifespan of an individual.

Lecture Two

Forces on and in the body



➢ Forces in the body:

1) ***Gravitational force (G.F):*** From Newton law: There is a force of attraction between any two objects. (F=mg). Where: g = acceleration due to gravity (cm/sec^2 or m/sec^2), m= the mass (g, kg), f = the force (N, dyne).

Our weight is due to the attraction between the earth and our bodies. The medical effects of gravitational force are the formation of varicose veins in the legs as the venous blood travels against the force of gravity on its way to the heart. Varicose veins are veins that have become enlarged and twisted. When veins become varicose, the leaflets of the valves no longer meet properly (as illustrated in figure-1), and the valves do not work. This allows blood to flow backwards and they enlarge even more. Varicose veins are most common in the superficial veins of the legs, which are 2 subject to high pressure when standing. Besides being a cosmetic problem, varicose veins can be painful, especially when standing.

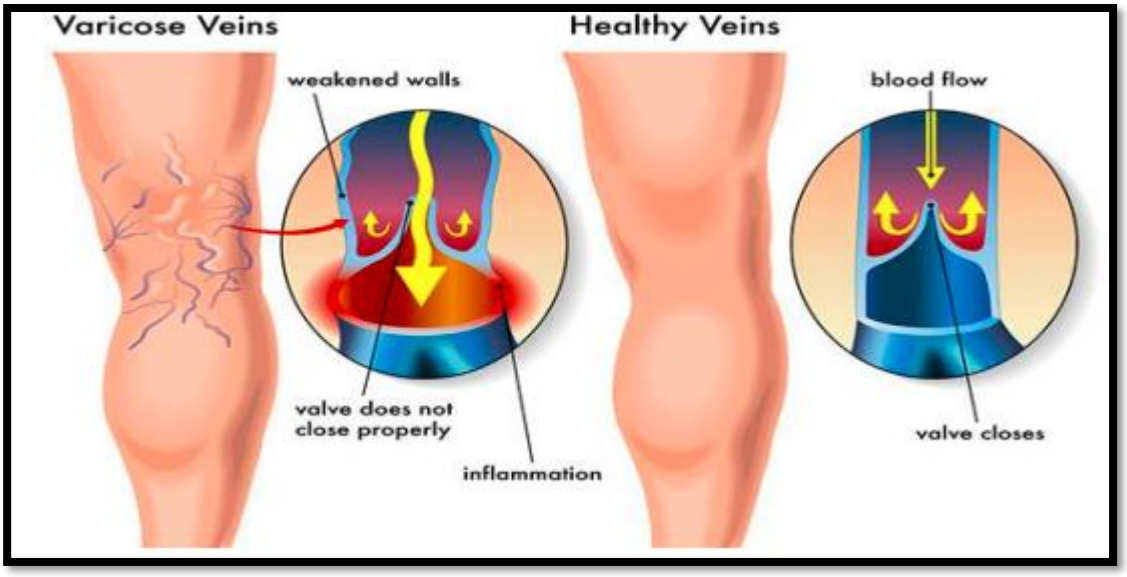


Figure (1): shows the cause of varicose veins.

2) ***The electrical force (E.F):*** This force more complicated than gravity since it involves attractive and repulsive forces between static electrical charges as well as magnetic force produced by moving electrical charges (electrical current).

3) ***Nuclear Force (N.F):***

A. ***strong nuclear force:*** is much larger than the other Þ it acts as the “glue" to hold the nucleus together against the repulsive force produced by the protons on each other.

B. ***Weaker nuclear force:*** is involved with electron (beta) decay from the nucleus.

➢ Forces on the body:

1) ***Statics Forces:*** when object is static they are of equilibrium means sum of force in any direction is equal to zero and the sum of the torques about axis also equal zero.

Many of muscle and bone system of the body acts as levers which are classified to:

A. ***First class levers:*** They are least common in the body. The fulcrum point (F) is between the muscle forces (M) and the weight (W), for example the ***head***.

B. ***Second class levers:*** They are found more than first class levers. Weight (W) is between the fulcrum point (F) and muscle forces (M), for example ***standing on the toes***.

C. ***Third class levers:*** They are most common in the body. Muscle forces (M) is between fulcrum point (F) and weight (W). For example, ***the arm in the elbow joint.***

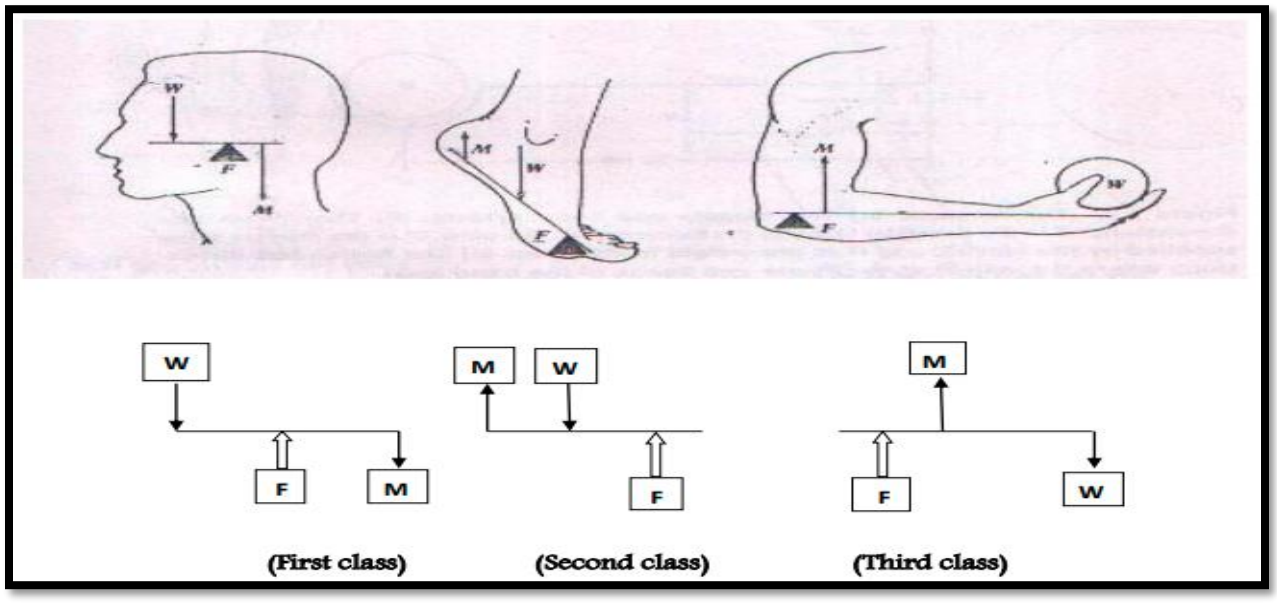


Figure (2): The three levers classes and schematic example of each in the body. W is a force that could be the weight, F is a force at the fulcrum point and M is the muscle force.

2) ***Dynamic:*** This force is important when the body is moving and hitting another body. It appears on the body where acceleration or deceleration is involved.

The Newton's second law, force equals mass times acceleration.

F= ma

Newton said" force equals the change of momentum Δ(mv) over a short interval of time Δt F

Δ(mv)= Δt F

Example 1: A person (60 kg) walking at (1 m/sec) bumps into a wall and stops in a distance of (2.5 cm) in about (0.05 sec). What is the force developed on impact?

Answer:

Δ(mv) = (60 kg) (1m/sec) – (60 kg) (0 m/sec) = 60 kg m/sec

Δ(mv)= Δt F → F= Δ(mv)/Δt

F = 60/0.05 = 1200 kg m/ sec^2 or 1200 N

Example 2: a- A person walking at (1 m/sec) hits his head on a steel beam Assume his head stops in (0.5 cm) in about 0.01 sec. If the mass of his head is (4 kg). what is the force developed? b- If it is increased to (0.04 sec). what is the force developed?

Answer:

a) Δ(mv) = (4 kg) (1m/sec) - (4 kg) (0 m/sec) = 4 kg m/sec

Δ(mv)= Δt F → F= Δ(mv)/Δt

F= 4 /0.01 = 400 kg m/ sec^2 or 400 N

b) F = 4 /0.04 = 100 kg m/ sec^2 or 100 N

3) ***Frictional Forces:*** when a person is walking, as the heel of the foot touches the ground a force is transmitted from the foot to the ground.

F = μ N

μ: is the coefficient of friction between two surfaces.

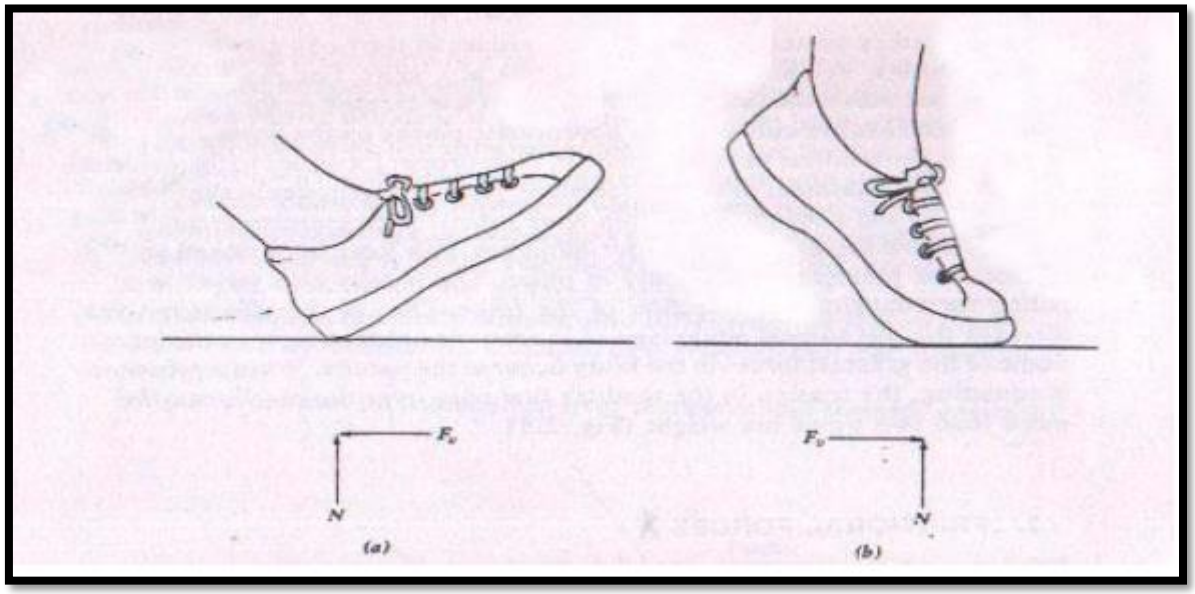


Figure (3). Normal walking. (a) both a horizontal frictional component of force Fv and a vertical (normal) component of force N exist on the heel as it strikes the ground. Frictional between the heel and the surface prevents the foot from slipping forward. (b) when the foot leaves the ground the frictional component of force Fv prevents the toe from slipping backward.