Medical physics module
semester 1

Session1

Lec.1

Forces in and on the Human Body

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Objectives

After the end of this lecture, the student must know:

1. The Fundamental Origins of Forces.

2· Types of Problems Involving Forces on Body.

3· Effects of the acceleration.

Obj.1

Physicists recognize four fundamental forces. In order of their relative strength from weakest to strongest.

There are:

1- **Gravitational force.**

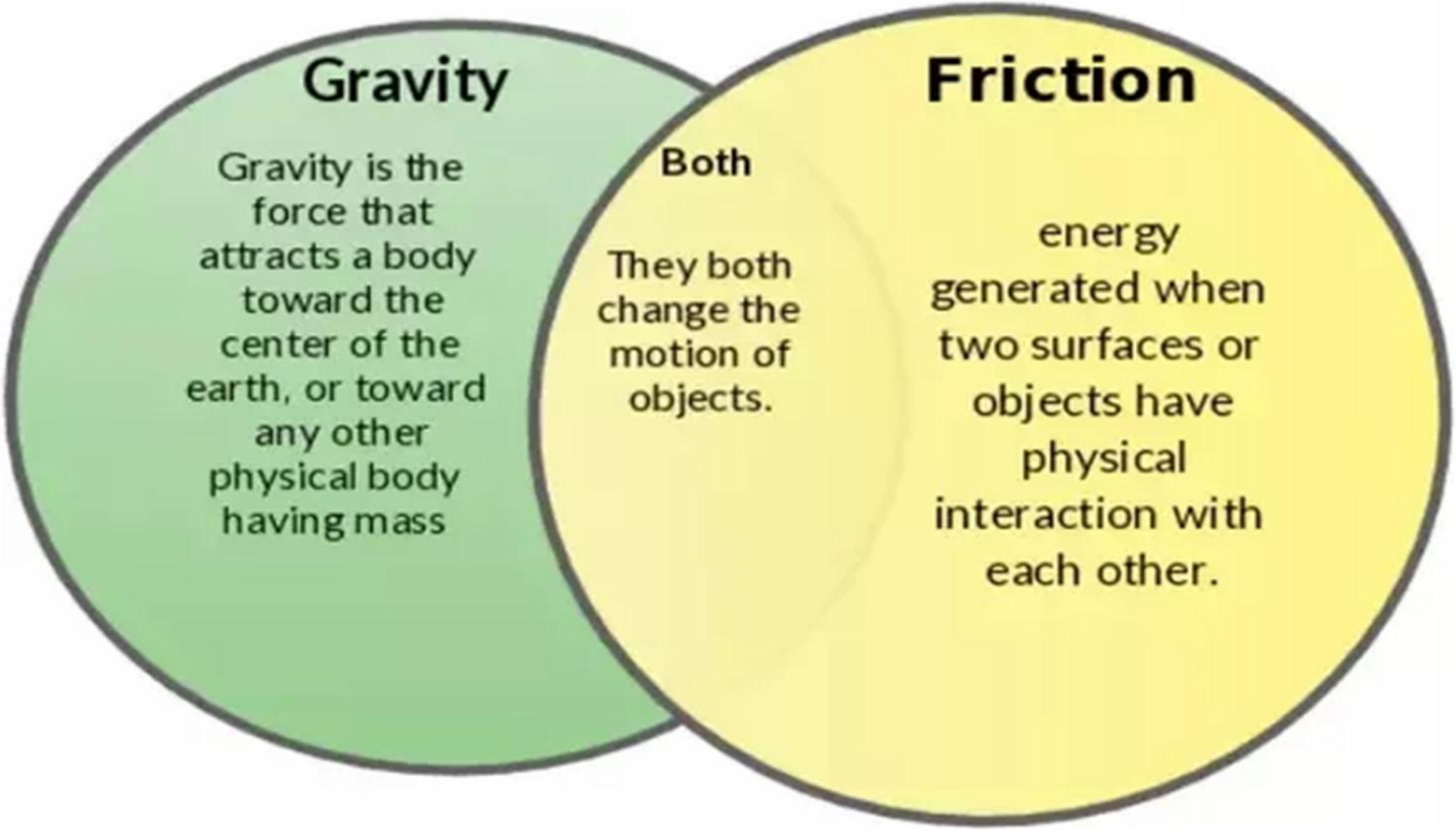
2- **Electrical force.**

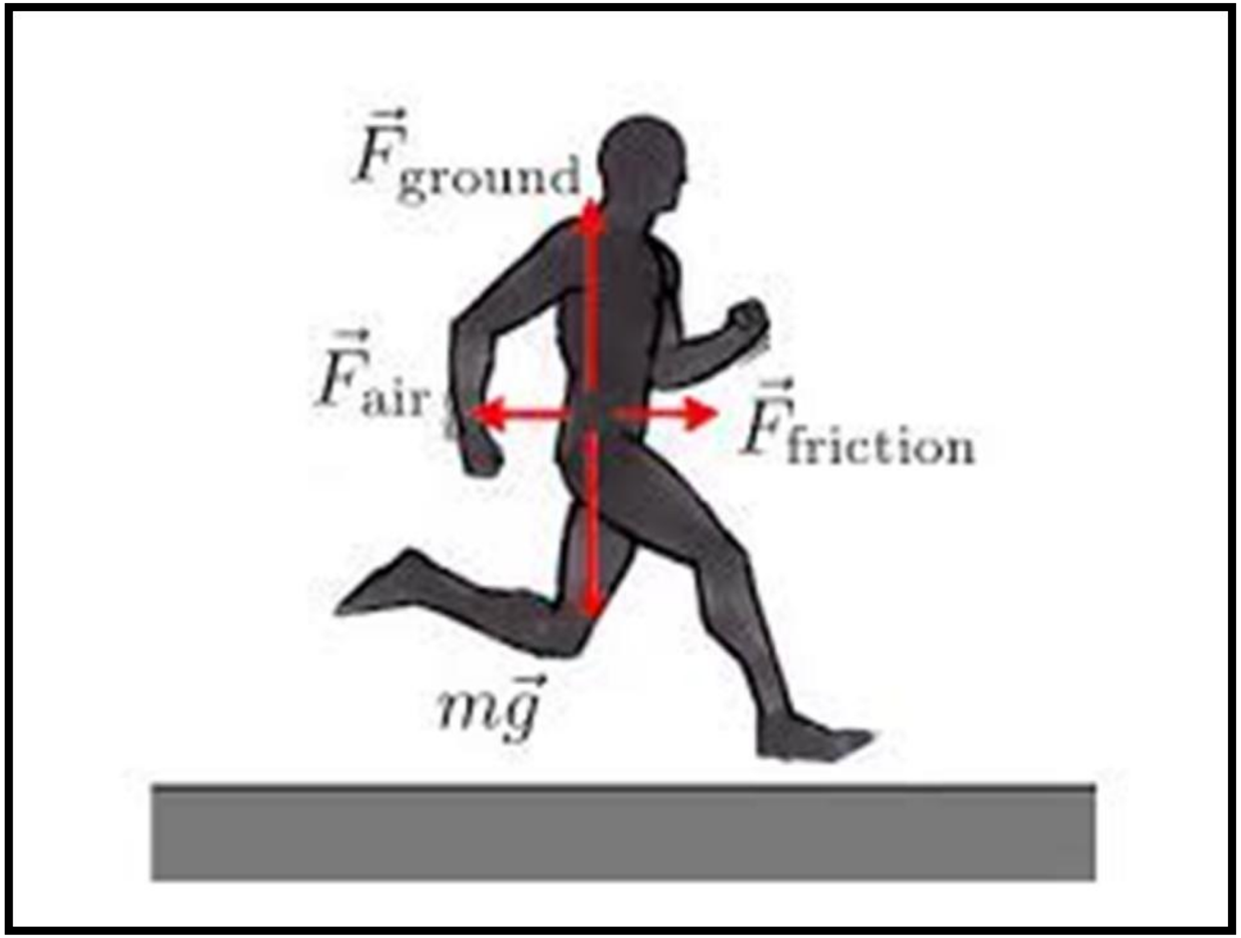
3- **Weak nuclear force.**

4- **Strong nuclear force .**

Important Forces

- Only the gravitational and electrical forces are importance in our study of the forces affecting the human body.
- The electrical force important at molecular and cellular levels, e.g. affecting the binding together of our bones and controlling the contraction of our muscles.
- Gravitational force, though very much weaker than the electrical force by a factor 10^{39}.


Gravity
Gravity is the force that attracts a body toward the center of the earth, or toward any other physical body having mass
Both
They both change the motion of objects.
Friction
energy generated when two surfaces or objects have physical interaction with each other.


$\vec{F}_{\text{ground}}$
$\vec{F}_{\text{air}}$
$\vec{F}_{\text{friction}}$
$m\vec{g}$

How Forces Affect the Body

- The muscular forces that cause the blood to circulate and lungs to take in air.

- In the bones there are many crystals of bone mineral that require calcium. A calcium atom will become part of crystal if it gets close to a natural place for calcium and electrical forces are great enough to trap it.

Gravitational Force

- **Newton's law: These laws state that there is a force of attraction between any two objects; our weight is due to attraction between the earth and our body.**

- **One important medical effect of gravitational force is the formation of varicose veins in the legs, as the venous blood travels against force of gravity on its way to the heart.**

Electrical Forces in the Body

The forces produced by muscles are caused by electrical charges attracting opposite electrical charges.

Cells in the body has an electrical potential difference across the cell membrane.

Frictional Forces

Friction and energy loss resulting from friction appear everywhere in our everyday life.

- Some diseases of the body, such as arthritis, increase the friction in bone joint.

Force of friction Ff is described by:

$$F_f = \mu N$$

N : is normal force

μ : is coefficient of friction between two surfaces

- Friction must be overcome when joints move, but for normal joints it is very small.

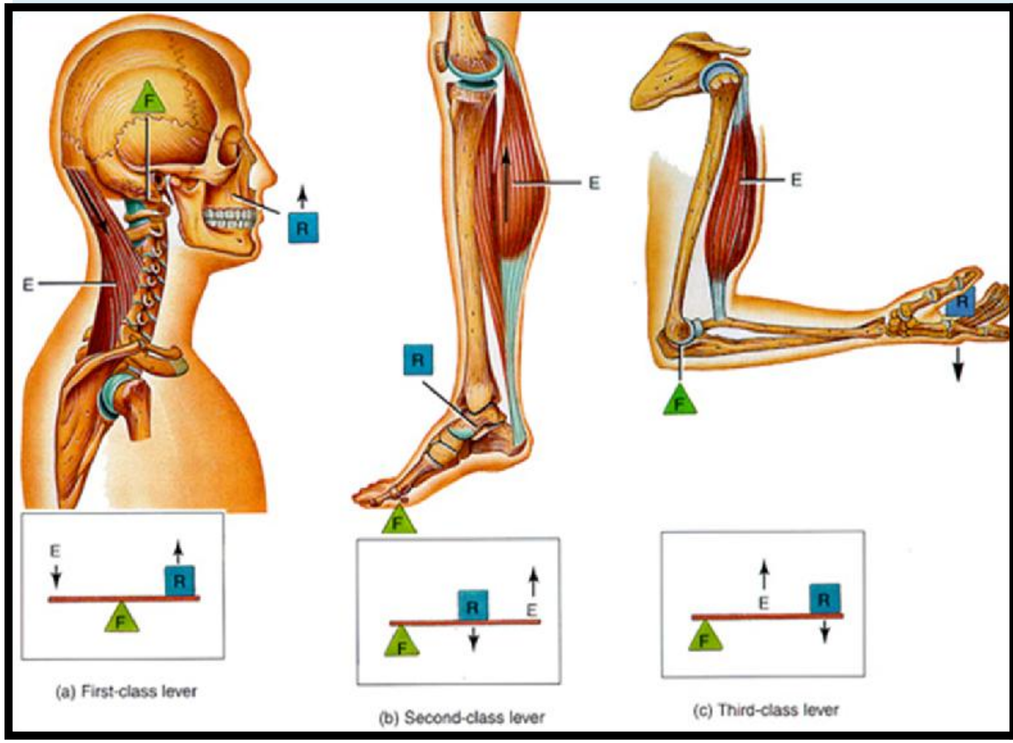
If a disease of the joint exists, the friction may become large.

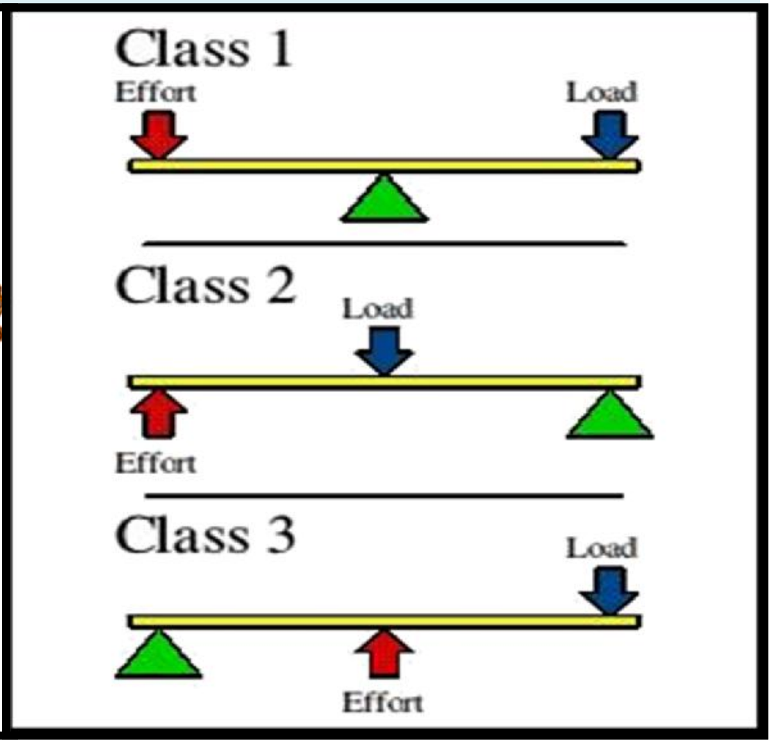
Obj.2

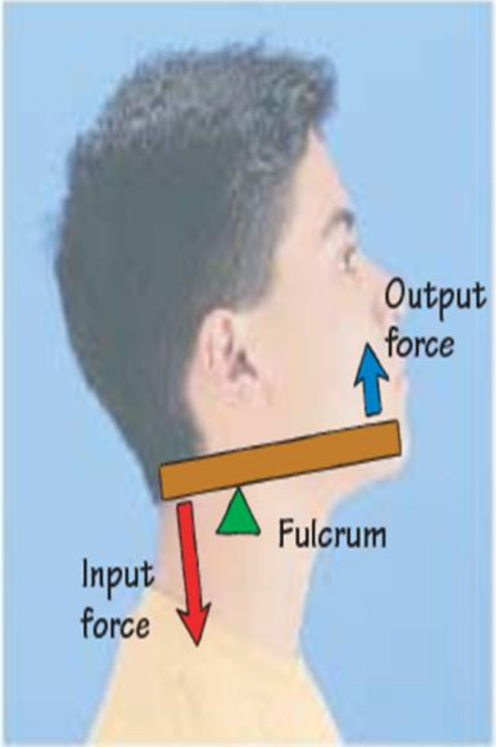
Forces, Muscles, and joints

Muscle forces involving levers for the body to be at rest and equilibrium (static),the sum of the forces acting on it in any direction and the sum of the torques any axis must both equal zero.

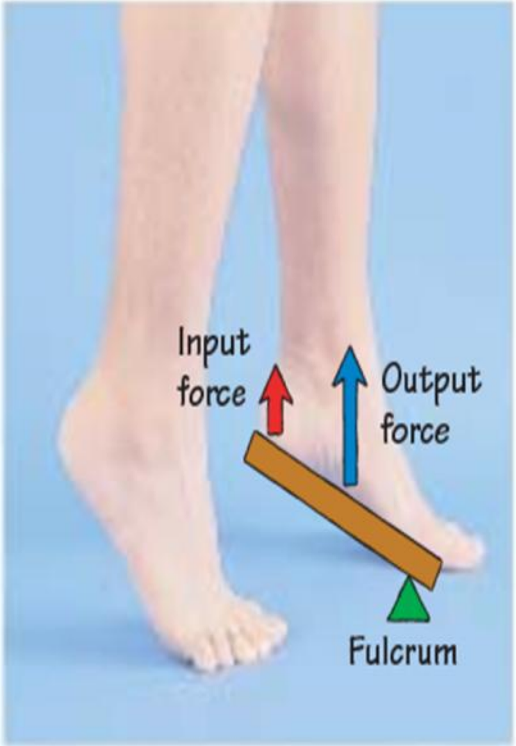
Many of Muscle and Bone Systems of the Body Acts as Levers, Levers are Classified as, First, Second, and Third. The Last are Most Common in the Body, Second are Next Common.



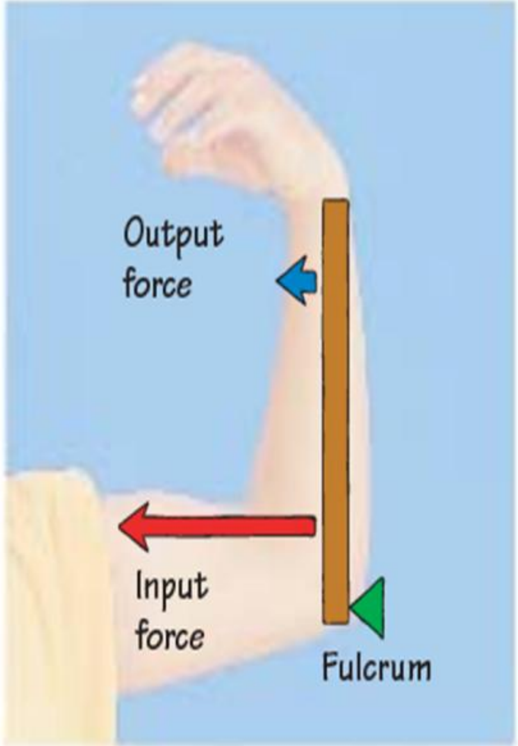




First-Class Lever The joint at the top of your neck is the fulcrum of a first-class lever. The muscles in the back of your neck provide the input force. The output force is used to tilt your head back.



Second-Class Lever The ball of your foot is the fulcrum of a second-class lever. The muscle in the calf of your leg provides the input force. The output force is used to raise your body.



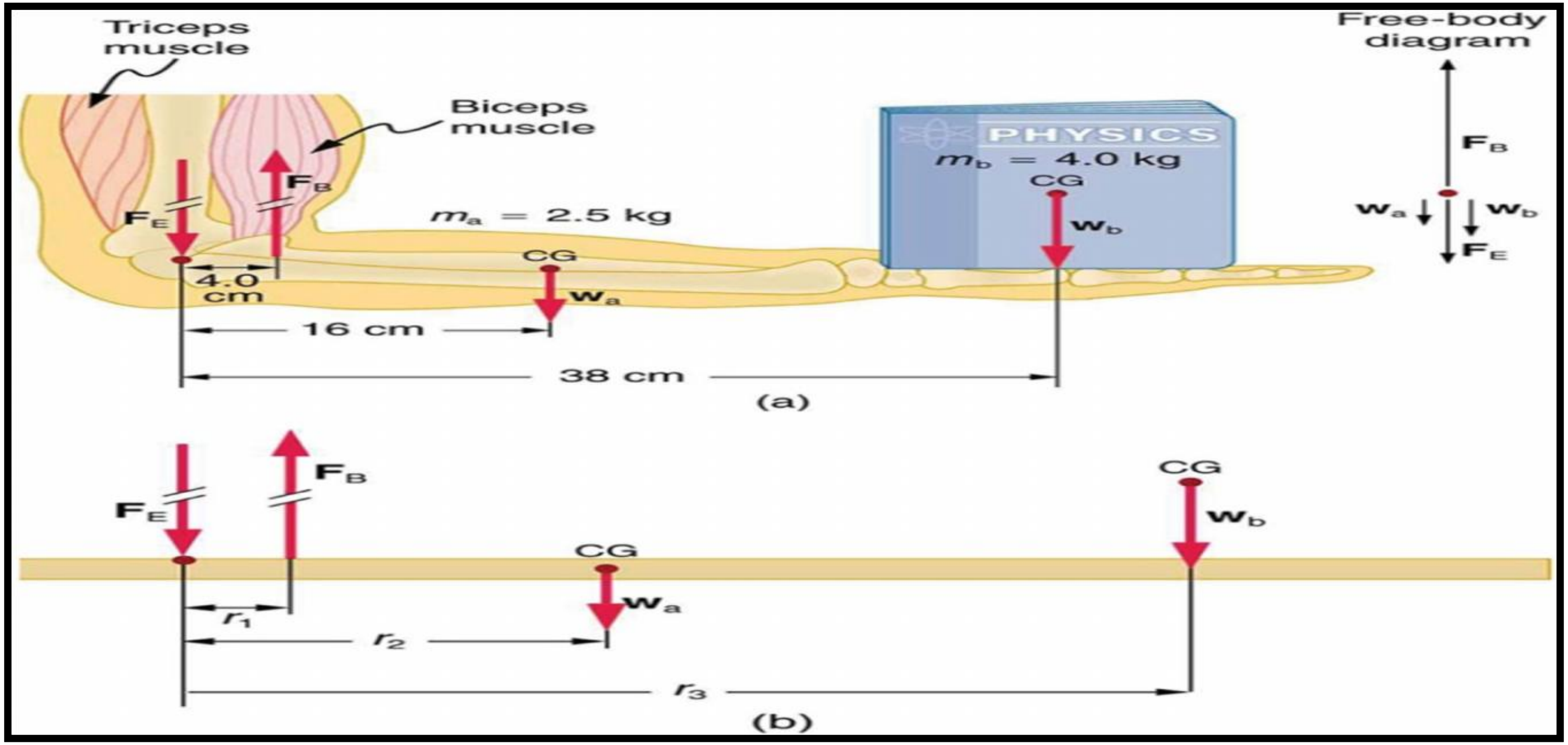
Third-Class Lever Your elbow is the fulcrum of a third-class lever. Your biceps muscle provides the input force. The output force is used to lift your arm.

We can find the force supplied by the biceps, if we sum the torques about pivot point at the joint

4M – 30 W= 0

M = 7.5 W **Neglect the weight of forearm**

M= 3.5 H - 7.5 W **Include forearm**



There are only two torques:

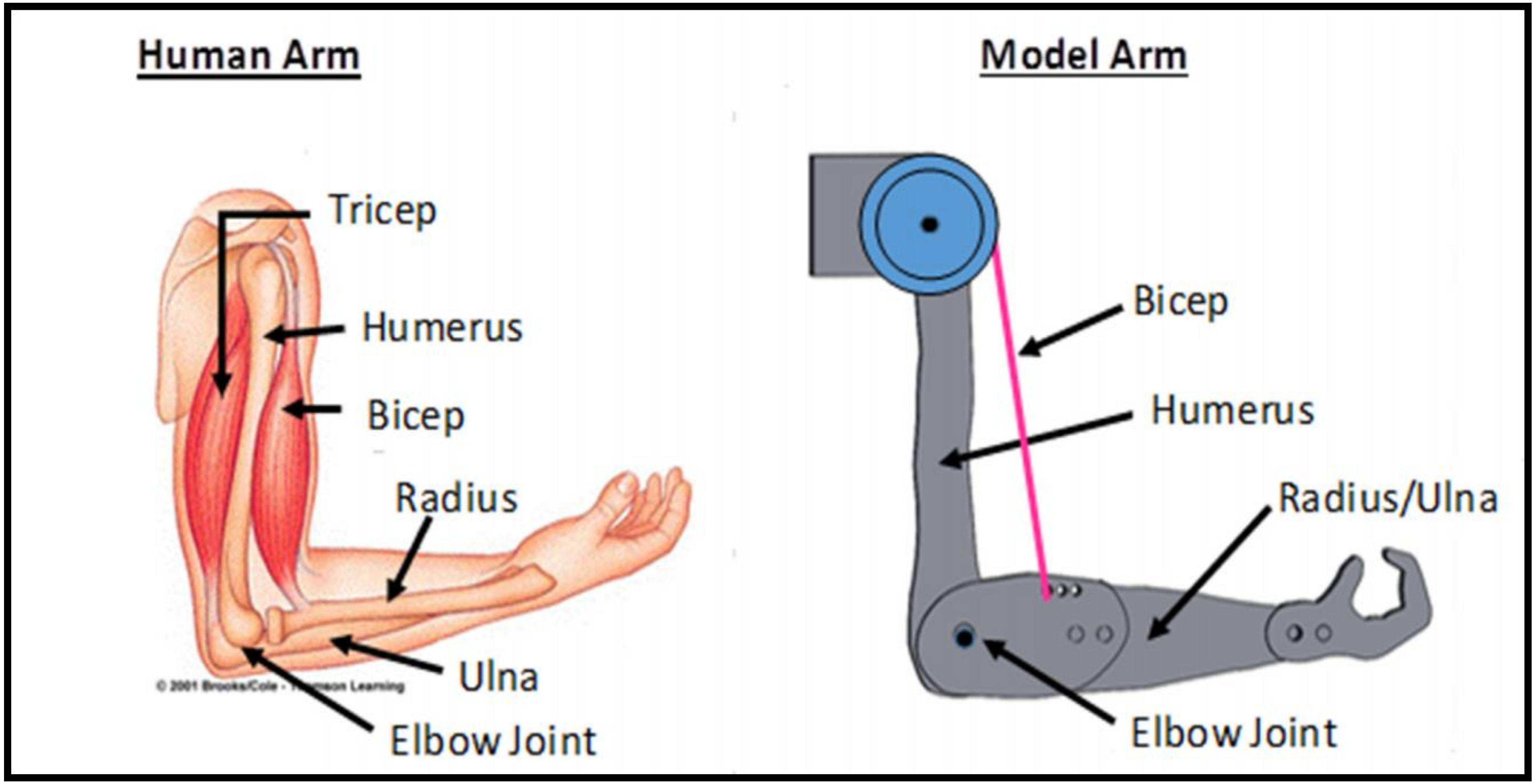
that due to the weight W, which is equal to30W acting clockwise and that produced by the muscle force M, which is counterclockwise and of magnitude 4M, with the arm in
equilibrium we find that:

The force supplied by the biceps if we sum the torques about the pivot point at the joint .

$4M - 30W = 0$ and $M = 7.5W$

A muscle force 7.5 times the weight, we neglected the weight of the forearm and hand

The forearm at the angle α to the horizontal



The torques remains constant as α change

- length of the biceps muscle changes with the angle. In general, each muscle has a minimum length to which it can be contracted and maximum length to which it stretched and still

  faction.
- At these two extremes the force the muscle can exert is essentially zero. At some point in between, the muscle can produce its maximum force

The arm can be raised and held out horizontally from the shoulder by the deltoid muscle.

By taking the sum of the torques about shoulder joint, the tension T can be calculated.

$$T = (2W1+4W2)/ \sin\alpha$$

T: is the tension in the deltoid muscle fixed .

W: is the weight of the arm located at its center of gravity

Dynamics

Forces on the body where acceleration, the Newton's second low, force equals mass times acceleration .

$$\mathbf{F = ma}$$

The force equals the change of momentum $\Delta(mv)$ over a short internal of time Δt or

$$\mathbf{F = (\Delta(mv))/\Delta t}$$

Obj.3

Accelerations can produce a number of effects such as:

1. An apparent increase or decrease in body weight.
2. Changes in internal hydrostatic pressure.
3. Distortion of the elastic tissues of the body.

4- The tendency of the solids with different densities suspended in a liquid to separate.

If the acceleration become large may pool in various regions of the body, the location of the pooling depends upon the direction of acceleration.

Tissue can be distorted by acceleration, if the forces are large, tearing or rupture can take place.

The speed at which small objects fall through a liquid depends on their size, viscosity, acceleration due to gravity g, we can artificially increase g by centrifuge.

Stokes has shown that for a spherical object or radius a, the retarding force Fd and terminal velocity V are related by $F_d = 6\pi\eta aV$

When the particle is moving at constant speed the retarding force is equilibrium with the difference between gravitational force and upward buoyant force (the weight of the liquid the particle displaces)

thus we have:

1- **Force of gravity** $Fg = 4/3 \pi a^3 \rho g$

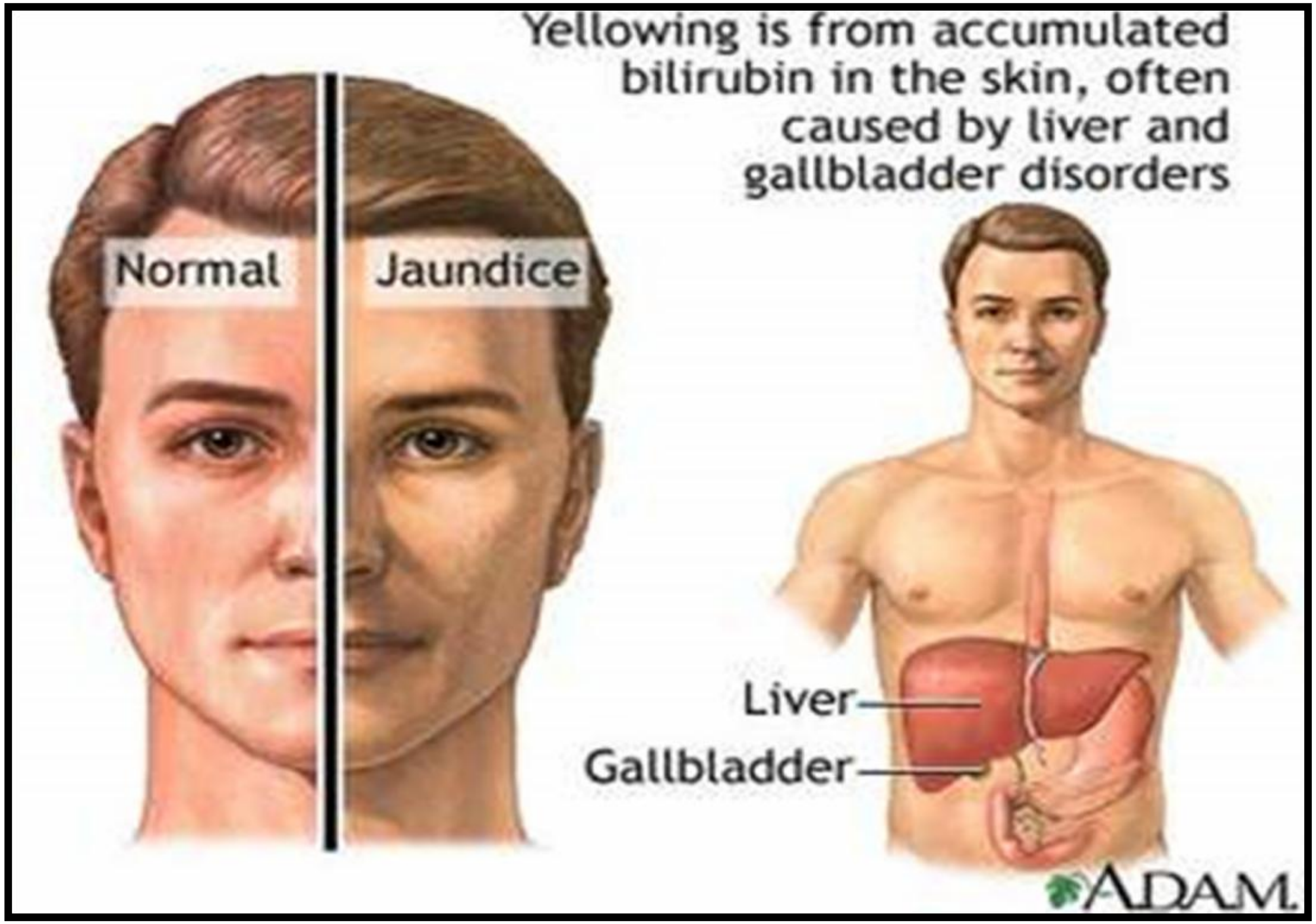
2- Buoyant force $Fb = 4/3 \pi a^3 \rho^o g$

3- Retarding force $Fd = 6 \pi \eta a V$

In equilibrium $Fg - Fb = Fd$

Sedimentation Velocity $V = 2 a^2 / 9 \eta [g (\rho - \rho^o)]$

This equation is valid for spherical objects.
In some forms of diseases such as rheumatic fever, rheumatic heart disease, and gout RBC clumps together, and the effective radius increase thus increased sedimentation velocity occur.
In other diseases such as hemolytic jaundice and sickle cell anemia RBC change shape or break, the radius decreases, thus the rate of sedimentation velocity decrease.


Yellowing is from accumulated
bilirubin in the skin, often
caused by liver and
gallbladder disorders
Normal
Jaundice
Liver
Gallbladder
A.D.A.M.


Thank you