PHYSICS FOR

PHYSIOTHERAPHY

EQULIBRIUM

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Definition of Equilibrium

Equilibrium is the condition of a system when neither its state of motion nor its internal energy state tends to change with time.

EQUILIBRIUM

DEFINITION

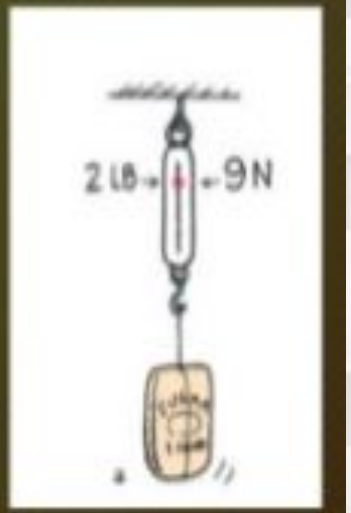
Equilibrium is a state of balance in which all forces are equal

Any rigid object will be in equilibrium when external forces acting on it don't tend to move it or rotate it around an axis, i.e.

Clockwise moments or forces = Counter clockwise- moments or forces.

Terms associated with Equilibrium

- A Force is a push or a pull.
- Net Force is the combination of all forces acting on an object.
- Tension is the stretching force (springs, rubber bands, etc.) The stretched spring is under the "stretching force" called tension.
- Support force is the upward force that acts opposite the force of gravity.
- Weight is force of gravity pulling on the mass of an object.
- Vector is an arrow that represents the magnitude and direction of a quantity.



Terms associated with Equilibrium

- Vector Quantity needs both magnitude and direction for a complete description.
- Scalar Quantity can be described by magnitude only, it has no direction.
- Torque is a 'turning force'. (τ) -"tau".
- A Couple is a pair of forces that have the same size but opposite direction.
- A Lever is a bar that is free to pivot or turn at a fixed point.
  The fixed point is called the FULCRUM.

Applications of Equilibrium

- Luggage compartment of tour bus is located at the bottom of the bus and not at the roof.
- Passengers are not allowed to travel while standing on the upper part of the double decker bus.
- Seesaw
- Tug of war
- Paddling the boat
- Support in oil ring

Factors affecting Equilibrium

- Temperature
- Pressure
- Concentration

Conditions for Equilibrium

Static equilibrium is defined as a state where an object is not accelerating in any way.

There are **two conditions for the equilibrium** of a rigid body;

- If a rigid body is in Static Equilibrium, it is at rest, no translational acceleration and no rotational acceleration. Both of the following must be true for anybody in static equilibrium.

Conditions for Equilibrium

Translational Equilibrium

An object is in translational equilibrium if it is not accelerating.

1. Translation equilibrium applies that the resultant external forces applied to the object is zero.

Translational equilibrium means;

$\sum F=0$

Conditions for Equilibrium

Rotational Equilibrium

An object is in rotational equilibrium if its rotational acceleration is zero.

2.Rotational equilibrium implies that the resultan external torque about any axis must be zero

Rotational equilibrium means;

$\sum \tau = 0$

Types of Equilibrium

Stable Equilibrium

A body is said to be in stable equilibrium if it tends to return to its original position when slightly displaced.

Types of Equilibrium

Examples are:

a) a cone resting on its base;

b) a racing car with low centre of gravity and wide base;

c) a ball or a sphere in the middle of a bowl.

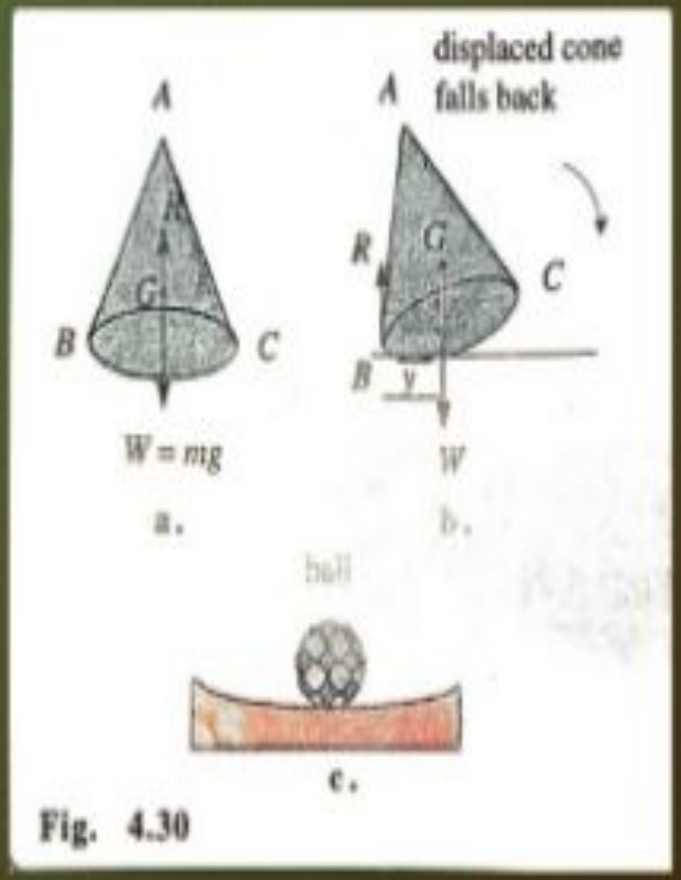


Fig. 4.30

Types of Equilibrium

Unstable Equilibrium

A body is said to be in an unstable equilibrium if when slightly displaced, it tends to move further away from its original position.

Types of Equilibrium

Examples are:

a) a cone or an egg resting on its apex or pointed end;

b) a ball or a sphere resting on an inverted bowl;

c) a tight-rope walker.

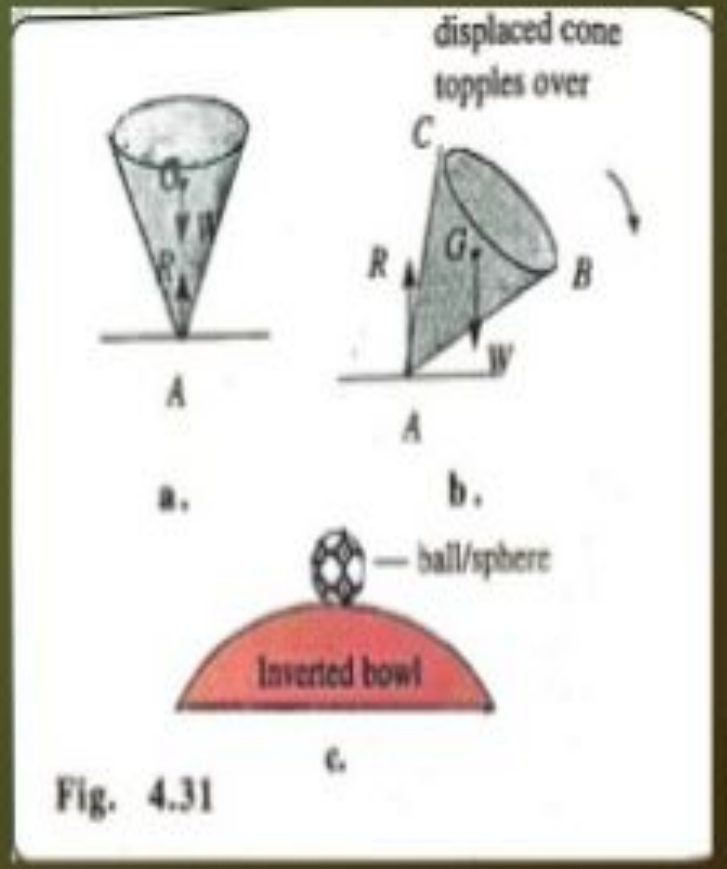


Fig. 4.31

Types of Equilibrium

Neutral Equilibrium

A body is said to be in neutral equilibrium if when slightly displaced, it tends to come to rest in its new position.

Types of Equilibrium

Examples are:

a) a cone or cylinder or an egg resting on its side;

b) a ball or a sphere on a smooth horizontal table.

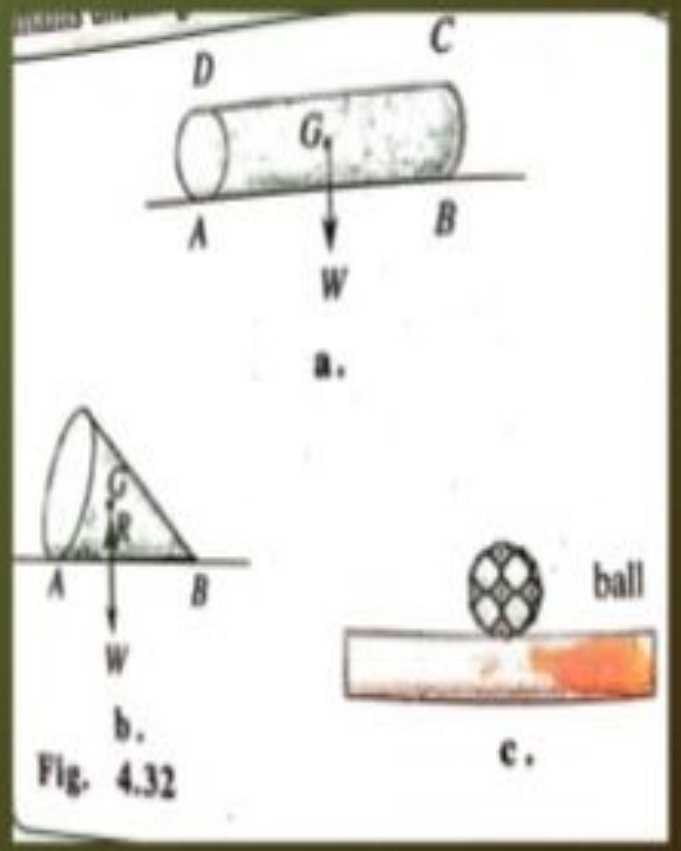


Fig. 4.32

Laws of Equilibrium

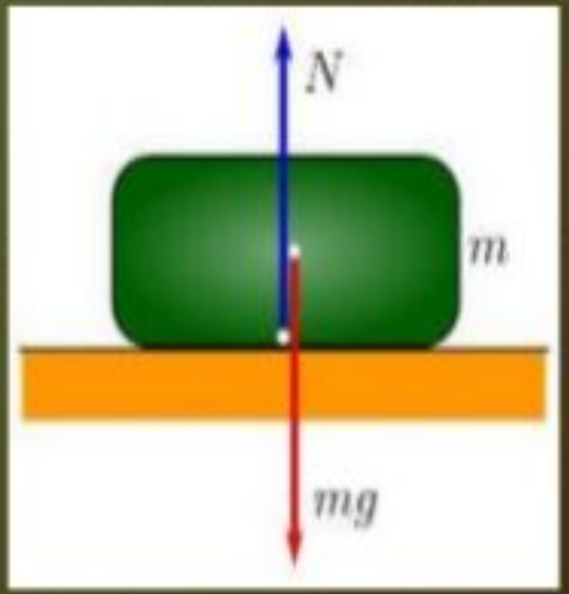
Newton's First Law

An object at rest or an object in motion at constant speed will remain at rest or at constant speed in the absence of a resultant force.

Laws of Equilibrium

Transitional Equilibrium

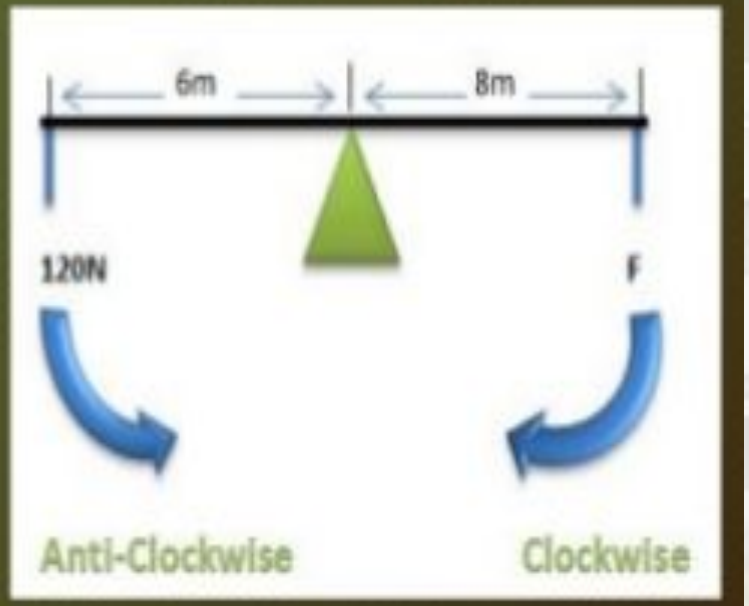
An object is said to be in Translational Equilibrium if and only if there is no resultant force. This means that the sum of all acting forces is zero.



Laws of Equilibrium

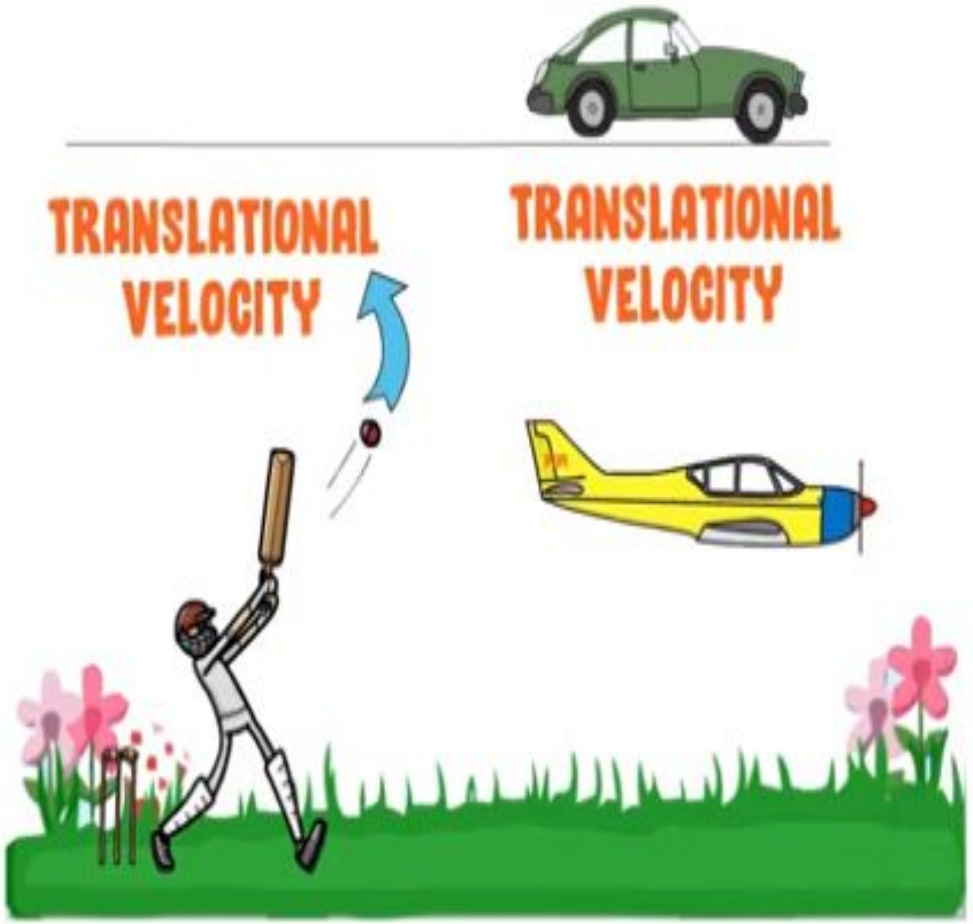
Rotational Equilibrium

A body is said to be in rotational equilibrium when the sum of torque is zero. The object in rotational equilibrium will rotate with angular velocity which could be zero.



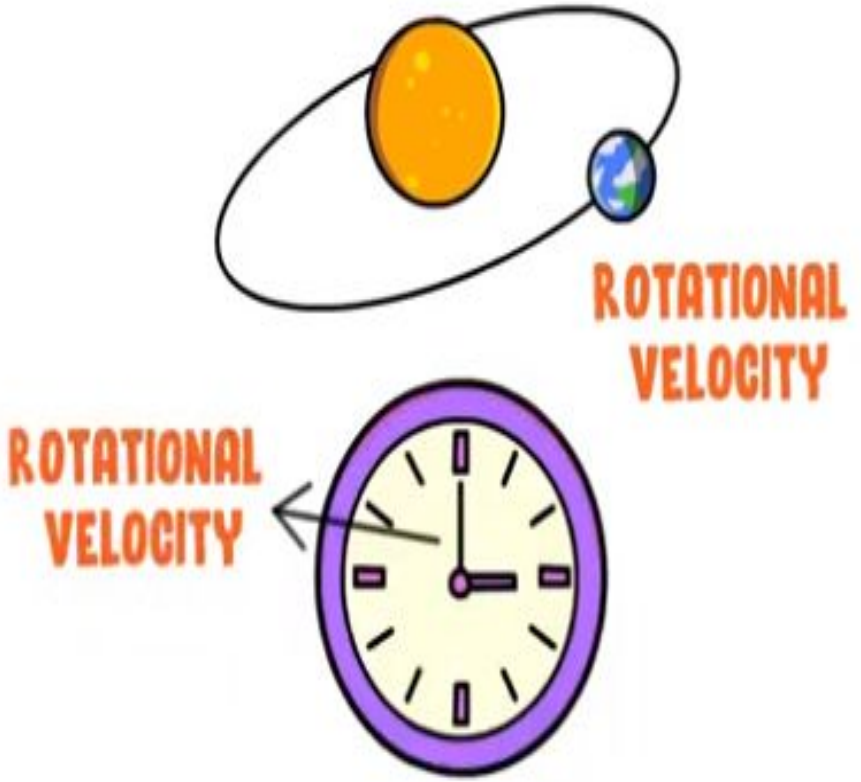
TRANSLATIONAL VELOCITY

If an object moves on straight or curved path...



ROTATIONAL VELOCITY

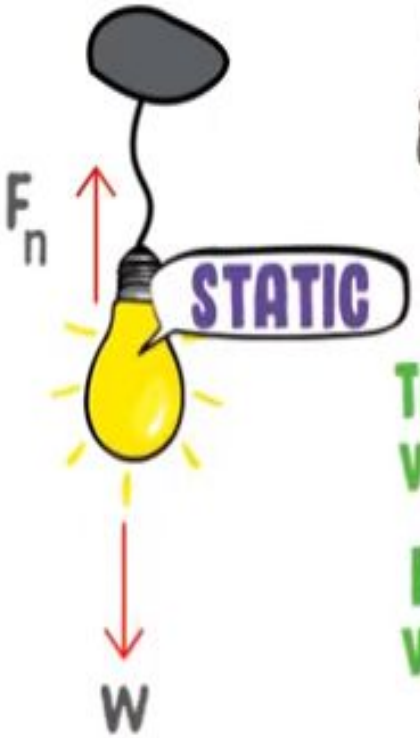
If an object moves on a cyclic path...



WHAT IS STATIC EQUILIBRIUM ?

The word Static means Stationary

A body is said to be in Static Equilibrium if it satisfies 2 conditions.

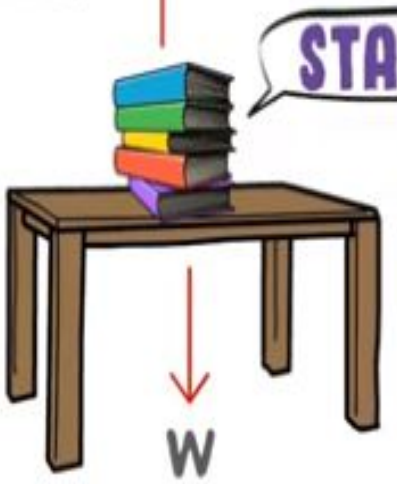


Translational and Rotaional Velocities of object must be ZERO.

TRANSLATIONAL VELOCITY = ZERO

ROTATIONAL VELOCITY = ZERO

The net force acting on an object must be ZERO.



DOWNWARD FORCE = UPWARD FORCE

Net force = zero

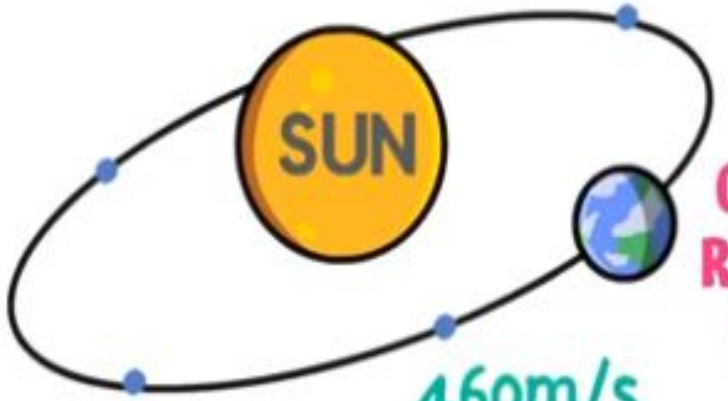
acceleration = zero

Translational and Rotaional Velocities exist, but not ZERO.

The net force acting on an object must be ZERO.

TRANSLATIONAL CONSTANT VELOCITY

40m/s 40m/s 40m/s



460m/s

CONSTANT ROTATIONAL VELOCITY

acceleration = zero

Net force = zero

acceleration = zero

Net force = zero

STABILITY

DEFINITION

Stability is the ability to maintain one's Balance in both static and dynamic situations without mechanical devices.

- **EQUILIBRIUM**

Equilibrium is a state of balance in which all forces are equal

- **STABILITY**

Stability is the resistance to disruption of equilibrium

- **BALANCE**

Balance is the ability to control equilibrium during changing body's position

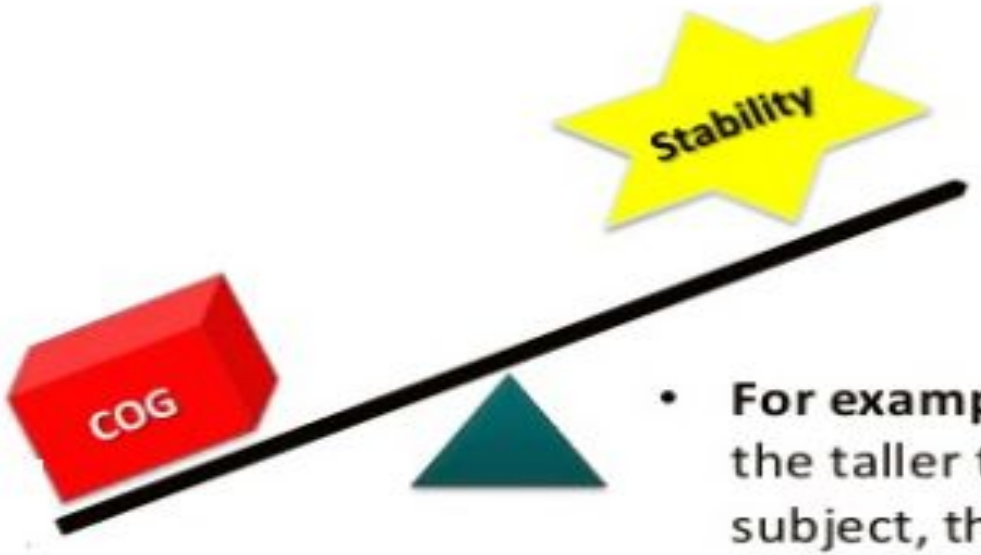
FACTORS AFFECTING STABILITY

1) COG height.
2) Base of support (BOS).
3) Relation of line of gravity to BOS.
4) Properties of the supporting surface.
5) Segmentation principle.
6) Subject vision and emotional state.

FACTORS AFFECTING STABILITY

1- COG HEIGHT:

While other things being equal,
the **lower** the **COG**, the **greater** will be the body's **Stability**.



- **For example:** the taller the subject, the less the stability.

FACTORS AFFECTING STABILITY

2- BASE OF SUPPORT (BOS):

1) *BOS is the area formed under the body by connecting with one continuous line all points in contact with the ground.*

2) BOS is the area between two feet during standing or the area of contact with the floor including two feet

Example: If a patient walks with sticks or crutches the BOS is the area between the crutches and the feet. Fig (C)

C

A

B

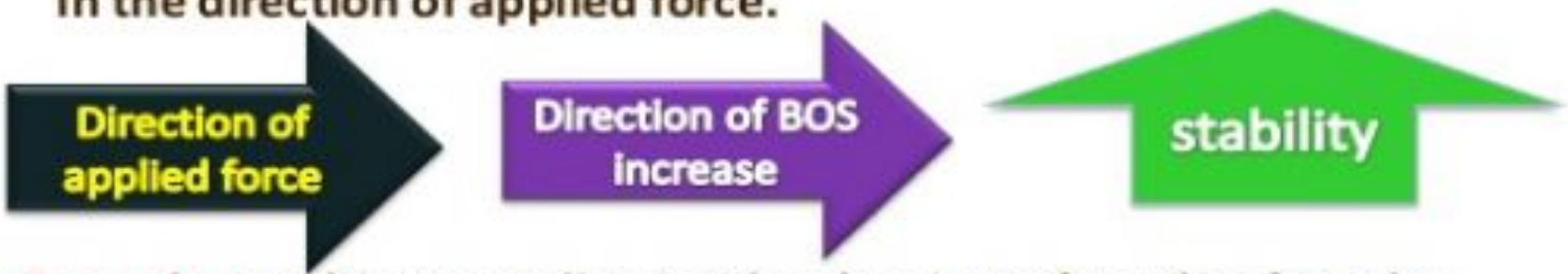
FACTORS AFFECTING STABILITY

BOS Considerations

1. An increase in the BOS will be associated with an increase in the stability.

BOS ↑ Stability ↑

2. An increase in the BOS should be in the direction of applied force. So, greater stability will be obtained if the BOS is widened in the direction of applied force.



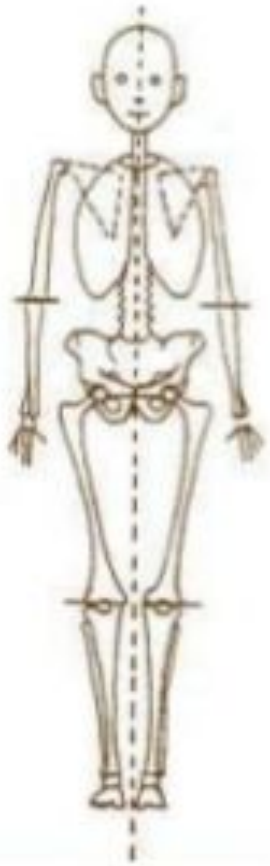
Example, a subject standing inside a bus is preferred to face the road or the front of the bus because when a force is applied by stoppage of the bus suddenly, it will be compensated by increasing the BOS forward (by taking step forward

FACTORS AFFECTING STABILITY

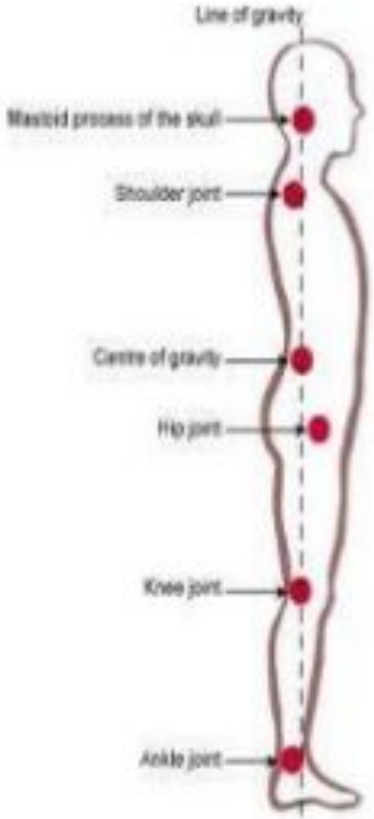
3- RELATION OF LINE OF GRAVITY TO BOS

- **Line of Gravity LOG:**

Line of gravity is a vertical line which falls through the COG and within the BOS. When the human body is in the standing position the line of gravity passes from the vertex through the 2nd sacral vertebra to just in front of the ankle joint and between the feet.



LOG



LOG

FACTORS AFFECTING STABILITY

- Line of gravity

For balance to be maintained, it is essential that the line from LOG should fall within the BOS.

The farer the line of gravity from the center of BOS, the lesser the stability.

The nearer the line of gravity to the center of BOS, the greater the stability.

FACTORS AFFECTING STABILITY

Examples

- In stride standing, LOG lies within BOS. If a subject stands on toes, the LOG will become near to edge of BOS so the stability will decrease so, any push to the subject will disturb standing easier than if LOG is in the middle of BOS.

Close standing Stride standing Standing on Toes

FACTORS AFFECTING STABILITY

4- PROPERITIES OF SUPPORTING SURFACE:

a) Friction:

- Other things being equal, the greater the friction between the supporting surface and the parts of the body which are in contact .with it, the more stable the body will be.

- But, this friction should increase up to certain limit then the friction will act as a disturbing factor limiting the movement.

FACTORS AFFECTING STABILITY

4- PROPERITIES OF SUPPORTING SURFACE:

Examples:

- Patients use crutches with rubber ends in order to increase
  stability via friction.
- Skating decreases stability unless the subject has coordination".
- Basket ball player wears rubber-soled shoes to increase
  friction between his body and the floor so increasing stability.

FACTORS AFFECTING STABILITY

4- PROPERITIES OF SUPPORTING SURFACE:

b- Softness of the supporting surface:

In lifting up exercises, more energy will be wasted in case of using soft mattress. So, hard mattress should be used to increase stability and to conserve energy of the patient.

c- Inclination of the supporting surface:

The inclination of the surface is the angle which the supporting surface makes in relation to the body movement. The greater the inclination, the less the stability.

FACTORS AFFECTING STABILITY

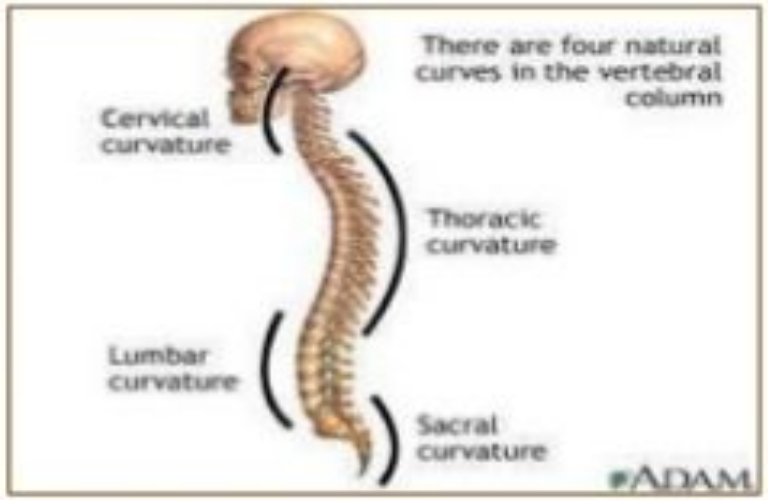
5-SEGMENTATION PRINCIPLE

- Segmentation principle stated that If there is deviation of a part of the body to certain direction, there is another compensator deviation of another part of the body to the opposite direction to maintain balance during this position".

FACTORS AFFECTING STABILITY

6-SEGMENTATION PRINCIPLE

For example: Any disturbance in the curvature of the spinal column will be compensated by movement of other segment that leads to change in the alignment of the vertebral column, i.e. cervical lordosis is compensated by dorsal kyphosis and lumbar lordosis is compensated by sacral kyphosis.



Another example: is obvious while holding an object in one direction, another deviation to the opposite side is necessary to gain stability.

FACTORS AFFECTING STABILITY

6- THE PERSON HIMSELF

a- Mass

b- Vision

c- Physical and Emotional State

d- Pain

e- Age

FACTORS AFFECTING STABILITY

6- THE PERSON HIMSELF

b- Vision:

Other things being equal, a person has a greater balance and stability in locomotion under difficult circumstances when he focuses his vision on a stationary object rather than on moving or disturbing stimuli.

FACTORS AFFECTING STABILITY

6- THE PERSON HIMSELF

c- Physical and Emotional State:

There is positive relationship between one's physical and emotional state and the ability to maintain balance under difficult circumstances.

For example; a diseased person is less stable than healthy one.

FACTORS AFFECTING STABILITY

6- THE PERSON HIMSELF

d- Pain:

Pain may decrease stability especially if the pain affects the lower extremities.

e- Age:

The person will be more stable in adulthood period than in childhood and the stability will also decrease in senile subjects due to the physiological changes occurring as a result of aging process.

- **Equilibrium** is a state of balance in which all forces are equal.

- **Stability** is the resistance to disruption of equilibrium.

- **Balance** is the ability to control equilibrium during changing body's position.

- **Factors Affecting stability**

1) COG height.
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Thank you