UNIT III

Muscular and Biomechanical Measurements

Analysis of EMG Waveform

- **Qualitative** – visual inspection (Size, shape and morphology of EMG signal
- **Quantitative** – Quantitative information about EmG signal
  - Amplitude of signal
  - Frequency response of the EMG
  - Time Duration
  - Power spectrum

Muscle Fatigue Characteristics

- decreased capacity to perform a maximum voluntary muscle action of a series of repetitive muscle action
- Decline in ability of muscle to generate force

Causes of Muscle fatigue

- Lactic acid – increase activity levels in muscle → muscle pain, soreness, fatigue, spasm & cramp
- Mineral deficiencies – minerals required for muscle function – deficiencies leads to muscle fatigue and cramps
- Failure to stretch or warm up
- Reduced activity – myasthenia gravis

Symptoms of muscle fatigue

- muscle weakness
- Localized pain
- Trembling/Shivering
- Weak grip
- Muscle cramps
- Shortness of breath
- Muscle twitching pain

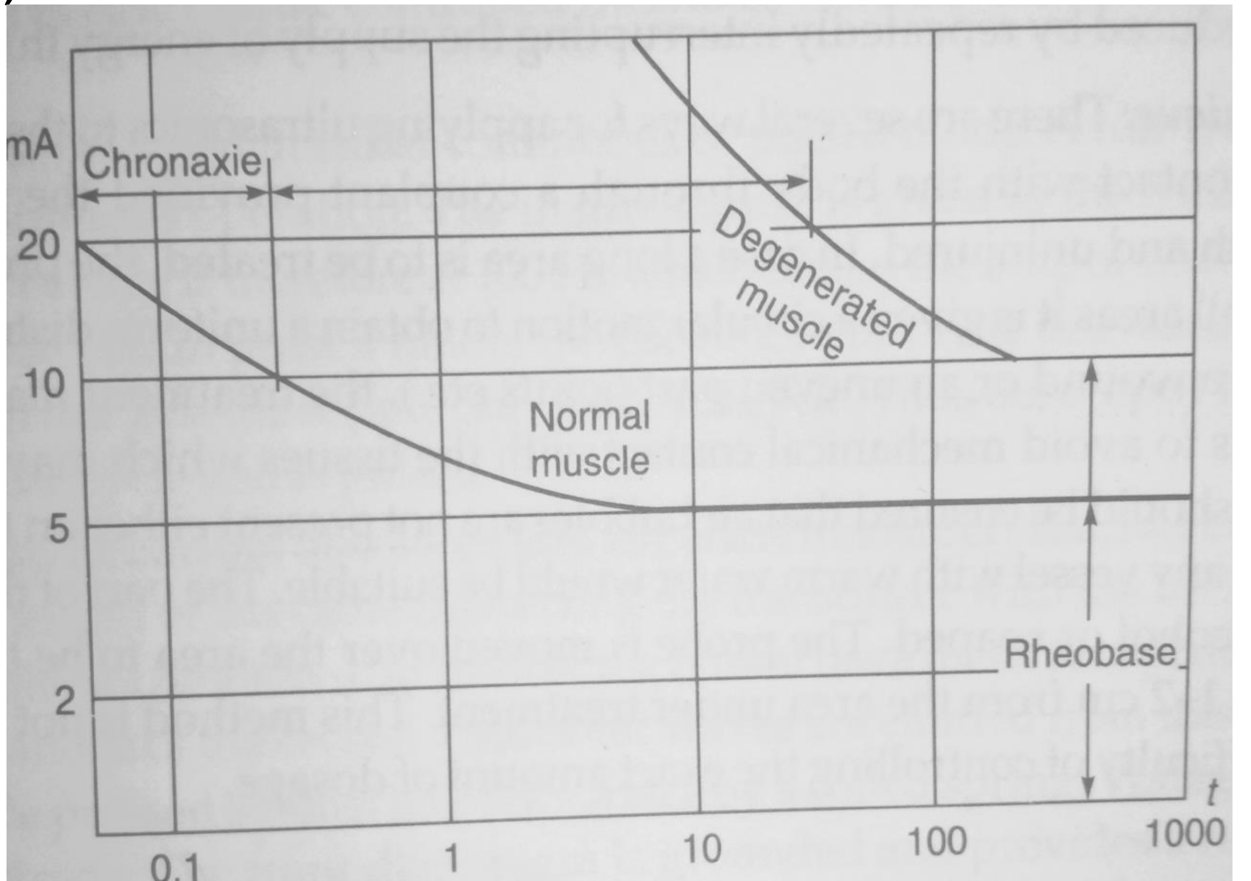
Treatment of muscle fatigue

- Warm up /cool down
- Cold & hot therapy
- Eat enough
- Professional massage

Muscle Stimulator

- Stimulator are device used to stimulate innervated muscle & nerve
- Used for the treatment of paralysis with totally or partially
- Used for the treatment of pain of muscle spasm
- This technique is called “ Electrotherapy”

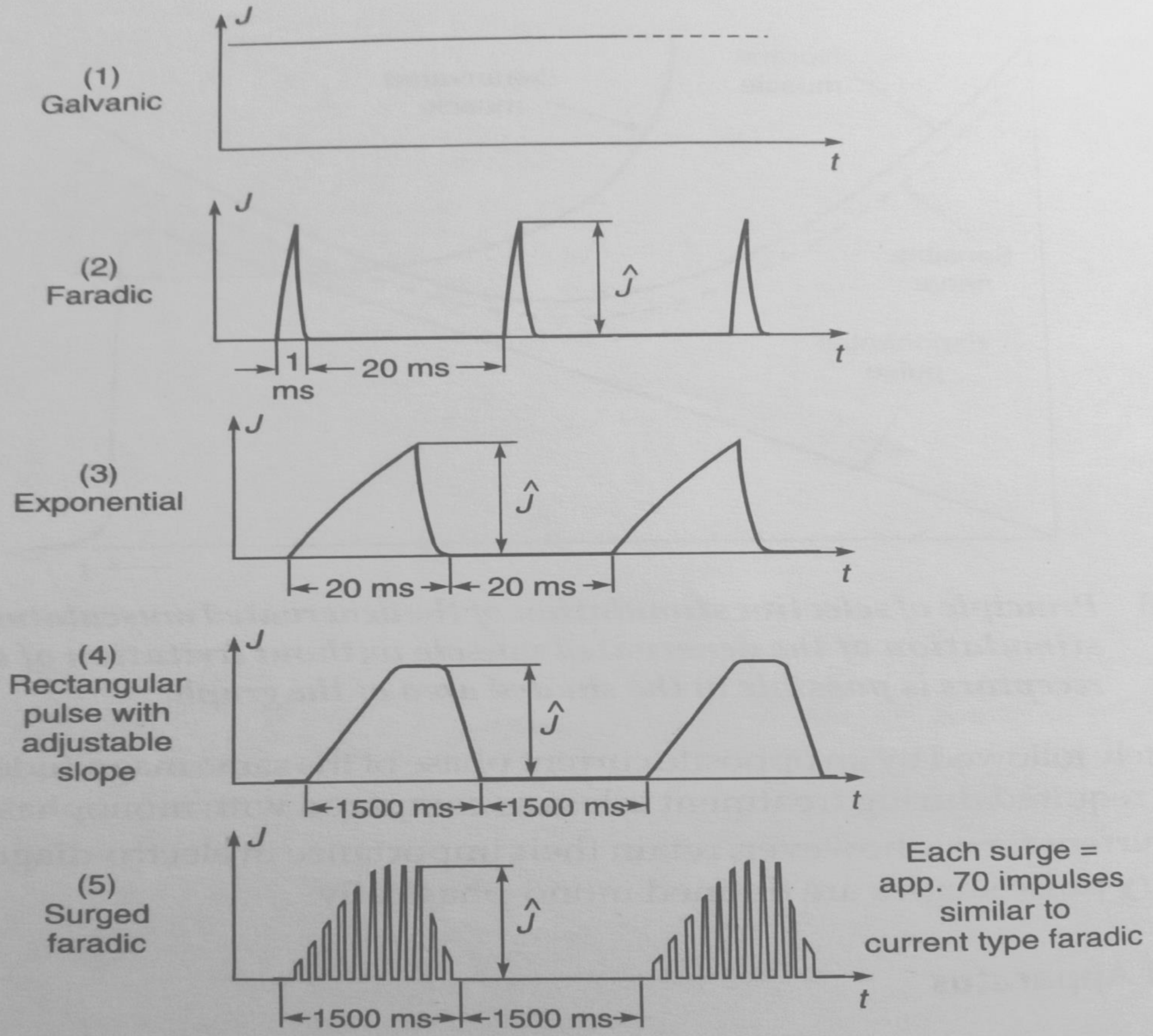
<u>Intensity Vs Time curve (I-T curve)</u>



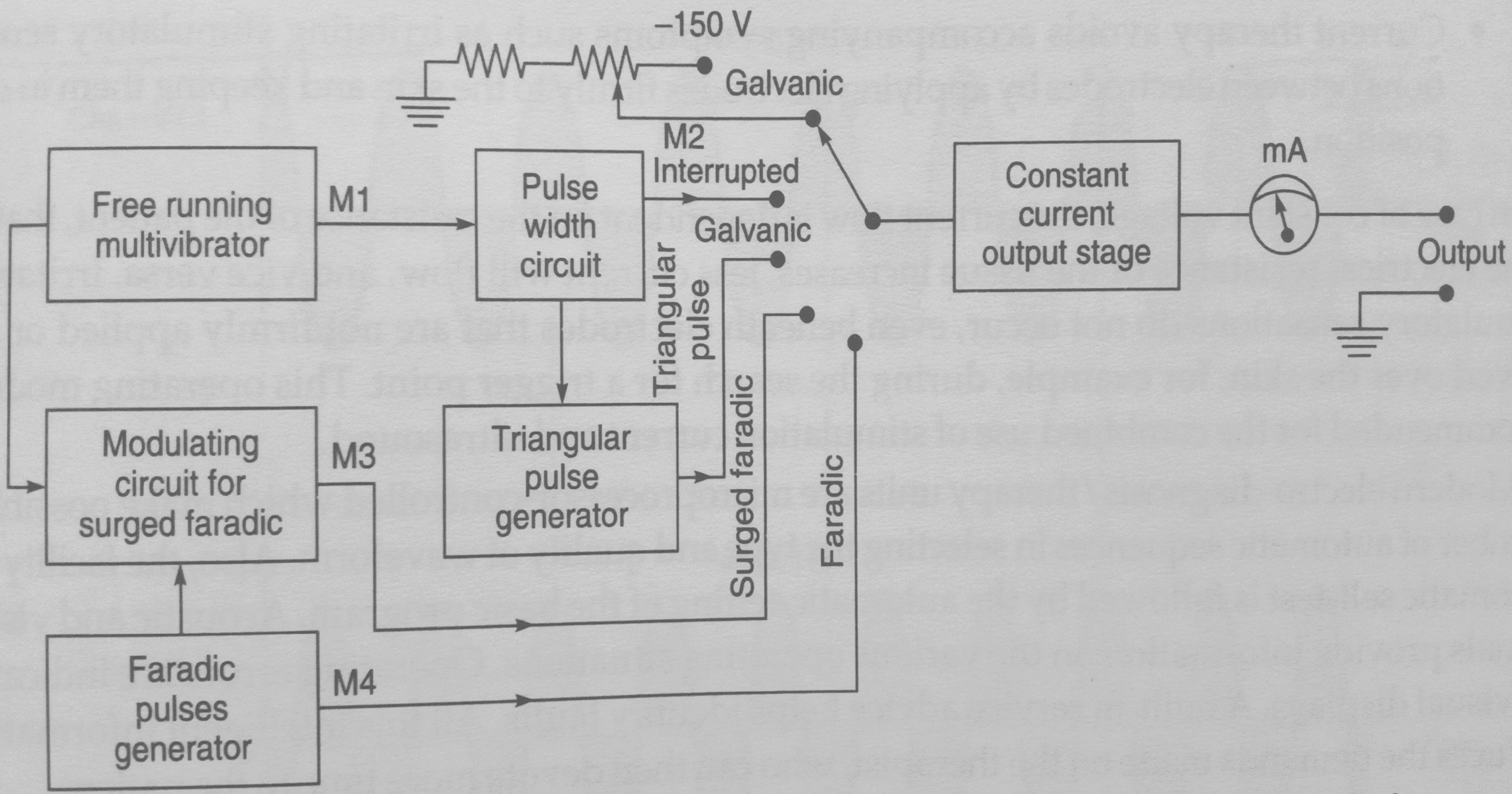
- Chronaxie and rheobase can be easily read from curves
  - Rheobase – minimum intensity of current that will produce a response if the stimulus is infinite
  - Chronaxie – minimum duration of impulse that will produce a response with a current of double rheobase

Types of current waveforms required for electrotherapy unit

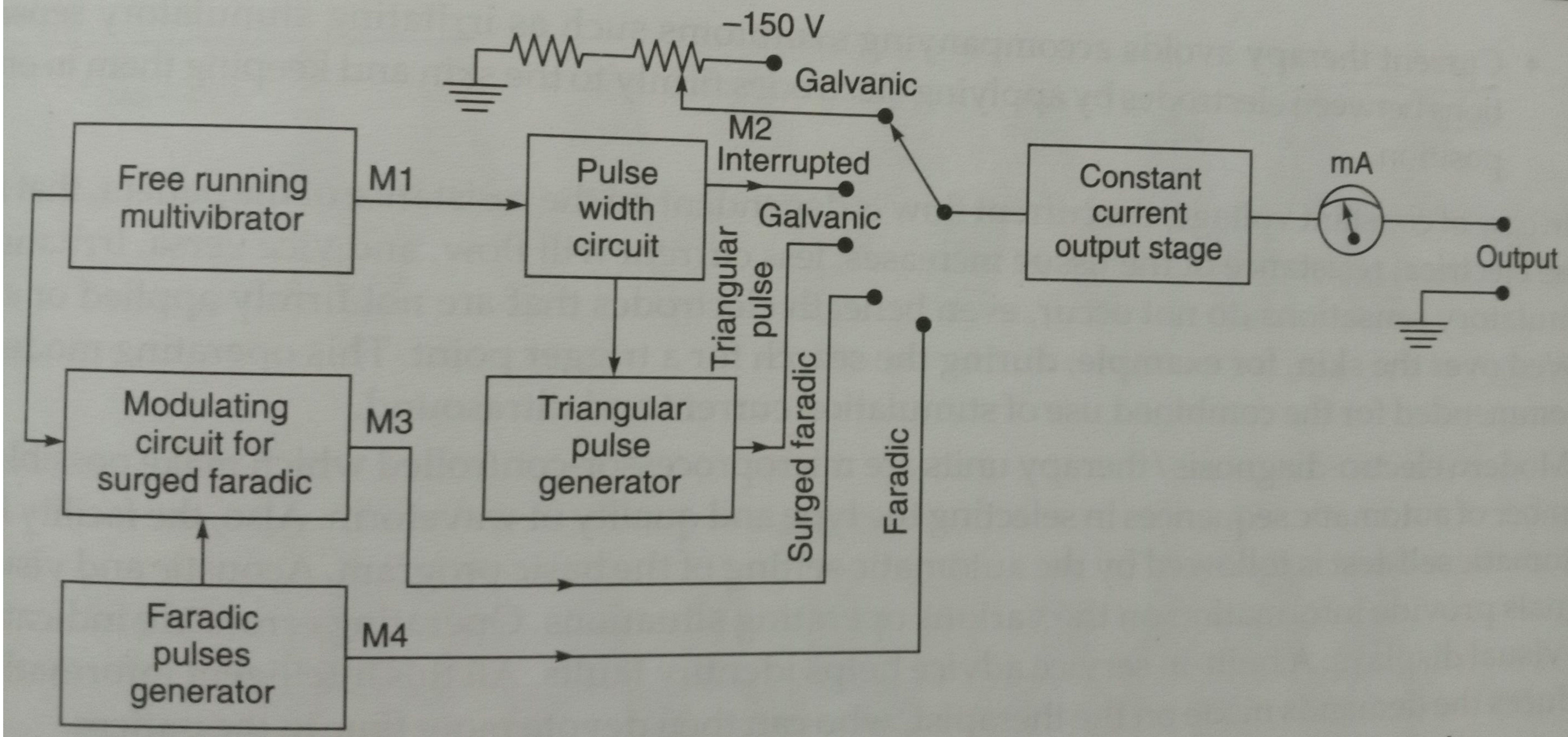
i) **Galvanic current** – constant flow of current
ii) **Faradic current** – sequence of pulses with defined shape & current intensity
iii) **Surged current** – current intensity is rapidly increasing and decreasing rhythmically
iv) **Exponential current** – exponentially varied current



29.9 ***Current waveforms normally employed in electrodiagnos*** ***electrotherapy***



➤ **Fig. 29.10** *Schematic diagram of a diagnostic/therapeutic stimulating unit*



➤ **Fig. 29.10** *Schematic diagram of a diagnostic/therapeutic stimulating unit*

Nerve stimulator (TENS)

- TENS – Transcutaneous Electrical Nerve Stimulator
- Method of non destructive, non invasive & effective way of relieving pain
- Uses electrical impulses to block the pathways of transmission of pain
- Components - Battery operated pulse generator, leads and electrodes

Pain Control Theory

- Gate Control theory : Electrically stimulating sensory nerve receptors, a gate mechanism is closed in a segment of the spinal cord, preventing pain carrying messages from reactive the brain & Blocking the perception
- Endorphin Release theory: Electrical impulse stimulate the production of endorphin and enkaphalins in the body. These natural, morphine – like substance block pain messages from reaching brain.

Two types of current waveform

- Square
- Spike wave

Square wave :

Current – 25mA

Time frequency – 0.1 to 1.0ms

Frequency – 20-200Hz

Voltage – 0 to 120 V

Spike wave :

Current – 75 mA

Time – 500 ms

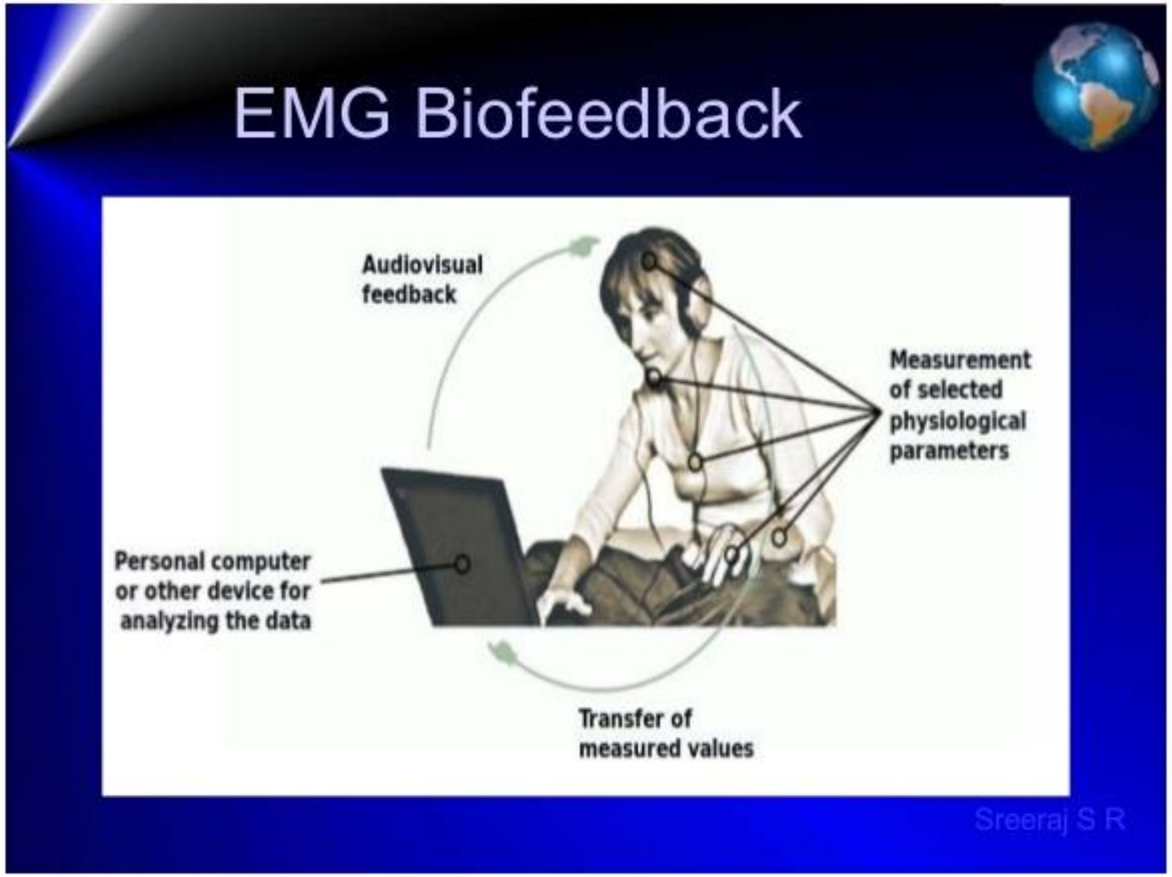
Frequency – 12 to 100 pulses per second

- (TENS) electrodes are commonly moulded from an elastomer such as silicon rubber, loaded with carbon particles to provide good conductance
- Conformability is achieved by making the electrode thin

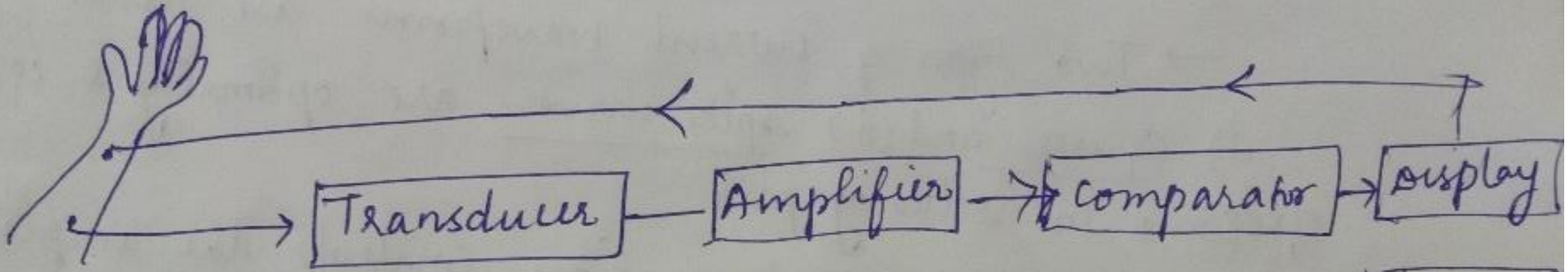
EMG BIOFEEDBACK INSTRUMENTATION

- Used in the treatment of bruxism.
- Paralytic patient are trained through biofeedback method to use paralysed muscle

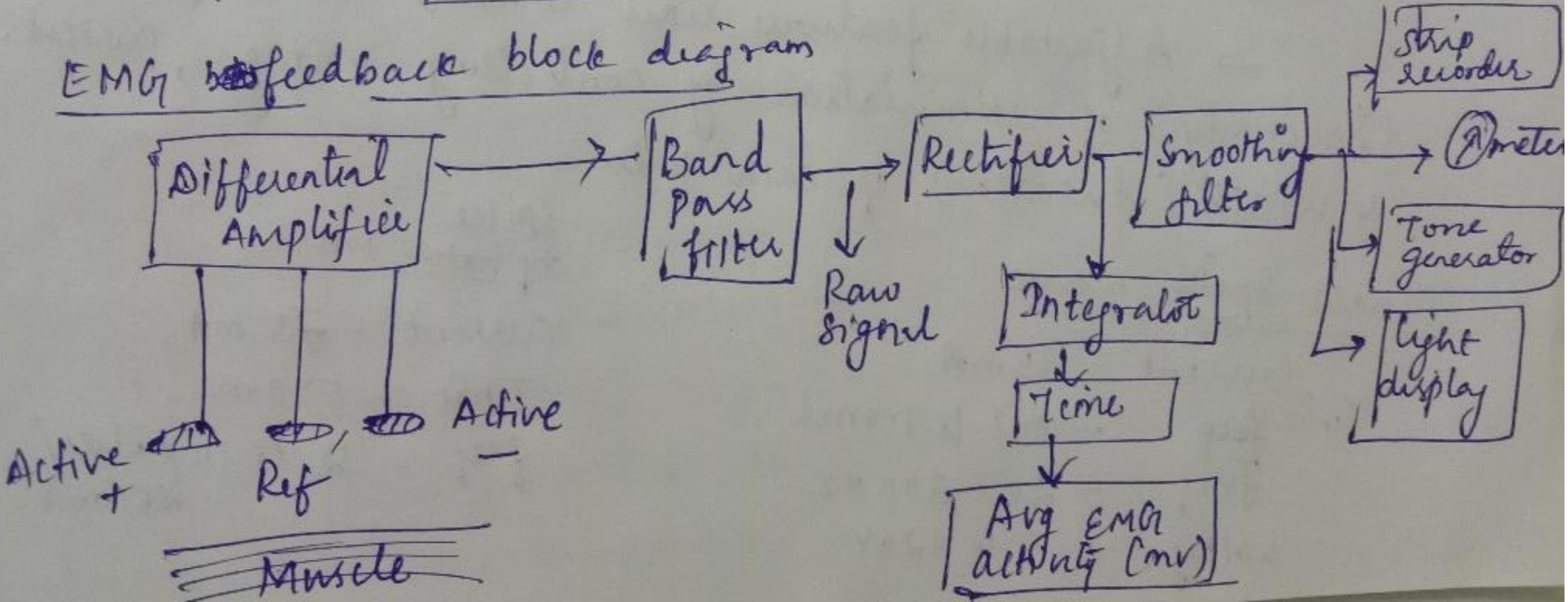
- EMG activity is measured via electroes
- EMG signal is amplified, compared and filtered out for noise
- Error signal is converted into more suitable visual or auditory signal



Basic principle of biofeedback instrumentation



EMG feedback block diagram



LOAD CELL

Introduction:

- Transducer that is used to convert a force/pressure into an electrical signal
- Electrical output is in the order of a few millivolts and requires amplification by an instrumentation amplifier for further use
- Load Cells are also called Load Transducer or Load Sensors
- Force is measured in terms of deflection or strain of elastic member (strain gauge type), increase in fluid pressure (hydraulic type).

Types of load cells

- Hydraulic load cells
- Pneumatic load cells
- Strain gauge load cells

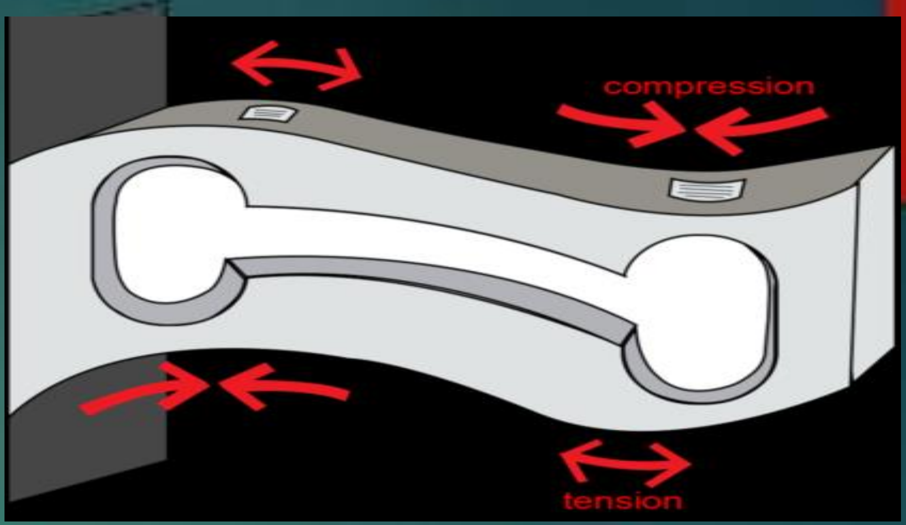
Working Principle:

- A load cell is made by bonding strain gauges to an elastic material.
- For accurate measurement, strain gauges are bonded to the position on the Elastic material where the impact of the stress will be the largest.
- The strain gauge utilizes this principle and detects a strain by changes in electrical resistance.

Advantages:

- Rugged and compact construction.
- No moving parts.
- Highly Accurate.
- Wide range of measurement, can be used for static and dynamic loading.

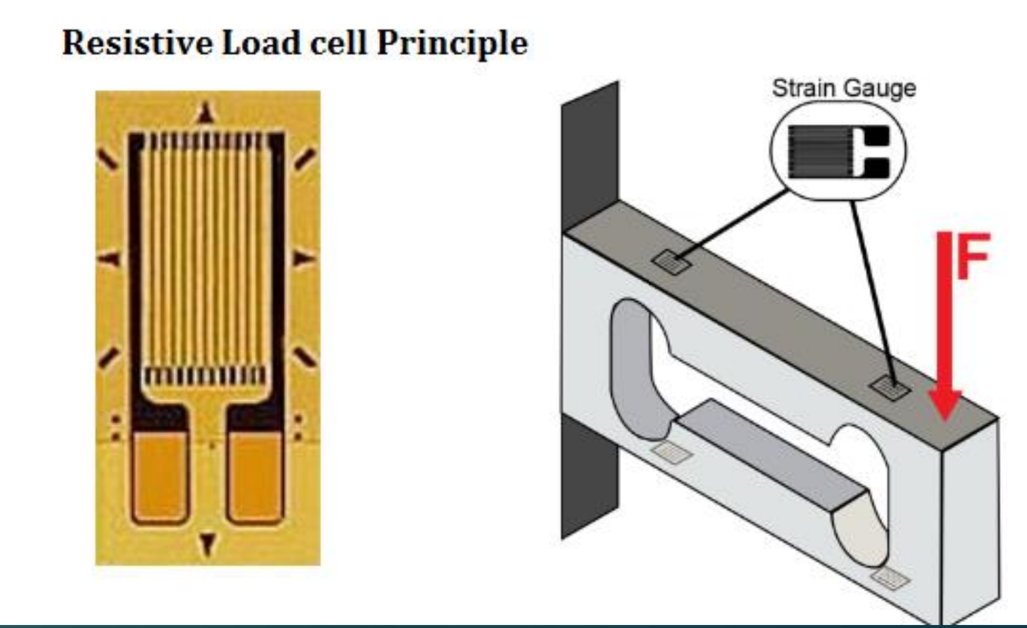
Resistive Load Cells



- The strain gauge measures the deformation (strain) as a change in electrical resistance, which is a measure of the strain and hence the applied forces
- **Working Principle**

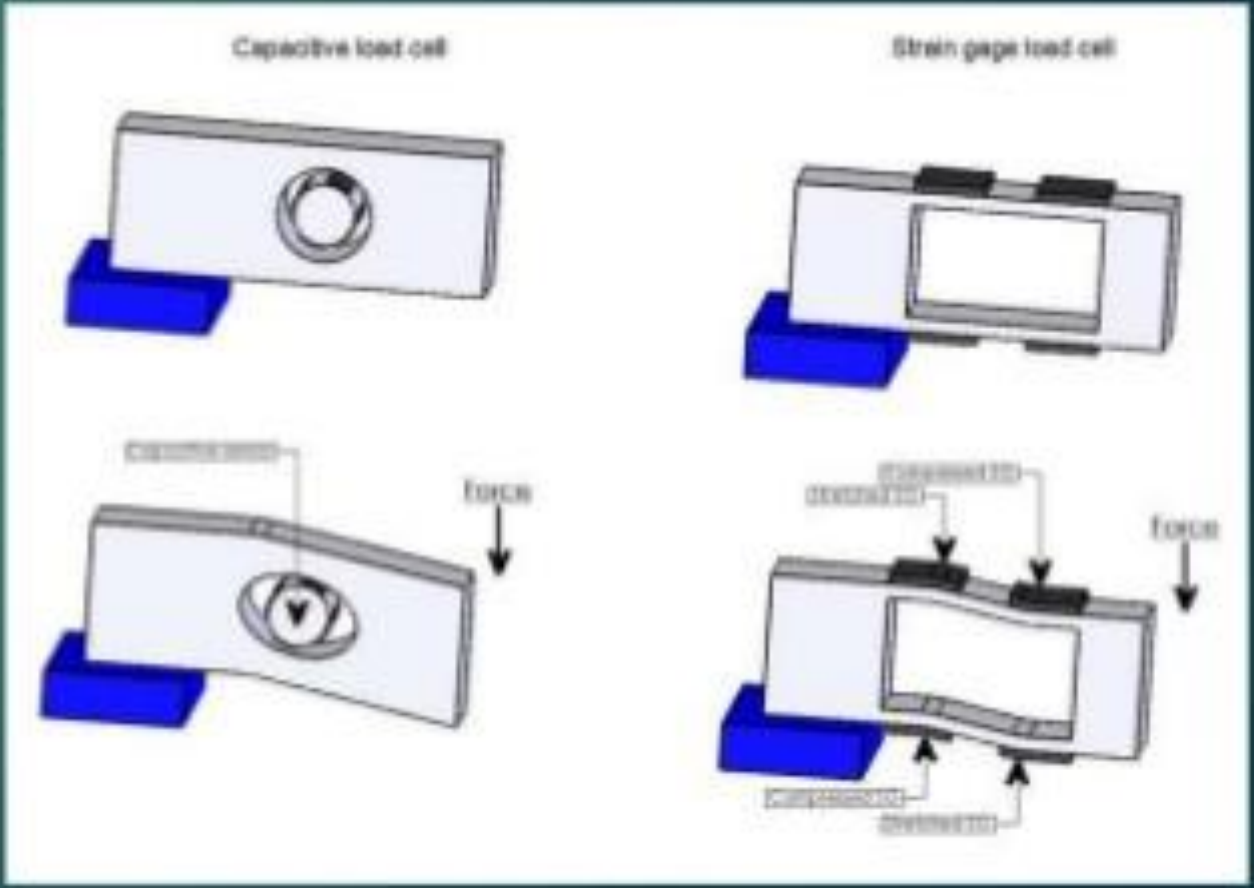
$$\frac{\Delta R}{R} = K \times \varepsilon$$

- Where
  R: Initial resistance of the strain gauge
- ΔR: Resistance change caused by elongation or contraction
- K: Proportional constant (called the "gauge factor")
- ε: Strain



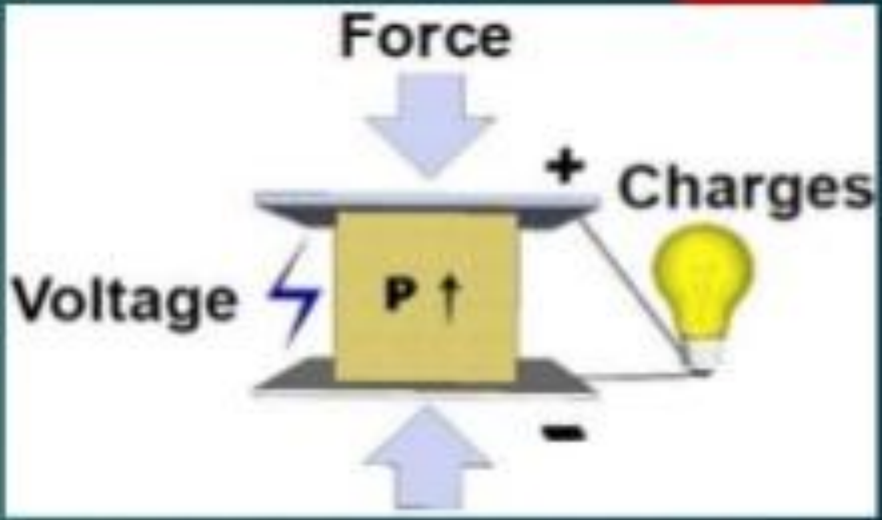
Capacitive Load Cell:

- Capacitive load cells measure the deformation of strain Gauge by their capacitance
- Working Principle:
- Capacitive load cells are built on the principal of a change in capacitance when a force is applied on the load cell



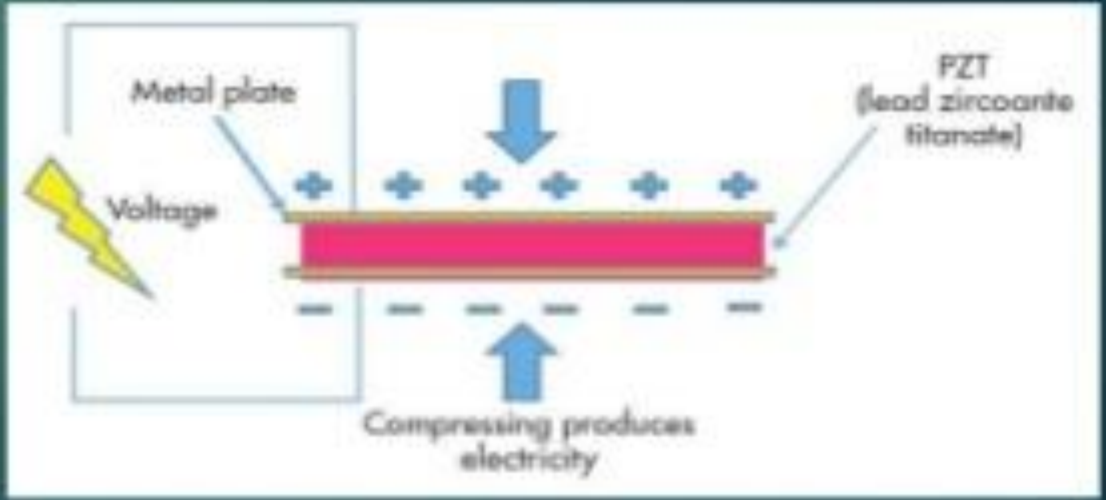
Piezoelectric Load Cell:

- A piezoelectric load cell converts an applied force into an electric charge by a piezoelectric ceramic or crystal. Piezoelectric load Cells consist of piezoelectric material.



Working:

When e force is applied to piezoelectric materials they Create Electric Voltage proportional to force



Piezoelectric Load Cell:

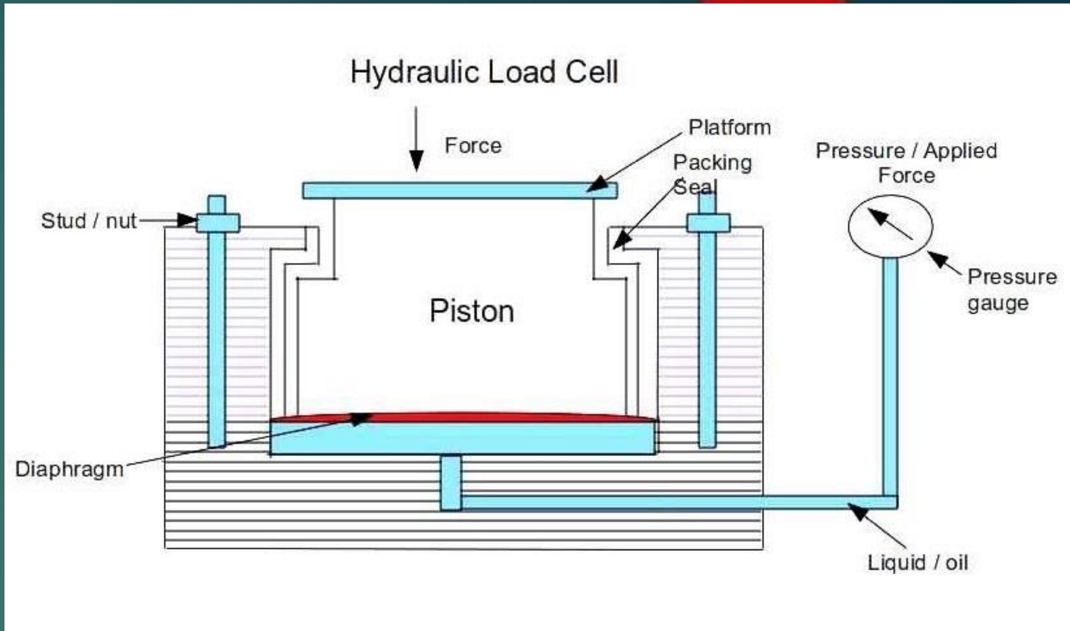
- **Advantages and Limitations:**

- **Advantages**
  - No need of external force.
  - Easy to handle and use as it has small dimensions.
  - High frequency response it means the parameters change very rapidly.
- **Limitations:**
  - It is not suitable for measurement in static condition.
  - It is affected by temperatures.
  - Output is low so some external circuit is attached to it.
  - It is very difficult to give desired shape to this material and also desired strength.

Hydraulic Load Cell:

Construction:

This particular type of load cell uses conventional piston and cylinder arrangement. The piston is placed in a thin elastic diaphragm. The piston doesn't actually come in contact with the load cell. The load cell is completely filled with oil.



Working principle:

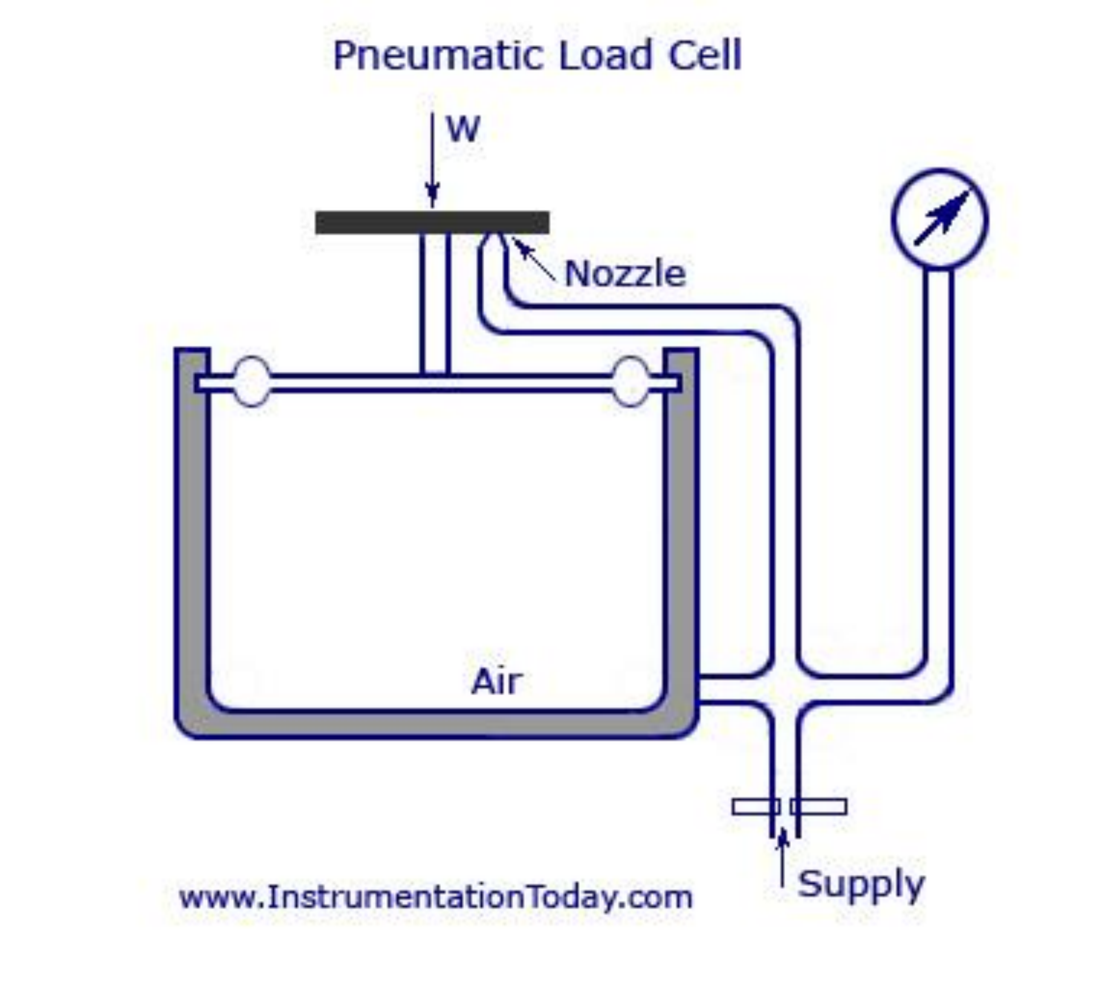
When the load is applied on the piston, the movement of the piston and the diaphragm results in an increase of oil pressure which in turn produces a change in the pressure on a Bourdon tube connected with the load cells.

Hydraulic Load Cell: Limitations:

- This technology is more expensive than other types of load cells. It is a more costly technology and thus cannot effectively compete on a cost of purchase basis

Pneumatic load cell:

- The Load cell is designed to automatically regulate the balancing pressure. Air pressure is applied to one end of the diaphragm and it escapes through the nozzle placed at the bottom of the load cell.



Working Principle:

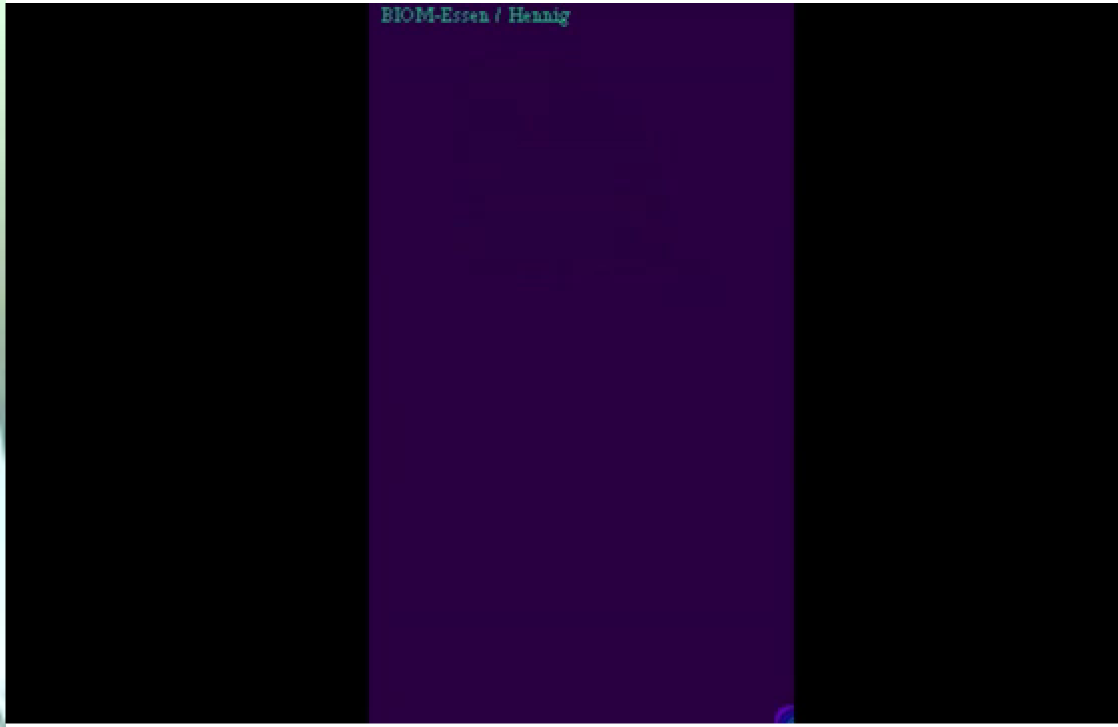
- The force is applied to one side of a diaphragm of flexible material and balanced by pneumatic pressure on the other side. The counter-acting pressure is proportional to force and is displayed on a pressure dial.

Pneumatic load cell: Advantages and Limitations:

- **Advantages:**
- The advantages of this type is that they are explosion proof.
- They are not sensitive to temperature variations.
- They contain no fluids like other type that might contaminate the process if diaphragm destroyed.
- **Limitations:**
- They are relatively slow speed of response.
- They need for clean, dry, regulated air or

Pedobargraph

- pedobarograph the instrument is used as a gait analysis tool that measures the pressure distribution on the bottom of the foot through all stages of the gait cycle.
- The optical pedobarograph uses digital video capture technology to record the pressure variations on the sole of the foot.
- The subject walks across the force plate fitted with an illuminated glass plate.
- As the foot hits the device, the glass surface deflects due to the force, causing the horizontal light beams to reflect downwards and be read by the video camera.
- The amount of light reflected is proportional to the pressure caused by the foot striking the plate.

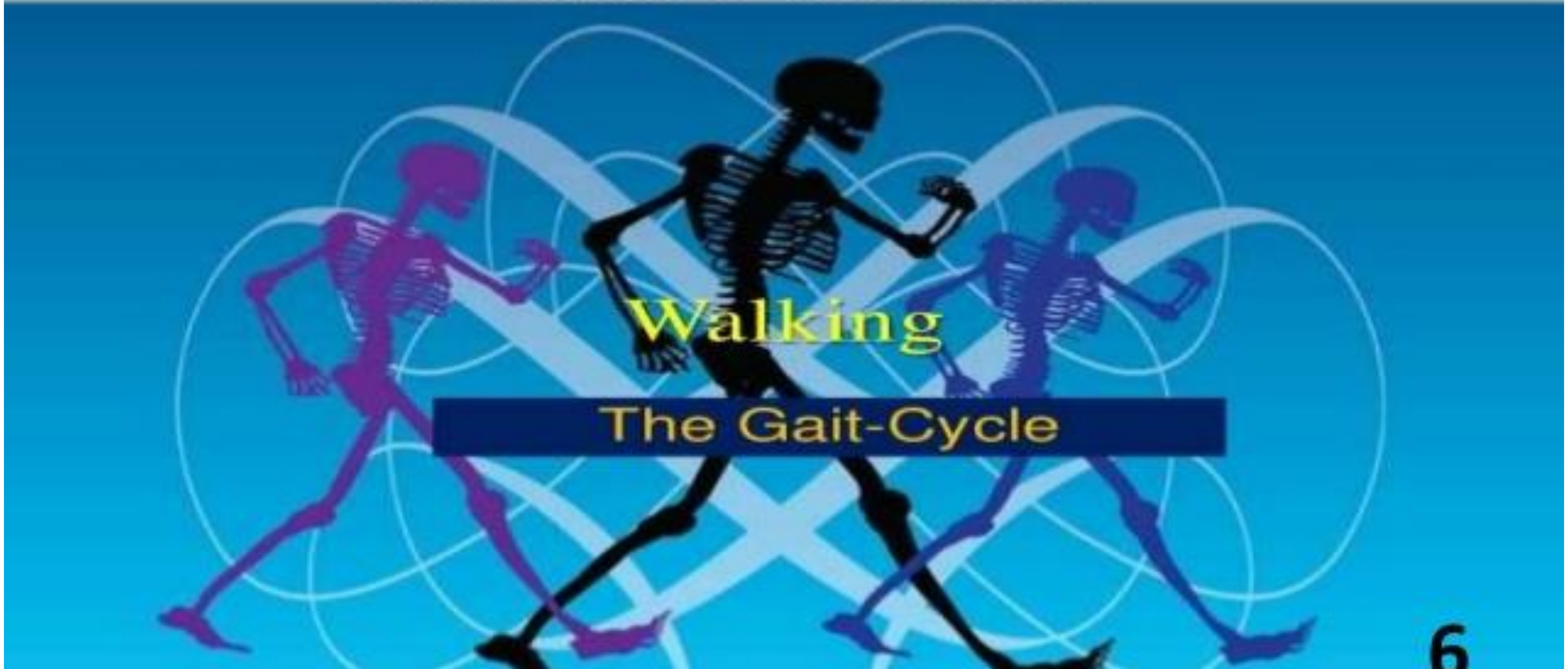

BIOM-Essen / Hennig

Gait

Normal Gait

Series of rhythmical , alternating movements of the trunk & limbs which result in the forward progression of the center of gravity...

- Gait is style , manner or a pattern of walking.
- Walking pattern may differ from individual to individual



Gait Cycle

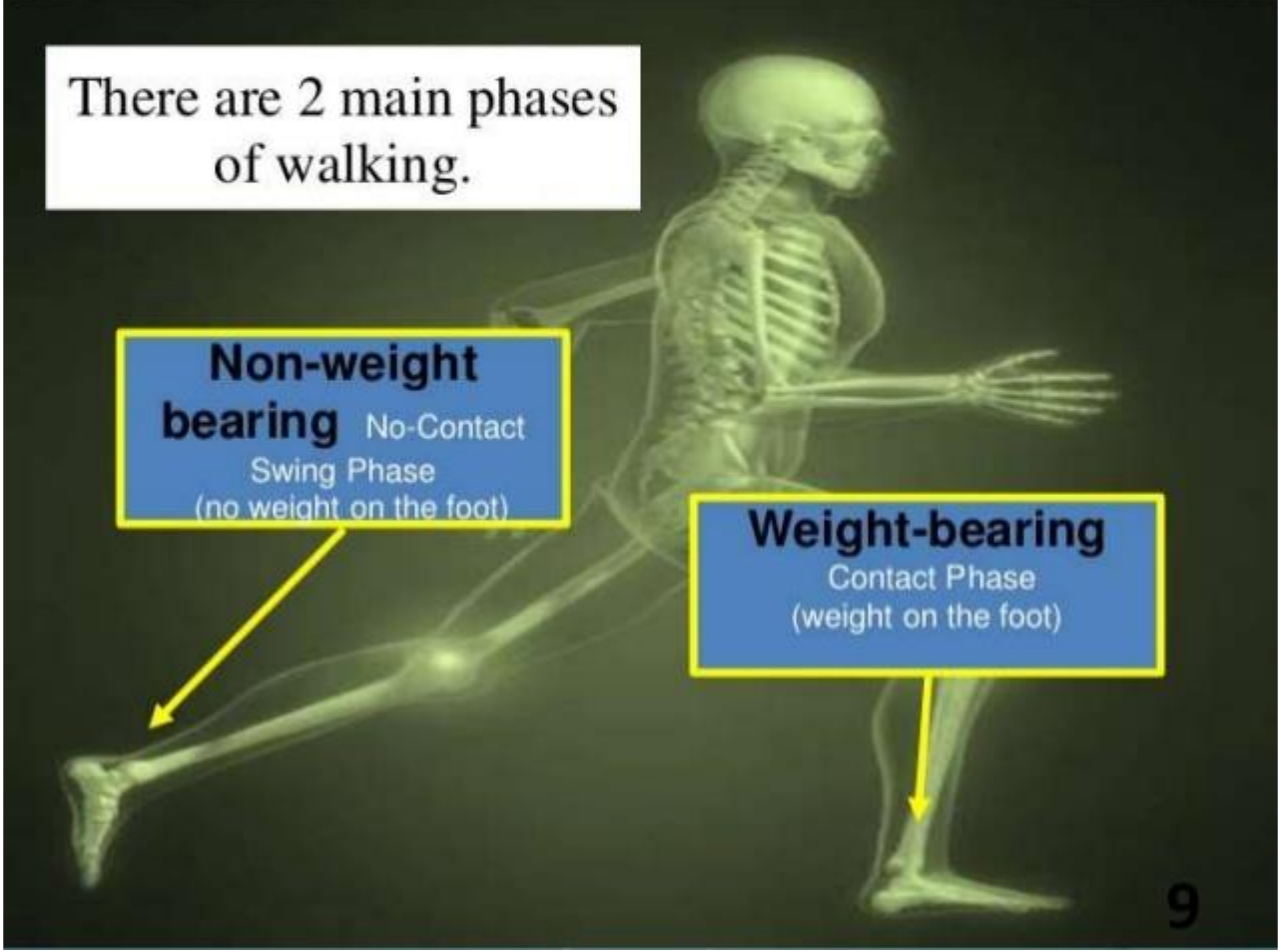
- Defined as the **period of time from one heel strike to the next heel strike of the same limb**

Gait Cycle

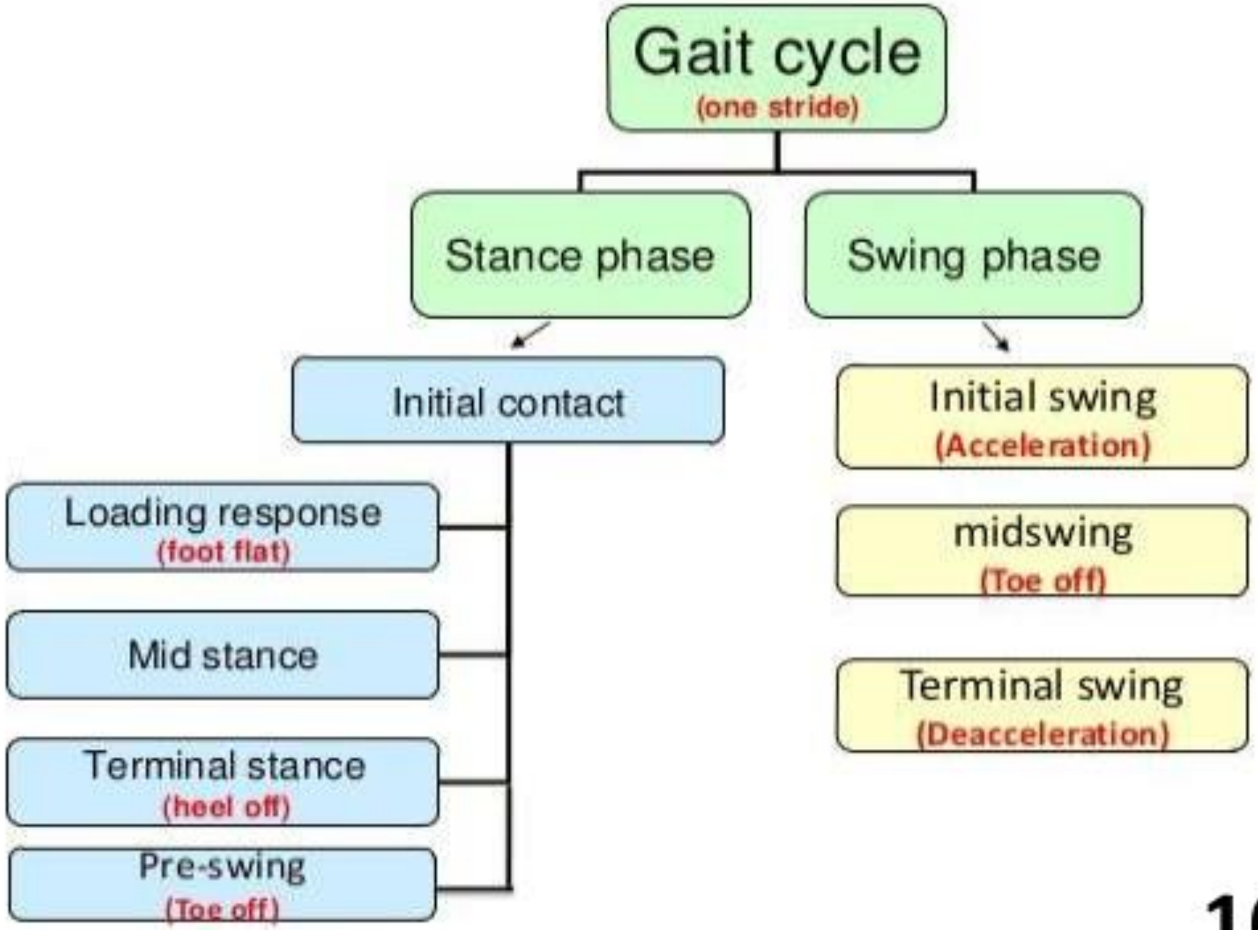
The gait cycle consists of two phases…

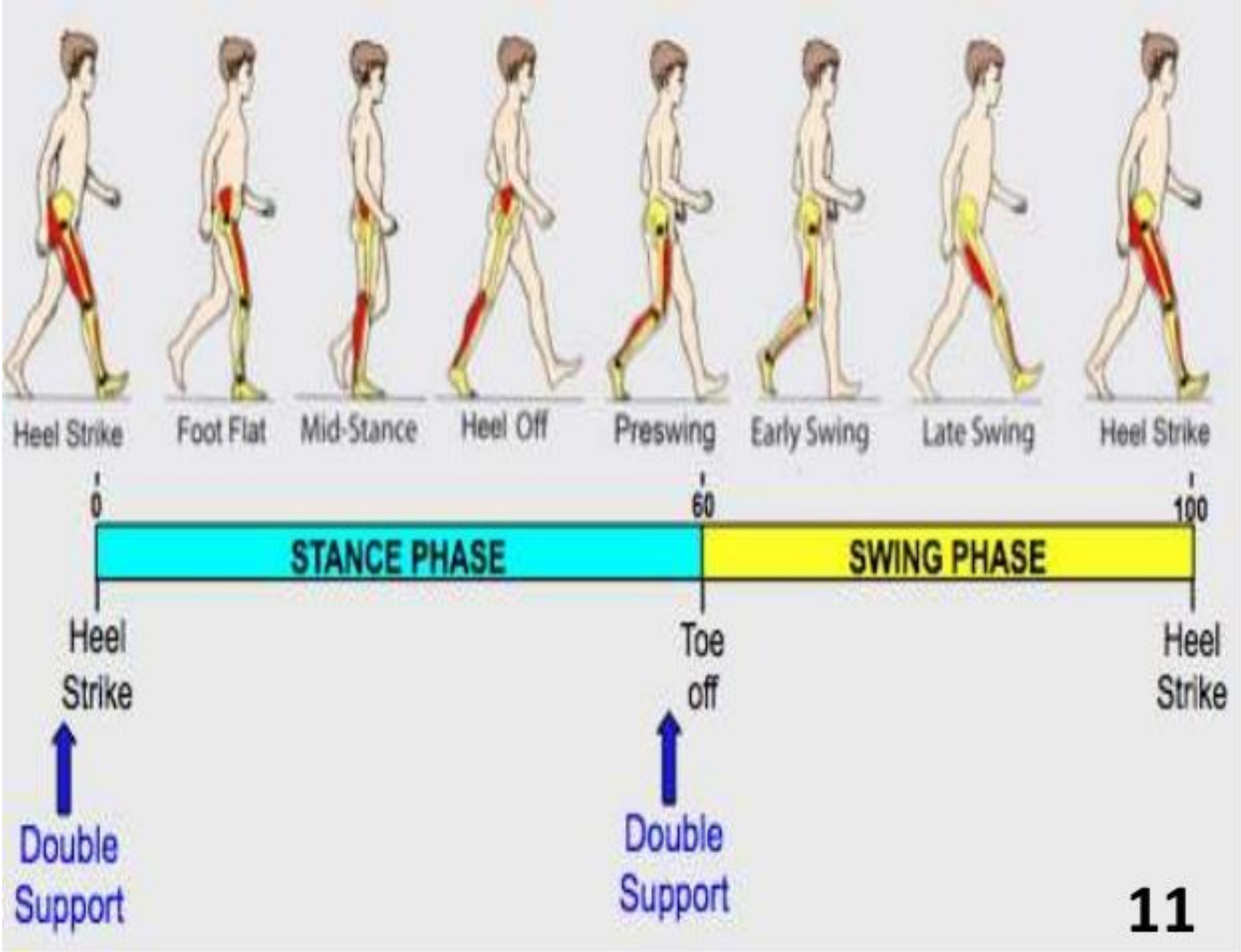
1) ***STANCE PHASE***

2) ***SWING PHASE***


There are 2 main phases of walking.
Non-weight bearing No-Contact
Swing Phase
(no weight on the foot)
Weight-bearing
Contact Phase
(weight on the foot)
9

PHASES OF GAIT CYCLE

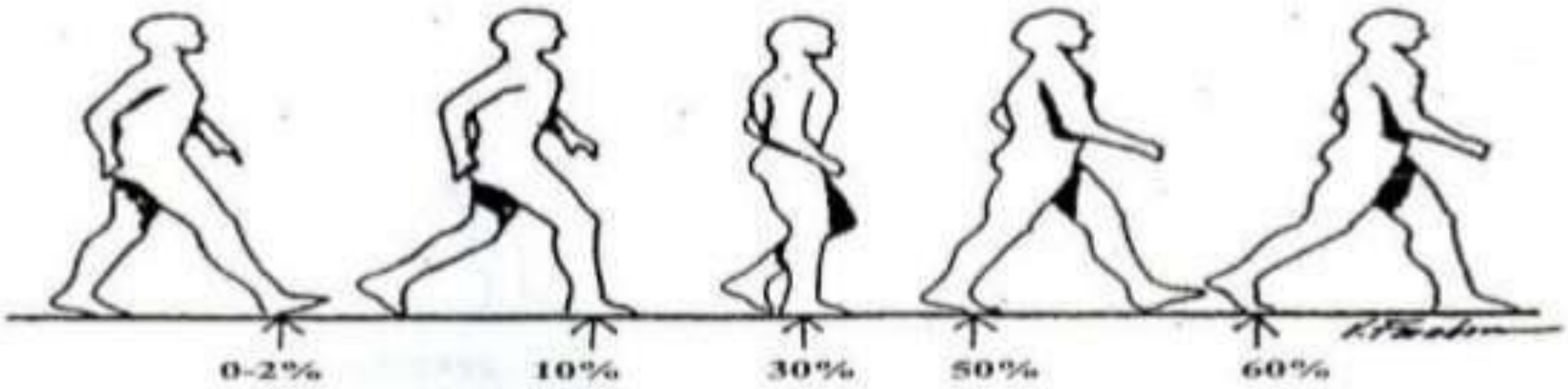



Heel Strike
Foot Flat
Mid-Stance
Heel Off
Preswing
Early Swing
Late Swing
Heel Strike
0
60
100
STANCE PHASE
SWING PHASE
Heel Strike
Toe off
Heel Strike
Double Support
Double Support

STANCE PHASE

- Begins when the heel of one leg strikes the ground and ends when the toe of the same leg lifts off.
- Constitutes approximately 60% of the gait cycle.

Gait Cycle - Subdivisions:



The five subphases of stance phase.

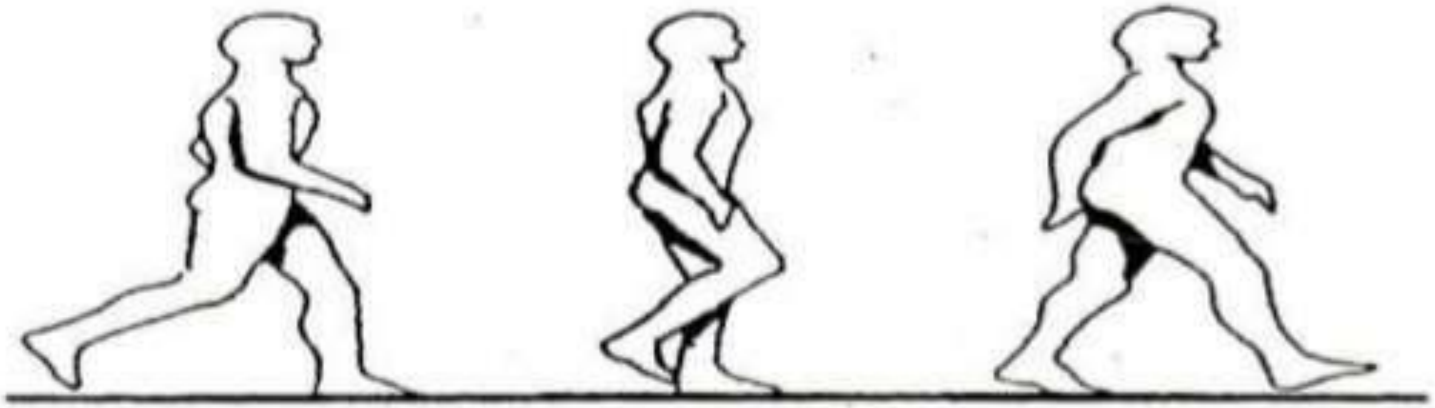
A. Stance phase:

1. **Heel contact**: 'Initial contact'
2. **Foot-flat**: 'Loading response', initial contact of forefoot w. ground
3. **Midstance**: greater trochanter in alignment w. vertical bisector of foot
4. **Heel-off**: 'Terminal stance'
5. **Toe-off**: 'Pre-swing'

SWING PHASE

- Swing phase represents the period between a toe off on one foot ad heel contact on the same foot.
- Constitutes approximately 40% of the gait cycle.

Gait Cycle - Subdivisions:



The three subphases of swing phase.

B. Swing phase:

1. **Acceleration**: 'Initial swing'
2. **Midswing**: Swinging limb overtakes the limb in stance
3. **Deceleration**: 'Terminal swing'

GAIT TERMINOLOGIES

- Time and distances are two basic parameters of motion.

1. **Temporal (Time) variables**
2. **Distance (Spatial) variables**

TEMPORAL VARIABLES

1. Single limb support time
2. Double support time
3. Cadence
4. Speed

Single Limb Support Time

Amount of time that spent during the period when only one extremity is on the supporting surface is a gait cycle.

Double Support Time

Amount of the time spent with both feet on the ground during one gait cycle.

- The time of double support may be increased in elder patients and in those having balance disorders
- The time of double support decreases when speed of walking increases

Cadence =

- Number of steps per unit time
- Normal: 100 – 115 **steps/min**
- Cultural/social variations

Speed (Velocity)=

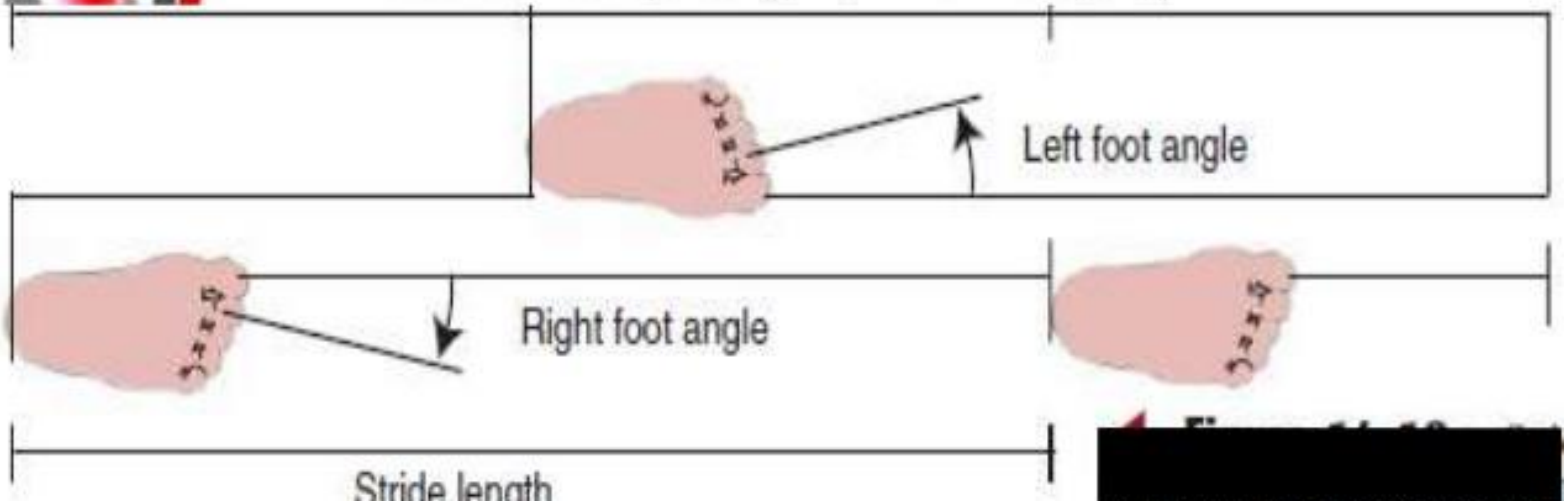
- **Distance covered by the body in unit time**
- **Usually measured in m/s**
- **Instantaneous velocity varies during the gait cycle**
- **Average velocity (m/min) = step length (m) x cadence (steps/min). Average walking speed= 80m/minute.**

Distance Variables

1. Stride length
2. Step length
3. Degree of toe out

Stride length

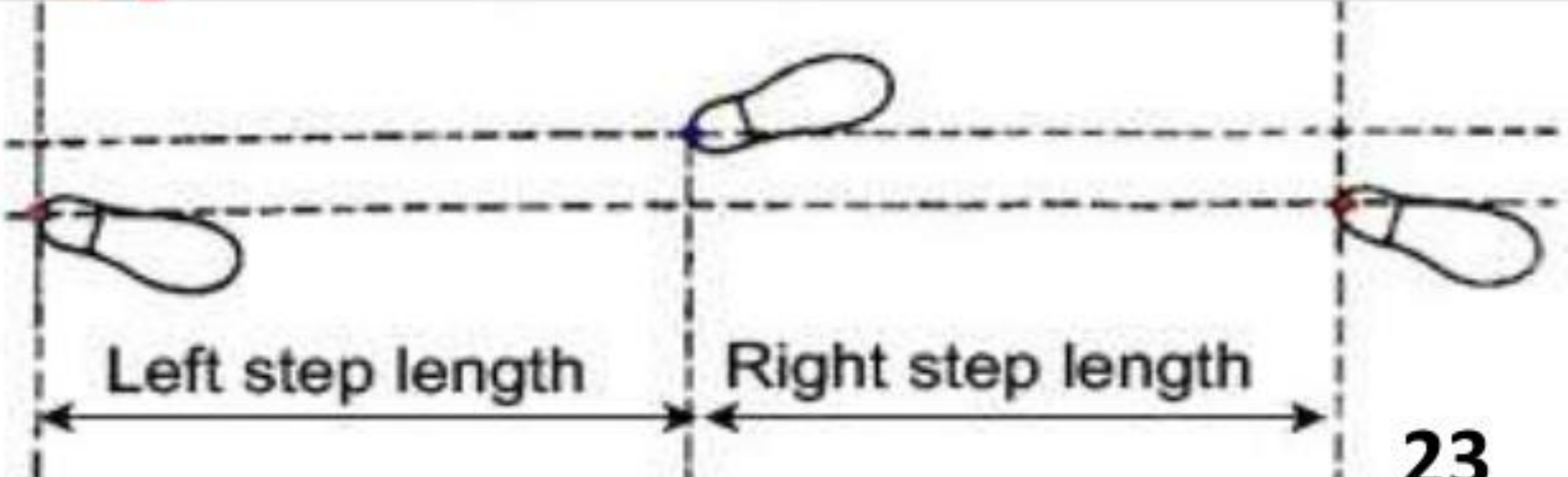
- Distance between successive points of heel contact of the **same foot**
- Double the step length (in normal gait)



[redacted]

Step length

- Distance between corresponding successive **points of heel contact of the opposite feet.**
- Rt step length = Lt step length (in normal gait).



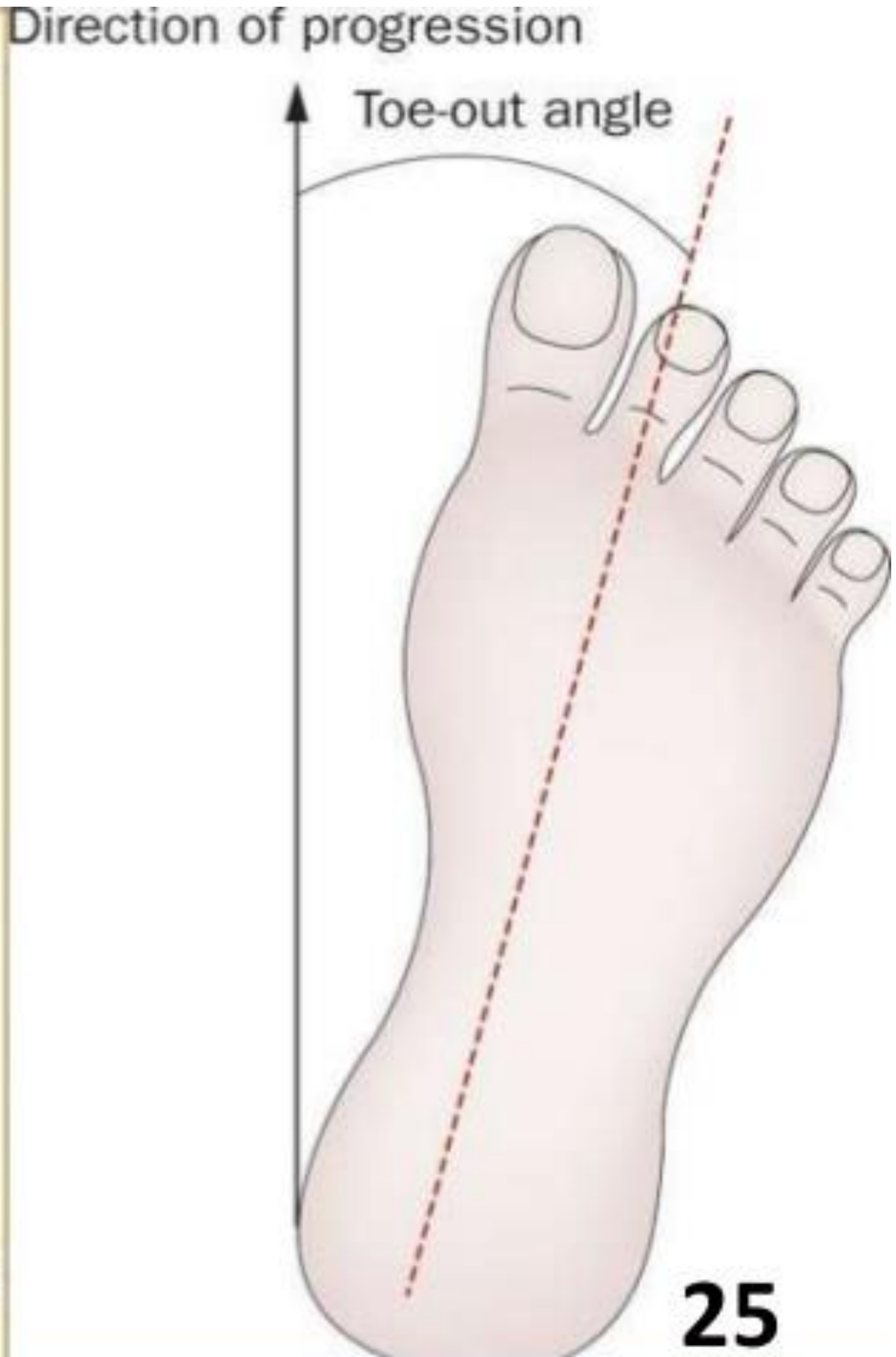
Degree of toe out

It represents the angle of foot placement and may be found by measuring the angle formed by each foot's line of progression and a line intersecting the center of heel and second toe.

The angle for men is about 7 degree.

the degree of toe out decreases as the speed of walking increases in normal men.


Line of
Progression
Foot Angle
θ
C
A
B


Direction of progression
Toe-out angle