Basics of kinetics

Kinesiology
RHS 341
Lecture **7**
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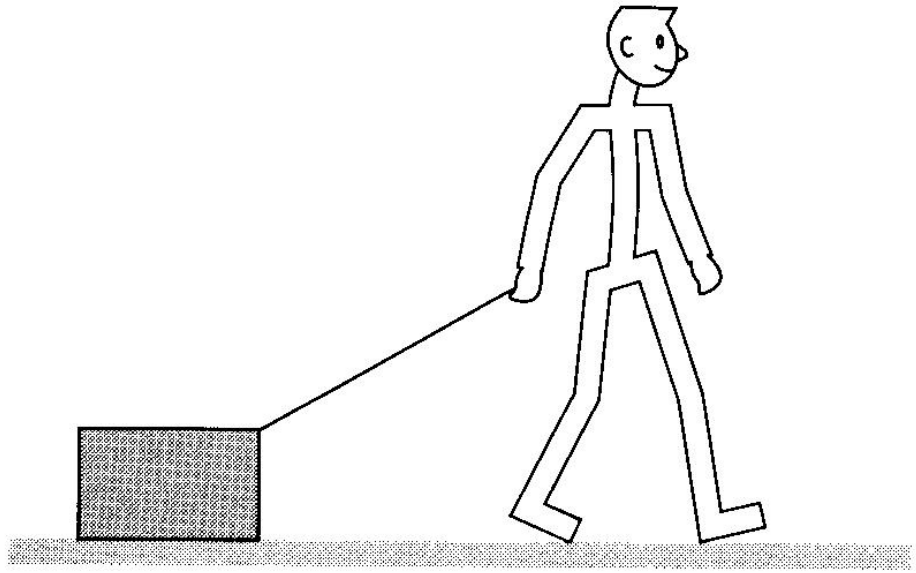
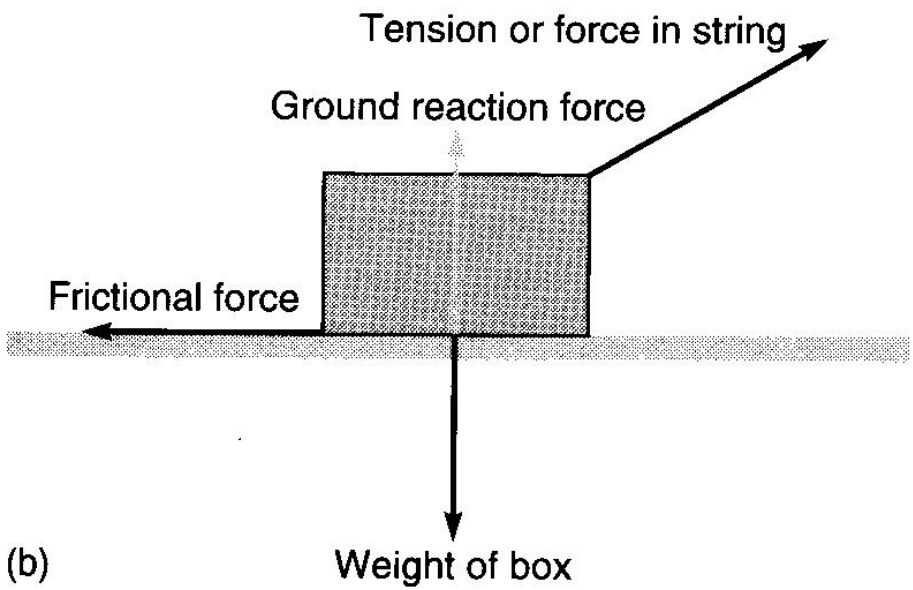
Mass	Weight
The amount of matter in an object	A force, which depends on the mass and acceleration

Free-body analysis

- A technique of looking and simplifying a problem



(a)


Tension or force in string
Ground reaction force
Frictional force
Weight of box

(b)

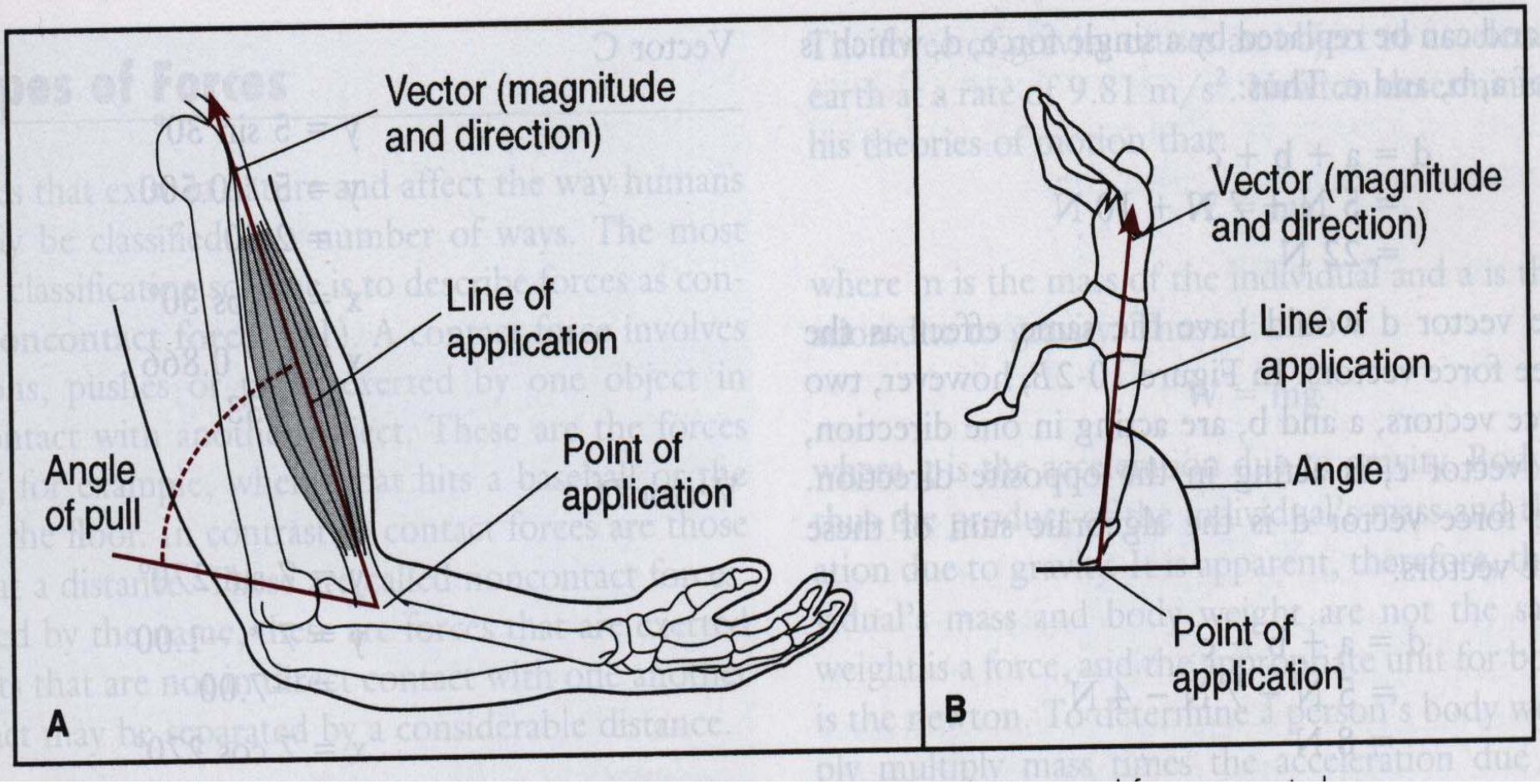
Resolution of forces

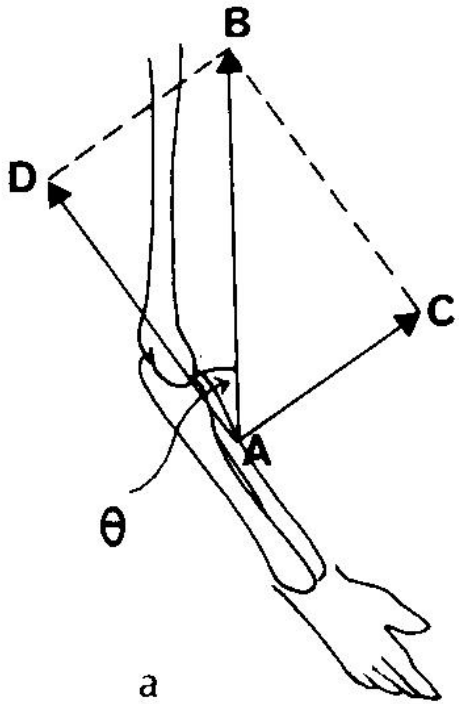
- = The process of replacing a single force by two or more equivalent force components
- Enables a wider appreciation of the effects of any force
- Useful in determining the effectiveness of a particular muscle force in moving a body segment

Angle of pull (of a muscle)

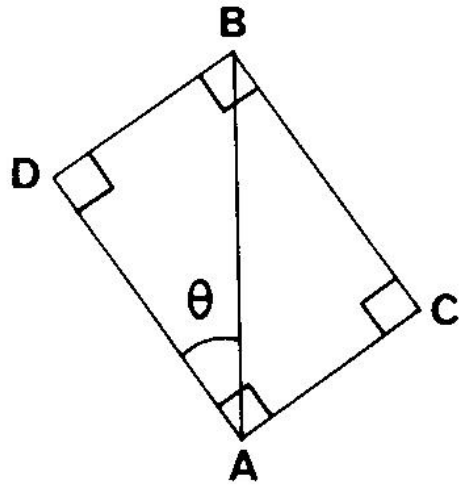
- = the angle between the line of pull of the muscle (action line) and the mechanical axis of the bone or segment involved

- Mechanical axis of a bone = a straight line connecting the midpoints of the joints at both ends of the bone


Vector (magnitude and direction)
Line of application
Point of application
Angle of pull
A
Vector (magnitude and direction)
Line of application
Angle
Point of application
B



a



b

Resolution of forces

AB: muscle force

AC: rotatory component

AD: stabilizing component

ɵ : angle of pull

Muscle force

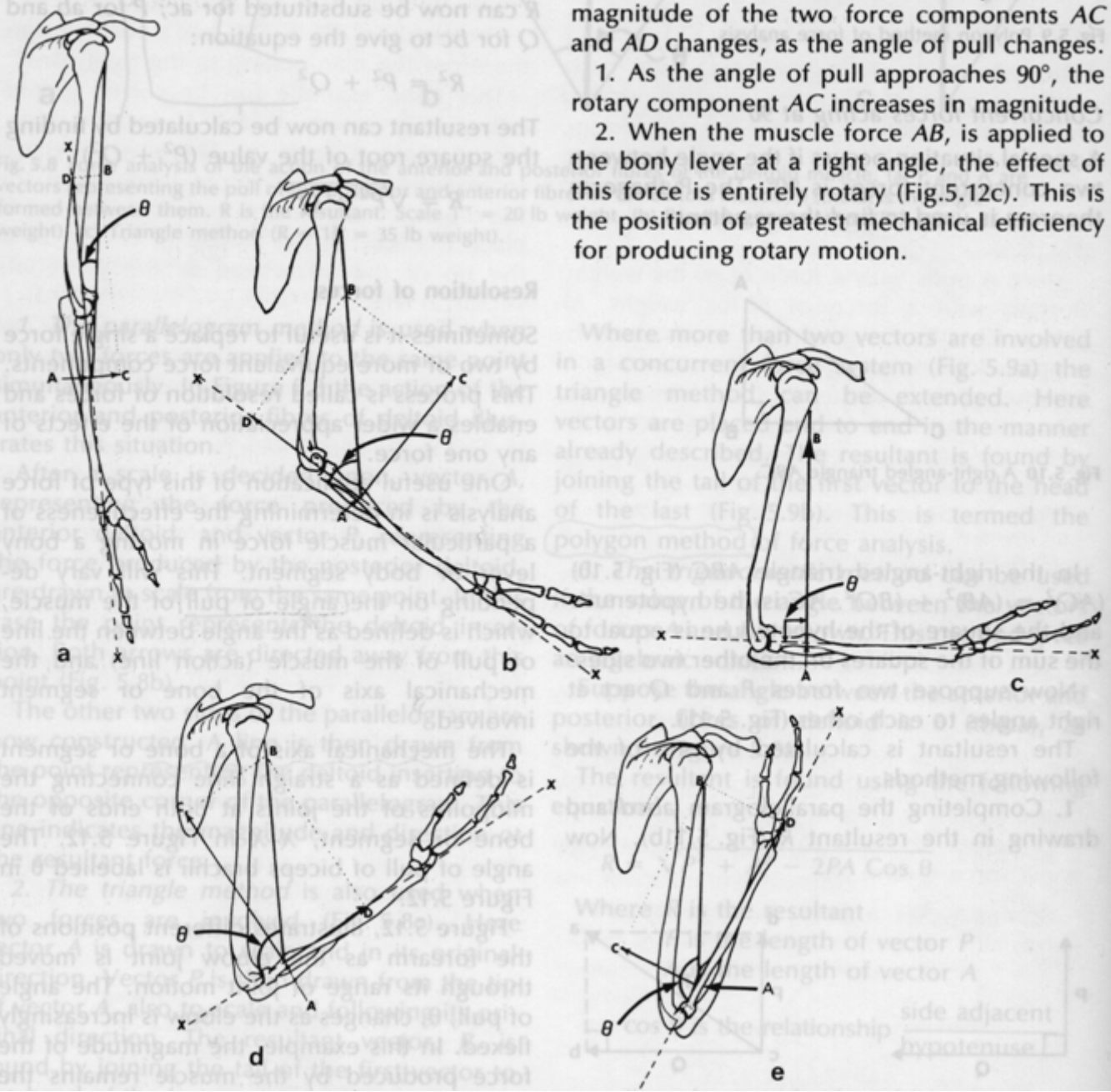
- **Rotatory component** = the force that tries to turn the body segment around the proximal joint

- **Stabilizing component** = the force that acts along the body segment forcing into, or pulling out of the joint

When joint movement takes place, the magnitude of the two force components *AC* and *AD* changes, as the angle of pull changes.

1. As the angle of pull approaches 90°, the rotary component *AC* increases in magnitude.

2. When the muscle force *AB*, is applied to the bony lever at a right angle, the effect of this force is entirely rotary (Fig.5.12c). This is the position of greatest mechanical efficiency for producing rotary motion.



Resolution of forces Example

- When the joint movement takes place, as the angle of the pull changes, the magnitude of the two components AC and AD also change:

1. As the angle approaches 90^{o}, the rotatory component AC increase in magnitude

Resolution of forces Example

2. When the angle of pull is $90^{o,}$ the effect of the force AB is entirely rotatory (the position of greatest **mechanical efficiency** for producing rotatory motion)

3. At small angles of pull, the mechanical efficiency of the muscle is low because of its large stabilizing component AD

Work

- Mechanical work is said to be done when a force (e.g., muscle contraction) is used to move a load through a distance

- **W = F D**

W: work

F: force

D: distance through which the load is move

Units: Joule (J = Nm)

Work

- **Positive work**: when muscles actively shorten (concentric contraction) to move an external load

- **Negative work**: when muscles are actively lengthening (eccentric contraction), work is being done on them by an external force (e.g., gravity) to produce movement

Work

- Isometric contraction 

  no movement 

  no mechanical work is done

Power

- = the rate of doing work

- The *work* capacity of a muscle relates to:
  1. the muscle **force** (tension) it can generate
  2. the **distance** through which it can be actively shortened

Power

- Muscle power is the rate at which work can be done by a muscle

- **Not** to be confused with muscle strength (which is the amount force the muscle can actively produce)

Power

- Power = $\frac{\text{work (F D)}}{\text{time (t)}}$

- Muscle power = $\frac{\text{work done by muscle}}{\text{time}}$

- Units: watts (J/s)

Power

- Power is a combination of force and velocity

- P = F V

P: power

F: force applied

V: velocity of the force application

- Relevant to many sports such as weightlifting, boxing, and batting in baseball

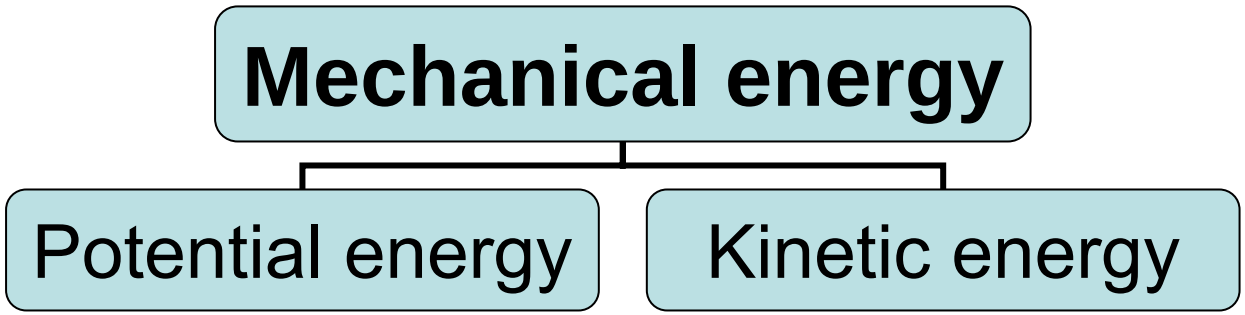
Energy

- Any object which has **the capacity to do work** posses energy

- **Law of conservation of energy**: Energy can not be created or destroyed, but it can be converted from one form to another

Energy

- Chemical energy used to produce a muscle contraction is transformed into **mechanical** energy (no energy is lost)


Mechanical energy
Potential energy
Kinetic energy

Energy

- **Potential energy** = a body's capacity to do work as it possesses stored up energy because of its *position* or *deformation*

Energy

- The more work done to overcome gravity, the greater the potential energy

- Example: the greater the distance an object is raised above the floor, the more potential energy it posses by virtue of its position relative to the floor

Energy

- When an object is deformed →

resistance to the deformation increases as the object is stretched →

the force that deforms the object is stored and maybe released as elastic energy (**strain energy**)

- Example: muscles and tendons may store strain energy and release it to aid in human movements

Energy

- **Kinetic energy** = the energy of a body due to its motion

- The amount of energy possessed by a body depends on its **velocity** (the higher the velocity, the greater the kinetic energy)

Energy
Example

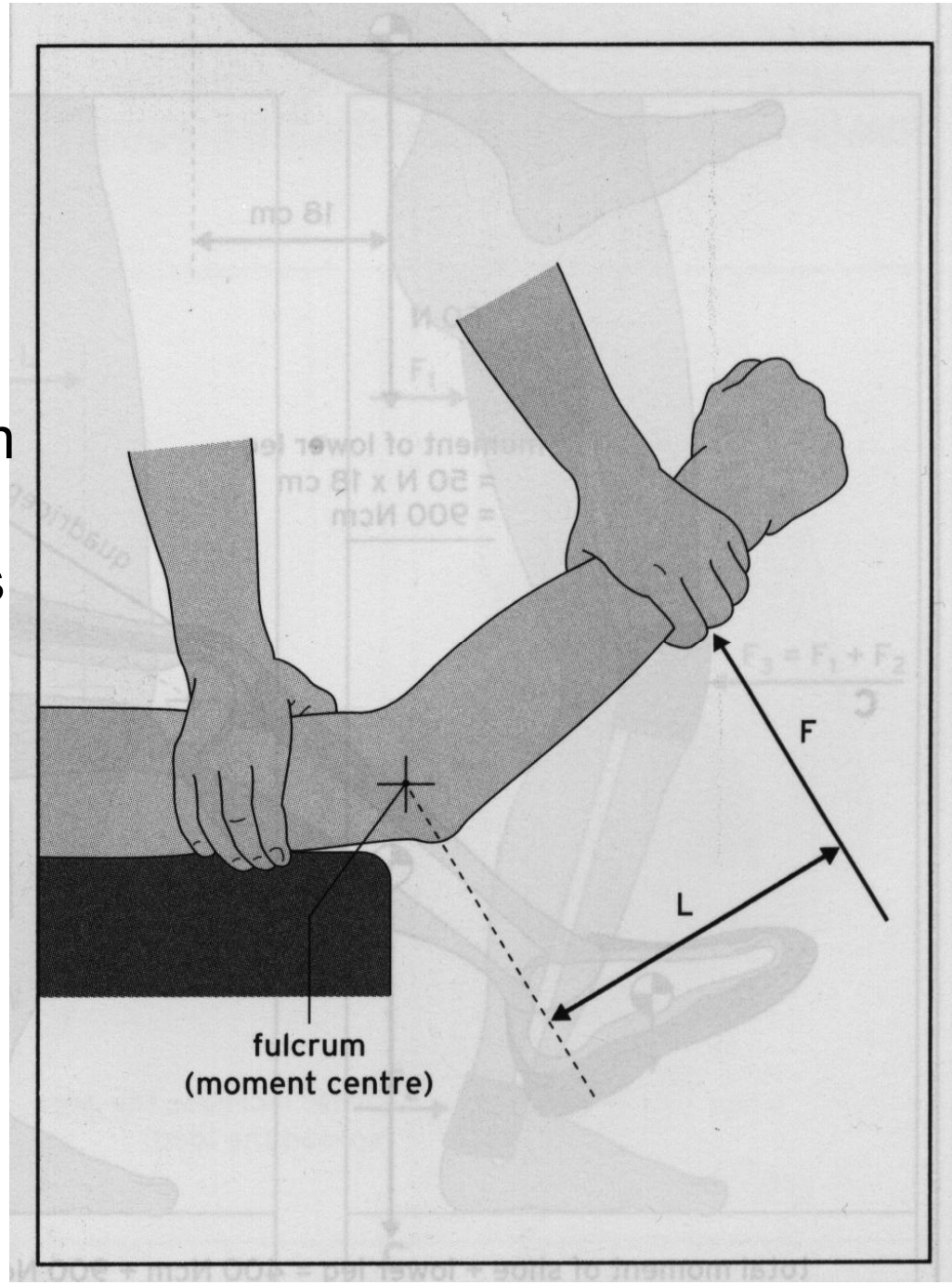
- If a person who is standing suddenly falls, the **potential energy** he possessed when in the upright position, is now converted to **kinetic energy** as he moves towards the floor.

Moments (torque)

- = the action of a force which tends to cause rotation of a body about a point (known as the fulcrum or moment center)

Example:

Giving passive movement
to the elbow,
the physiotherapist applies
a force some way from
the elbow joint (fulcrum)
in order to cause the forearm
to rotate about the elbow.
The further away the force is
from the fulcrum,
the easier it is to produce
the turning effect



Moments
Example

- In the case of an unstable knee due to extensors paralysis:
- With the knee fully extended, the lower limb can support the weight of the body (despite muscular deficiency)
- But, if the knee is put into a small degree of flexion, it will collapse under the weight of the body because the weight acting vertically produces a moment about the knee