

Basic Biomechanics II

DEA 3250/6510

Professor Alan Hedge

Definitions

- Scalar quantity – quantity with magnitude only (e.g. length, weight)
- Vector quantity – quantity with magnitude + direction (e.g. lifting a box)
- Coplanar – vectors operating in the same plane.

Vector Addition

- Tip-to-tail method – simple method using graphic representation of vectors.
 - ◆ Tip of 1st vector coincides with tail of the 2nd vector.
 - ◆ Tip of 1st vector is joined to tail of 2nd vector to create the resultant.

Vector Addition :

Tip-to-tail method

Vector Subtraction :

Tip-to-tail method

Vector Addition : >2 vectors

Force

- Force – mechanical disturbance or load (e.g. push, pull, throw, kick, hold, squeeze etc.)

LAWS OF MOTION

- Newton's 1st Law – a body that is originally at rest will remain at rest, or a body moving with constant velocity in a straight line will maintain its motion until an external resultant force is applied.

Inertia

- Inertia – tendency for a body to maintain its state of rest or uniform motion in a straight line.
- The more inertia an object has the harder it is to start moving it from rest.

LAWS OF MOTION

- Newton's 2nd Law – Acceleration of a body is directionally proportional to the net force acting on the body and inversely proportional to its mass.

LAWS OF MOTION

- Newton's 3rd Law - for every action there is an equal and opposite reaction.

Definitions

Units of Force

- SI system:
 - ◆ Newton (N) [kilogram_meter/second²]
- CG system (cgs)
 - ◆ Dyne (dyn) [gram_centimeter/second²]
- British system (Imperial system)
 - ◆ Pound (lb) [slug_foot/second²]

$$1 \text{ N} = 10^5 \text{ dyn} = 0.225 \text{ lb f}$$

External Forces

- Hammering a nail, pushing a cart, kicking a ball etc. are all examples of external forces

External Forces

- Compression force (e.g. pushing the hand against the edge of an object).

External forces

- Newton's 3rd law of motion.

Normal force

- Normal force acts perpendicular to a surface e.g. book on desk, sitting on chair, leaning back against a wall etc.

Tangential forces

- Force applied on a surface in a direction parallel to the surface (e.g. frictional forces).

Tensile force

- Force that cause stretching/ elongation of a body (muscles produce tensile forces).

Collinear Forces

- All forces have a common line of action (e.g. tug of war, tendons).

Concurrent Forces

- Lines of action of force have a common point of intersection (e.g. surgical traction system).

Parallel Forces

- Lines of action are parallel to each other (e.g. flexed arm).

Compressive Forces

- Compressive forces depend on the load and the area.

Gravitational Force

W = weight

m = mass

g = gravity

$$W = mg$$

$$SI = 9.81 \text{ m/s}^2$$

$$cgs = 981 \text{ cm/s}^2$$

$$Brit = 32.2 \text{ ft/s}^2$$

Pressure

- Pressure measures the intensity of distributed loads (e.g. sitting on chair, foot on floor, finger on key etc).

Units of Pressure

- SI system:
 - ◆ Pascal (Pa) [kilogram/second²_meter]
- CG system (cgs)
 - ◆ Gram/centimeter_second² or dyne/cm²
- British system (Imperial system)
 - ◆ Pound per square foot (lb/ft²)

Center of Gravity

- Distributed load over a surface can be represented by a single force (equivalent force or concentrated load).
- Line of action of this force passes through a point called the center of gravity or center of mass.

Center of Gravity

- Center of gravity plays an important role for lifting boxes.

Frictional forces

- Frictional force measures the resistance between the surfaces of sliding bodies in contact with each other.
- Usually measured as the coefficient of friction.

MOMENTS (TORQUE)

- Force applied to an object can translate, deform and/or rotate the object (e.g. opening a door – torque – rotational force at hinges).

MOMENTS (TORQUE)

- When a perpendicular force is applied on a lever arm at some distance from its axis of rotation (fulcrum) there is a rotational tendency that is termed torque or moment.
- Torques generated by the body translate muscle contractions into mechanical work (e.g. movements of the fingers, arms, legs etc.)

POSITIVE WORK

- Positive Work occurs whenever the product of muscle force and the force arm ($F \times FA$) > the product of the resistance and

Second Class Lever System

- In a second class lever system the fulcrum is at one end of the force arm, and FA is always $>$ RA.
- Only a few examples of such systems in the body (e.g. opening mouth when teeth are stuck together with gooey toffee).

Third Class Lever System

- Many examples of third class lever systems in the body. Here RA always $>$ FA, so systems are at a mechanical disadvantage.

Third Class Lever System

- Lifting an object using the hand and pivoting at the elbow is an example of a third class lever system.