Learning Objectives

- Hoop stresses / SMA & IM Nails
- Applied statics
- Locomotion or Gait cycle
- Types of Gait
- Team Quiz
Bending Stress =
(applied force x distance from neutral axis)
Second Moment Area of Material
Second Moment Area

\[ \pi/4 \times r^4 \]

\[ \pi/4 \times (r^4 - i^4) \]

\[ \text{wh}^3/12 \]
Choosing a prosthesis

- Bending rigidity = SMA x Young’s Modulus
Hoop Stress = \( \frac{P r}{t} \)

\( P \) = Internal pressure
Intramedullary Nails

- Unreamed
  - Lower infection rate in open fractures

- Reamed
  - Bigger nail size
  - Tight fitting
  - Bone graft

- Consider Pipe/Cylinder, metal type, locking, dynamising
Normal walking produces a force of three times body weight.

Fast walking increases this to 7 times body weight.

We use free body diagrams to estimate Joint Reaction Force JRF.

Several assumptions are made.
Examples: Single leg stance

To calculate JRF:

- $A = 0.05\text{m}$
- $B = 0.15\text{m}$
- $BW = 600 \text{ N} (500)$
- $AM = BW \times B$
- $M = \frac{75}{0.05}$
  - $= 1500 \text{ N}$

Using triangle (top to tail) to scale:

$JRF = 2000$
Upright Stance (Standing rest)

- Balancing body on lower limbs and head on body
- Weight evenly distributed between legs
- Shifting centre of gravity
- Line of gravity
  - Behind head of femur
  - Patella
  - 2-5 cm anterior to ankle
- Soleus, gluteus medius & spine extensors
Posterior Pelvic Anatomy
Sitting

- If sat straight weight goes through ischial tuberosities
- Usually hunched forward putting weight through midthighs and increasing pressure through the L4/5 disc
- Dependant on position of arms
- Good to change positions regularly as it relieves the strain
Locomotion/Gait cycle

HS  MSt / MSw  TO

The four joints with the most movement during walking:

Key
- Hip
- Knee
- Ankle
- Big Toe
Types of Gait

- Antalgic
- Trendelenberg
- Skeletal deformity
- Scissor
- Waddling
- Hemiplegic
- High stepping
- Ataxic
- Cerebellar
- Parkinsonian
Questions ?
Team Quiz
1. [Image: Portrait of a man with curly hair]
4. Name the three classes of levers

Bonus points
Define statics, kinetics, kinematics and kinesiology
11. Define Stress & Strain
12. Stress-Strain Curves
13. Label these phenomenon:

(a) Linear elastic material

(b) Non-linear material

(c) [Diagram showing hysteresis loop]

(d) [Diagram showing hysteresis loop]
14. What biomechanical property does bone cement exhibit?
15. Define Wolff’s Law
17. Wolffs Law in Space?
18. Label the ligaments
19.

- Name the muscles when resting in the standing stance.
Name the phases of the Swing cycle
Answers
2 Newton’s First Law

- Inertia

The body at rest tends to stay at rest and a body in motion will remain in motion unless acted upon by an external force.

$$\text{Sum } F = 0$$
3. Newton’s Third Law

For every action there is an equal and opposite reaction.
4. Levers

- First class
  - Scissors (Atlanto-axial joint)

- Second class
  - Nutcracker (Tip toes)

- Third class
  - Shovel
E – Calf muscles

L – Ankle

F – Toes
5.

- **Statics** - the study of forces acting on rigid bodies in equilibrium, either at rest or moving at a constant velocity.

- **Kinetics** - the forces acting on a body to produce motion.

- **Kinematics** - the study of motion without reference to force or mass.

- **Kinesiology** - the study of human movement with reference to mechanics and anatomy.
Stress = Force per unit area (N/m²)

Strain = Change in length/original length

Hooke’s Law = Strain \propto Stress

Young’s (Elastic) Modulus = Stress/Strain
(E = \delta/\varepsilon \text{ in } \text{N/m}^2)
12. Stress-Strain Curves

1. Elastic limit
2. Yield stress
3. Ultimate tensile stress
4. Fracture stress/rupture
13. Biomaterial properties

(a) Linear elastic material
(b) Non-linear material
(c) Material with hysteresis
(d) Plastic deformation
14. Creep
Wolff J 1884: “the trabecular pattern in lamellar bone is laid down in accordance with the lines of transmitted force”
17. Wolff’s Law in Space
18. Label the ligaments

- Sacroiliac
- Sacrospinous
- Sacrotuberous
19.

- Spine Extensors
- Glutius Medius
- Soleus
Heel strike
Stance
Toe off
Swing
Summary

- Hoop stresses, SMA & IM Nails
- Free Body Diagrams
- Applied statics
  - Upright stance
  - Sitting
- Locomotion/Gait cycle
- Types of Gait
- Principles: Definition, Units & Laws
- Static & dynamic biomechanics
- Material mechanics
  - Stress Strain
For next time:

- Look at gait cycle
- Think about what you need to allow you to walk normally
- Think about what sorts of questions you might want to ask a patient with an abnormal gait
- Some patients have been invited