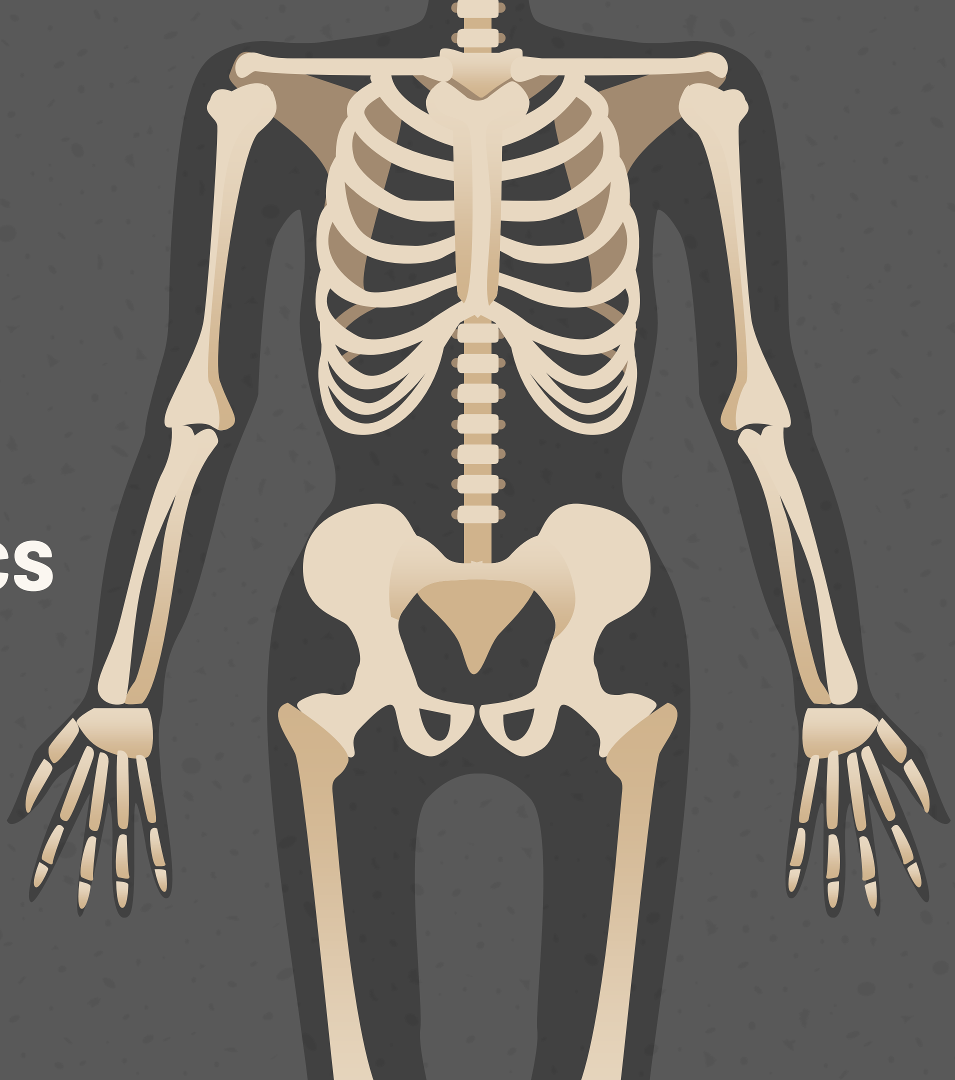
Statics and Dynamics of Body



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01. Overview

First of all, we’re going to take a general look at this concept.

02. Generals

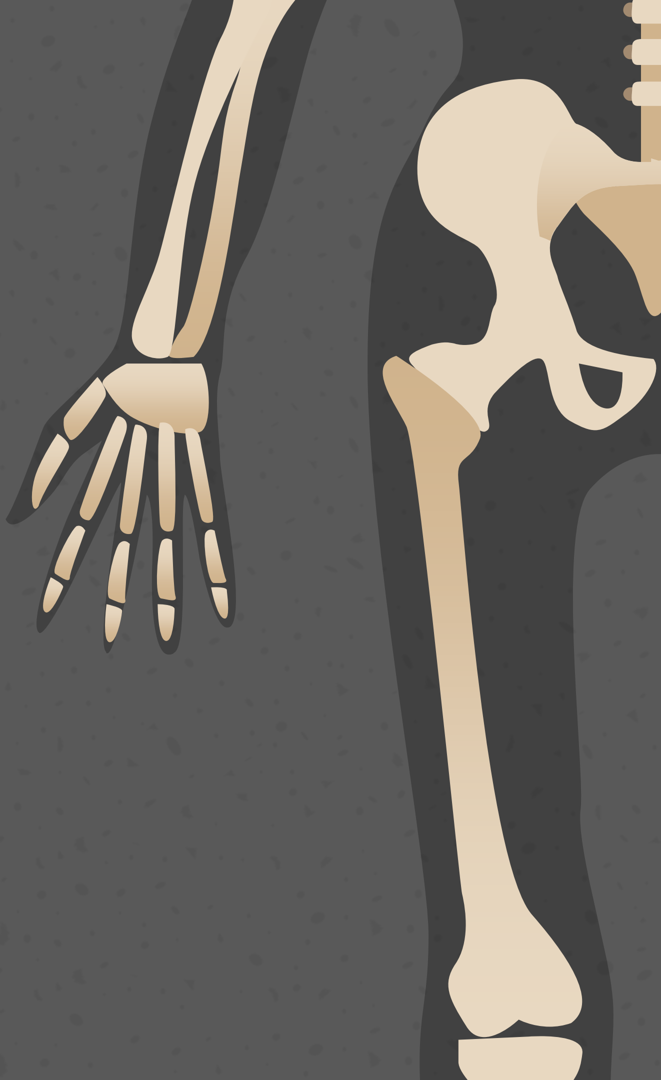
Some useful advice

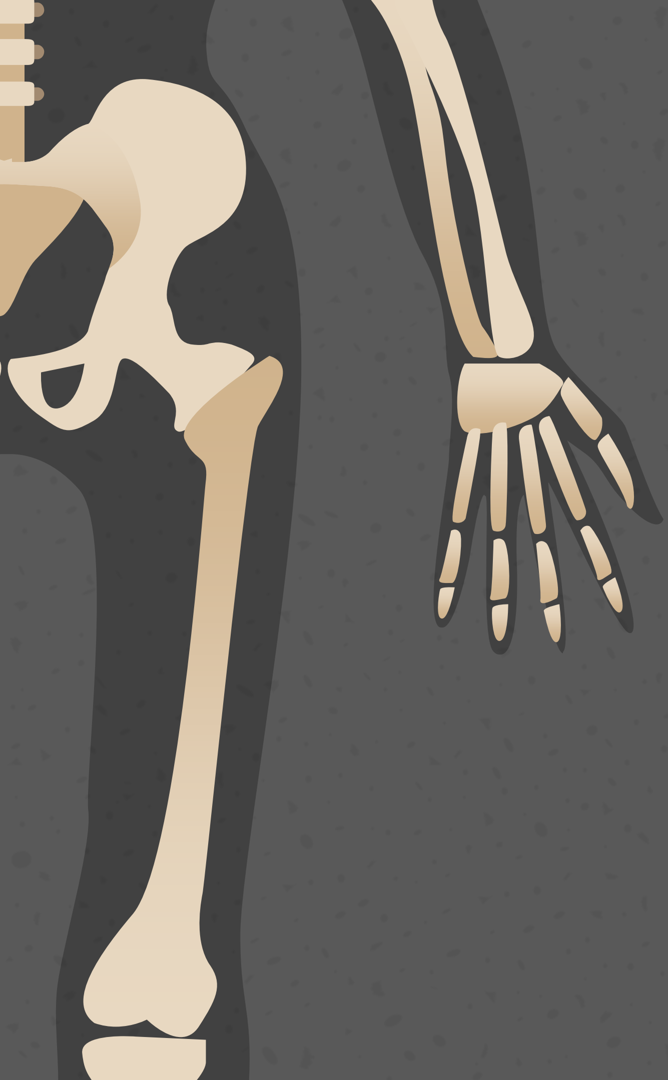
03. Examples

There are some educational and some practical examples which we will discuss.

04. Assignment

At the end, we will take an overview of your homework and explain some possible problems.





Introduction

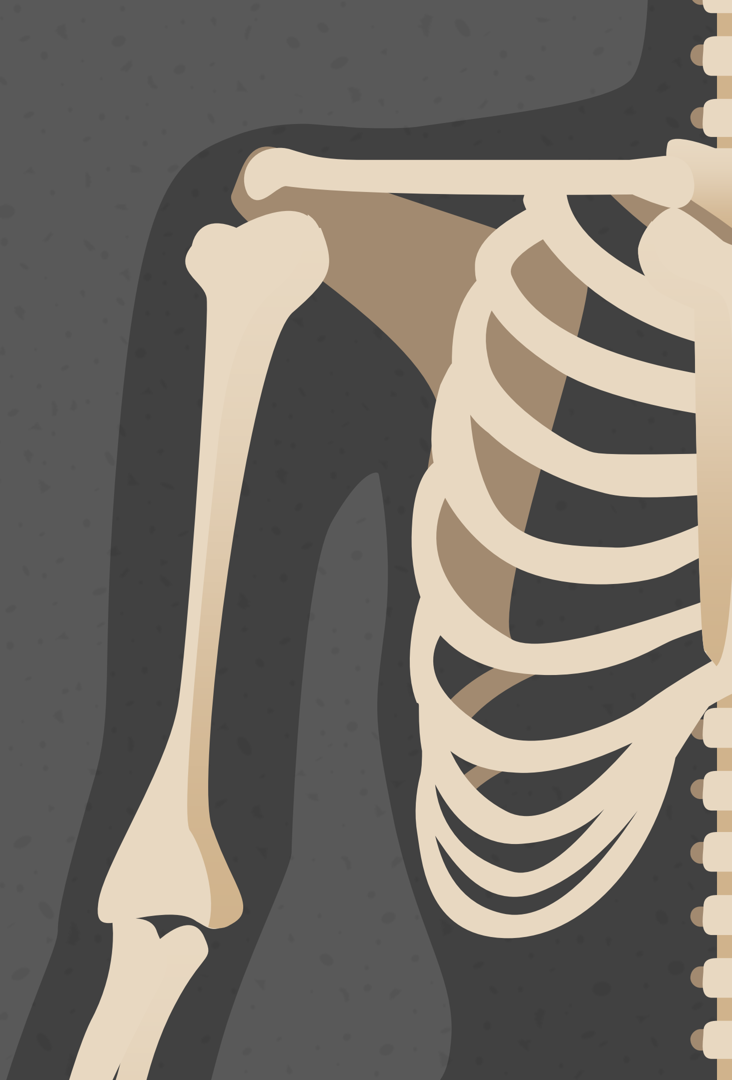
The study of the force balance of an object at rest is called "**statics**." Moreover, the study of very slow motion can usually be treated as a series of static conditions – as if there were no motion; this is called "**quasistatics**."

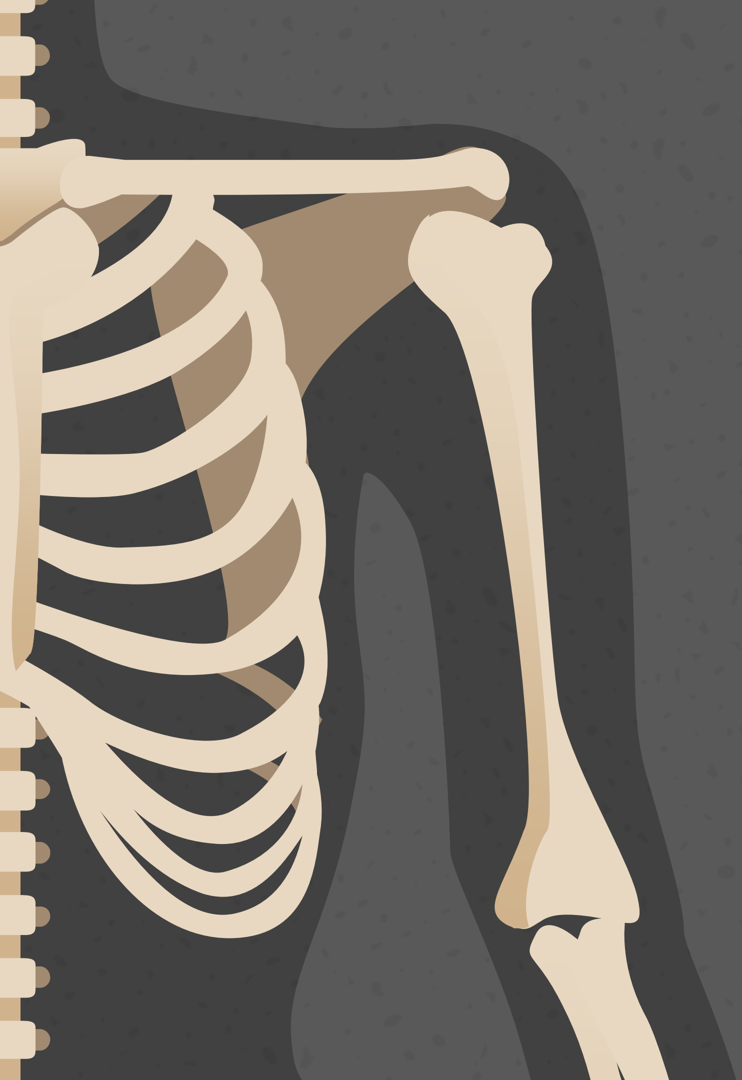
> After reviewing the conditions for static equilibrium in three dimensions, we will examine the useful simplification to two dimensions, examples of which can often be characterized as one of the three types of levers. We will then apply these equilibrium conditions to the lower arm, hip, and the spine (lower back). Statics is one important area in biomechanics

—The course's reference

01.

OVERVIEW



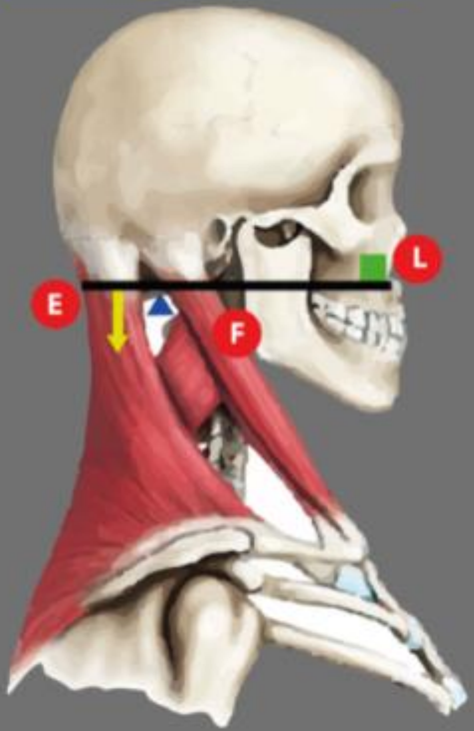


What Is This Topic About?

- At the end of this course, we are able to solve statics and dynamical questions
- We will review the topics and formulas here
- You could give a brief description of the topic you want to talk about after this class
- You will able to find your way to challenging problems

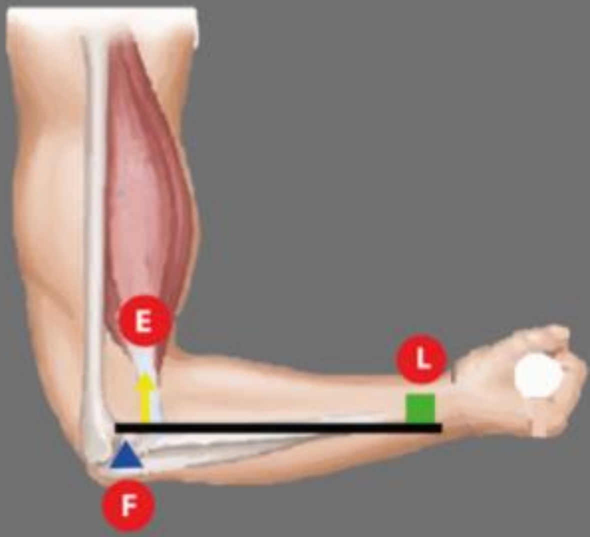
Levers Of Human Body

First Class Lever



Second Class Lever

Third Class Lever



Equilibrium conditions

x

$$\sum F_x = 0$$

$$\sum \tau_x = 0$$

y

$$\sum F_y = 0$$

$$\sum \tau_y = 0$$

z

$$\sum F_z = 0$$

$$\sum \tau_z = 0$$

In general, the torque (vector τ) about any axis is defined as the vector cross product between the distance vector from that axis to the point where the force is applied r and the force vector F

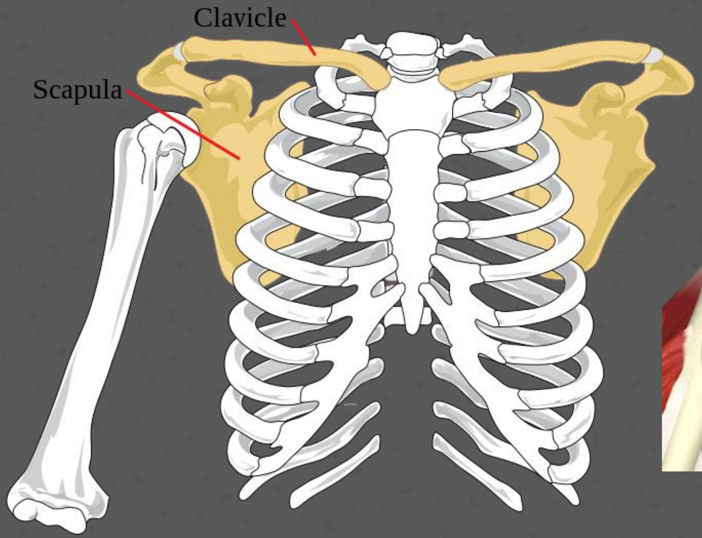
$$\tau = r \ \times F$$

$$\tau_z = r \ F sin\theta$$

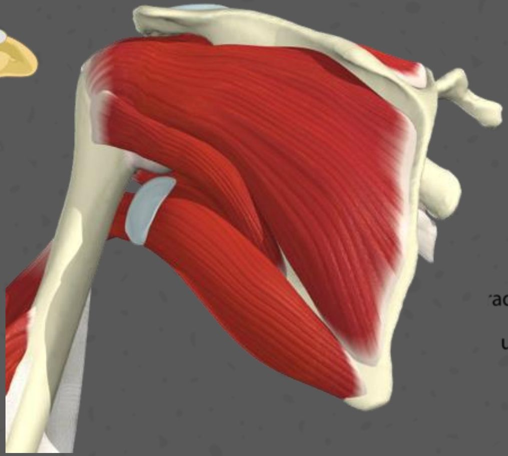
Bones and muscles of the hand

Radius, Ulna, Scapula	Bone

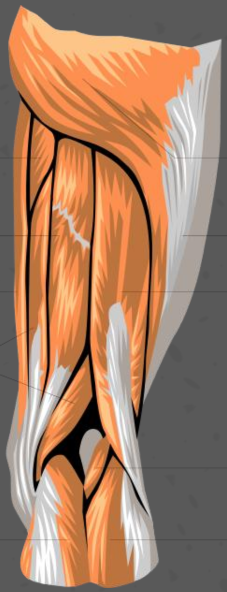
Muscle	Deltoid, Biceps

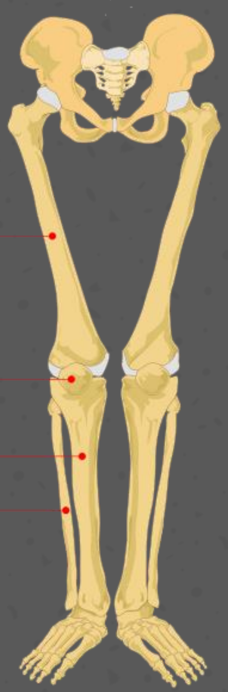


Front view

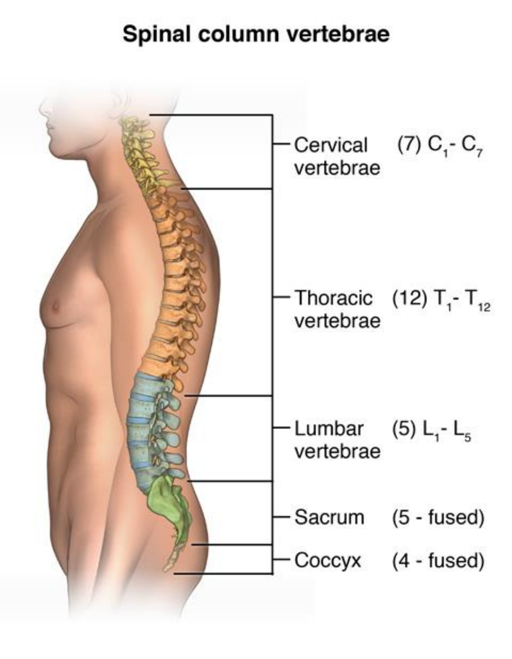


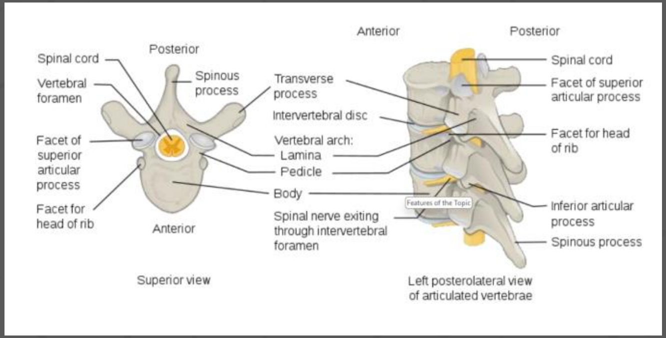
Leg bones and muscles





Back Bones and muscles





$$F = m \times a$$

$$\frac{\Delta(mV)}{\Delta t} = F$$

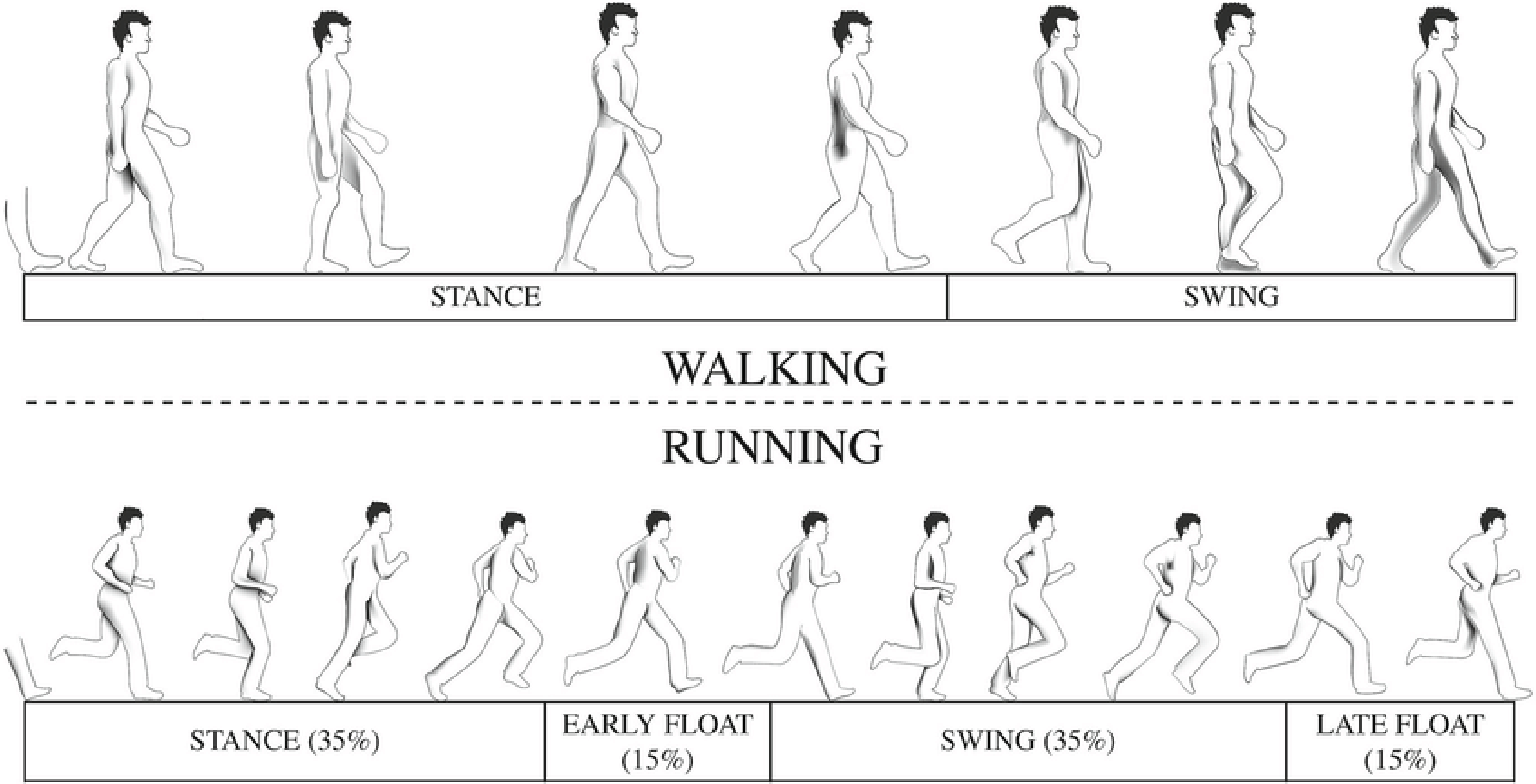
$$E = KE + PE$$

$$PE = m_b gh$$

$$KE = KE_H + KE_V$$

$$KE_H = \frac{1}{2} m_b v_x^2 = \frac{1}{2} m_b \left(\frac{dx}{dt}\right)^2$$

$$KE_V = \frac{1}{2} m_b v_z^2 = \frac{1}{2} m_b \left(\frac{dz}{dt}\right)^2$$

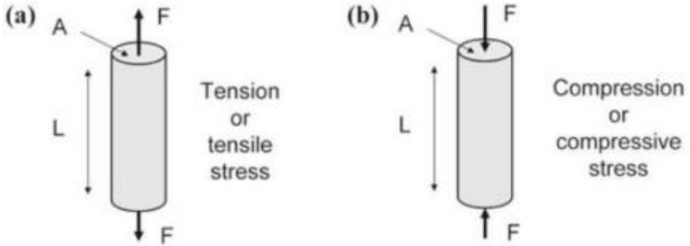

STANCE
SWING
WALKING
RUNNING
STANCE (35%)
EARLY FLOAT (15%)
SWING (35%)
LATE FLOAT (15%)

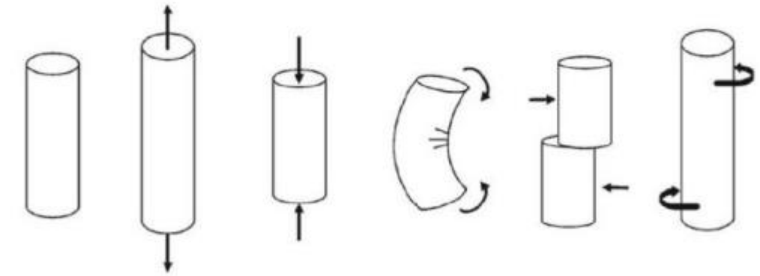
$$\text{engineering stress} \quad \sigma = \frac{F}{A}$$

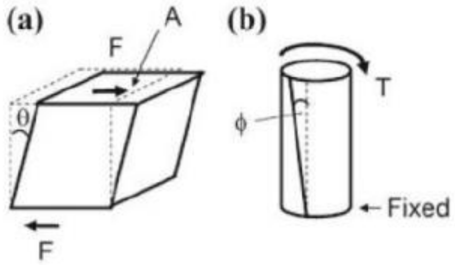
$$\text{engineering strain} \quad \zeta = \frac{\Delta L}{L}$$

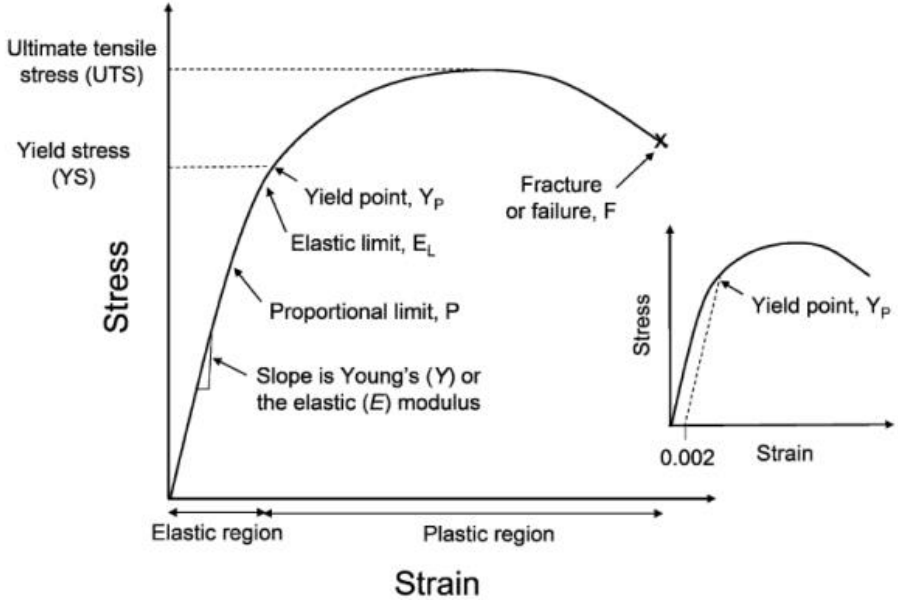
$$\text{Young's modulus } Y = E = \frac{\sigma}{\zeta} = \frac{FL}{A\Delta L}$$

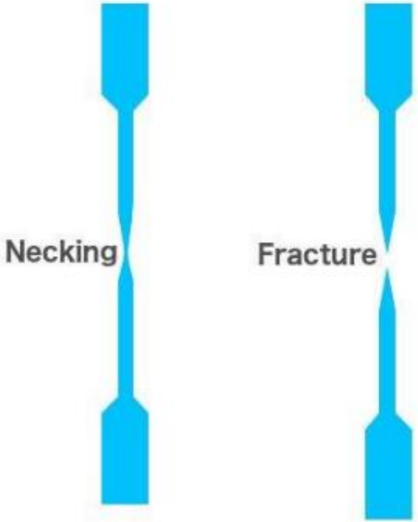
$$\textit{Hookean elastic material} \quad \sigma = Y\zeta$$

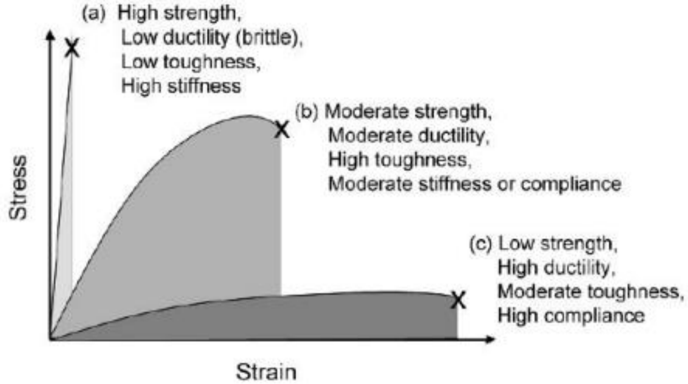


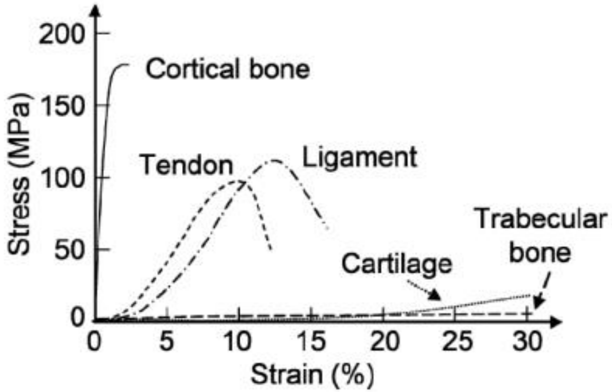




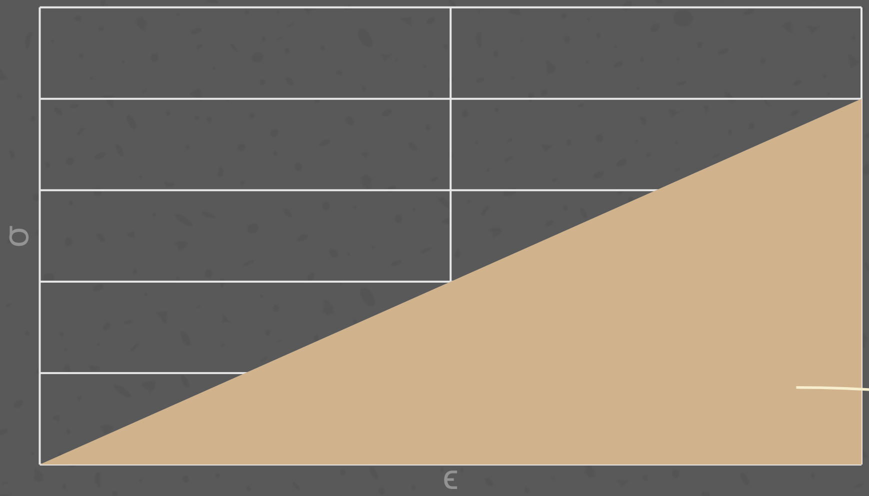

Ultimate tensile stress (UTS)
Yield stress (YS)
Stress
Strain
Yield point, Y_P
Elastic limit, E_L
Proportional limit, P
Slope is Young's (*Y*) or the elastic (*E*) modulus
Fracture or failure, F
Elastic region
Plastic region
Stress
Yield point, Y_P
0.002
Strain


Necking
Fracture


(a) High strength,
Low ductility (brittle),
Low toughness,
High stiffness
(b) Moderate strength,
Moderate ductility,
High toughness,
Moderate stiffness or compliance
(c) Low strength,
High ductility,
Moderate toughness,
High compliance
Stress
Strain


Stress (MPa)
200
150
100
50
0
Cortical bone
Tendon
Ligament
Trabecular bone
Cartilage
0
5
10
15
20
25
30
Strain (%)

Energy stored in the elastic region



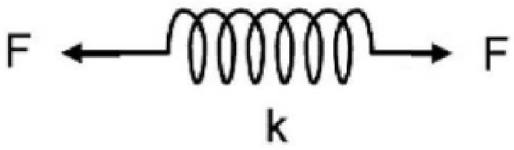
$$PE = \frac{1}{2}\sigma\epsilon V$$
$$= \frac{1}{2}\frac{\sigma^2}{Y}V$$
$$= \frac{1}{2}\sigma\epsilon A L_0$$

$$Area = \frac{Potential\ energy}{Volume}$$

Hookean elastic model

$$F = kx.$$

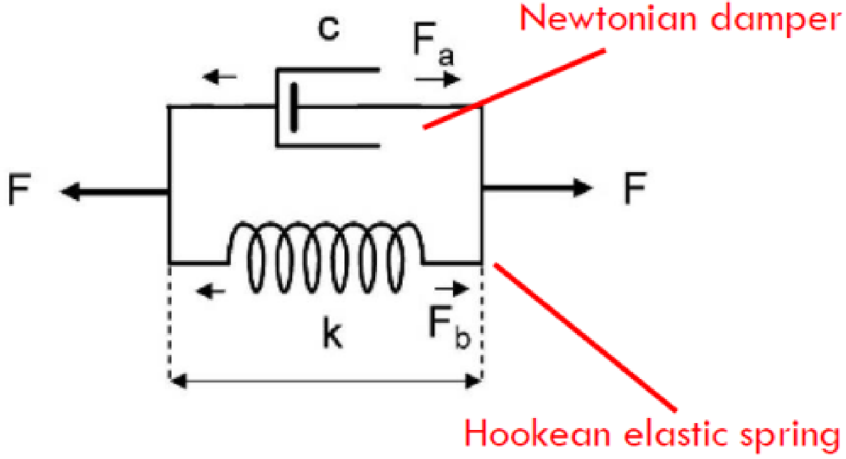
$$\sigma = E\zeta$$

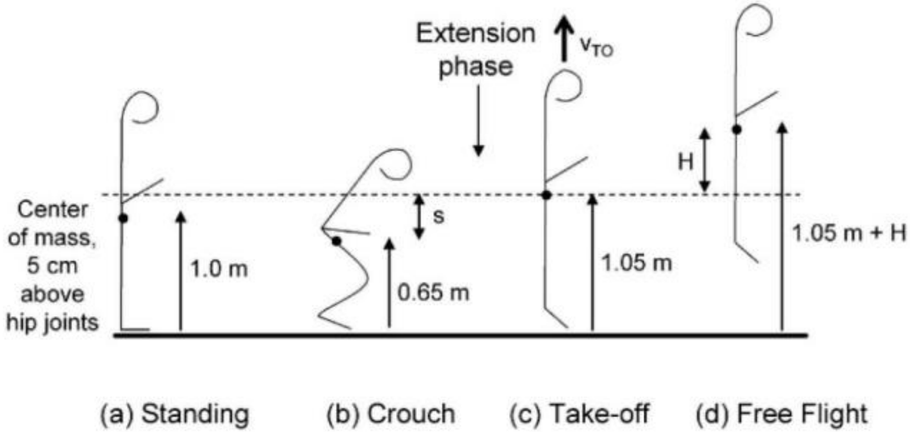


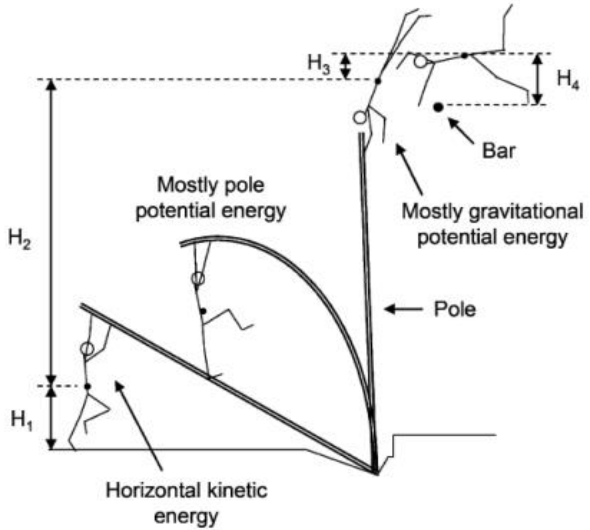
Kelvin–Voigt model (Voigt model)

$$F = c\frac{\mathrm{d}x}{\mathrm{d}t} + kx.$$

$$\sigma = E\zeta + \eta\dot{\zeta}$$

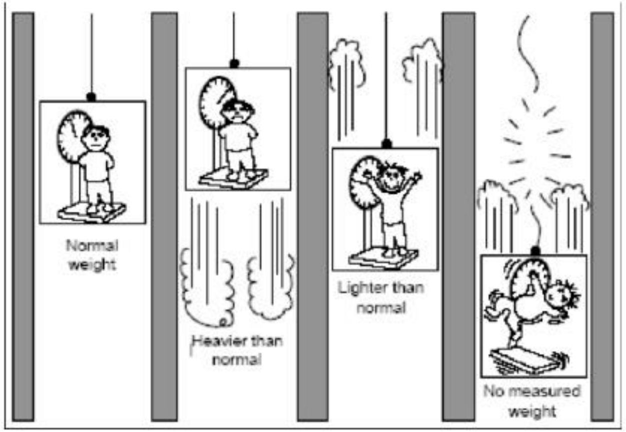


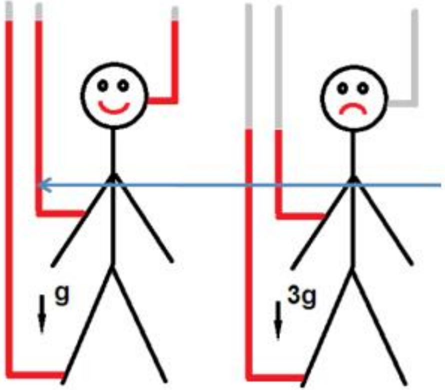




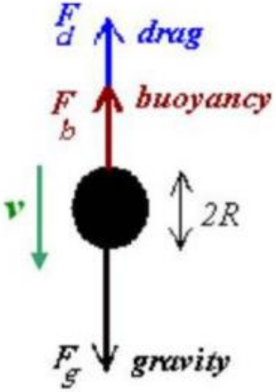
$$\frac{1}{2}mv_{\mathrm{H,i}}^2 = mg(h_{\mathrm{bar}} + h_{\mathrm{min}} - h_{\mathrm{CM}})$$

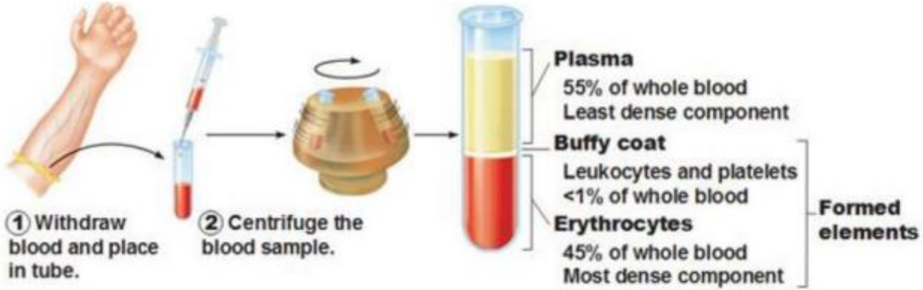
$$h_{\mathrm{bar}} = h_{\mathrm{CM}} - h_{\mathrm{min}} + \frac{v_{\mathrm{H,i}}^2}{2g}.$$


Normal weight
Heavier than normal
Lighter than normal
No measured weight


g
3g

$$p = \rho g h$$


F_d drag
F_b buoyancy
v
$2R$
F_g gravity


① Withdraw blood and place in tube.
② Centrifuge the blood sample.
Plasma
55% of whole blood
Least dense component
Buffy coat
Leukocytes and platelets
<1% of whole blood
Erythrocytes
45% of whole blood
Most dense component
Formed elements

02.

Generals

Process

Statics of Human Body

01.

02.

Examples

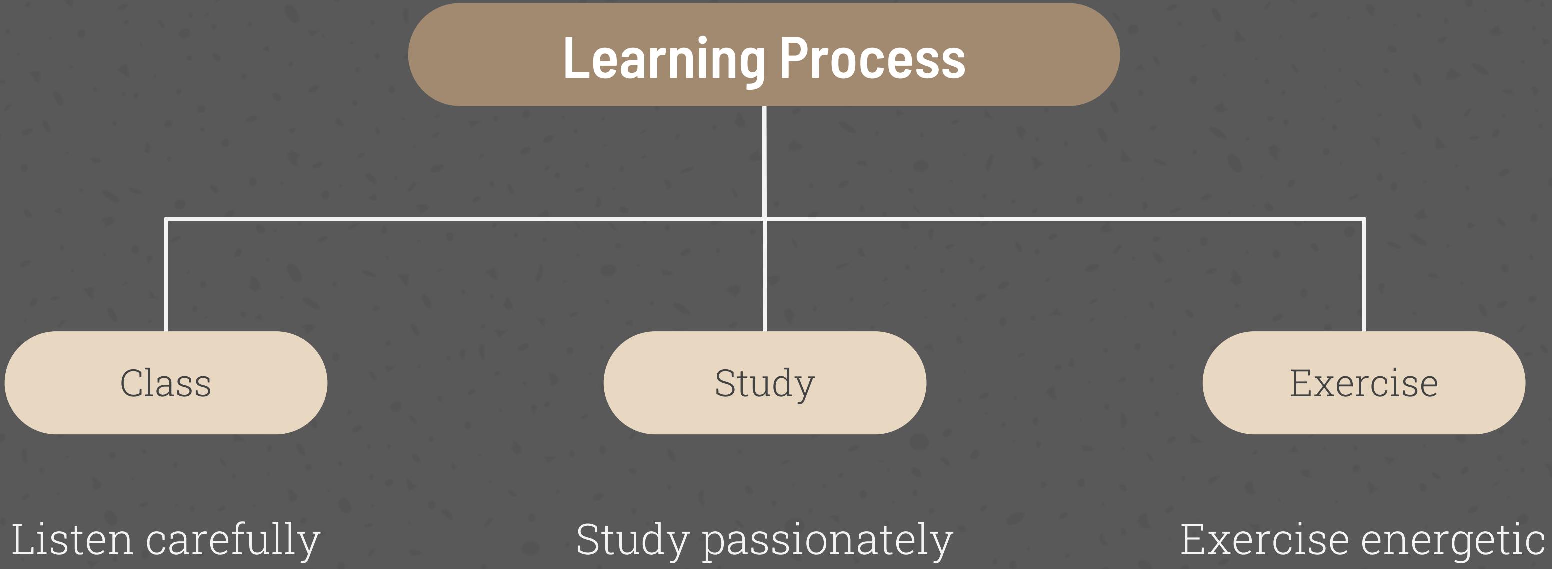
Dynamics of Human Body

03.

04.

Examples

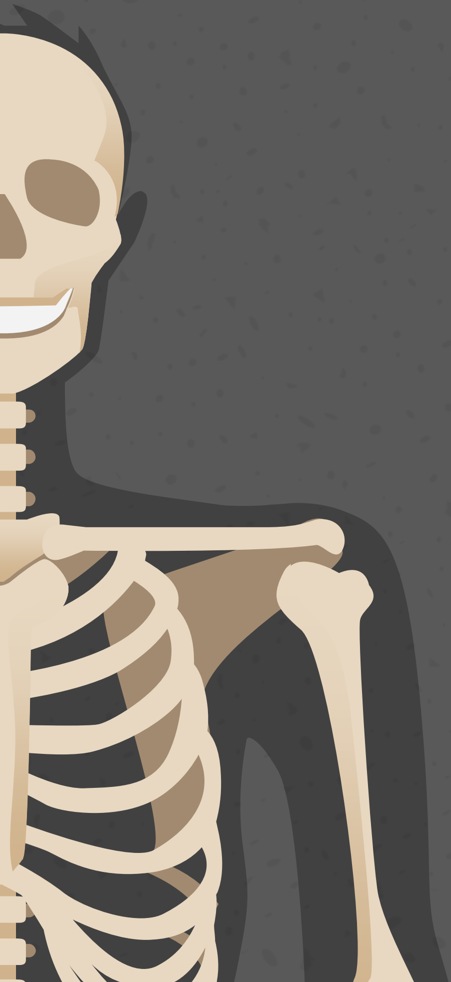
Learning Diagram



More Passion
More Passion

More Energy
More Energy

Team Works



%50

Your understanding of the question

%30

The right approach in solving the question

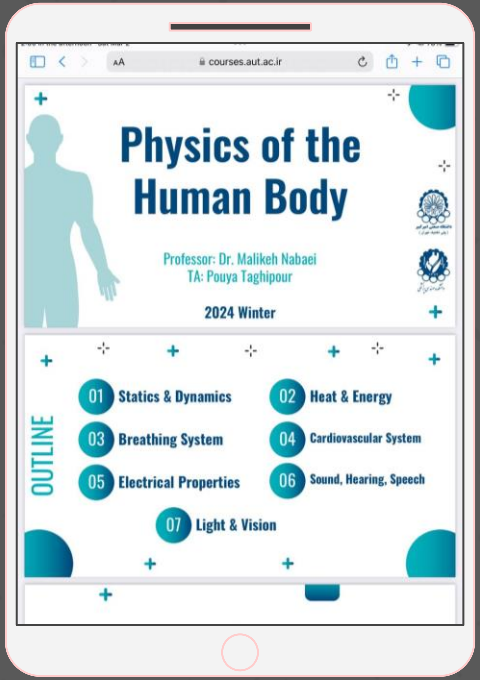
%20

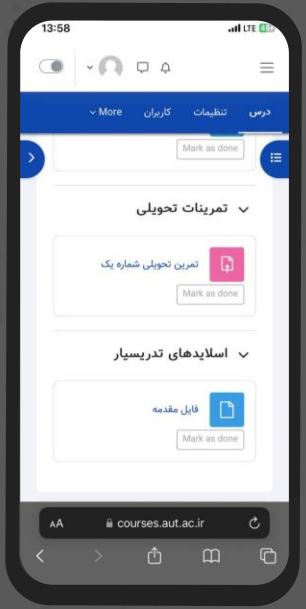
The final answer

Steps to solve a problem

- Block Diagrams
- Problem Solving
- Assumptions
- Calculations

Courses

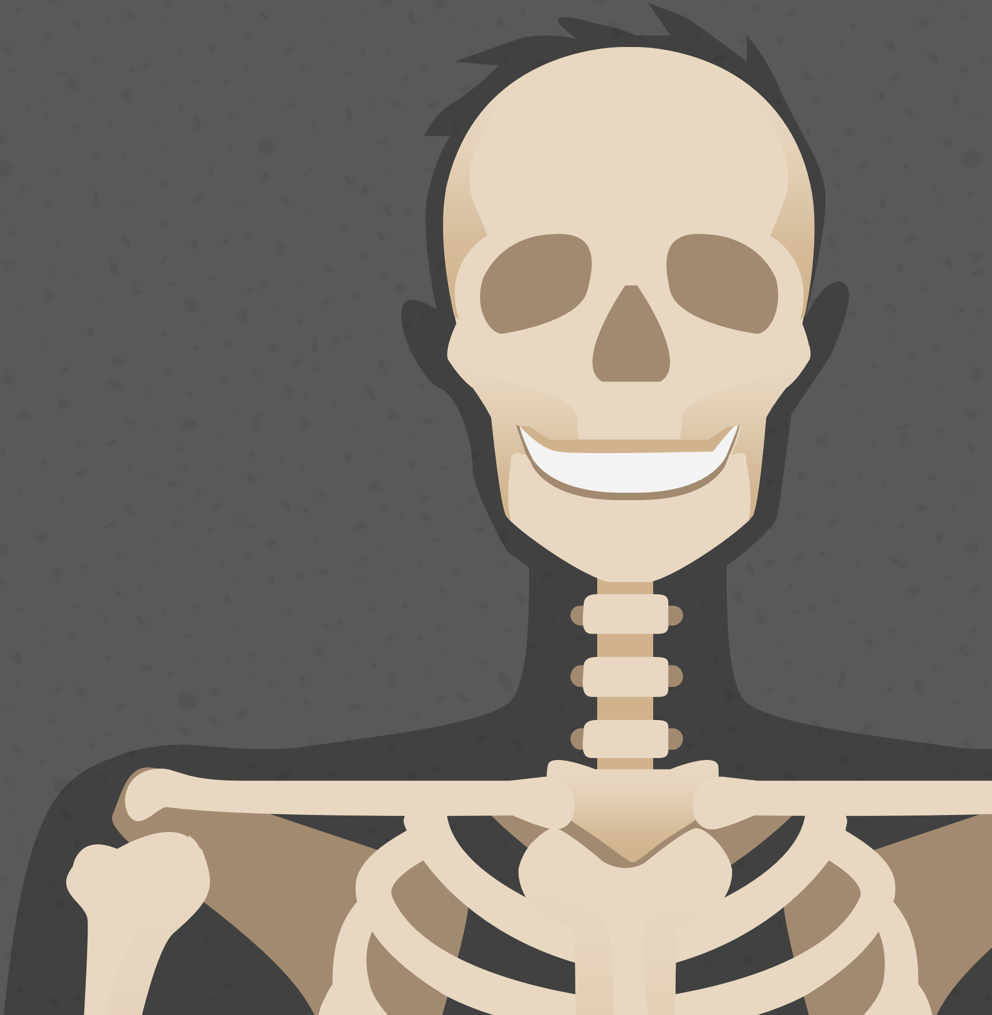




A place to upload assignments and course materials

03.

Examples



Example 2-1

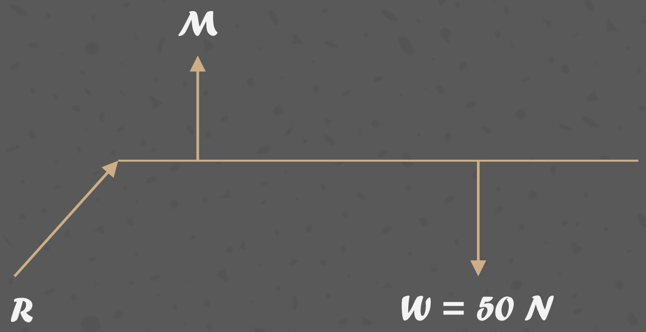
A basket with a handle containing 5 kg of fruit is placed on the table. Suppose you want to lift the basket from the table in two ways.

1) In the situation where the angle of your forearm is 90 degrees with your arm, try to hold the basket handle with your palm and lift it.
2) Throw the basket handle around your forearm (at a distance of half the length of the forearm) and lift the basket.

Example 2-1

Answer:

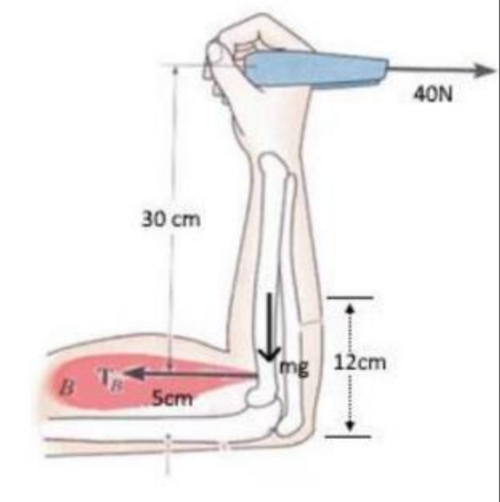
Using hands



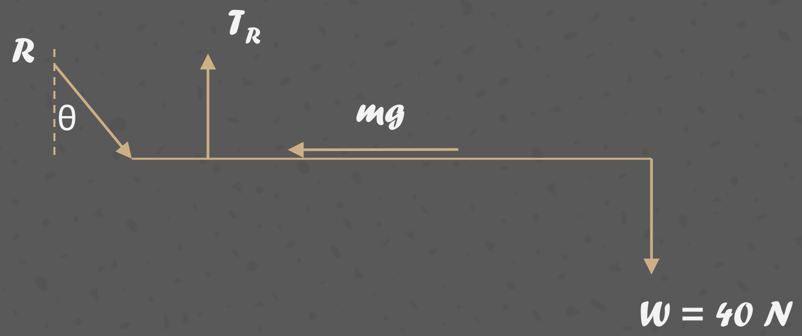
Using forearm

Example 2-2

According to the figure below, a force of 40 newtons is applied to the elastic and the person tries to keep his hand straight. If the mass of the forearm is 2 kg, find the force of the muscle and the joint.



Example 2-2



Answer:

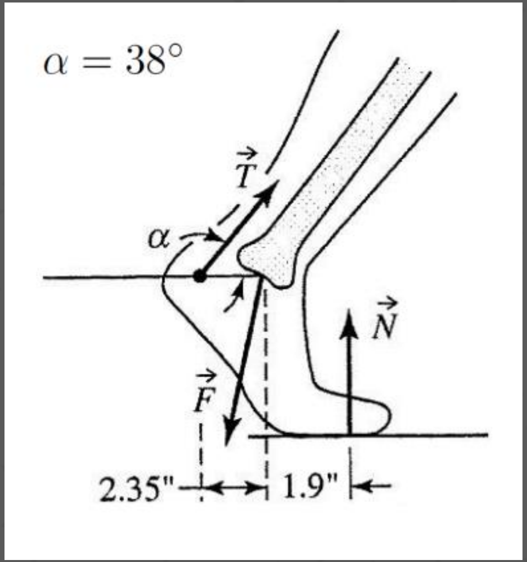
$$\sum M_o = 0 \rightarrow T \times 5 = 40 \ \times 35 \rightarrow T_R = 280N$$

$$\sum F_y = 0 \rightarrow mg = Rsin\theta = 20$$

$$\sum F_x = 0 \rightarrow 40 + Rcos\theta = T_R \rightarrow Rcos\theta \ = 240 \begin{cases} \theta = \ \tan^{-1}\dfrac{20}{240} \rightarrow \theta = 4.76 \\ R = 240.83N \end{cases}$$

Example 2-3

A person weighing 200 pounds is standing on his toes as shown below. Find the force on the ankle joint and hamstring.



Example 2-3

A person weighing 200 pounds is standing on his toes as shown below. Find the force on the ankle joint and hamstring.

$$\sum M_o = 0 \rightarrow T_x(sin38) \times 2.35 = N \times 1.9$$

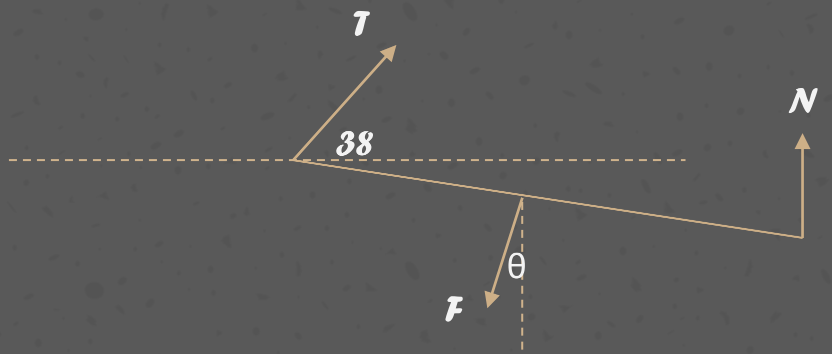
$N = 100$
$T = 131.3$

$$\sum F_x = 0 \rightarrow Tcos38 = Fsin\theta = 103.48$$

$$\sum F_y = 0 \rightarrow N + Tsin38 = Fsin\theta = 180.8$$

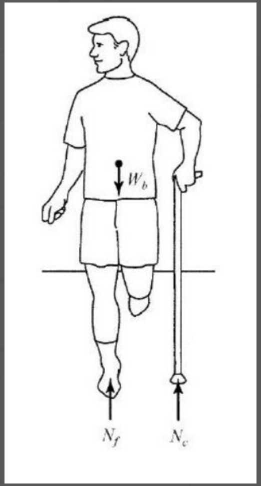
$\theta = 29.76$

$$F = \frac{103.48}{sin\theta} = 208.47$$



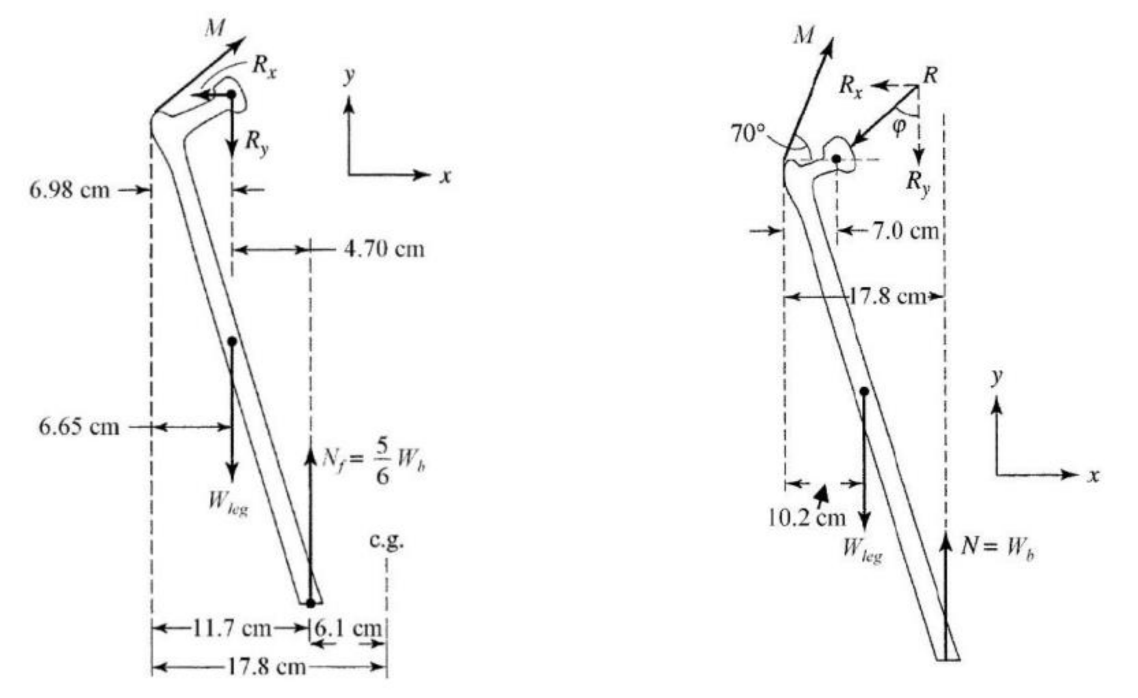
Example 2-4

A person is standing on his right leg with the help of a cane as shown in the figure below, and suppose that the cane supports one-sixth of the body weight, find the force on the hip joint and the muscle force. (The weight of the foot is equal to 0.16 of the body weight.)



Example 2-4

Attention:



Example 2-4

Answer:

$$\sum f_y = 0 \rightarrow N_f + N_C - W_b = N_f - \frac{5}{6}W_b = 0 \rightarrow N_f = \frac{5}{6}W_b$$

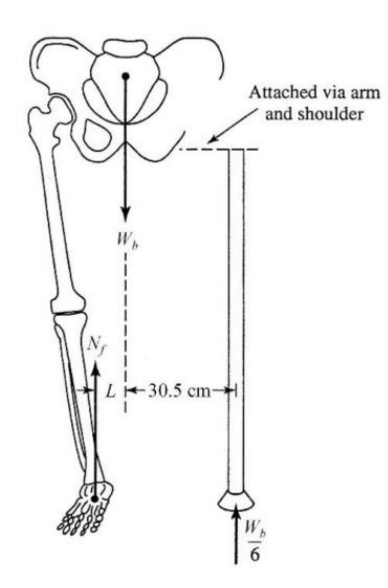
$$\sum M = 0 \rightarrow L(N_f) + 30.5(N_C) = L = \frac{1}{5}(30.5) = 6.1\ cm$$

$$\sum M_O = 0 \rightarrow M(sin70) \times 6.98 = 4.7 \times \frac{5}{6}W_b + (6.98 - 6.65)0.16W_b = M = 0.602W_b$$

$$\sum F_x = 0 \rightarrow Mcos70 = R_x = 0.21W_b$$

$$\sum F_y = 0 \rightarrow Msin70 + \frac{5}{6}W_b = R_y + 0.16W_b \rightarrow R_y = 1.24W_b$$

$R = 1.26W_b$
$\theta = 9.5$



Example 2-5

If we consider the leg bone as a cylinder 1.2 meters long with a cross section of 3 square centimeters. When a person with If the weight of 70 kg is standing on one leg, estimate the shortening of the length of the leg bone due to the applied pressure? Consider the compressive modulus of the leg bone $179 \times 10^8 \frac{N}{m^2}$

Example 2-5

Answer:

$$\left.\begin{array}{r}\sigma = E\varepsilon \\ \varepsilon = \dfrac{\Delta L}{L}\end{array}\right\} \rightarrow \Delta L = \frac{\sigma L}{E}$$

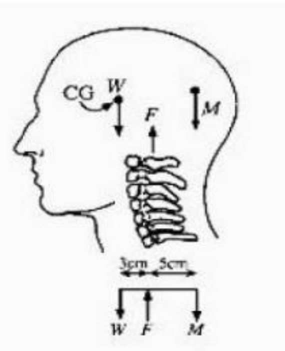
$$\sigma = \frac{F}{A} = \frac{70 \times 10^{(N)}}{3 \times 3^{-4}{}_{(m^2)}} = 2.3 \times 10^6 \frac{N}{m^2}$$

$$\left.\begin{array}{r}L = 1.2\, m^2 \\ A = 3cm^2 \\ E = 179 \times 10^8 \dfrac{N}{m^2}\end{array}\right\} \rightarrow \Delta L = \frac{2.3 \times 10^6 \times 1.2}{179 \times 10^8} = 1.5 \times 10^{-4} m$$

Example 2-6

A first-type lever system involves the extensor muscle, which exerts M force to hold the head. The force W is the weight of the head, which acts at the center of mass of the head. F force is also introduced by the first cervical vertebra. The mass of the head is about 3 kg.

A. Find the force F and M.
B. If the surface of the first cervical vertebra on which the head is located, find the stress on the vertebra $5 \times 10^{-4} m^2$.
C. How does this stress compare with the fracture compressive strength for the vertebral disc? $1.1 \times 10^7 \frac{N}{m^2}$



Example 2-6

Answer:

$$\sum M_0 = 0 \rightarrow -M \times 5_{cm} + W \times 3_{cm} = 0$$

$A.$

$$\sum F_y = 0 \rightarrow F = W + M = 30 + 18 = 48\ N$$

B.

$$\sigma = \frac{F}{A} = \frac{48\ N}{5 \times 10^{-4}} = 9.6 \times 10^4 \frac{N}{m^2}$$

C.

$$\frac{\sigma}{\sigma_r} = \frac{9.6 \times 10^4}{1.1 \times 10^7} = 8.7 \times 10^{-3} < 0.01\sigma_r$$

Example 2-7

The intervertebral disc can withstand a stress equal to $1.1\times\ 10^{7}\,\frac{N}{m^{2}}$ before breaking.
If the cross-sectional area of the intervertebral disc is about 10 square centimeters, what will be the maximum force it can withstand before breaking?

Example 2-7

Answer:

$$F_{max} = A \times \sigma_{max}$$
$$A = 10\ cm^2$$

$$F_{max} = A\ \times\ \sigma_{max} = 1.1 \times 10^4 N$$

Example 2-8

A person with a mass of 70 kg jumps onto a mat from a height. If the person's speed at the moment of hitting the mat is 6 m/s and he stops on the mat in 0.2 seconds, calculate the force on the person's leg.

Example 2-8

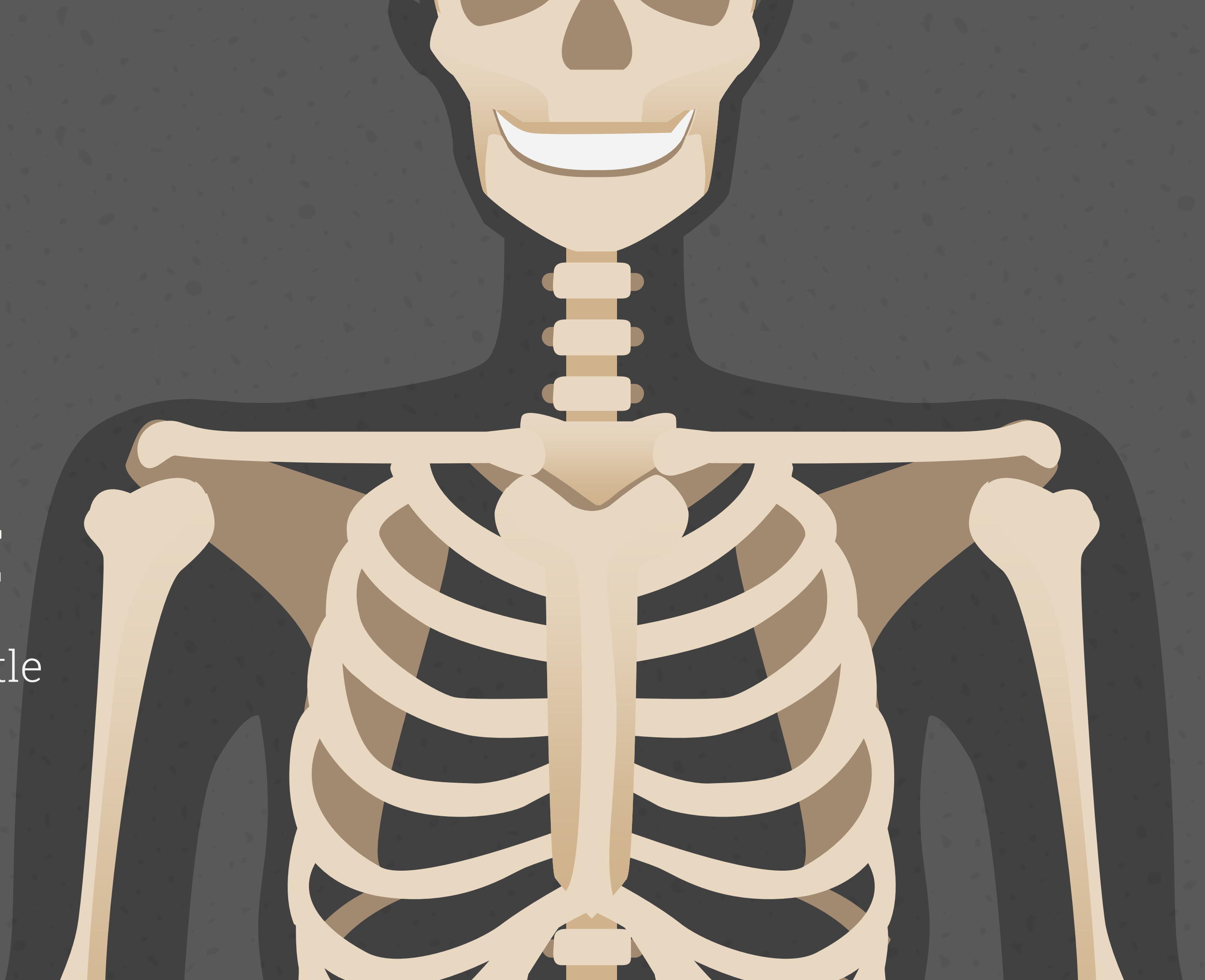
Answer:

$$\left.\begin{array}{c} m = 70kg \\ V_1 = 6\dfrac{m}{s} \\ V_2 = 0 \end{array}\right\} \rightarrow F = \frac{m(6-0)}{0.2} = \frac{70 \times 6}{0.2} = 2100\ N$$

04.

Assignment

You could enter a subtitle here if you need it



Future Works

Deadline

Monday
What then?

Next Session

HW & Our Lessons

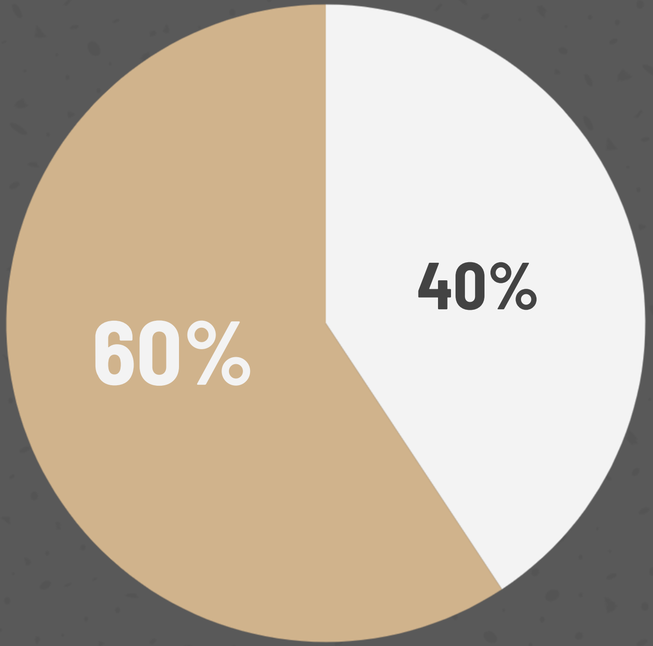
Your Understanding Process

Reviewing

The importance of learning the same topic more than once is faded for university students

Examples

You will learn much more than you'd thought during the process of solving problems



Class Activity

____________?

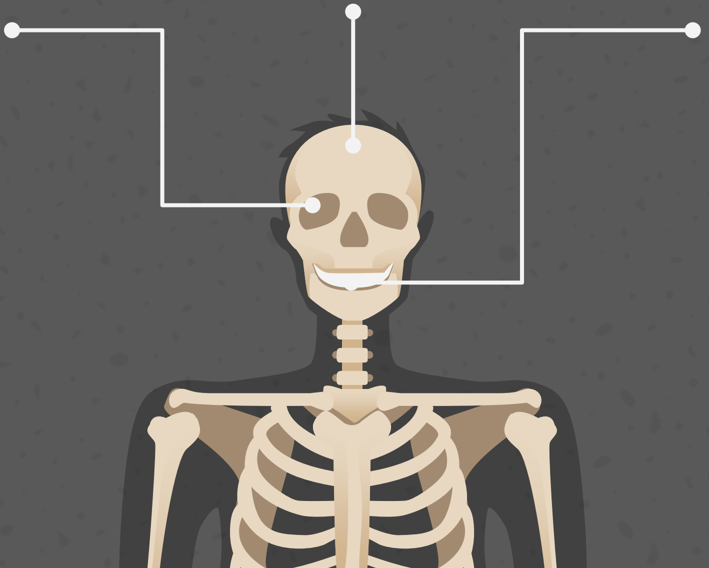
Think

____________?

Observe

____________?

Discuss



Assignment

Your First Class Activity!

?

Resources

Dr. Malikeh Nabaei

- Slides
- Classes

Faezeh Jahani

- Slides

Thanks!

Do you have any questions?

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CREDITS: This presentation template was created by Slidesgo, including icons by Flaticon, and infographics & images by Freepik

Additionally, Some Icons are taken from “Vector Icons and Stickers” and all the pictures are taken from the web

Have a good afternoon