Q Midterm

PHYS 107 - Week 5 - Wednesday

* Announcements: - Eid on Friday, tophat should work ~~work~~ but excused absence taken
- practice questions not graded

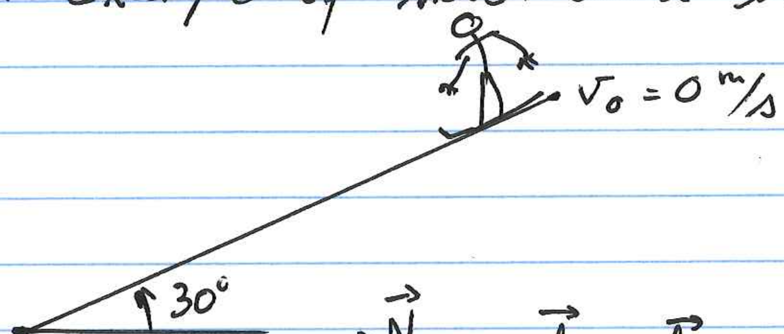
* Friction:

kinetic friction: $f_k = \mu_k N$

static friction: $0 \leq f_s \leq \mu_s N$

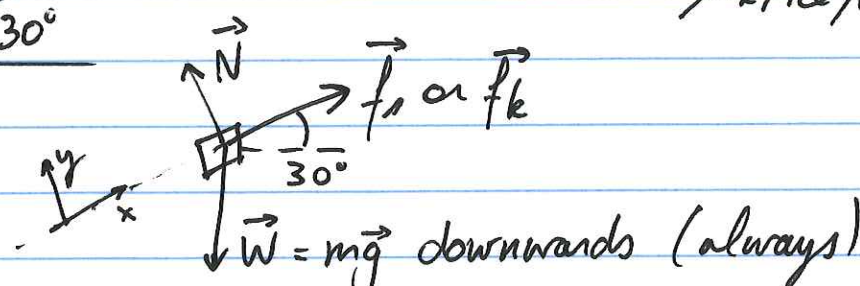
normal force $N \neq$ weight W

* Example of skier on a slope ($m = 70\,kg$)



$\mu_{s,\,ice/wood} = 0.05$
($\mu_{s,\,rubber/road} = 1$)
$\mu_{k,\,ice/wood} = 0.03$

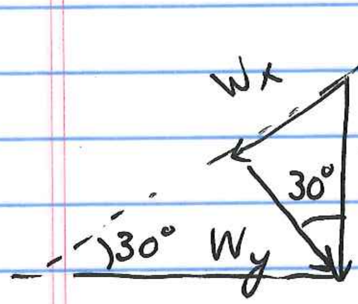
FBD



1) will the skier start moving?
2) what will be the velocity after 5 m?

Q Friction in skier
Q Weight in skier

- components : $\vec{N} = (0, N)$
  $\vec{W} = (-mg \sin 30°, -mg \cos 30°)$
  $\vec{f} = (f, 0)$



$\vec{W} = m\vec{g}$ → both components negative

- acceleration in y : $a_y = 0 \rightarrow N - mg\cos 30° = 0$

  $\hookrightarrow N = mg\cos 30° = 606\,N$

- acceleration in x :

  if $a_x = 0$, what does f_s have to be ?

  $\hookrightarrow f_s - mg \sin 30° = 0$

  $\hookrightarrow f_s = mg \sin 30° = 350\,N$

  is $f_s \leq \mu_s N$: for $\mu_{s,\,\text{ice/wood}} = 0.05$:

  $350\,N \not\leq (0.05)(606\,N)$

  $\downarrow$

  $a_x \neq 0$

(for $\mu_{s,\,\text{rubber/road}} = 1 \rightarrow 350\,N \leq (1.0)(606\,N)$)

$$a_x \neq 0 \rightarrow \quad \underset{\mu_k N}{\overset{f_k}{\parallel}} - mg \sin 30° = m a_x$$

$$a_x = \frac{f_k - mg \sin 30°}{m} = \frac{(0.03)(606N) - 350N}{70kg}$$

$$a_x = -4.7 \, m/s^2$$

- ~~p~~ velocity at $x = -5m$ from $x_0 = 0$

$$v^2 = v_0^2 + 2a_x(x - x_0)$$

$$v^2 = 0 + 2(-4.7 \, m/s^2)(-5m) \Rightarrow v = -4.87 \, m/s$$

negative x direction!

* Elasticity & Hooke's law

change of the shape of an object under an external force → deformation that is reversible

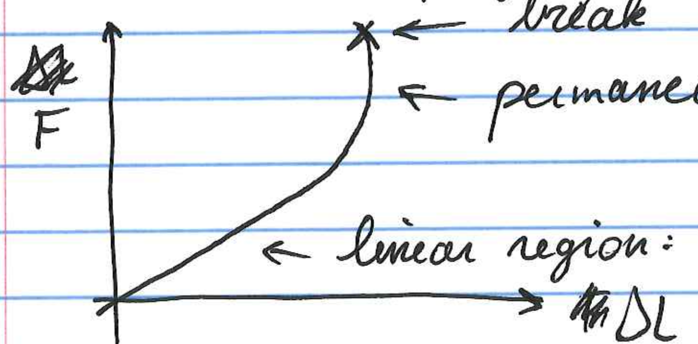
Hooke's law is often valid, for small deformations / forces

$$F = k\,\Delta L$$

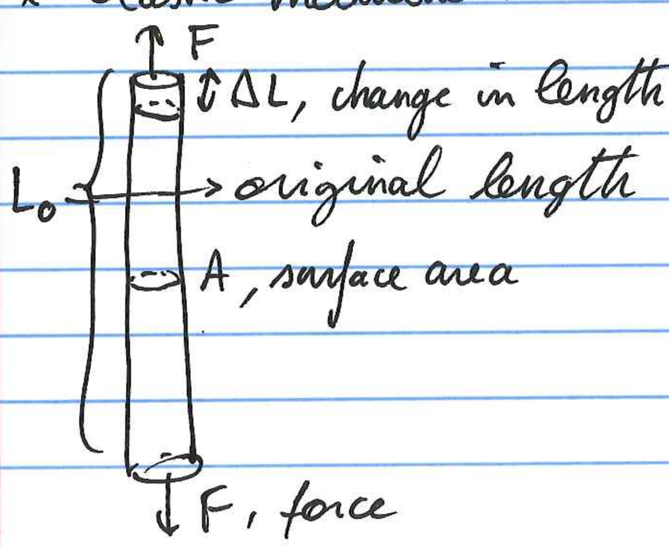
F: force (N)

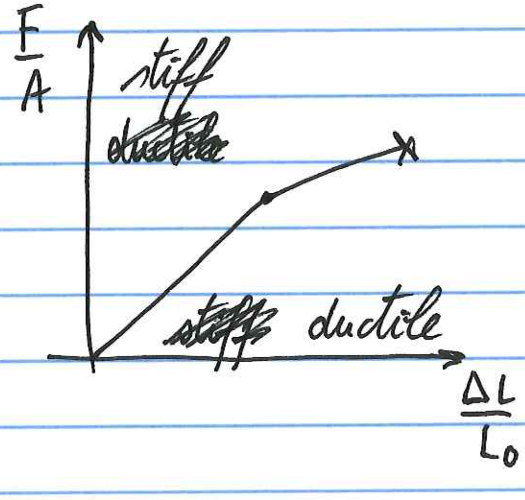
k: constant specific for the material $\left(\frac{N}{m}\right)$

ΔL: change in length (m)



* Elastic modulus :





$$\underbrace{\frac{F}{A}}_{\substack{\text{stress} \\ \left(\frac{N}{m^2}\right)}} = Y \underbrace{\left(\frac{\Delta L}{L_o}\right)}_{\substack{\text{strain} \\ \text{(no units)}}} \rightarrow \underline{k = \frac{AY}{L_o}}$$

Y: Young's modulus $\left(\frac{N}{m^2}\right)$
elastic

↳ slope of stress vs. strain graph

Q Ductile vs. Stiff

* Example: how much shorter is your femur when you stand up?

$L_0 = 43\,cm = 0.43\,m$

$A = 8\,cm^2 = 8 \times 10^{-4}\,m^2$

F = half of the weight if standing on both legs

$Y_{bone} = 9 \times 10^9\,N/m^2$

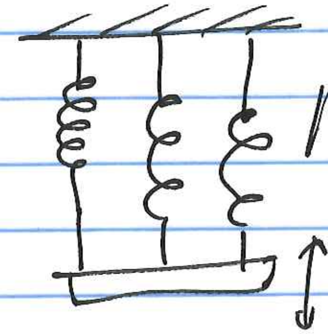
$$\hookrightarrow \Delta L = \frac{L_0}{Y}\frac{F}{A} = \frac{(0.43\,m)}{9 \times 10^9 \frac{N}{m^2}} \frac{\frac{1}{2}(80\,kg)(10\,m/s^2)}{8 \times 10^{-4}\,m^2}$$

$$= 2.4 \times 10^{-5}\,m$$

$$= 24\,\mu m \quad \text{(diameter of a hair)}$$

* Tendons : ductile for small strain
stiffer for larger strain (~10% strain in leg tendons)

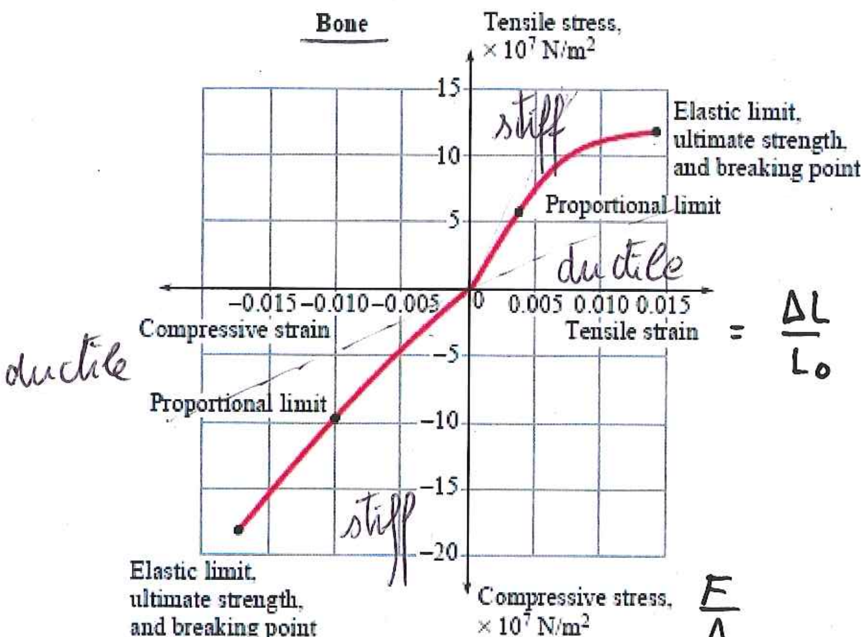
toe region : fibers align
linear region : fibers stretch
failure : fibers break



* Bone compression & tension :

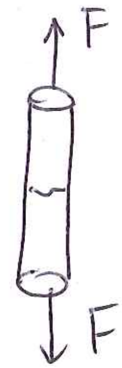
compression : hydroxy apatite (crystals)
extension : collagen protein (strands)

- osteoporosis : larger mineral content
→ stiffer, more brittle
- children have smaller mineral content
→ ductile but weaker

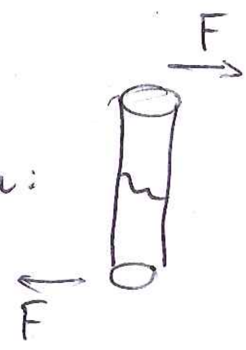


$= \dfrac{\Delta L}{L_0}$

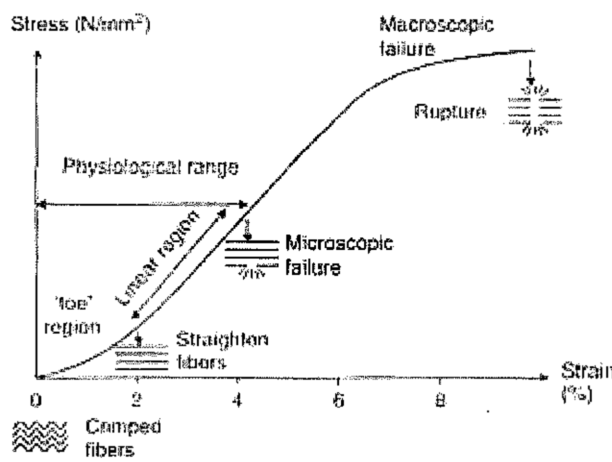
$\dfrac{F}{A}$



shear:



Tendon



Stress (N/mm²)
Macroscopic failure
Rupture
Physiological range
Linear region
Microscopic failure
'Toe' region
Straighten fibers
Strain (%)
0
2
4
6
8
Crimped fibers