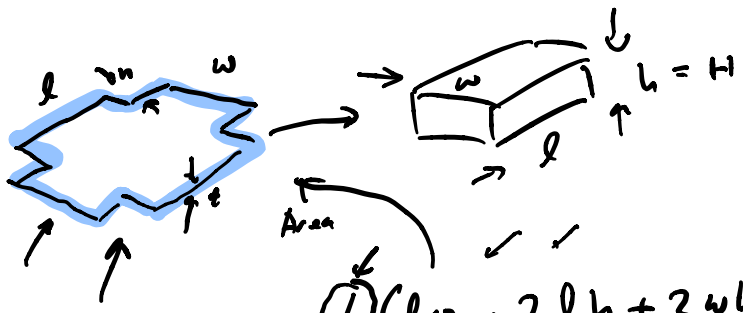
- Optimization examples
  - Box of min weight
  - Spring network problem
  - Four bar optimization
- Design project
- FEA intro!

Design of a box that minimizes the weight, but has volume V, and height H

minimize **w**



$$\text{Weight} = \rho\,(lw + 2lh + 2wh)$$

$$\vec{x} = [l, w, h] \quad x(1)\ x(2)\ x(3)$$

Constraints:

$l > 0$

$w > 0$

Input

$h - H = 0$

Vol

$l \cdot w \cdot h - V = 0$

lower bound = [0, 0, 0]

obj function $f(\vec{x}) = x(1)\,x(2) + 2x(1)\,x(3) + 2\,x(2)\cdot x(3)$

equality constraint $h(\vec{x}, H, V) = \begin{bmatrix} x(3) - H \\ x(1)\cdot x(2)\, x(3) - V \end{bmatrix}$ implied $= 0$

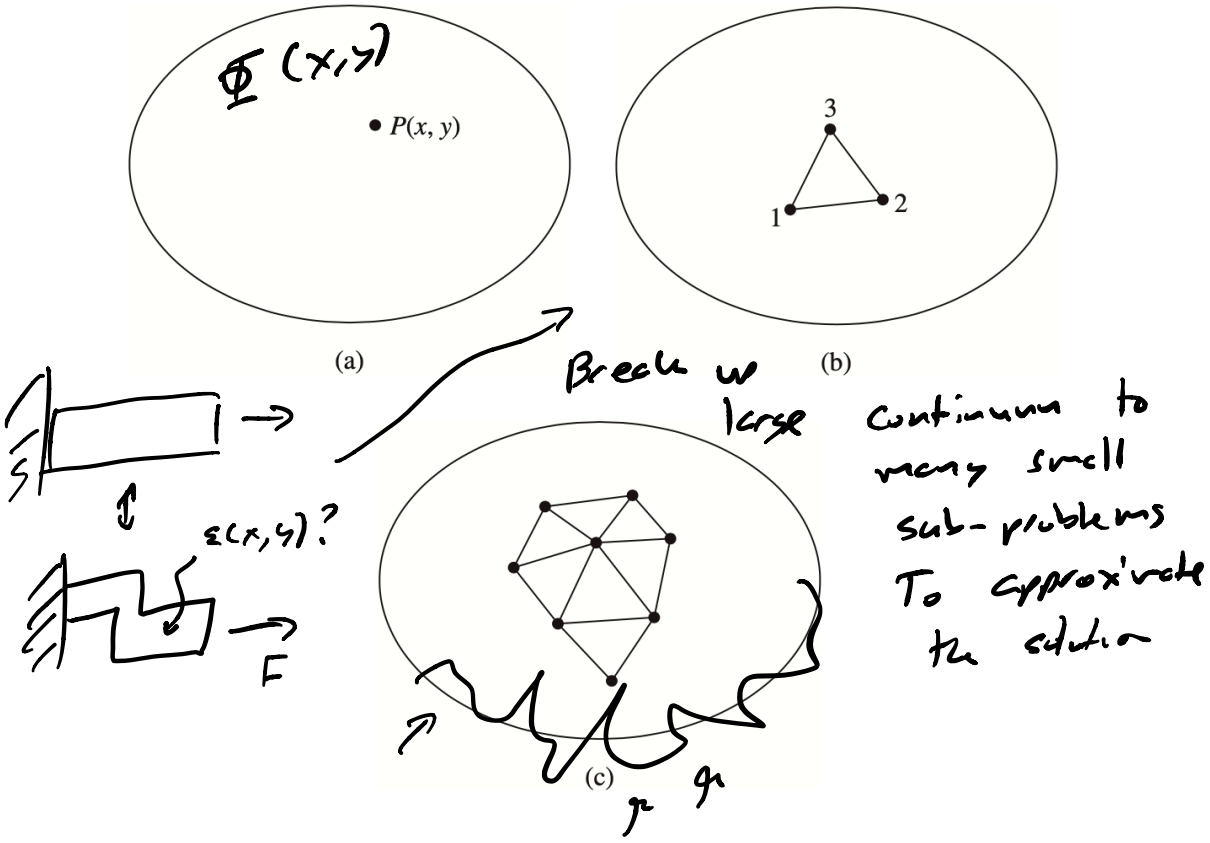
@(x) h(x, H, V)

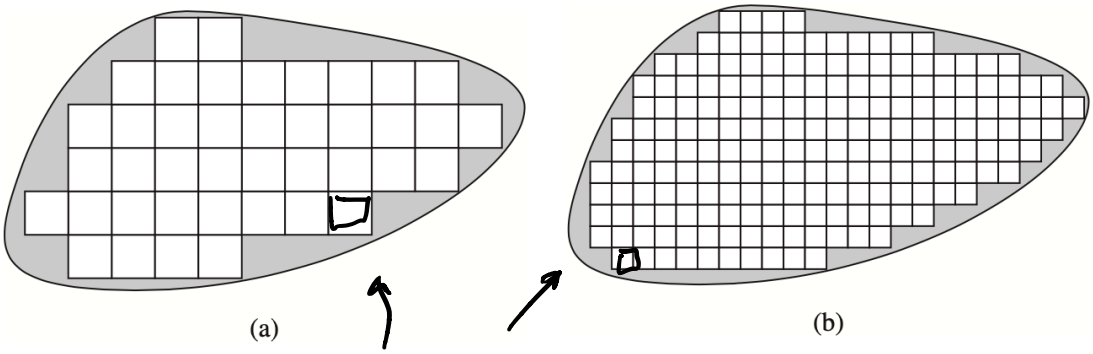
Anonymous functions

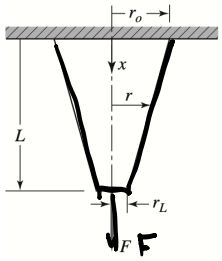
I could write $g(\vec{x}) = \begin{bmatrix} -x(1) \\ -x(2) \end{bmatrix} < 0$

Don't need

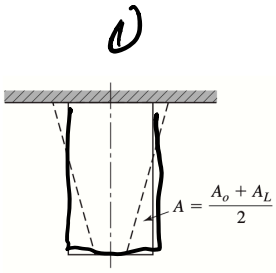
- Finite element analysis
  - Structural mechanics
  - Thermal systems
  - Fluid flow


Φ(x,y)
P(x, y)
(a)
3
1
2
(b)
Break up
large
continuum to
many small
sub-problems
To approximate
the solution
ε(x,y)?
F
(c)
q_1
q_n

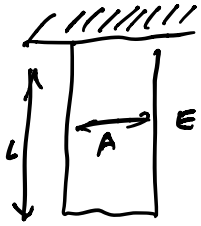

(a)
(b)


r_o
x
r
L
r_L
F
F

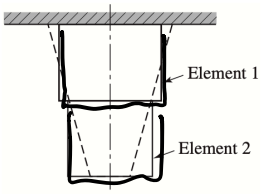
(a)

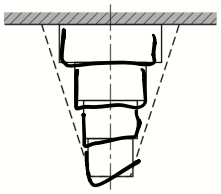

$A = \frac{A_o + A_L}{2}$

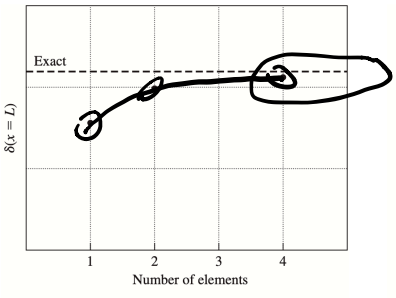
(b)

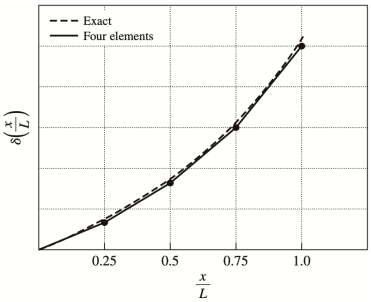

L
A
E

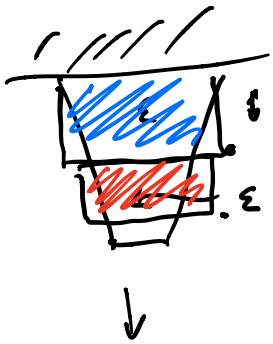

F

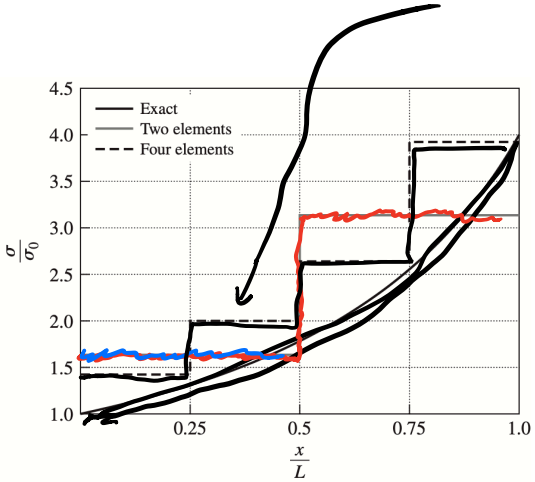

Element 1
Element 2




Exact
$\delta(x = L)$
1
2
3
4
Number of elements


Exact
Four elements
$\delta\left(\frac{x}{L}\right)$
0.25
0.5
0.75
1.0
$\frac{x}{L}$





FEA →

1) Break down shape into units / elements
2) Define mechanical response of elements
3) Solve equilibrium equations at nodes of each element
4) Evaluate $\underline{\phi}$ across the FEM mesh using shape function of that element