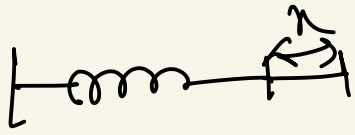
* Project-3 Topology Optimization *

In topology optimization we are trying to minimize the compilance of beam.

$$\min \; f := d^T K(x) d.$$

⇒ ⇒ As if we consider beam as an elastic member. (spring)



'x' is displaced.

$$\text{Energy stored} = \frac{1}{2} k x^2$$

⇒ ∴ $d^T K(x) d$ is the energy stored/ compilance

⇒ we need to minimize that.

Constrain : $h = K(x) d = u.$ → [Equality Constrain]

$u \rightarrow$ applied force / load.

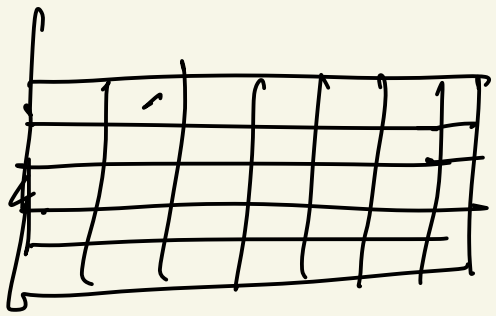
As $f = Kx$ is for spring system.

Inequality constraint :

$$g : V(x) \leq \bar{V}$$

$\Rightarrow \bar{V}$ is the total volume of the body.

Ex: If we are trying to construct a cantilever beam of volume ($\bar{V}$) using lego blocks.



$\bar{V}$ = max volume.

But If we do not have all blocks to fill but trying to compensate the load

applied from the given blocks $V(x)$

ie, $V(x) \leq \vartheta$ (max blocks)

↳ inequality constraints.

→ Ideally we need to either place (or) not place any logo block.

ie, $x \in$ either 0 (or) 1

↑ No material ↑ Presence of material.

→ But inorder to have continuity.

$$x \in [0,1]$$

ie, x can take any value b/w 0 to 1, including 0 & 1

$k = k_e E(x_i)$

$K(x) = G[k_1 \cdots\cdots k_n]$

$E(x_i) = \Delta E x_i^p + E_{min}$

∴ The final problem is a constrained optimization problem

Reduced gradient :

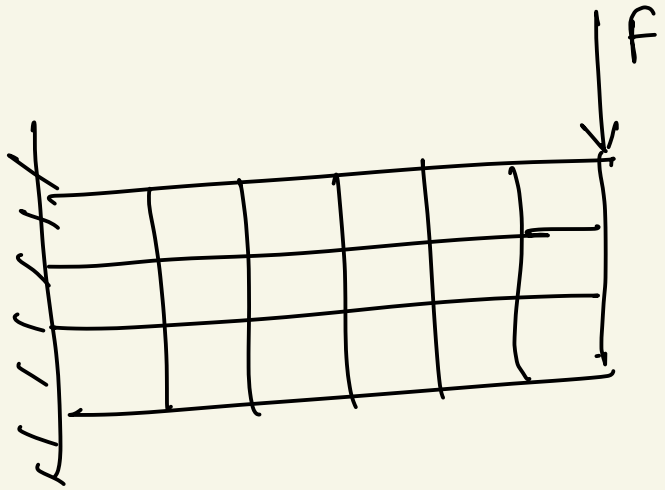
$$\frac{df}{dx} = \frac{\delta f}{\delta x} - \frac{\delta f}{\delta u}\left(\frac{\delta h}{\delta u}\right)^{-1}\frac{\delta h}{\delta x}.$$

$$\frac{dc}{dx} = -u^T \frac{\delta k}{\delta x} u.$$

Topology Optimization problem is solved by famous professor Dr. Sigmund. using 99 line MATLab code.

An improved version of 99 line MATLab code is a 88 line MATLab code.

Using 88 line code:-



Input for 88 line code is

top88(nelx, nely, volfrac, penal, rmin, ft)

nelem → no of elements along x

nely ⇒ no of elements along y.

vol fraction ⇒ inequality contrain $V(x) \leq V^0$

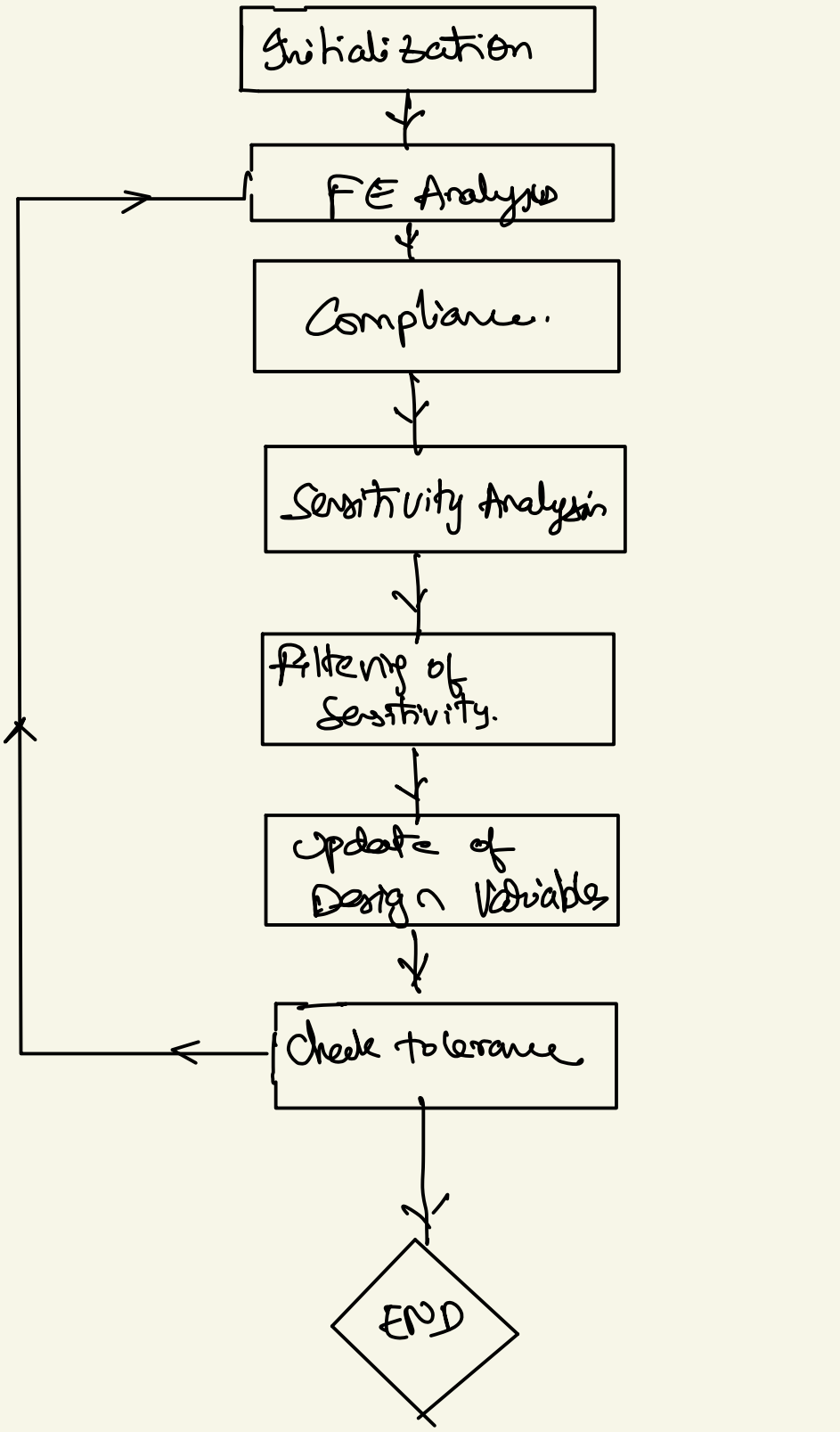
↳ value should be b/w (0, 1)

Penal ⇒ Penality makes the curve smooth.

It is that such that we dont

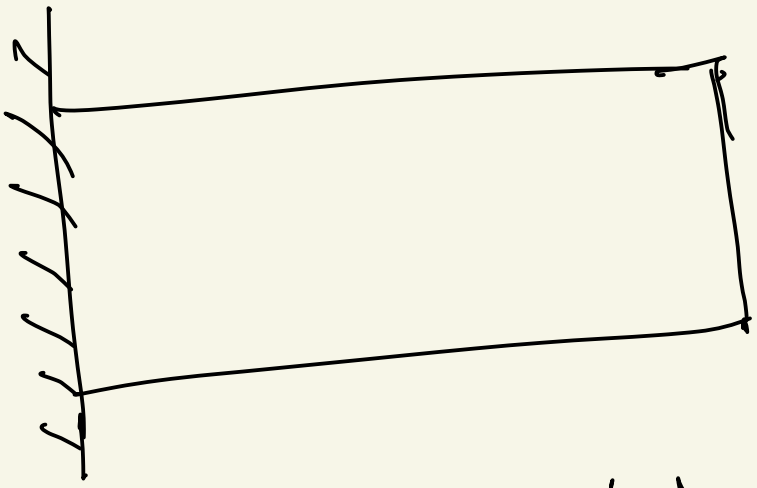
end up in checker board pattern.

Topology Optimization Flowchat



Our Problem :-

Using 88 line MATLAB code.



The cantilever beam is taken.

We used 88 line code and modified

. top88 (nelx, nely, volfr, penal, rmin, ft, Pr)

where Pr is the place where force

is specified.

for $n_{elg} = 100$

$n_{elg} = 160$

Pr: [32522, 3200, 31500, 31000, 30500]

and flow distribution of material is varied can be observed.