MEMS PROJECT

LUMPING MASS AND STIFFNESS OF COMPLIANT SUSPENSIONS

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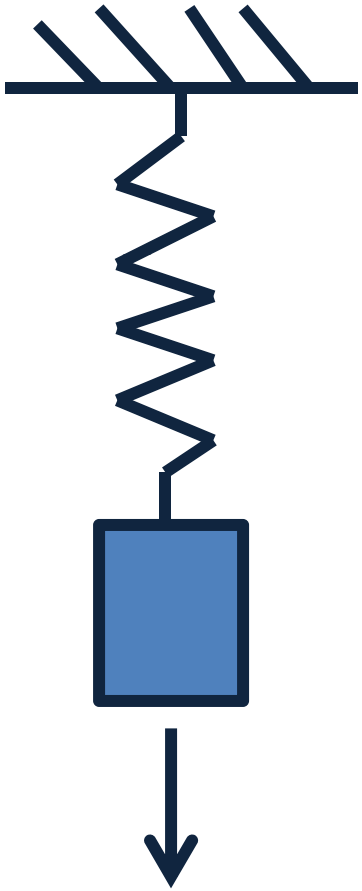
- What is lumping?

- Lumping refers to reducing the degrees of freedom of a system.

Generally, physical properties are distributed throughout a system. Finding an effective value of these properties at a localized region such that they have the same effect on the system is called lumping.

Distributed system

Lumped system



Lumping of stiffness

Arbitrarily choose a point on the system, and find the stiffness at that point.

Lumping of mass

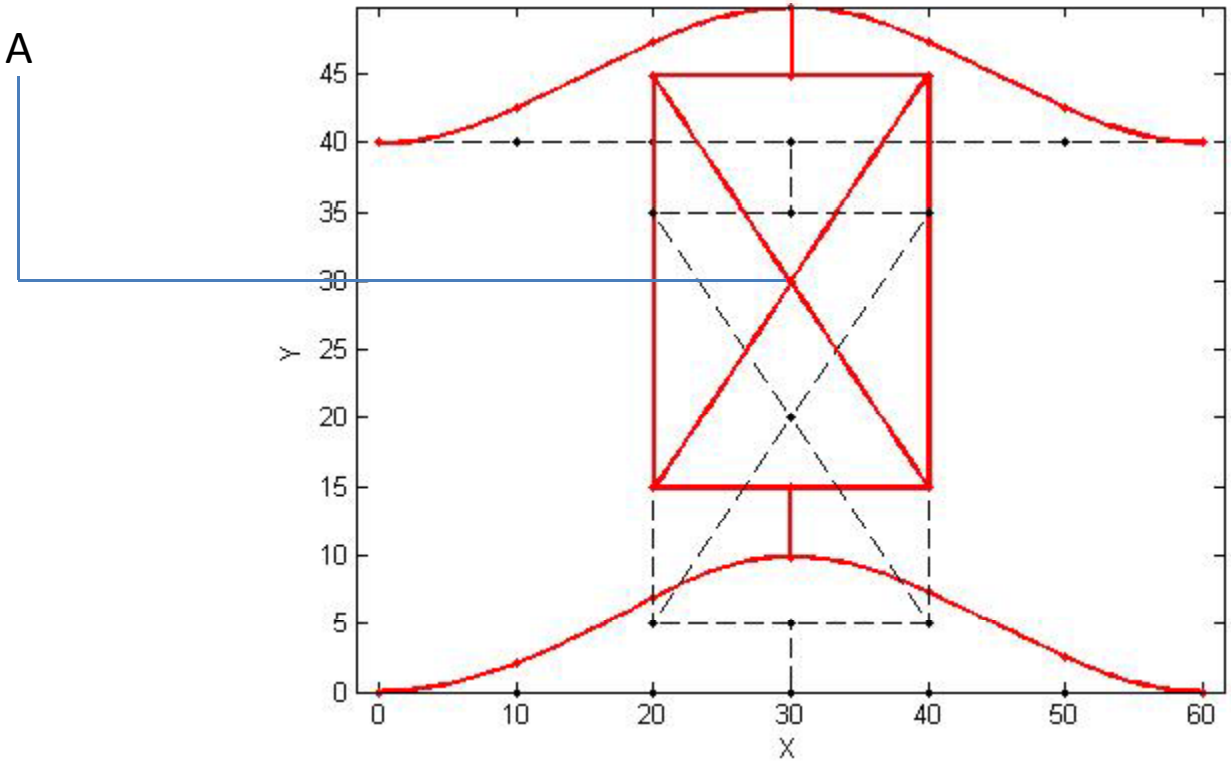
The effective value of mass at that point is calculated by comparing the kinetic energies of the system in lumped and distributed configurations.

$$\frac{1}{2}M\dot{Y}^2 = \frac{1}{2}\int_m \dot{y}^2 \mathrm{dm} = \frac{\rho T}{2}\int_A \dot{y}^2 \, \mathrm{dA}$$

- y(x,t)=y(x)sin (*wt*)
- $\dot{y} = y(x)w\cos(wt)$
- $MY^2 = \rho T \int_A y(x)^2 dA$
- $M = \frac{\rho T}{Y^2}\int_A y(x)^2 dA$

M is effective mass

- Suspension chosen



- Modification made to the beam FEM code

```
aa=forces(1,2); % node numner for calculating efective stiffness

Uaa=U(3*(aa-1)+2); % displacement of node aa in y direction
keff=forces(1,4)/Uaa
mm=0;

for ie=1:NELEM,
   if(elem(ie,9)==1)
      mm=mm+ U(3*(ie-1)+2)^2*L(ie)*A(ie);
   end
end
meff=rho*mm/Uaa^2
```

- REMARK

The accuracy of the effective mass can be increased by decreasing the element length, thereby accounting for the displacements of more number of nodes(points) along the length of the element.

- Mass of the suspension.

m=$\rho * volume$

=2300*1460

=3.35E6 kg

Lumped mass at node A obtained from matlab

M=2.33E6 kg.

Stiffness at node A, k_{eff} **=201.6 N/m**

THANK YOU