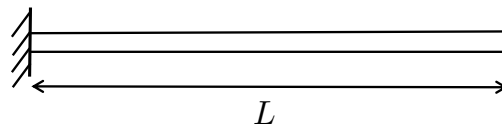


# Abaqus Handout: Natural frequency and Buckling

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## 1 Natural Frequency



Elastic modulus,  $E$   
Moment of inertia,  $I$   
Mass density,  $\rho$   
Cross sectional area,  $A$

Natural frequencies:  $\omega^2 = \frac{k^2}{L^2} \sqrt{\frac{EI}{\rho A}}$

where  $k$  is the root of the transcendental equation  $1 + \cos(k) \cosh(k) = 0$

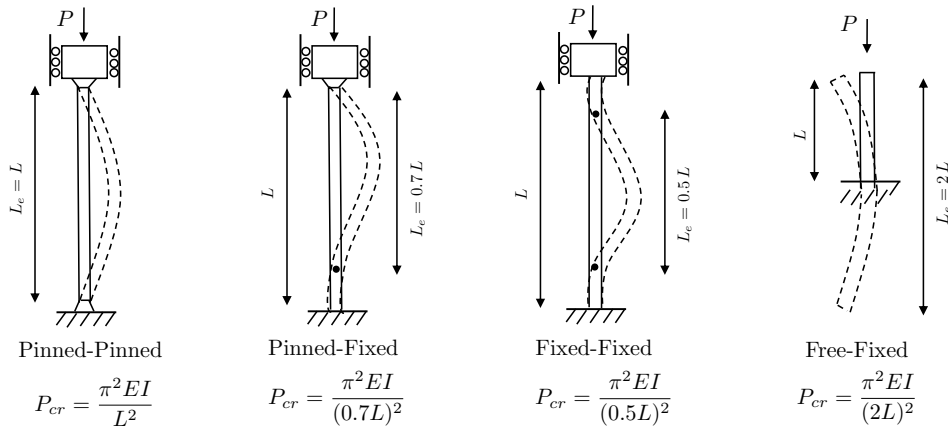
- Part
  - Part  $\Rightarrow$  Create
  - Select 2D Planar, Deformable, Wire, and Approximate size of 5
  - Sketch the part and click done
- Property
  - Material  $\Rightarrow$  Create
  - Mechanical  $\Rightarrow$  Elasticity  $\Rightarrow$  Elastic
  - Enter the material properties for steel
  - Go to General  $\Rightarrow$  density  $\Rightarrow$  enter mass density and click OK
  - Profile  $\Rightarrow$  Create - Rectangular  $\Rightarrow$  Enter the cross sectional dimensions and click OK
  - Section  $\Rightarrow$  Create - Select Beam  $\Rightarrow$  Beam  $\Rightarrow$  Continue
  - Assign  $\Rightarrow$  Section - Select the entire part and click done
  - Assign  $\Rightarrow$  Beam section orientation - Select the entire part and click done
  - Accept the default orientation and click OK
- Assembly
  - Create instance  $\Rightarrow$  OK
- Step
  - Step  $\Rightarrow$  Create  $\Rightarrow$  Static/Linear perturbation  $\Rightarrow$  Select Frequency and continue
  - Number of eigenvalues - write 8  $\Rightarrow$  OK

- Load
  - BC  $\Rightarrow$  Create  $\Rightarrow$  Mechanical  $\Rightarrow$  Displacement/Rotation  $\Rightarrow$  Continue  $\Rightarrow$  Select the left end and click done  $\Rightarrow$  Enter  $U1 = U2 = UR3 = 0$  and click OK
- Mesh
  - Make sure Object is set to part
  - Mesh  $\Rightarrow$  Element Type  $\Rightarrow$  Select the entire part and click done  $\Rightarrow$  Family: Beam  $\Rightarrow$  Select Beam type: Cubic Formulation
  - Seed  $\Rightarrow$  Part  $\Rightarrow$  Approximate global size: 20  $\Rightarrow$  Click OK
  - Mesh  $\Rightarrow$  Part  $\Rightarrow$  Yes
- Job
  - Job  $\Rightarrow$  Create  $\Rightarrow$  Continue/OK - Job  $\Rightarrow$  Submit  $\Rightarrow$  Job-1 - When the job successfully completes: Job  $\Rightarrow$  Results  $\Rightarrow$  Job-1
- Visualization
  - Open the odb file and visualize the mode shapes and frequencies

## 2 Buckling

Smallest  $P$  corresponding to first buckling mode is  $P_{cr}$

Euler's formula  $\rightarrow$  
$$P_{cr} = \frac{\pi^2 EI}{L^2}$$



- Part
  - Part  $\Rightarrow$  Create
  - Select 2D Planar, Deformable, Wire, and Approximate size of 5
  - Sketch the part and click done
- Property
  - Material  $\Rightarrow$  Create
  - Mechanical  $\Rightarrow$  Elasticity  $\Rightarrow$  Elastic

- Enter the material properties for steel and click OK
- Profile  $\Rightarrow$  Create - Rectangular  $\Rightarrow$  Enter the cross sectional dimensions and click OK
- Section  $\Rightarrow$  Create - Select Beam  $\Rightarrow$  Beam  $\Rightarrow$  Continue
- Assign  $\Rightarrow$  Section - Select the entire part and click done
- Assign  $\Rightarrow$  Beam section orientation - Select the entire part and click done
- Accept the default orientation and click OK
- Assembly
  - Create instance  $\Rightarrow$  OK
- Step
  - Step  $\Rightarrow$  Create  $\Rightarrow$  Static/Linear perturbation  $\Rightarrow$  Select Buckle and continue
  - Number of eigenvalues - write 4
- Load (Pinned-Pinned)
  - BC1  $\Rightarrow$  Create  $\Rightarrow$  Mechanical  $\Rightarrow$  Displacement/Rotation  $\Rightarrow$  Continue  $\Rightarrow$  Select the bottom end and click done  $\Rightarrow$  Enter  $U1 = U2 = 0$  and click OK
  - BC2  $\Rightarrow$  Give  $U1 = 0$  at the top end
  - Load  $\Rightarrow$  Mechanical  $\Rightarrow$  Select concentrated force  $\Rightarrow$  Enter  $CF2 = -1$
- Mesh
  - Make sure Object is set to part
  - Mesh  $\Rightarrow$  Element Type  $\Rightarrow$  Select the entire part and click done  $\Rightarrow$  Family: Beam  $\Rightarrow$  Select Beam type: Cubic Formulation
  - Seed  $\Rightarrow$  Edges  $\Rightarrow$  Select the entire part and click done  $\Rightarrow$  Method: By number  $\Rightarrow$  Number of elements: 20  $\Rightarrow$  Click OK - Mesh  $\Rightarrow$  Part  $\Rightarrow$  Yes
- Job
  - Job  $\Rightarrow$  Create  $\Rightarrow$  Continue/OK - Job  $\Rightarrow$  Submit  $\Rightarrow$  Job-1 - When the job successfully completes: Job  $\Rightarrow$  Results  $\Rightarrow$  Job-1
- Visualization
  - Open the odb file and visualize the mode shapes and corresponding eigenvalues