CIEM5110-2: FEM, lecture/workshop 7.1

Frequency analysis

Frans van der Meer & Iuri Rocha

TUDelft

CIEM5110-2 workshops and lectures

	(Theory)	SolidModel (1.2, 5.2)	FrameModel (4.1, 4.2)	TimoshenkoModel (2.1)
SolverModule	(2.2)	3.2	3.2	3.2
NonlinModule	(3.1, 5.2)	6.1	4.1 + 4.2 + 5.1	
ArclenModule	(4.2)		4.2	
LinBuckModule	(4.1)		4.1 + 5.1	
ModeShapeModule	(7.1)	7.1	7.1, 8.2	
ExplicitTimeModule	(6.2)		7.2 + 8.2	
Newmarkmodule	(6.2)			

Frequency analysis

Back to the undamped semi-discretized system of equations

$$\mathbf{M}\ddot{\mathbf{a}} + \mathbf{K}\mathbf{a} = \mathbf{f}$$

We can find natural frequencies with a generalized eigenvalue problem

$$\det\left(\mathbf{K} - \omega^2\mathbf{M}\right) = 0$$

Eigenmodes are the modes of vibration

Frequency analysis

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Compare with linear buckling analysis, where we solved

$$\det\left(\mathbf{K}_M + \lambda\mathbf{K}_G\right) = 0$$

To compute the critical buckling load and buckling mode

FE analysis of dynamics of solids and structures: discussion

Explicit time-dependent analysis (central difference scheme)

- Individual time steps are very efficient (especially with mass lumping)
- Need small time steps, related to the mesh size
- Sometimes this is used/abused for quasi-static analysis (mass scaling)

Implicit time-dependent analysis (Newmark scheme)

- Stable but more costly per time step
- Time steps can be much larger, related to the time scale of the problem at hand
- Numerical damping comes at a price in accuracy

Frequency analysis

- Provides natural frequencies and vibration modes
- If structure (bridge/building/...) cannot be modeled as a prismatic beam
- Gives information on vibration mode, could proceed with forced modal analysis