CE 225: Dynamic of Structures **Fall 2025**

Discussion 5: Response Spectrum - Applications

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Announcements

- Solution for HW#4 is up on bCourses.

Summary of Central Difference and Newmark's Methods

Scheme:	**Central Difference**	**Newmark**
Algorithm	Define Δt (see Stability) Initial Calculations $\ddot{u}_0$, u_{-1}, $\hat{k}$, a, b For each time step $i = 1, ..., N-1$ - $\hat{p}_i = p_i + au_{i-1} + bu_i$ - $u_{i+1} = \dfrac{\hat{p}_i}{\hat{k}}$ - If we want: $\dot{u}_i$, $\ddot{u}_i$	Define Δt (See stability) Define β and γ (See stability) Initial Calculations $\ddot{u}_0$, a_1, a_2, a_3, $\hat{k} = k + a_1$ For each time step $i = 1, ..., N-1$ - $\hat{p}_{i+1} = p_{i+1} + a_1 u_i + b\dot{u}_i + c\ddot{u}_i$ - $u_{i+1} = \dfrac{\hat{p}_{i+1}}{\hat{k}}$ - We need $\dot{u}_{i+1}$, $\ddot{u}_{i+1}$
Type	Explicit - EOM enforced at time t_i	Implicit - EOM enforced at time t_{i+1}
Stability	Conditionally stable: $\dfrac{\Delta t}{T_n} \leq \dfrac{1}{\pi}$	It depends on the chosen scheme: $\dfrac{\Delta t}{T_n} \leq \dfrac{1}{\pi\sqrt{2}} \dfrac{1}{\sqrt{\gamma - 2\beta}}$ In practice: Constant acceleration ($\beta = 1/4$, $\gamma = 1/2$) - Unconditionally stable Linear acceleration: ($\beta = 1/6$, $\gamma = 1/2$) - Conditionally stable under: $\dfrac{\Delta t}{T_n} < 0.551$
Nonlinear Systems	Modified $\hat{p}_i$ to account $f_S(u_i)$ $\hat{p}_i = p_i - au_{i-1} + \dfrac{2m}{(\Delta t)^2} u_i - (f_S)_i$	Incremental form of the EOM: $m\Delta\ddot{u}_i + c\Delta\dot{u}_i + \Delta(f_S)_i = \Delta p_i$ 2 Options: - Approximate $(f_S)_{i+1} \approx (k_T)_i u_{i+1}$ - Newton-Raphson Iterations

Table 0.1: Comparison between the schemes

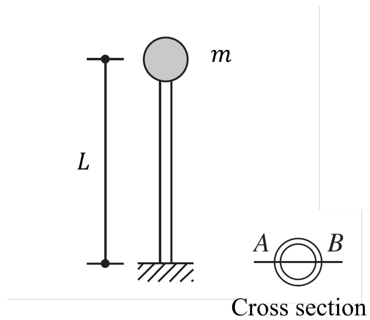
Some relevant concepts about the response spectrum

Some questions...

Response Spectrum Applications

Example 1 - Peak response

A 10-ft long vertical cantilever made of a steel pipe supports a 3000-lb weight attached at the tip, as shown in the Figure below. The properties of the pipe are: outside diameter = 6.625 in, inside diameter = 6.065 in, thickness = 0.280 in, second moment of cross-sectional area $I = 28.1$ in^4, Young's modulus $E = 29,000$ ksi, and weight per unit length = 18.97 lb/ft. Determine the peak deformation and the bending stress in the cantilever due to the El Centro ground motion. Assume $\zeta = 5\%$. The peak ground acceleration (PGA) of the El Centro Ground motion is 0.319g, and the response spectrum is shown below.



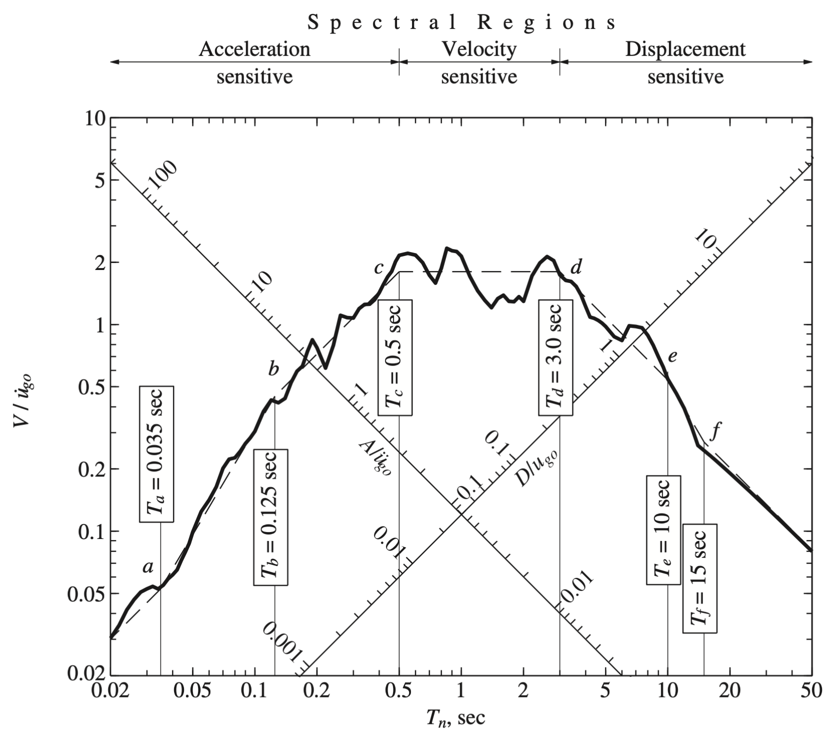
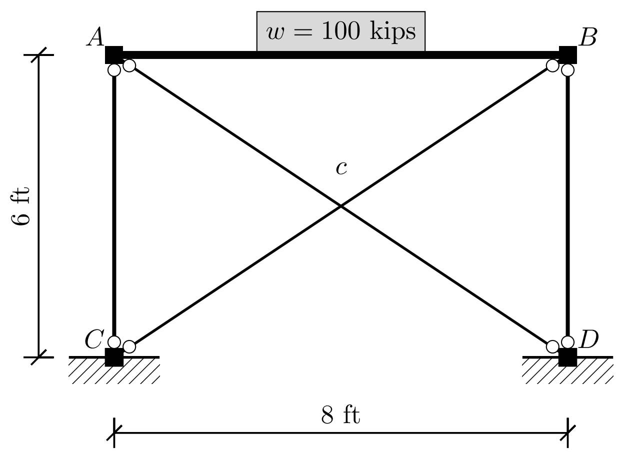


Figure 6.8.3 Response spectrum for El Centro ground motion shown by a solid line together with an idealized version shown by a dashed line; $\zeta = 5\%$.

Example 2

The braced frame in the Figure below is made of two hinged columns and two wires. The columns do not participate in the lateral stiffness. The wires are prestressed to an initial tension of $p_o = 20$ kips. The properties of each wire are: cross-section area $A = 0.153$ in^2 and $E = 29,000$ ksi. The structure supports a rigid beam, which supports a weight of 100 kips. The structure is subjected to the El Centro ground motion. Will the wires become loose during the earthquake?



Mid-semester evaluation

I'd like to get your input on how you feel discussions and office hours are going so far. Your feedback is very much appreciated! Here's the link to my mid-semester evaluation. Your responses will remain anonymous.

https://tinyurl.com/ce225-gsi-eval