EXAM 4 STUDY GUIDE
Exam Date: Wednesday, November 2nd, 2016
8am
Room 206
50 Minute Time Limit

EXAM FORMAT
Students are allowed one 8 ½” x 11” handwritten sheet of their own notes and the Chopra textbook. Students must also have the AISC steel manual for the potential use of beam formulae.

EXAM COVERAGE
The scope of the exam is limited to Lessons 20 to 25.

LESSONS, LESSON OBJECTIVES, AND SAMPLE PROBLEMS
ASSUME STEEL, ELASTIC, AND 5% DAMPING, UNLESS NOTED OTHERWISE

LESSON 20: TIME-HISTORY ANALYSIS

• Apply the Constant Acceleration Method to an earthquake excitation to obtain the time-history response of an SDOF.
• Develop an acceleration response spectrum, based on the El Centro earthquake.

1. (5 points) The displacement response of an SDOF with a natural period $T_n = 1$ second was determined for a particular earthquake base excitation, using the Constant Acceleration Method (Newmark’s Method), resulting in the following plot. What is the maximum Pseudoacceleration of this SDOF?

2. (5 points). If a structure with a natural period of 0.5 seconds undergoes a peak Pseudoacceleration of 1g, what is the maximum displacement?

3. (25 points). Plot the Pseudoacceleration Response Spectrum for Earthquake X, based on the following data.
Given:
Newmark’s Constant Acceleration Method was used to produce the following Five Displacement Time Series plots, each for a different SDOF. All SDOF’s had 20% damping.
LESSON 21: RESPONSE SPECTRUM ANALYSIS

- Compute responses (acceleration, velocity, and displacement) for a braced-frame or rigid frame structure, using Response Spectra.
- Distinguish between pseudo-responses and actual responses, that the pseudo-acceleration is nearly the same as the actual acceleration response (when periods are low) and demonstrate that displacements found on RSA plots represent total displacements, rather than relative displacements.

4. (25 points). The water tower shown is considered to be an SDOF with 5% damping. When the water tank is filled, it has a weight of 1000 kips. The support structure consists of a hollow steel pipe with a 6-ft outside diameter and a wall thickness of 1 inch (note: \( I = \frac{\pi r^4}{4} \)). The centroid of the water tank is elevated 175 feet off the ground. If the tower is subjected to ground shaking from the El Centro earthquake, draw the moment diagram of the support structure. Assume it remains ELASTIC.

**GIVEN:**

\[ W = 1000 \text{ kips, filled} \]

**PIPE CROSS-SECTION**

- 6-ft Outside Diameter
- 1” wall thickness

**WATER TOWER**

\[ 6\text{-ft-diam pipe} \]

\[ 175 \text{ feet} \]
LESSON 23: RESPONSE SPECTRUM ANALYSIS II – DESIGN SPECTRA

- **Plot** a standard design spectrum using the Newmark and Hall (Chopra) procedure and **Apply** it to determine the forces and displacements of an SDOF.
- **Describe** the effects of earthquake size, soil conditions, and distance to fault on the frequency content of the earthquake.

5. **(8 points)** Two (Pseudo) Acceleration Response Spectra are shown, for two different sites, A and B. Circle all that are correct.

a. Site A is more likely a hard-rock site, while Site B is more likely a soft-soil site.

b. Site A is more likely a soft-soil site, while Site B is more likely a hard-rock site.

c. Site A may plausibly represent a very large, but distant earthquake, while Site B may plausibly represent a smaller, closer earthquake.

d. Site A may plausibly represent a smaller, closer earthquake, while Site B may plausibly represent a very large, but distant earthquake.
6. (3 points). TRUE or FALSE. If the peak ground acceleration of a certain earthquake is 0.6g then the structure must be designed for a peak acceleration of 0.6g.

7. (3 points). TRUE or FALSE. Given the Response Spectrum, below, the peak ground acceleration for this earthquake must be 0.2g.

![Acceleration Response Spectrum - A](image)

8. (3 points). TRUE or FALSE. If the peak ground acceleration of a certain earthquake is 0.2g, then it is not possible for an SDOF at that site to experience less than 0.2g.

9. (3 points). TRUE or FALSE. If the peak ground acceleration of a certain earthquake is 0.2g, then it is not possible for an SDOF at that site to experience more than 0.2g.

10. (50 points). Construct a standard 0.5g earthquake (5% damping) on the DVA plot, below, using the standard “hard soil” assumptions of Newmark: \( \ddot{u}_g + \frac{48}{\pi^2} \ddot{u}_g + \ddot{u}_g = 6 \) in consistent units (e.g., inches, seconds). Then, determine the brace force for the single-story gymnasium shown if it is a simple-braced in one direction (the direction shown), but a rigid frame in the other direction. Do not analyze the rigid-frame direction.

   Given: Story height = 35 ft. Building footprint: 60ft x 120ft. Roof dead load = 20 psf. Snow load = 20 psf. Assume that the controlling case occurs when the roof is snow-loaded.

   - Each brace has an area of 40 in². These ARE NOT TENSION-ONLY BRACES (they are huge and will resist compression, as well). Consequently, all four braces contribute to stiffness and the redundant braces will share the horizontal forces, equally.
LESSON 24: RESPONSE SPECTRUM ANALYSIS III – SOIL EFFECTS

- **Plot ASCE7 Acceleration Spectra**

  11. (35 points). Consider the Gymnasium Building (see previous). It is located on a Class D soil. From the ASCE7 maps, it is found that the mapped 1-second spectral acceleration is 0.1g, while the 0.2-second spectral acceleration is 0.3g. Determine the brace force, assuming it remains elastic.

LESSON 25: INELASTIC RESPONSE I

- **Describe** the reason “making it stronger” doesn’t always work in seismic problems.
- **Describe** the role of ductility and energy absorption in seismic force resistance.
- **Compute** the theoretical (based on physics) elastic and plastic drift of a structure, assuming that its lateral system is elastic-plastic with sufficient ductility (and compute theoretical peak velocities, just to prove that your physics knowledge is paying off).

  12. (15 points). Draw an illustrative Acceleration Response Spectrum and a simple braced frame, using these visual aids to illustrate why it is often difficult to design a structure to remain elastic in high-seismic zones.

  13. (5 points). Suppose a structure was built by gluing together pieces of porcelain with Krazy Glue. What should the $R_y$ value be?

  14. (50 points). The simple-braced frame shown below is located on a Class D soil. From the ASCE7 maps, it is found that the mapped 1-second spectral acceleration is 0.4g, while the 0.2-second spectral acceleration is 1g. The braces are considered tension-only (ignore the compression brace). If the braces have a yield strength of 36 ksi and brace areas of 0.5in$^2$, determine the maximum amount of plastic deformation.

  Given: story height = 30 ft. All bays are 30 ft. Roof total load: 40 psf.