Problem L

Periodic Loading

Steel
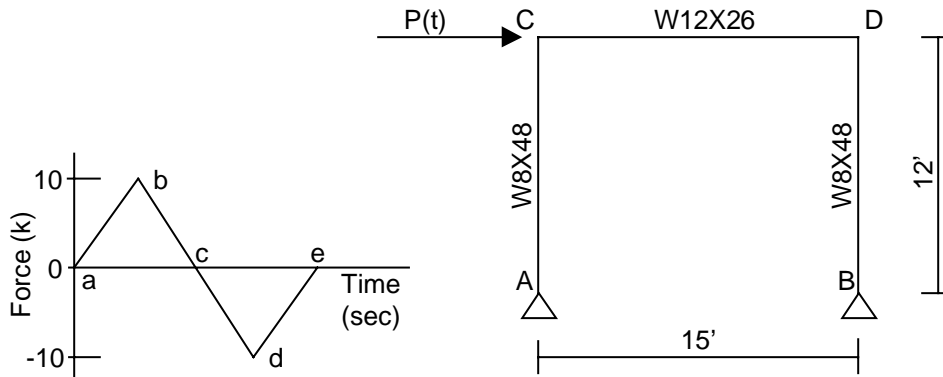E =29000 ksi, Poissons Ratio = 0.3
Pinned base
All beam-column connections are rigid

Joint Masses
Lumped mass at joints C and D is 0.02 kip-sec^2 / in

Loading
The load P(t), applied to joint C, is a periodic load. Three different loading cases (functions) are defined for P(t). The three loading functions, which have periods of 0.25, 0.50 and 1.00 seconds respectively, are shown in the chart and graph below. Assume 5% damping for all loading.
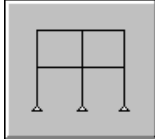

Point	Force (k)	Time Function 1 (sec)	Time Function 2 (sec)	Time Function 3 (sec)	Note: The period of time functions 1, 2 and 3 is 0.25, 0.5 and 1 seconds respectively.
a	0	0	0	0	
b	10	0.0625	0.125	0.25	
c	0	0.125	0.25	0.5	
d	-10	0.1875	0.375	0.75	
e	0	0.25	0.5	1	

To Do
1. Verify natural period of structure is approximately 0.50 seconds.
2. Determine displacement at joint D for the three periodic functions.

Note: Our intent is that you try this problem on your own first. After you have solved it on your own, you can step through our solution if desired. If you have problems trying to create the model, then follow the steps in our solution.

Problem L Solution

1. Click the drop down box in the status bar to change the units to kip-ft. `Kip-ft ▾`

2. From the **File** menu select **New Model From Template…**. This displays the Model Templates dialog box.

3. In this dialog box click on the **Portal Frame** template ⊞ button to display the Portal Frame dialog box.

4. In this dialog box:

   - Type **1** in the Number of Stories edit box.

   - Type **1** in the Number of Bays edit box.

   - Type **15** in the Bay Width edit box.

   - Click the **OK** button.

5. Click the "X" in the top right-hand corner of the 3-D View window to close it.

6. Click the drop down box in the status bar to change the units to kip-in. `Kip-in ▾`

7. From the **Define** menu select **Materials...** to display the Define Materials dialog box. Highlight the STEEL material and click the **Modify/Show Material** button to display the Material Property Data dialog box.

8. In this dialog box:

   - Verify that the modulus of elasticity is 29000 and poisson's ratio is 0.3.

   - Click the **OK** button twice to exit the dialog boxes.

9. From the **Define** menu select **Frame Sections...** to display the Define Frame Sections dialog box.

10. In the Click To area, click the drop-down box that says Import I/Wide Flange and then click on the Import I/Wide Flange item.

11. If the Section Property File dialog box appears then locate the Sections.pro file which should be located in the same directory as the SAP2000 program files. Highlight Sections.pro and click the **Open** button.

12. A dialog box appears with a list of all wide flange sections in the database. In this dialog box:

- Scroll down and click on the W12X26 section.

- Scroll down to the W8X48 section, and click on it while holding down the Ctrl key on the keyboard.

- Click the **OK** button three times to exit all dialog boxes.

13. Select the beam element.

14. From the **Assign** menu select **Frame** and then **Sections...** from the submenu to display the Define Frame Sections dialog box.

15. In this dialog box:

- Click on W12X26 in the Frame Sections area to highlight it.

- Click the **OK** button.

16. Select the two column elements.

17. From the **Assign** menu select **Frame** and then **Sections...** from the submenu to display the Define Frame Sections dialog box.

18. In this dialog box:

- Click on W8X48 in the Frame Sections area to highlight it.

- Click the **OK** button.

19. Select the joints labeled C and D in the problem statement.

20. From the **Assign** menu select **Joint** and then **Masses...** from the submenu to display the Joint Masses dialog box.

21. In this dialog box:

- Type **.02** in the Direction 1 edit box.

- Type **.02** in the Direction 3 edit box.

- Click the **OK** button.

22. Click the drop down box in the status bar to change the units to kip-ft. Kip-ft

23. Click the **Show Undeformed Shape** button ◎ to remove the displayed joint mass assignments.

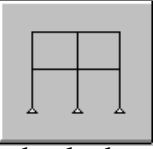24. Select the joint labeled C in the problem statement.

25. From the **Assign** menu select **Joint Static Loads...** and then **Forces...** from the submenu to display the Joint Forces dialog box.

26. In this dialog box:

    - Type **1** in the Force Global X edit box.

    - Click the **OK** button.

27. Click the **Show Undeformed Shape** button ⊙ to remove the displayed joint force assignments.

28. From the **Define** menu select **Time History Functions...** to display the Define Time History Functions dialog box.

29. In this dialog box:

    - Click the **Add New Function** button to display the Function Definition dialog box.

    - In this dialog box:

        ➢ Accept the default FUNC1 function name.

        ➢ Click the **Add** button.

        ➢ Type **.0625** in the Time edit box, type **10** in the Value edit box, and click the **Add** button.

        ➢ Type **.125** in the Time edit box, type **0** in the Value edit box, and click the **Add** button.

        ➢ Type **.1875** in the Time edit box, type **-10** in the Value edit box, and click the **Add** button.

        ➢ Type **.25** in the Time edit box, type **0** in the Value edit box, and click the **Add** button.

        ➢ Click the **OK** button to return to the Define Time History Functions dialog box.

    - Click the **Add New Function** button to display the Function Definition dialog box.

    - In this dialog box:

        ➢ Accept the default FUNC2 function name.

        ➢ Click the **Add** button.

        ➢ Type **.125** in the Time edit box, type **10** in the Value edit box, and click the **Add** button.

- ➢ Type **.25** in the Time edit box, type **0** in the Value edit box, and click the **Add** button.

- ➢ Type **.375** in the Time edit box, type **-10** in the Value edit box, and click the **Add** button.

- ➢ Type **.5** in the Time edit box, type **0** in the Value edit box, and click the **Add** button.

- ➢ Click the **OK** button to return to the Define Time History Functions dialog box.

- • Click the **Add New Function** button to display the Function Definition dialog box.

- • In this dialog box:

  - ➢ Accept the default FUNC3 function name.

  - ➢ Click the **Add** button.

  - ➢ Type **.25** in the Time edit box, type **10** in the Value edit box, and click the **Add** button.

  - ➢ Type **.5** in the Time edit box, type **0** in the Value edit box, and click the **Add** button.

  - ➢ Type **.75** in the Time edit box, type **-10** in the Value edit box, and click the **Add** button.

  - ➢ Type **1** in the Time edit box, type **0** in the Value edit box, and click the **Add** button.

  - ➢ Click the **OK** button twice to exit all of the dialog boxes.

30. From the **Define** menu select **Time History Cases...** to display the Define Time History Cases dialog box.

31. In this dialog box:

- • Click the **Add New History** button to display the Time History Case Data dialog box.

- • In this dialog box:

  - ➢ Accept the default History Case Name, HIST1.

  - ➢ Select Periodic from the Analysis Type drop-down box.

  - ➢ Click the **Modify/Show** button for modal damping to display the Modal Damping dialog box.

  - ➢ In this dialog box:

- ✓ Type **.05** in the Damping For All Modes edit box.

- ✓ Click the **OK** button.

- ➢ Type **25** in the Number of Output Time Steps edit box.

- ➢ Type **.01** in the Output Time Step Size edit box.

- ➢ Check the Envelopes check box.

- ➢ In the Load drop-down box, select LOAD1.

- ➢ In the Function drop-down box, select FUNC1.

- ➢ Click the **Add** button.

- ➢ Click the **OK** button to return to the Define Time History Cases dialog box.

- • Click the **Add New History** button to display the Time History Case Data dialog box.

- • In this dialog box:

  - ➢ Accept the default History Case Name, HIST2.

  - ➢ Select Periodic from the Analysis Type drop-down box.

  - ➢ Click the **Modify/Show** button for modal damping to display the Modal Damping dialog box.

  - ➢ In this dialog box:

    - ✓ Type **.05** in the Damping For All Modes edit box.

    - ✓ Click the **OK** button.

  - ➢ Type **50** in the Number of Output Time Steps edit box.

  - ➢ Type **.01** in the Output Time Step Size edit box.

  - ➢ Check the Envelopes check box.

  - ➢ In the Load drop-down box, select LOAD1.

  - ➢ In the Function drop-down box, select FUNC2.

  - ➢ Click the **Add** button.

  - ➢ Click the **OK** button to return to the Define Time History Cases dialog box.

- Click the **Add New History** button to display the Time History Case Data dialog box.

- In this dialog box:

  - Accept the default History Case Name, HIST3.

  - Select Periodic from the Analysis Type drop-down box.

  - Click the **Modify/Show** button for modal damping to display the Modal Damping dialog box.

  - In this dialog box:

    - Type **.05** in the Damping For All Modes edit box.

    - Click the **OK** button.

  - Type **100** in the Number of Output Time Steps edit box.

  - Type **.01** in the Output Time Step Size edit box.

  - Check the Envelopes check box.

  - In the Load drop-down box, select LOAD1.

  - In the Function drop-down box, select FUNC3.

  - Click the **Add** button.

  - Click the **OK** button twice to exit all dialog boxes.

32. From the **Analyze** menu select **Set Options...** to display the Analysis Options dialog box.

    - In this dialog box click the **Plane Frame XZ Plane** button [ ] to set the available degrees of freedom.

    - Check the Dynamic Analysis check box, if it is not already checked.

    - Click the **Set Dynamic Parameters** button to display the Dynamic Analysis Parameters dialog box.

    - In this dialog box:

      - Type **4** in the Number of Modes edit box.

      - Click the **OK** button twice to exit all dialog boxes.

33. Click the **Run Analysis** button [ ] to run the analysis.

34. When the analysis is complete check the messages in the Analysis window (there should be no warnings or errors). Note in the messages that the first mode period is about 0.5 seconds. Click the **OK** button to close the Analysis window.

35. Note again in the window title on the screen that the first mode period is about .5 seconds.

36. From the **Display** menu select **Set Output Table Mode…** to display the Select Output dialog box.

37. In this dialog box:

    - Click on the HIST1 history to highlight it.

    - Hold down the shift key on the keyboard and click on the HIST3 history. The HIST1, HIST2, and HIST3 histories should all be highlighted (selected) now.

    - Click the **OK** button.

38. Right click on the joint labeled D in the problem statement to display a table of envelope values for the displacement at joint D. Note that the maximum displacement occurs for HIST2, as would be expected since the period of Function 2 is close to the first mode period of the structure.

39. Click the "X" in the upper right-hand corner of the table to close it.

40. We have viewed the envelopes of the joint displacement at joint D. Now we will view the time histories of the displacement. Select the joint labeled D in the problem statement.

41. From the **Display** menu select **Show Time History Traces…** to display the Time History Display Definition dialog box.

42. In this dialog box:

    - Click the **Define Functions** button to display the Time History Functions dialog box.

    - In this dialog box:

        ➢ Highlight Joint 4.

        ➢ Click the **Modify/Show TH Function** button to display the Time History Joint Function dialog box.

        ➢ In this dialog box:

            ✓ Verify that the Displ option is selected in the Vector Type area.

            ✓ Verify that the UX option is selected in the Component area.

- ✓ Click the **OK** button twice to return to the Time History Display Definition dialog box.

- Verify that HIST1 is selected in the Time History Case drop-down box.

- Click on Joint 4 in the List of Functions area to highlight (select) it.

- Click the **Add** button to move Joint 4 to the Plot Functions area.

- Click the **Display** button to display the time history.

- Click the **OK** button to close the time history display and return to the Time History Display Definition dialog box.

- Select HIST2 in the Time History Case drop-down box.

- Click the **Display** button to display the time history.

- Click the **OK** button to close the time history display and return to the Time History Display Definition dialog box.

- Select HIST3 in the Time History Case drop-down box.

- Click the **Display** button to display the time history.

- Click the **OK** button to close the time history display and return to the Time History Display Definition dialog box.

- Click the **Done** button to close the Time History Display Definition dialog box.