This experiment consists of determining modal properties of the pedestrian bridge over Millikan Pond at Caltech. The second experiment, which introduced modal analysis on a shear beam model in the laboratory with five lateral degrees of freedom and therefore five lateral modes, is a good starting point for this experiment. We move to a real-world setting in which modal analysis is now performed on a distributed system using methods established in the first two experiments.

The bridge over Millikan Pond is a cast-in-place concrete slab structure with a span of approximately 50 feet and a width of 10 feet. The bridge deck is not a constant thickness but is tapered from the middle to each edge. The bridge is a continuous system with no lumped mass at discrete points like the laboratory building model. For a continuous system, there are infinite modes and mode shapes. We will attempt to find a few modes both along the bridge deck and transverse to the bridge deck. The general procedure will be to select test points on the bridge and collect transfer function data from each point. We must establish a grid of points on the bridge from which to collect data. The number of mode shapes that we will be able to calculate will be governed by the resolution of the points at which we perform the experiment.

Equipment
- 5 Episensor seismometers borrowed from the USGS and 1 Dynamics Lab Episensor.
- Data acquisition systems: 5 RT130s (Reftek digitizer) borrowed from the USGS, and 1 Granite digitizer, battery, laptop, cables.
- Tape measure for distances between accelerometers across bridge deck.
- Sledge hammer to impart impulse-like accelerations to the bridge deck.
- Notebook, watch and pen for recording the experimental setup.

We will determine modal properties (natural frequencies, damping ratios, and mode shapes) both on the bridge deck and in the transverse direction. Five accelerometers will be placed in the horizontal configuration along the bridge with the central Episensor near the apex of the bridge. The horizontal components should be parallel to and orthogonal to the flow of traffic. You will need to use cardboard or paper wedges to make the horizontal components lie in a perfectly horizontal plane. Next, we will establish test points on the side of the bridge and designate them as the points from which we will collect transfer function data. Someone must stand in the pond and impart several crisp blows to the bridge with the sledge hammer. Data will be recorded after several clean taps to the bridge at the single test point. We will then tap the bridge at the next test point and repeat. This will continue until all the test points have been recorded. Using appropriate pairs of data, show how reciprocity has been recorded.

Next, we will find the vertical modes on the bridge deck itself. Points at which to gather data must be established on the deck of the bridge. We will perform the impact hammer test on the bridge deck by striking the bridge deck with the sledge hammer in the direction perpendicular to the deck. Again, there will be an infinite number of modes in both directions but our ability to calculate the mode shapes will be determined by spacing of the data collection points. As with the first section, show how reciprocity has been recorded.

Finally, we will move two Episensors to the opposite side of the bridge to attempt to record torsional modes. Use these pairs of data to identify torsional mode frequencies through waveform subtraction.

Procedure
1. Place 5 Episensors along long direction of bridge. Tap bridge 3 times at each Episensor point. Determine longitudinal and transverse frequencies, mode shapes, and damping of fundamental mode in each direction. Determine vertical frequencies.
2. Place 2 Episensors on one long side and 2 exactly opposite on the other long side of bridge. Determine torsional frequencies through subtraction. Measure angle of rotation of torsion.

3. Discuss reciprocity.

Report
Supply a report with all the sections as discussed in the syllabus. Sketch the arrangement of the experimental apparatus and all experimental conditions. From the impact sledge hammer tests, determine at least the first three modal frequencies in each direction (discuss higher modes if they are visible in the transfer function data). Attempt to calculate mode shapes for the first three modes in both the transverse and vertical directions. There may be coupling between the data from both experiments. Remember that the mode shapes on the bridge deck will be over the entire two-dimensional surface of the bridge. Finally, calculate the damping for only the fundamental modes in both directions. Use opposite side pairs of data to identify the torsional mode frequencies if they have been sufficiently excited. Wherever appropriate, determine and discuss reciprocity. Also discuss how the modal parameters are relevant with respect to this continuous, arched structure. Discuss the significance of bending or flexure in this structure. Discuss how well (or not) the impact hammer can supply a true impulsive force and the effects on obtaining the transfer functions.