

Shaking Tower Kit

ME-7018

Introduction

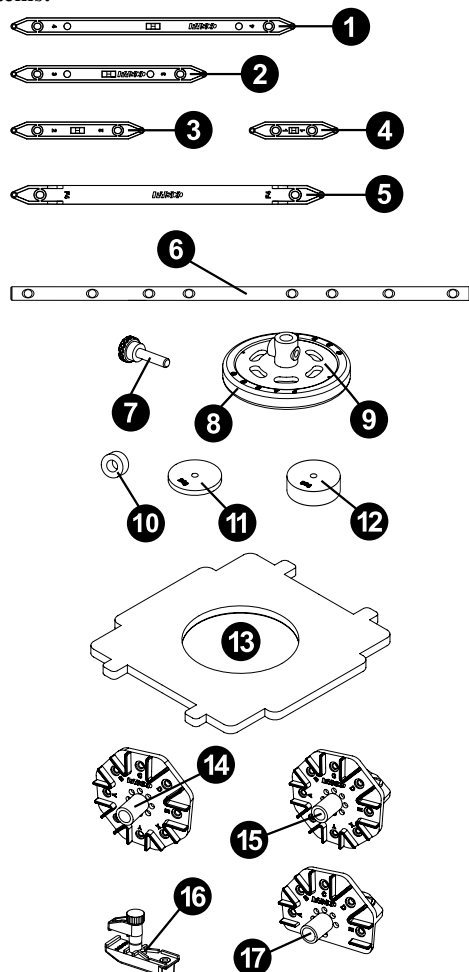
The Shaking Tower Kit contains the parts needed to build a model of a five-story-tall tower building.

The kit also includes parts needed to build a damping pendulum which fits on the top of the tower. The pendulum is modeled after the passive damping mechanisms installed in modern buildings to dampen oscillations during earthquakes. The Large Slotted Mass Set (ME-7566) is required to construct the damping pendulum.

The Shaking Tower Kit is also included in the Shaking Tower Experiment (EX-5555). The Shaking Tower Experiment package includes the additional equipment needed to shake the tower at various frequencies, and to measure the force of the shaking at each floor.

Equipment

Included items:



- ① #4 I-beam
- ② 24× #3 I-beams
- ③ 8× #2 I-beams
- ④ 10× #1 I-beams
- ⑤ 20× Flat F4 Beams

- ⑥ Medium axle
- ⑦ 2× 80 pack of truss set screws
- ⑧ Structure tire
- ⑨ Structure wheel
- ⑩ 2× nylon spacers
- ⑪ 2× 20 g masses
- ⑫ 2× 50 g masses
- ⑬ 5× foam floors
- ⑭ 4× flat round connectors
- ⑮ 5× full round connectors
- ⑯ Sliding connector
- ⑰ 20× half round connectors
- ⑱ Storage box (not shown)
- ⑲ Rubber cord (1 m; not shown)

Required equipment:

- Large Slotted Mass Set (ME-7566)

Construction

There are four stages to constructing the Shaking Tower Kit.

- The first stage is the ground floor structure.
- The second stage is the five floors above the ground floor, which are all constructed in the same way.
- The third stage is the completion of the tower using the ground floor structure and the five floors.
- The fourth stage is the damping pendulum, which is attached to the top of the fifth floor.

The following sections explain how to complete each stage of the construction.

Ground floor construction

Items needed:

- 1× flat round connector
- 4× full round connectors
- 4× #3 I-beams
- 4× #2 I-beams
- 4× Flat F4 Beams
- 20× truss set screws

Procedure:

1. Attach the four #2 I-beams to the flat round connector in a radially symmetric pattern using truss set screws.
2. Attach the four full round connectors to the #2 I-beams using truss set screws, as shown in Figure 1.

- Use the four #3 I-beams and eight truss set screws to connect the full round connectors to each other, as shown in Figure 1.

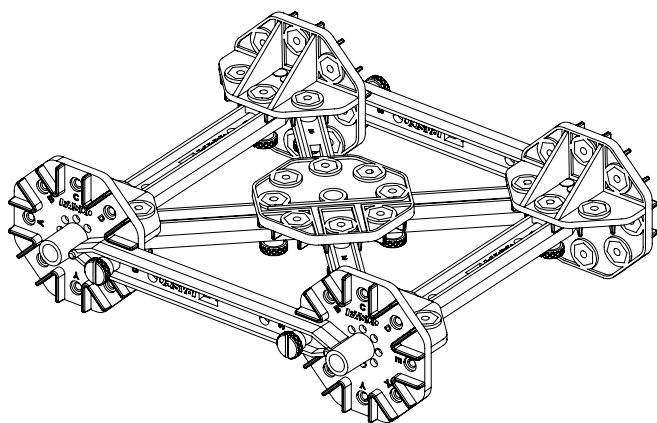


Figure 1: Ground floor structure base.

- Align a Flat F4 I-beam and a truss set screw with the top vertical slot on a full round connector. Attach the beam using the truss set screw. (See Figure 2.)
- Repeat Step 4 to attach the other Flat F4 Beams to the other full round connectors using truss set screws.

The completed ground floor structure should resemble what is shown in Figure 2.

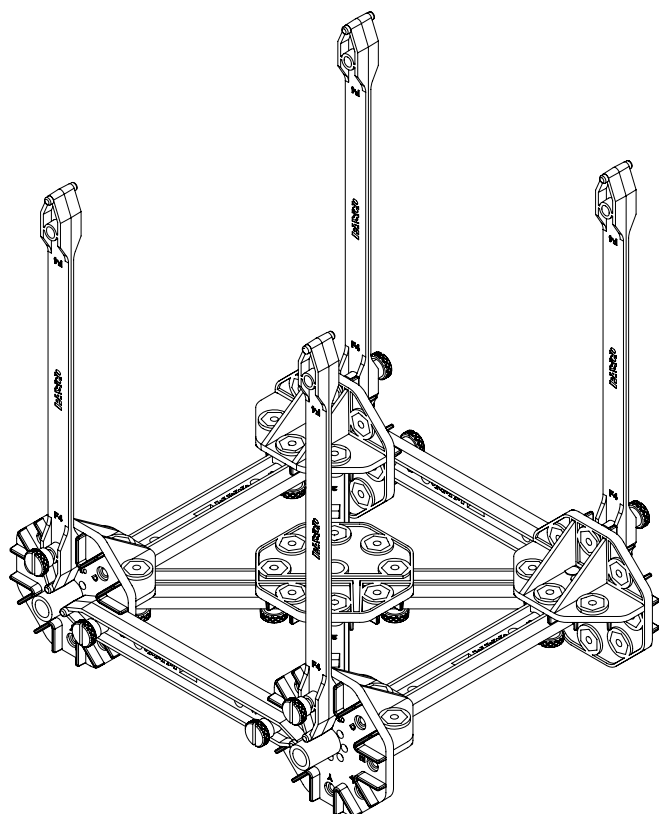


Figure 2: Completed ground floor structure with Flat F4 Beams.

Floor construction

Items needed per floor:

- 4× half round connectors
- 4× #3 I-Beams
- 1× foam floor
- 8× truss set screws

Procedure:

- Attach one #3 I-Beam between two full round connectors using truss set screws. Make sure the "cross-bar" on the #3 I-Beam faces outward, as shown in Figure 3.

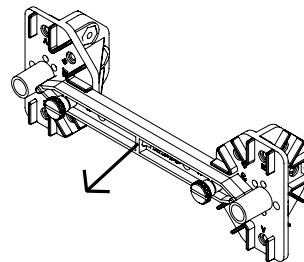


Figure 3: Floor construction, first step.
Arrow indicates direction of cross-bar.

- Place the foam floor between the half round connectors, with one edge of the floor against the back of the #3 I-beam, as shown in Figure 4.

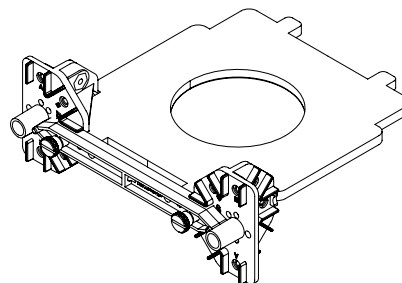


Figure 4: Floor construction, second step.

- Add two additional half round connectors at the remaining corners of the foam floor and attach them using additional #3 I-beams and truss set screws, as shown in Figure 5. Note that the cross-bar on each I-beam should face outward.

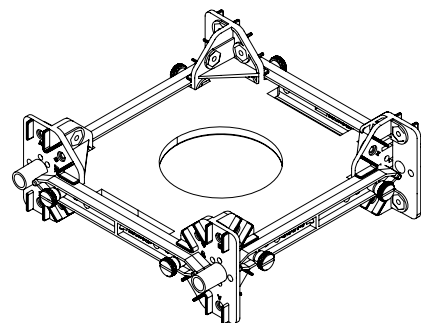


Figure 5: Floor construction, third step.

Repeat Steps 1 through 3 four additional times to construct a total of five floors.

Tower construction

Items needed:

- 1× ground floor structure
- 5× floors
- 16× Flat F4 Beams
- 28× truss set screws

Procedure:

1. Align the Flat F4 Beams of the ground floor structure with the bottom vertical slots of the half-round connectors on the first floor, as shown in Figure 6.

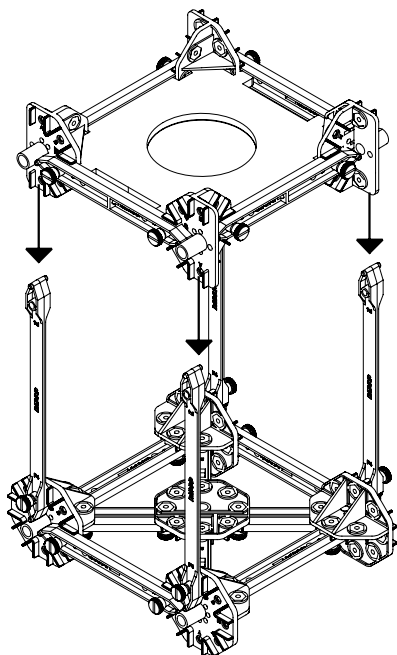


Figure 6: Connecting the ground floor to the first floor.

2. Use truss set screws to attach the first floor to the Flat F4 Beams.
3. Use four truss set screws to attach four additional Flat F4 Beams to the top vertical slots of the half round connectors on the first floor. (See Figure 7.)

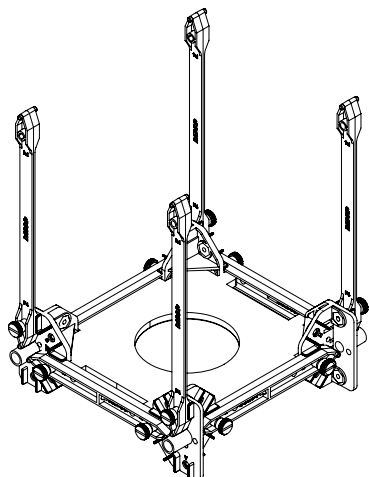


Figure 7: Attaching Flat F4 Beams to the first floor.

4. Add the second floor to the top of the Flat F4 Beams on the first floor. Secure in place with four truss set screws.
5. Repeat Steps 3 and 4 until all five floors have been attached on top of the ground floor. Do not add Flat F4 Beams to the fifth floor.
6. Place three of the 0.5 kg iron disks from the Large Slotted Mass Set (ME-7566) on the center of the ground floor structure, then place one disk on each of the floors. The circular step on top of each disk fits into the hole in the foam floor.

Damping pendulum construction

The damping pendulum is constructed above the fifth floor of the Shaking Tower. The pendulum part of the structure extends downward through the hole in the foam floor.

Items needed:

- 4× #2 I-beams
- #4 I-beam
- 3× flat round connectors
- 1× full round connector
- Structure wheel
- Structure tire
- 14× truss set screws
- Sliding connector
- Medium axle
- 1× nylon spacer
- 2× 20 g masses

Procedure:

1. Remove the circular mass from the fifth floor.
2. Attach a #2 I-beam to the 45° angle slot on each of the half round connectors on the fifth floor, as shown in Figure 8. Note the orientation of the supports relative to the Flat F4 Beams.
3. Attach a flat round connector to each of the two 45° angled supports, as shown in Figure 8. Make sure that the flat round connectors face outwards.

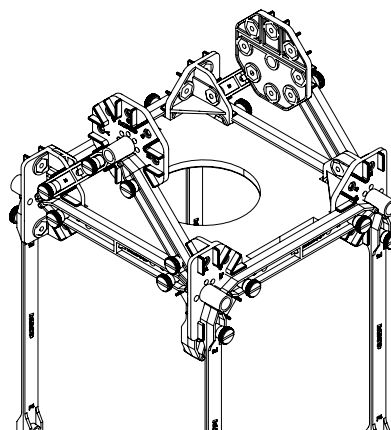


Figure 8: Supports for the damping pendulum axle.

4. Place the end of the medium axle through the center hole of one of the flat round connectors.

5. Slide the following components onto the side of the medium axle hanging over the fifth floor. Make sure to slide the parts on in the specified order and orientation.
 - First, place the nylon spacer onto the axle.
 - Second, place the tire onto the wheel and slide the wheel onto the axle with the "hub" facing away from the spacer, as shown in Figure 9.
 - Finally, put the full round connector onto the axle, with the "right angle" part oriented to face downward toward the hole in the floor and away from the wheel, as shown in Figure 9.
6. Slide the other end of the axle through the hole in the center of the other flat round connector. Figure 9 shows a side view of the axle attached to the flat round connectors on top of the fifth floor.

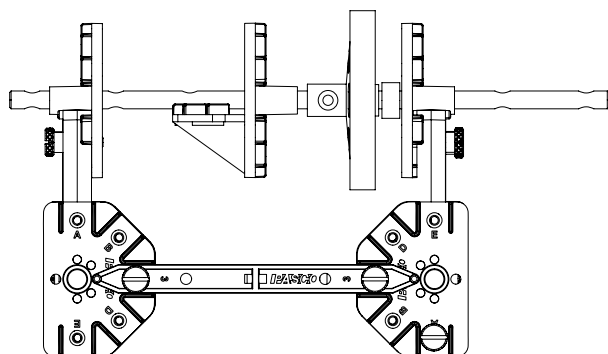


Figure 9: Axle (with spacer, tire, wheel, and full round connector) attached to fifth floor.

7. Attach a flat round connector to one end of the #4 I-beam.
8. Add a 20 g mass to the flat round connector on both sides of the #4 I-beam, as shown in Figure 10. Secure the masses in place with truss set screws.
9. Lift the other end of the #4 I-beam up through the hole in the middle of the fifth floor, then attach the upper end of the beam to the bottom vertical slot on the full round connector, as shown in Figure 10.

 **NOTE:** In Figure 10, to make the pendulum more visible, the wheel on the axle and the half-round connector at the nearest corner are not shown.

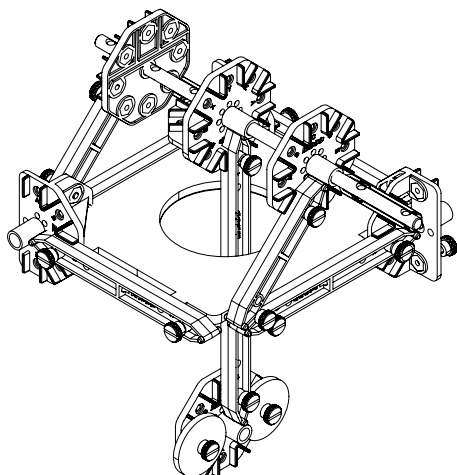


Figure 10: I-beam with masses installed on the damping pendulum.

10. Attach the full round connector and the wheel "hub" to the medium axle using truss set screws. Adjust the position of the full round connector on the axle so that the third hole in the axle is below a threaded hole on the connector, as shown in Figure 11. Insert a screw into the threaded hole on the wheel "hub" and tighten it until the screw makes solid contact with the axle.

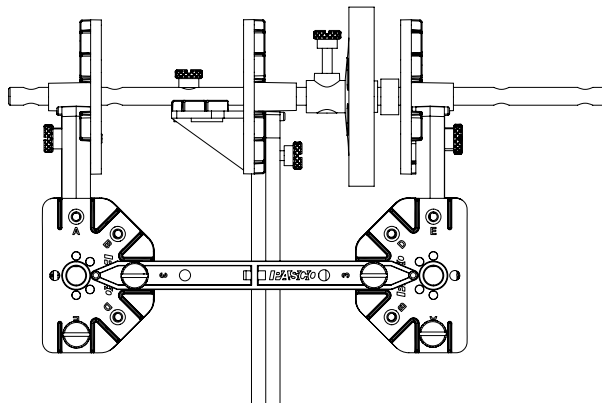


Figure 11: Side view of the damping pendulum with the full round connector and tire secured to the axle.

11. Mount the sliding connector at the middle of one of the #2 I-beams nearest to the wheel and tire, as shown in Figure 12.



Figure 12: Sliding connector attached to I-beam.

When the tower begins shaking, the damping pendulum can be damped by adjusting how hard the sliding connector rubs against the tire.

Shaking Tower Experiment

On its own, the Shaking Tower Kit cannot collect quantitative data on vibrations. You can use the equipment from the Shaking Tower Experiment (EX-5555) to collect this data, allowing more precise observations of the tower's behavior under vibration. In this experiment, load cells are implemented into the tower's construction and a wave driver is used to vibrate the tower at specified frequencies. The rubber cord provided with the Shaking Tower Kit is used to connect the tower to the wave driver.

Aside from the Shaking Tower Kit, the Shaking Tower Experiment contains the following equipment:

- Large Slotted Mass Set (ME-7566)
- Round Base with Rod (ME-8270)
- Large Rod Base (ME-8735)
- 4× Wireless Load Cells and Accelerometers (PS-3216)
- 2-Meter Patch Cord Set (SE-9415A)
- Wave Driver (WA-9855)

The experiment files for the Shaking Tower Experiment contain procedures for adding load cells to the tower's design, connecting the tower to the Wave Driver, and collecting data while driving the tower. To view these files, visit the Experiment Library page for this experiment at [pasco.com/resources/lab-experiments/1305](https://www.pasco.com/resources/lab-experiments/1305). Teacher files for the experiment can be accessed via PASCO Portal.

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