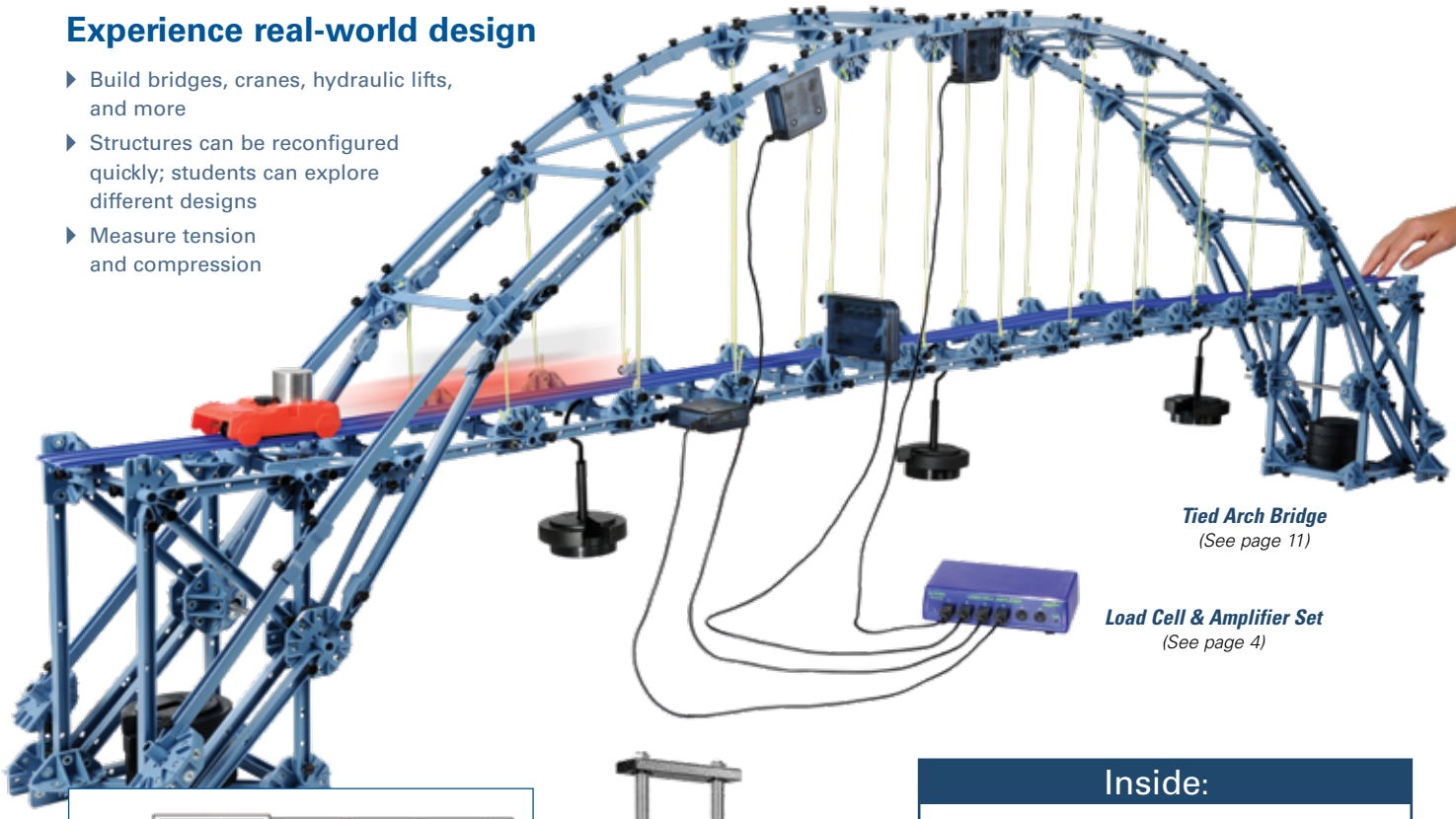
Structures System

Imagine • Design • Analyze

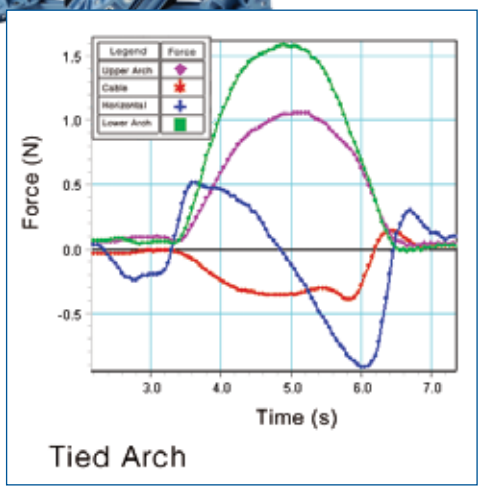
Experience real-world design

- Build bridges, cranes, hydraulic lifts, and more
- Structures can be reconfigured quickly; students can explore different designs
- Measure tension and compression



Tied Arch Bridge
(See page 11)

Load Cell & Amplifier Set
(See page 4)



The PASCO Capstone™ graph shows changes in the compression and tension in the supporting members as the car traverses the bridge.

Materials Testing System
Makes your study of structures complete.
(See pages 14-15)

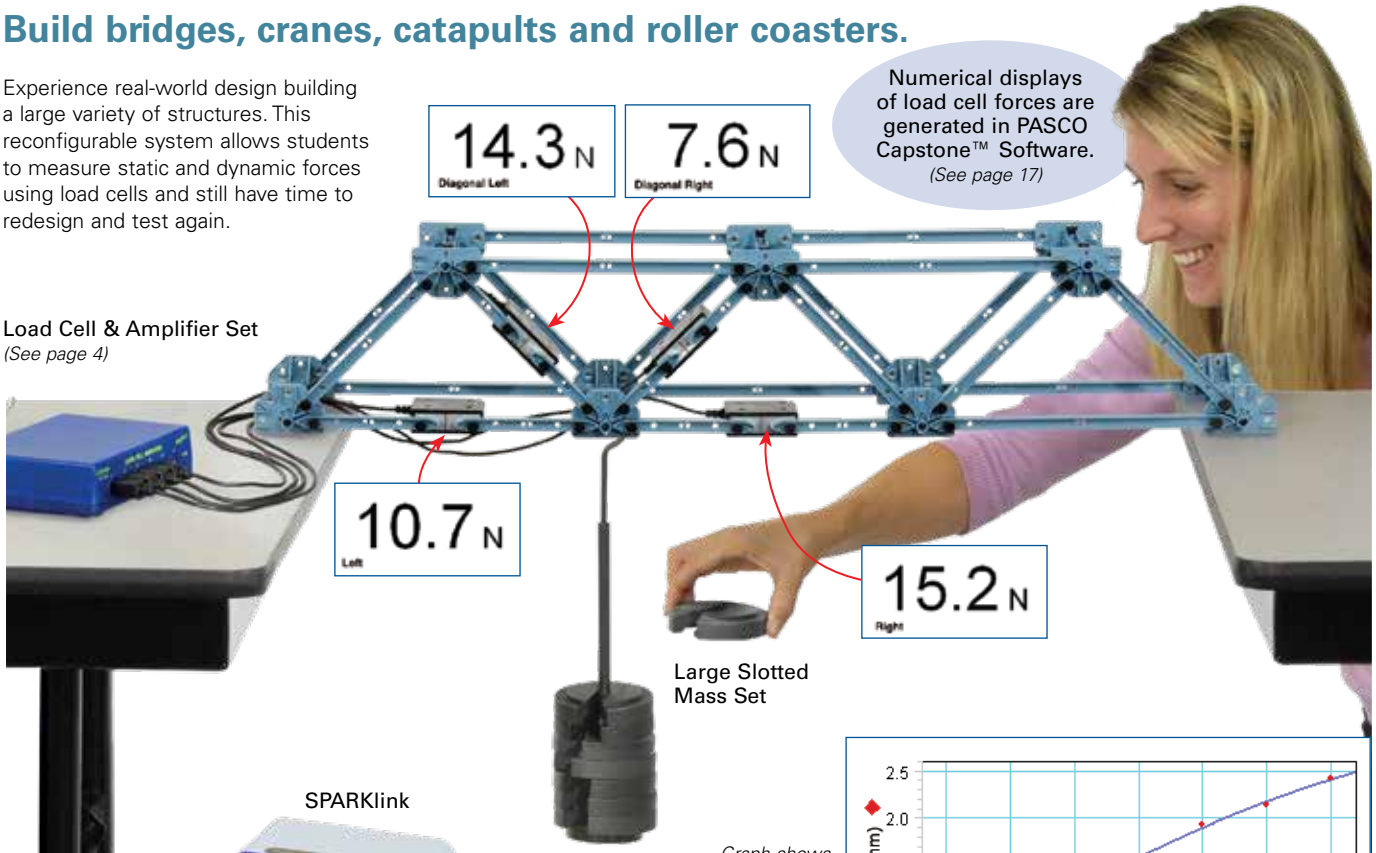
Inside:

PASCO
2018

Build bridges, cranes, catapults and roller coasters.

Experience real-world design building a large variety of structures. This reconfigurable system allows students to measure static and dynamic forces using load cells and still have time to redesign and test again.

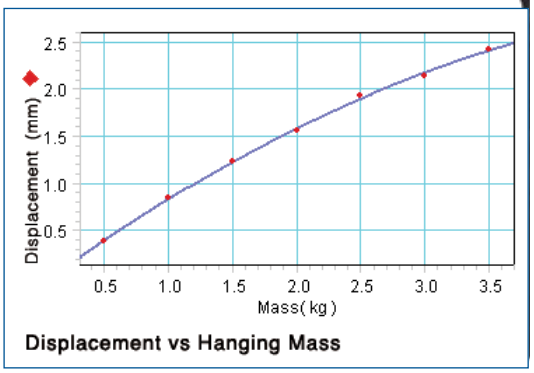
Numerical displays of load cell forces are generated in PASCO Capstone™ Software.
(See page 17)



Load Cell & Amplifier Set
(See page 4)

Large Slotted Mass Set

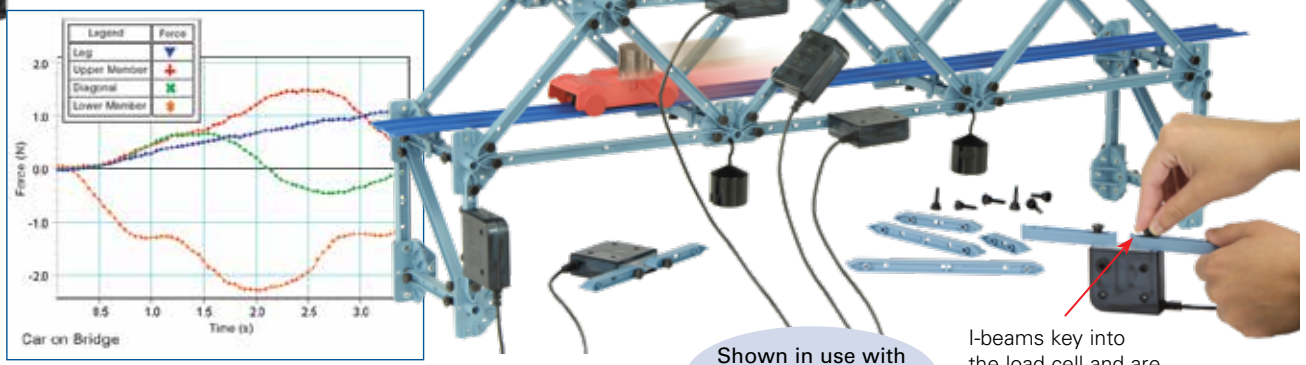
SPARKlink



Graph shows displacement of bridge as a function of hanging mass.

Displacement vs Hanging Mass

Motion Sensor



As the car crosses the bridge, the forces measured by each load cell are graphed in real-time in PASCO Capstone™. Notice the diagonal member (green trace) switches from compression to tension as the car passes by.

Shown in use with Bridge Set ME-6991.
(See pages 6-7)

I-beams key into the load cell and are fastened with thumb screws.

Only PASCO allows students to construct an endless array of structures and measure forces on them in real time.

Imagine… Design… Analyze…

Trusses, bridges, roller coasters, cranes, booms, human models and much more can all be quickly built and analyzed. Far more advanced than toothpick models and much more hands-on than computer simulations, PASCO Structures are ideal for real-world design.

And the ease of use of PASCO Structures Systems allows students to quickly build, test and then redesign their structures quickly and efficiently which supports the engineering process.

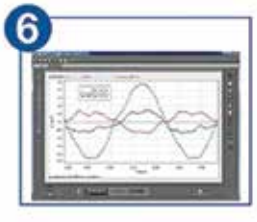
Designing and building structures is simple and easy.

I-beams fit into connectors and are secured with thumb screws.

Load Cells measure the compression and tension…

…and may be placed anywhere in your structure.

Load Cells are then plugged into a Load Cell Amplifier which connects to a PASCO interface which is connected by USB or Bluetooth to a device running PASCO software.
(See interfaces page 17)



PASCO software then allows students to view a graph of the forces in real-time and analyze the resulting data with a suite of powerful tools. PASCO Capstone runs on Mac or Windows Computers. SPARKvue software runs on computers, iPads, Android tablets, or Chromebooks.
(See software page 17)

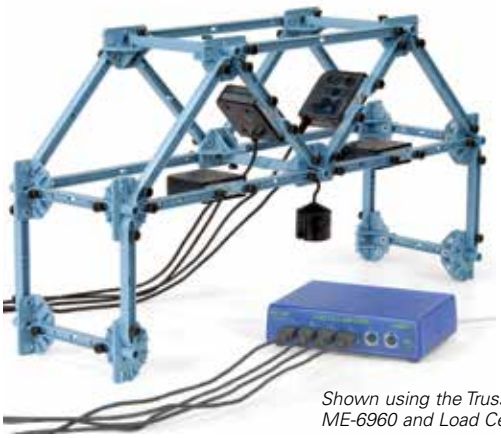
Choice of Load Cell Amplifiers:

Load Cell Amplifier (6 ports)

PS-2198

This Load Cell Amplifier can accommodate up to six load cells and only needs a single PS-2100A USB Link (p. 2) to connect to a computer. Useful for doing an extensive analysis of a bridge by inserting six load cells at various points in the structure.

The Amplifier accepts either the 100N load cell or the 5N load cell or a combination of both. The maximum data sample rate is 500 Hz for each port.



Shown using the Truss Set ME-6960 and Load Cells.

Load Cell Amplifier (6 ports) **PS-2198**

Requires:

Load Cell 100N PS-2200
Load Cell 5N PS-2201
Interface ..... (See page 17)

Also available:

Load Cell and Amplifier Set PS-2199

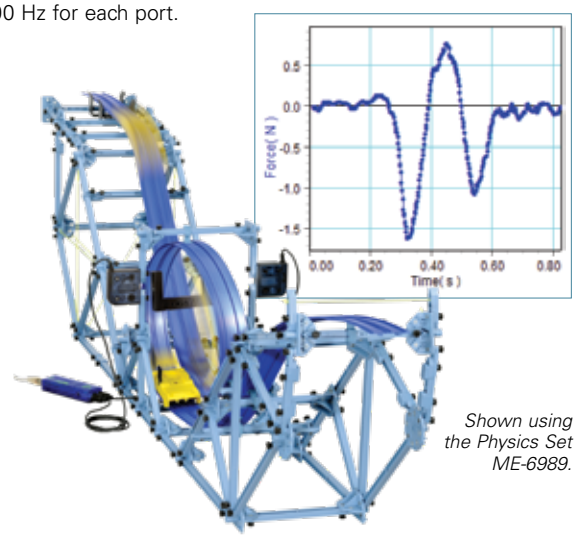
Set Includes:
Load Cell Amplifier
Load Cell 100N (4)
Instruction manual

Dual Load Cell Amplifier

PS-2205

Use for applications where only one or two load cells are needed, such as measuring the force on the track at the top of a roller coaster loop. If you only want to examine the forces in a bridge one at a time, you can move a single load cell around in the bridge.

The Amplifier accepts either the 100N load cell or the 5N load cell or a combination of both. The maximum data sample rate is 1000 Hz for each port.



Shown using the Physics Set ME-6989.

Dual Load Cell Amplifier **PS-2205**

Requires:

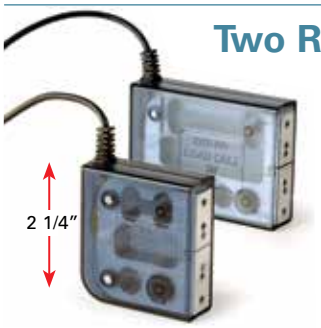
Load Cell 100N PS-2200
Load Cell 5N PS-2201
Interface ..... (See page 17)

Also available:

Load Cell and Dual Amplifier Set PS-2206

Set Includes:
Dual Load Cell Amplifier
Load Cell 100N (1)

Two Ranges of Load Cells:



Load Cell 100N and 5N

Both load cells can be used with the same amplifier in any combination. The semi-transparent case lets students see the strain gauge and beam inside.

Load Cell 100N **PS-2200**
Load Cell 5N **PS-2201**

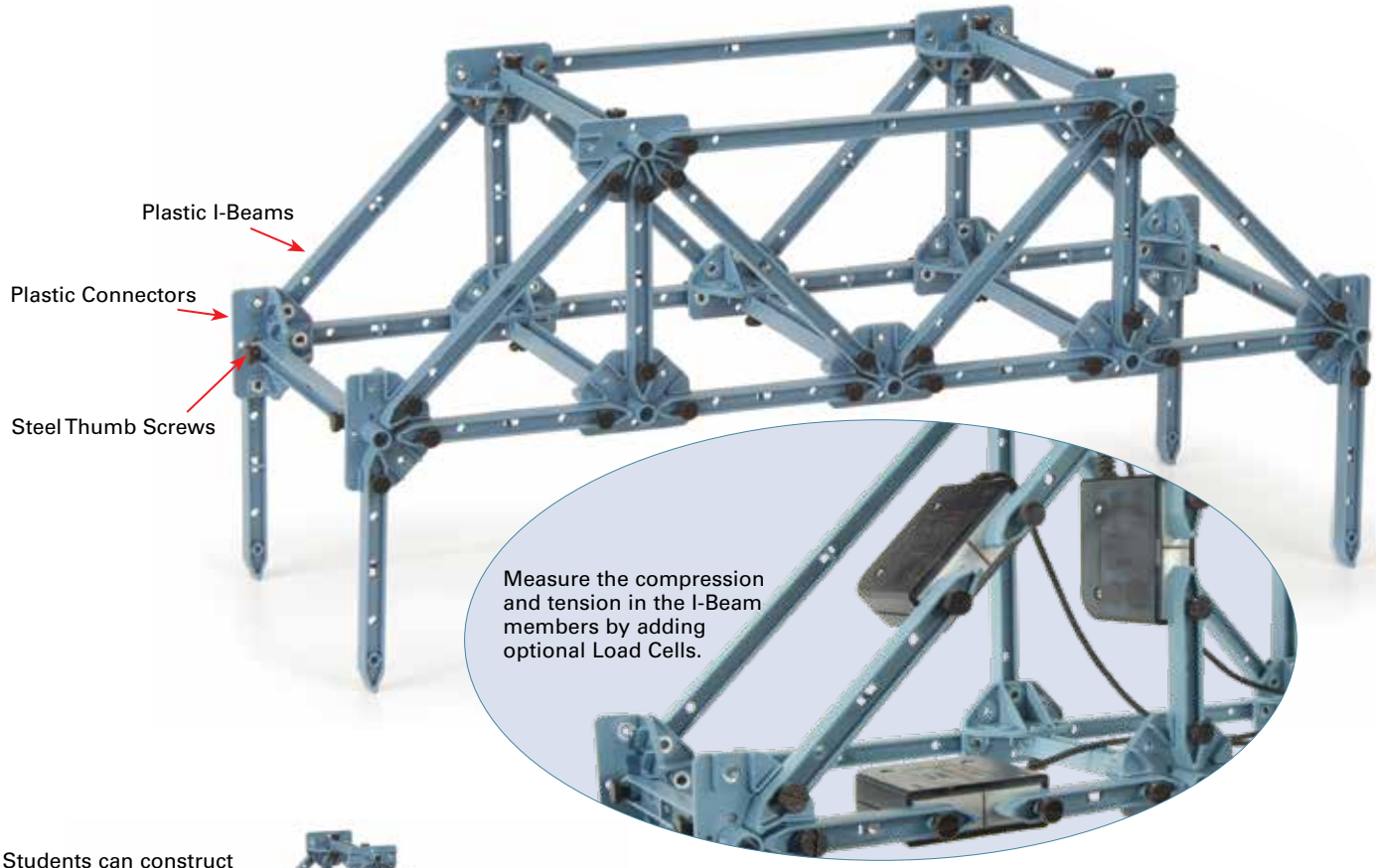
Specifications		
	Load Cell 100N PS-2200	**Load Cell 5N** PS-2201
Range:	-100 N to +100 N	-5 N to +5 N
Accuracy:	±1% (± 1 N)	±1% (±0.05 N)
Resolution:	0.02 N	0.001 N
Safe Overload:	-150 N to +150 N	-7.5 N to +7.5 N

Truss Set

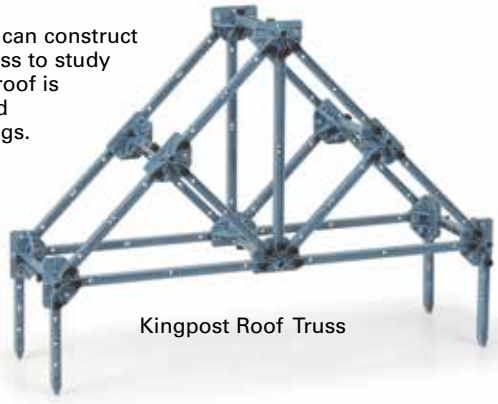
ME-6990

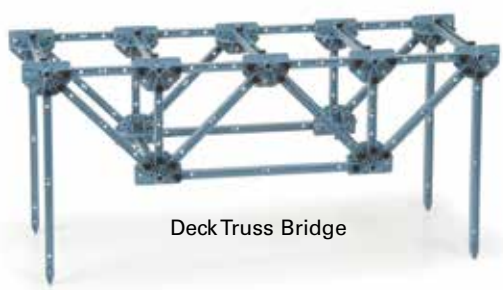
- Teach the basics of trusses
- Demonstrate the properties of I-Beams

Use the Truss Set to build a variety of structures to investigate the principles of trusses. The ABS plastic I-Beams fasten securely together using the provided connectors and thumb screws. Load cells can be inserted anywhere into the design by replacing one beam at a time. Students can load the truss by hanging weights.



Students can construct a roof truss to study how the roof is supported in buildings.





Truss Set Includes:

One package each of Truss Set Members and Truss Set Screws.
See pages 22-23 for details.

Truss Set **ME-6990**

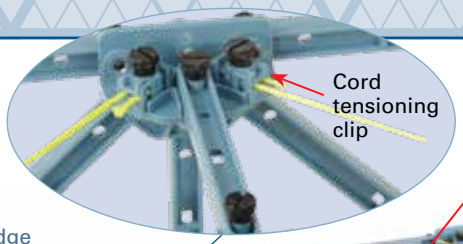
Recommended:

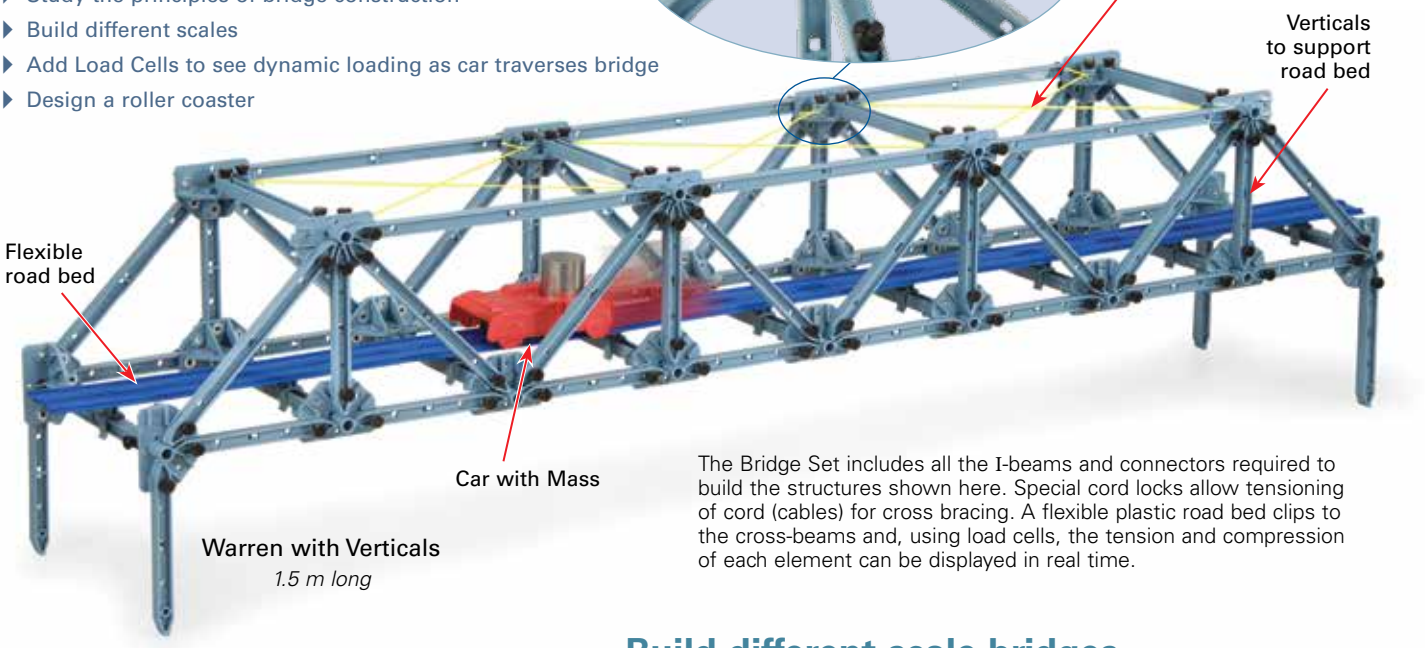
Load Cell and Amplifier Set PS-2199
includes four load cells. *(See page 4)*

Bridge Set

ME-6991

- Study the principles of bridge construction
- Build different scales
- Add Load Cells to see dynamic loading as car traverses bridge
- Design a roller coaster

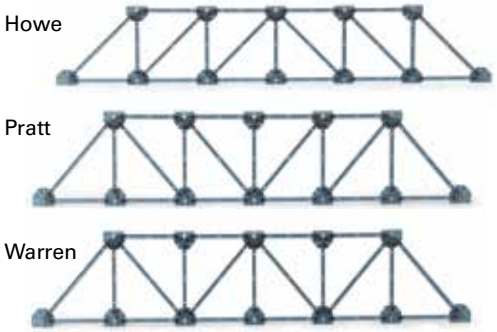




Warren with Verticals
1.5 m long

The Bridge Set includes all the I-beams and connectors required to build the structures shown here. Special cord locks allow tensioning of cord (cables) for cross bracing. A flexible plastic road bed clips to the cross-beams and, using load cells, the tension and compression of each element can be displayed in real time.

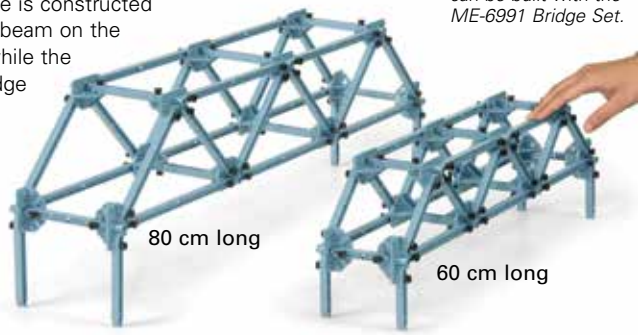
Build different types of bridges



Build different scale bridges

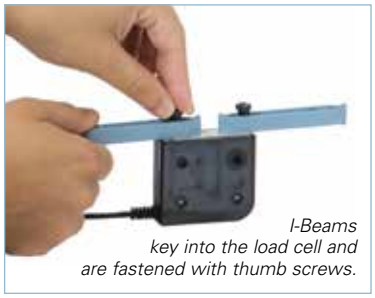
Students will learn the advantages of building taller bridges. Here, the larger bridge is constructed with a #4 I-beam on the diagonal, while the smaller bridge uses a #3 I-beam on the diagonal.

Both of these bridges can be built with the ME-6991 Bridge Set.

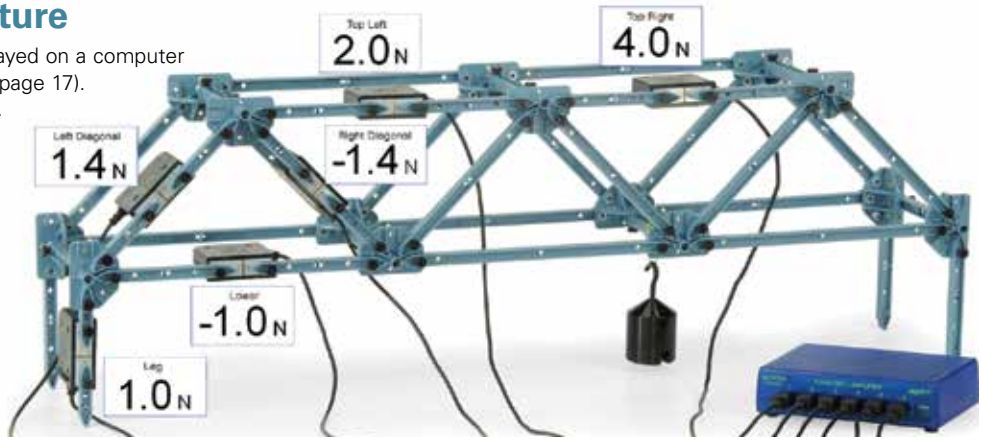


Add load cells to measure static forces anywhere in the structure

Forces measured by Load Cells are displayed on a computer using PASCO Capstone™ Software (see page 17).
A positive value represents compression.



I-Beams key into the load cell and are fastened with thumb screws.

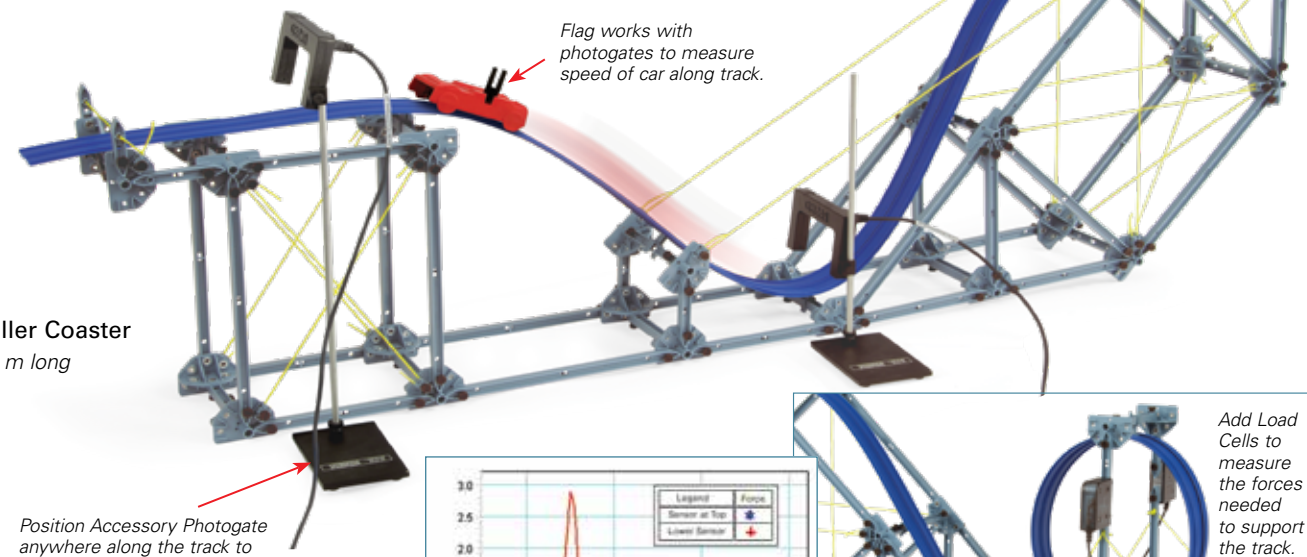


Design your own roller coaster

PASCO's Bridge Set allows students to design and build their own roller coaster for detailed studies of conservation of energy and centripetal force. The flexible track is perfect for building hills, valleys and even a loop! Car with low-friction ball-bearing wheels minimizes energy losses. Measure the speed of the car using photogates or a Motion Sensor.

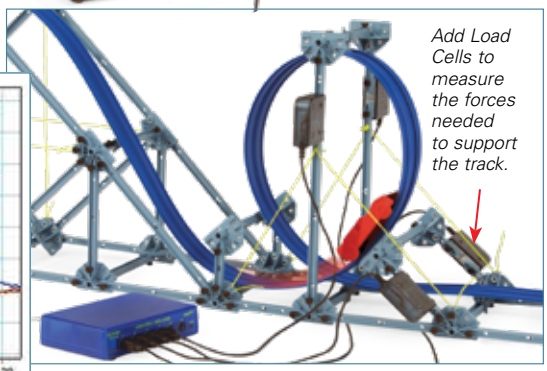
Mini Car
Starter Bracket

Flag works with photogates to measure speed of car along track.

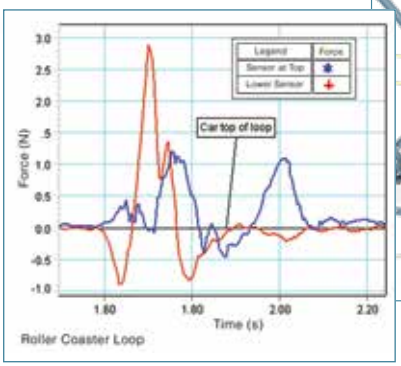


Roller Coaster
1.3 m long

Position Accessory Photogate anywhere along the track to measure speed.

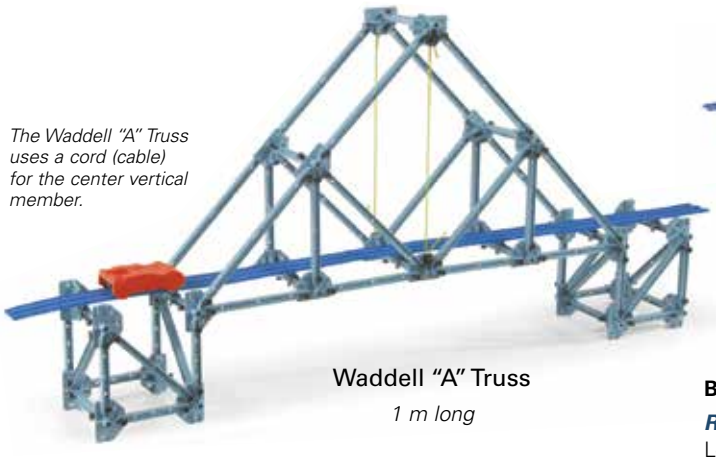


Add Load Cells to measure the forces needed to support the track.



PASCO Capstone™ graph shows support forces exerted on the track as the car goes up and over the loop.

The Waddell "A" Truss uses a cord (cable) for the center vertical member.



Waddell "A" Truss
1 m long

Deck Truss
80 cm long

Bridge Set Includes:
Two packages each of Truss Set Members and Truss Set Screws
One package each of Roadbed Spares and Cord Lock Spares
See pages 22-23 for details.

Bridge Set **ME-6991**

Recommended:
Load Cell and Amplifier Set PS-2199
includes four load cells. *(See page 4)*

Shown in use with:
Accessory Photogate ME-9204B

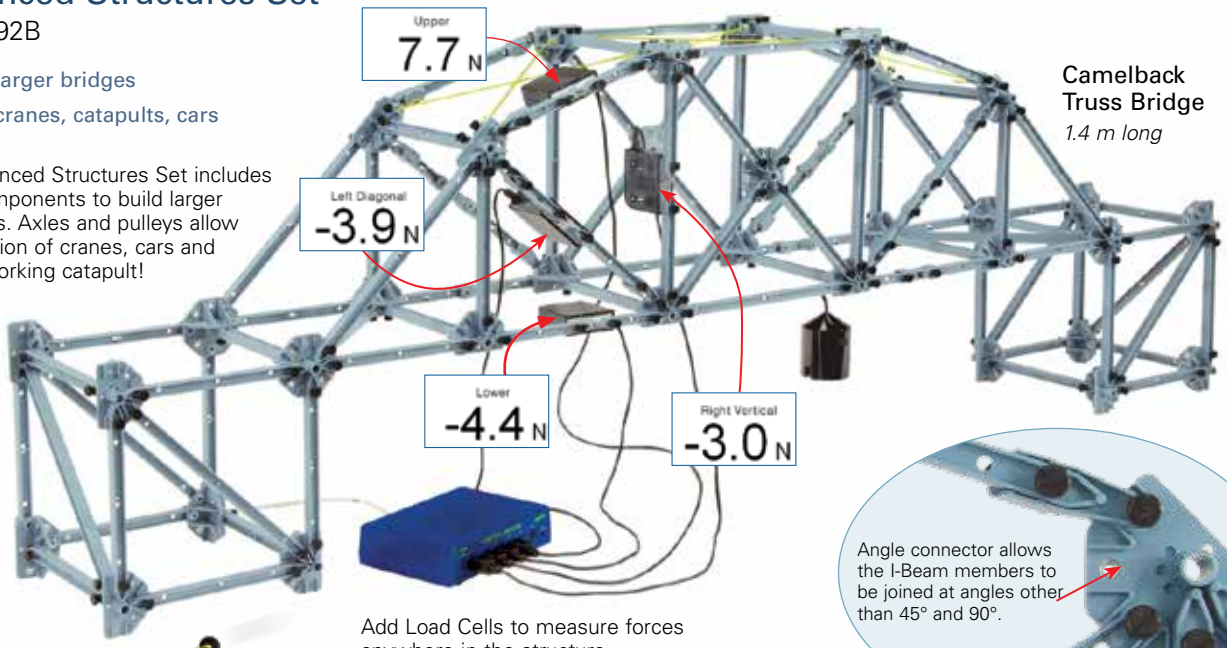
Requires:
Interface ..... (See page 17)

Advanced Structures Set

ME-6992B

- Build larger bridges
- Build cranes, catapults, cars

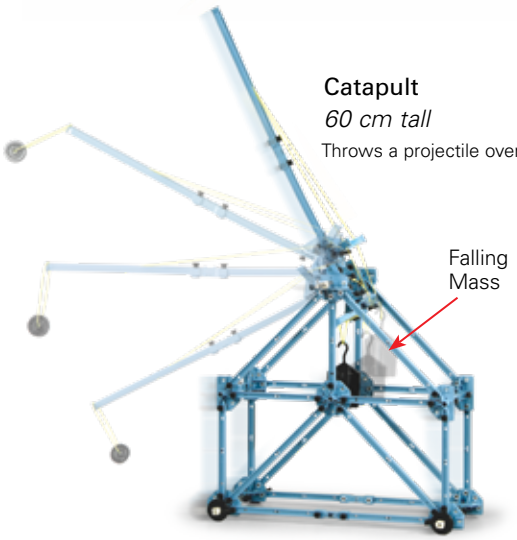
The Advanced Structures Set includes more components to build larger structures. Axles and pulleys allow construction of cranes, cars and even a working catapult!



Camelback Truss Bridge
1.4 m long

Add Load Cells to measure forces anywhere in the structure.

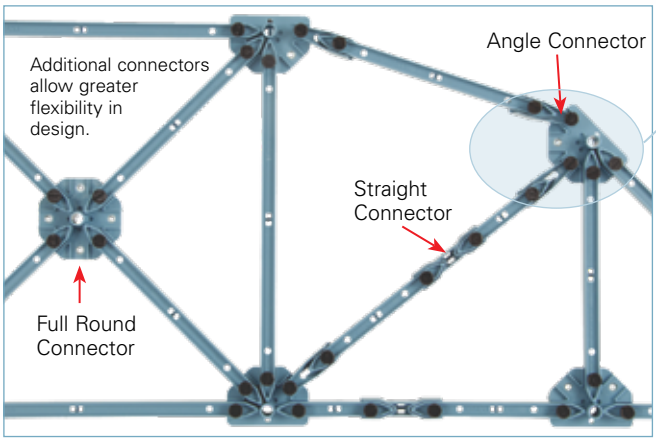
Angle connector allows the I-Beam members to be joined at angles other than 45° and 90°.

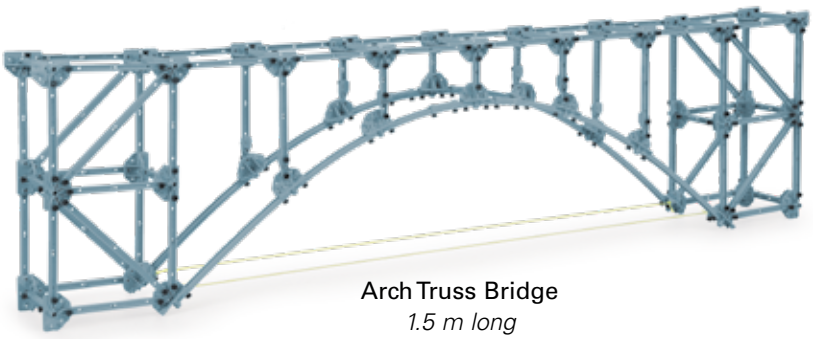


Catapult
60 cm tall
Throws a projectile over 10 meters!

Falling Mass

Wheels allow catapult to move.





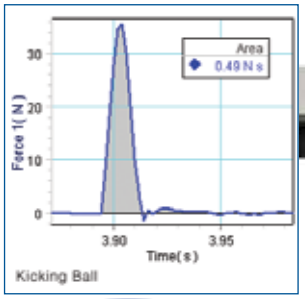
Arch Truss Bridge
1.5 m long

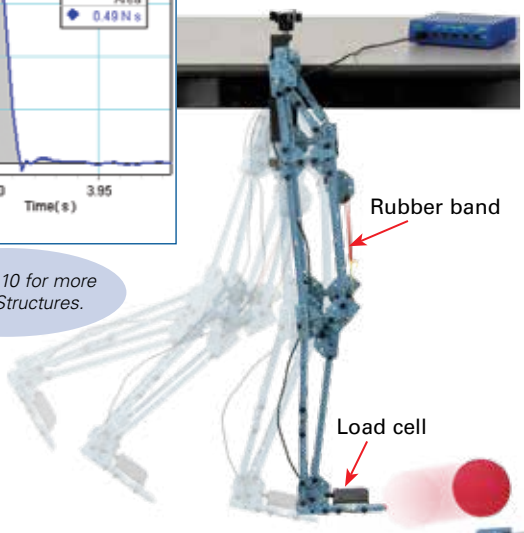
Angle Crane
1.5 m tall

Also see the Tower Crane on page 18.

Human Leg Model

The articulated leg shown below uses a rubber band (not included) for the quadriceps and has a load cell on the foot to measure the force that the "toe" exerts on the ball. The impulse (area under the curve) is equal to the resulting momentum of the ball.

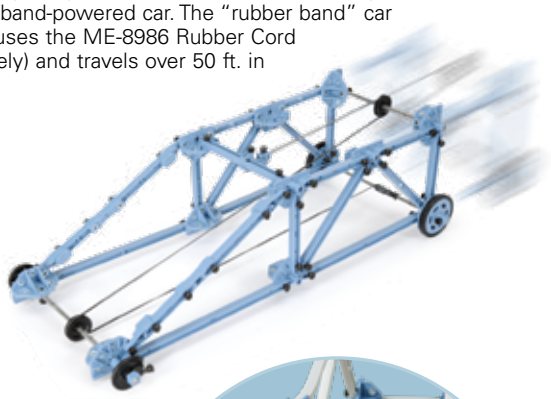


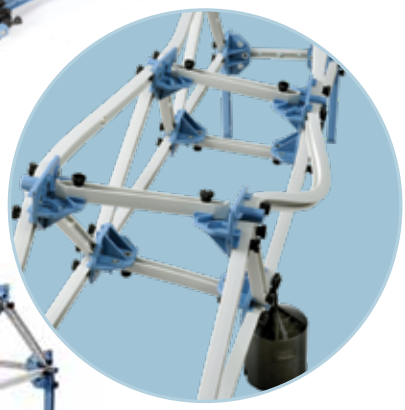


See page 10 for more Human Structures.

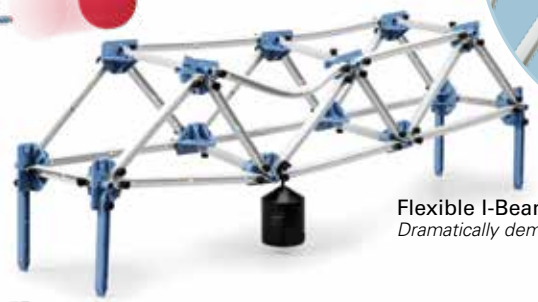
Rubber Band Car

Build a working catapult, a car with rubber band suspension, and a rubber band-powered car. The "rubber band" car shown here uses the ME-8986 Rubber Cord (sold separately) and travels over 50 ft. in 10 seconds.



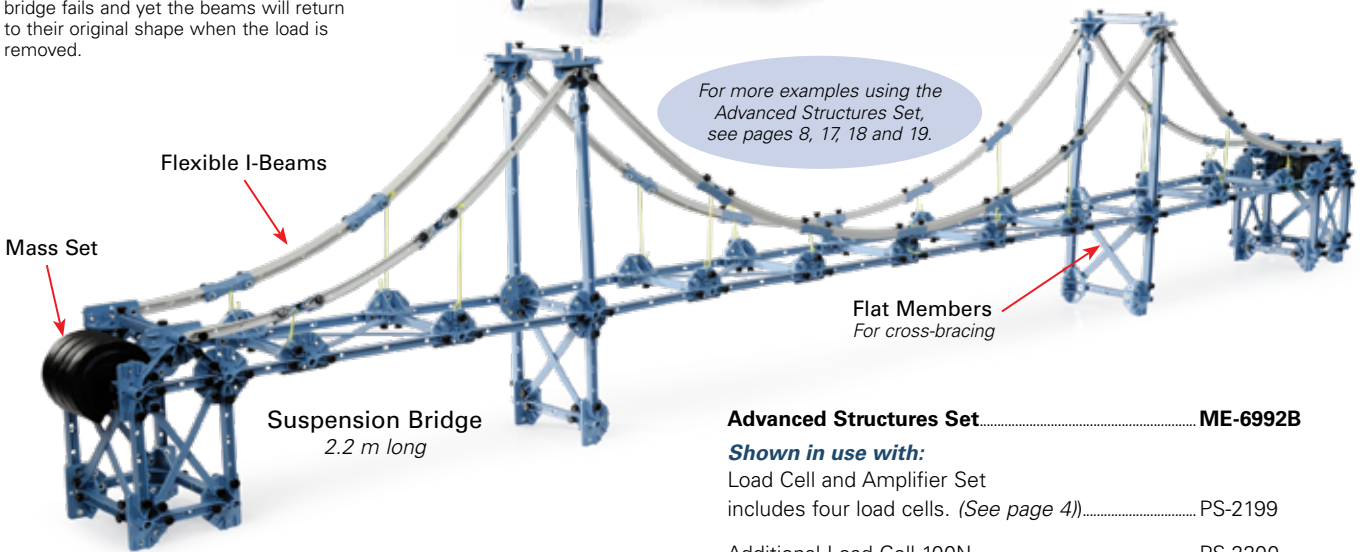


Use these flexible I-Beams to make a bridge which dramatically demonstrates how a bridge fails and yet the beams will return to their original shape when the load is removed.



Flexible I-Beams
Dramatically demonstrate structural failure

For more examples using the Advanced Structures Set, see pages 8, 17, 18 and 19.



Advanced Structures Set Includes

- Truss Set Members (3 pkgs.)
- Truss Set Screws (4 pkgs.)
- Flexible I-Beams (1 pkg.)
- Cord Lock Spares (1 pkg.)
- Axle Spares (1 pkg.)
- Round Connector Spares (1 pkg.)
- Angle Connector Spares (1 pkg.)
- Flat Beams (1 pkg.)
- Structures Rod Clamps (1 pkg.)
- Force Platform Structures Bracket

See pages 22-23 for details.

Advanced Structures Set **ME-6992B**

Shown in use with:

Load Cell and Amplifier Set
includes four load cells. *(See page 4)* PS-2199

Additional Load Cell 100N PS-2200
Hooked Mass Set SE-8759
Large Slotted Mass Set ME-7566
Motion Sensor PS-2103A
Rubber Cord (spool of 30 m) ME-8986

Requires:

Interface ..... (See page 17)

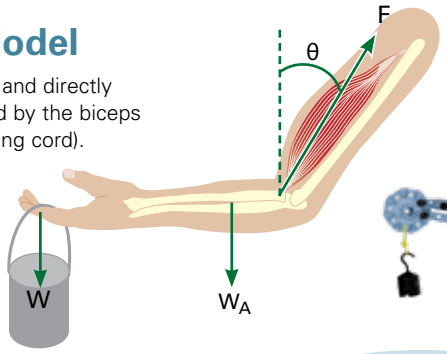
Human Structures Set

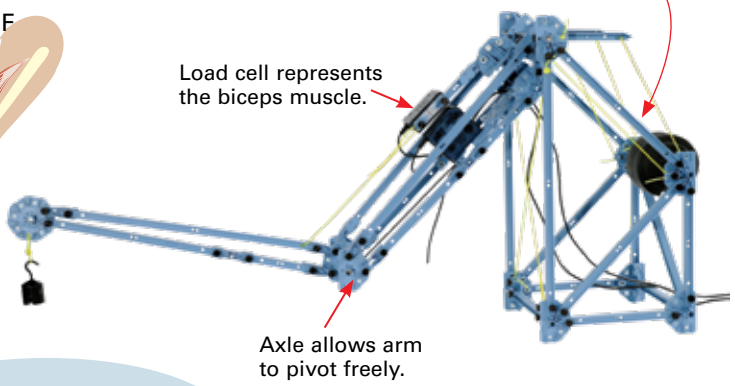
ME-7001

- Build models that represent real life examples.
- Bring homework problems to life.

Human Arm Model

Build a realistic arm model and directly measure the forces exerted by the biceps muscle (tension in supporting cord). Vary the length and angle of upper and lower arm, as well as the point of attachment of the muscle.

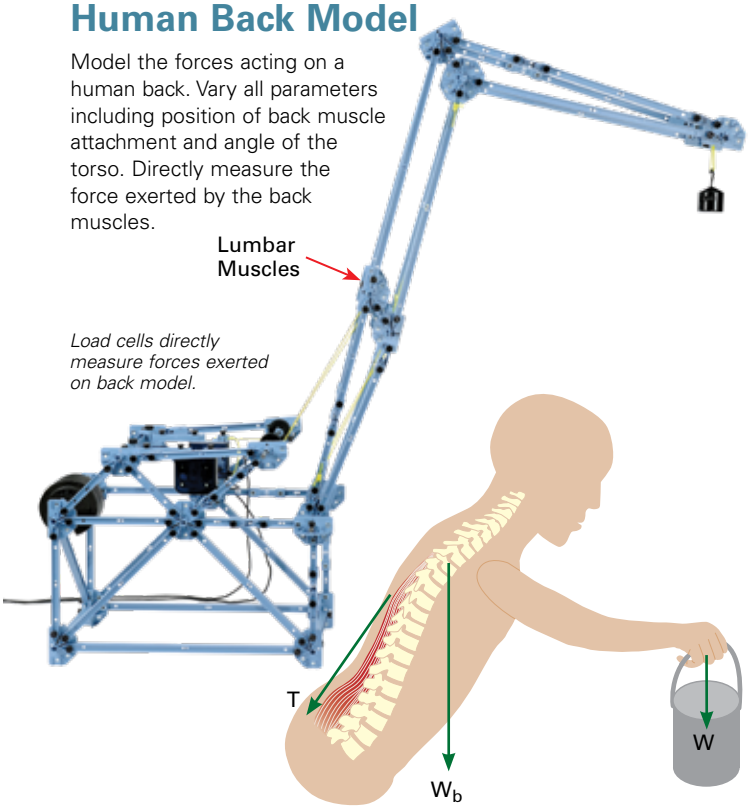




Construct all three models concurrently with this set.

Human Back Model

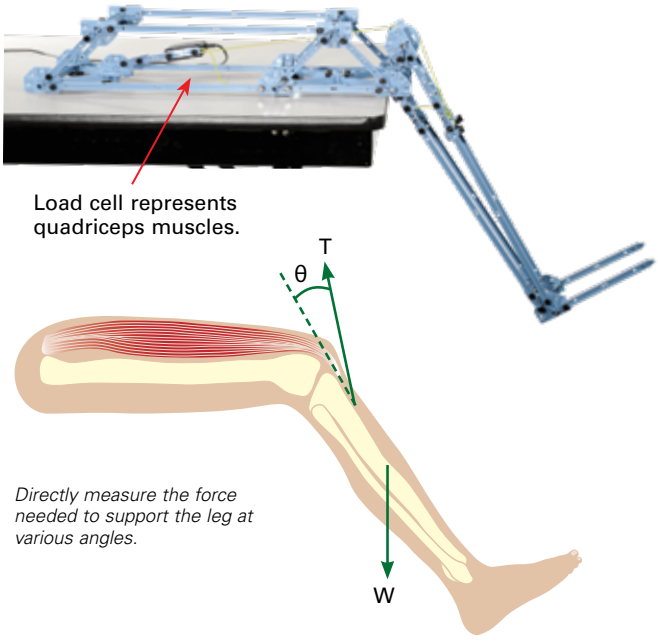
Model the forces acting on a human back. Vary all parameters including position of back muscle attachment and angle of the torso. Directly measure the force exerted by the back muscles.



Load cells directly measure forces exerted on back model.

Human Leg Model

Measure the force needed to support the leg at various angles.



Directly measure the force needed to support the leg at various angles.

Human Structures Set Includes

Five packages of Truss Set Screws
Two packages of Truss Set Members
Two packages of Connector Spares
One package each of #6 I-Beam Spares, Cord Lock Spares, Axle Spares, Round Connector Spares, Angle Connector Spares, roll of rubber cord.

See pages 22-23 for details.

Human Structures Set **ME-7001**

Shown in use with:

Load Cell and Amplifier Set PS-2199
(includes four load cells)
Hooked Mass Set SE-8759
Large Slotted Mass Set ME-7566

Large Structures Set

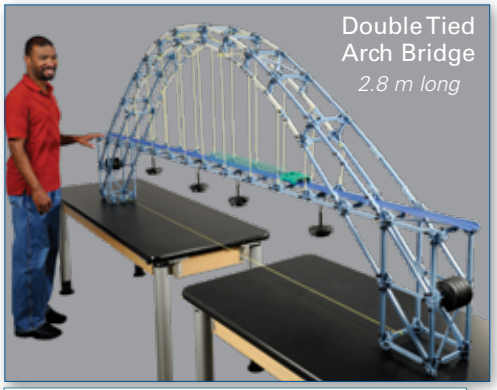
ME-7003

The Large Structures Set includes all the components contained in the Advanced Structures Set (ME-6992B) plus additional parts to build even bigger structures. It also includes the Mini Cars with plastic track to build roller coasters and to add realistic roadbeds to your bridges.

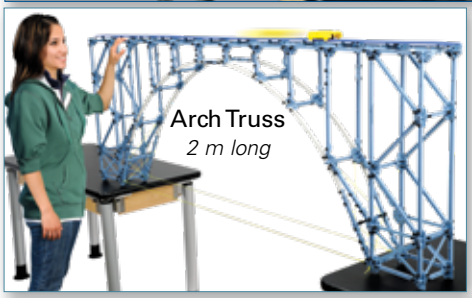
Build this crane and 15 other HUGE structures with this one comprehensive set!

Add load cells (page 4) to measure forces anywhere in the structure.

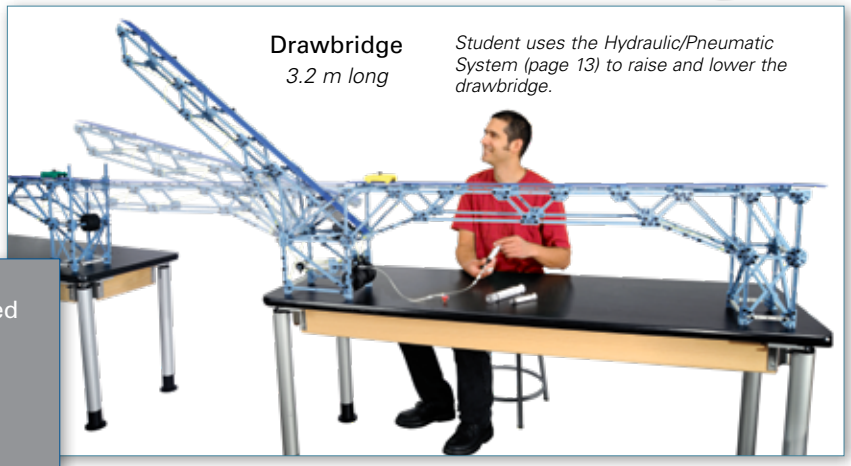
Student uses the Hydraulic/Pneumatic System (page 13) to adjust the crane.



Double Tied Arch Bridge
2.8 m long



Arch Truss
2 m long



Drawbridge
3.2 m long

Student uses the Hydraulic/Pneumatic System (page 13) to raise and lower the drawbridge.

Cable Stayed
3.8 m long

Suspension Bridge
3 m long

Large Structures Set Includes

Six packages of Truss Set Screws
Three packages of Truss Set Members
Two packages of Connector Spares
One package each of #6 I-Beam Spares, Flexible I-Beams, Cord Lock Spares, Axle Spares, Round Connector Spares, Angle Connector Spares, Flat Beams, Structures Rod Clamps, Mini Car Track Spares, Force Platform Structures Bracket, and one each Green Car, Yellow Car, 9.1 m Track, and Starter Bracket

Large Structures Set ME-7003

Shown in use with:

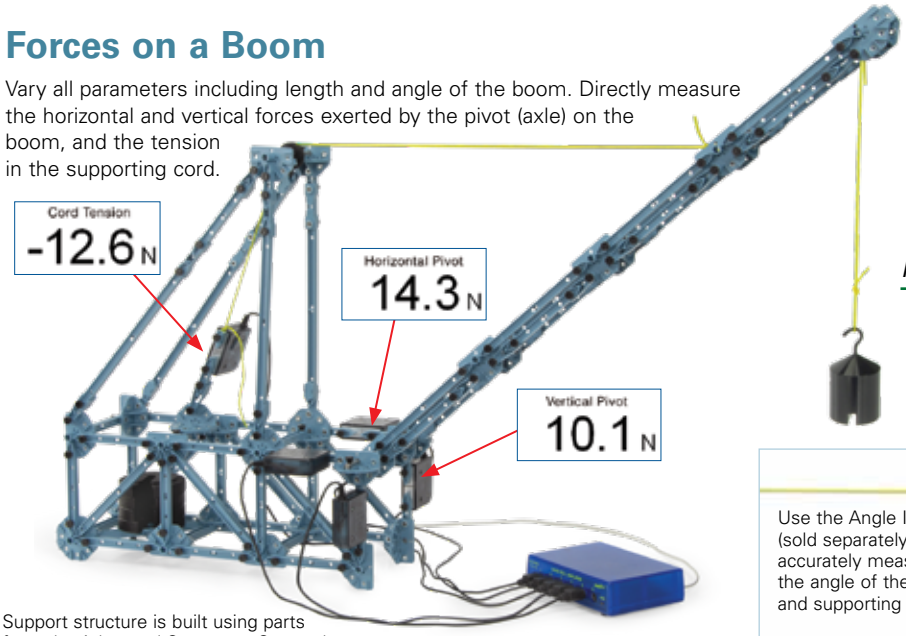
Load Cell and Amplifier Set
includes four load cells..... PS-2199
Hydraulic/Pneumatic Structures ME-6984
Slotted Mass Set..... ME-7589

Requires:

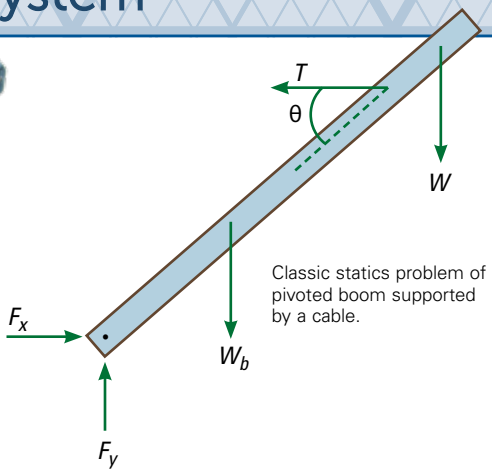
Interface..... (See page 17)

Forces on a Boom

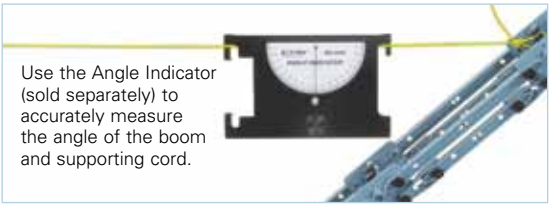
Vary all parameters including length and angle of the boom. Directly measure the horizontal and vertical forces exerted by the pivot (axle) on the boom, and the tension in the supporting cord.



Support structure is built using parts from the Advanced Structures Set, and uses 1/2 kg masses from the ME-7566 Large Slotted Mass Set (sold separately) for counter balance.



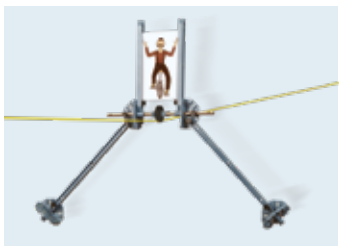
Classic statics problem of pivoted boom supported by a cable.



Use the Angle Indicator (sold separately) to accurately measure the angle of the boom and supporting cord.

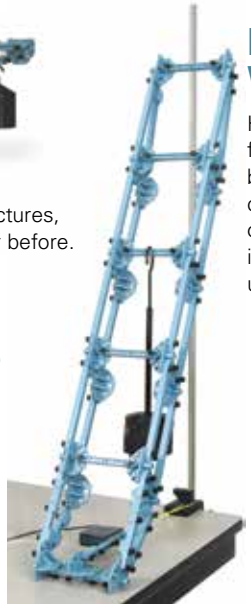
Teeter Totter

Take "meter stick" torque to a new level! By building their own unique structures, students learn about center of mass, torque, and static equilibrium as never before.



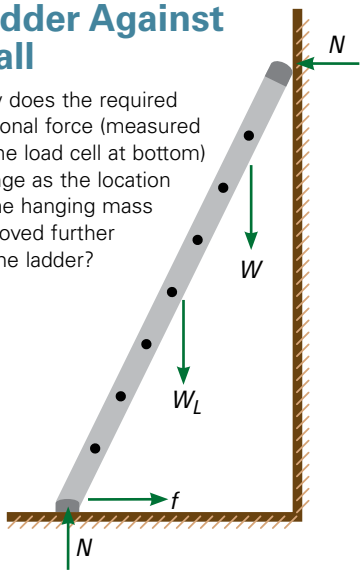
A Lesson in Balance

Circus performer not included!

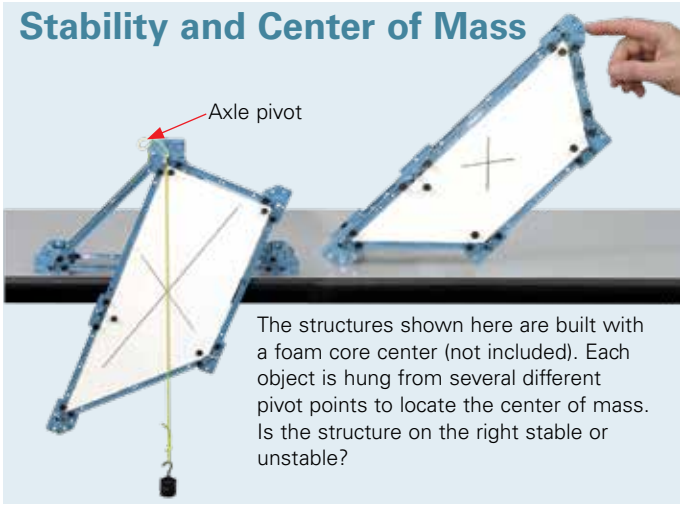


Ladder Against Wall

How does the required frictional force (measured by the load cell at bottom) change as the location of the hanging mass is moved further up the ladder?



Stability and Center of Mass



The structures shown here are built with a foam core center (not included). Each object is hung from several different pivot points to locate the center of mass. Is the structure on the right stable or unstable?

Advanced Structures Set **ME-6992B**

Shown in use with:

Load Cell and Amplifier Set (includes four load cells) PS-2199
Additional 100 N Load Cell PS-2200
Hooked Mass Set SE-8759
Large Slotted Mass Set ME-7566
Angle Indicator ME-9495A
Mass and Hanger Set ME-8979
Large Table Clamp ME-9472
Steel Rod (90 cm) ME-8738

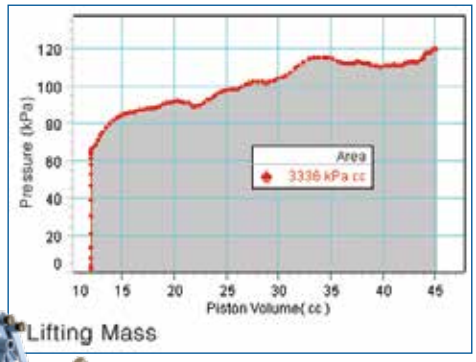
Requires:

Interface ..... (See page 17)

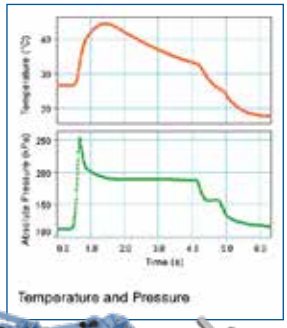
Hydraulic and Pneumatic Structures

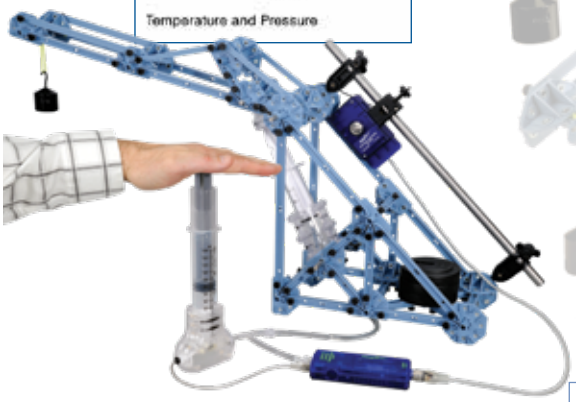
ME-6984

Add a hydraulic/pneumatic ram to make your structures move and do work. Not only will students see the cranes and jacks in action, they can directly measure the pressure and volume to calculate how much work was done.



Pressure and volume are recorded as the weight is lifted, and the work done is the area under the curve.





The weight is lifted using a syringe of water to fill the master cylinder. An Absolute Pressure Sensor (PS-2107) measures the pressure and a Rotary Motion Sensor (PS-2120) records the movement of the piston.

An Ideal Gas Law Apparatus (TD-8596A), which has an internal thermistor, is used to pump air into the cylinder. A Pressure/Temperature Sensor (PS-2146) records the air pressure and temperature while the Rotary Motion Sensor (PS-2120) records the movement.

Includes
Master Cylinder
Pressure Sensor "T"
Check Valves and Tubing
10 ml Syringe
20 ml Syringe
60 ml Syringe
Drive belt for Rotary Motion Sensor (not shown)

This scissor lift uses pulleys to change the mechanical advantage.

Valves are used with the syringe to pump up this fork lift. The use of different size syringes shows how a smaller force requires a greater number of pumps to do the same amount of work as a larger force.

Hydraulic/Pneumatic Structures ME-6984

Required:

Advanced Structures Set ME-6992B
Steel Rod (90 cm) ME-8738
Absolute Pressure Sensor PS-2107
Rotary Motion Sensor PS-2120A
Pressure/Temperature Sensor PS-2146
Ideal Gas Law Apparatus TD-8596A

Not shown but required for data collection:

Interface and PASCO Capstone™ Software ..... (see page 17)

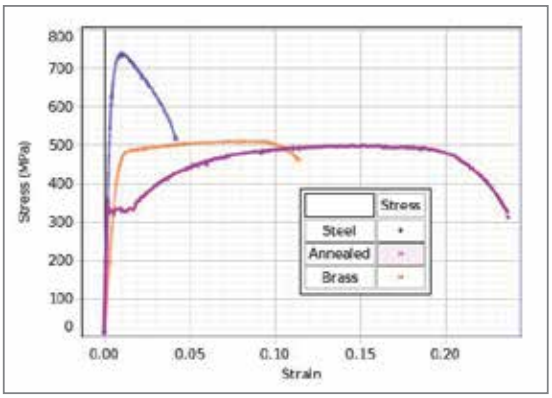
Materials Testing Machine

ME-8236

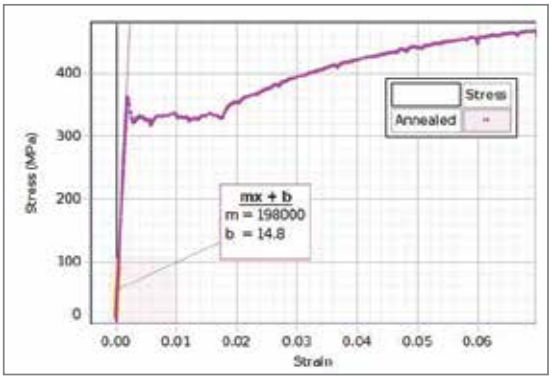
- 7100 N max load
- Hand-cranked so students can feel samples break
- Inexpensive samples make it possible for each student to experience it firsthand

Measure force and displacement for various materials as they are stretched, compressed, sheared, or bent. Investigate material properties including Young's Modulus, Tensile Strength, Yield Strength, Ductility and Modulus of Resilience.

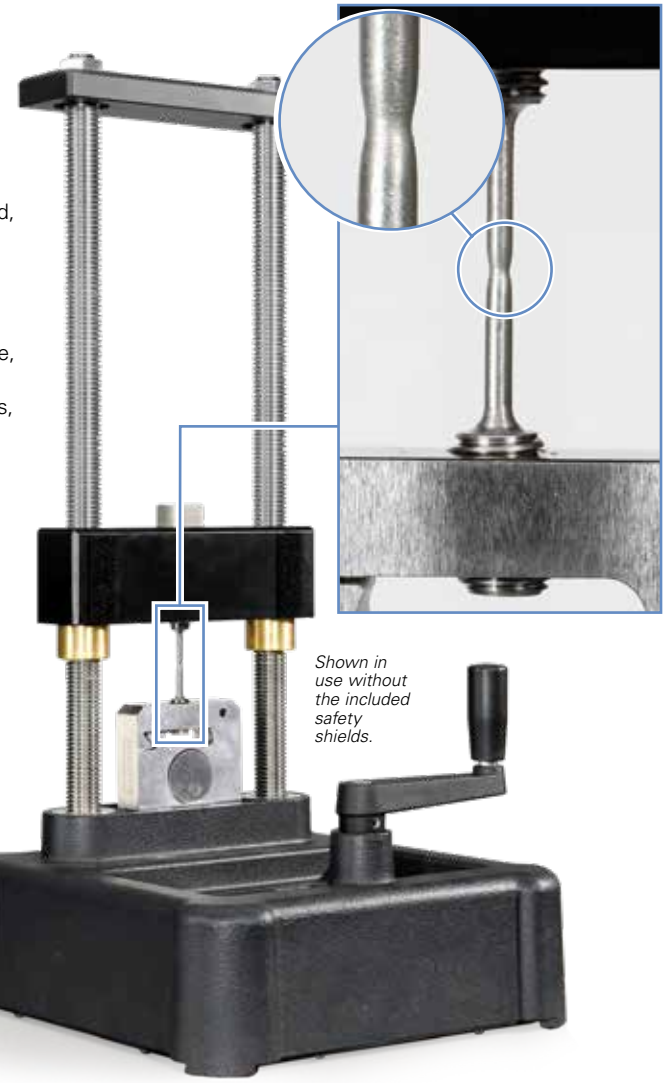
The Materials Testing Machine measures force with a 7100 N load cell and displacement with an optical encoder. It runs on PASCO Capstone software, which has a built-in compliance calibration wizard and has all the tools to record and display stress vs. strain, apply linear fits to find Young's Modulus, and to record and play back webcam movies of the breaking samples synced to the data.



Tensile stress versus strain is plotted in PASCO Capstone software for steel, annealed steel, and brass.



For annealed steel, a linear fit is applied to find Young's Modulus.



Shown in use without the included safety shields.

Tensile Samples (set of 10 each) Shown using tensile sample from Steel Set (ME-8243).

Specifications

Load cell capacity: 7100 N (1600 lbs)
Machine weight: 20 lbs (9 kg)
Footprint: 24 wide x 25 depth x 51 cm height
Lead screw length: 38 cm
Sturdy base: cast aluminum
Mounting holes: for bolting to table

Materials Testing Machine Includes

Machine
Compliance Calibration Rod
Safety Shields
Requires Capstone software *(See page 17)*
(does not include any samples)

Materials Testing Machine **ME-8236**

Tensile Samples (set of 10 each)

Aluminum ME-8231
Brass ME-8232
Annealed Steel ME-8233
Steel ME-8243
Acrylic ME-8234
Polyethylene ME-8235

Required:

PASCO Capstone™ Software ..... (See page 17)

Comprehensive Materials Testing System

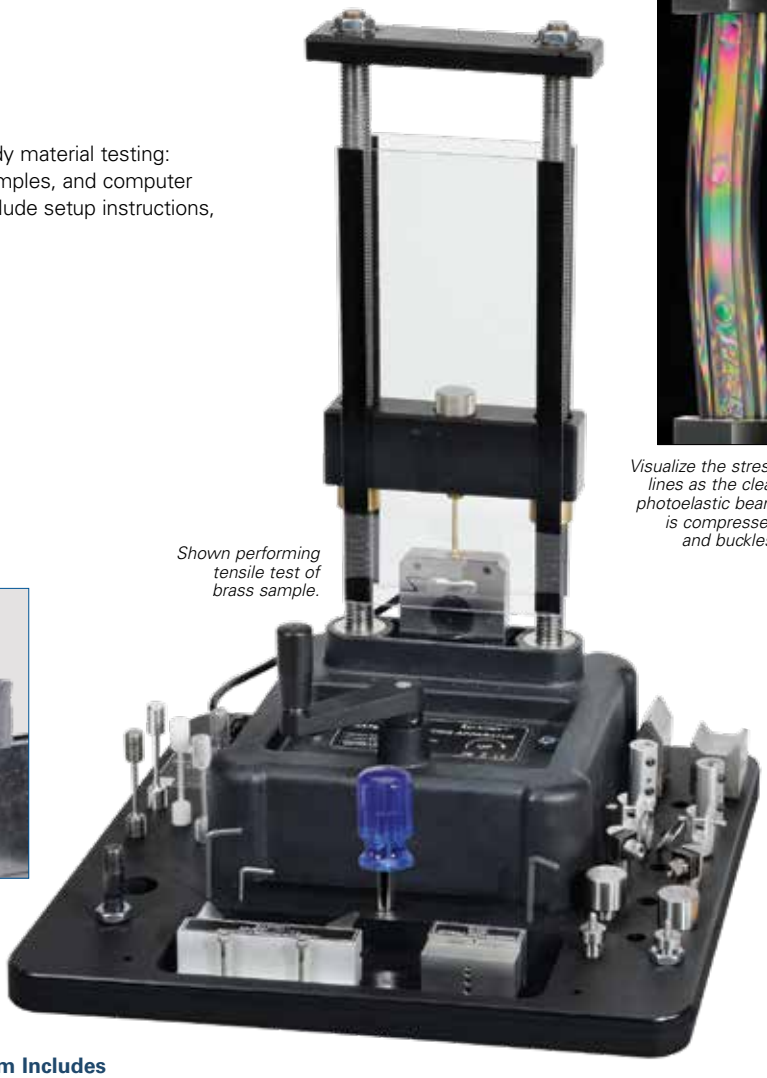
ME-8244

- Compression and tensile testing
- Column buckling
- Three-and four-point bending
- Shear testing
- Stress lines with photoelasticity

System includes everything needed to study material testing: Testing Machine with attachments, test samples, and computer software. PASCO Capstone Workbooks include setup instructions, theory, and detailed analysis questions.

Perform three-point and four-point bending.

Perform a four-point bend test on the ME-6983 Cast Beams from the PASCO Structures System. Quantities measured include the Flexural Elastic Modulus and the Modulus of Rupture for the material.



Shown performing tensile test of brass sample.

Visualize the stress lines as the clear photoelastic beam is compressed and buckles.

Comprehensive Materials Testing System Includes

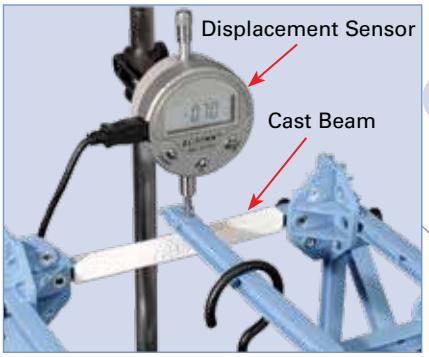
Materials Testing Machine
Storage Base
Tensile Samples (10 of each): aluminum, brass, annealed steel, steel, acrylic, and polyethylene
Bending Accessory
Four-point Bending Load Anvil
Photoelasticity Accessory (with photoelastic beams)
Shear Accessory (with Shear Samples)
Structures Beam Fixture
Thin Beams
Cast Spares
Compression Accessory (with Compression Samples)
Flat Coupon Fixture
Plastic Flat Coupons
Metal Flat Coupons
Clevis Grip
10-32 Adapter
AirLink Interface
PASCO Capstone Software Single User License *(See page 17)*

Comprehensive Materials Testing System ME-8244

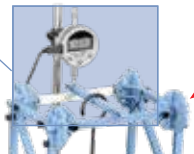
Cast Beam Structures Set

ME-7009

Make your own cast beams that look like pre-stressed concrete beams. Test them and you'll find they perform like them, too. These beams are cast with a mixture of sand and plaster of Paris (not included). The rebar is made of the same plastic used for the I-beams. Students can explore how the strength of the beam is affected by the amount of tension put on the rebar, the mixture of sand and plaster of Paris, or using one or two rebar.

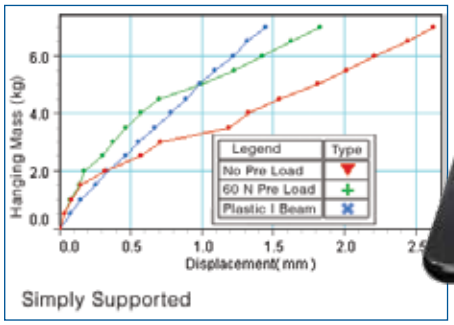


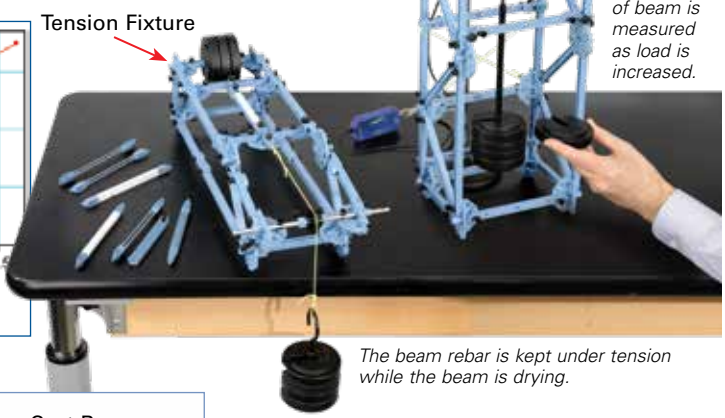
Both the tension fixture and the test fixture can be built concurrently with this set.



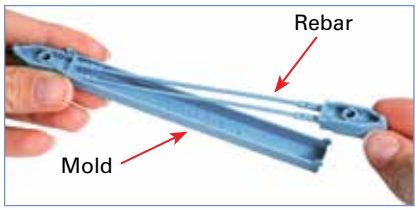
Displacement of beam is measured as load is increased.

The graph of hanging mass versus displacement shows the relative strengths of three beams: one cast beam made with no pre-load; one cast beam made with 60N of pre-load; and one normal plastic I-beam. Notice that the traces for the cast beams show discontinuities when the beams cracked. Also notice that the pre-loaded cast beam is stronger than the plastic I-beam until the cast beam cracks.

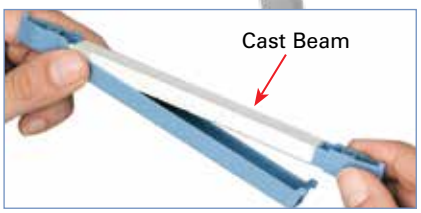




The beam rebar is kept under tension while the beam is drying.

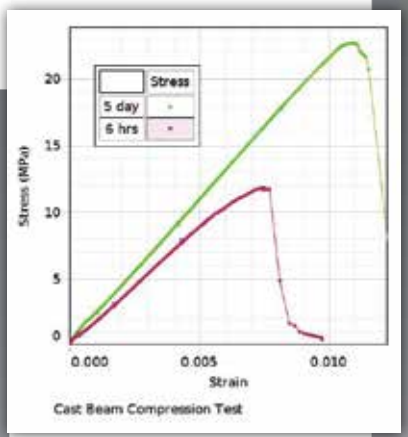


Step 1: The rebar with connecting ends snaps into the plastic mold. Pour a mixture of sand and plaster of Paris into the mold.



Step 2: After it dries, it is easy to remove the flexible plastic mold from the cast beam.

The cast beam shown here is tested to destruction under compression using the Materials Testing Machine on pages 14-15.



PASCO Capstone graph shows that strength of Plaster of Paris increases with cure time.

Cast Beam Spares

Consumable replacement parts for Cast Beams; these can also be used with the Advanced Structures Set (page 8).

Includes
10 Reusable Plastic Molds
30 Rebar with Connectors

Cast Beam Spares ME-6983

Cast Beam Structures Set Includes

One package each of Truss Set Members, Cord Lock Spares, Axle Spares, Round Connector Spares, Angle Connector Spares and two packages of Truss Set Screws

See pages 22-23 for details.

Cast Beam Structures Set ME-7009

Also shown:

Displacement Sensor PS-2204
Large Slotted Mass Set ME-7566
Round Base with Rod ME-8270

Not shown but required for data collection:

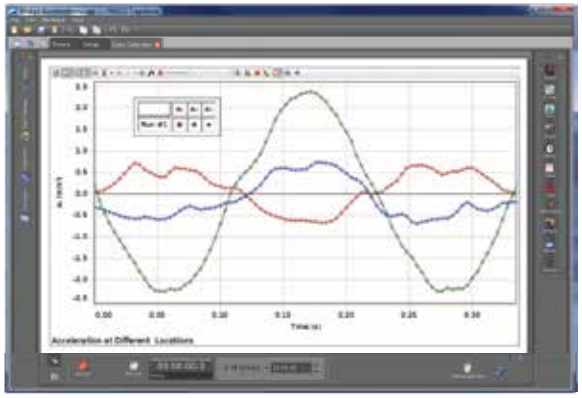
Interface and
PASCO Capstone™ Software .....(see next page)

PASCO's Data Collection and Analysis Software

PASCO Capstone™ Software

- Compatible with all PASCO USB interfaces
- For use with Mac® and Windows® computers

Whether you want your students to explore and create lab write-ups on their own, or you want to tailor a lab write-up with very specific instructions, PASCO Capstone™ has the power and flexibility to meet the needs of your lab.



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- 1 MHz sampling rate
- 2 high-speed analog inputs
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- Fully compatible and expandable
- An incredible value
- Runs on PASCO Capstone™

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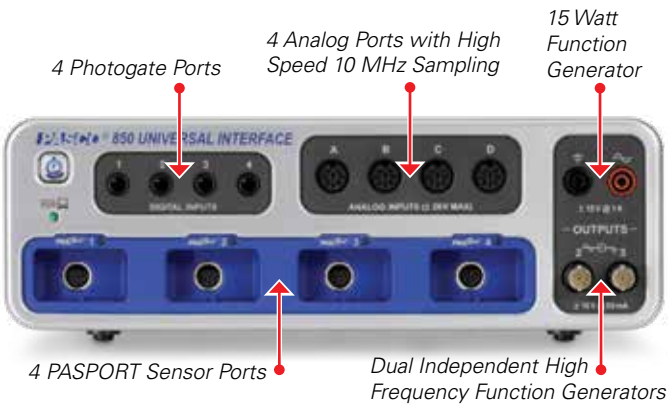


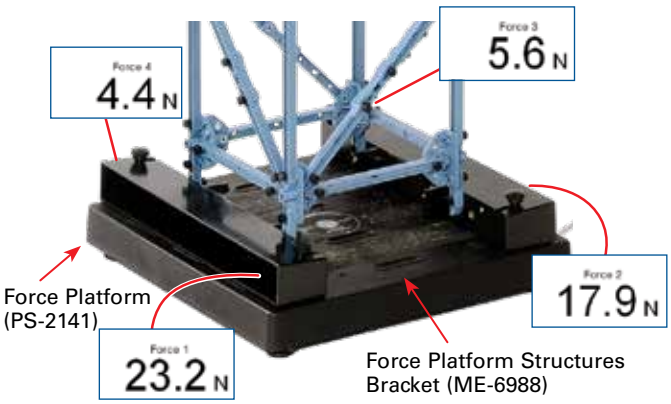
850 Universal Interface **UI-5000**
Requires:
PASCO Capstone Software ***OR*** SPARKvue Software

For more information visit www.pasco.com/850

Measure support forces with a Force Platform

Force Platform
PS-2141

Measure the support forces of a crane by connecting it to a Force Platform (PS-2141) using the special Force Platform Structures Bracket (ME-6988). The Force Platform is supported by four individual load cells that combine to measure the total vertical force on the platform. These four readings can also be viewed separately to measure the unequal forces on the crane supports.



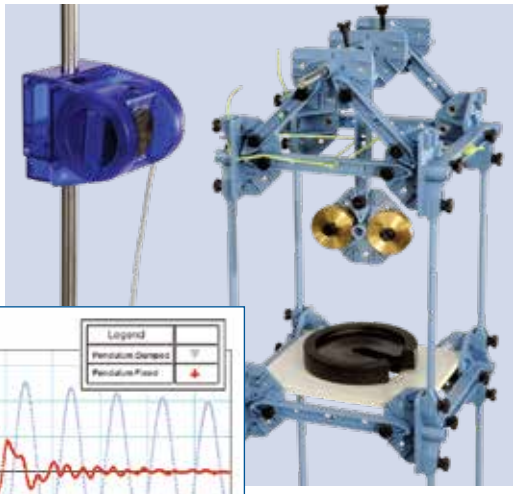
Tower Crane
2.3 m tall

Crane built using the Advanced Structures Set (ME-6992A) shown on page 8.

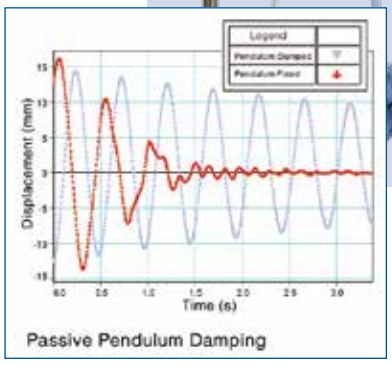
Force Platform.....PS-2141
Force Platform Structures Bracket.....ME-6988A

Measure passive damping with a Motion Sensor

This building frame is built with an Advanced Structures Set using the Flat Beams. A pendulum with drag caused by strings is suspended from the top of the building. The Motion Sensor is positioned to record the oscillation of the building.



See page 20 for more examples using the Shaking Tower.



The gray graph, in PASCO Capstone™ Software (page 17) shows the oscillation without the pendulum. The red graph shows the damping caused when the pendulum is allowed to oscillate.

Advanced Structures Set.....ME-6992B
Motion Sensor.....PS-2103A
Large Slotted Mass Set.....ME-7566

Measure bridge deflection with a Displacement Sensor

Displacement Sensor
PS-2204

The Displacement Sensor measures the travel of a spring-loaded indicator pressed against a bridge as the bridge is loaded. It consists of a PASPORT sensor that plugs into the included Digital Indicator and a digital travel indicator that has its own digital LED readout and can be used as a stand-alone device. When the PASPORT sensor is plugged into an interface, the reading can be recorded.

Specifications
Maximum Travel: 10 mm
Maximum Sample Rate: 5 Hz
Resolution: 0.013 mm (0.0005 in)

Displacement Sensor.....PA-2204

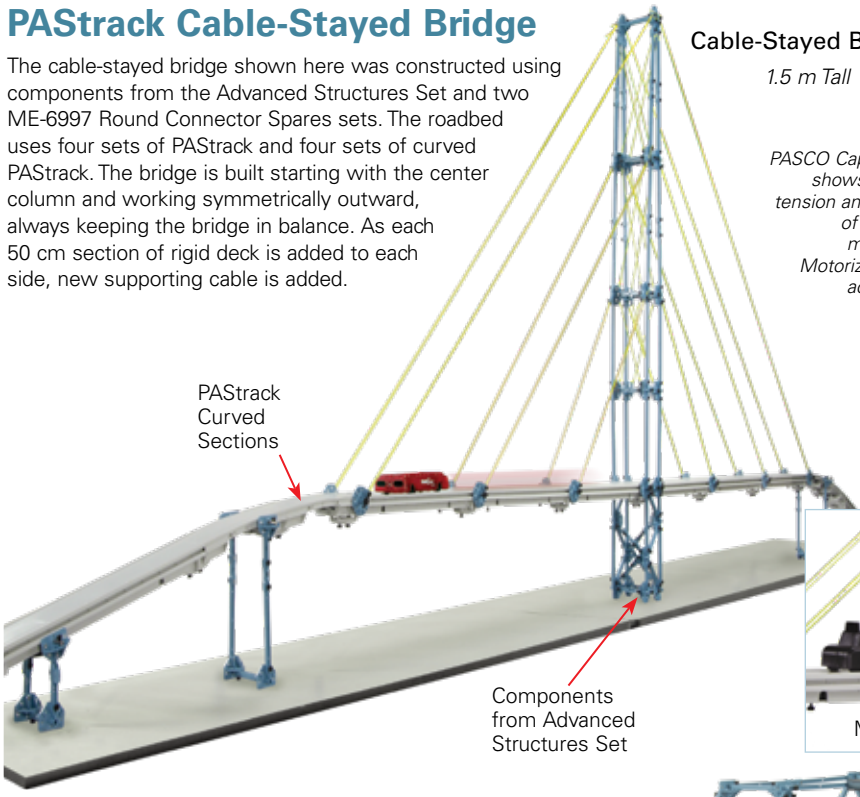
Shown in use with:
Hooked Mass Set.....SE-8759
Small "A" Base.....ME-8976
60 cm long Steel Rod (threaded).....ME-8977

Required:
Interface.....(See page 17)

Combine the rigid, plastic PAStrack sections with components from the Structures System to build truss and cable-stayed bridges with realistic rigid decks.

PAStrack Cable-Stayed Bridge

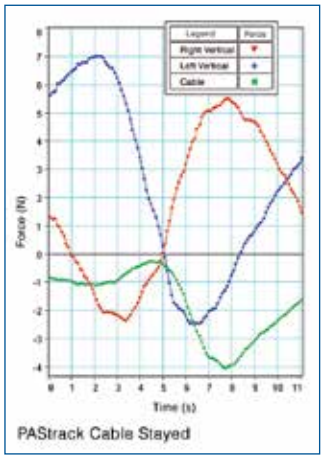
The cable-stayed bridge shown here was constructed using components from the Advanced Structures Set and two ME-6997 Round Connector Spares sets. The roadbed uses four sets of PAStrack and four sets of curved PAStrack. The bridge is built starting with the center column and working symmetrically outward, always keeping the bridge in balance. As each 50 cm section of rigid deck is added to each side, new supporting cable is added.



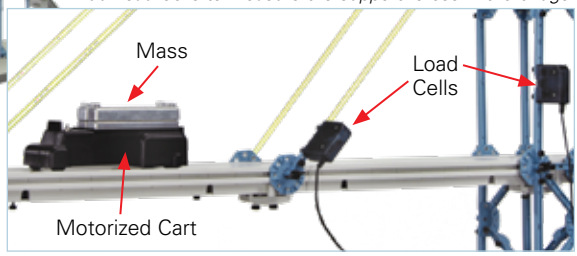
Cable-Stayed Bridge

1.5 m Tall

PASCO Capstone™ graph shows the change in tension and compression of the supporting members as the Motorized Cart moves across the span.

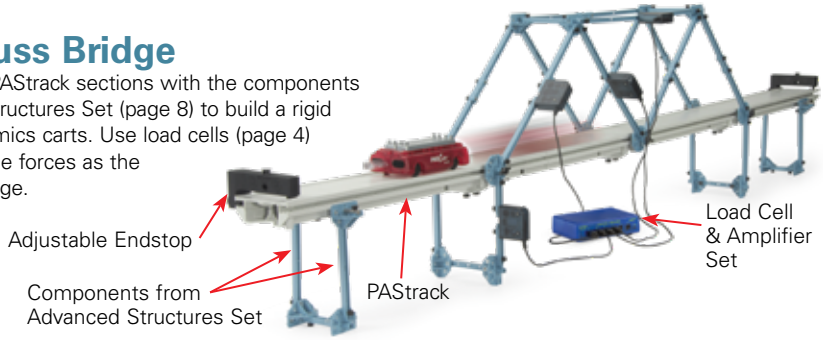


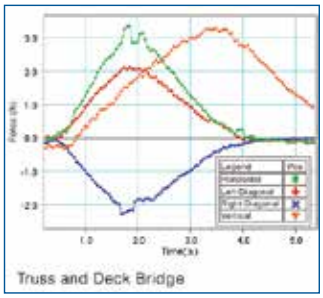
Add Load Cells to measure the support forces in the bridge.



PAStrack Truss Bridge

Combine the plastic PAStrack sections with the components from the Advanced Structures Set (page 8) to build a rigid deck to support dynamics carts. Use load cells (page 4) to directly measure the forces as the cart traverses the bridge.

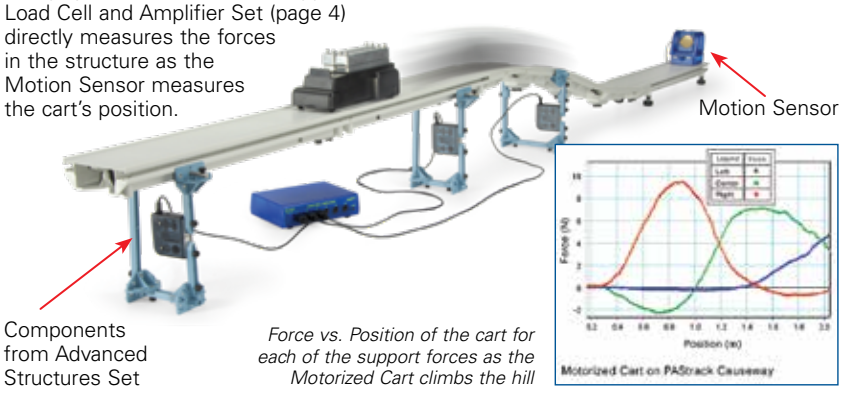




Load cells are used to measure the tension and compression in the members.

Dynamics Track Support Reactions

Combine the plastic PAStrack sections with the components from the Advanced Structures Set (page 8) to measure the support reactions as the Motorized Cart climbs the hill. The Load Cell and Amplifier Set (page 4) directly measures the forces in the structure as the Motion Sensor measures the cart's position.



Force vs. Position of the cart for each of the support forces as the Motorized Cart climbs the hill

Equipment Shown:

Advanced Structures Set	**ME-6992B**
PAScar (set of 2)	ME-6950
PAStrack (2 sections)	ME-6960
Curved PAStrack	ME-6841
Motorized Cart	ME-9781
PAScar Cart Mass (set of 2)	ME-6757A
Adjustable Endstop	ME-8971
Round Connector Spares	ME-6997
Load Cell & Amplifier Set (includes four load cells)	PS-2199
Motion Sensor	PS-2103A
PASCO Capstone Software	(see page 17)
Interface	(see page 17)

Structures Resonance

PASCO's Structures System is perfect for demonstrating resonance in complex systems. The plastic I-Beams clearly show two different bending moments and can be connected together to build a variety of structures.

Composite I-Beam
1.2 m tall

The long plastic I-Beam is constructed of components from the Advanced Structures Set (page 8). It is driven using the Mechanical Wave Driver and the Function Generator, demonstrating the three lowest harmonics.

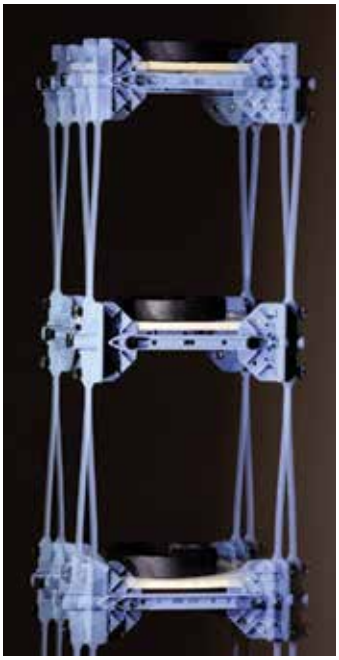
Equipment Shown:

Advanced Structures Set	**ME-6992B**
Function Generator	PI-8127
Mechanical Wave Driver	SF-9324
Large Slotted Mass Set	ME-7566
5N Load Cell	PS-2201
45cm Stainless Steel Rod	ME-8736
Large Rod Base	ME-8735

Shaking Tower
75 cm tall

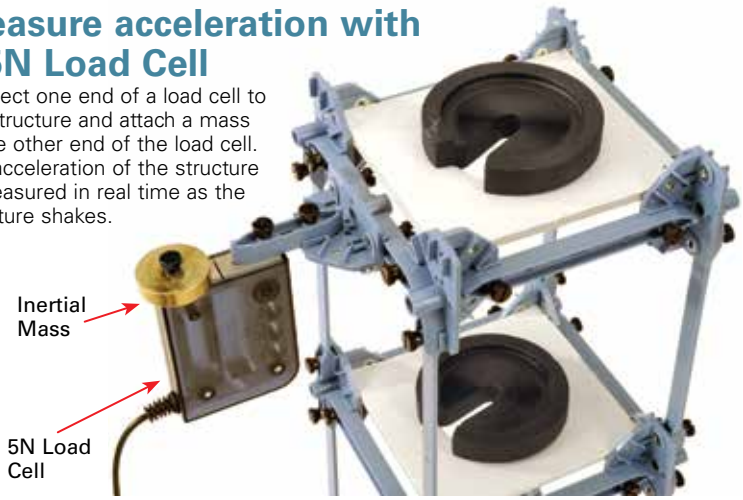
See page 18 for more examples using the Shaking Tower.

This building frame is built with an Advanced Structures Set that includes Flat Members. The building is being shaken with the Mechanical Wave Driver. Additional mass is added to the foam core floors (not included).



Measure acceleration with a 5N Load Cell

Connect one end of a load cell to the structure and attach a mass to the other end of the load cell. The acceleration of the structure is measured in real time as the structure shakes.

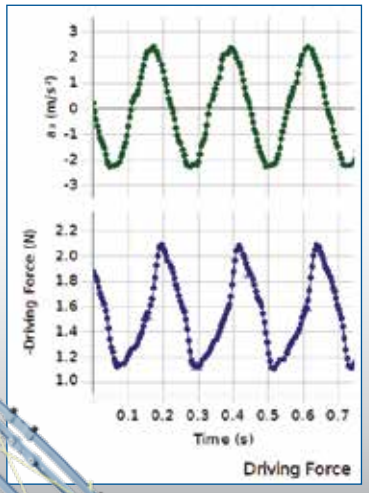


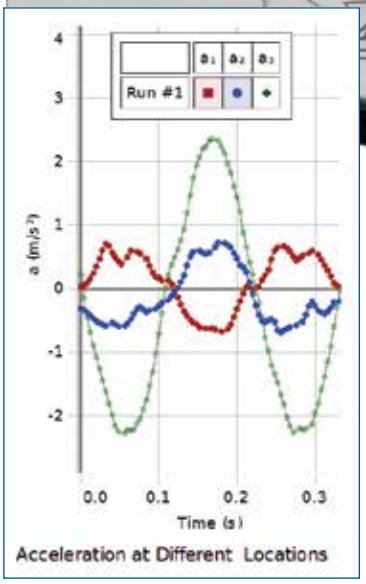
Bridge Vibrations

Concepts:

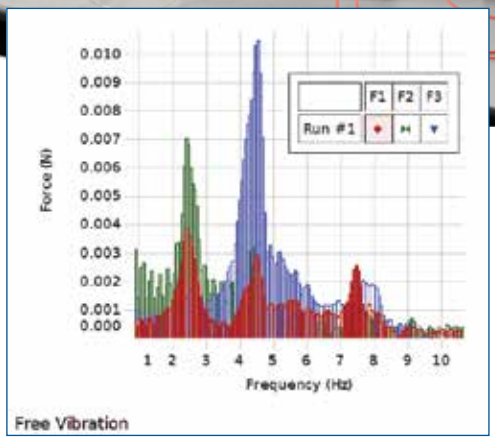
- Study resonance in complex systems
- Compare driven vs. free vibrations

Compare the driving force to the resulting acceleration at different positions on the bridge.

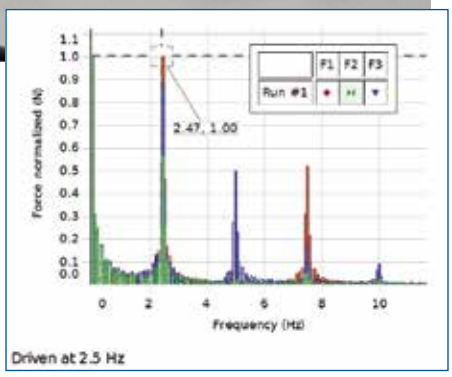




5N Load Cells are used to measure the oscillations of the bridge at different positions.



The bridge is struck by hand and allowed to freely oscillate. The FFT (using PASCO Capstone™) shows several resonant frequencies.



The resonance of the bridge is characterized by driving the bridge at different resonant frequencies. Note how different the amplitudes are at different locations on the bridge.

Download This Experiment

The FREE experiment files include instructions in Microsoft Word™, PASCO Capstone™ workbook files with sample data, and graphics. Download these experiments at **www.pasco.com/CapstoneExperiments**.

Experiment Includes

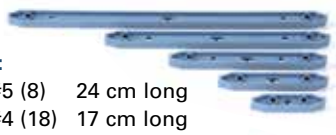
Large Structures Set	ME-7003	4 mm Banana Plug Cords	SE-9750
Load Cell Amplifier	PS-2198	Rubber Cord	ME-8986
100N Load Cell	PS-2200	Large Slotted Mass Set (4)	ME-7589
5N Load Cell (5)	PS-2201	Short Mass Hanger (2)	ME-7590
Mechanical Wave Driver	SF-9324	20 g Masses (3 sets of 6)	ME-8983

Bridge Vibrations EX-5548

Required:

850 Universal Interface (see page 17)
PASCO Capstone Software (see page 17)

Truss Set Members



Includes:
I-beam #5 (8) 24 cm long
I-beam #4 (18) 17 cm long
I-beam #3 (18) 11.5 cm long
I-beam #2 (8) 8 cm long
I-beam #1 (8) 5.5 cm long
Connectors (14)

Truss Set Members.....ME-6993

Truss Set Screws

Includes:
75 screws
All components in the Structures System use this same 6-32 thumb screw.

Truss Set Screws ME-6994

Connectors Spares

Set of 14 connectors used to join truss members. This is the same connector included in the Truss Set ME-6990.

Connector Spares.....ME-7002

Angle Connector Spares

Includes:
Sliding connectors (12),
Angle connectors (24),
Straight connectors (24).

Angle Connector Spares.....ME-6999A

Round Connector Spares

Includes:
Round connectors (6)
Flat connectors (6)
Six bolts with nuts.

Round Connector Spares.....ME-6997

Cord Lock Spares

Includes:
32 cord-tensioning clips and a spool of yellow cord.

Cord Lock Spares.....ME-6996
Yellow Cord (2 pack).....ME-9876

Axle Spares

Includes:
Drive wheel with rubber tire (4), pulleys with "O" rings (12 each), axles (two each of three lengths), spacers (12) and collets (24).

Axle Spares ME-6998A

Thin I-Beams

Includes:
Thin I-beam #4 (24) 17 cm long
Thin I-beam #3 (24) 11.5 cm long

Thin I-Beams ME-7012

Photoelastic Beams

Includes:
Clear, Polycarbonate Thin I-beams #4 (24) 17 cm long, and #3 (24) 11.5 cm long.

Photoelastic Beams.....ME-7011

Flexible I-Beams

Includes:
Flex I-beam #5 (10) 24 cm long
Flex I-beam #4 (18) 17 cm long
Flex I-beam #3 (18) 11.5 cm long

Flexible I-Beams ME-6985

Flat Beams

Includes:
2x3 beams 12 cm long
F4 beams 17 cm long
3x4 beams 19 cm long

Flat Beams ME-6987

#6 I-Beam Spares

Longer beam to supplement the Truss Set ME-6990. Has the same cross section as the shorter beams.

Includes:
24 of the #6 I-beams, 35 cm long.

#6 I-Beam Spares.....ME-7008

Cast Beam Spares

Consumable replacement parts for Cast Beams ME-7009. Includes 10 Reusable Plastic Molds and 30 Rebar with Connectors. These can also be used with the Advanced Structures Set ME-6992B.

Cast Beam Spares ME-6983

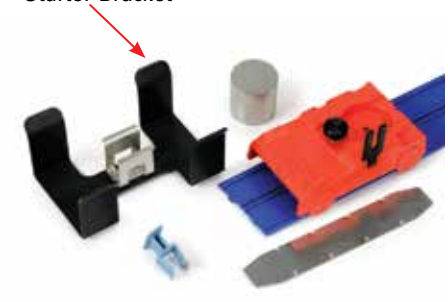
Roller Coaster Track (9.1 m)

Longer replacement roll of flexible plastic track for use with the Bridge Set ME-6991, Physics Structures Set ME-6989, Large Structures Set ME-7003, and Roadbed Spares ME-6995.

Roller Coaster Track ME-9814

Roadbed Spares

Starter Bracket



Includes:
Flexible roadbed (3 m)
Roadbed clips (24)
Car with flag
Extra mass, mini car starting bracket, and track couples (2).

Roadbed Spares.....ME-6995

Force Platform Structures Bracket

Includes:
Brackets (2)
Screws (4)

Force Platform Structures Bracket ME-6988A

Mini Cars (Set of 3)

These cars feature low-friction ball bearings and ABS construction to withstand repeated impacts. One red, one yellow, and one green Mini Car included. Each car includes a slot for a supplied photogate flag, cup/mass holder, and cup. The body of the car extends just far enough below the wheels to protect them should the car leave the track.

Includes:
Mini Cars (3)
Decals
Elastic Bumpers (3)
Flags (3)
Rubber Bands

Mini Cars (Set of 3) ME-9813

Mini Car Track Spares

Includes:
Two gates
Two track couplers
One bag (24) of roadbed clips

Mini Car Track Spares.....ME-6974

Large Slotted Mass Set

Consists of nine iron disks of 0.5 kg each. The hanger is 0.5 kg. Each piece cast and machined to 1 gram accuracy. The 2 kg Mass Set is similar in mass and hanger weight to the Large Slotted Mass Set, but this more compact set includes a shorter 1/2 kg hanger and three 1/2 kg slotted masses. The size and weight of these sets make both ideal for creating loads on the Structures Systems.

Large Slotted Mass Set.....ME-7566

Hydraulic and Pneumatic Structures

Includes:
Master Cylinder
Pressure Sensor "T"
Check Valves and Tubing
Syringes (10, 20, 60 ml)
Drive Belt for Rotary Motion Sensor (not shown)

Hydraulic/Pneumatic Structures.....ME-6984

Structures Rod Clamps (Set of 2)

Connects structure members to 1/2 inch rod.

Structures Rod Clamps (2) ME-6986

PASCO

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This model of the Louisville 2nd Street Bridge was built using the PASCO Structures System. The section shown here is approximately 4 m long.