



PASCO Structures Systems  
**Large Structures Set**  
ME-7003



The cover page shows an Angle Crane model built with components from the ME-7003 Large Structures Set. The picture shows Load Cells, a Load Cell Amplifier, Large Slotted Masses, and the Hydraulics Structures Set which are available separately. The ME-7003 Large Structures Set can be used to build over a dozen different models. Instructions for building twenty models are included in this manual.

## Table of Contents

Included Items . . . . .	2
Recommended Equipment . . . . .	2
Introduction . . . . .	2
About the Components . . . . .	3
Operation . . . . .	8
Adding Load Cells . . . . .	8
Large Structures Construction . . . . .	9
1. Car Building Jump . . . . .	10
2. Cable Stayed Bridge . . . . .	13
3. Arch Truss Bridge . . . . .	15
4. Roller Coaster . . . . .	17
5. Canyon Car Jump . . . . .	20
6. Suspension Bridge . . . . .	22
7. High Road/Low Road . . . . .	24
8. Tied Arch Bridge . . . . .	26
9. Baltimore Bridge . . . . .	28
10. Double Tied Arch Bridge . . . . .	31
11. Cantilever Truss Bridge . . . . .	33
12. Brachistochrone . . . . .	34
13. Drawbridge . . . . .	35
14. Vertical Lift Drawbridge . . . . .	39
15. Tower Crane . . . . .	41
16. Arch Causeway . . . . .	43
17. Skyscraper . . . . .	45
18. House Frame . . . . .	46
19. Angle Crane . . . . .	47

20. Windmill . . . . . 50  
Technical Support, Warranty, and Copyright. . . . . 54  
Windmill Sail Template . . . . . 55

# Large Structures Set

ME-7003



ME-9814 Coaster Track (9.1 m)



ME-7002 Connector Spares



ME-6993 Truss Set Members



ME-6988A Force Platform Structure



ME-6999A Angle Connectors



ME-6996 Cord Lock Spares



ME-6998A Axle Spares



ME-6997 Full Round Connector Set



ME-6985 Flexible I-Beams



ME-7008 #6 I-Beams



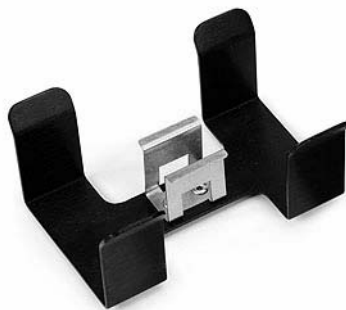
ME-6994 Truss Set Screws



ME-9839 and ME-9840 Mini Cars



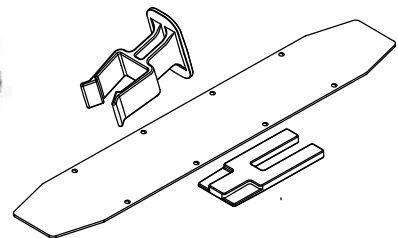
ME-6986 Structures Rod Clamp



ME-9856 Mini Car Starter Bracket



ME-6987 Flat Structures Members



ME-6974 Large Structure Parts

Included Items	Qty	Included Items	Qty
ME-6974 Large Structures Parts	1 set	ME-6998A Axle Spares	1 set
ME-6986 Structures Rod Clamps (2/set)	1 set	ME-6999A Angle Connectors	1 set
ME-6985 Flexible I-Beams	1 set	ME-7002 Connector Spares	2 sets
ME-6987 Flat Structures Members	1 set	ME-7008 #6 I-Beam Spares	1 set
ME-6988A Force Platform Structure	1 set	ME-9814 Coaster Track (9.1 m)	1
ME-6993 Truss Set Members	3 sets	ME-9839 Mini-car, Green	1
ME-6994 Truss Set Screws (75/set)	6 sets	ME-9840 Mini-car, Yellow	1
ME-6996 Cord Lock Spares	1 set	ME-9856 Mini-car Starter Bracket	1
ME-6997 Full Round Connector Set	1 set	Container (not shown)	2

The ME-7003 Large Structures Set can be used with other sets from the PASCO Structures System\* such as the following:.

ME-6984 Hydraulics Structures Set	ME-6991 Bridge Set
ME-6990 Truss Set	ME-6992A Advanced Structures Set

\*See the PASCO catalog or Web site at [www.pasco.com](http://www.pasco.com) for information about the PASCO Structures System.

The following equipment\* is recommended for use with a PASCO Interface to measure tension and compression forces in the structures or to measure the motion of a Mini Car as it moves on a structure..

Recommended Equipment*	Recommended Equipment*
Load Cell Amplifier (PS-2198, PS-2206 or CI-6464)	PS-2204 Displacement Sensor
PS-2200 100 N Load Cell	PS-2159 PASPORT Digital Adapter
PS-2201 5 N Load Cell	ME-9498A Photogate Head

\*See the PASCO catalog or Web site at [www.pasco.com](http://www.pasco.com) for more information about the recommended items.

## Introduction

The ME-7003 Large Structures Set is one part of the PASCO Structures System and can be combined with other parts of the Structures System. The Large Structures Set allows you to build a variety of realistic truss structures. You can add Load Cells to the structures in order to measure the forces anywhere in the structure. This manual describes the construction of sixteen structures.

**Load Cell Amplifier (PS-2198 or CI-6464)** - The amplifier requires a PASPORT or *ScienceWorkshop* interface to connect to a computer. The PS-2198 accepts up to six Load Cells and the CI-6464 supports one Load Cell.

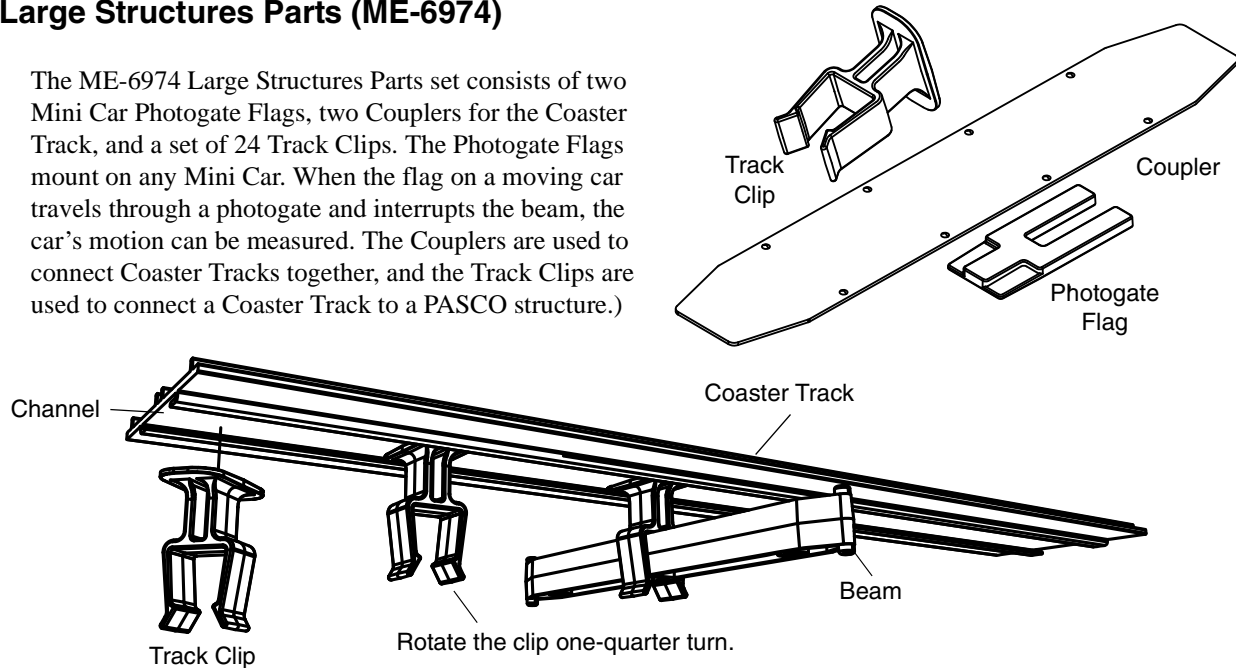
**100 N Load Cell (PS-2200) and 5 N Load Cell (2201)** - Strain gauges mounted on a beam with no electronics so a Load Cell requires a Load Cell Amplifier (PS-2198), Dual Load Cell Amplifier (PS-2206), *ScienceWorkshop* Load Cell Amplifier (CI-6464), or CI Sensor Voltage Monitor (CI-6611).

**Displacement Sensor (PS-2205)** - A PASPORT Sensor and a digital displacement indicator designed to measure the deflection of parts of a structure such as a truss or a bridge as forces are applied.

## About the Components

### Large Structures Parts (ME-6974)

The ME-6974 Large Structures Parts set consists of two Mini Car Photogate Flags, two Couplers for the Coaster Track, and a set of 24 Track Clips. The Photogate Flags mount on any Mini Car. When the flag on a moving car travels through a photogate and interrupts the beam, the car's motion can be measured. The Couplers are used to connect Coaster Tracks together, and the Track Clips are used to connect a Coaster Track to a PASCO structure.)



Use track clips to connect the Coaster Track to the structure beams. Slide the clip into the channel on the underside of the track. Move the clip into position and lock it into place with a quarter twist as shown.

### Flexible I-Beams (ME-6985)

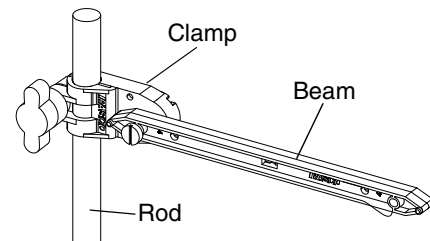
The Flexible I-Beam Set contains forty-six flexible beams of three different lengths. The flexible beams have the same lengths as three of the I-beams from the Truss Set Members (ME-6993). The flexible beams allow you to explore the concept of structural failure. By replacing a #3, #4, or #5 I-beam in a structure with one of the flexible I-beams you can observe the effect of a load that causes deformation. These I-beams are designed to demonstrate stress and failure and then return to their original shape once the load is removed.

Flexible I-Beam Set (ME-6985)	Qty	Equivalent Truss Set Members
#3 Flexible I-Beam (11.5 cm)	18	#3 I-Beam
#4 Flexible I-Beam (17 cm)	18	#4 I-Beam
#5 Flexible I-Beam (24 cm)	10	#5 I-Beam

Please note that the flexible I-beams are a different color (beige) than the other I-beams (light blue).

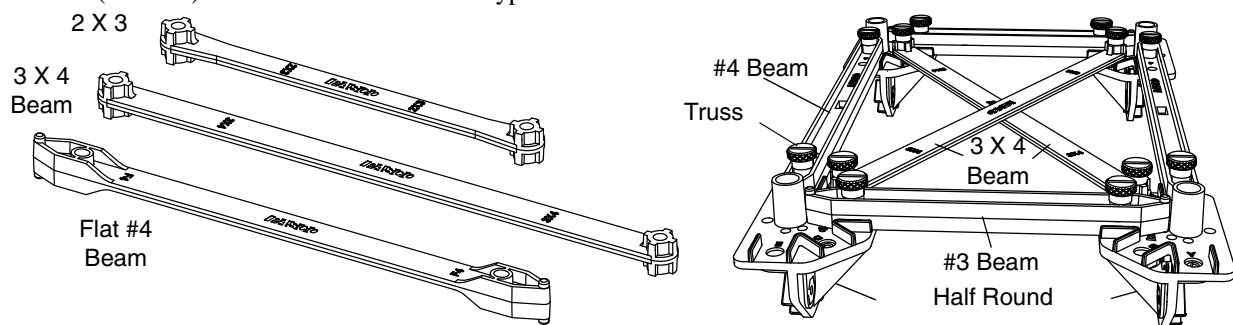
### Structures Rod Clamp (ME-6986)

Use a rod clamp to attach a structure beam to any 12.7 mm (1/2") diameter rod.



### Flat Structures Members (ME-6987)

This set contains three types of flat structures: Flat 3 X 4 Beam (19 cm), Flat #4 Beam (17 cm), and Flat 2 X 3 Beam (12.5 cm). There are sixteen of each type of beam in the set.



### Force Platform Structure (ME-6988A)

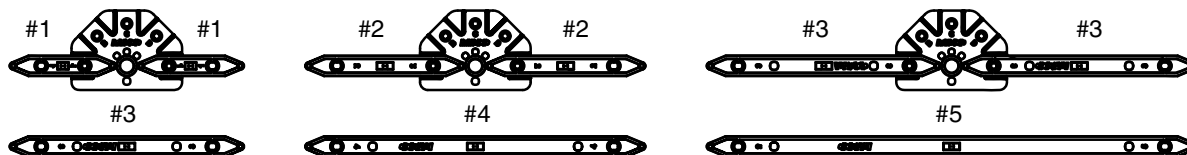
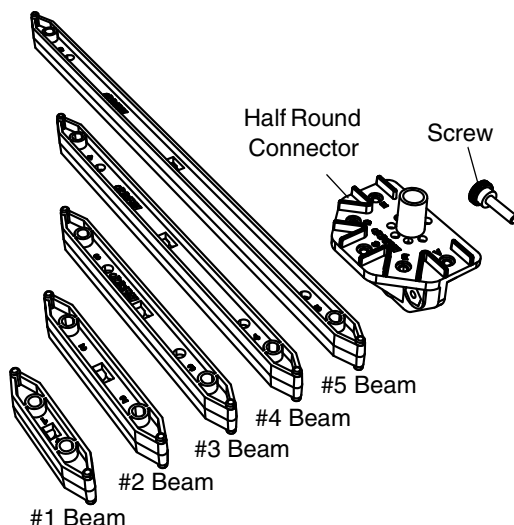
The PASCO model ME-7003 Force Platform Structures Bracket includes two brackets and four thumbscrews. The adapter bracket is designed to connect members of the PASCO Structures System to a PASCO Force Platform (not included). The brackets can also serve as foundation plates for larger structure models. (Please see the Force Platform Structures Bracket instruction sheet for more information.)

### Truss Set Members (ME-6993)

The Truss Set Members consists of five types of “I-beams” and one type of connector. Each set has the following quantities:

Item	Qty	Item	Qty
#1 Beam (5.5 cm)	8	#4 Beam (17 cm)	18
#2 Beam (8 cm)	8	#5 Beam (24 cm)	8
#3 Beam (11.5 cm)	18	Half Round Connector	14

When connected at 180° to a connector, two identical beams have a combined length equal to one longer beam. For example, two #1 beams connected at 180° have the same length as a #3 beam.



### Truss Set Screws (ME-6994)

Each set of Truss Set Screws contains 75 Thumbscrews for attaching I-beams to connectors or load cells.

### Cord Lock Spares (ME-6996)

A set of Cord Lock Spares includes 32 Cord Tensioning Clips (Cord Clips) and one roll of yellow braided cord. When attaching cords for lateral bracing or for suspension or cable-stayed bridges, Cord Clips are used to assist in adjusting the tension in the cords.

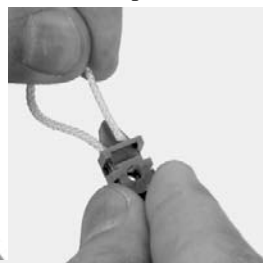
The Cord Clip does not come apart. It is best to thread the cord through the clip before the clip is installed on the bridge or structure. Prepare to thread the cord by holding the top half of the clip as shown in Figure A so the two



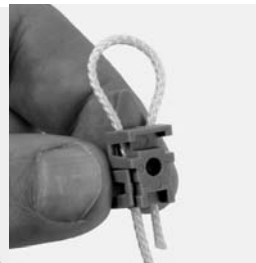
halves of the clip will separate, leaving an opening through which the cord is threaded. The cord is inserted into the end opposite the pointed end of the clip. The cord should be looped back through the clip as shown in Figure C. Then the Cord Clip can be used in the structure, using the attachment screw to tighten the clip shut. To adjust the cord tension, loosen the screw and pull on the cord to the desired tension and then tighten the screw.



**Figure A:** Hold half of the cord clip so the two halves separate



**Figure B:** Loop the cord back through the cord clip



**Figure C:** The cord goes around the screw hole



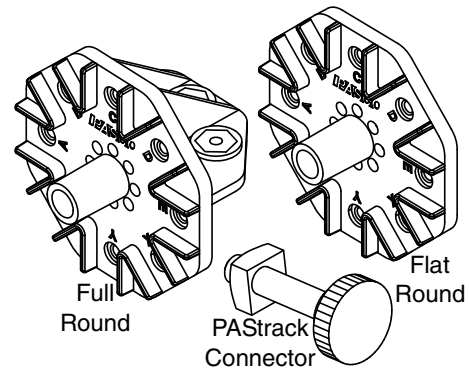
**Figure D:** The cord clip is ready to be attached to the structure using a screw

### Full Round Connectors Spares (ME-6997)

**Full Round Connector:** The Full Round Connector has eleven slots, labeled A through H and X, Y, and Z, for attaching beams. There are six Full Round Connectors in the set.

**Flat Round Connector:** The Flat Connector has eight slots, labeled A through E, and X, Y, and Z, for attaching beams. There are six Flat Connectors in the set.

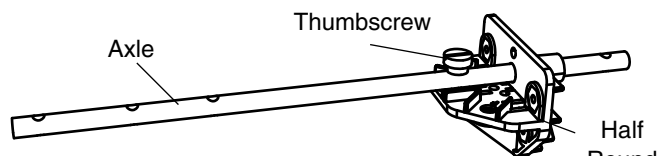
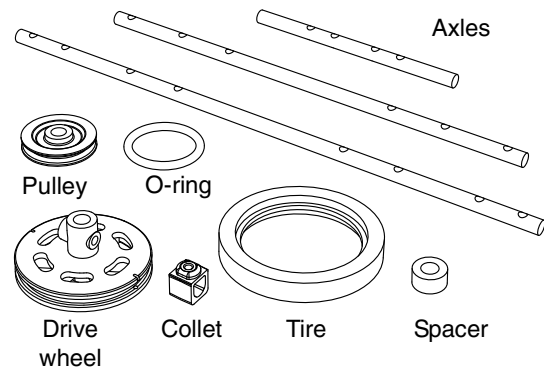
**PAStack Connector:** The PAStack Connector is a nut and bolt that allows a PAStack to be connected to a structures model. There are six PAStack Connectors in the set.



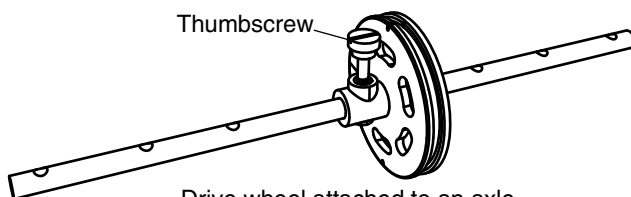
### Axle Spares (ME-6998A)

The Axle Spares set includes two Axles each of three different lengths, twelve Pulleys, twelve O-rings, four Drive Wheels, four Tires, 24 Collets, and twelve Spacers.

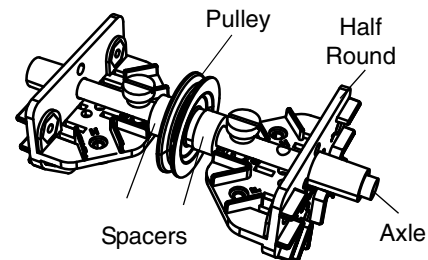
The illustrations show example uses of axles, pulleys, and wheels.



Axle attached to a half-round connector



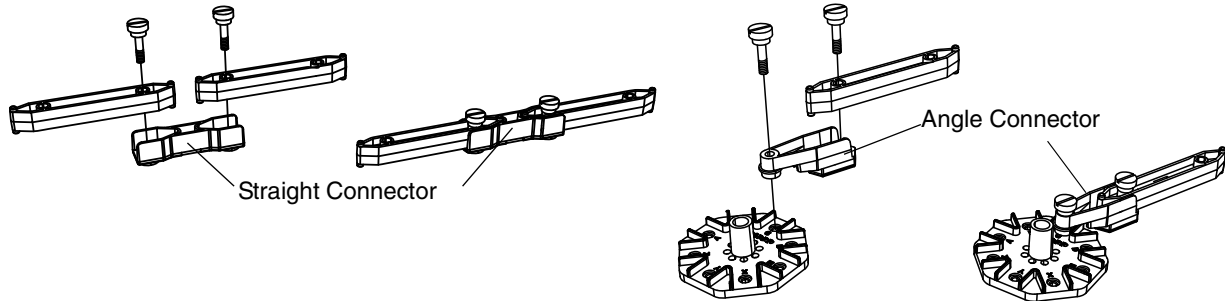
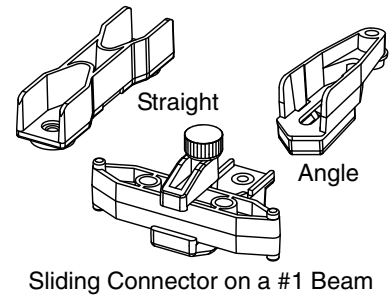
Drive wheel attached to an axle



This pulley is free to rotate.

## Angle Connectors (ME-6999A)

The Angle Connectors set includes 24 Straight Connectors, 24 Angle Connectors, and twelve Sliding Connectors. The Straight Connector can connect two beams to make a longer beam. The Angle Connector can allow a beam to be connected to a half round connector, full round connector, or flat round connector at an angle different than zero, 45, or 90 degrees. The angle connector also allows for a small adjustment of the length of the beam. The Sliding Connector allows one beam to be connected to another beam at any position along the length of the second beam.



To use the sliding connector, loosen the thumbscrew and rotate the top “jaw” to the side. Place the beam onto the lower part of the connector, rotate the top “jaw” into place, and tighten the thumbscrew. The Structures Set includes two Angle Connector sets.

## Connector Spares (ME-7002)

Each set of Connector Spares includes fourteen Half Round Connectors.

## #6 I-Beam Spares (ME-7008)

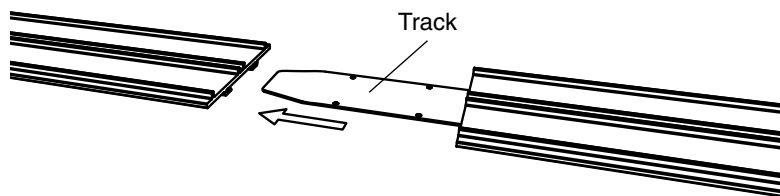
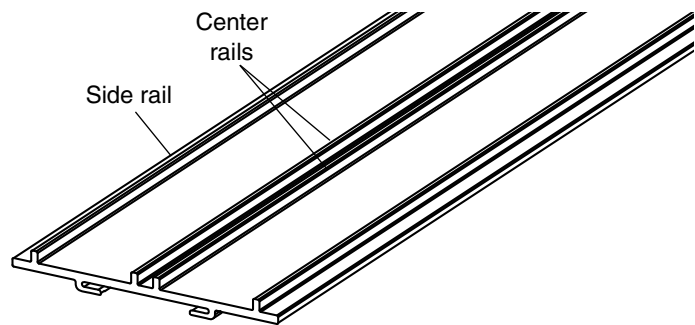
The #6 I-Beam is 35 cm long. There are 24 beams per set.

## Coaster Track (ME-9814)

The ME-9814 Coaster Track is a section of flexible track that is 9.1 m long. Side rails and center rails help to keep a Mini Car on the track.

Use a sharp knife or scissors to cut the track to the desired length.

Use a Track Coupler to connect two sections of Coaster Track together.

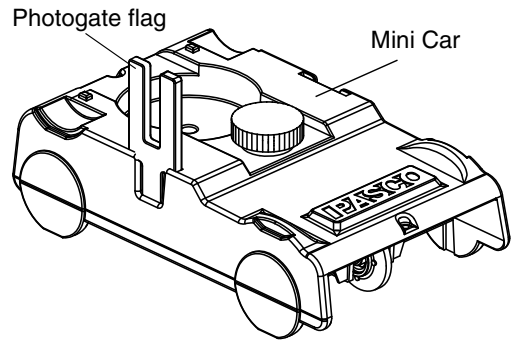


Slide the Track Coupler into the channel on the underside of each Coaster Track section.

### Mini Cars (ME-9839 and ME-9840)

The ME-9839 Green Mini Car and ME-9840 Yellow Mini Car are designed to run on the Coaster Track.

If you are using a photogate (available separately) to measure the speed of the car, attach a photogate flag (included with the ME-6974) as pictured. The flag will interrupt the photogate twice as the car passes, allowing the speed to be calculated.

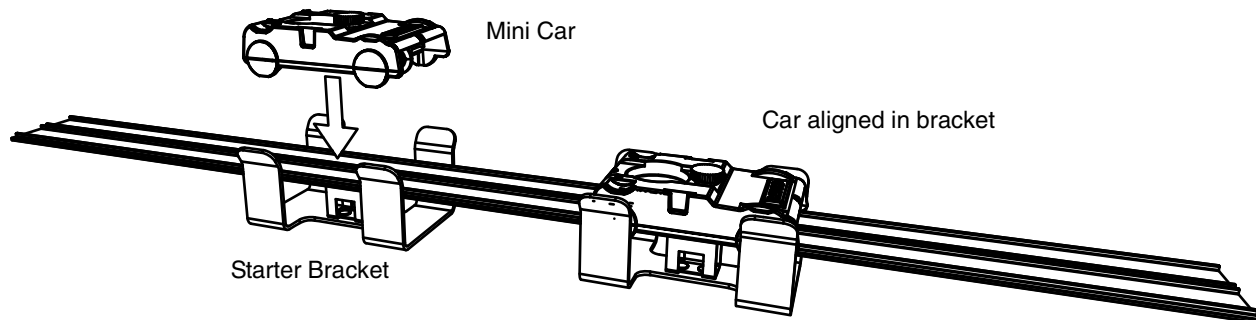
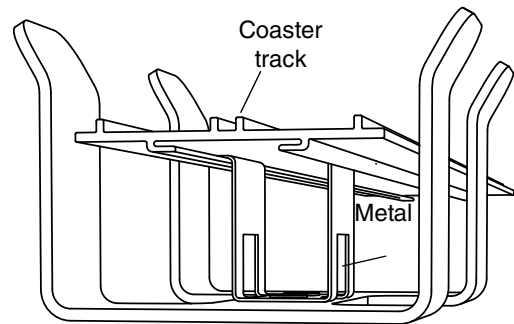


### Mini Car Starter Bracket (ME-9856)

The ME-9856 Mini Car Starter Bracket is designed to help align the wheels of the Mini Car on the Coaster Track. Squeeze the metal clip of the starter bracket and insert it into the channel on the underside of the track.

Slide the bracket along the track to the desired position.

Drop the Mini Car into the bracket as shown.



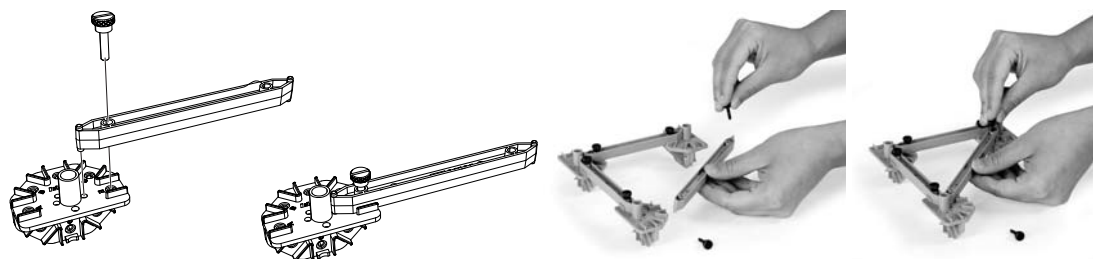
### Total Quantities

Included Items	Qty	Included Items	Qty	Included Items	Qty
#6 Beam (35 cm long)	24	#4 Flexible Beam (17 cm)	18	Force Platform Structure	2
#5 Beam (24 cm long)	24	#3 Flexible Beam (11.5 cm)	18	Cord Tensioning Clip	32
#4 Beam (17 cm long)	54	Angle Connector	24	Yellow Cord	1 roll
#3 Beam (11.5 cm long)	54	Straight Connector	24	Coaster Track (9.1 m)	1
#2 Beam (8 cm long)	64	Sliding Connector	12	Mini Car (Green and Yellow)	2
#1 Beam (5.5 cm long)	24	Flat Round Connector	6	Mini Car Starter Bracket	1
Flat 2 X 3 Beam (12.5 cm)	16	Full Round Connector	6	Track Clip	24
Flat 3 X 4 Beam (19 cm)	16	Half Round Connector	70	Track Coupler	2
Flat #4 Beam (17 cm)	16	PAStrack Connector	6	Mini Car Photogate Flat	2
#5 Flexible Beam (24 cm)	10	Screw (6-32)	450	Container (not shown)	2

# Operation

## Assembling Beams

All beams attach to connectors in the same way. Use the included screws (6-32, slotted) to attach beams to a connector (such as the half round connector) as illustrated.



Attaching beams to connectors

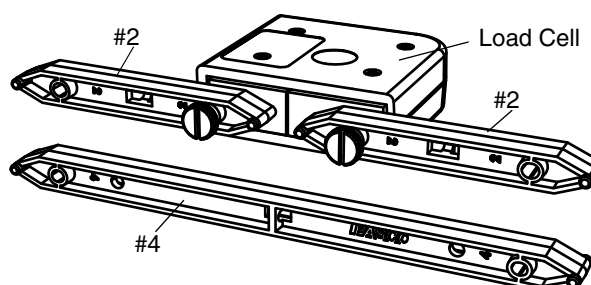
## Adding Load Cells

To measure the compression and tension forces in individual members of a structure, add load cells (available separately) to the PASCO Structure. Replace a beam with two shorter beams and a load cell.

#5 beam = load cell + two #3 beams

#4 beam = load cell + two #2 beams

#3 beam = load cell + two #1 beams



A load cell combined with two #2 beams is the same length as a #4 beam

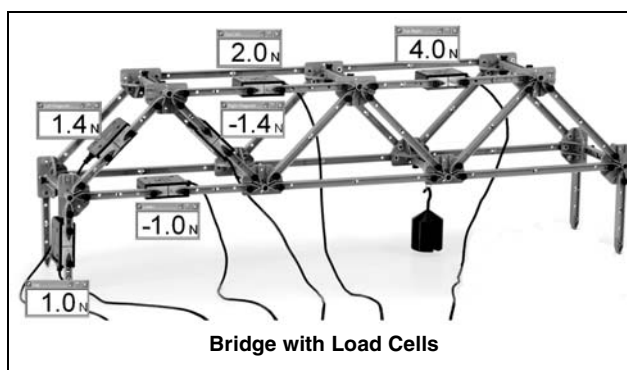
Use thumbscrews to attach two beams to a load cell as shown in the figure.

*When using load cells, assemble your structure with the screws loose.* This will simplify the analysis by ensuring that the members experience only tension and compression without moments.

## Example: Bridge with Load Cells

### Static Load

The bridge shown in the figure incorporates six load cells to measure the tension or compression in various members. A hanging mass is used to apply load. The mass is adjusted so that the compression in one of the legs is 1.0 N. Compression is registered as a positive value and tension as a negative value.



Bridge with Load Cells

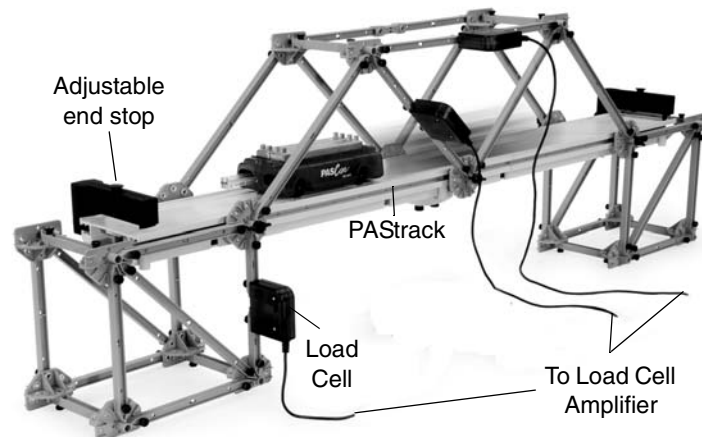
If the screws are loose, then the theoretical analysis of the bridge can be carried out by assuming that the net force at each node is zero. Thus, the vertical component of compression in the left-most diagonal member must be 1 N (to oppose the force applied by the leg). The horizontal component must also be 1 N since the member is at a 45° angle. The predicted resultant force is:

$$\sqrt{(1.0 \text{ N})^2 + (1.0 \text{ N})^2} = 1.4 \text{ N}$$

## Dynamic Load

With the load cells inserted as shown in the figure, push a Cart with its extra mass across the bridge. Zero the load cells before the measurement. Examine which members are under tension or compression.

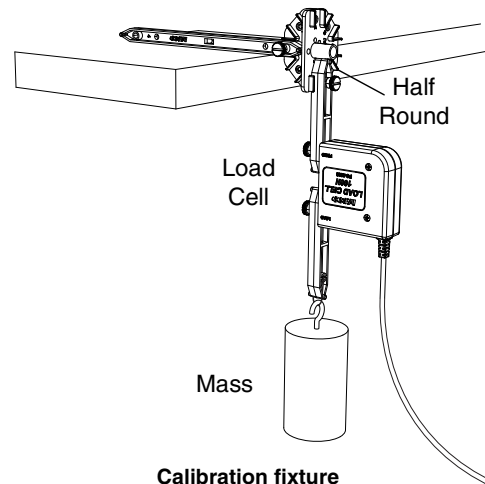
Note that the Load Cell Amplifier can support up to six Load Cells in any combination (5 N, 100 N, or both).



Recording the forces measured by the load cells as the cart traverses the PAStack bridge.

## Calibration.

See the instructions that came with the load cells for details about how to connect the load cells to an interface or datalogger. Follow the instructions to calibrate the load cells and use them to collect data. (Load cells are factory calibrated; however, you can re-calibrate them in software or on the datalogger. See the documentation for your software or datalogger for instructions.)



## Large Structures Construction

The manual illustrates construction of twenty large structures such as trusses, bridges, and cranes. The descriptions show what components are used for each structure and how they are connected to each other. Close-up photographs show the details of construction where possible.

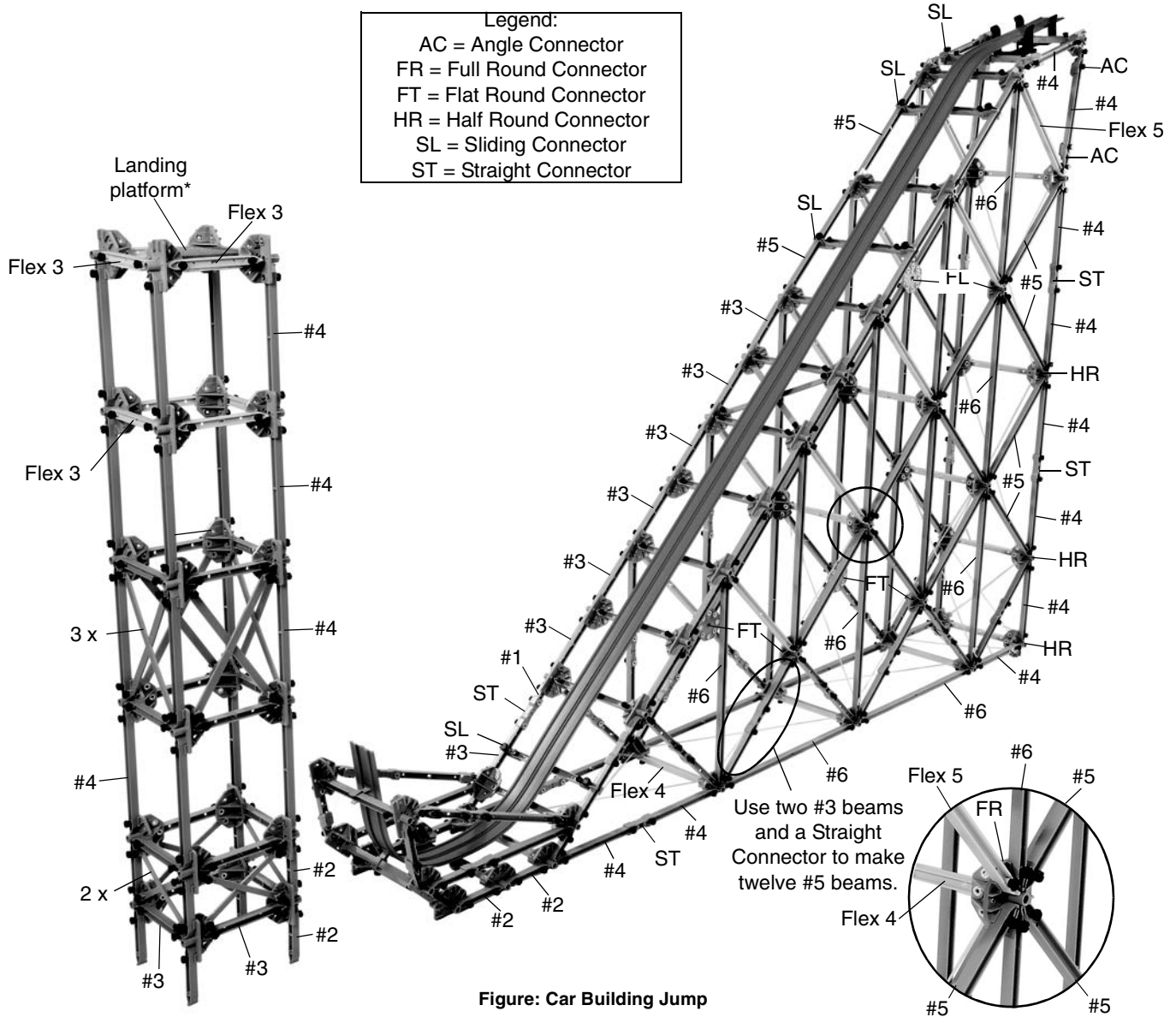
Table 1.1:

Structure	Structure	Structure	Structure
Car Building Jump	Suspension Bridge	Cantilever Truss	Arch Causeway
Cable Stayed Bridge	High Road/Low Road	Brachistochrone	Skyscraper
Arch Truss	Tied Arch Bridge	Drawbridge	House Frame
Roller Coaster	Baltimore Bridge	Vertical Lift Drawbridge	Angle Crane
Canyon Car Jump	Double Tied Arch Bridge	Tower Crane	Windmill



# Car Building Jump

Use beams, connectors, cord (for cross bracing), and a section of Coaster Track to build a ramp next to a building. Use Track Clips to attached the Coaster Track to the ramp. Add a Mini Car Starter Bracket to the top of the ramp and let a Mini Car roll down the ramp and “jump” onto the adjacent building’s landing platform.



Adjust the position of the building as needed so that the car lands on top of the building.

\*Make a landing platform using a square of cardboard or foam core board.

If the building is too high or too low, change the beams at the bottom of the building. Replace the #2 beams with #1 beams, or remove the bottom beams altogether.

### Car Building Jump Details

Use Track Clips to attach the Coaster Track to the #4 cross beams. Attach the Mini Car Starter Bracket to the underside of the Coaster Track.

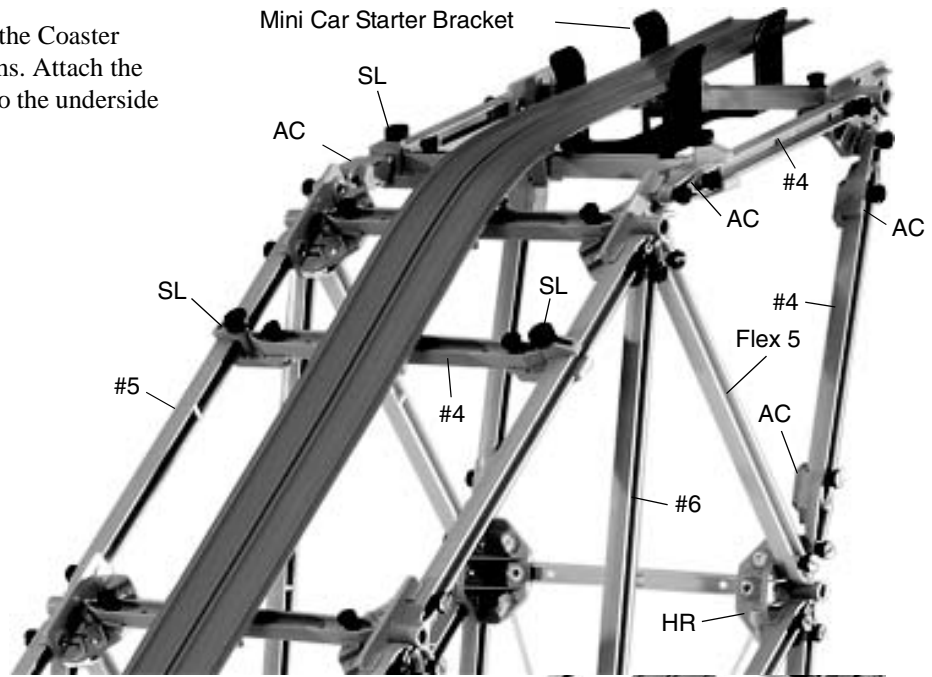
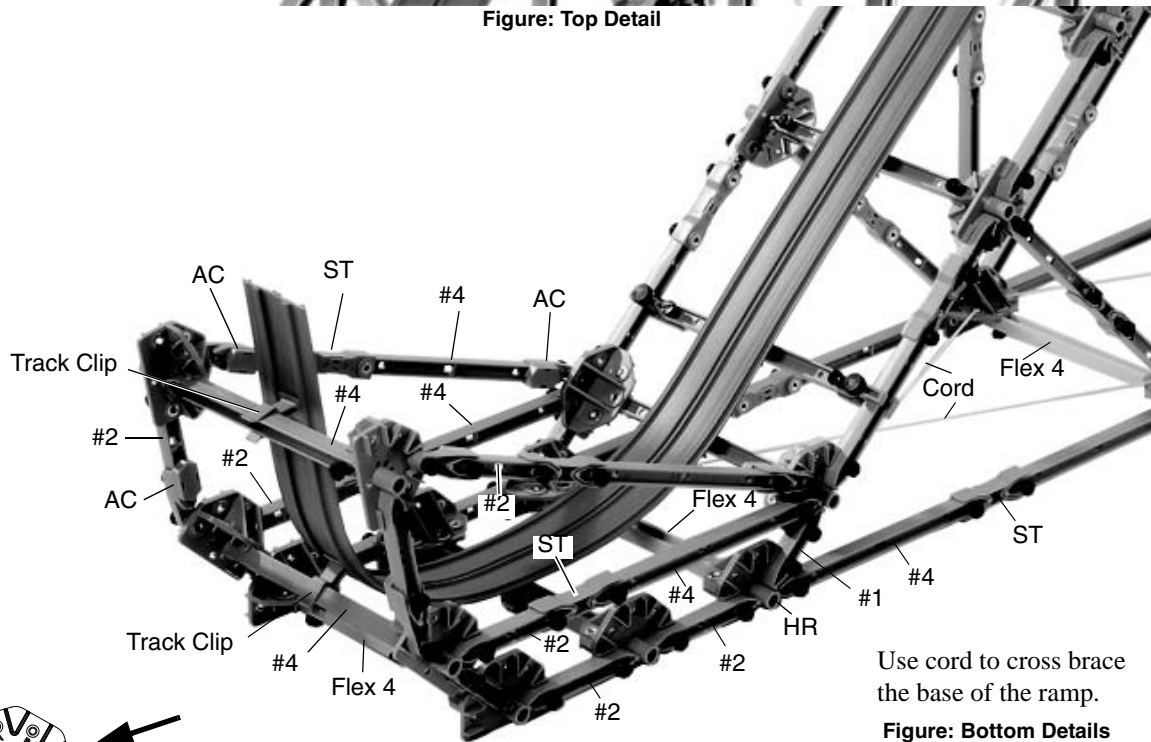
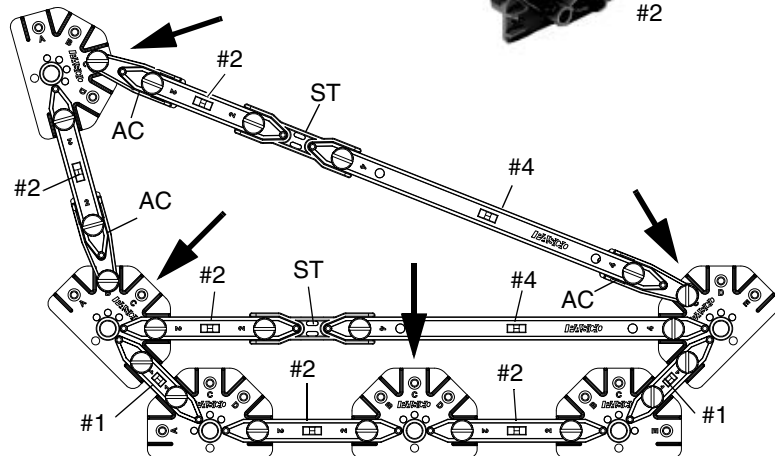


Figure: Top Detail



Use cord to cross brace the base of the ramp.

Figure: Bottom Details



For the bottom of the ramp, attach Track Clips to the Coaster Track and then to the #4 beams in the locations indicated by the arrows in the diagram.

Loosen the Angle Connectors to adjust the angle of the upward-curved section at the end of the Coaster Track so that the Mini Car is able to “jump” to the top of the landing platform. Tighten the connectors to keep the angle.

### Car Building Jump Details

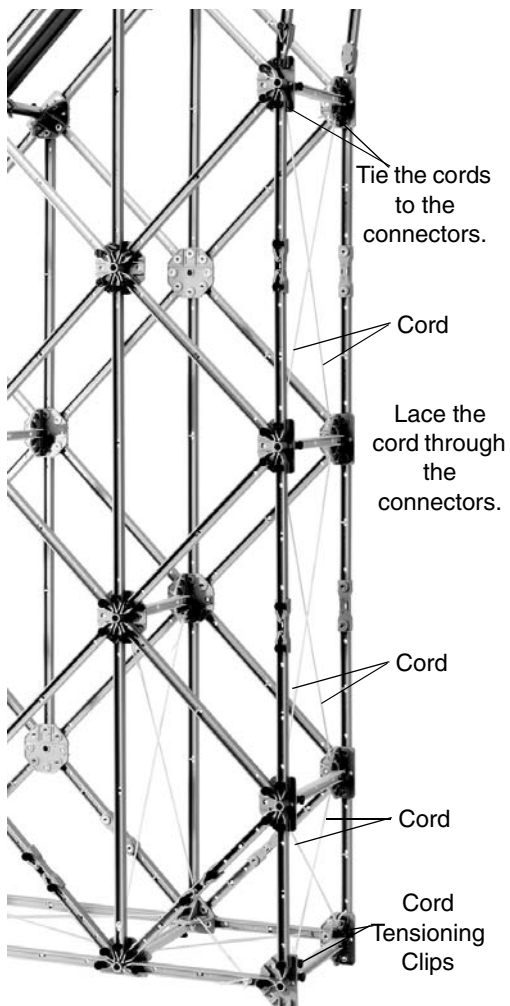
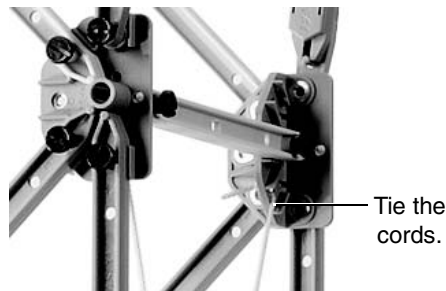


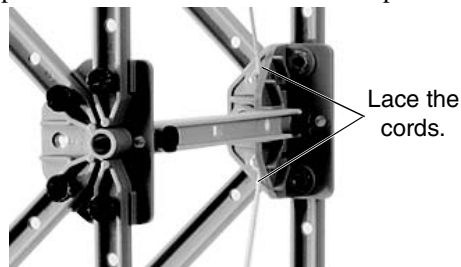
Figure: Back of Ramp Details

Use cord and Cord Tensioning Clips to cross brace the back of the ramp.

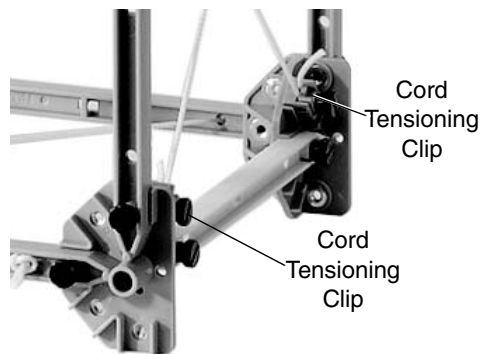
Tie the cords to the Half Round Connectors near the top of the ramp,



Lace the cord through holes in the Half Round Connectors that are between the top and bottom of the back of the ramp.



Attach the cords to Cord Tensioning Clips on the bottom connectors.





# Cable Stayed Bridge

The Cable Stayed Bridge has a deck that is suspended on cords from two towers. There is a deck support structure at each end of the deck.

The modular approach to the construction of this structure is to build the deck in two halves and also build each tower and deck support structure before trying to suspend the deck. Do not attach the Coaster Track to the deck halves yet. Next, insert one half of the deck through one of the towers and use cord to suspend the deck from the top of the tower. Repeat for the other half of the deck. Connect the ends of the deck halves to the deck support structures and then connect the deck halves between the towers. Adjust the length of the cords so that the deck is level. Finally, use Track Clips to attach the Coaster Track to the finished deck..

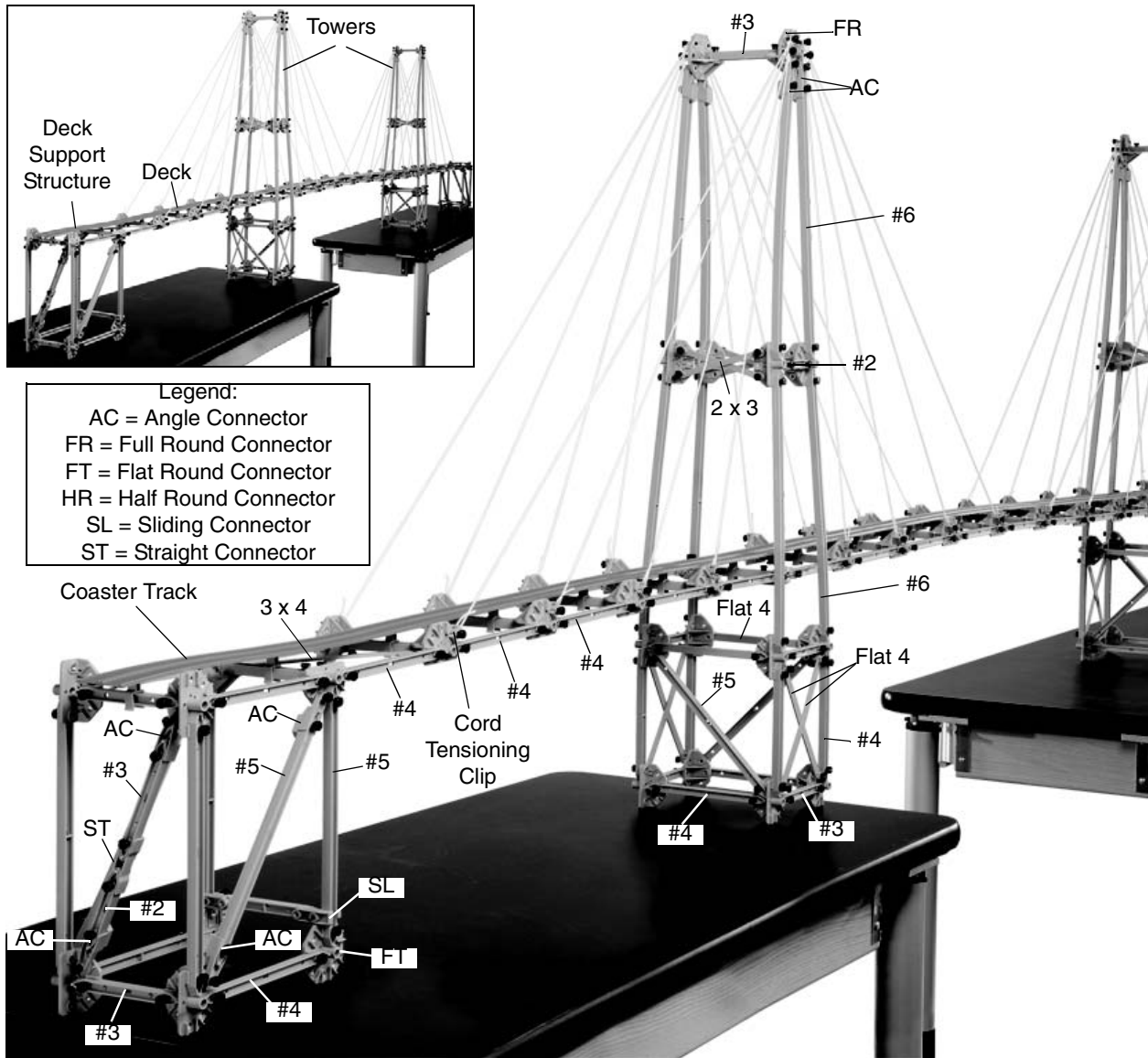


Figure: Cable Stayed Bridge

### Cable Stayed Bridge Details

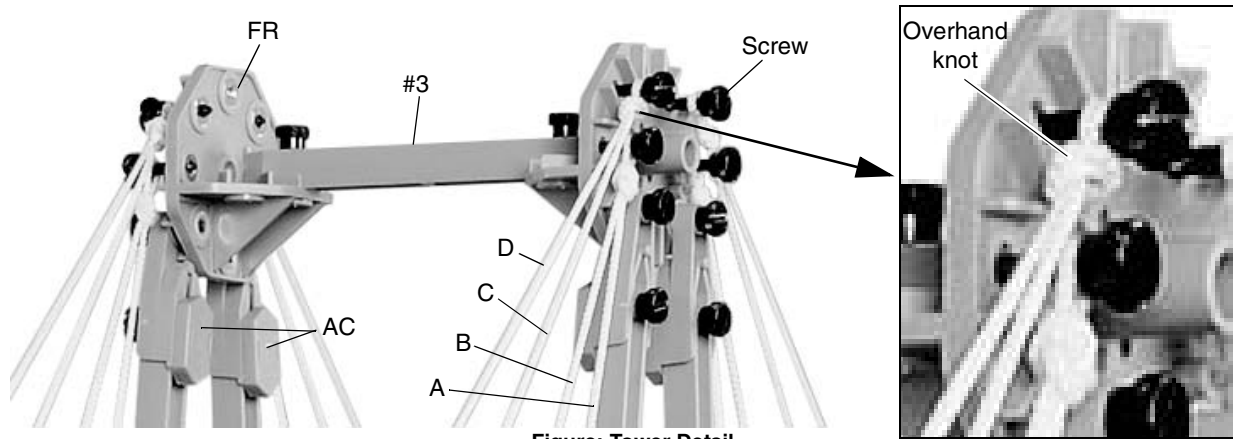
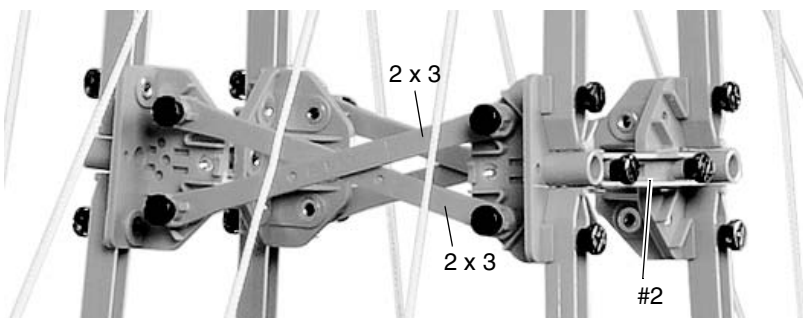
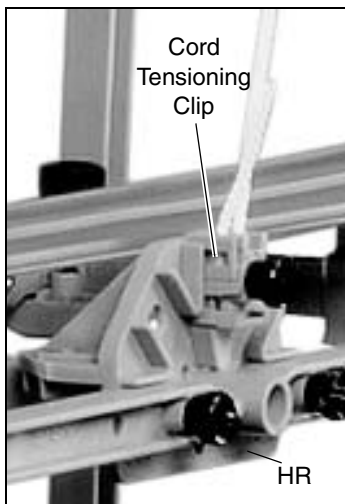


Figure: Tower Detail

There are eight strands of cord from each side of the top of the tower that are used to suspend each half of the deck. Start with the strands of cord closest to the tower (for example, A and B in the figure). Get a piece of cord that is twice as long as the distance from the top of the tower to the deck. Make an overhand knot near the middle of the piece of cord and fasten the loop of the knot to the Full Round Connector at the top of the tower using a screw as shown. Put the two ends of the cord into Cord Tensioning Clips and attach the clips to two of the Half Round Connectors on the side of the deck. Repeat the process for strands C and D and the rest of the strands of cord.



At the middle of the tower, use 2 x 3 beams to cross brace the tower.

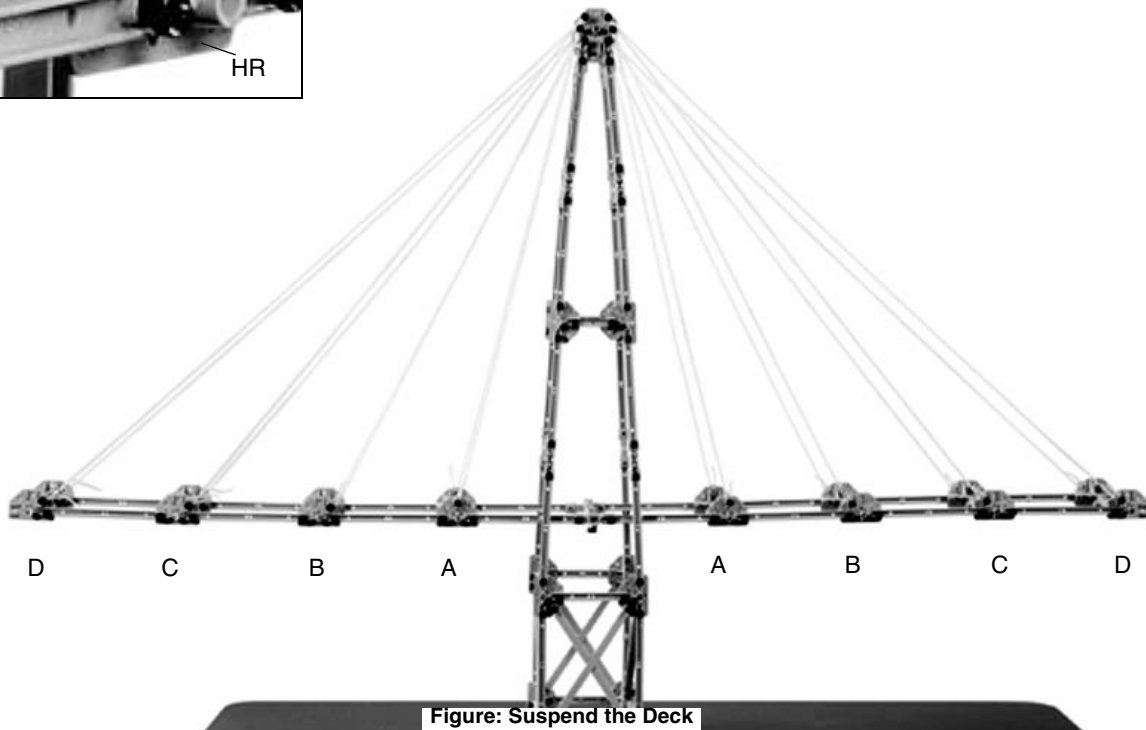


Figure: Suspend the Deck

# Arch Truss Bridge

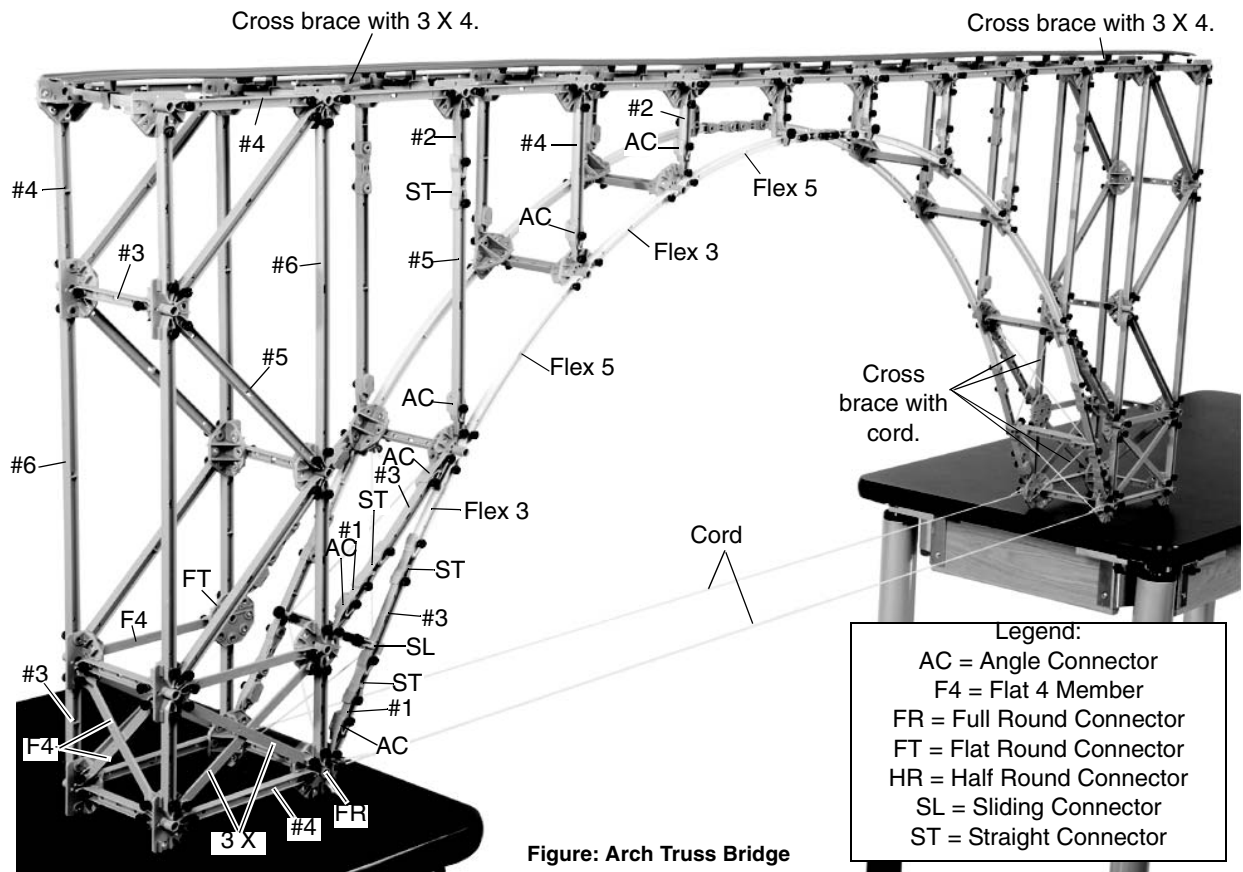


Figure: Arch Truss Bridge

The Arch Truss design is one of the most frequently used designs in history. Construct the end supports and then add the deck. Tie cords from the base of one end support to the base of the other end support. Next, add the arch and suspension beams. Use Flat 3 X 4 members to cross brace the deck at the point where it joins the top of the end supports. Use cord to cross brace the bottom sections of the arch. Finally, use Track Clips to attach the Coaster Track.

Connect the center of the arch with Straight Connectors and a #1 Beam.

Use Sliding Connectors and #1 Beams to suspend the center of the arch.

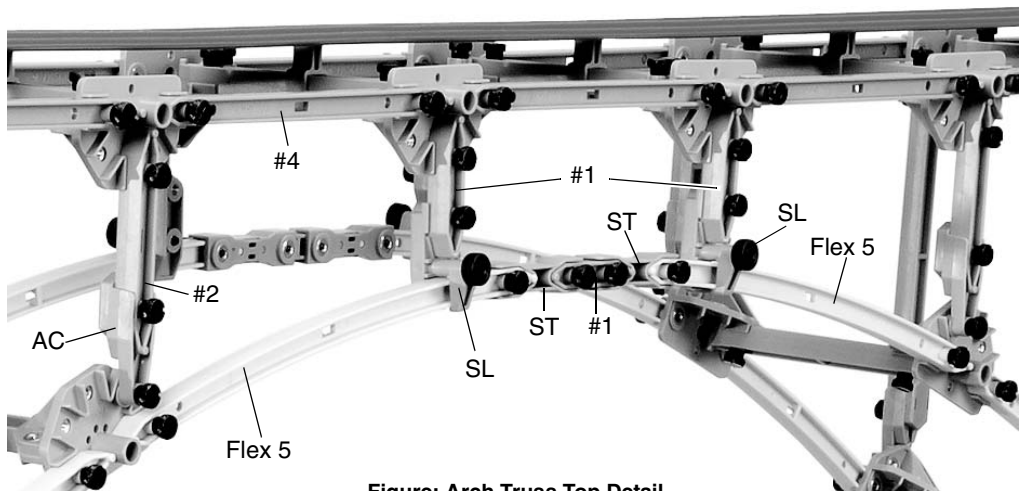
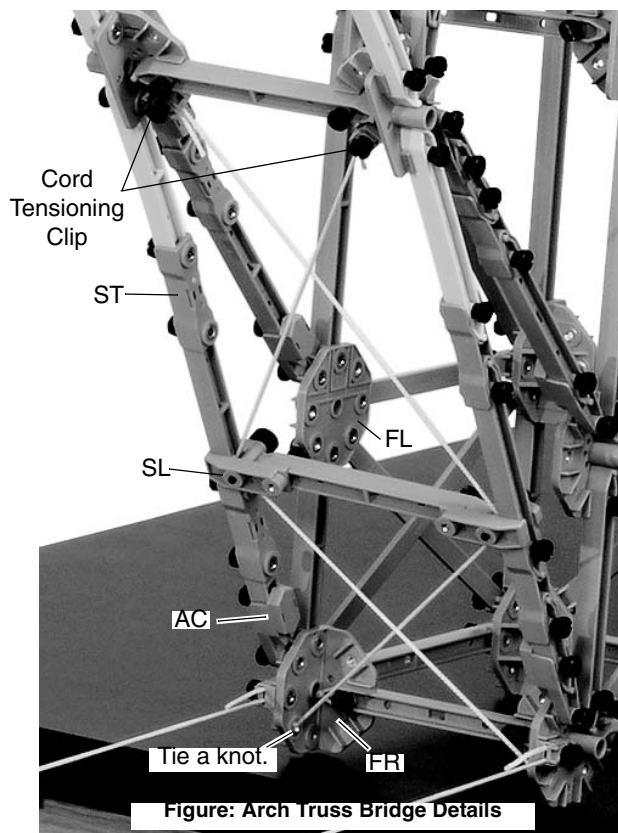


Figure: Arch Truss Top Detail

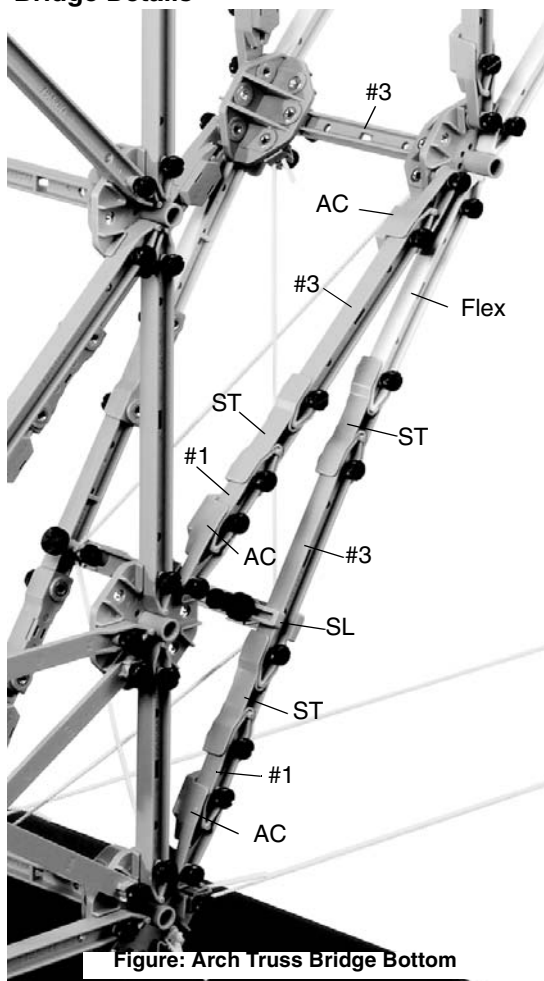
### Arch Truss Bridge Details

Use two pieces of cord to cross brace the two lower sections of the arch. Attach the cords with Cord Tensioning Clips at one end. Lace the cords through the Sliding Connectors. Tie the cords to holes in the Full Round Connectors at the other end.

Repeat for the other side of the bridge.



Bridge Details

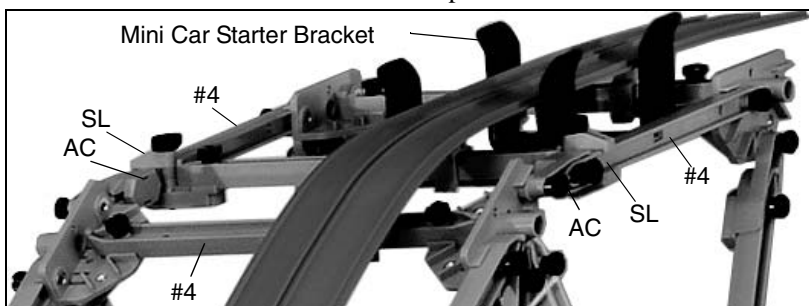






### Roller Coaster Details - Right End

Make fourteen extra “#5” Beams using fourteen Straight Connectors and twenty-eight #3 Beams. Use cord to cross brace the bottom and the back of the ramp.



- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

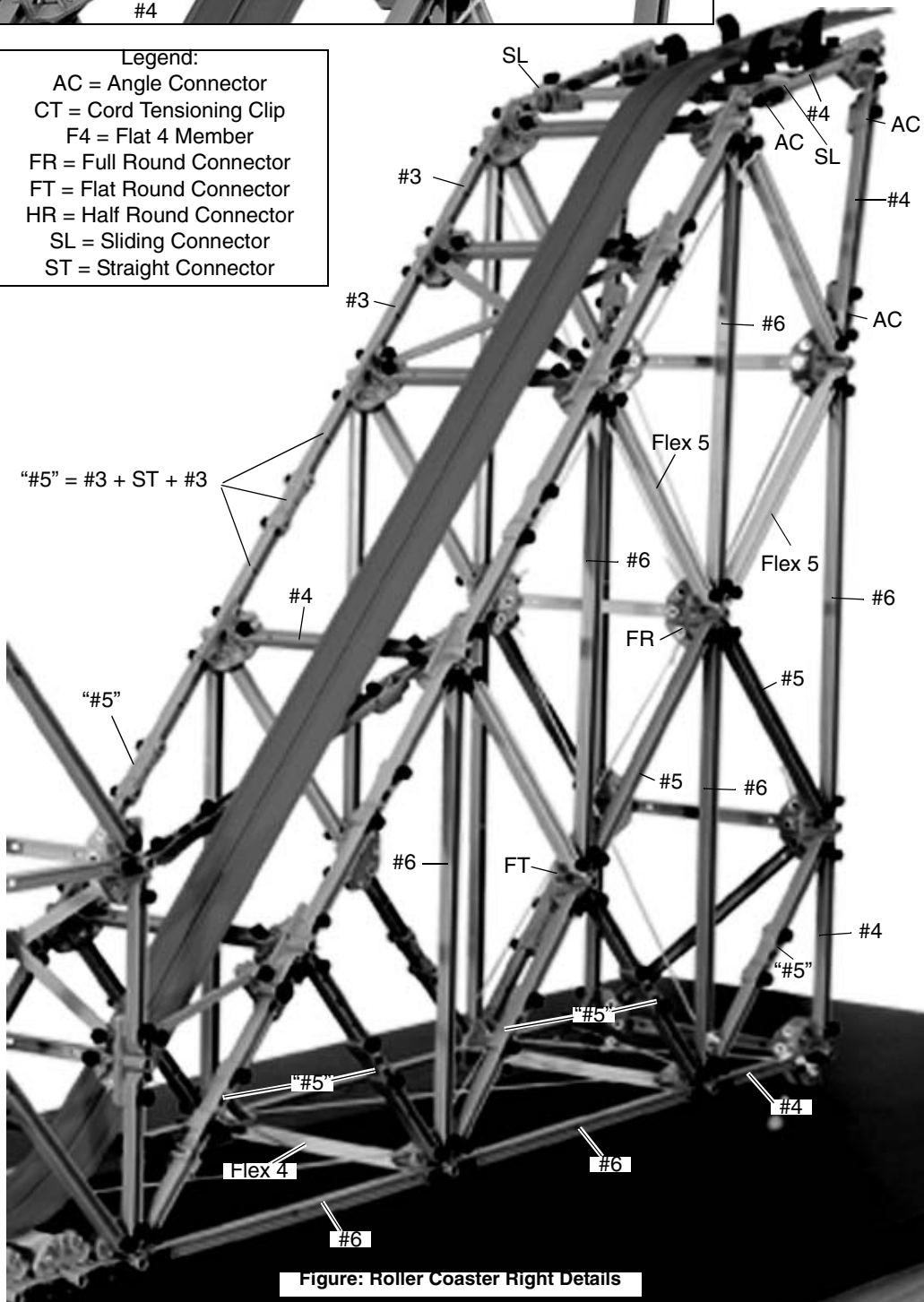


Figure: Roller Coaster Right Details

### Roller Coaster Details - Center

Attach the Track Clip to a Flexible #4 Beam at the top of the Roller Coaster.

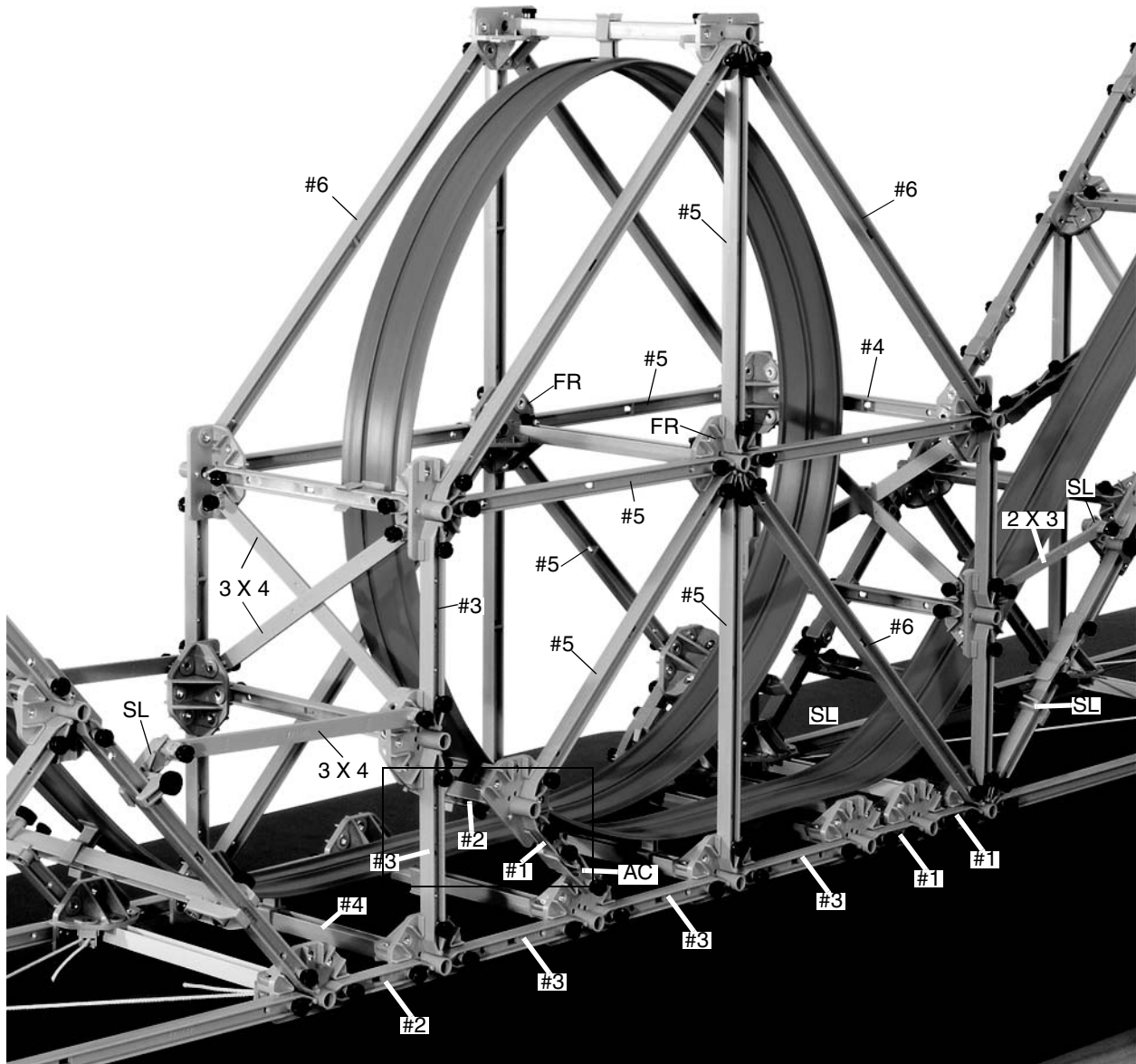


Figure: Roller Coaster Center Details

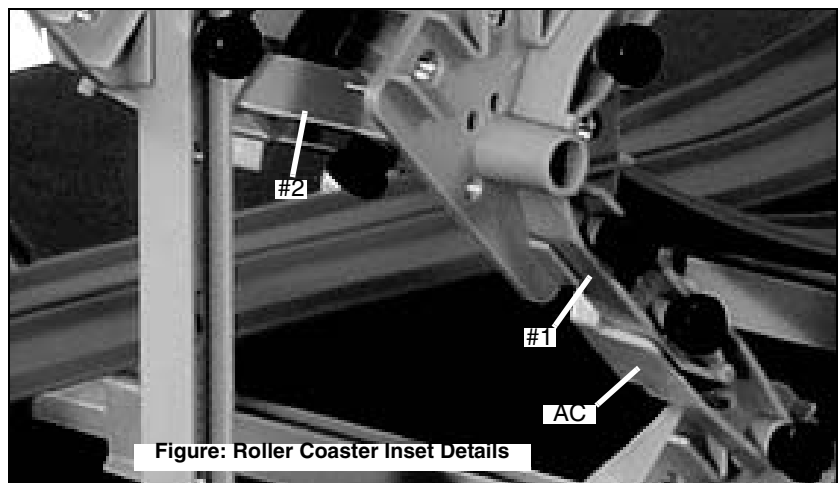
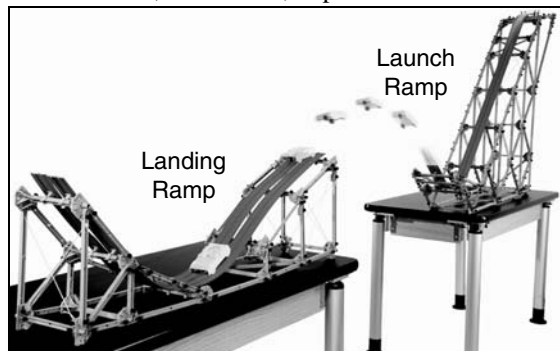


Figure: Roller Coaster Inset Details

# Canyon Car Jump

Use beams, connectors, clips and cord to construct a landing ramp.



- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

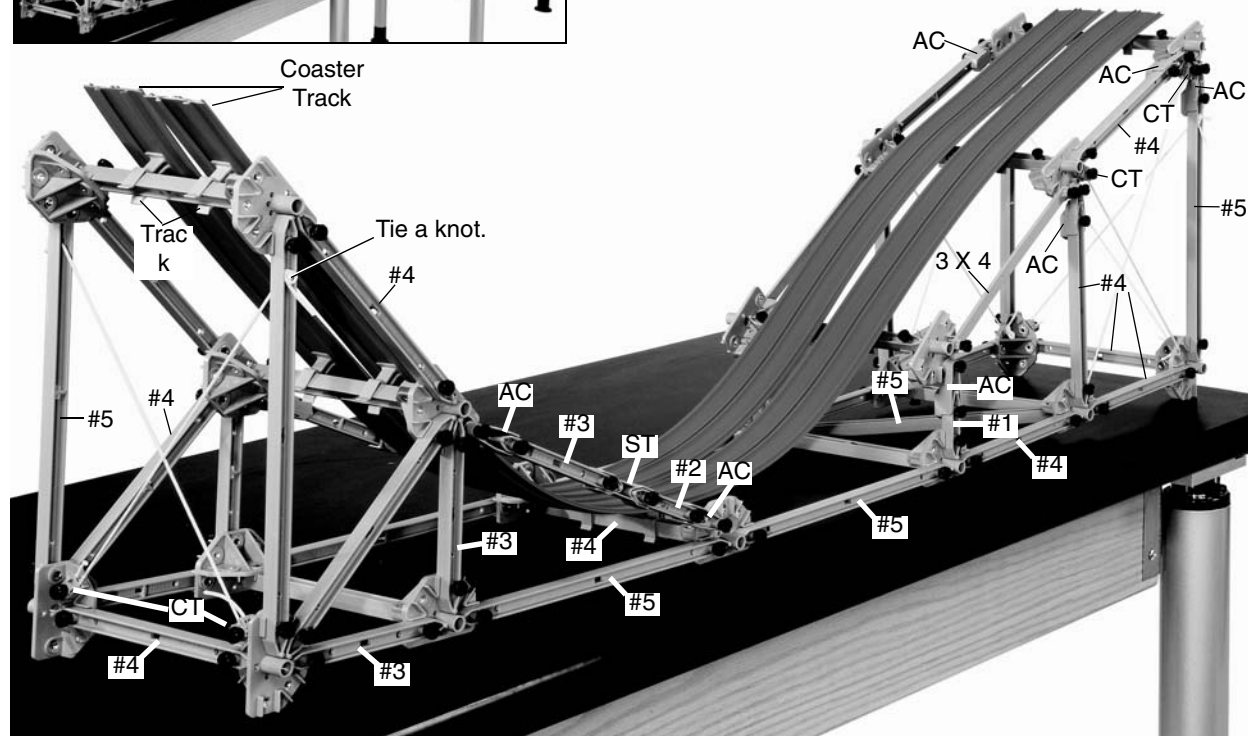


Figure: Canyon Car Jump Landing Ramp

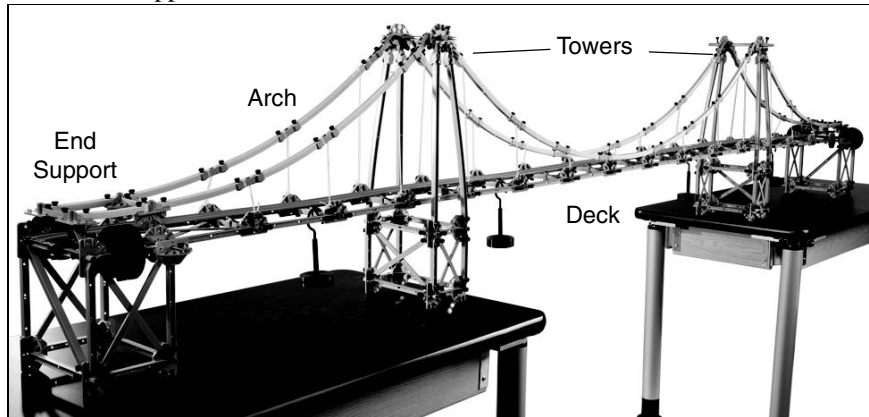
Use cord and Cord Tensioning Clips to cross brace both ends of the landing ramp. Also use cord to cross brace the side panels at the right-hand end of the landing ramp. Use Track Clips to attach two sections of Coaster Track side-by-side to the #4 Beam cross members.





# Suspension Bridge

The construction of the Suspension Bridge uses a modular approach. The construction involves building the End Supports, Towers, Arches, and Deck, and then suspending the Deck from the Arches and connecting the Deck to the End Supports.



**Legend:**  
 AC = Angle Connector  
 CT = Cord Tensioning Clip  
 FR = Full Round Connector  
 FT = Flat Round Connector  
 HR = Half Round Connector  
 SL = Sliding Connector  
 ST = Straight Connector

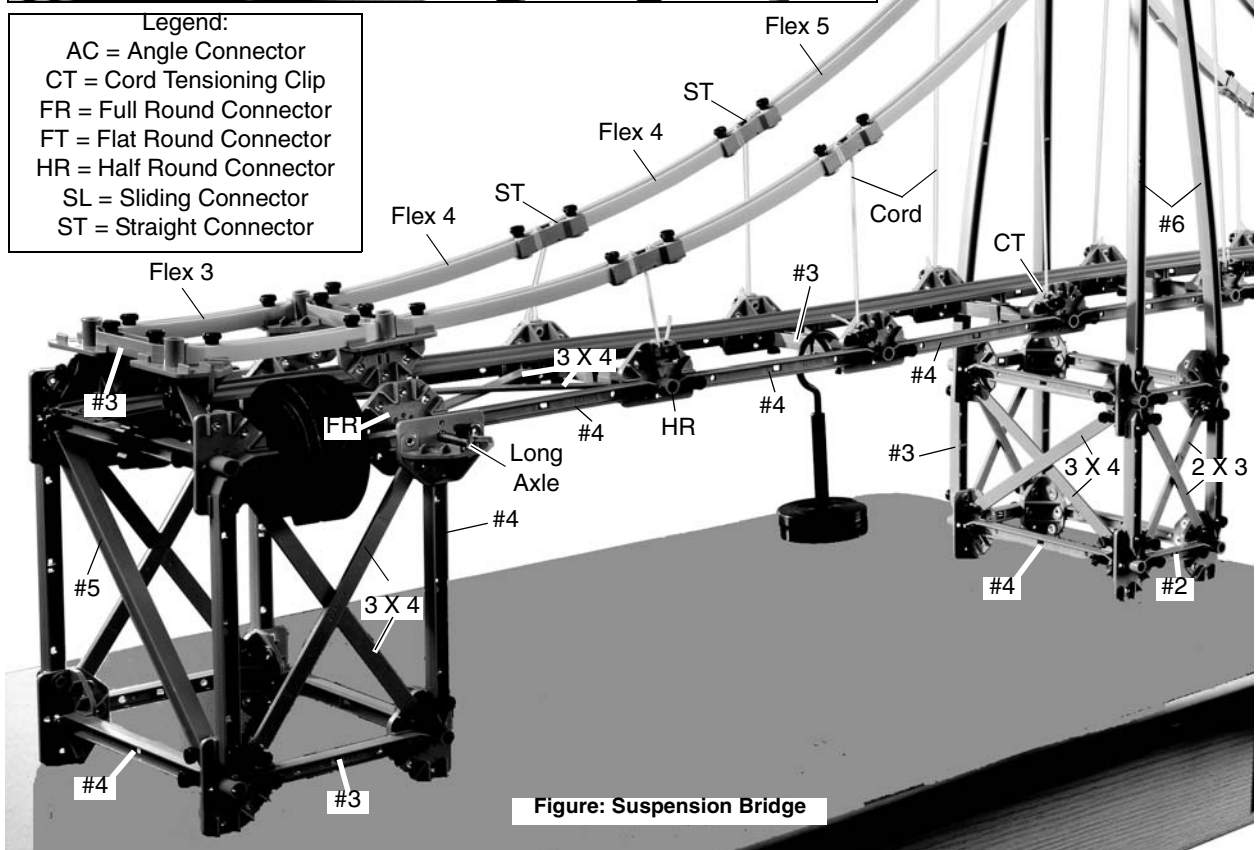
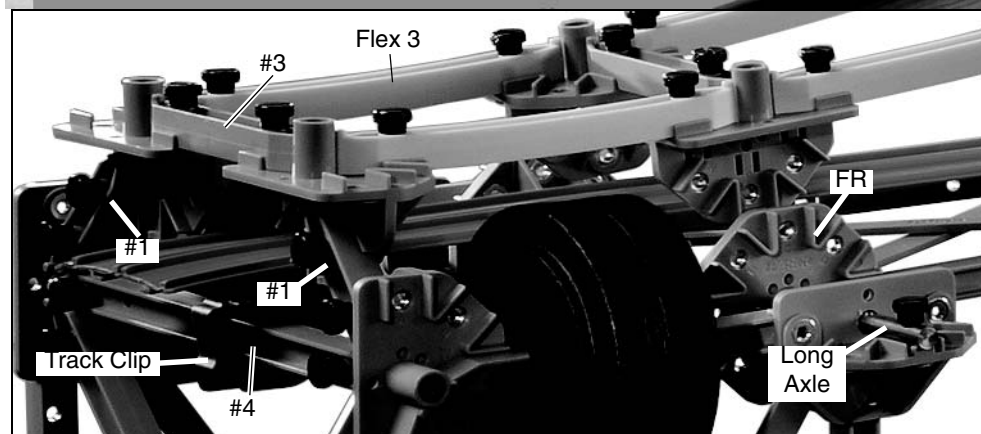


Figure: Suspension Bridge



Put a Collet at the middle of the Long Axle. Attach a Track Clip to the Collet.

### Suspension Bridge Details

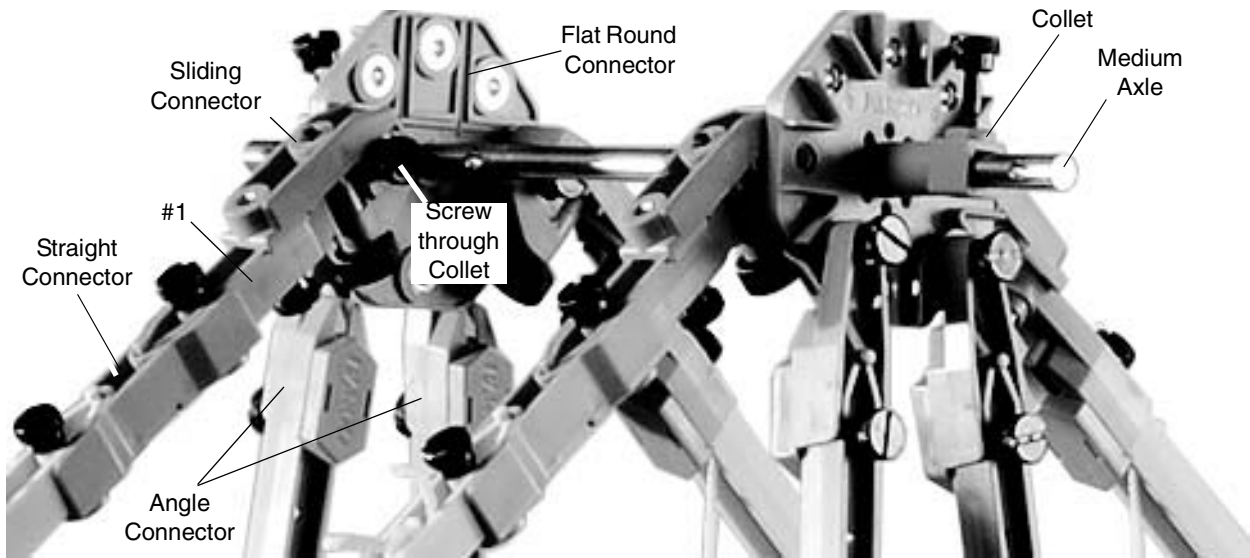


Figure: Suspension Bridge Tower Detail

Put a screw through the center hole of a Collet and attach the screw to the Flat Round Connector. Clamp the jaws of the Sliding Connector over the Collet. Connect a #1 Beam to the Sliding Connector and connect a Straight Connector to the #1 Beam. Repeat for the other arches.

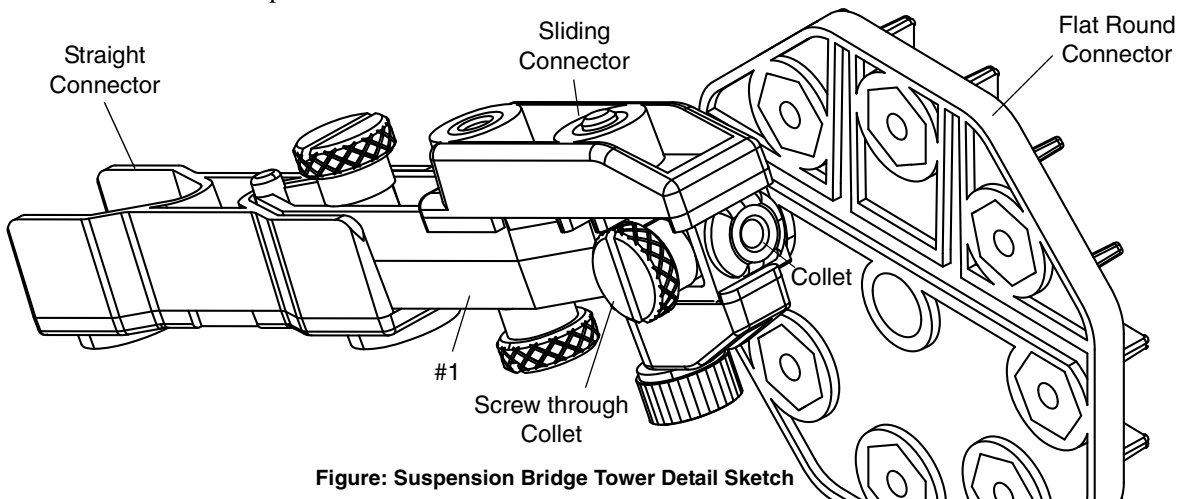


Figure: Suspension Bridge Tower Detail Sketch

Suspend the deck from the arches using cord and Cord Tensioning Clips. Tie one end of each cord to the arch and attach the other end of the cord to the Cord Tensioning Clip.

Connect the end of the deck to the end support. Put one end of a Long Axle through the Half Round Connector of the end support and the Full Round Connector of the deck, Add a Collet to the Long Axle and then put the Long Axle through the Full Round Connector and Half Round Connector on the other side to attach the end of the deck to the end support. Position the Collet at the middle of the Long Axle and use a Track Clip to attach the Coaster Track to the Collet on the axle.

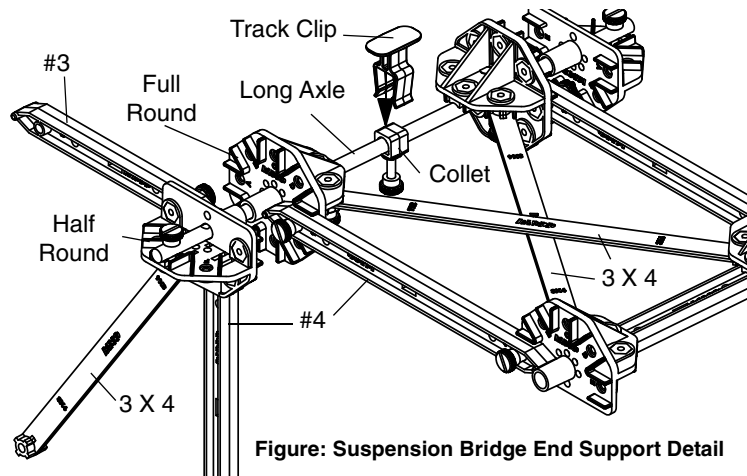
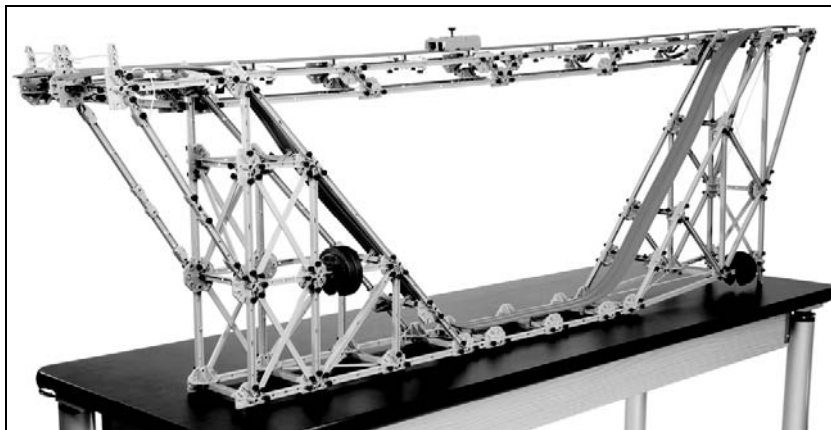


Figure: Suspension Bridge End Support Detail



# High Road/Low Road

Build a support for two Coaster Tracks side-by-side. One Coaster Track (the “High Road”) has a constant gradual slope from start to finish. The other Coaster Track (the “Low Road”) has a steep drop near the start and an equally steep rise near the end. If two Mini Cars start together on the two “roads”, which car finishes first?



- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

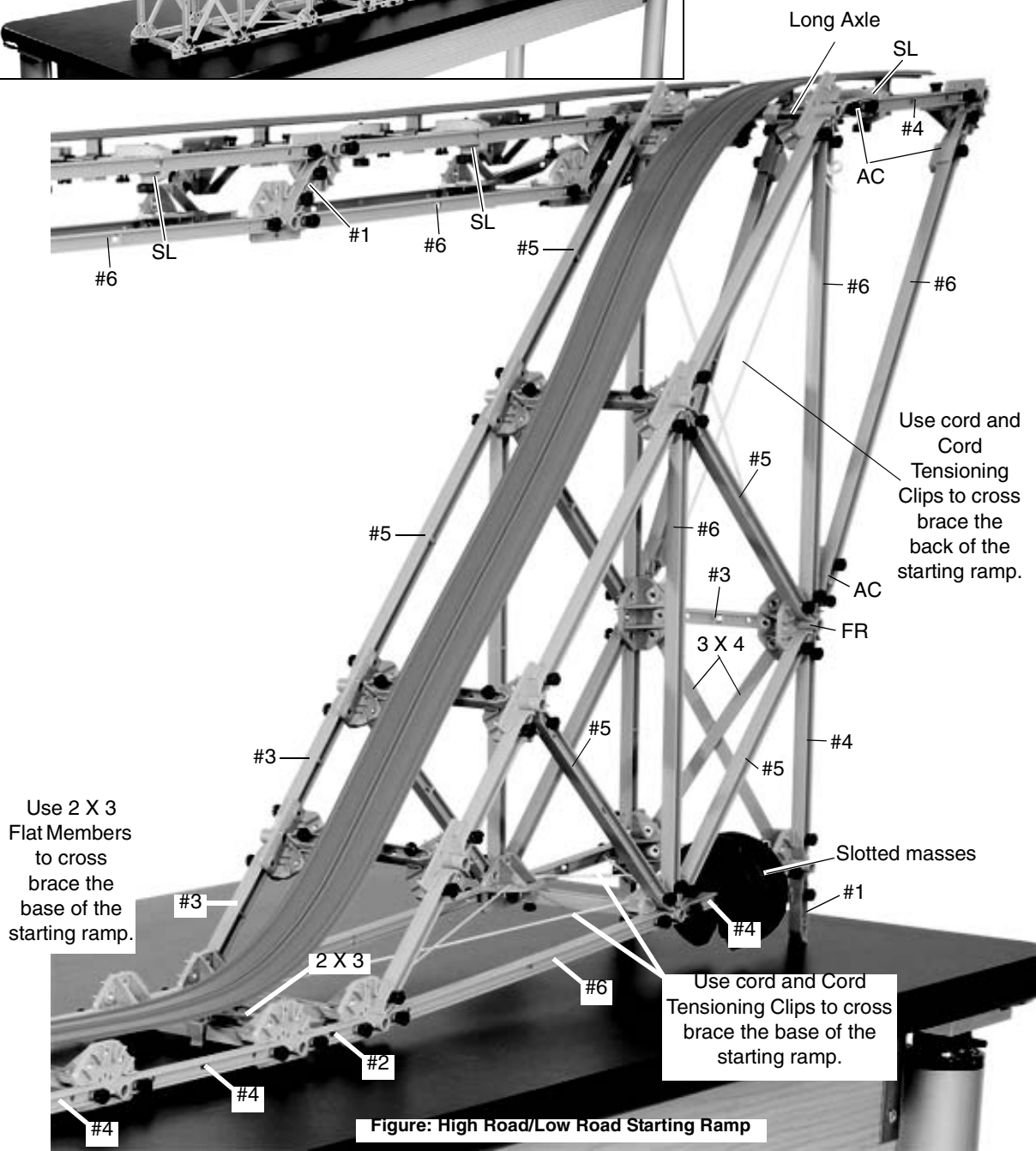
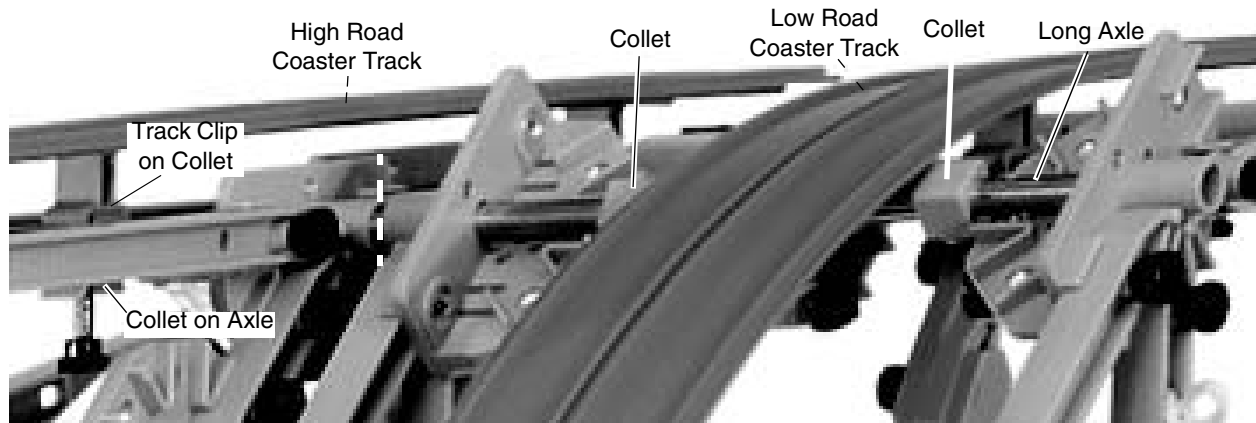


Figure: High Road/Low Road Starting Ramp

### High Road/Low Road Details

The Long Axle extends through the support structures at the starting ramp for both the High Road and the Low Road.



This illustration shows the High Road/Low Road starting ramp from another angle.

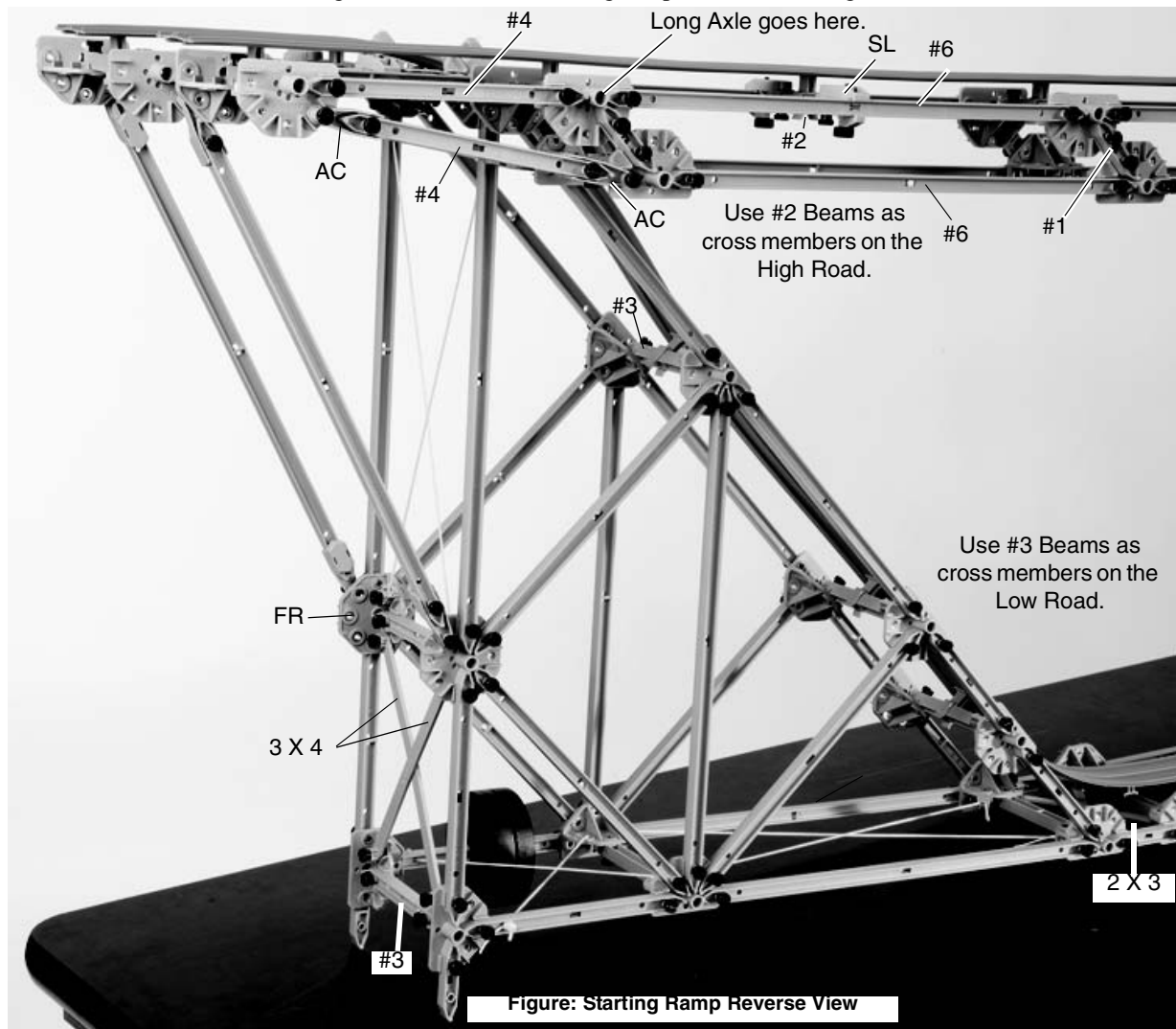


Figure: Starting Ramp Reverse View

### High Road/Low Road Details

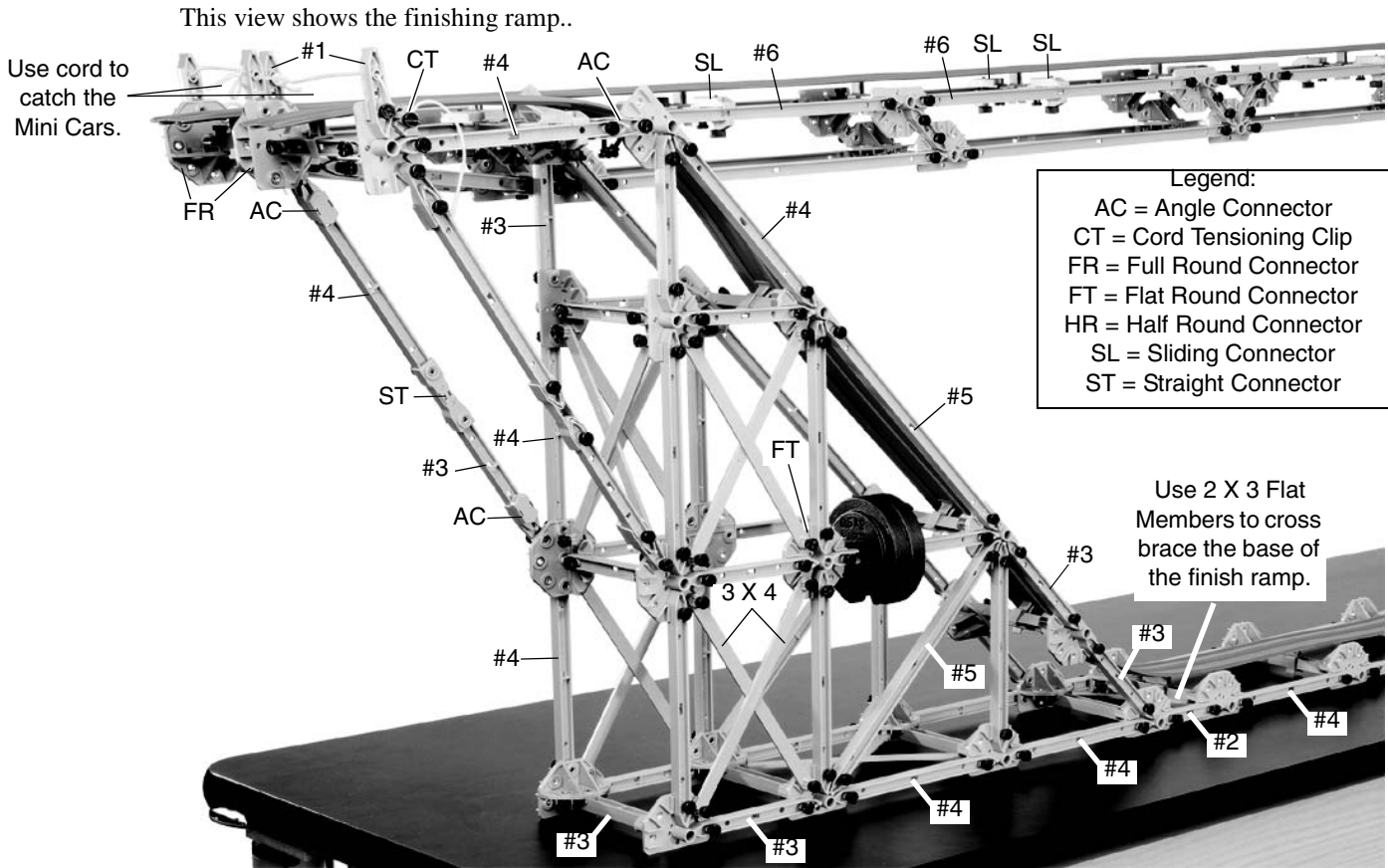


Figure: High Road/Low Road Finishing Ramp

### Tied Arch Bridge

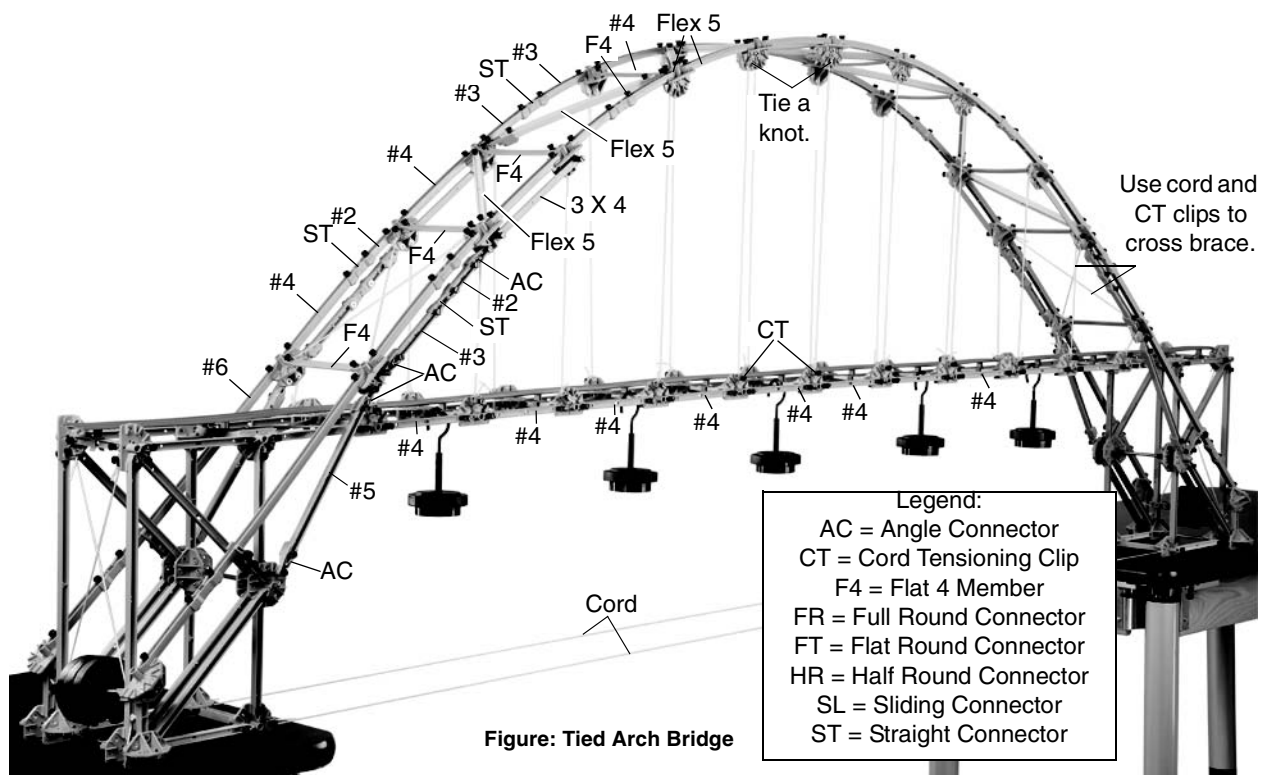


Figure: Tied Arch Bridge



### Tied Arch Bridge Details

Use a #3 Beam and two Sliding Connectors to support the slotted masses at the back of the end support.

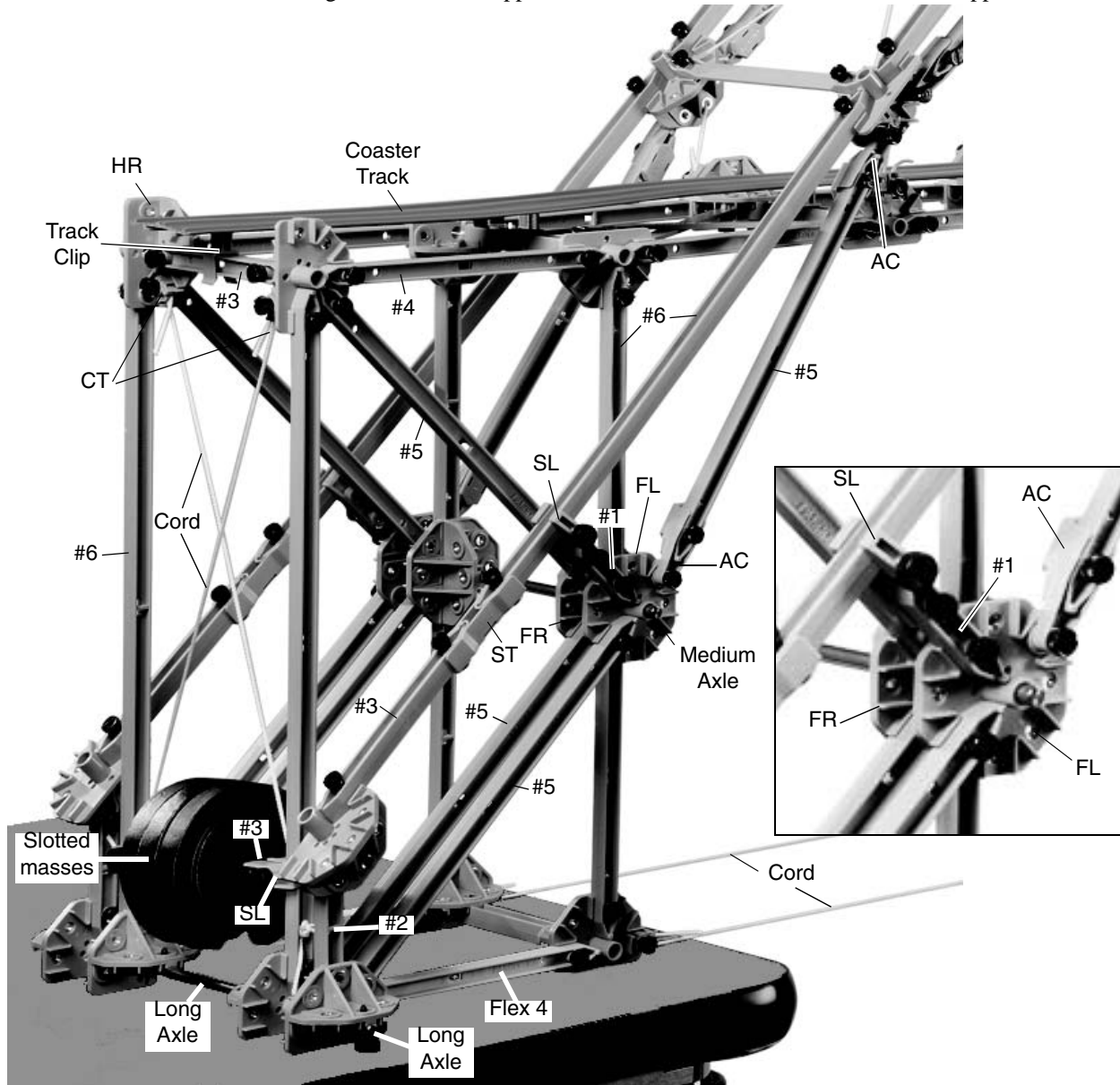


Figure: Tied Arch Bridge End Support

Use cord and Cord Tensioning Clips to cross brace the back of the end support. Tie cords between the bottoms of the two end supports.

### Tied Arch Bridge Details

At the top of the Arch, use a Flat Round Connector and four Flex 3 Beams to form a cross brace.

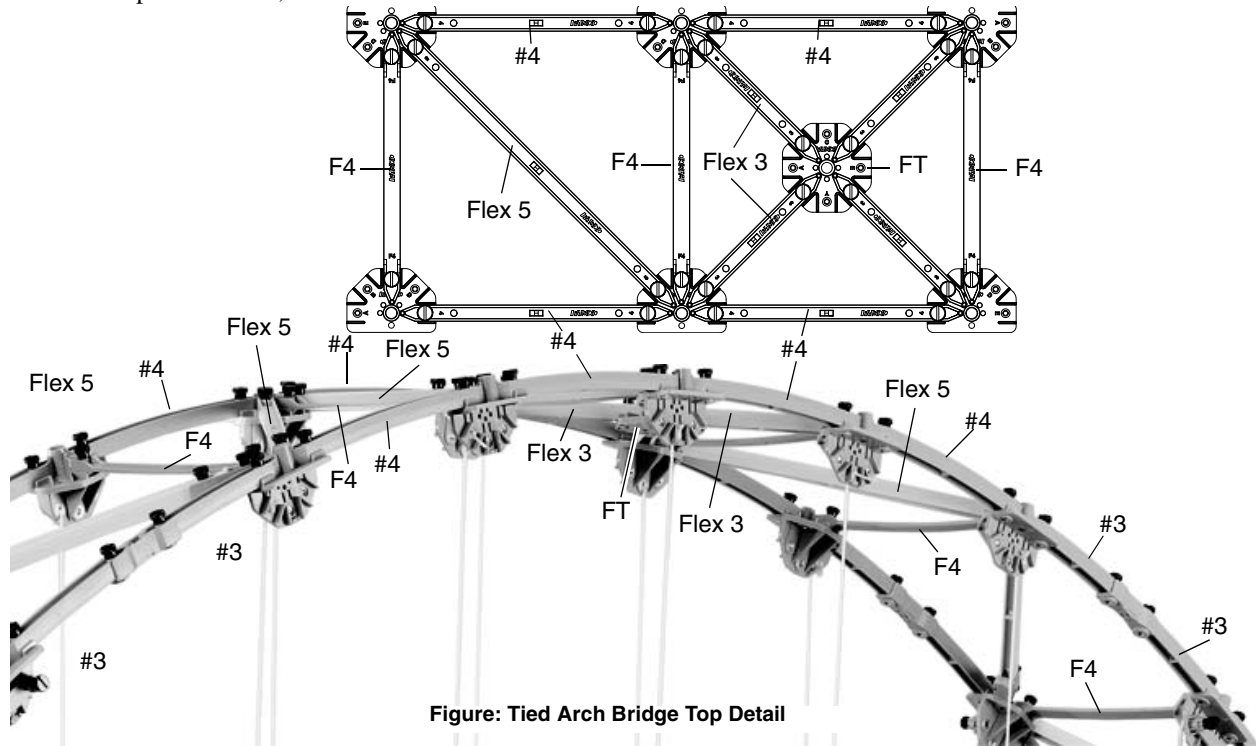


Figure: Tied Arch Bridge Top Detail

### Baltimore Bridge

Use 40 #3 Beams and twenty Straight Connectors to make twenty extra “#5 Beams”.

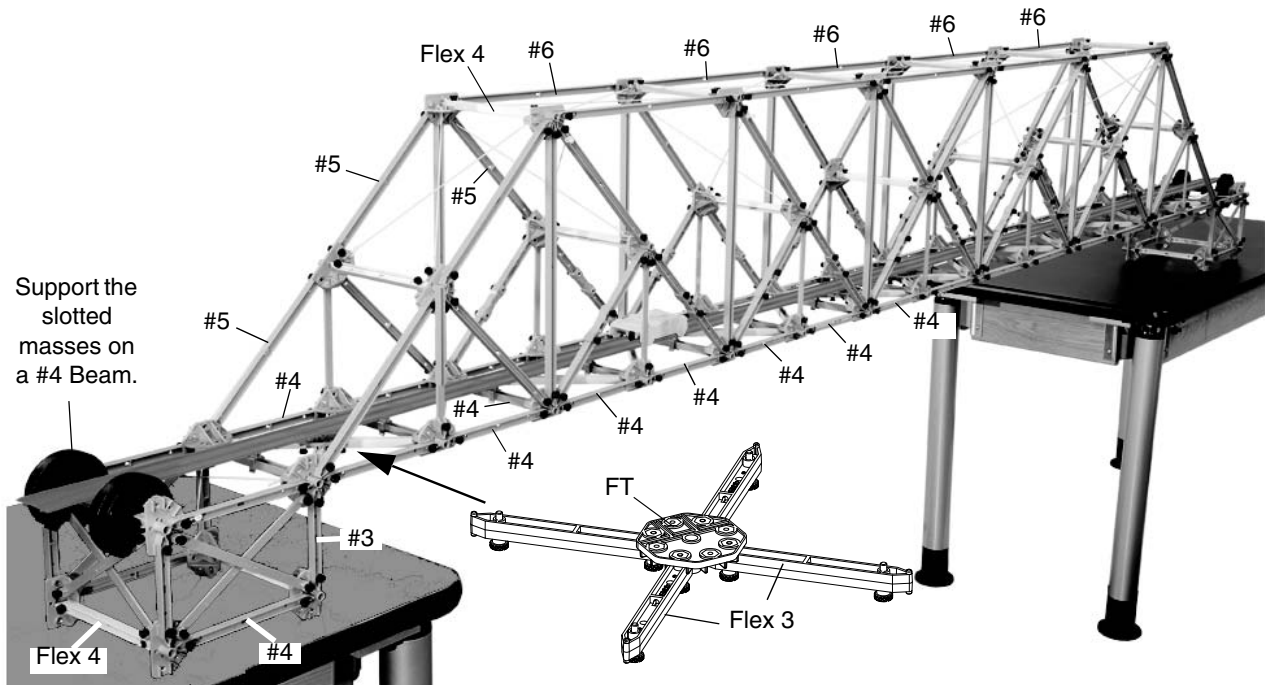


Figure: Baltimore Bridge

Use Flat Round Connectors and four Flexible #3 Beams to make four cross braces for the deck. Place one at each end of the deck where it joins the end support and put the other two on both sides of the center of the deck.



### Baltimore Bridge Details

Use cord and Cord Tensioning Clips to add cross bracing to each panel on the top of the truss and to several of the diagonal panels. Use Flexible #5 Beams to cross brace several of the panels of the deck.

- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

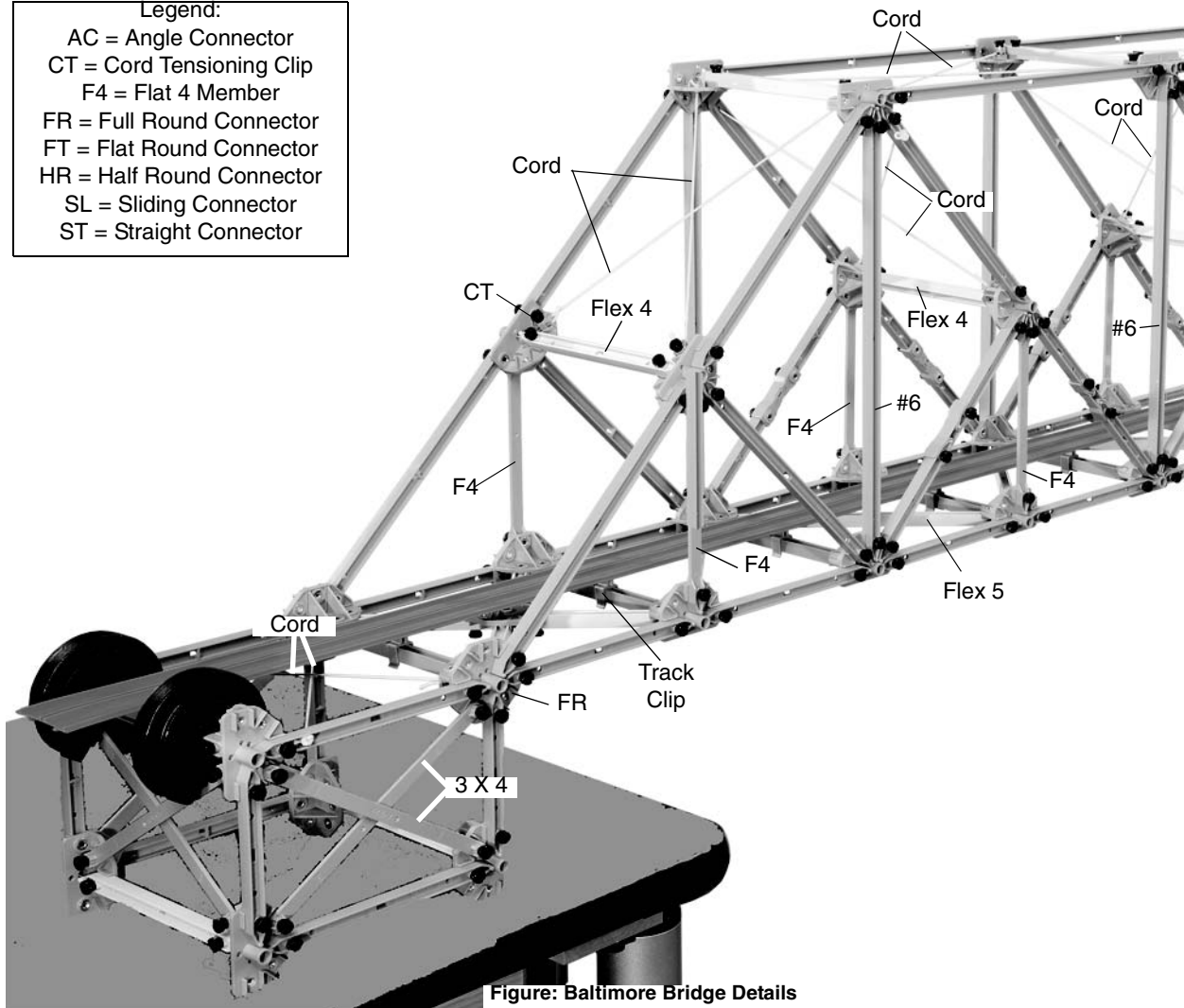


Figure: Baltimore Bridge Details

### Baltimore Bridge Details

Use a Full Round Connector at the center of the bridge.

Add two of the cross brace structures to the deck on both sides of the center of the deck.

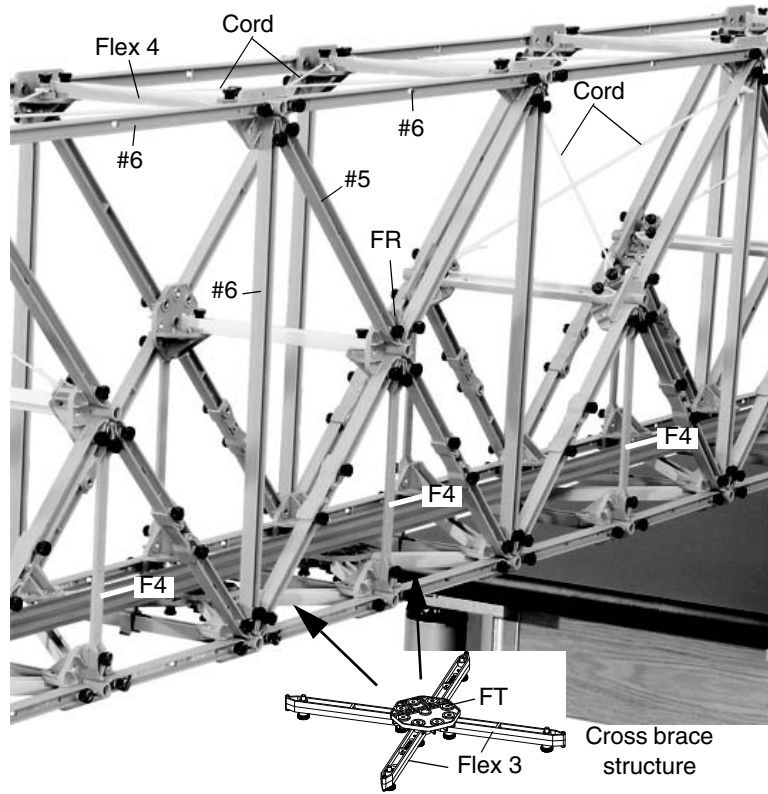


Figure: Baltimore Bridge Details

# Double Tied Arch Bridge

- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

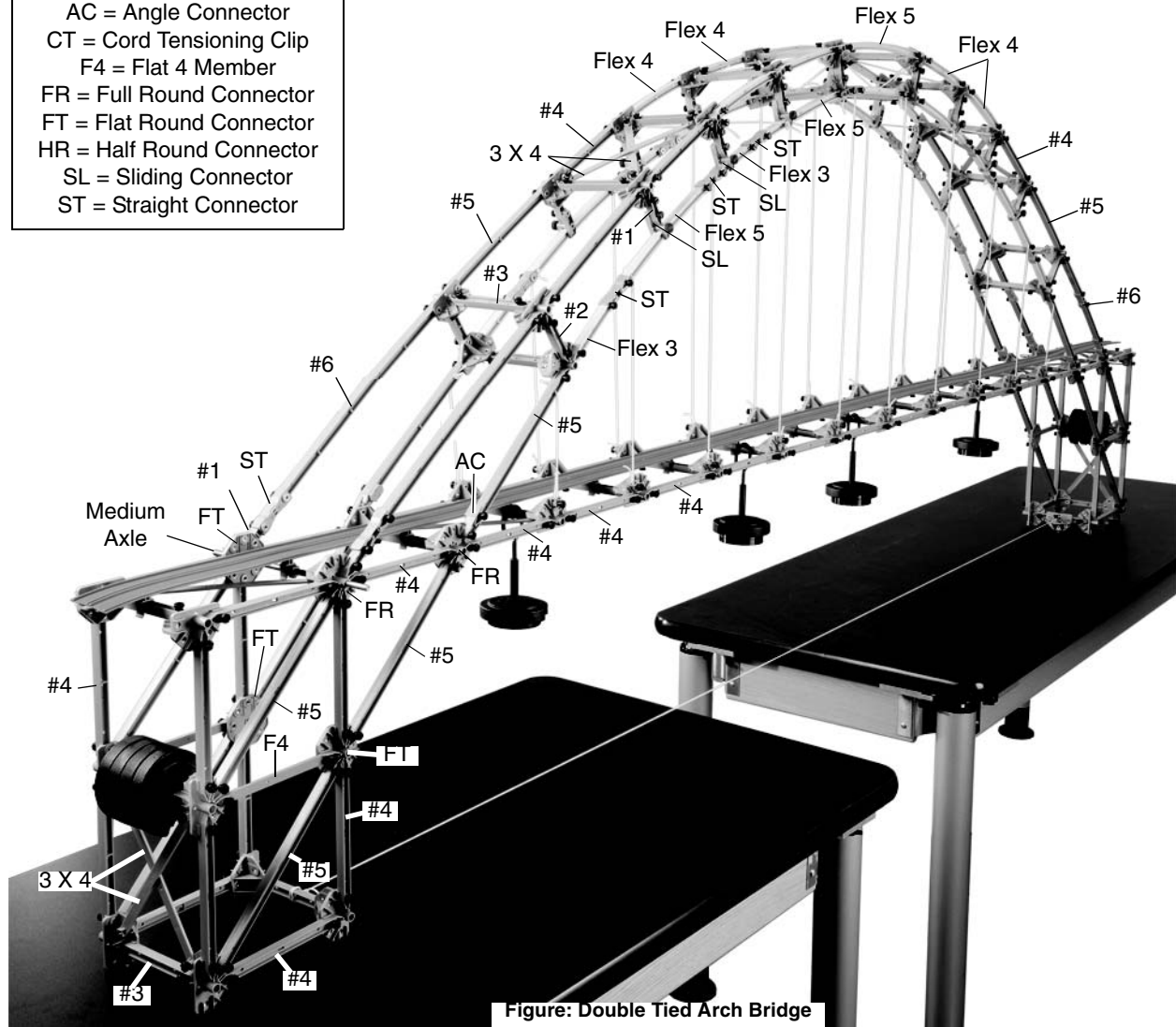


Figure: Double Tied Arch Bridge

In the end supports, put a Collet in the middle of the Medium Axle and use a Track Clip to attach the Coaster Track to the Collet. Use a 3 X 4 Flat Beam to cross brace the top of the end support.

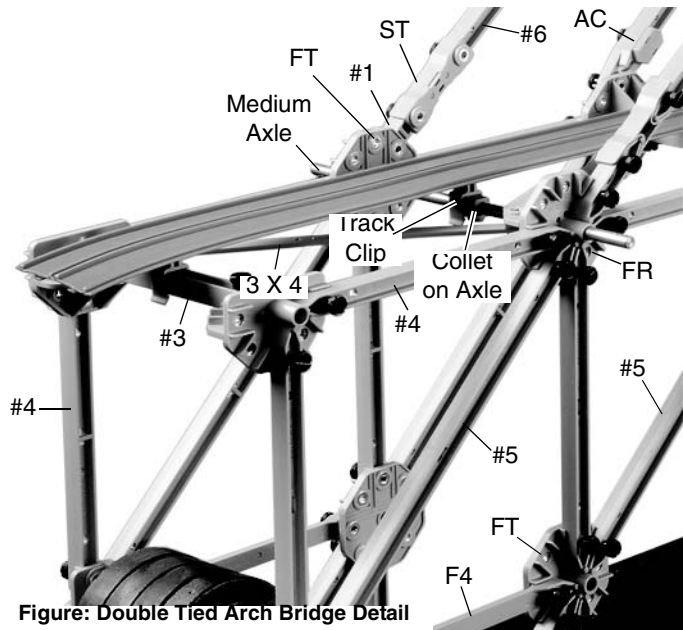


Figure: Double Tied Arch Bridge Detail

### Double Tied Arch Bridge Details

Use cord and Cord Clips to support the deck from both sides of the arch..

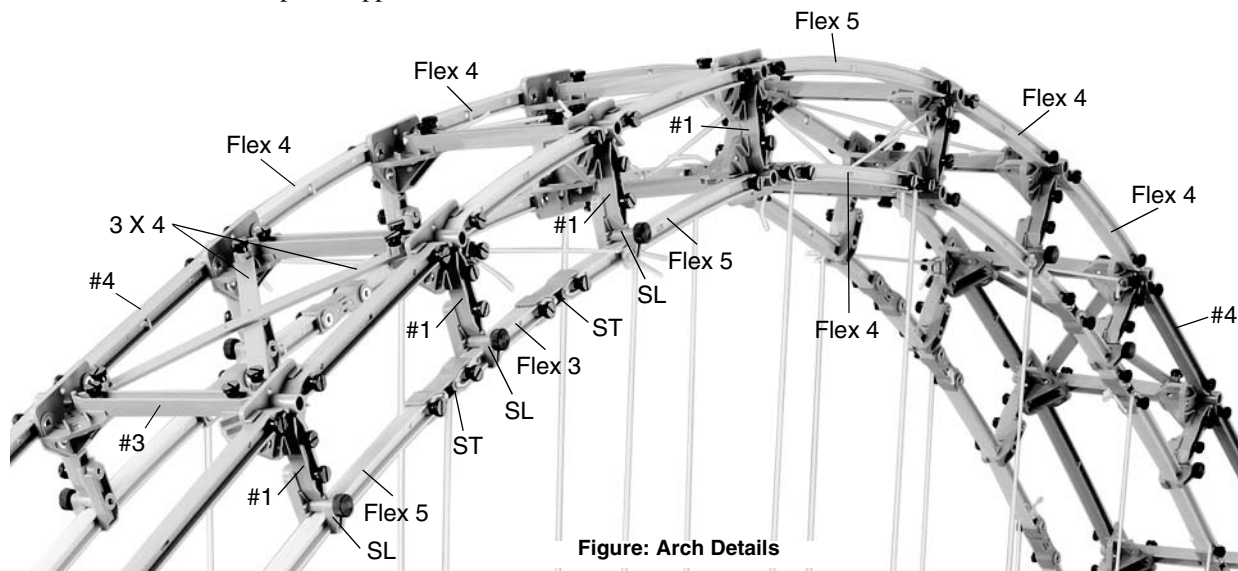


Figure: Arch Details

Note that there are three different positions on the Half Round Connector for the Cord Clip. Choose the position that makes the cord as vertical as possible. Adjust the length of the cords to make the deck level.

### Add Masses

The mass hanger usually hangs from the #3 Beam that is near the #1 Beam where the 5 N Load Cell will be attached. Re-adjust the tension in the supporting cords to make the Deck level and give the bridge its proper shape.

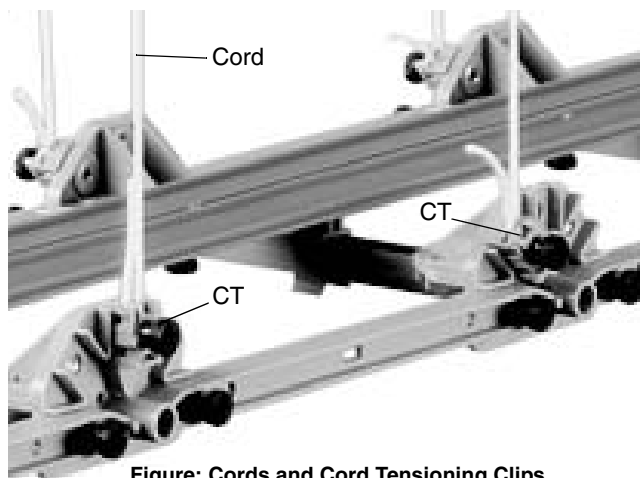


Figure: Cords and Cord Tensioning Clips



# Cantilever Truss Bridge

The Cantilever Truss Bridge balances the torque on one side of the center tower with the torque on the other side.

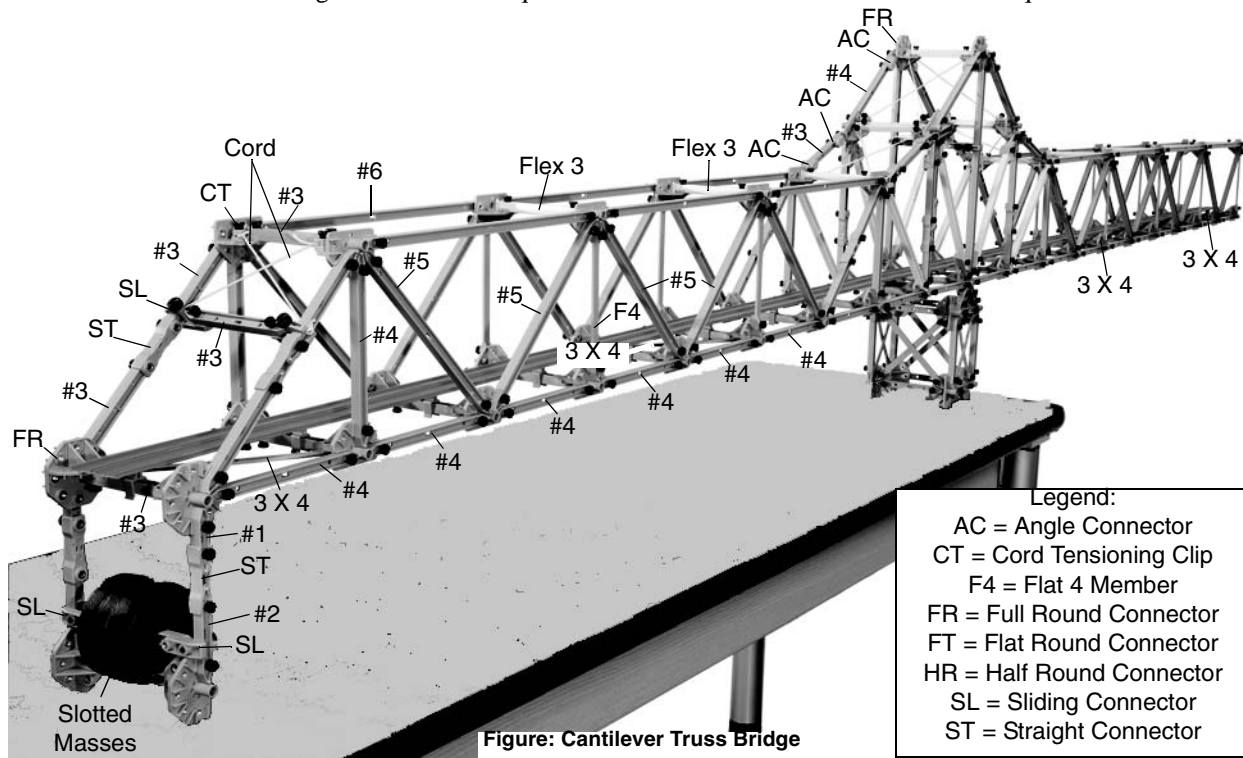


Figure: Cantilever Truss Bridge

Use cord and Cross Tensioning Clips to cross brace the top section of the truss at the end of the bridge. Use Track Clips to attach the Coaster Track to the #3 Beam cross members. On each “arm” of the bridge, use a Flat 3 X 4 Member to cross brace the first section and the fifth section (counting from the end toward the tower).

## Cantilever Truss Bridge Tower Details

Use cord and Cross Tensioning Clips to cross brace the top sections of the truss tower. Use Full Round Connectors at the top and the bottom of the #6 Beams at the center of the tower. Use two Sliding Connectors and a #3 Beam as a cross member between the #6 Beams at the center of the tower.

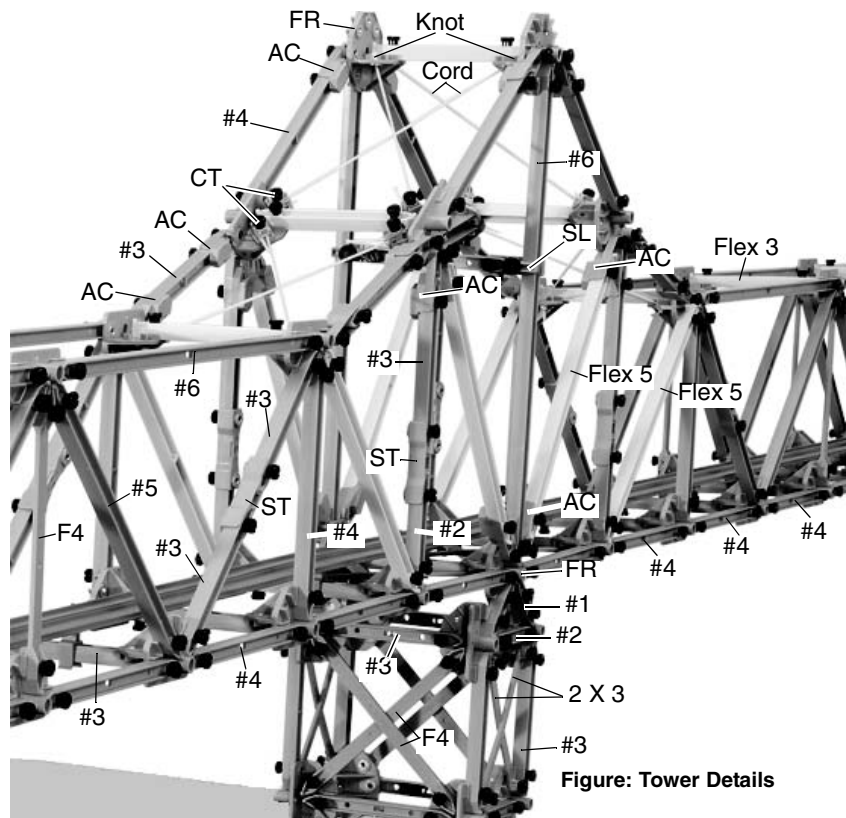


Figure: Tower Details

# Brachistochrone

The word “brachistochrone” is from the Greek words meaning “shortest” (Βραχιστοζ) and “time” (χρονοζ).

Imagine two fixed points in a vertical plane so that one of the points is not directly below the other. If a particle starts from rest at one of the points and descends to the other point under its own weight, the *brachistochrone* is the path the particle must take to reach its destination in the briefest time. The *brachistochrone* may not be the shortest path, but it is the quickest path..

- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

\*Do not tighten the Cord Tensioning Clip on the cord next to the finish line. Leave extra cord so that the cord can slide through the clip when the Mini Cars hit the cord.

See the next page for a more detailed view of the ramp structure.

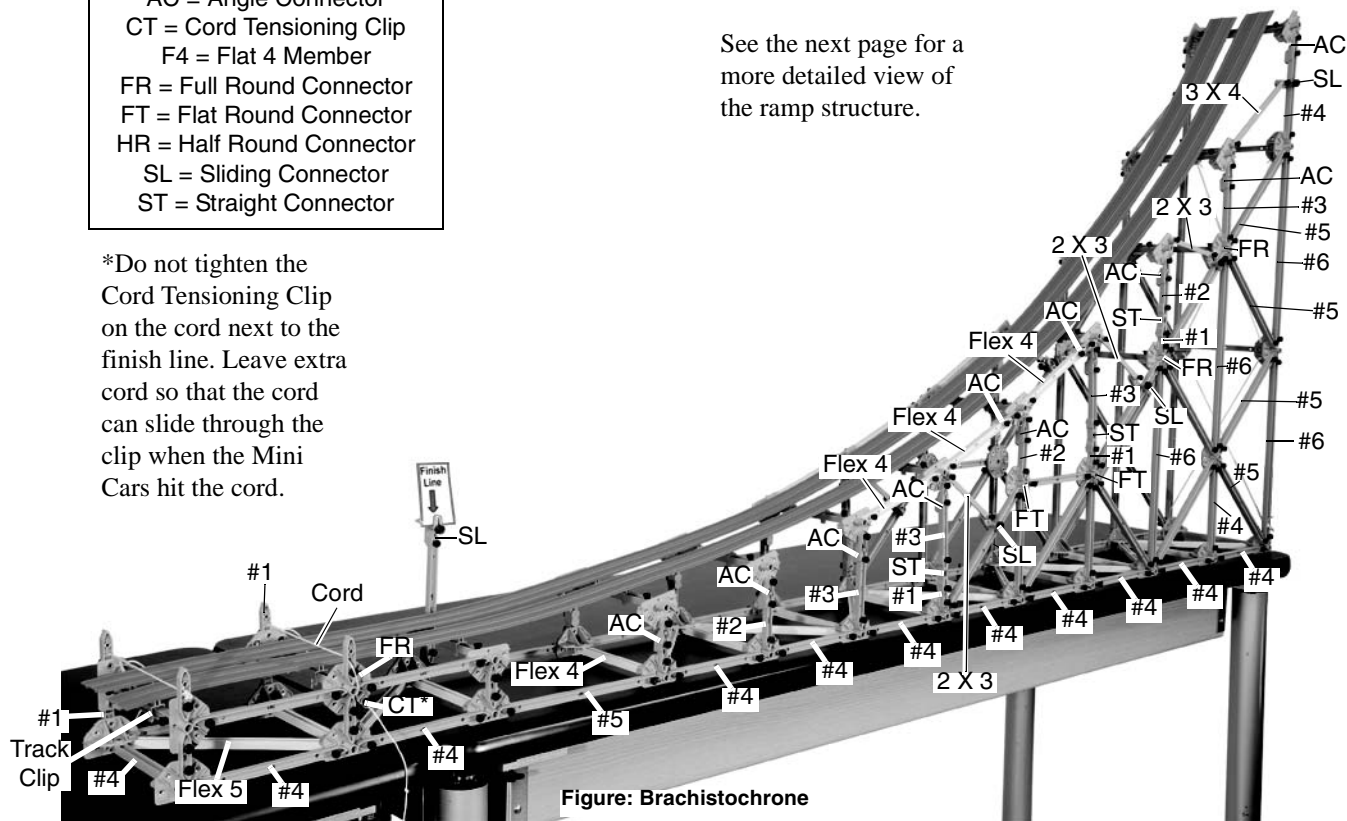


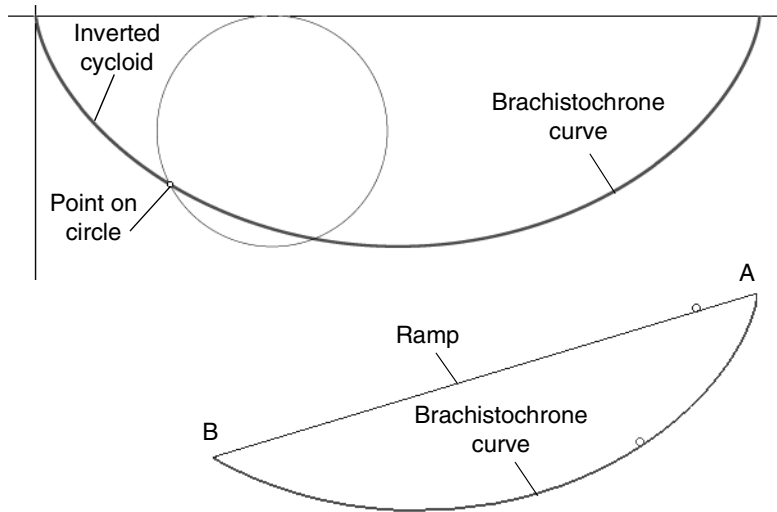
Figure: Brachistochrone

Set up the structure with two Coaster Tracks side-by-side. Place two Mini Cars at different starting points on the track and let them go. What happens?

Use cord and Cord Tensioning Clips to cross brace the back of the high end of the ramp.

The brachistochrone curve is part of an inverted cycloid. A cycloid is the path of a point that is fixed on the edge of a circle as the circle rolls along a straight line.

Imagine a straight ramp and a brachistochrone curve as shown. In a race from A to B between a ball rolling down the brachistochrone curve and a ball rolling down the straight ramp, which ball will finish first?



### Brachistochrone Details

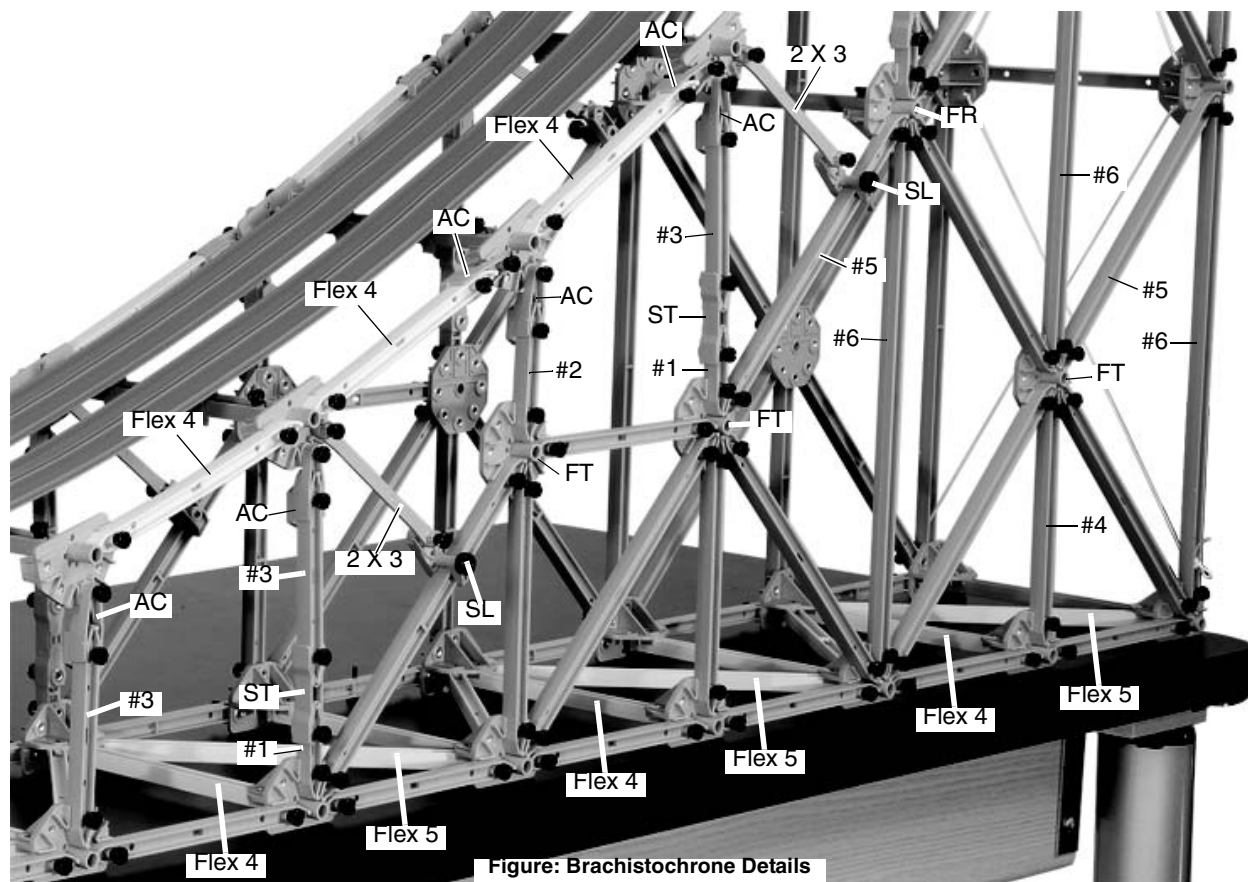


Figure: Brachistochrone Details

### Drawbridge

- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector

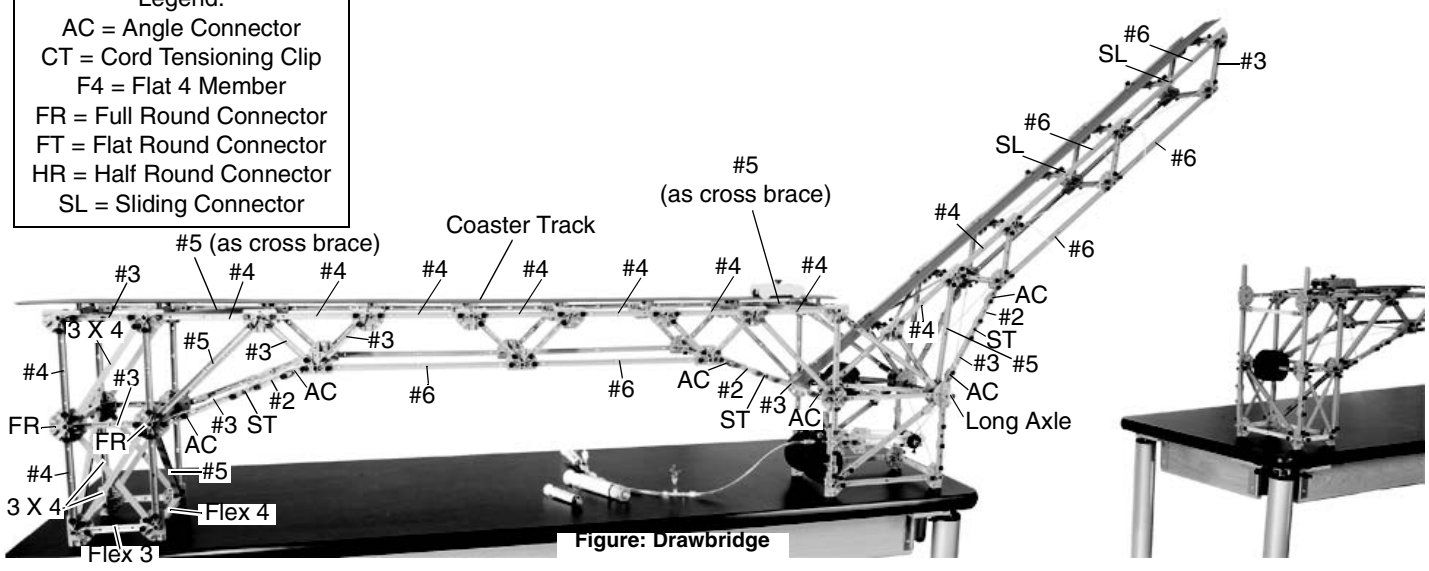


Figure: Drawbridge

The drawbridge structure is a “working” model. You can use parts from the ME-6984 Structures Hydraulic System (not included\*) in order to raise and lower the drawbridge. Use #4 Beams or Flexible #4 Beams as cross members on the bridge support section. Use two #3 Beams and a Straight Connector to build extra #5 Beams. Use two #2 Beams and a Straight Connector to make extra #4 Beams. Note: Additional members from PASCO Structures Sets are needed in order to extend the right hand end of the bridge shown in the illustration.

(\*See the PASCO catalog or the PASCO Web site at [www.pasco.com](http://www.pasco.com) for information about the ME-6984 Structures Hydraulics System.)

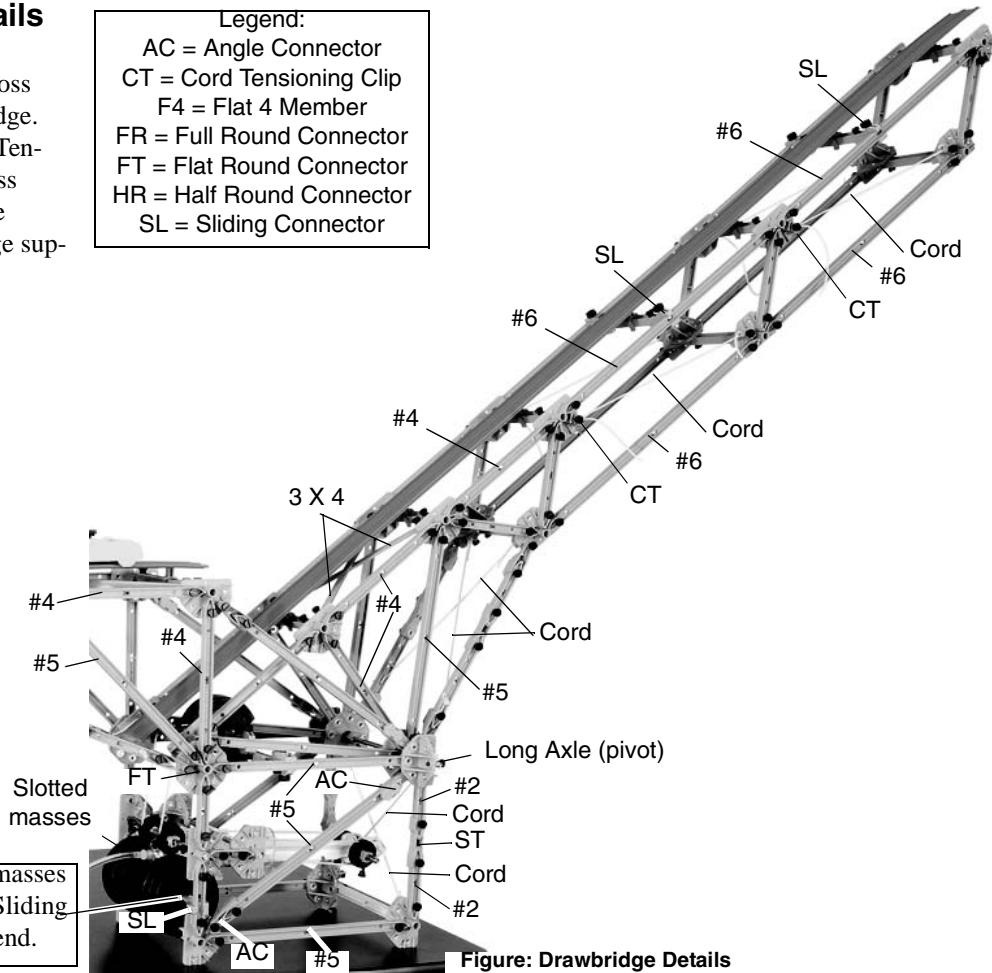


### Drawbridge Details

Use #3 Beams as cross members on the bridge.  
Use cord and Cord Tensioning Clips to cross brace sections of the bridge and the bridge support.

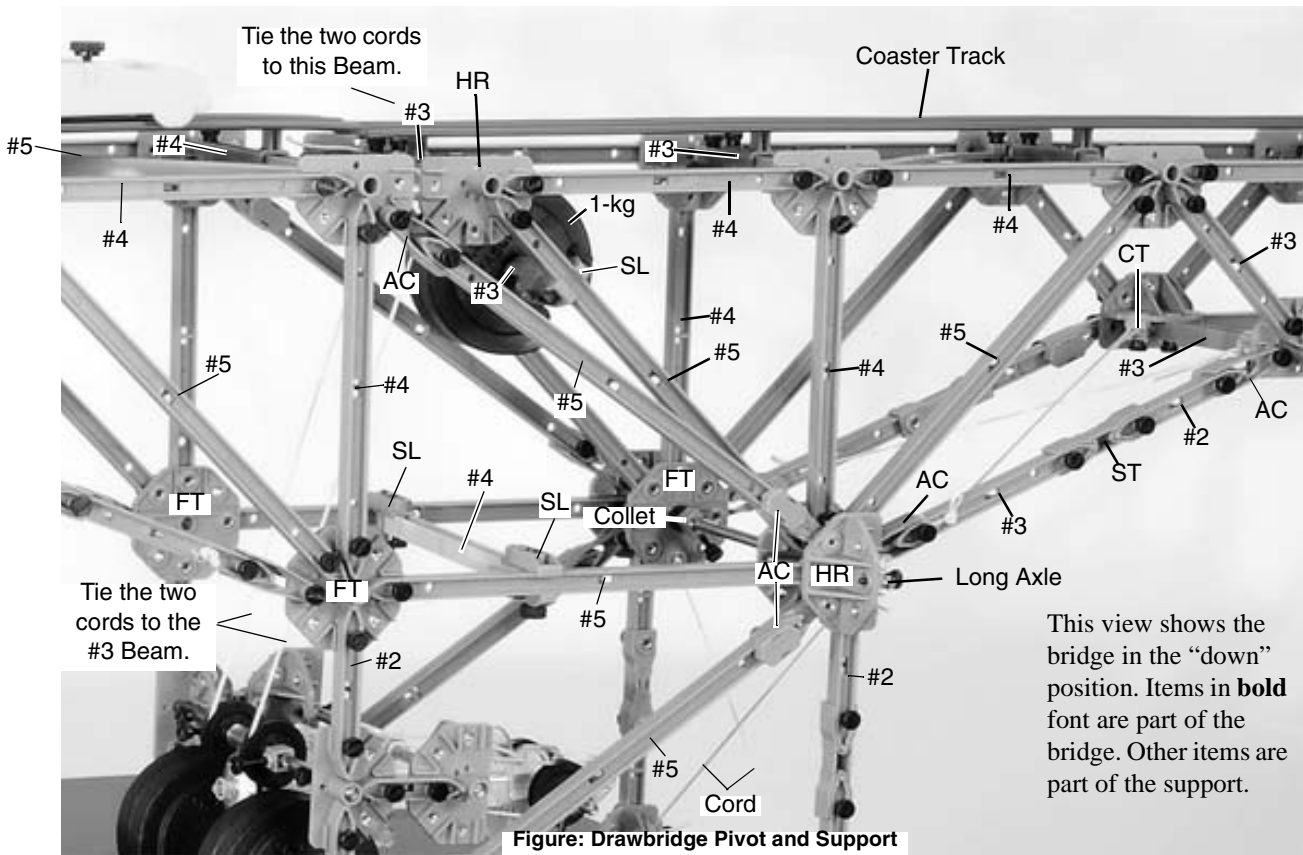
Legend:

- AC = Angle Connector
- CT = Cord Tensioning Clip
- F4 = Flat 4 Member
- FR = Full Round Connector
- FT = Flat Round Connector
- HR = Half Round Connector
- SL = Sliding Connector



Support the slotted masses on a #4 Beam with Sliding Connectors at each end.

Figure: Drawbridge Details

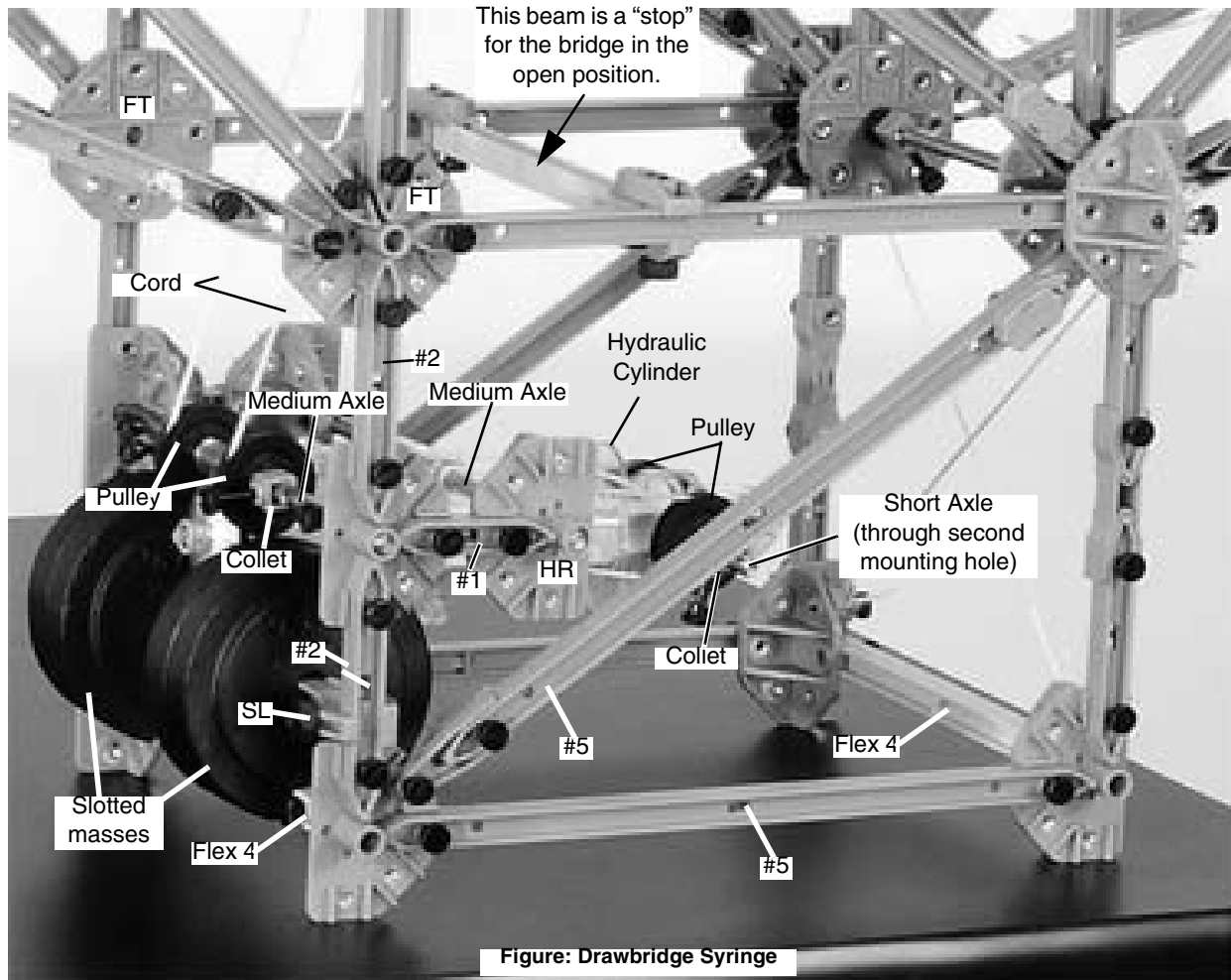


This view shows the bridge in the "down" position. Items in **bold** font are part of the bridge. Other items are part of the support.

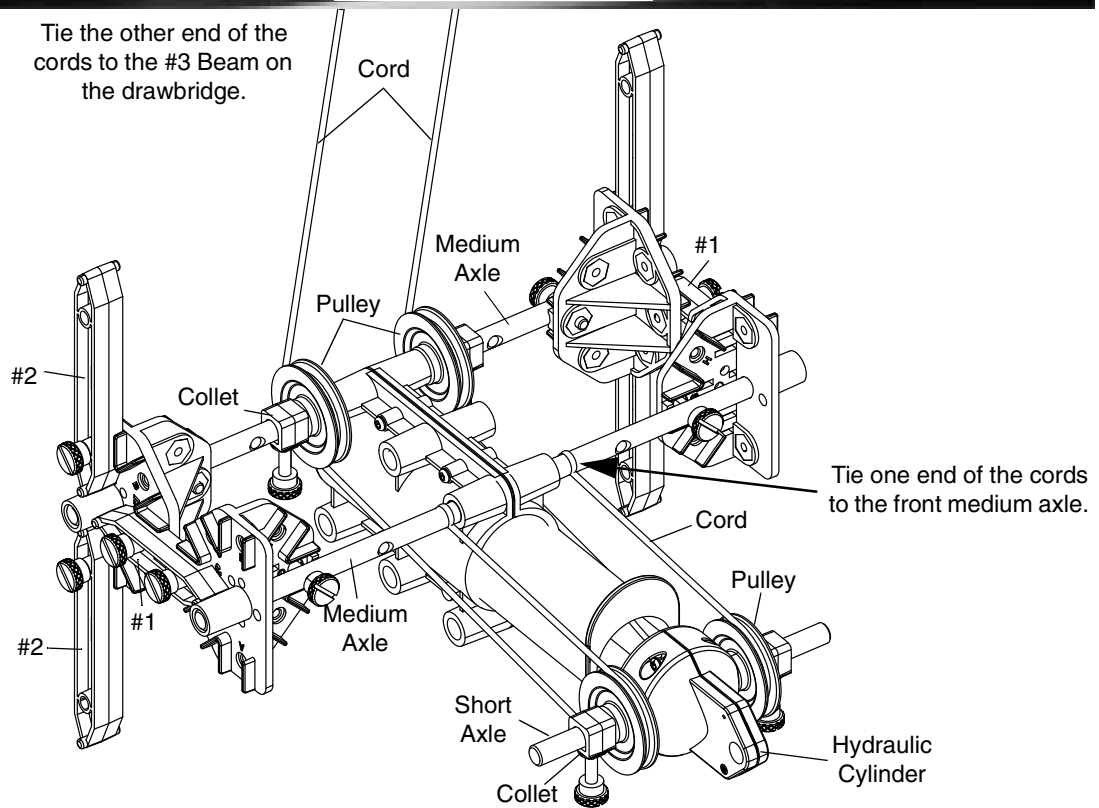
Figure: Drawbridge Pivot and Support



### Drawbridge Syringe Details



Tie the other end of the cords to the #3 Beam on the drawbridge.



**Figure: Drawbridge Syringe Details**

### Drawbridge Details Continued

Use a #4 Beam or Flexible #4 Beam and two Sliding Connectors to form a "stop" bar for the drawbridge when it is in the closed position.

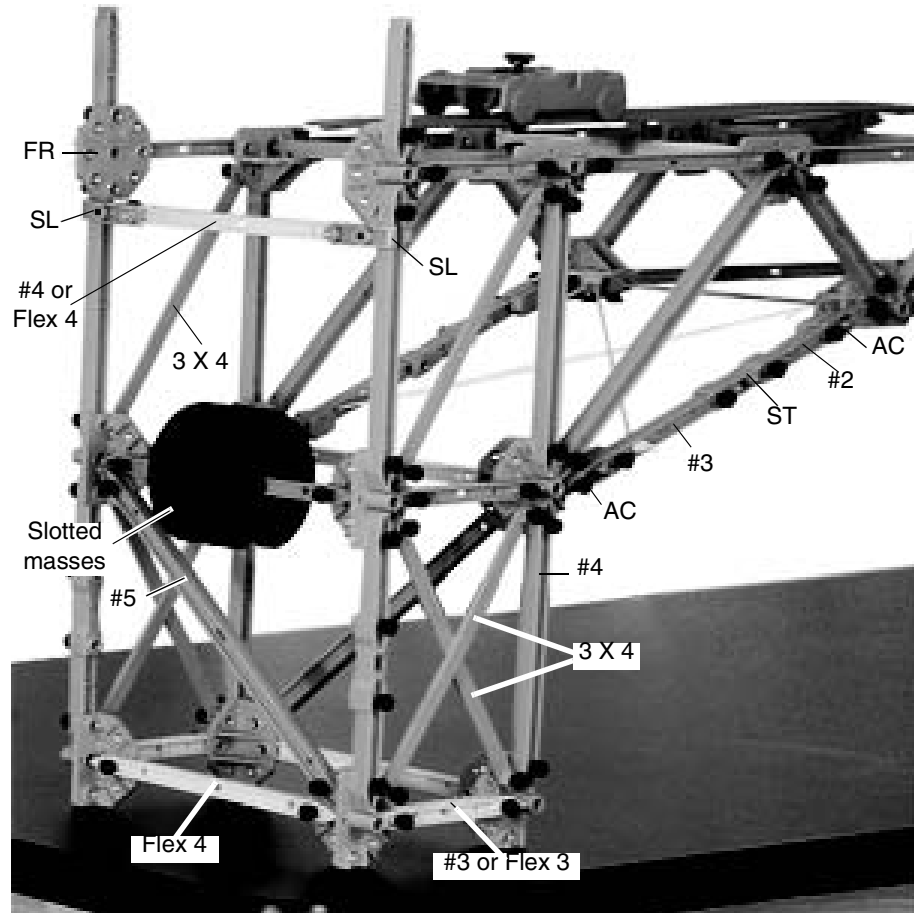
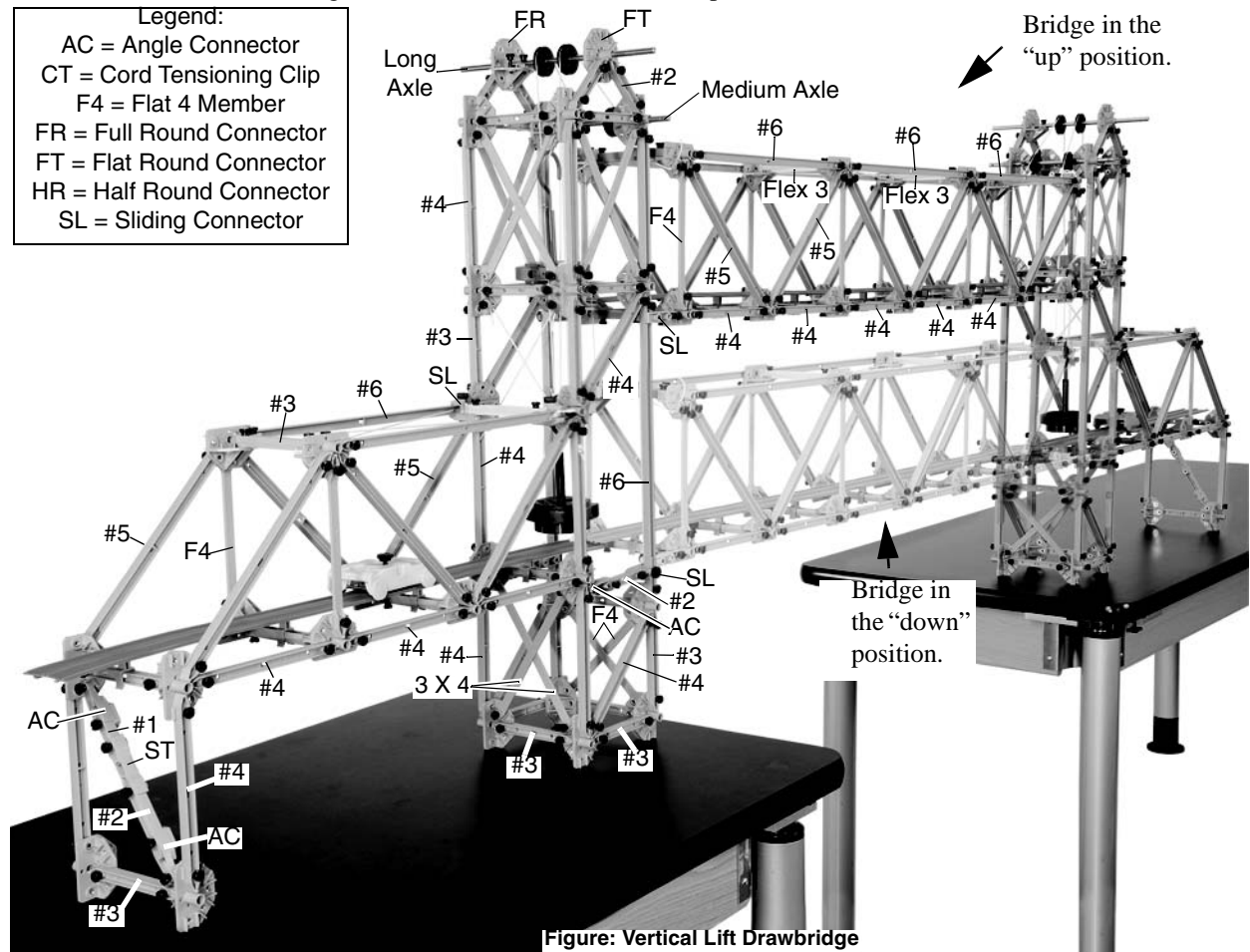


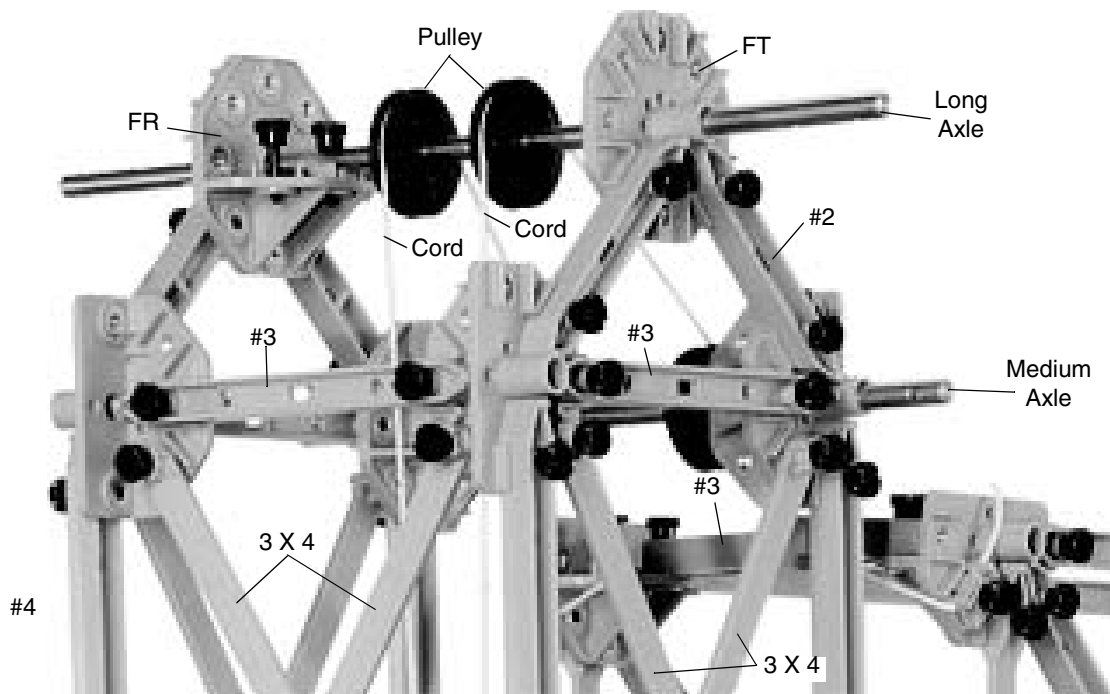
Figure: Drawbridge Right Side

# Vertical Lift Drawbridge

The Vertical Lift Drawbridge has a middle section that slides up and down between the two towers.



The middle section is counterbalanced by hanging masses connected by cords over pulleys. The hanging masses move up and down inside each tower.



## Vertical Lift Drawbridge Details

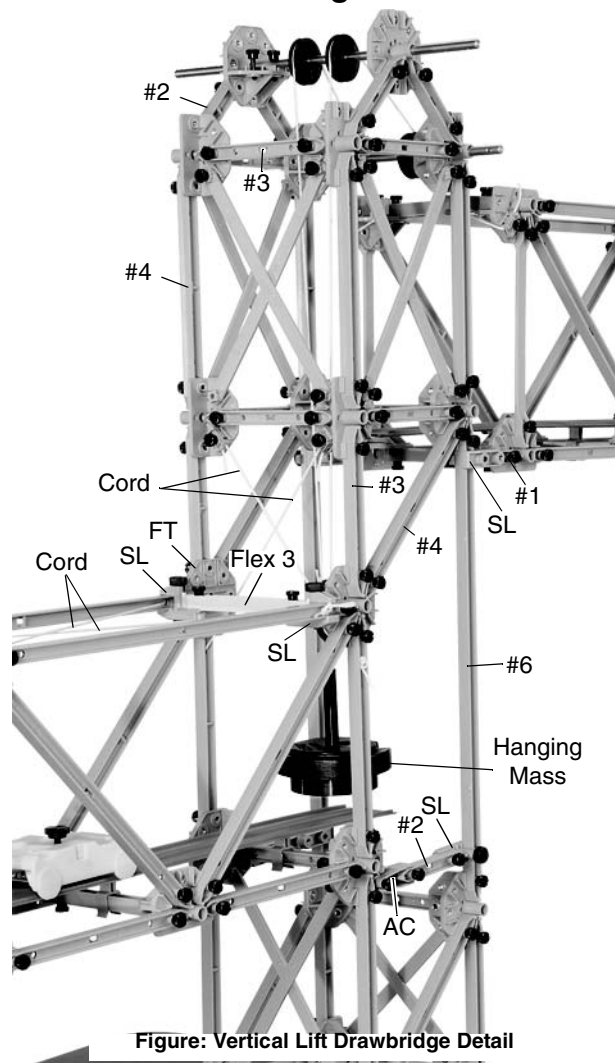


Figure: Vertical Lift Drawbridge Detail

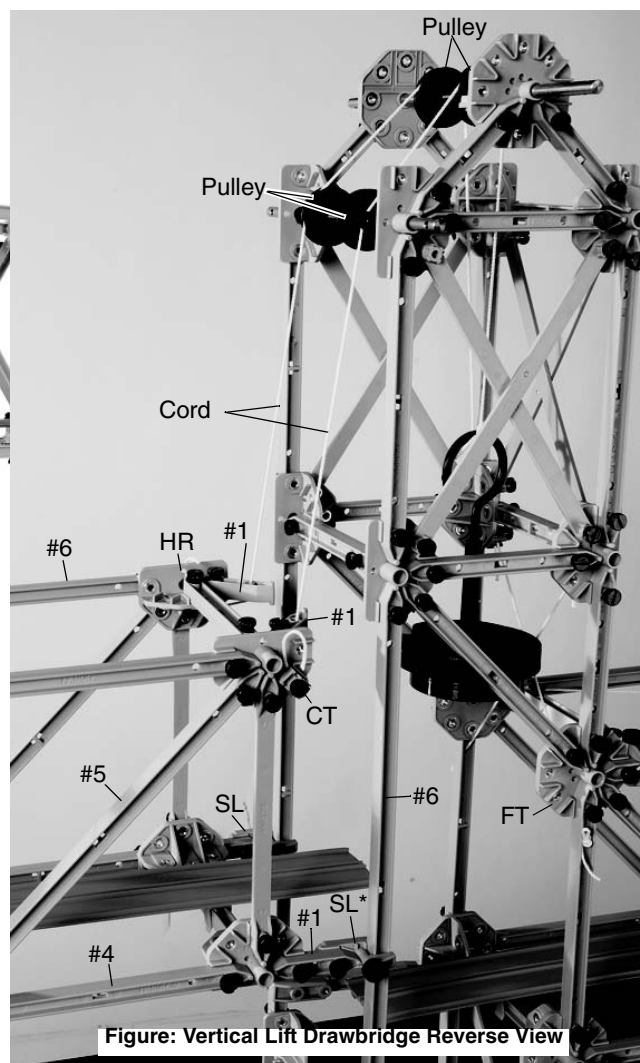


Figure: Vertical Lift Drawbridge Reverse View

(\*Do not overtighten the Sliding Connectors that grasp the vertical #6 Beams. The middle section must be able to slide up and down the #6 Beam.)

Use cord and Cord Tensioning Clips to cross brace the tower and the tower support. For the hanging mass cord, determine how long the cord must be so that the middle section can slide up and down on the #6 Beam on the outside of the tower while the hanging mass moves up and down inside the tower. Double that length. Thread the ends of the cord through the #1 Beams at the top edge of the middle section. Fasten the ends of the cords to Cord Tensioning Clips on the Half Round Connectors. Place the cords over the pulley, and hang the mass hanger from the middle of the cord. Adjust the amount of mass on the mass hangers so that the middle section of the bridge can be lifted or lowered easily.

# Tower Crane

The Tower Crane stands 2.3 meters tall and can be mounted on a PASPORT Force Platform (PS-2141 or PS-2142) or a ScienceWorkshop Force Platform (CI-6461) using the Force Platform Structure Brackets (ME-6988).

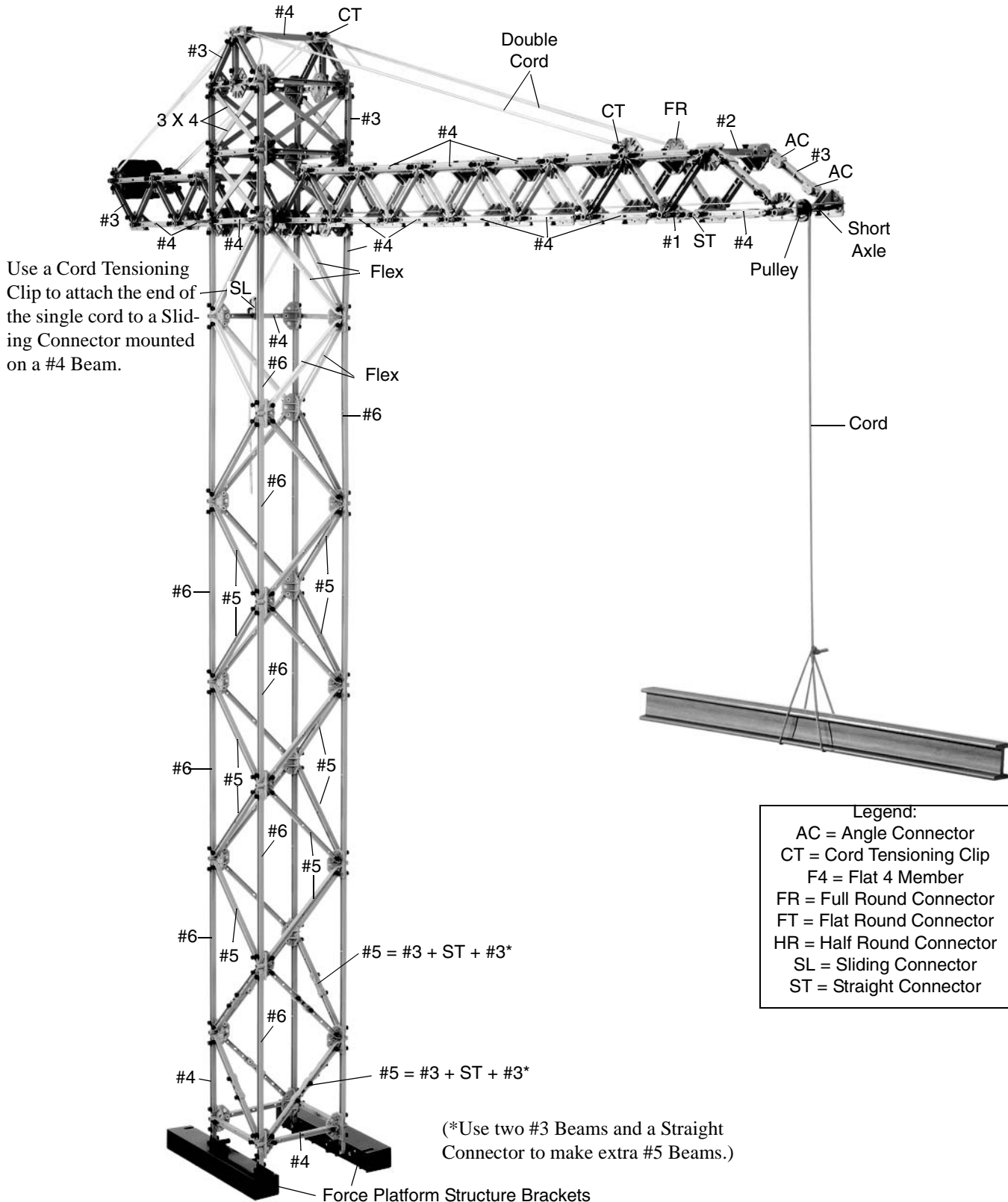
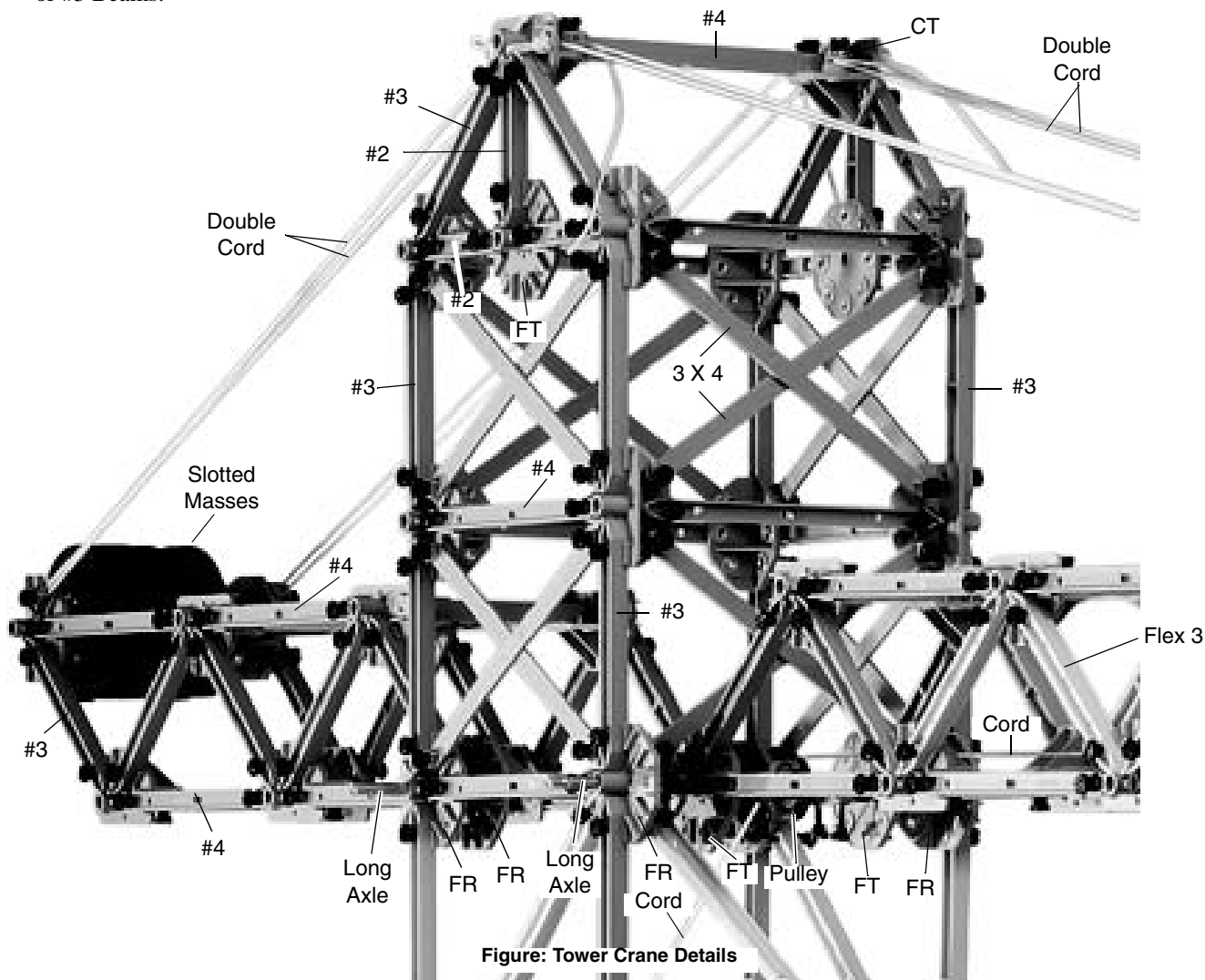


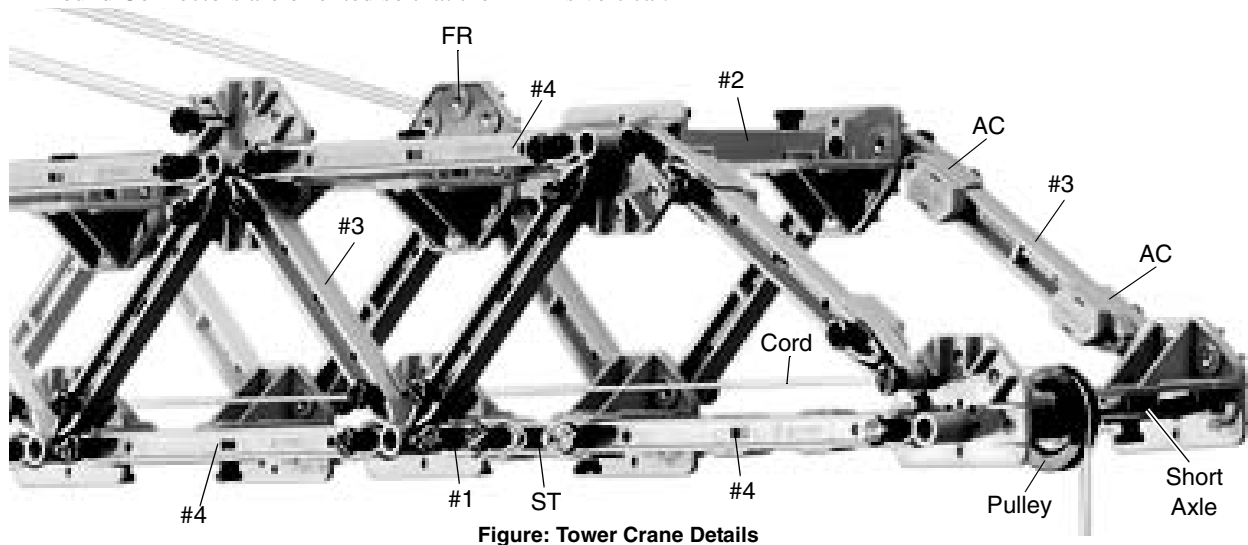
Figure: Tower Crane



The Tower Crane consists of three parts: tower, rear boom and front boom. The tower has a #4 Beam by #4 Beam cross section, uses #4 and #6 Beams for the vertical members, and #5 Beams for the cross braces. The rear boom is a #3 Beam in width and the front boom is a #2 Beam in width. Flexible beams are used when there are no more #5 or #3 Beams.



Put a Collet on each side of the Pulley to keep it in place on the front Long Axle. Make sure that the front Full Round Connectors are oriented so that the “fin” is vertical.



### Tower Crane Boom Details

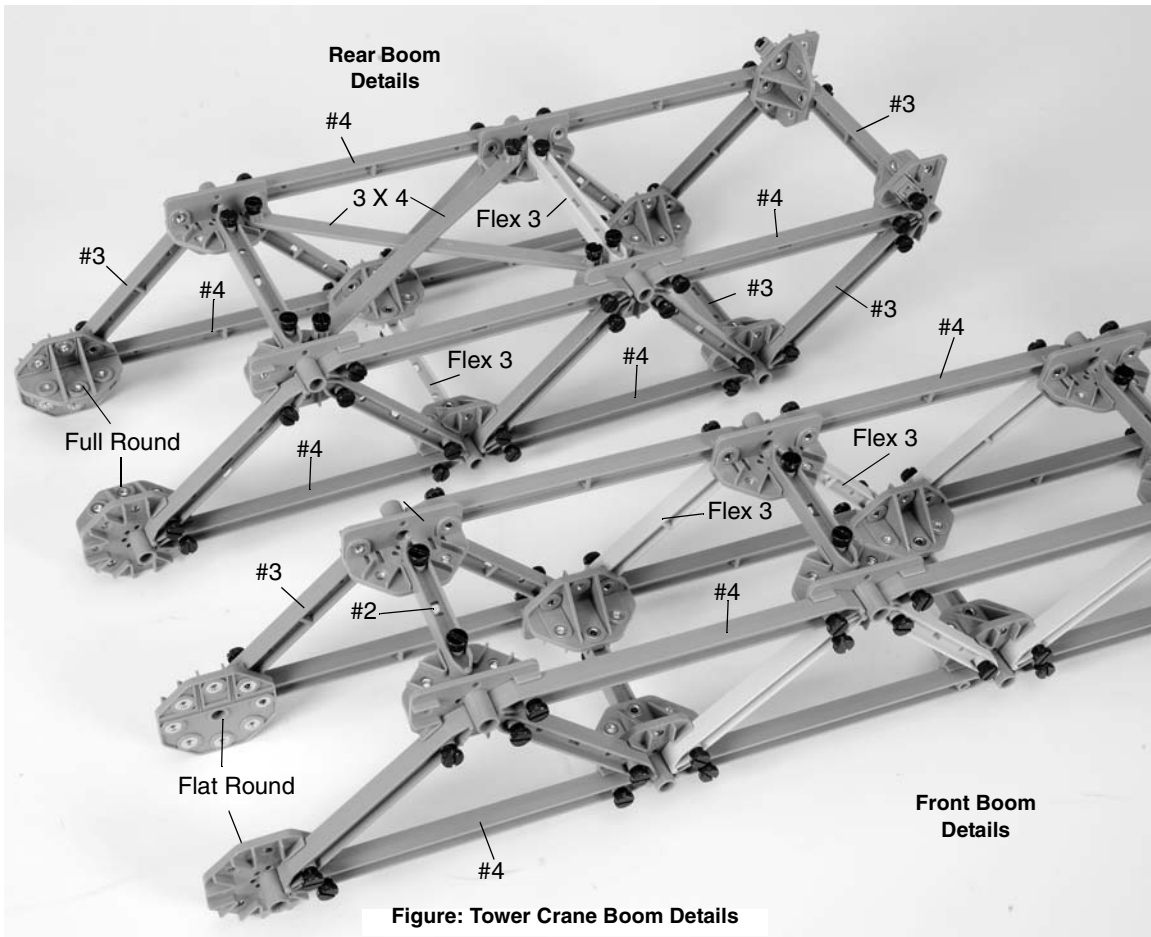


Figure: Tower Crane Boom Details

### Arch Causeway

- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

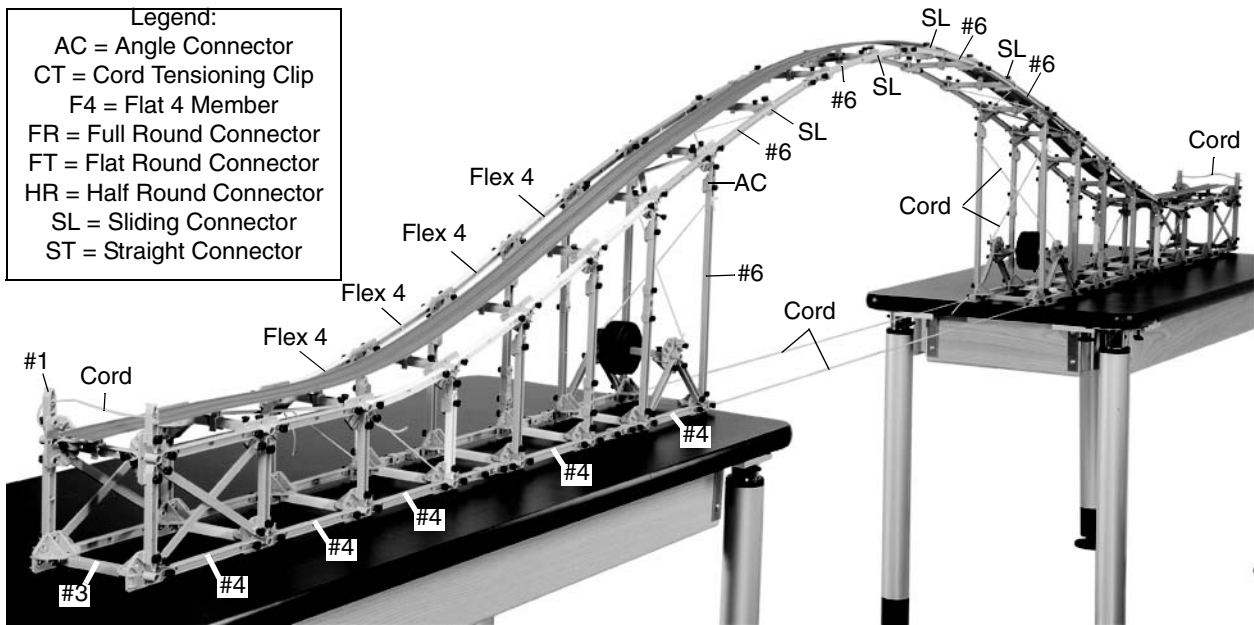
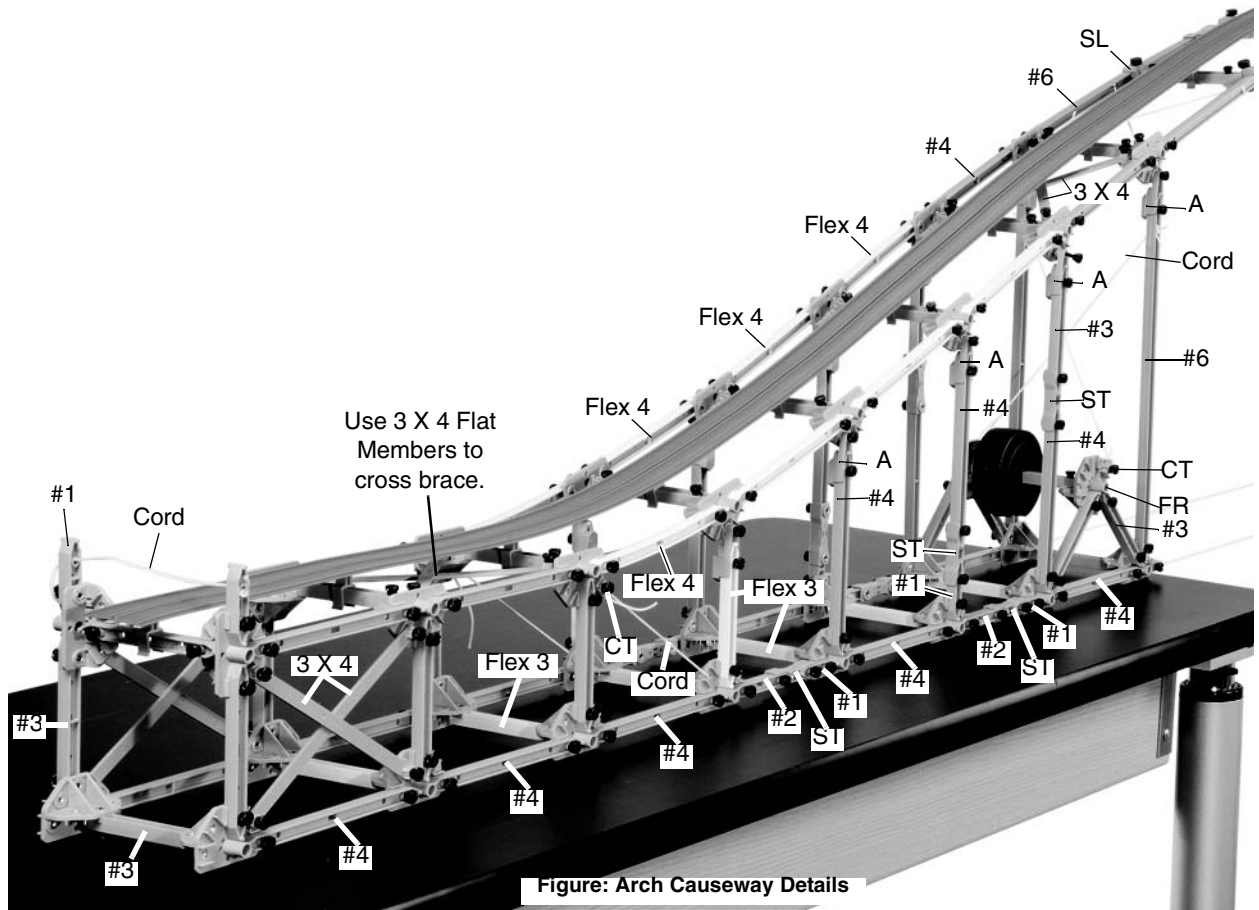


Figure: Arch Causeway

Use cord to connect the two support structures and to cross brace the tallest vertical sections. The arch uses four #6 Beams on each side with #3 Beams and Sliding Connectors as cross members.

### Arch Causeway Details



Use Flexible #3 Beams as cross members in the base of the support when there are no more #3 Beams.





# House Frame

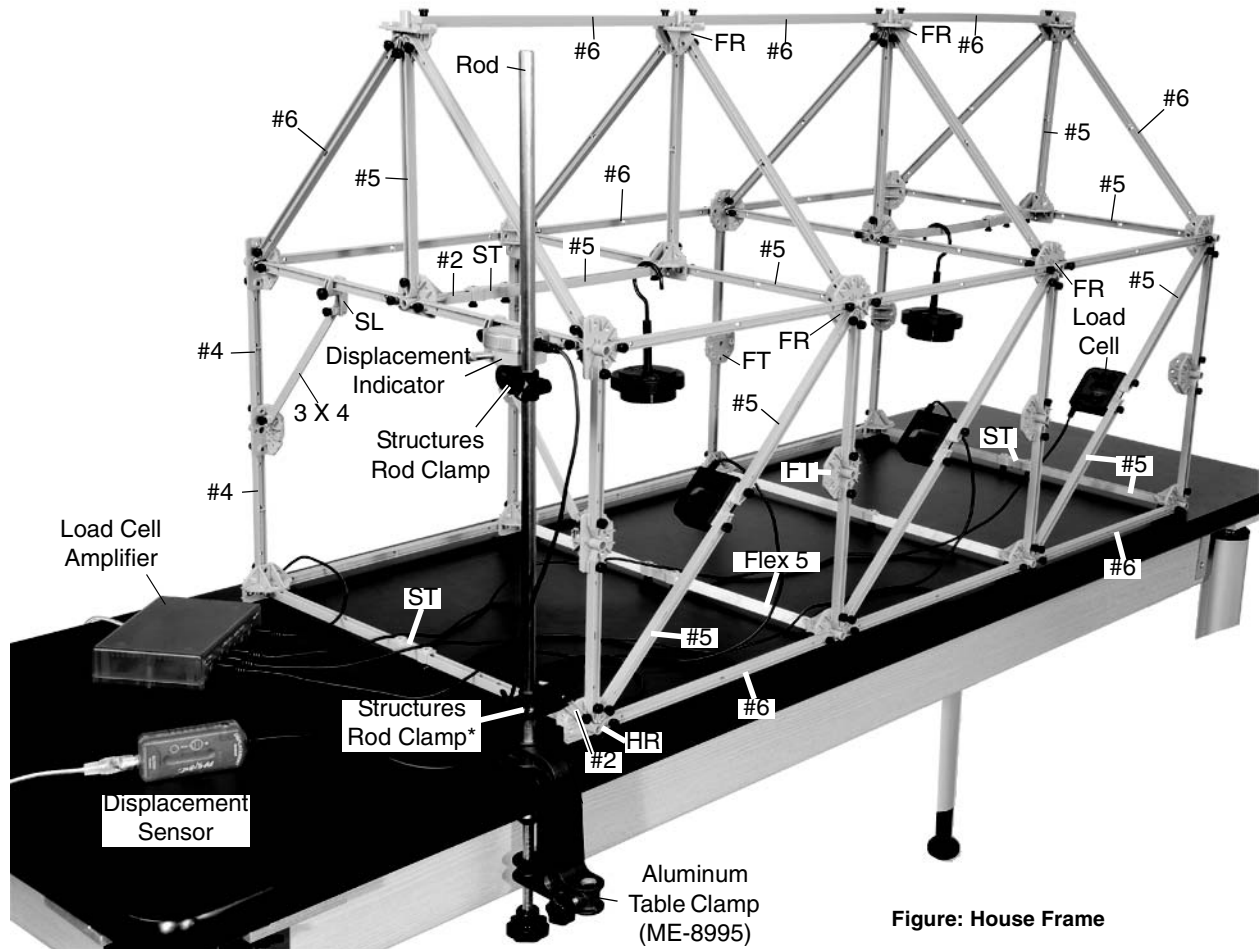
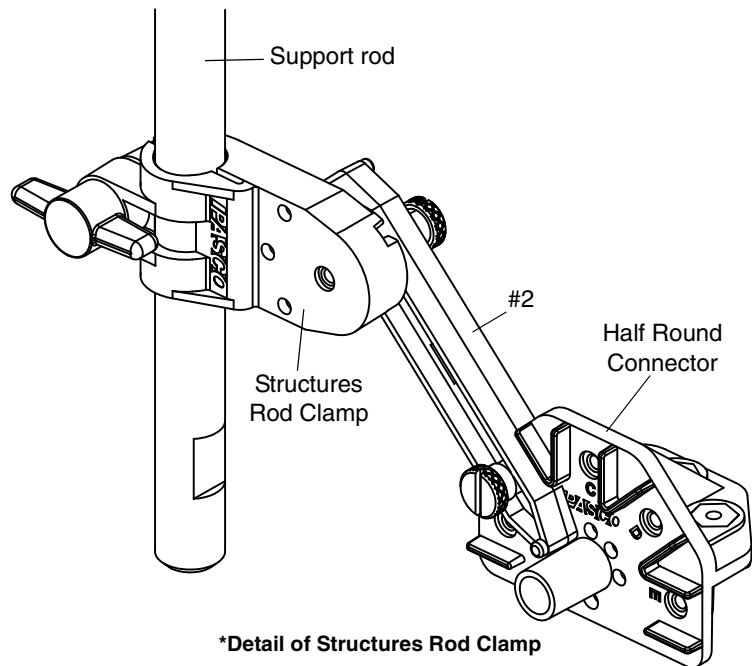


Figure: House Frame

To hold the House Frame in place, attach a #2 Beam to the Half Round Connector at one corner. Put a clamp on the edge of the table and use it to hold a support rod (ME-8995). Attach a Structures Rod Clamp between the support rod and the #2 Beam at the corner of the House Frame.

To make measurements of the flexing of the House Frame when masses are hung from the members, mount the Displacement Indicator of the Displacement Sensor (PS-2204) on another Structures Rod Clamp and mount the clamp on the support rod so that the plunger of the indicator contacts a beam on the House Frame. To make measurements of the forces in the members, mount 100 N Load Cells as shown and connect them to a Load Cell Amplifier (PS-2198).



\*Detail of Structures Rod Clamp



# Angle Crane

The Angle Crane is one of the largest structures to be built with the Large Structures Set. The crane's boom can be raised or lowered using the Hydraulic Cylinder and other parts from the ME-6984 Structures Hydraulics System (available separately). The Angle Crane has three main parts: Boom, Tower, and Base. The Tower is joined to the Base by an axle mounted on the Base, and the Boom pivots on another axle near the top of the Tower.

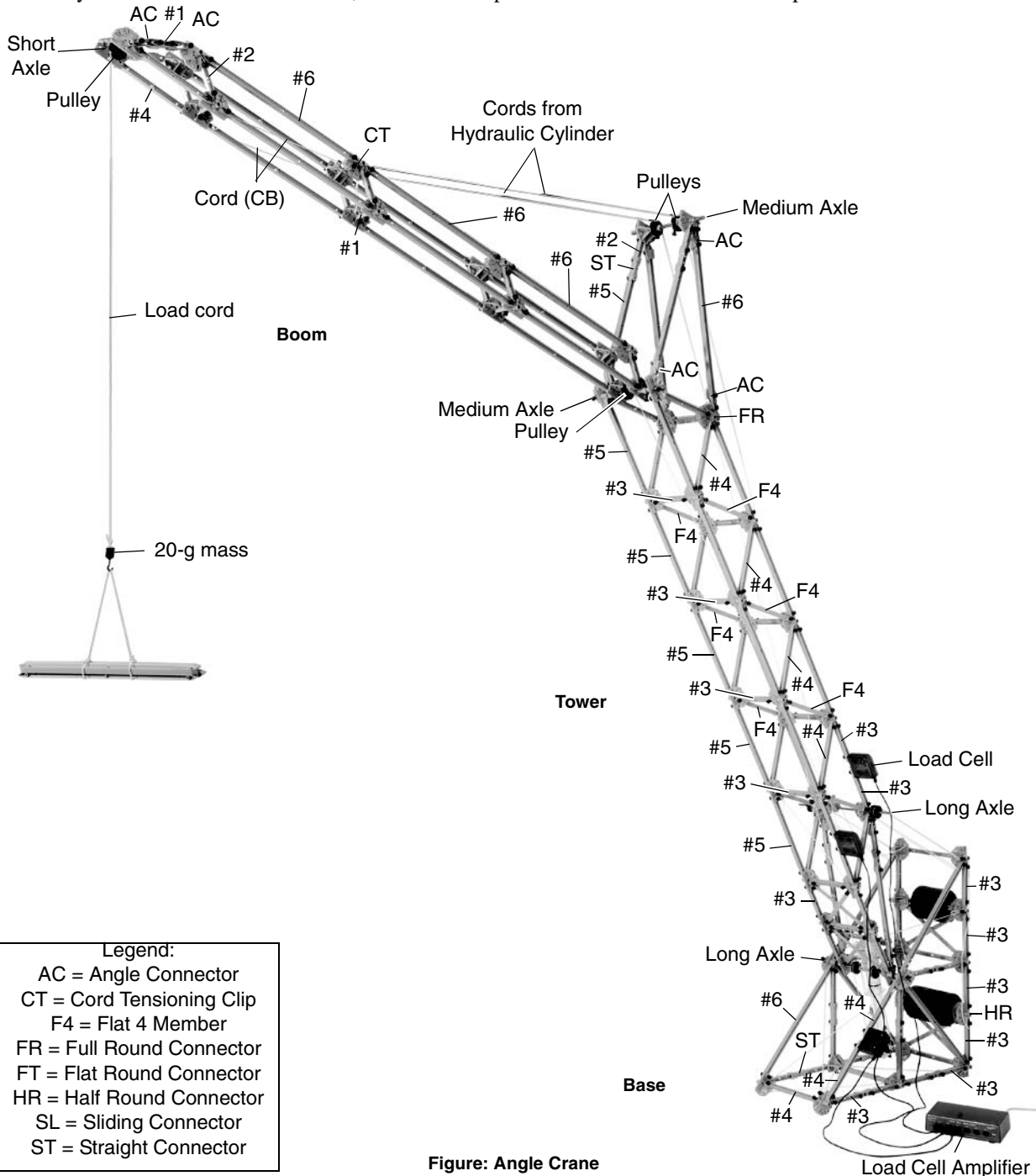
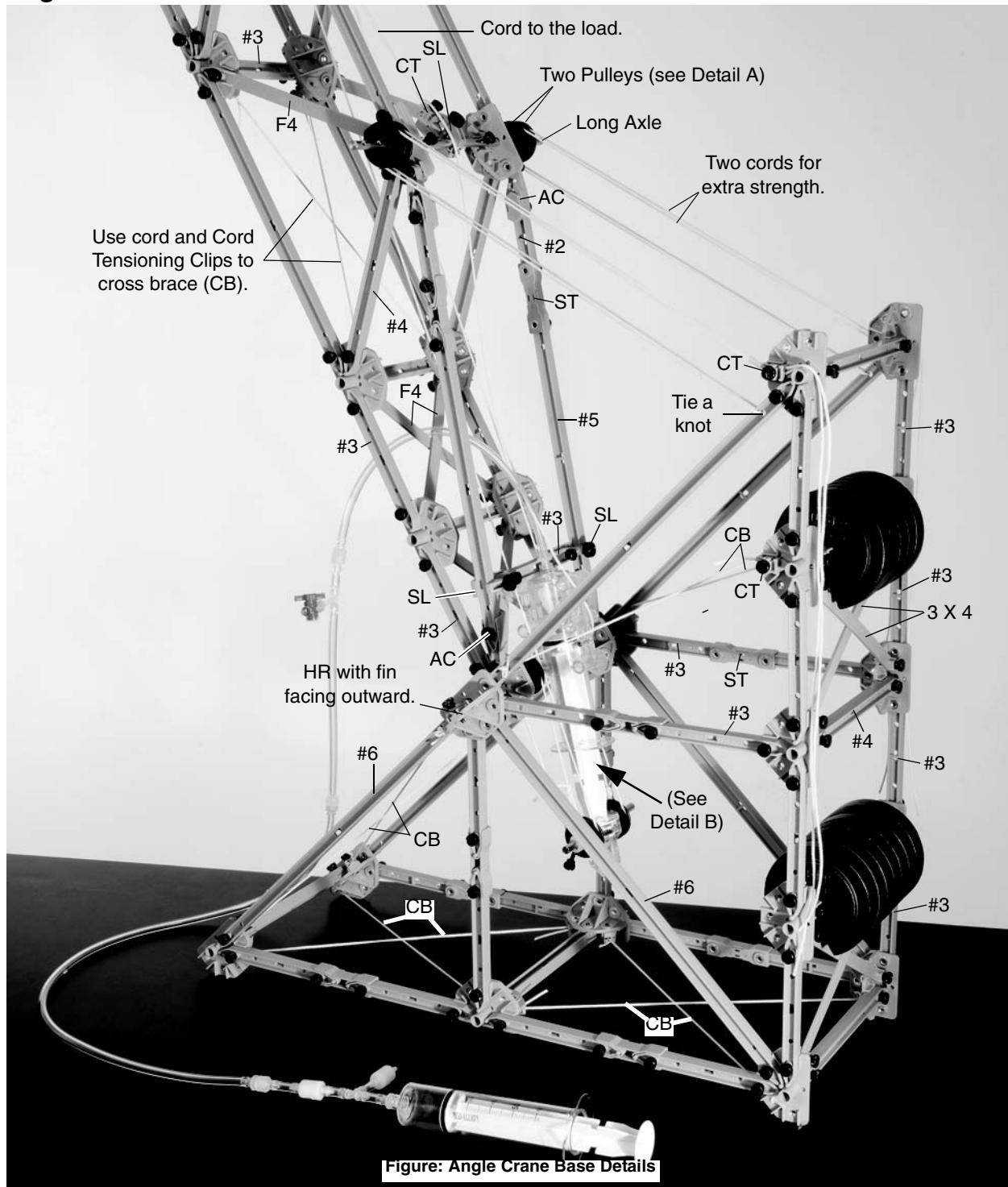


Figure: Angle Crane

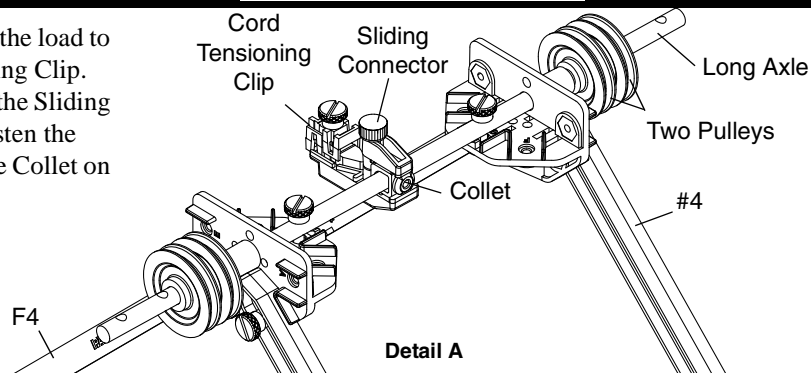
Use two #3 Beams and a Straight Connector to make ten extra #5 Beams for the Base and Tower. The hook on the end of the cord is a 20 g mass from the Hooked Mass Set (SE-8759). Slotted masses on the back of the base are counterweights for the Tower and Boom, and forces in the Tower and Base are measured by 100 N Load Cells connected to a Load Cell Amplifier. The Base width is a #4 Beam, the Tower width is a #3 Beam, and the Boom width is a #1 Beam.

### Angle Crane Details



**Figure: Angle Crane Base Details**

Tie the cord from the load to the Cord Tensioning Clip. Attach the clip to the Sliding Connector and fasten the connector onto the Collet on the axle.



**Angle Crane Details**

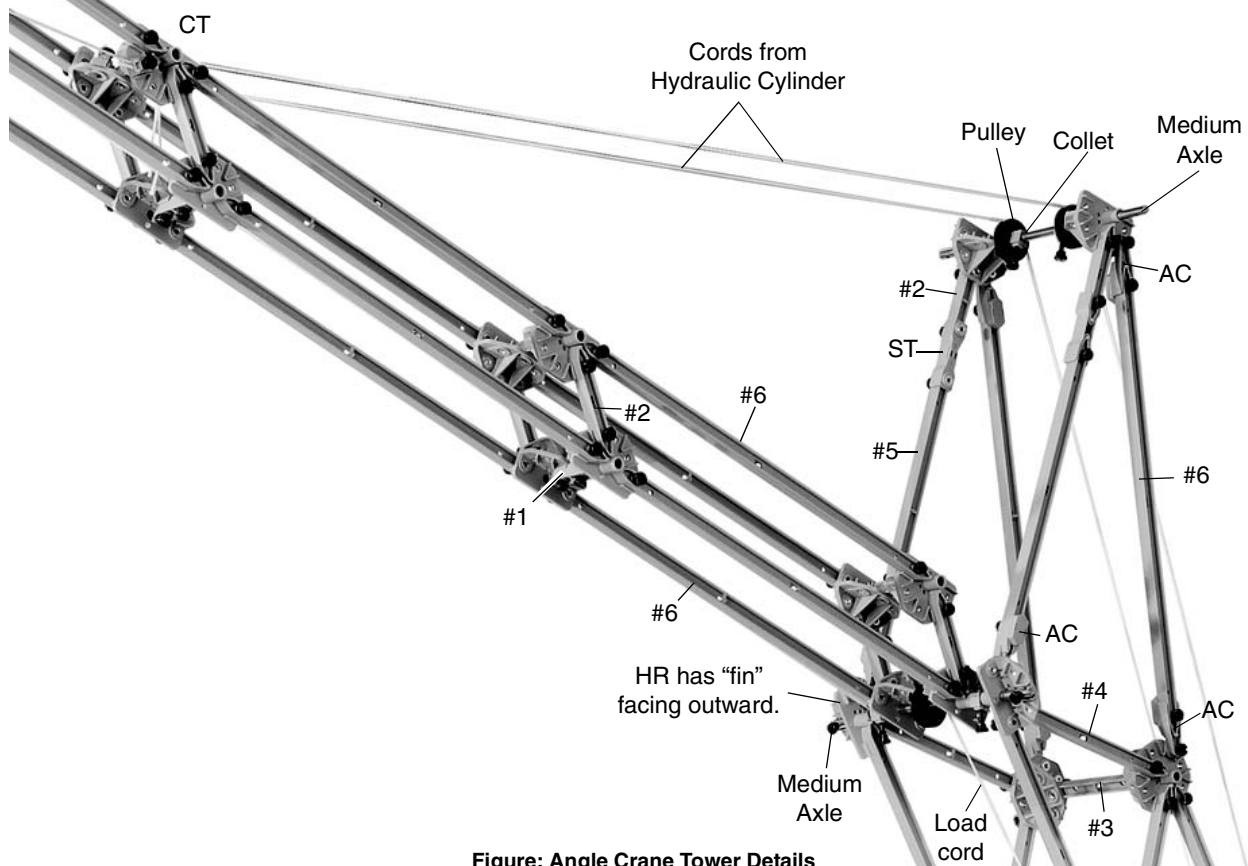
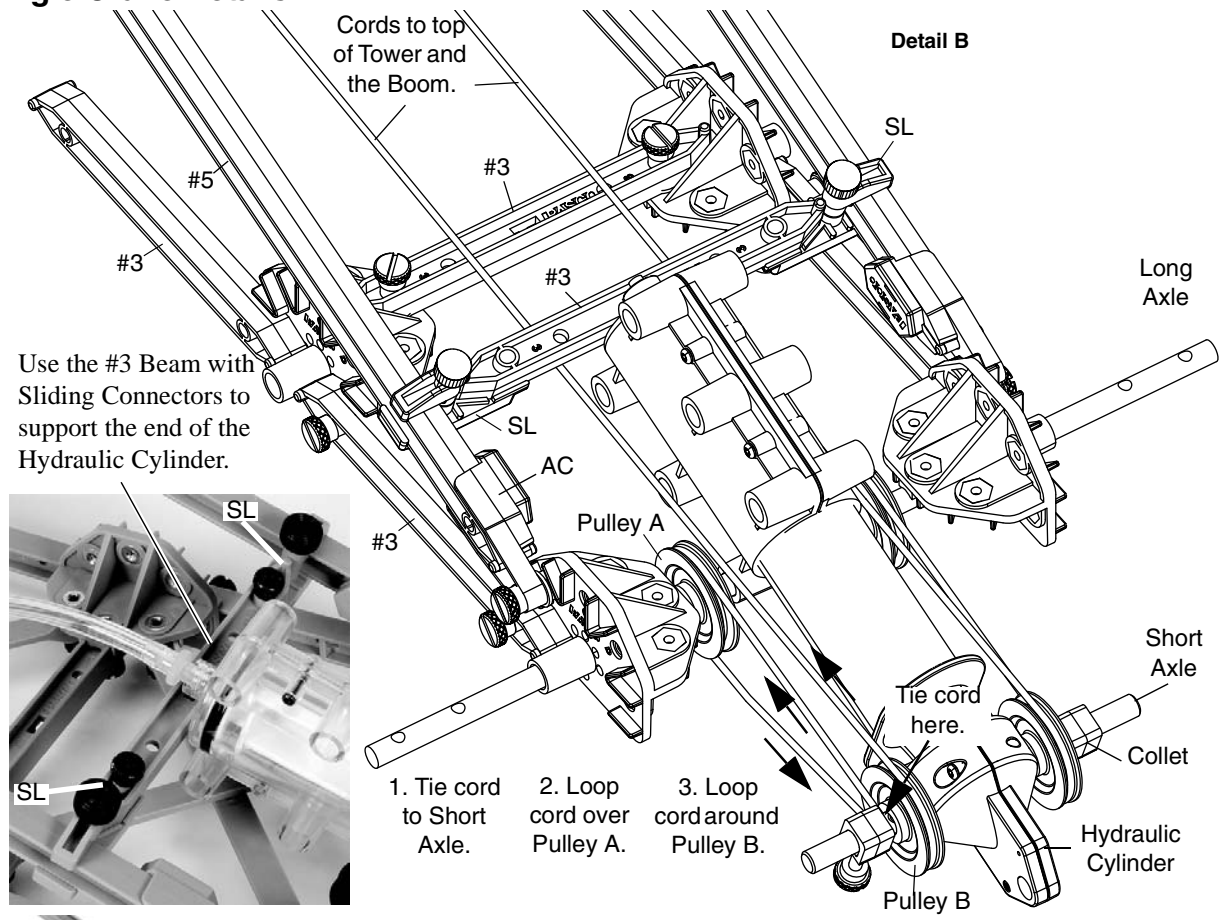


Figure: Angle Crane Tower Details





### Windmill Details

- Legend:
- AC = Angle Connector
  - CT = Cord Tensioning Clip
  - F4 = Flat 4 Member
  - FR = Full Round Connector
  - FT = Flat Round Connector
  - HR = Half Round Connector
  - SL = Sliding Connector
  - ST = Straight Connector

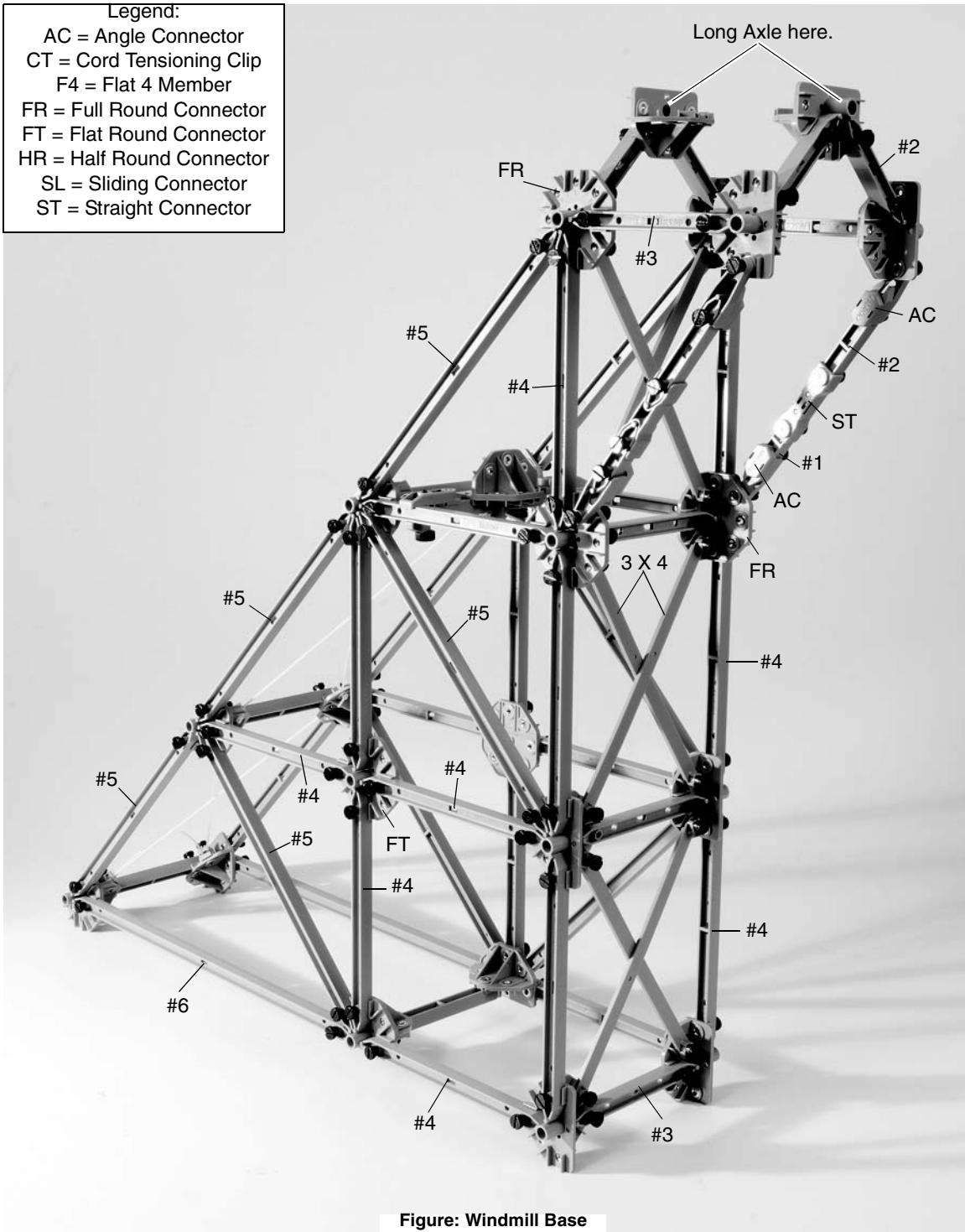


Figure: Windmill Base

Make a sleeve in each sail to slide over the #6 Beams by folding the lower part of the sail to the dotted line, and then taping the edge in place. Clamp the small end of the sail between a Sliding Connector and a Cord Tensioning Clip.

Windmill Details

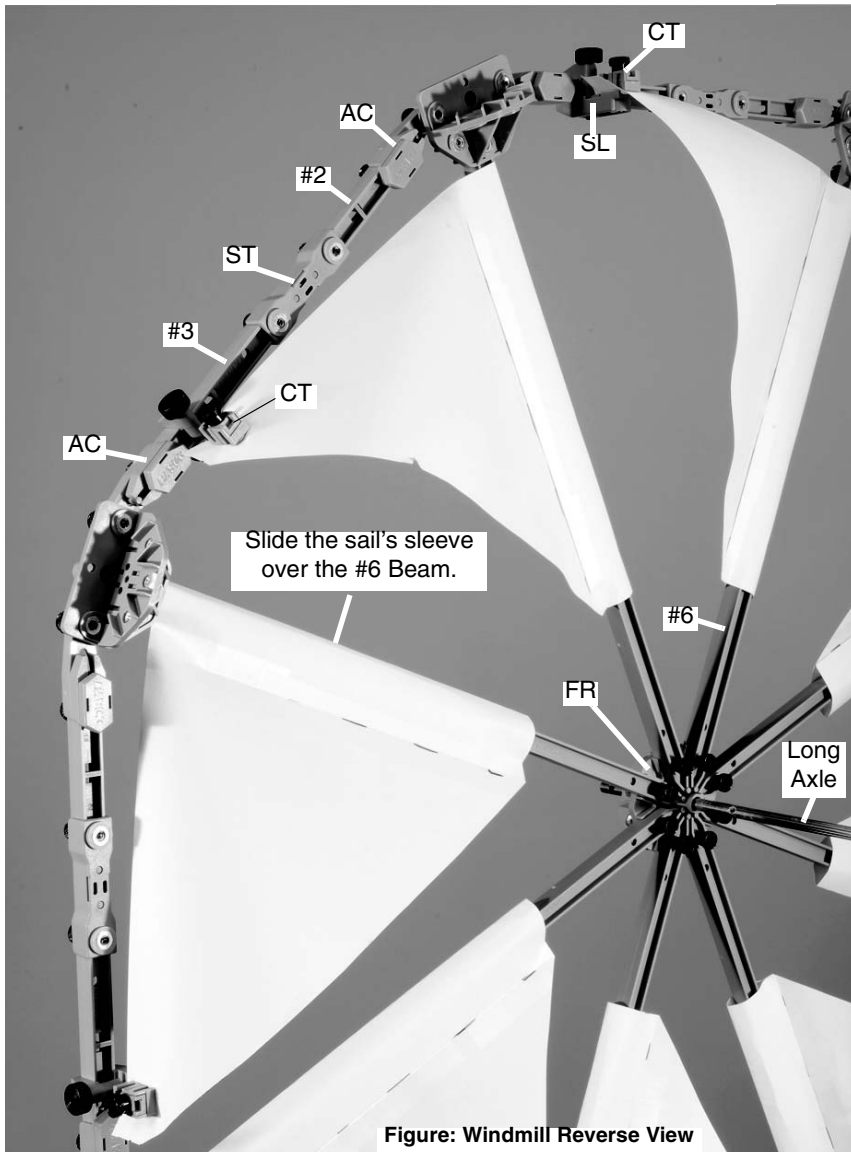


Figure: Windmill Reverse View

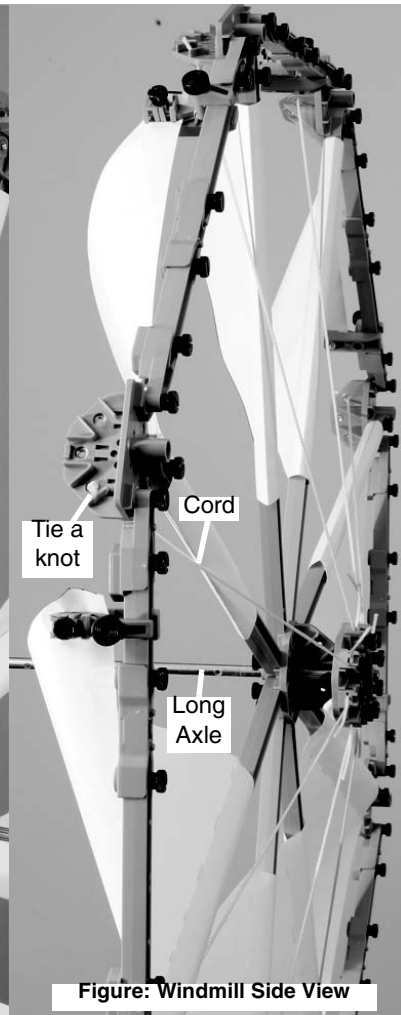
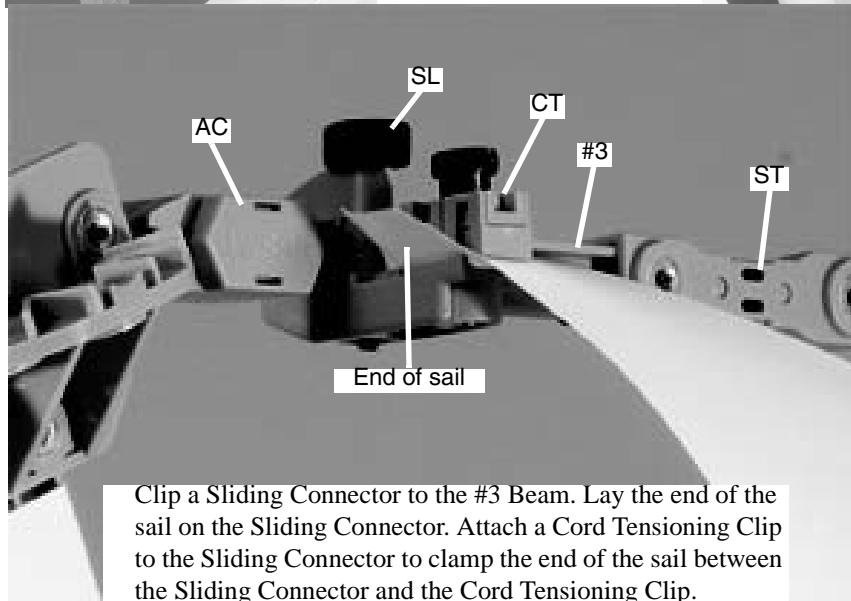


Figure: Windmill Side View



Clip a Sliding Connector to the #3 Beam. Lay the end of the sail on the Sliding Connector. Attach a Cord Tensioning Clip to the Sliding Connector to clamp the end of the sail between the Sliding Connector and the Cord Tensioning Clip.

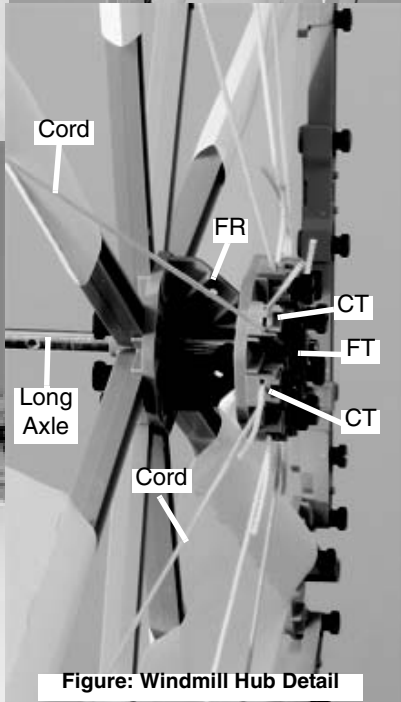


Figure: Windmill Hub Detail

### Windmill Details

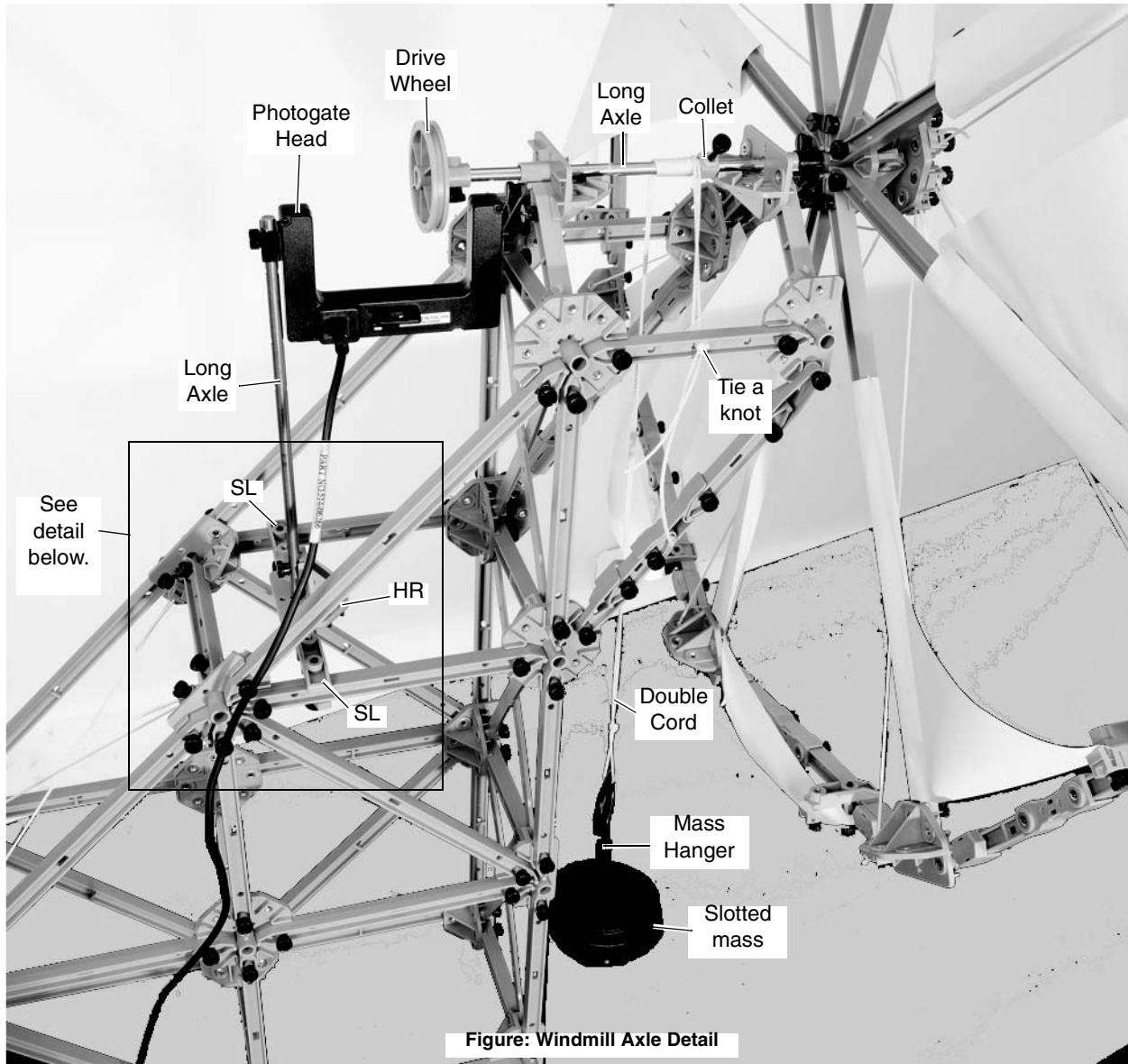


Figure: Windmill Axle Detail

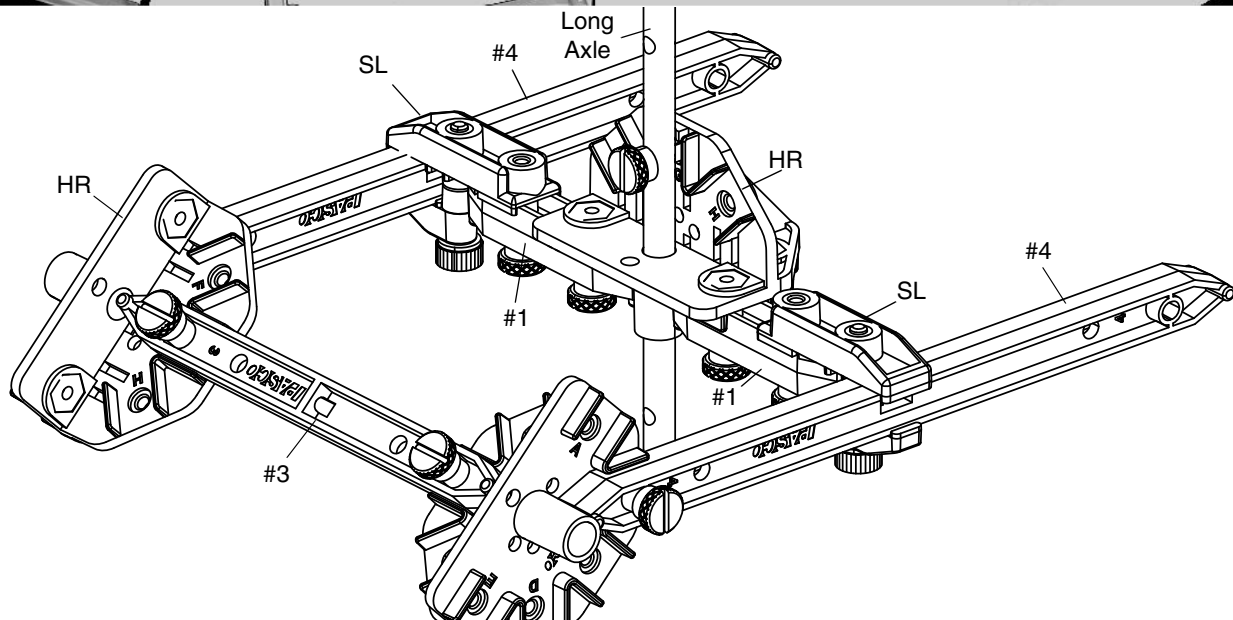


Figure: Windmill Photogate Support Detail

## Technical Support

For assistance with any PASCO product, contact PASCO at:

Address: PASCO scientific  
10101 Foothills Blvd.  
Roseville, CA 95747-7100

Phone: 916-786-3800 (worldwide)  
800-772-8700 (U.S.)

Fax: (916) 786-7565

Web: [www.pasco.com](http://www.pasco.com)

Email: [support@pasco.com](mailto:support@pasco.com)

For more information about the Large Structures Set and the latest revision of this Instruction Manual, visit the PASCO web site and enter ME-7003 into the Search window.

**Limited Warranty** For a description of the product warranty, see the PASCO catalog.

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**Patents Pending:** The following are some of the PASCO products that have patents pending:

ME-6990 Truss Set	ME-6991 Bridge Set
ME-6992A Advanced Structures Set	ME-6993 Truss Set Members
ME-6994 Truss Set Screws	ME-6995 Road Bed Spares
ME-6996 Cord Lock Spares	ME-6997 Full Round (XYZ) Connector Spares
ME-6998 Axle Spares	ME-6999A Angle Connector Spares
PS-2198 Load Cell Amplifier	PS-2199 Load Cell and Amplifier Set
PS-2200 100 N Load Cell	PS-2201 5 N Load Cell
PS-2205 Dual Load Cell Amplifier	



Sail Template

Clamp position

(Discard this part.)

Cut along this line.

Tape bottom edge along this line.

Fold along this line.

