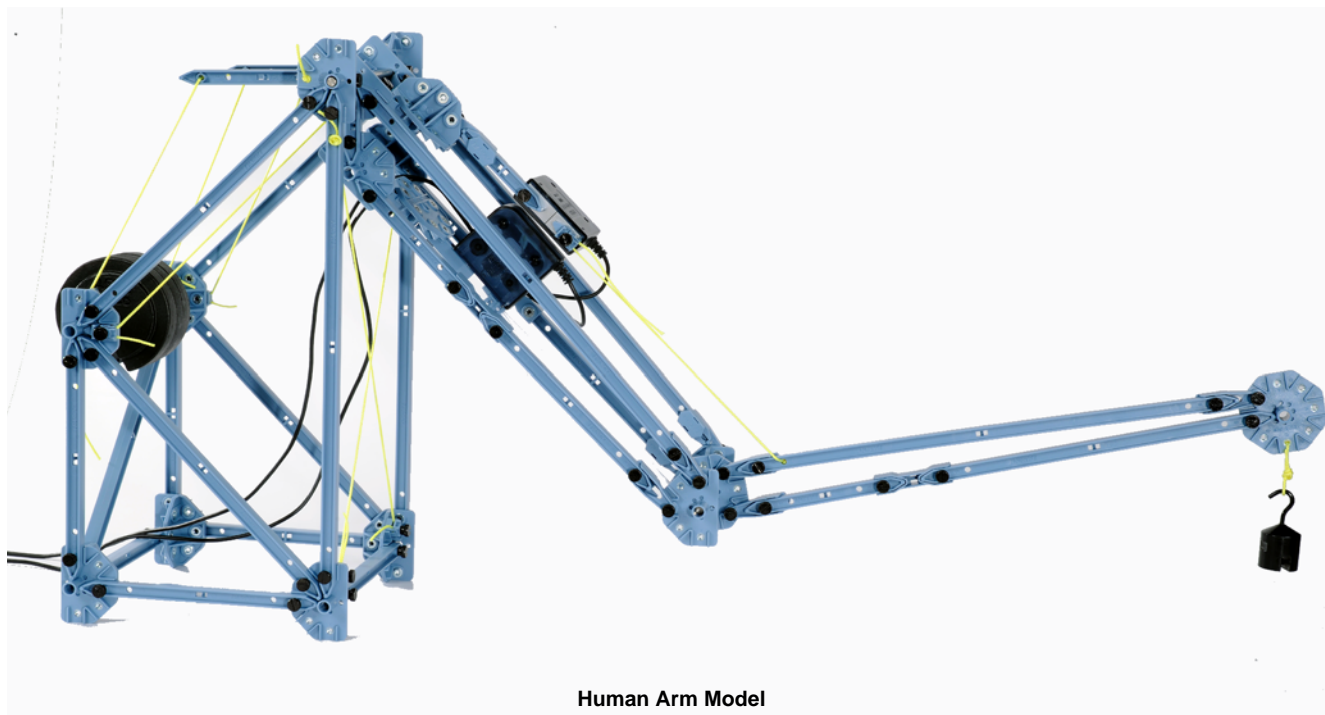


# Human Structures Set

## ME-7001



The Human Arm Model is one of three models that can be constructed at the same time with the ME-7001 Human Structures Set. The set consists of items from the following members of the PASCO Structures System.

Structure System	Qty	Structure System	Qty
ME-6993 Truss Set Members	2 sets	ME-6998A Axles	1 set
ME-6994 Truss Set Screws	5 sets	ME-6999A Angle Connectors	1 set
ME-6996 Cord Lock Spares	1 set	ME-7002 Connector Spares	2 sets
ME-6997 Full Round Connectors	1 set	ME-7008 Structures Member 6	1 set

The Human Structures Set also includes a 30 meter spool of rubber cord (ME-8986) and a plastic storage box (not shown).

Included Items	Qty	Included Items	Qty
#6 Beam (36 cm long)	24	Axle (2 each of 3 lengths)	6
#5 Beam (24 cm long)	16	Drive Wheel and Tire	4
#4 Beam (17 cm long)	36	Pulley	12
#3 Beam (11.5 cm long)	36	Collet	24
#2 Beam (8 cm long)	16	Spacer	12
#1 Beam (5.5 cm long)	16	Screw (6-32)	375
Flat Connector	6	Small "O" Ring (1-5/16" OD)	12
Full Round Connector	6	Large "O" Ring (3-5/8" OD)	4
Half Round Connector	56	Nut and Bolt (for PAStrack)	6
Angle Connector	24	Cord Tensioning Clip	32
Sliding Connector	12	Yellow Cord	1 roll
Straight Connector	24	Rubber Cord	1 roll

Recommended Equipment	Recommended Equipment
Hooked Mass Set (SE-8759)	Large Slotted Mass Sets (ME-7566 or ME-7589)

Other PASCO equipment is closely related to the Human Structures Set.

Related Equipment	Related Equipment
PS-2198 Load Cell Amplifier	PS-2201 5-N Load Cell
PS-2199 Load Cell and Amplifier Set	PS-2205 Displacement Sensor
PS-2200 100-N Load Cell	PS-2206 Dual Load Cell Amplifier
PASPORT Interface*	Data Acquisition Software*

\*See the PASCO catalog or PASCO web site ([www.pasco.com](http://www.pasco.com)) for more information

## Introduction

The ME-7001 Human Structures Set is one part of the PASCO Structures System. The Human Structures Set can be used as a stand-alone set and it can also be combined with other parts of the PASCO Structures System. The set includes all of the items necessary to build one each of the following: Human Arm Model, Human Back Model, Human Leg Model. A Load Cell and Amplifier Set (PS-2199) can be added to measure compression and tension forces in the human structure models.

### Related Equipment

**Load Cell Amplifier (PS-2198)** - Can plug in up to six Load Cells; requires a PASPORT interface to connect to the USB port of a computer.

**Load Cell and Amplifier Set (PS-2199)** - Load Cell Amplifier (PS-2198) with four 100 N Load Cells (PS-2200).

**100 N Load Cell (PS-2200)** - Strain gauges mounted on a beam with no electronics so a Load Cell requires a Load Cell Amplifier (PS-2198) or Dual Load Cell Amplifier PS-2206).

**5 N Load Cell (PS-2201)** - Strain gauges mounted on a beam with no electronics so a Load Cell requires a Load Cell Amplifier or Dual Load Cell Amplifier.

**Displacement Sensor (PS-2205)** - A PASPORT Sensor and a digital displacement indicator designed to measure the deflection of parts of a structure.

**Dual Load Cell Amplifier (PS-2206)** - Can plug in one or two Load Cells; requires a PASPORT interface to connect to the USB port of a computer.

## About the Components

### Beams

There are six sizes of plastic I-Beams, labeled #1 through #7. Beam #1 is the shortest beam.

### 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.

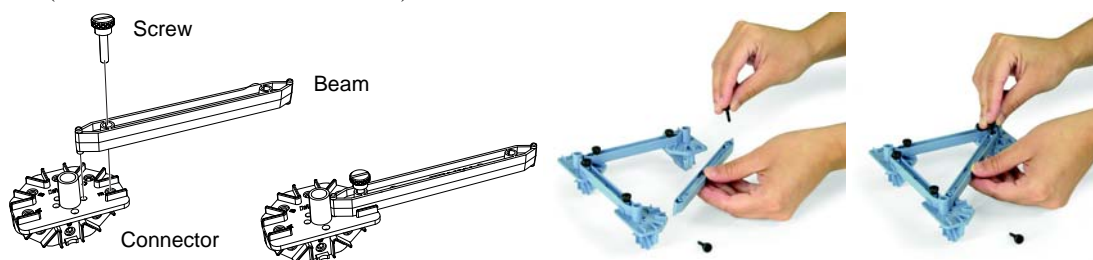


Figure 1: Attaching beams to connectors

### Attaching Cords

When attaching cords for lateral bracing or for suspension or cable-stayed bridges, Cord Tensioning 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 structure. Prepare to thread the cord by holding the top half of the clip as shown in Figure 2a 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 2c. Then the Cord Clip can be used in the structure, using a 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.

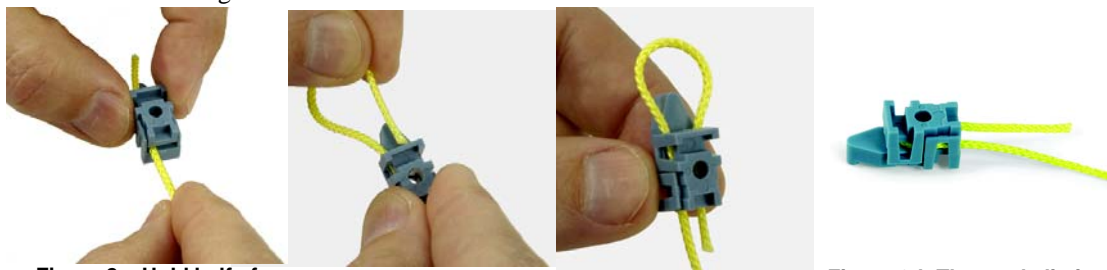


Figure 2a: Hold half of the cord clip so the two halves separate

Figure 2b: Loop the cord back through the cord clip

Figure 2c: The cord goes around the screw hole

Figure 2d: The cord clip is ready to be attached to the structure using a screw

## Connectors

**Half Round Connector:** The half round connector has eight slots, labeled A through H, for accepting beams.

**Full Round Connector:** The full round connector has eleven slots, labeled A through H and X, Y, and Z, for attaching beams.

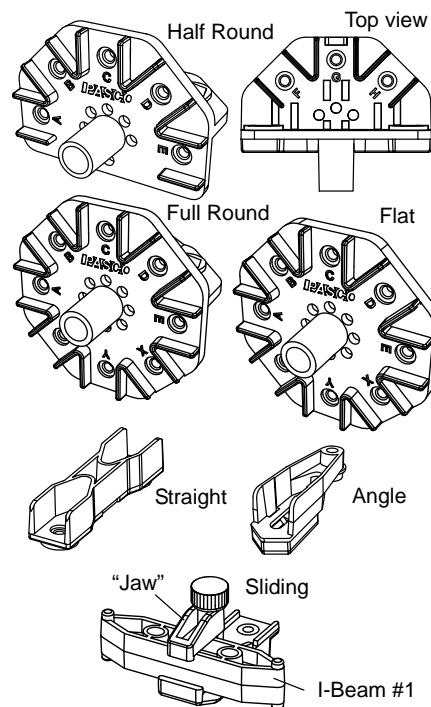
**Flat Connector:** The flat connector has eight slots, labeled A through E, and X, Y, and Z, for attaching beams.

**Straight Connector:** The straight connector can connect two beams to make a longer beam.

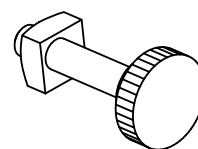
**Angle Connector:** The angle connector can allow a beam to be connected to a half round connector, full round connector, or flat connector at an angle different than zero, 45, or 90 degrees. The Angle Connector also allows for a small adjustment of the length of the beam.

**Sliding Connector:** 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.

**Nut and Bolt for PASTrack:** The square nut and bolt can be used with a flat connector to fasten a structure to a PASCO PASTrack (see the PASCO catalog or web site at [www.pasco.com](http://www.pasco.com) for information about PASTrack equipment.)



**Figure 3: Connectors**



**Figure 4: Nut and Bolt for PASTrack**

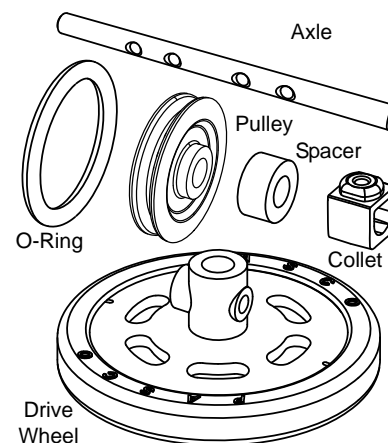
## Axles, Pulleys, Spacers, Collets, and Drive Wheels

**Axles:** There are two each of three different lengths: 10.4 cm (4.1 in), 21.3 cm (8.4 in), and 26.6 cm (10.5 in). Each axle is 0.635 cm (0.250 in) in diameter.

**Pulleys:** There are twelve pulleys, each 3.175 cm (1.250 in) in diameter and 0.558 cm (0.220 in) wide. To make a wheel, put one of the small “O” rings into the pulley’s groove.

**Spacers and Collets:** There are twelve spacers, each 0.635 cm (0.250 in) inside diameter, 1.25 cm (0.50 in) outside diameter, and 0.635 cm (0.250 in) wide. Collets: There are twenty-four collets that can be used with screws (6-32) to hold pulleys and spacers in place on an axle.

**Drive Wheel with Tire:** There are four drive wheels with tires. The drive wheel can be attached to an axle using a thumbscrew. To attach the wheel firmly to the axle, line up a hole on the axle with the thumbscrew hole on the wheel. If the rubber tire is removed, the wheel can be used as a large pulley.



**Figure 5: Axle items**

## Adding Load Cells

To measure the compression and tension forces in individual members, add load cells (e.g., PASCO Model PS-2200) to any 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

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.

See the instructions that came with the load cells for details about how to connect the load cells to an interface or datalogger and collect data.

### Calibration of Load Cells

Load cells are factory calibrated; however, you can re-calibrate them in software or on the datalogger. Assemble the fixture shown in Figure 10 to support the load cell. See the documentation for your software or datalogger for instructions.

When calibrating a load cell, it is necessary to apply a known load. Hold or clamp the fixture at the edge of a table and hang a mass from it as shown.

Note that the hanging mass applies tension to the load cell; therefore the known force that you enter into the software or datalogger should be a negative value. For example, if the mass is 1.0 kg, the applied force is -9.8 N.

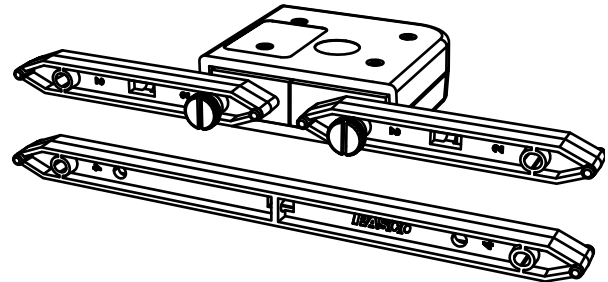


Figure 6: A load cell combined with two #2 beams is the same length as a #4 beam

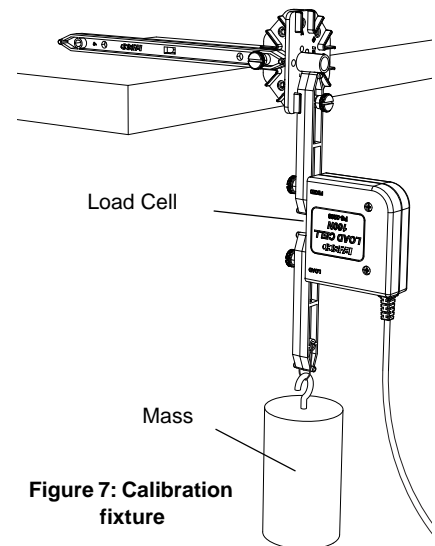


Figure 7: Calibration fixture

The following list shows the number of each item needed for a particular model.

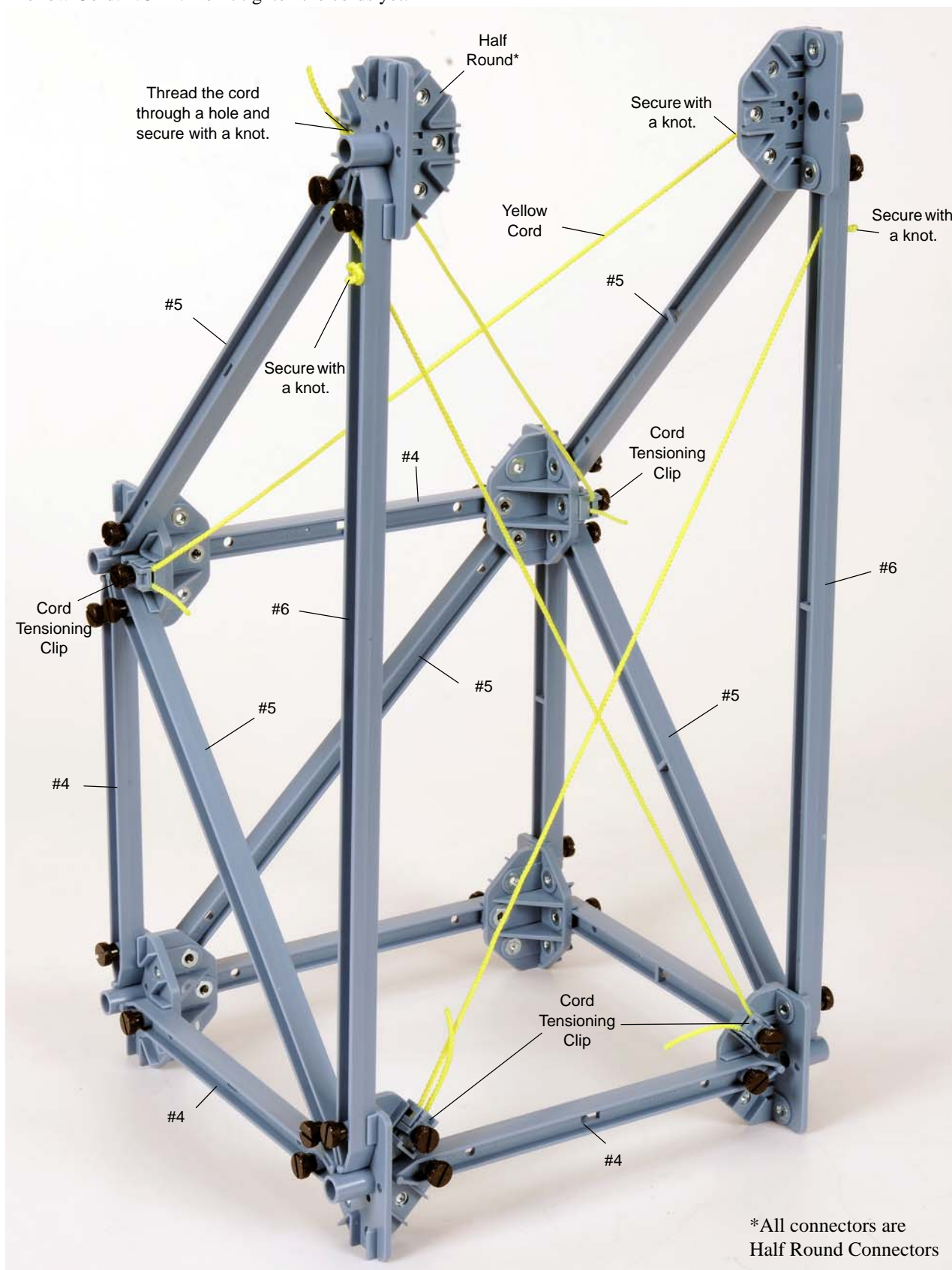
Item	Arm	Leg	Back	Total
Half Round Connector	14	16	22	52
Full Round Connector	1	1	2	4
Flat Round Connector	3	1	2	6
Straight Connector	3	4	8	15
Angle Connector	8	3	12	23
Sliding Connector	0	2	2	4
#6 Beam	5	8	8	21
#5 Beam	6	0	9	15
#4 Beam	9	8	13	30
#3 Beam	5	14	12	31
#2 Beam	1	3	12	16
#1 Beam	7	4	4	15
Cord Tensioning Clip	7	1	6	14
Short Axle	1	1	0	2
Medium Axle	1	1	0	2
Long Axle	0	0	2	2
Pulley	0	0	2	2
Drive Wheel	0	1	0	1
Collet	0	3	4	7
Spacer	2	0	6	8
Screw	83	83	142	307

## Human Arm Model

The Human Arm Model consists of a “shoulder” that serves as the base of the model, an “upper arm” with Load Cells for the biceps muscle and triceps muscle, and a “lower arm” or “forearm”.

### Shoulder (Base)

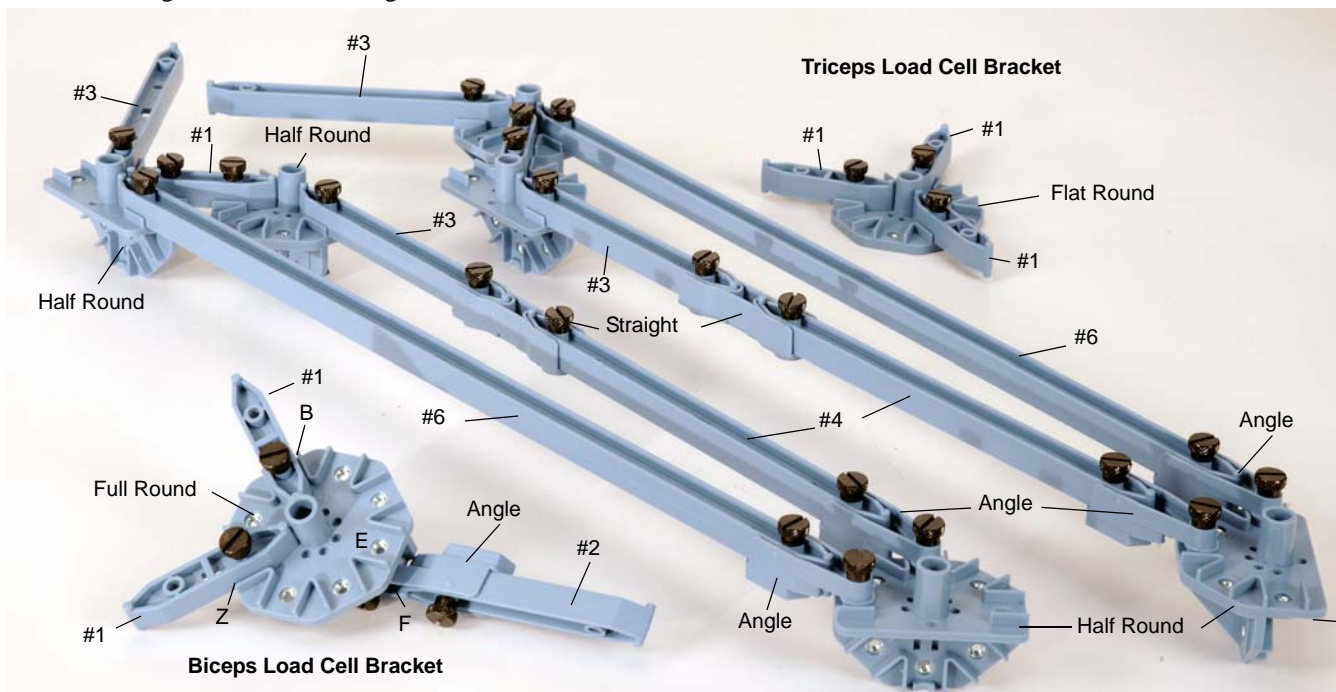
The shoulder part of the Human Arm Model uses Half Round Connectors, various I Beams, Cord Tensioning Clips, and Yellow Cord. NOTE: Don't tighten the cords yet.



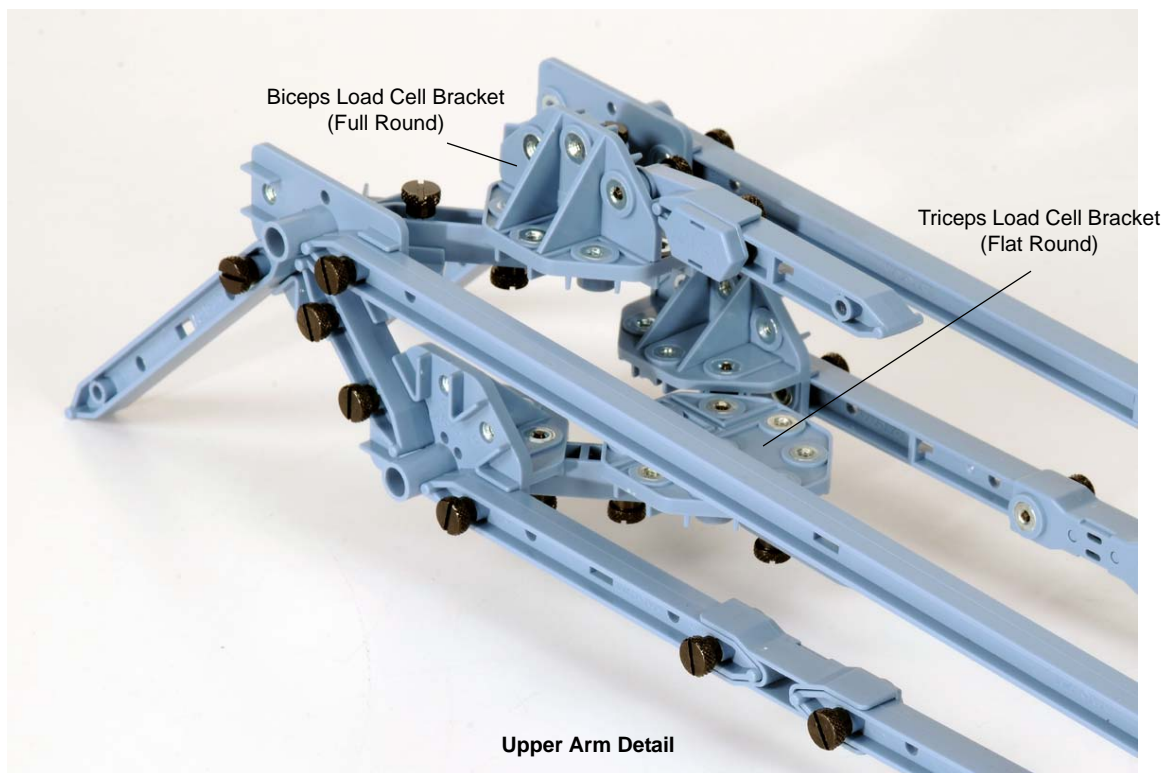


### Upper Arm Parts

The upper arm parts of the Human Arm Model uses Half Round Connectors, a Full Round Connector, a Flat Round Connector, Angle Connectors, Straight Connectors, and various I Beams. Note the slots used on the Full Round.



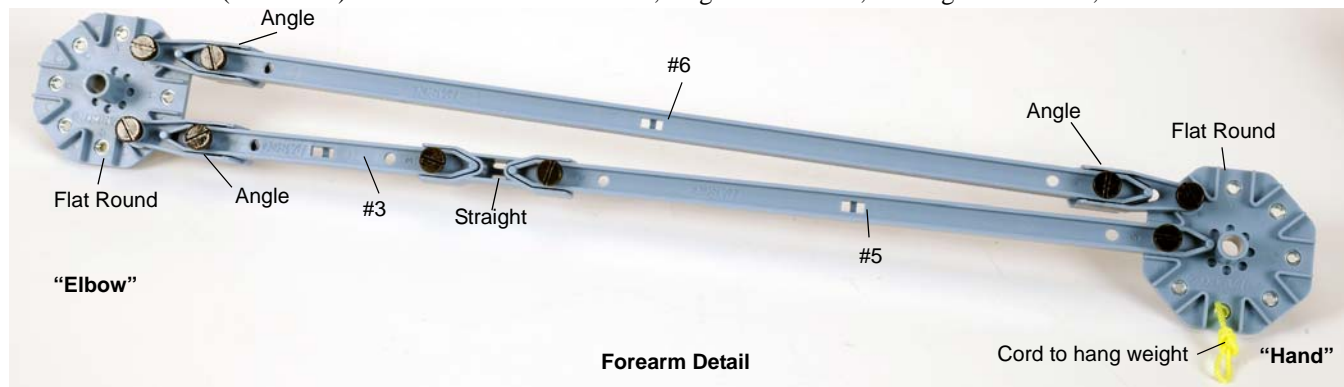
Connect the two upper arm parts using the Biceps Load Cell Bracket and the Triceps Load Cell Bracket.





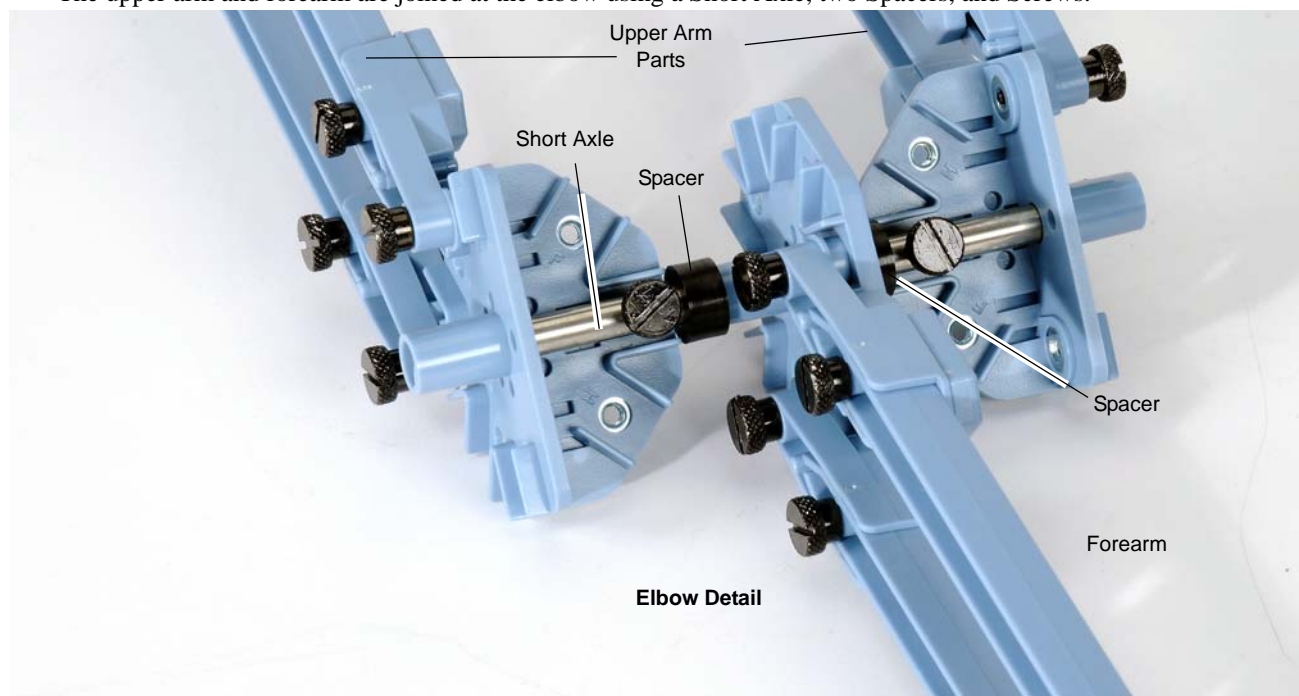
### Lower Arm

The lower arm (“forearm”) uses Flat Round Connectors, Angle Connectors, a Straight Connector, and various I Beams.



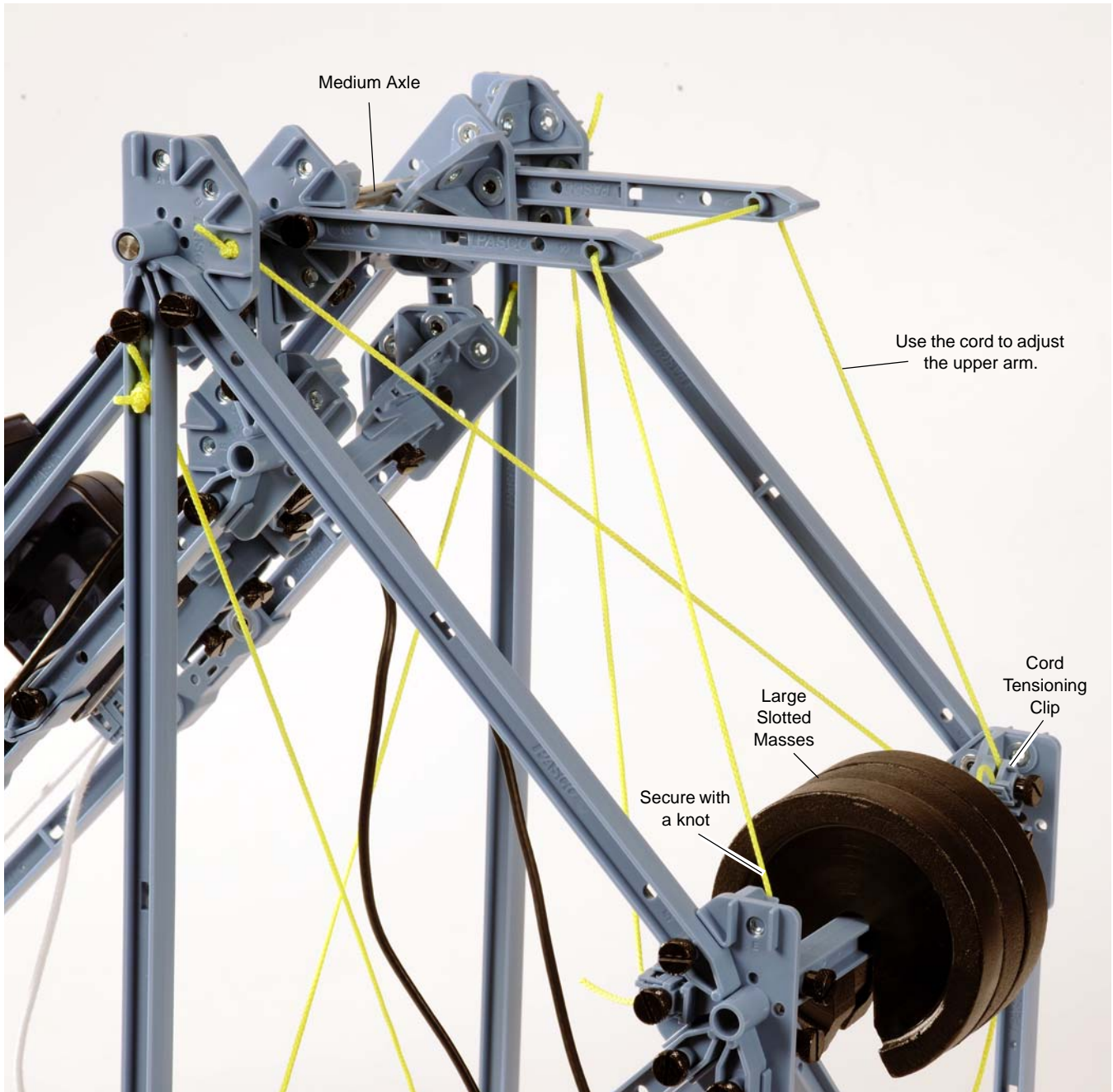
### Human Arm Elbow Detail

The upper arm and forearm are joined at the elbow using a Short Axle, two Spacers, and Screws.



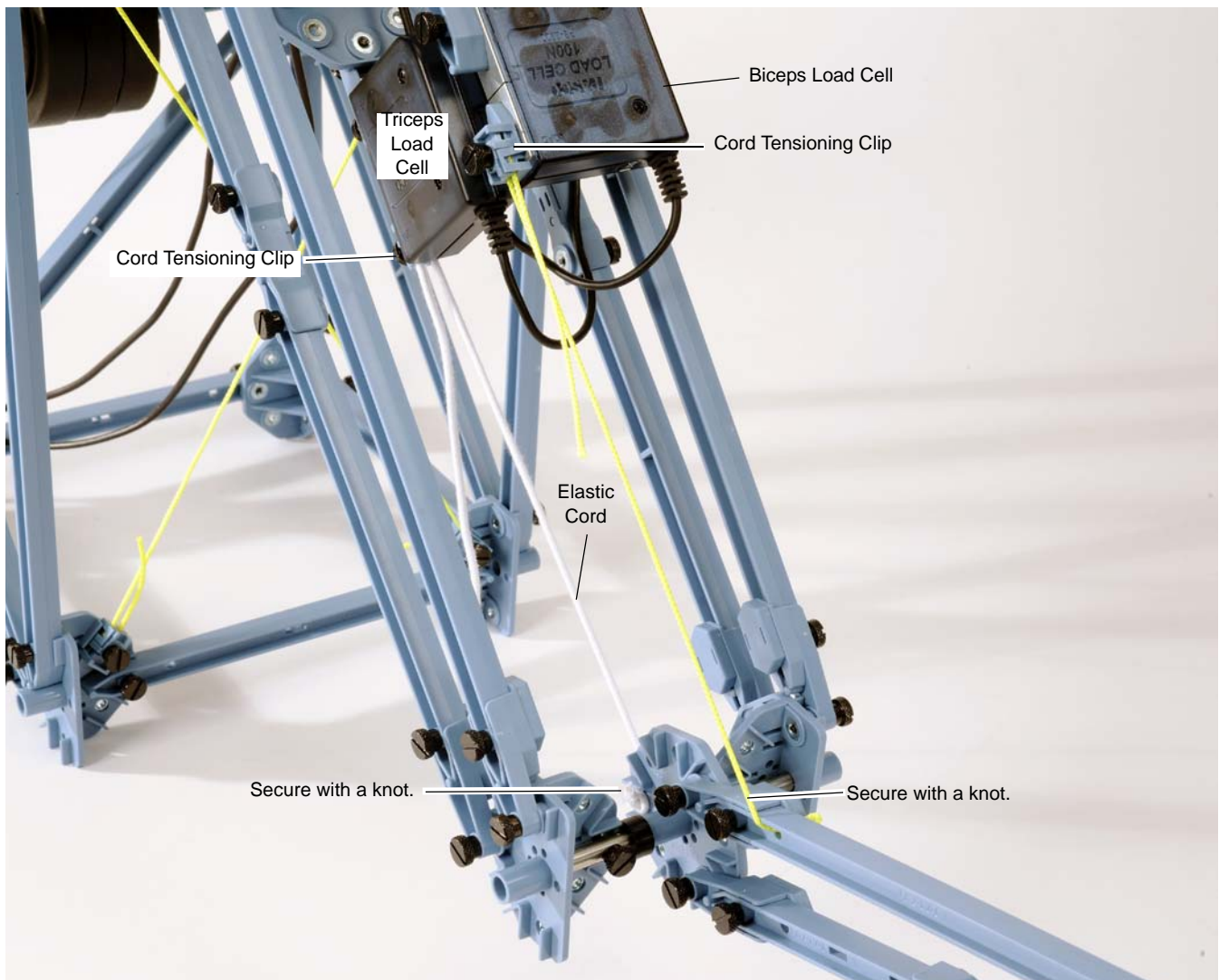
## Upper Arm/Shoulder Detail

The upper arm connects to the shoulder with a Medium Axle and Screws. Use a cord attached to a Cord Tensioning Clip to adjust the angle of the upper arm. Add large slotted masses to stabilize the model. Tighten the various cords.



## Biceps and Triceps Load Cell Detail

Add Load Cells to the Biceps Load Cell Bracket and the Triceps Load Cell Bracket. Tie a piece of yellow cord to the top part of the forearm near the elbow. Attach the cord to a Cord Tensioning Clip and attach the clip to the Biceps Load Cell. Tie a piece of elastic cord to one of the holes on the back edge of the Flat Round Connector at the elbow. Attach the elastic cord to a Cord Tensioning Clip and attach the clip to the Triceps Load Cell.

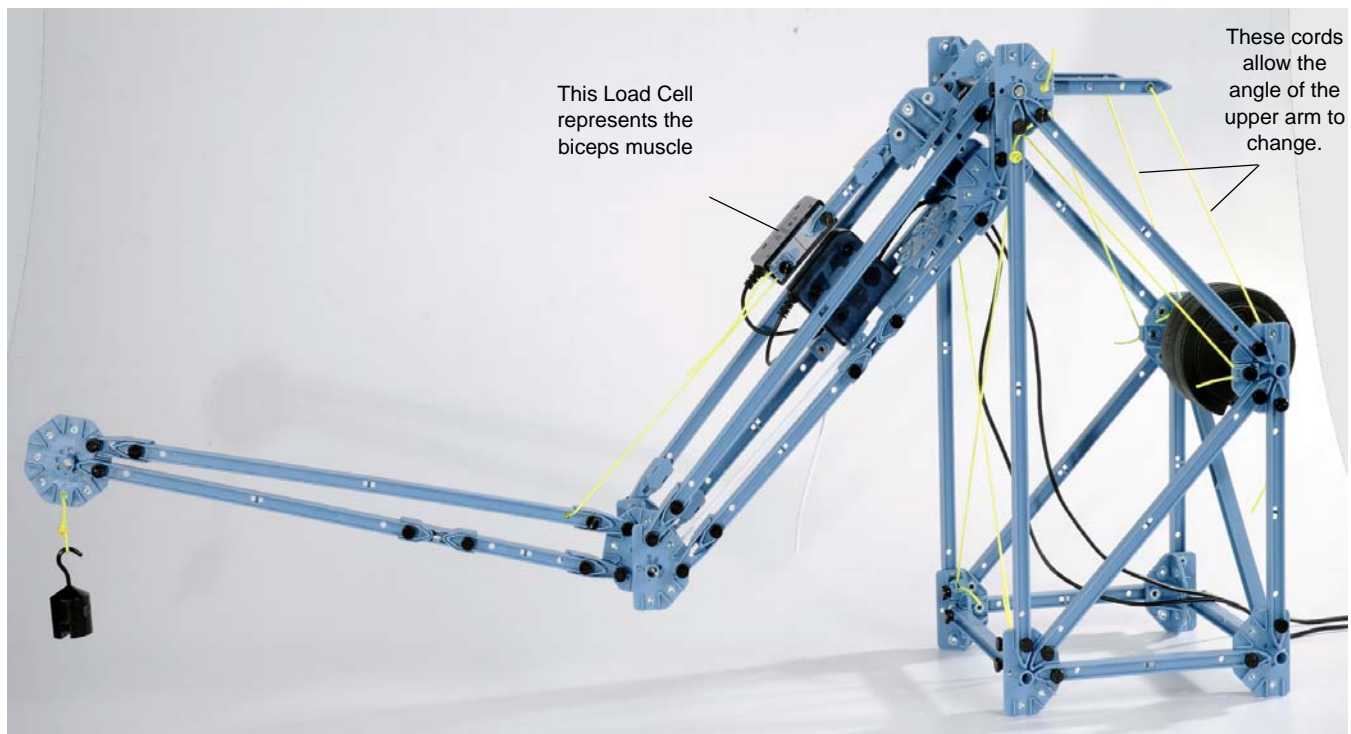
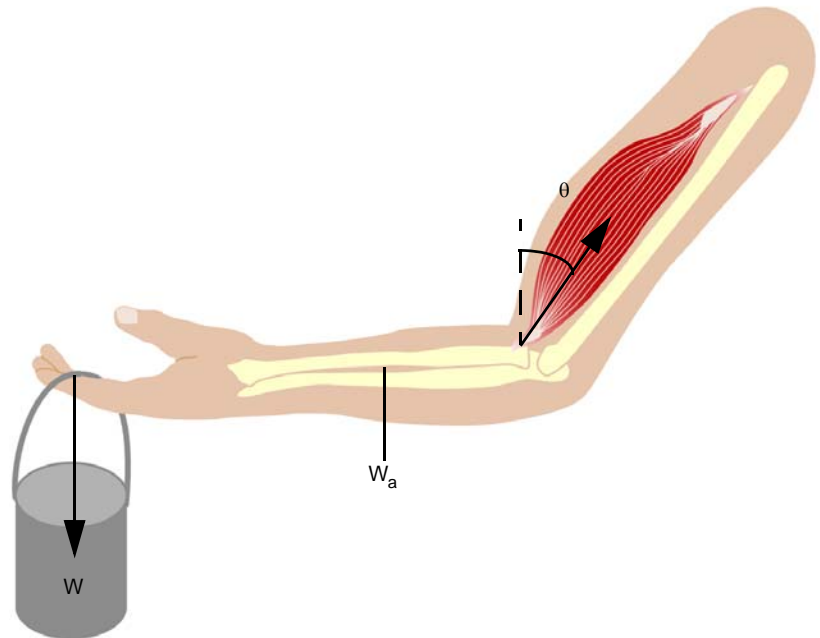


### Human Arm Model: Extra Equipment

Extra Equipment	Extra Equipment
Hooked Mass Set SE-8759	100-N Load Cell PS-2200 (2)
Large Slotted Mass Set ME-7566	Load Cell Amplifier PS-2198



## Human Arm Model: Force Vector Diagram



The Human Structures Set allows students to build a realistic arm model and directly measure the forces exerted.

The diagram shows the forces acting on the lower arm.

### Suggestions

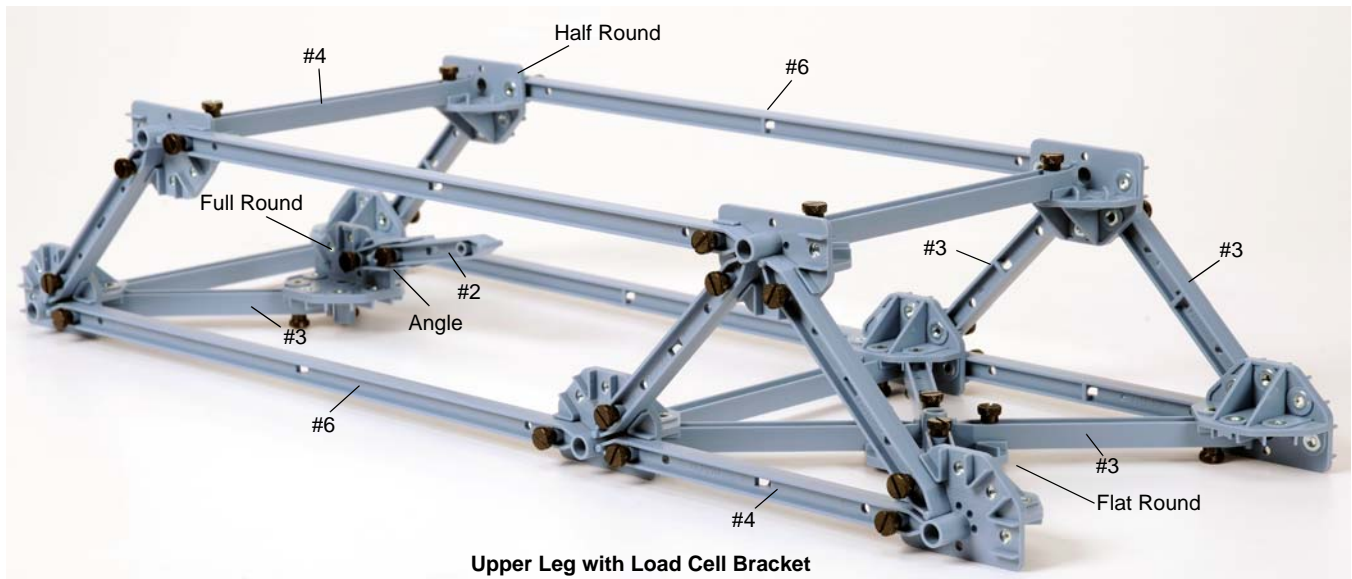
Vary the length and angle of the upper and lower arm, as well as the point of attachment of the cord connected to the Load Cell.

# Human Leg Model

The Human Leg Model consists of an upper leg or “thigh”, a lower leg, and a knee joint.

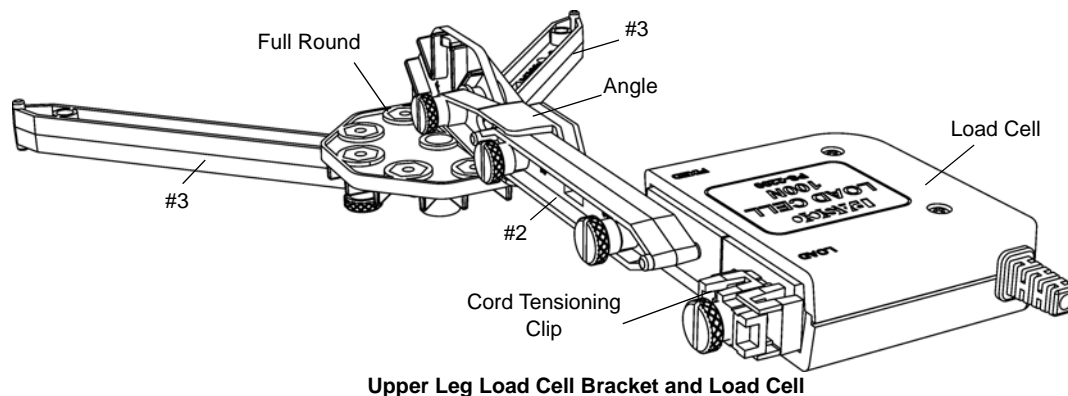
## Upper Leg (Thigh)

Use Half Round Connectors, a Full Round Connector, a Flat Round Connector, an Angle Connector, and various I Beams to construct the upper leg



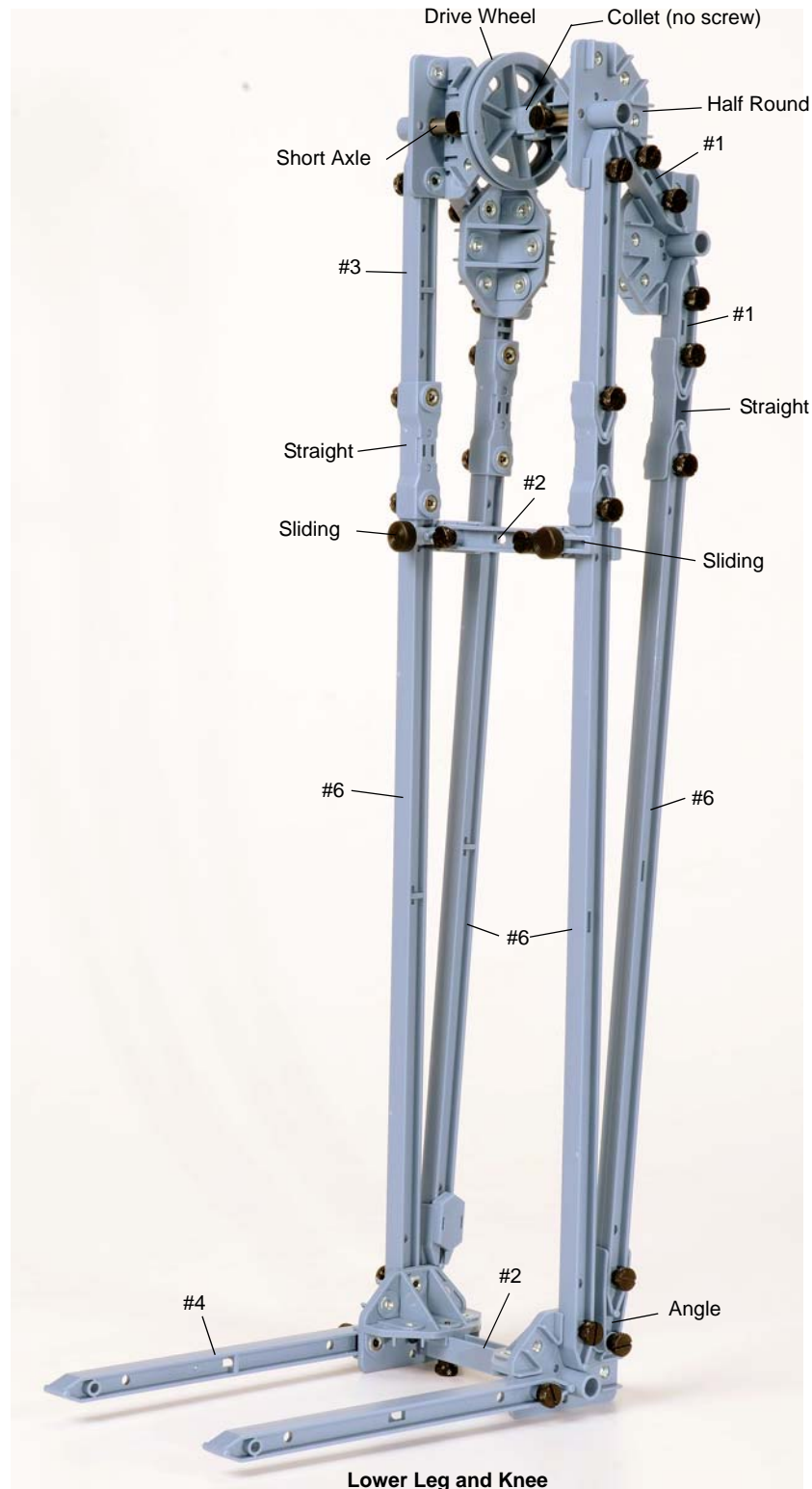
### Upper Leg Load Cell Bracket Detail

The Upper Leg Load Cell Bracket consists of #3 Beams, a #2 Beam, an Angle Connector, and a Full Round Connector. The diagram shows a Load Cell and a Cord Tensioning Clip attached to the bracket.



## Lower Leg and Knee

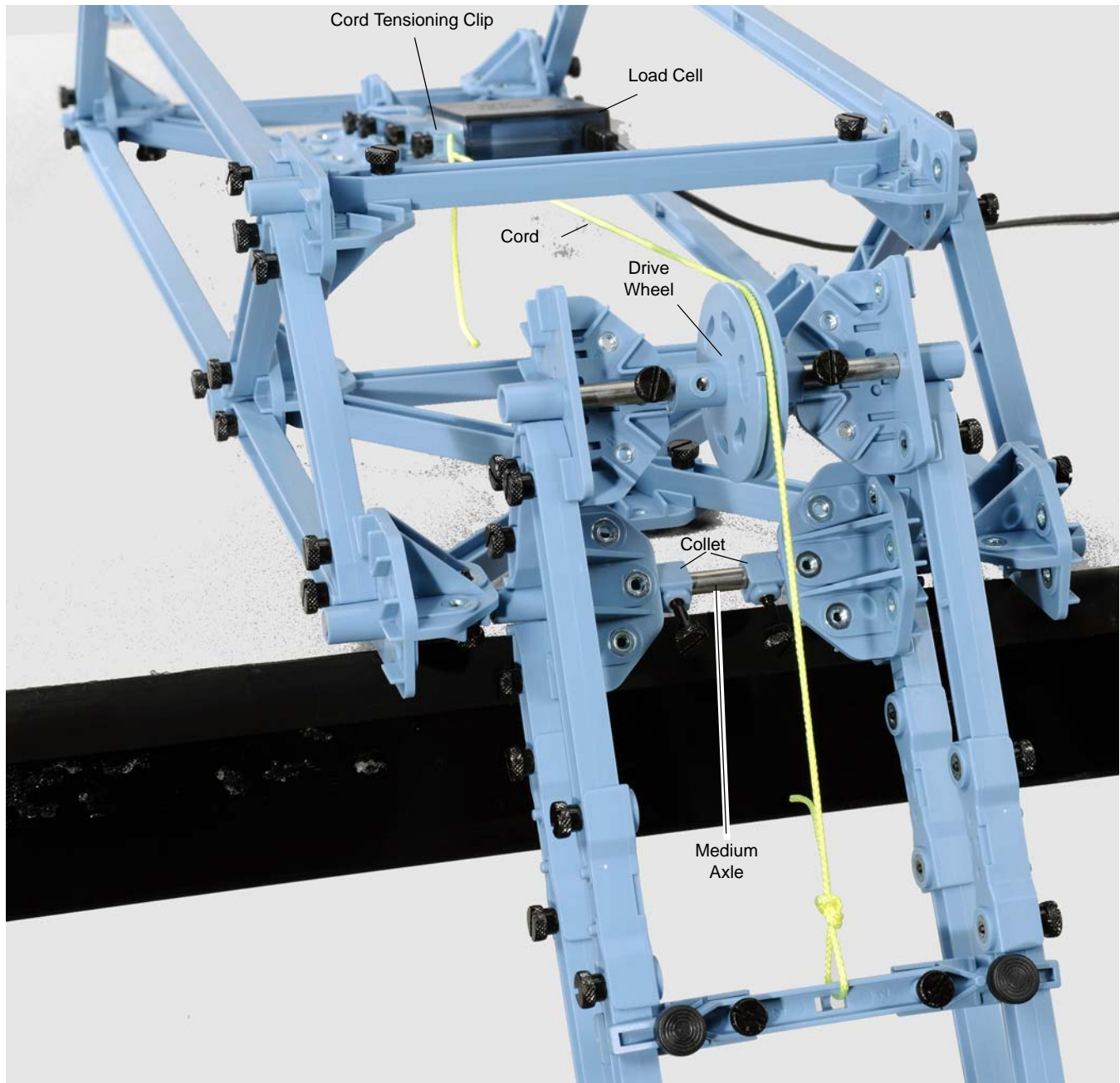
Use Half Round Connectors, Angle Connectors, Sliding Connectors, Straight Connectors, a Short Axle, a Drive Wheel, a Collet (without screw), and various I Beams to construct the lower leg and knee.





### Human Leg Knee Detail

Use a Medium Axle and Collets to connect the upper leg to the lower leg. Attach a Load Cell to the Upper Leg Load Cell Bracket. Tie a piece of cord to the #2 I Beam just below the knee. Connect the other end of the cord to a Cord Tensioning Clip, and attach the clip to the Load Cell. Put the cord over the Drive Wheel



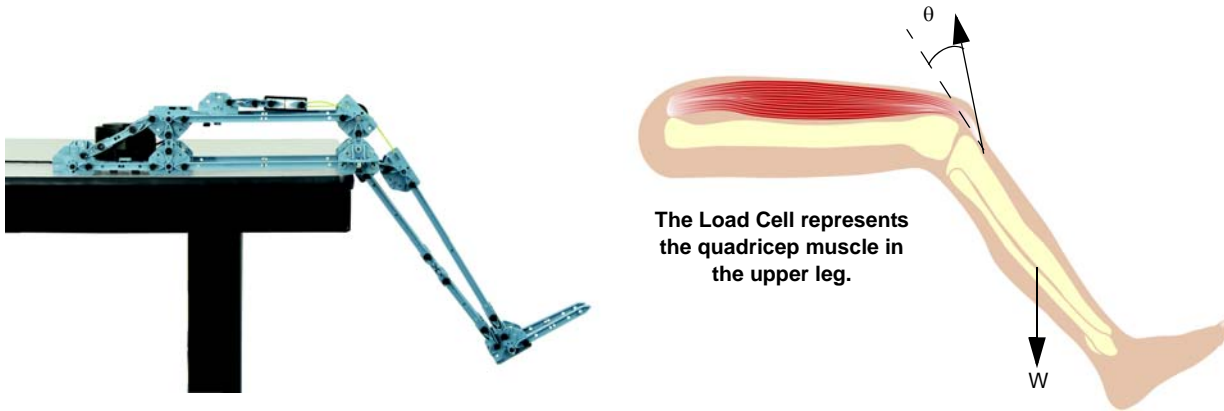
#### Human Leg Model: Extra Equipment

Extra Equipment	Extra Equipment
Large Slotted Mass Set ME-7566	Load Cell Amplifier PS-2198
100-N Load Cell PS-2200	

## Human Leg Model: Force Vector Diagram

### Knee Forces

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

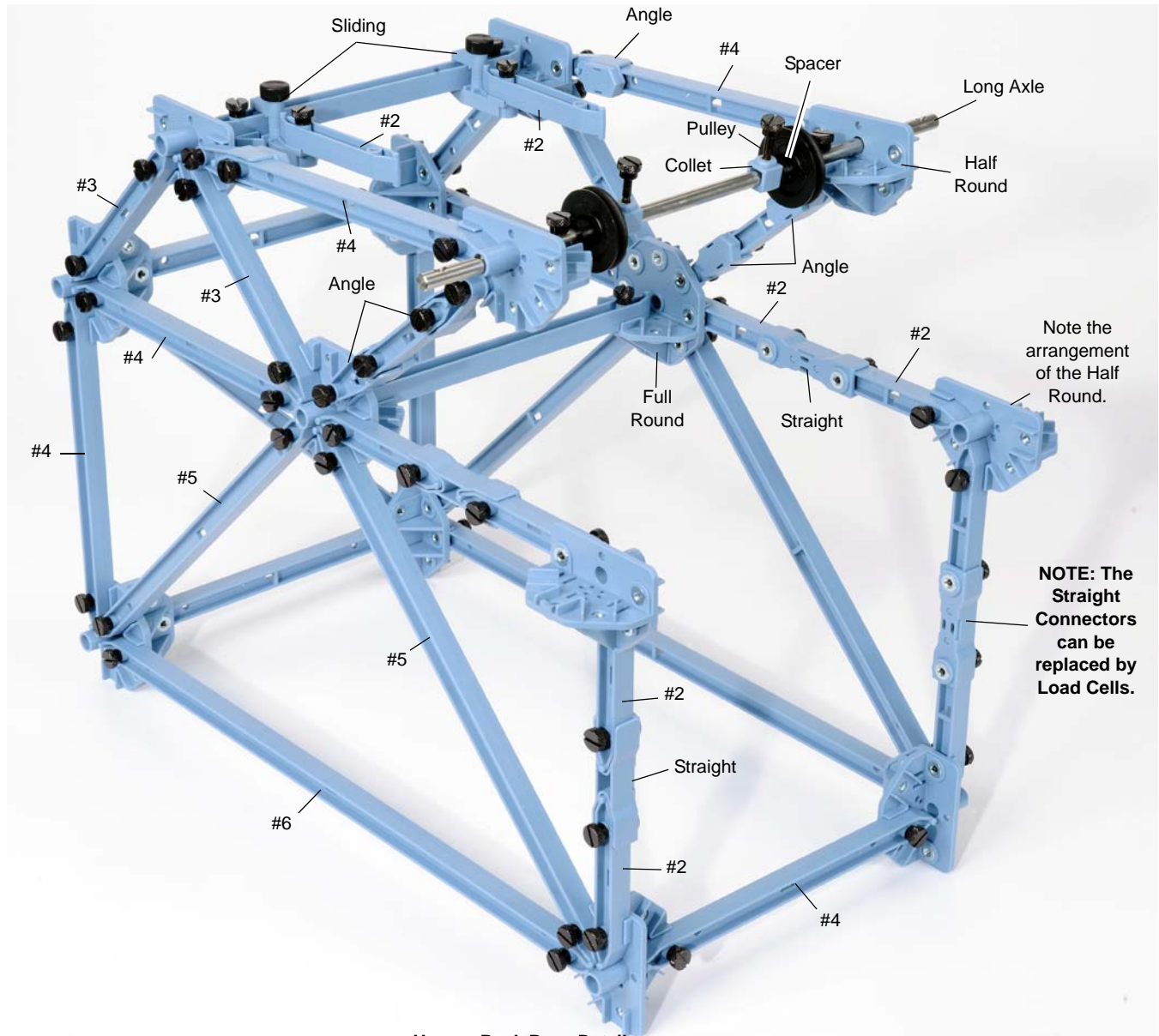


## Human Back Model

The Human Back Model consists of a base, a torso, and an outstretched arm.

### Human Back Base Details

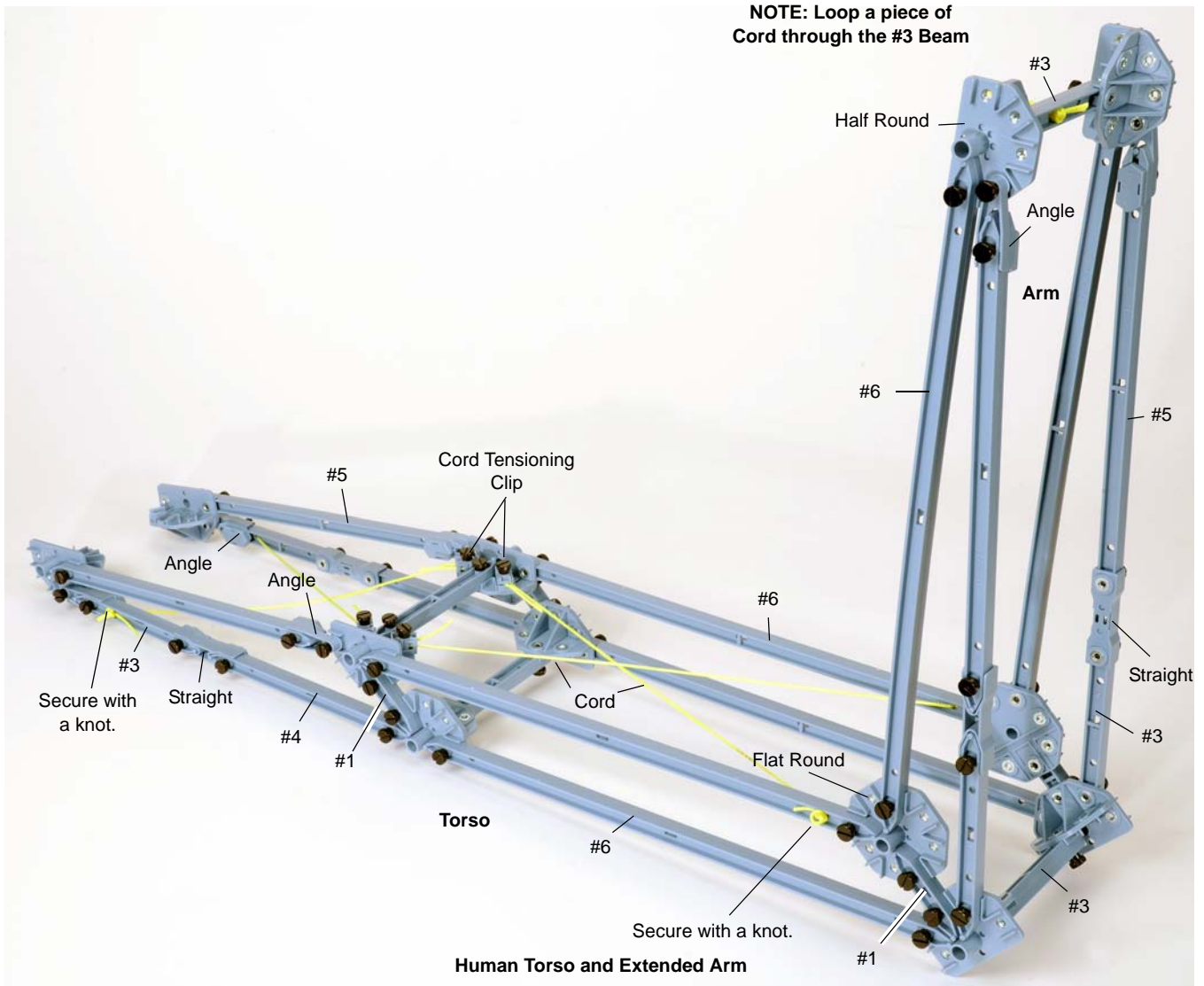
The Human Back Base uses Half Round Connectors, Full Round Connectors, Angle Connectors, Sliding Connectors, Straight Connectors, a Long Axle, Pulleys, Spacers, Collets, and various I Beams. The structure can use two, four or six Load Cells.



Human Back Base Details

### Human Torso and Extended Arm Details

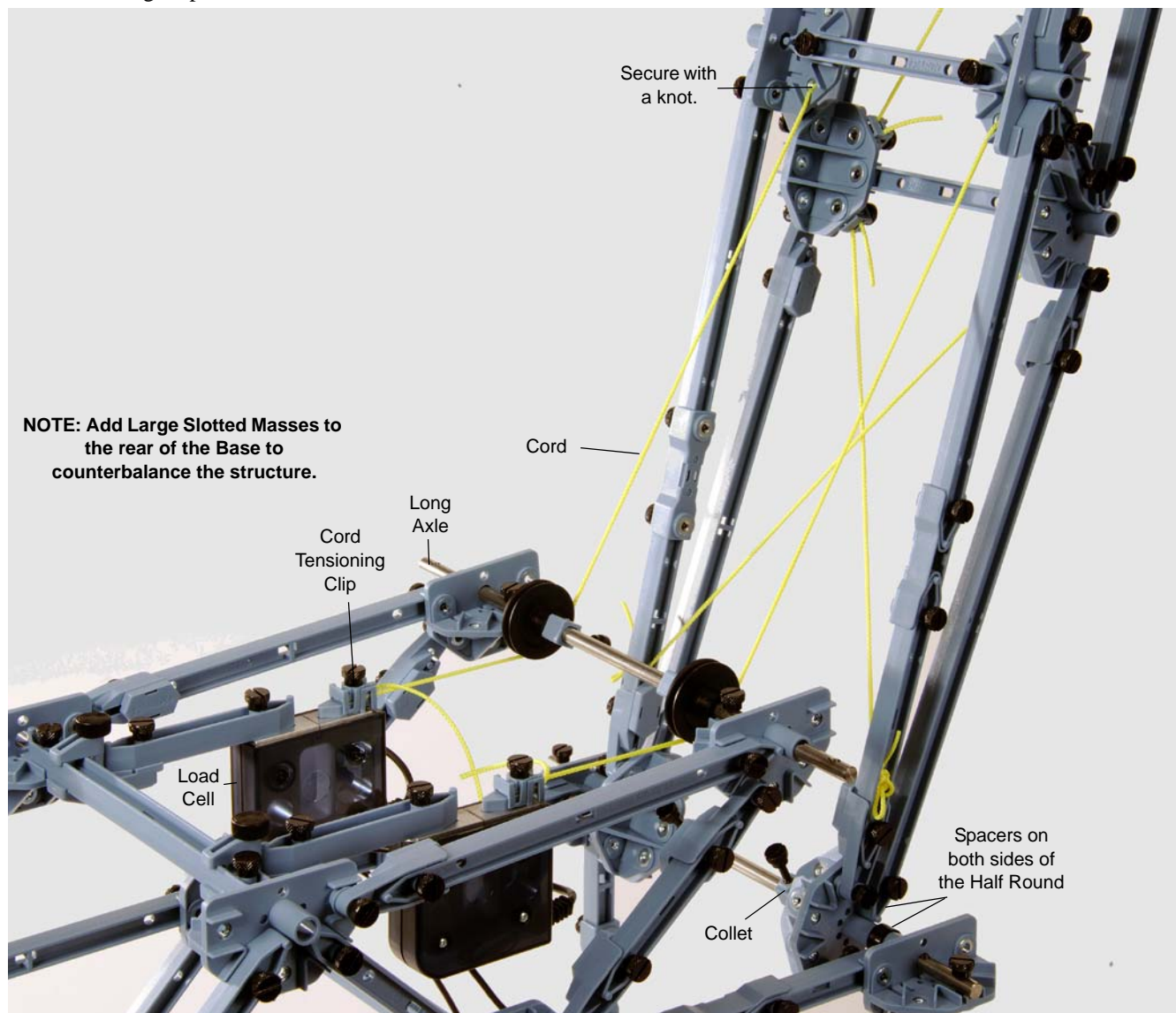
The Human Torso and Extended Arm uses Half Round Connectors, Flat Round Connectors, Angle Connectors, Straight Connectors, Cord and Cord Tensioning Clips, and various I Beams.





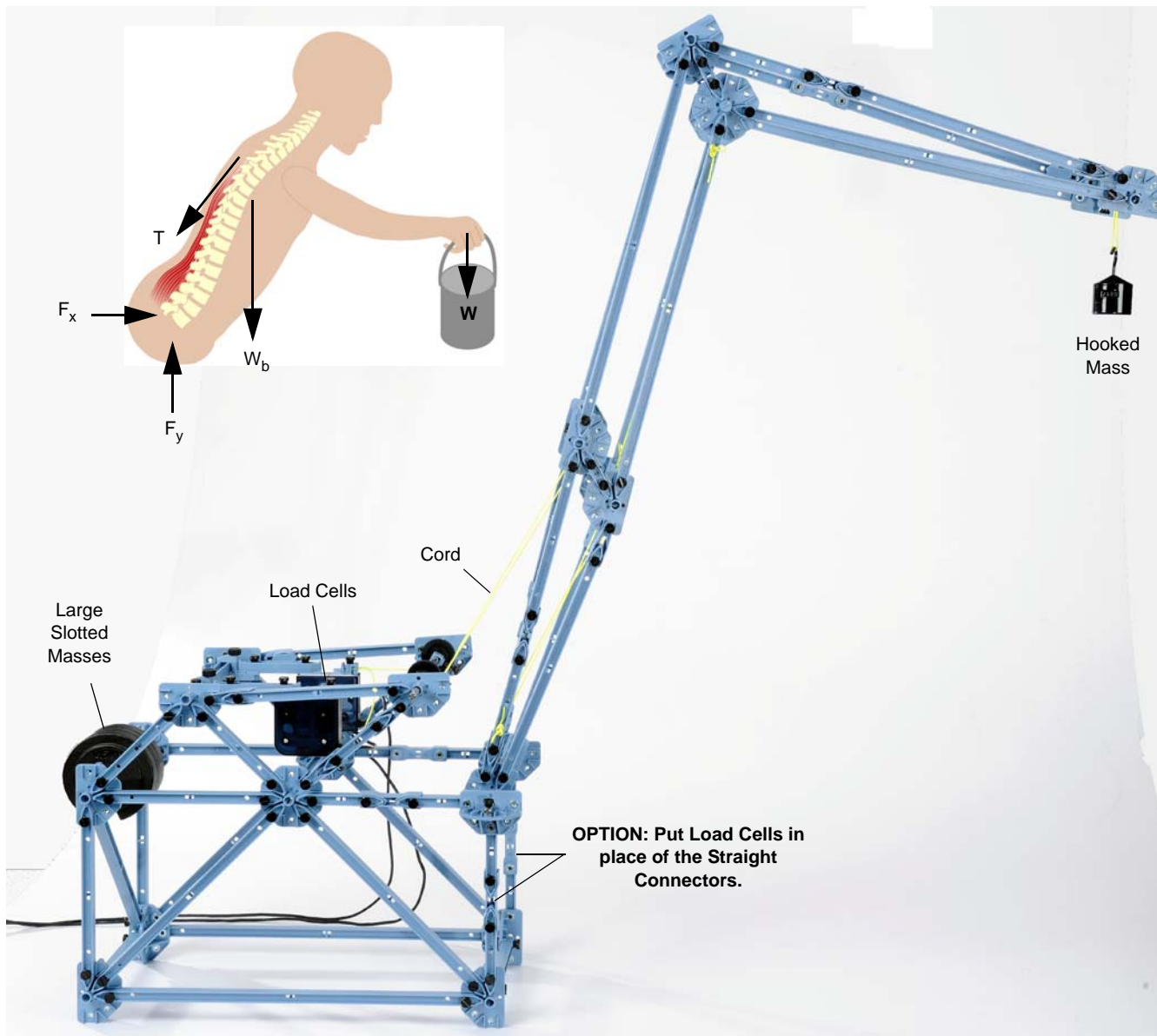
### Human Back Model: Load Cell Details

Join the Human Back Model Base to the Human Back Model Torso using a Long Axle, Spacers, Collets, Cord and Cord Tensioning Clips, and Load Cells.



## Human Back Model: Force Vector Diagram

The following diagram shows the force vectors acting on the human back model.



### Load Cells

The Load Cells directly measure the forces exerted on the back model. The structure is shown with two Load Cells measuring the tension in the cords representing lower back muscles. The experiment can be performed using more Load Cells mounted in place of the Straight Connectors in the base.

### Suggestions

Experiment with the 'back' at different angles and use the Load Cells to measure the tension in the cord.

What is the affect of increasing or decreasing the angle of the 'back'?

Experiment with the amount of weight attached to the end of the 'arm'.

Does doubling the weight also double the tension in the cords attached to the Load Cells?



**Human Back Model: Extra Equipment**

<b>Extra Equipment</b>	<b>Model</b>
Large Slotted Mass Set ME-7566	Hooked Mass Set SE-8759
100-N Load Cell PS-2200 (2, 4, 6)	Load Cell Amplifier PS-2198

## Technical Support

For assistance with any PASCO product, contact PASCO at:

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

Phone: 1 916 786 3800 (worldwide)  
800-772-8700 (U.S.)

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

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

For more information about the Human Structures Set and the latest revision of this Instruction Manual, visit the PASCO web site at [www.pasco.com](http://www.pasco.com) and enter ME-7001 in the Search window.

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

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

### ME-6990 Truss Set

ME-6992A Advanced Structures Set

ME-6994 Truss Set Screws

ME-6996 Cord Lock Spares

ME-6998A Axle Spares

PS-2198 Load Cell Amplifier

PS-2200 100 N Load Cell

PS-2206 Dual Load Cell Amplifier

### ME-6991 Bridge Set

ME-6993 Truss Set Members

ME-6995 Road Bed Spares

ME-6997 Full Round (XYZ) Connector Spares

ME-6999A Angle Connector Spares

PS-2199 Load Cell and Amplifier Set

PS-2201 5 N Load Cell