Welcome to

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RIGGING SESSIONS

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https://www.facebook.com/EntertainmentRiggingSessions

www.entertainmentriggingsessions.com

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Ethan Gilson
CV

- BFA from Emerson College
- ETCP Certified Rigger. Arena & Theatre #0048
- ETCP Recognized Trainer
- Rigging Specialist for Advanced Lighting & Production Services, Inc.
- Voting Member of ESTA Technical Standards Rigging Work Group
  - Chairman of BSRE1.39-2015 task group
  - Chairman of BSRE 1.4.2-20xx
  - Subject Matter Expert for ETCP Arena Test
- CM trained repair technician
- Certification By I & I Sling for rigging hardware inspection
- ETC Prodigy Hoist Factory Trained installer

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Certification Vs. Certificate

Certification	Certificate
Results from an assessment process	Results from an educational process
For individuals	For individuals
Typically requires some amount of professional experience	For both newcomers and experienced professionals alike
Awarded by a third-party, standard-setting organization	Awarded by an educational program or institution
Indicates mastery/competency as measured against a defensible set of standards, usually by application or exam	Indicates completion of a course or series of courses with specific focus; is different than a degree granting program
Standards set through a defensible, industry-wide process (job analysis/role delineation) that results in an outline of required knowledge and skills	Course content set a variety of ways (faculty committee; dean; instructor; occasionally through defensible analysis of topic area)
Typically results in a designation to use after one's name (CFRE, ACFRE, FAHP, CFP, APRA, CAE); may result in a document to hang on the wall or keep in a wallet	Usually listed on a resume detailing education; may issue a document to hang on the wall
Has on-going requirements in order to maintain; holder must demonstrate he/she continues to meet requirements	Is the end result; demonstrates knowledge of course content at the end of a set period in time

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A quick note

In is down, down is front
Out is up, up is back
Off is out, on is in
And of course-
Left is right and right is left
A drop shouldn't and a
Block and fall does neither
A prop doesn't and
A cove has no water
Tripping is OK
A running crew rarely gets anywhere

A purchase line buys you nothing
A trap will not catch anything
A gridiron has nothing to do with
football
Strike is work (In fact a lot of work)
And a green room, thank god, usually
isn't
Now that you're fully versed in
Theatrical terms,
Break a leg.
But not really.

OSHA

- Occupational Safety and Health Administration (OSHA)
- With the Occupational Safety and Health Act of 1970, Congress created OSHA to assure safe and healthful working conditions for working men and women by setting and enforcing standards and by providing training, outreach, education and assistance.

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OSHA

- The OSH Act covers employers and their employees either directly through federal OSHA or through an OSHA-approved state program. State programs must meet or exceed federal OSHA standards for workplace safety and health.

OSHA

- Alaska
- Arizona
- California
- Connecticut
- Hawaii
- Illinois
- Indiana
- Iowa
- Kentucky
- Maryland
- Michigan
- Minnesota
- Nevada
- New Jersey
- New Mexico
- New York
- North Carolina
- Oregon
- Puerto Rico
- South Carolina
- Tennessee
- Utah
- Vermont
- Virgin Islands
- Virginia
- Washington
- Wyoming

NOTE: The Connecticut, Illinois, New Jersey, New York and Virgin Islands plans cover public sector (State & local government) employment only.

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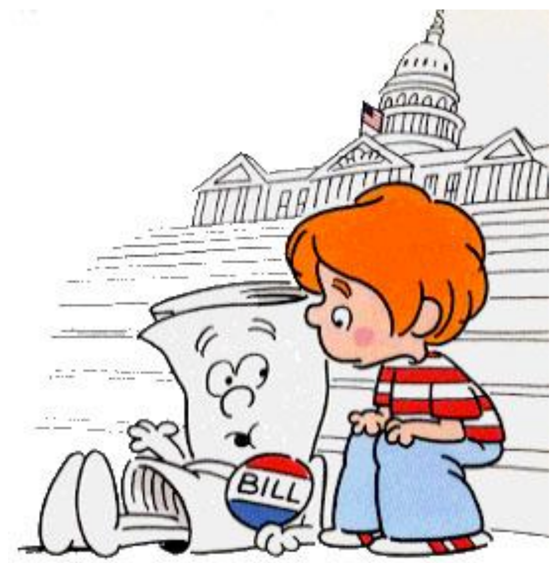
OSHA

- How was OSHA created?
  - Congress passed Bill into Law (1970)
  - Law was then published in the *Code of Federal Regulations* (CFR).
- OSHA law is in Title 29.



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OSHA

- **29 CFR, Part 1910** Occupational Safety and Health Standards (General Industry Safety Orders)
- **29 CFR, Part 1926** Safety and Health Regulations for Construction (Construction Industry Safety Orders)

OSHA

- **OSHA Jurisdiction**
  - Covers private sector employers
  - Excludes self-employed, family farm workers, and government workers (except in state plan states)
  - Approves and monitors 27 State Plan states which cover private and public sector employees.
  - Assists Federal Agency Programs
- **OSHA Inspection**
  - Conducted without advance notice
  - On-site inspections, or Phone/Fax investigations
  - Highly-trained compliance officers
- **Inspection Priorities**
  - Imminent danger
  - Catastrophes
  - Worker complaints and referrals
  - Targeted inspections - high injury/illness rates, severe violators
  - Follow-up inspections

OSHA

- OSHA must issue a citation and proposed penalty within six months of the violation's occurrence.
- Citations describe OSHA requirements allegedly violated, list any proposed penalties and give a deadline for correcting the alleged hazards.
- Violations are categorized as other-than-serious, serious, willful, repeated and failure to abate.
- Penalties may range up to $12,934 for each serious violation, $12,934 per day for failure to abate, and up to $129,336 for each willful or repeated violation.

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ANSI

- American National Standards Institute
- Mission
  - To enhance both the global competitiveness of U.S. business and the U.S. quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems, and safeguarding their integrity.
- Membership
  - Comprised of Government agencies, Organizations, Companies, Academic and International bodies, and individuals, the American National Standards Institute (ANSI) represents the interests of more than 270,000 companies and 30 million professionals.

ANSI

- ANSI does not develop standards. It oversees the development and use of standards by accrediting the procedures of standards developing organizations.
- Designates specific standards as American National Standards, or ANS, when the Institute determines that the standards were developed in an environment that is equitable, accessible and responsive to the requirements of various stakeholders.
- There are approximately 11,500 American National Standards that carry the ANSI designation.
- The American National Standards process involves:
  - consensus by a group that is open to representatives from all interested parties
  - broad-based public review and comment on draft standards
  - consideration of and response to comments
  - incorporation of submitted changes that meet the same consensus requirements into a draft standard
  - availability of an appeal by any participant alleging that these principles were not respected during the standards-development process.
-

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ESTA

ESTA, the Entertainment Services and Technology Association, is a non-profit trade association based in North America with members around the world. ESTA's members are responsible for creating some of the most important programs in our industry including the Technical Standards Program, Entertainment Technician Certification Program and Rental Guard. By joining ESTA you are investing in the future of the entertainment technology industry. Membership in ESTA supports: increasing safety through the development of standards and certifications; educating members and providing business resources to increase profitability; representing the interests of the industry to government, regulatory bodies, and related industries; and raising the bar for ethical and professional behavior.

ESTA

Technical Standards Program

The Technical Standards Program (TSP) was established in 1994 (by ESTA) in response to the increasing number of members who were encountering situations where the lack of standards, or the imposition of standards developed outside the entertainment industry, were making it increasingly difficult to conduct business safely, efficiently, and profitably. As a trade association in a technology-based industry, it was the obvious duty of the association to serve its membership by establishing a program to deal with issues of technology and standards. Every standard addresses a problem.

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ESTA
Published ANSI Standards

tsp.esta.org/tsp/documents/published_docs.php

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ESTA
ETCP Certification Program

etcp
CERTIFIED

Setting the stage for safety.

http://etcp.esta.org/

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ESTA
ETCP Vision Statement

ETCP was created to develop an ANSI Accredited Personnel Certification Program to recognize those individuals who have demonstrated knowledge, skills and abilities in specific disciplines within the entertainment technology field. By providing a thorough, independent assessment of knowledge, skills and abilities for entertainment technology disciplines, the Program seeks to enhance safety, reduce workplace risk, improve performance, stimulate training, and give due recognition to the professional skills of entertainment technicians.

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ESTA
ETCP Independent Testing

ETCP has contracted with Applied Measurement Professionals, Inc. (AMP) to assist in the development, administration, scoring and analysis of ETCP's certification examinations. AMP, located in the greater Kansas City area, is a leading provider of licensing and certification examinations for professional organizations

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ESTA
ETCP

Qualification Points Table

Type of Experience	Points	Documentation Required
Entertainment Rigging Work Experience	1 for each 100 hours 100 hour min. increment 1000 hours (10 points) in a year is equivalent to 20 hours per week	A completed Employment History form containing contact information sufficiently detailed to allow verification by ETCP. (Experience related to an academic degree cannot be used as professional work experience.)
Internship	1 for each 200 hours with a maximum of 5 points.	A completed Applicant Evaluation form by the official representative of the internship is required.
Apprenticeship	1 for each 100 hours with a maximum of 10 points	A completed Applicant Evaluation form by the official representative of the apprenticeship is required.
Notes: Education credits may contribute a maximum of 10 points. *All degrees must be achieved from an accredited institution.*		
Associates Degree	2	An official transcript is required from the granting institution, photocopies are not accepted.
Associates Degree in entertainment technology field	3	An official transcript is required from the granting institution, photocopies are not accepted.
Undergraduate Degree	3	An official transcript is required from the granting institution, photocopies are not accepted.
Undergraduate Degree in entertainment technology field	7	An official transcript is required from the granting institution, photocopies are not accepted.
Graduate Degree	1	An official transcript is required from the granting institution, photocopies are not accepted.
Graduate Degree in entertainment technology field	3	An official transcript is required from the granting institution, photocopies are not accepted.

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Event Safety Alliance

event
safety
alliance

The Event Safety Alliance (ESA) is a non-profit safety trade association dedicated to promoting the concept of "life safety first" during all phases of event production. The Event Safety Alliance strives to eliminate the knowledge barrier that often contributes to unsafe conditions and behaviors through the promotion of best practices and the development of training and planning resources.

http://eventsafetyalliance.org/

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When is Fall Protection needed?

If a worker is exposed to the possibility of falling six feet or more, fall protection MUST be provided and USED.

Fall Protection Vs. Fall Arrest?

OSHA 1926.501(b)(1)

"Unprotected sides and edges."

Each employee on a walking/working surface (horizontal and vertical surface) with an unprotected side or edge which is 6 feet (1.8 m) or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems.

Conditions You Must Meet

- Be continuous
- Be exclusive
- Reduce the arrest forces communicated to the fallen worker to safe levels
- Limit the free-fall distance before arrest
- Be composed of components of safe design
- Be engineered as a total system
- Incorporate rescue after the fall is arrested
- Incorporate formal training in system use

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Continuous

A worker must be protected from fall injuries at all times when exposed to fall hazards. Continuous and uninterrupted attachment to the fall arrest system is required whenever a worker is aloft and exposed to the possibility of falling more than 6 feet. At no time, while exposed to a fall hazard, may the worker detach him/herself from the system. The common practice among riggers of moving around aloft unprotected and then tying-in only when a work position is reached is not permitted. Neither may a worker exposed to a fall hazard temporarily disconnect from one anchorage in order to attach to another.

Fall Protection & Fall Arrest

Exclusive

A fall protection system must only be used to catch a falling worker. This means that lanyards, lifelines, hardware, or anchorages which are used as part of the fall arrest system may not be put to any other use. You can't use a system lifeline or lanyard to support your weight when you are working nor can you use any of the components of the system for doing anything but arresting the fall of a worker. Harnesses which are designed to do so may be used for both work positioning and fall protection, but all equipment for work positioning (rappelling, for instance) must be completely separate from the fall arrest system with separate anchorages above and separate attachment points to the harness.

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Reduction of Arrest Forces

To protect falling workers from injury when their fall is arrested, OSHA sets specific maximum limits for how much of the arrest force can be communicated to falling workers through their body support harness or belt. (For systems using full-body harnesses, the Maximum Arresting Force (MAF) is 1800 lbs. For systems employing body belts, the MAF is 900 lbs.) Since fall forces generated by a falling worker can quickly exceed these levels after only a few feet of free-fall, methods of dissipating a substantial amount of the energy generated by the falling worker needs to be carefully engineered into the system

Limit Free-fall Distance

The maximum distance that the falling worker is allowed to fall before the fall arrest system begins to arrest his fall is 6 feet. The falling worker must also be prevented from hitting any lower surface.

Components of Safe Design

OSHA specifies generally that "all personal protective equipment shall be of safe design." (29CFR 1910.132(c)) In addition, specific minimal strength, testing, and/or performance criteria for anchorages, harnesses, lanyards, connectors, lifelines, and shock absorbers are listed in various places in 29CFR 1910 and 1926. Parts must meet these rigorous criteria, or they cannot be used. Most of the rescue/rock climbing equipment commonly used by riggers is not legal for fall protection use because it does not meet specific OSHA testing requirements. For instance, connectors such as carabineers must be individually proof tested, a process few rescue or rock climbing carabineers are put through.

System Designed As A Total System

The ideal personal fall protection system, according to OSHA, is "designed, tested, and supplied as a completed system." (29CFR 1910.66 Appendix C III(c)) OSHA's concern here is that it is very possible to mismatch approved components to make a system that fails to meet minimal performance criteria. For instance, if you use a rope lanyard without an integral shock absorber to attach your harness to a horizontal lifeline system that was designed and engineered to be used only with shock absorbing lanyards, when a fall occurs, the fall forces communicated to the worker's body could exceed safe limits.

System Designed As A Total System

Additionally, the forces communicated to the lifeline and end anchorages could exceed their strength, causing the whole system to fail and allow the worker to fall. Whole system design selects components which are engineered to work in concert so that the entire system has sufficient strength to withstand twice the potential impact energy of an employee free-falling a distance of 6 feet, or the free-fall permitted by the system, which ever is less. (29CFR 1926.502 (16)(v))

Rescue Plan

Preventing injuries due to falls requires the speedy rescue of the worker who is left dangling in mid-air by the fall arrest system. (1910.66 section I Paragraph (e)(8)) Sometimes rescue is possible by remounting a nearby ladder or by employing a retractable lifeline with descent capabilities while other times it will be necessary to use trained rescue personnel with ladders, descent devices, personnel lifts, or other rescue equipment. Regardless of the method of rescue decided upon, the employer must develop a written rescue plan and have trained personnel ready to quickly implement that plan when a worker fall occurs.

Training

Workers must be thoroughly trained and certified in the proper use of the fall protection system as designed, prior to using the system. (29CFR 1910.66 (i)(1)) They must be instructed in the specifics of the system they are to use, not just to the general safety instructions of the fall protection system component manufacturers. This training must also include the assessment of hazards to which the workers will be exposed by working in elevated workplaces. Workers must be certified by the employer through written tests with periodic re-certification.

Competent Person

A person who is capable of identifying existing and predictable hazards in the work space and who is authorized to take prompt corrective measures to eliminate them.

Qualified person

A person who, by possession of a recognized degree or certificate of professional standing, or who by extensive knowledge, training and experience, has successfully demonstrated the ability to solve problems relating to the subject matter and work.

PFAS Hardware

- Harness
- Lanyard
- Self Retractable Lifeline
- Attachment point

Fall Protection & Fall Arrest

Harness

- Must be Full body harness
- Dorsal ring for attachment to PFAS
- Can have positioning attachments
- Must be fitted correctly
- 130LBS min - 310LBS max

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Lanyard

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SRL (Self Retractable Lifeline)

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Attachment Points

- Uncertified must be rated to 5000LBS
- Certified can be 2 times the Maximum Arresting Force

Fall Protection & Fall Arrest

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How often should you replace your fall arrest hardware?

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ANSI A10.32-2004 states that the service life of fall protection equipment manufactured of synthetic fiber shall be 5 years unless otherwise specified by the manufacturer. This is stated as a general guideline. This guideline only applies to product that exhibits no visual damage and that has not been exposed to chemicals, abnormal heat, or excessive UV Light.

The user is required to inspect their harness before use and the company must inspect and document that inspection annually. Ultimately, it is the responsibility of the end-user to determine when a harness or lanyard is unfit for use and should be removed from service. Proper adherence to the inspection and maintenance criteria may extend useful life beyond 5 years.

Fall Protection & Fall Arrest

The fall protection industry recommends 2 to 3 years as a service life for a harness or belt in use. They recommend 7 years for the shelf life. The military was using 7 years as a service life for nylon products. The Climbing Sports Group of the Outdoor Recreation Coalition of America says that a climbing harness should last about two years under normal weekend use. At this time, the rescue industry does not have a recommended service life for harnesses.

Through the ASTM consensus standards process, the rescue industry set 10 years as the maximum service life for a life safety rope, see ASTM Standard F1740-02 Guide for Inspection of Nylon, Polyester, or Nylon/Polyester Blend, or both Kernmantle Rope. The guide stresses that the most significant contributing factor to the service life of a rope is the history of use. A rope that is shock loaded or otherwise damaged should be retired immediately. Hard use would call for a shorter service life than would be acceptable for a rope that sees very little use.

Fall Protection & Fall Arrest

If we apply the same analysis to the rescue harness, then the actual use and the conclusions drawn from inspection would be the significant criteria for retirement. We do know that with any use, a rope will age, and thus a harness is likely to do the same, so a 10-year maximum service life may well be appropriate for harnesses as well assuming inspection has not provided any reason for early retirement. At 10-years, PFAS equipment like harnesses lose 30% of their strength just from natural degradation.

As with ropes, if the harness has been subjected to shock loads, fall loads, or abuse other than normal use, the harness should be removed from service. If there is any doubt about the serviceability of the harness for any reason, it should be removed from service.

Fall Arrest in a Lift?

Fall Protection & Fall Arrest

Summary of Fall Protection Requirements For Genie Products:

ANSI Standard	Genie Products Affected	Fall Protection Requirement
ANSI A92.2 / CSA-C225 Vehicle Mounted Booms	TMZ, TZ trailer mounted booms	Use of approved harness and lanyard **is** required
ANSI A92.3 / CSA B354.1 Manually Propelled Elevating Platforms	AWP, IWP,CWP, DPL, PLI, PLC, EUP, EUM, PLP	The guardrail provides fall protection. Personal fall protection **Is Not** required
ANSI A92.5 / CSA B354.4 Boom Supported Work Platforms	All self-propelled "S" and "Z" booms	Use of approved harness and lanyard **is** required
ANSI A92.6 / CSA B354.2 Self Propelled Elevating Work Platforms	Scissors, Runabout	The guardrail provides fall protection. Personal fall protection **Is Not** required

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Fall Protection & Fall Arrest

Do NOT under any circumstance clip off to anything else besides the Lift Attachment point when using fall arrest in a lift, unless you are transferring out of the basket.

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Challenges of Fall arrest on a Portable Structure

Challenges of Fall arrest on a Portable Structure

- Attachment points which meet the minimum requirement

Challenges of Fall arrest on a Portable Structure

- Attachment points which meet the minimum requirement
- Limiting Free fall distance

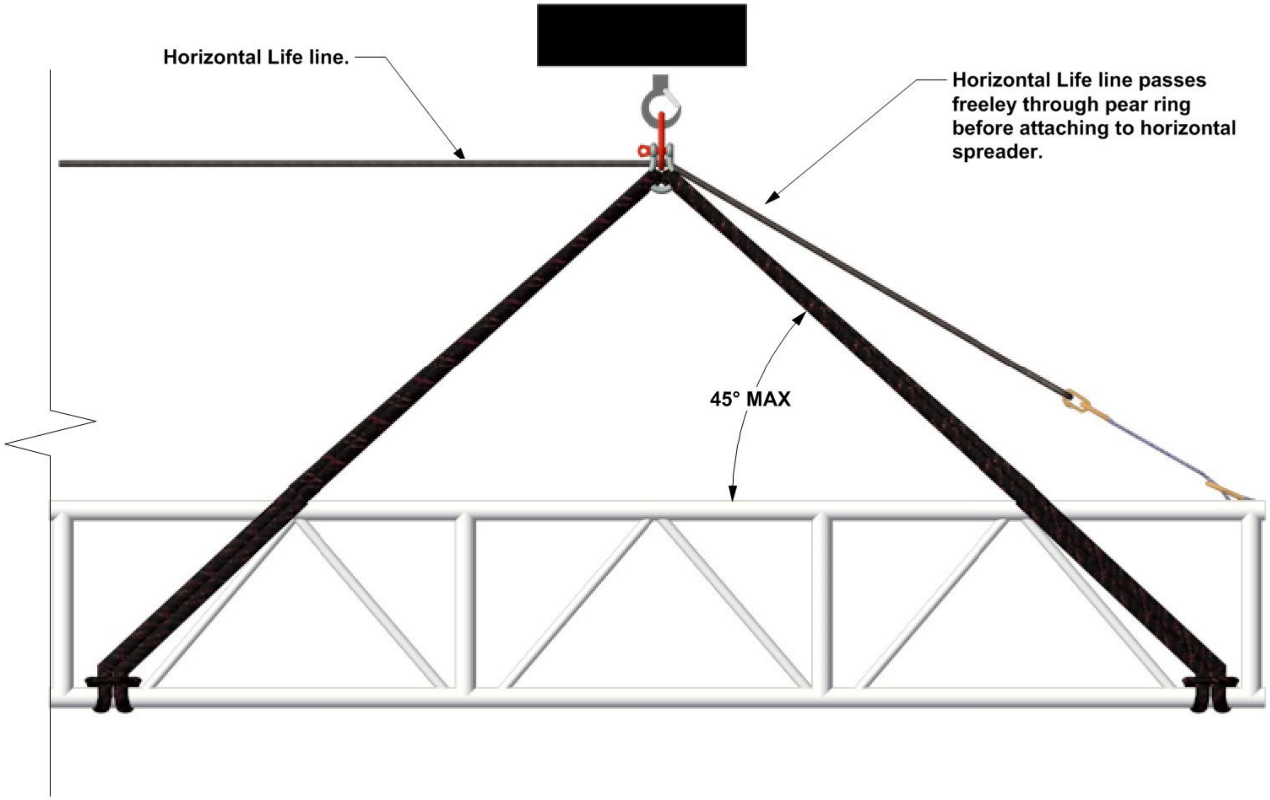
Challenges of Fall arrest on a Portable Structure

- Attachment points which meet the minimum requirement
- Limiting Free fall distance
- Additional forces applied to the system

Challenges of Fall arrest on a Portable Structure

- Attachment points which meet the minimum requirement
- Limiting Free fall distance
- Additional forces applied to the system
- Rescue plan

Fall Protection & Fall Arrest



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Fall Protection & Fall Arrest

Fall Protection & Fall Arrest

6.2.2 Where certified anchorages are unavailable on portable structures, the employer shall have a competent person make the determination of whether it is feasible to use the structure as an anchorage. In addition, the competent person shall train the users in the appropriate use and location of the anchorages. If no such determination is made by a competent person either; (a) the structure shall not be used as an anchorage or; (b) a qualified person shall certify anchorages on the structure prior to its use as an anchorage.

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Fall Protection & Fall Arrest

***E6.2.2** The most common anchorage location for HLLs on suspended portable structures, as noted by this task group, is the horizontal (spreader). Preliminary industry testing indicates that the 51 mm, (2 in), O.D., 3.2 mm (.125 in) wall thickness, horizontal spreaders on 521 mm and 762 mm (20.5 and 30 inch), wide trussing conforming to the requirements of ANSI E1.2 may meet the22.2 kN (5,000lb), strength required of a non-certified anchorage. However, the arresting force imposed on the spreader also affects the structural integrity of the structure as a whole. It is imperative that a determination be made that the addition of the arresting forces to the structure will not cause a structural failure considering any existing loads on the structure prior the arresting force being applied.*

What about Fall arrest on a ground supported structure?

The Rescue

- Have CPR and AED training.
- “Fall to Floor” as quickly as possible.
- Best position for victim is “Barcalounger” position
- Everyone exposed to a fall gets medical treatment, no exceptions.
- Keep an eye on everyone who assisted with the rescue, the stress of the situation can cause them to have problems afterwards.

The Roles

It's easy for panic to set in once an accident takes place. Proper training and rehearsals help reduce that panic. Knowing what is expected of you and your coworkers helps reduce the panic level even more. In an ideal situation and assuming an assisted rescue, the rescue team consists of five people.

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- **The leader**: This person is in charge. They keep an eye on everything and everyone else.

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- **The announcer**: This is the person who alerts the venue staff and the outside organizations that an accident has happened and maintains contact with these people.

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- **The rescuer**: This is the person who goes up to the victim with the rescue kit and sets up the rescue equipment.

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- **The floor person**: This person handles the actual rescue. Their role will depend on the type of equipment being used but it's their job to make sure the victim is lowered to the deck safely.

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Fall Protection & Fall Arrest

- **The communicator**: This person has the job of staying in constant contact with the victim. The communicator keeps the victim informed of the progress of the rescue and what the victim can do to help promote that progress. The communicator will also continually assess the victim’s physical and mental condition and alert the leader of any changes in those conditions, no matter how minor.

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Fall Protection & Fall Arrest

- Written document with:
- Location of Rescue equipment
- Phone number of EMS
- List of First aid kits
- Roles of each member of the rescue team.
- Documentation on training of staff.
- Cell phone dead zones
- Where does the ambulance go to when it arrives?

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Fall Protection & Fall Arrest

- Never work alone when working overhead. There should be at least one other person in the immediate vicinity that can begin the rescue process. If you are working above the stage and the only other person in the building is working in the box office with the door closed and the radio on, that person is not going to be of any help to you. The second person should have clear line of sight and hearing.

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Fall Protection & Fall Arrest

- Always lower the victim to the floor, even if the catwalk they just fell from is only 5′ away. The goal is to get the victim safely on the floor. You don't want to have to carry them across the catwalk, down the ladder, around the spiral staircase and down five flights of steps. Any injuries they may have sustained in the fall will only be exacerbated by a protracted trip through the venue.

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- Once the victim is on the stage do not attempt to diagnose their problems unless you are trained to do so. A medical person of some stripe—be they EMT, paramedic or something else—should have been notified as part of the rescue plan and should already be on site. Let them do their job.

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- Do not let the victim convince you that they're OK. Do not let them wander off to shake it off or go home. Internal injuries are not an uncommon result of a fall, whether the victim feels them or not. Keep the victim calm until the medical personnel have made their assessment and then follow their instructions."

Domestic or Imported?

Hardware

- All Hardware must have the following:
  - Manufacturer name
  - Working Load limit
- May have:
  - Batch Number
  - Country of origin

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Hardware

Working Load Limit?

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Hardware

Yield point and Ultimate Breaking Strength

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Hardware: Rope

- Characteristic of rope
  - Stretch
  - Flexibility
  - Durability
  - Strength
  - Handling
  - Cost

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Hardware: Rope

- Stretch

  Low stretch = Static

  High stretch = Dynamic

  Most rigging applications require static rope

Hardware: Rope

- Flexibility

A stiffer rope is harder to work with. Harder to knot.

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Hardware: Rope

- Durability

  The rope needs to withstand abuse from sheaves, knots, and environmental conditions. General wear and tear.

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Hardware: Rope

- Strength

  The rope must have a WLL that will support the load, have head room for friction and inertia, and be able to deal with shock load.

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Hardware: Rope

- Cost

    Purchase cost is not the only factor. Will a more expensive rope last longer and need less frequent replacement?

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Hardware: Rope

What two materials are used for constructing rope?

Hardware: Rope

- Natural Fiber rope
  - Hemp
    - Not readily available in US
  - Sisal
    - Not very durable.
  - Manila
    - Graded by Color
    - Sizes are rated the same. Grade reflects the speed of deterioration.
    - Type M Class 1
  - Cotton

Hardware: Rope

- Natural Fiber rope
  - Fiber length is based on the size of the leaf/plant
  - Fibers are twisted together to make yarn
  - Yarn is twisted to together to make strands
  - Strands are twisted together to make rope

Regular-Lay or Right-Lay

Fibers twisted to the right, Yarns twisted to the left, Strands twisted to the right.

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Hardware: Rope

- Synthetic Fiber rope
  - Polyester
  - Do not use nylon
    - Stretches to much
    - Moisture
  - Do not use polypropylene for counter weight rigging.
    - Low melting point
    - Low strength
    - prone to abrasion

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Hardware: Rope

- Synthetic Fiber rope
  - Two types of construction
    - Parallel-core
    - Twisted

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Hardware: Rope

- Parallel-core
  - 3 ½ times stronger than hemp
  - Resists environmental conditions
  - Made from continuous fibers that run the length of the rope.
  - Jacket made of braided polyester
  - Jacket can wear without reducing strength. 95% of the strength is in the core.
  - Can be stiff for hemp rigging. Good hand line for counterweight.
  - Good value

Stage Set X

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Hardware: Rope

- Three Strand twisted polyester
  - 2 times the strength of manila
  - Cheaper than Parallel-core
  - Resists environmental conditions
  - Broken fibers reduce the strength
  - Ties well
  - Great hand line
  - Can be used for hemp rigging

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Hardware: Rope

Fiber Rope Breaking Strength			
Rope diameter	Manila (pounds)	Three strand twisted polyester (pounds)	Parallel core polyester (pounds)
3/16"	406	n/a	n/a
1/4"	540	1,500	n/a
5/16"	900	2,300	n/a
3/8"	1,220	3,200	4,600
7/16"	1,580	4,100	6,300
1/2"	2,380	5,800	8,100
9/16"	3,100	6,600	n/a
5/8"	3,960	8,230	12,500
3/4"	4,860	10,540	16,700
13/16"	5,850	n/a	n/a
7/8"	6,950	15,500	23,000
1"	8,100	18,700	32,000
1 1/16"	9,450	n/a	n/a
1 1/8"	10,800	n/a	n/a
1 1/4"	12,200	n/a	n/a

Hardware: Rope

Standard design factor for rope used in the entertainment industry is 10 to 1

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Hardware: Rope

- Inspection of Rope
  - Wear
  - Thin
  - Broken strands
  - Wet/dry
  - Rot
  - High Strands (one strand is no taking the load evenly)

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Hardware: Rope

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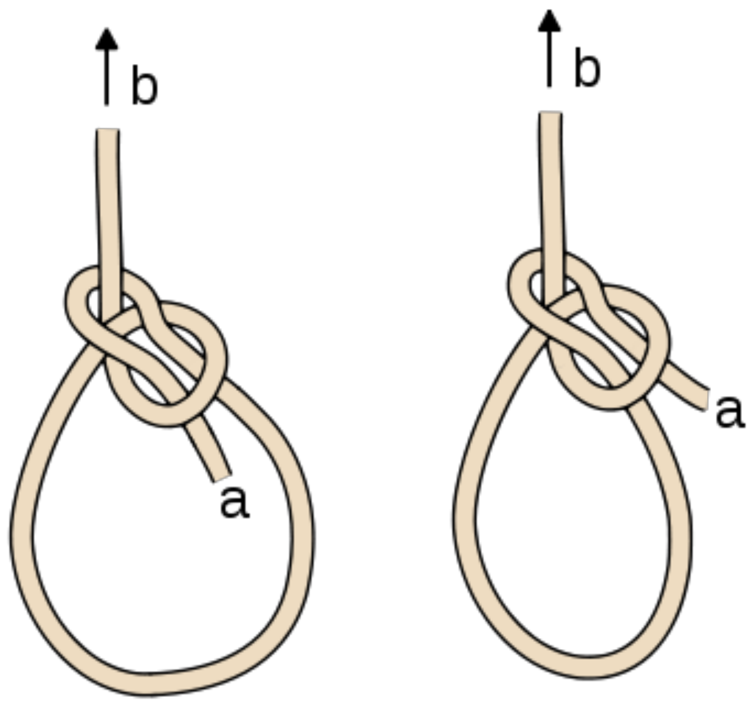
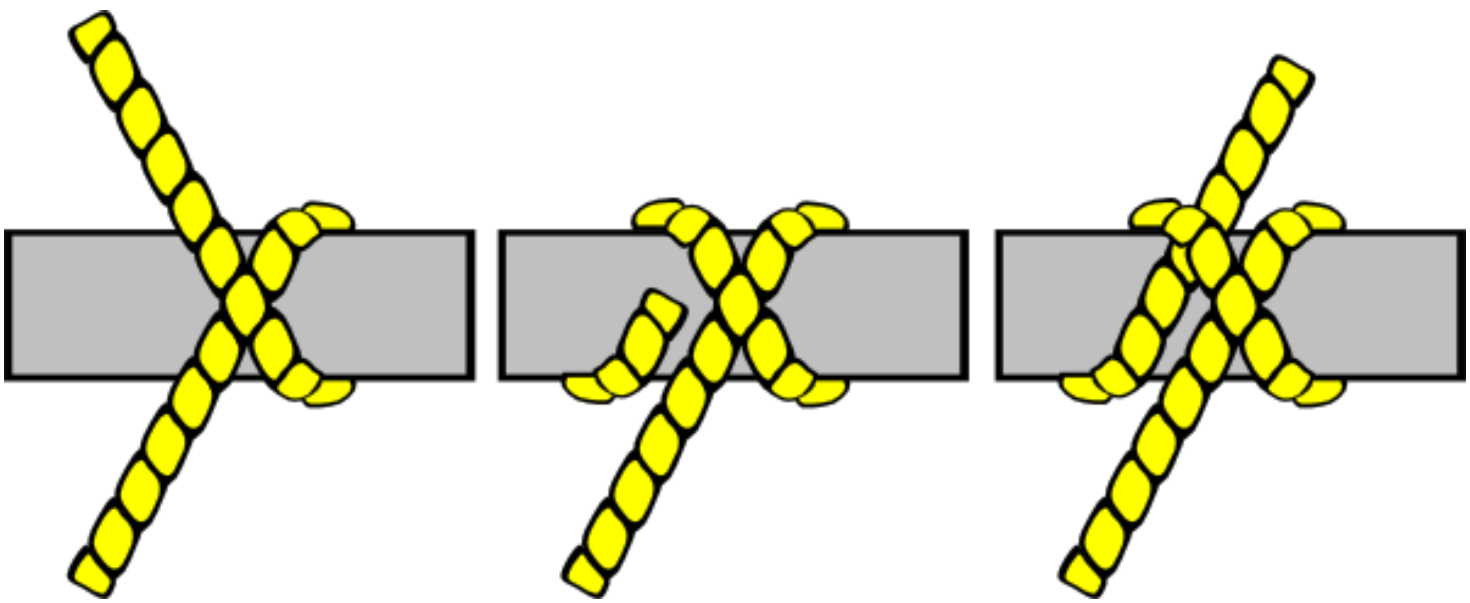
Hardware: Rope - Knots

Bowline



Hardware: Rope - Knots

Clove Hitch



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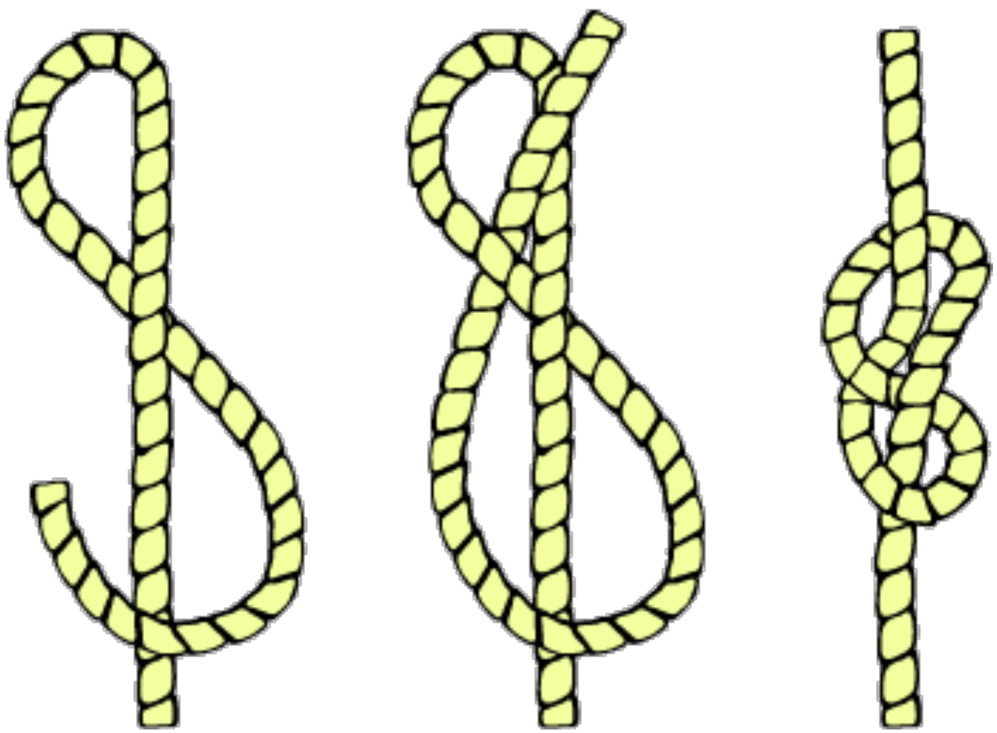
Hardware: Rope - Knots

Figure Eight



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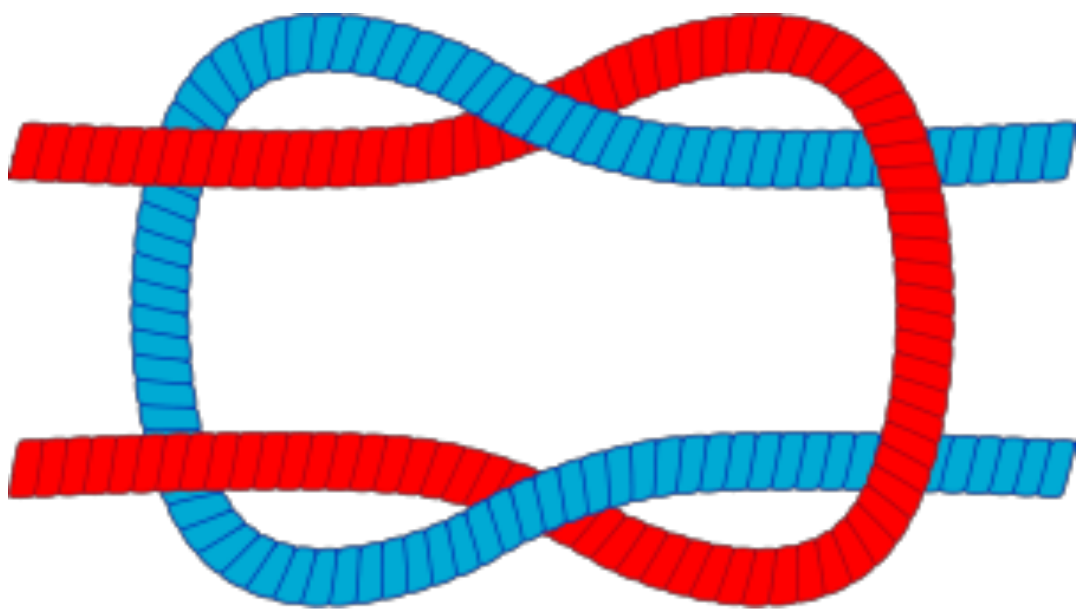
Hardware: Rope - Knots

Square Knot



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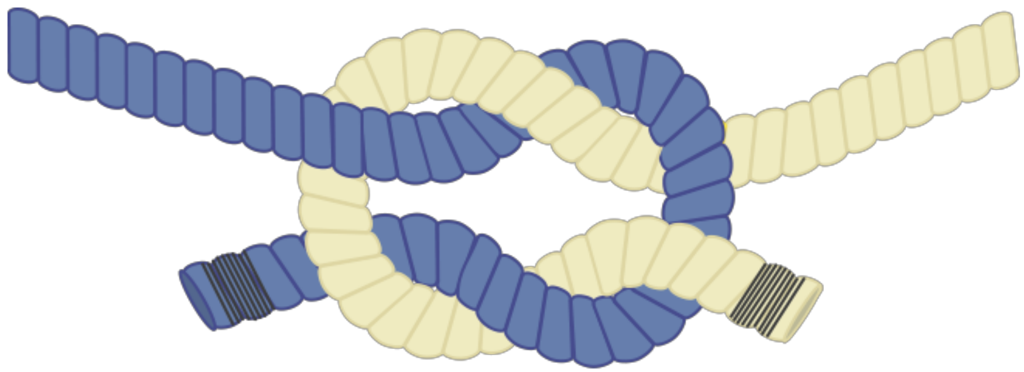
Hardware: Rope - Knots

Granny Knot



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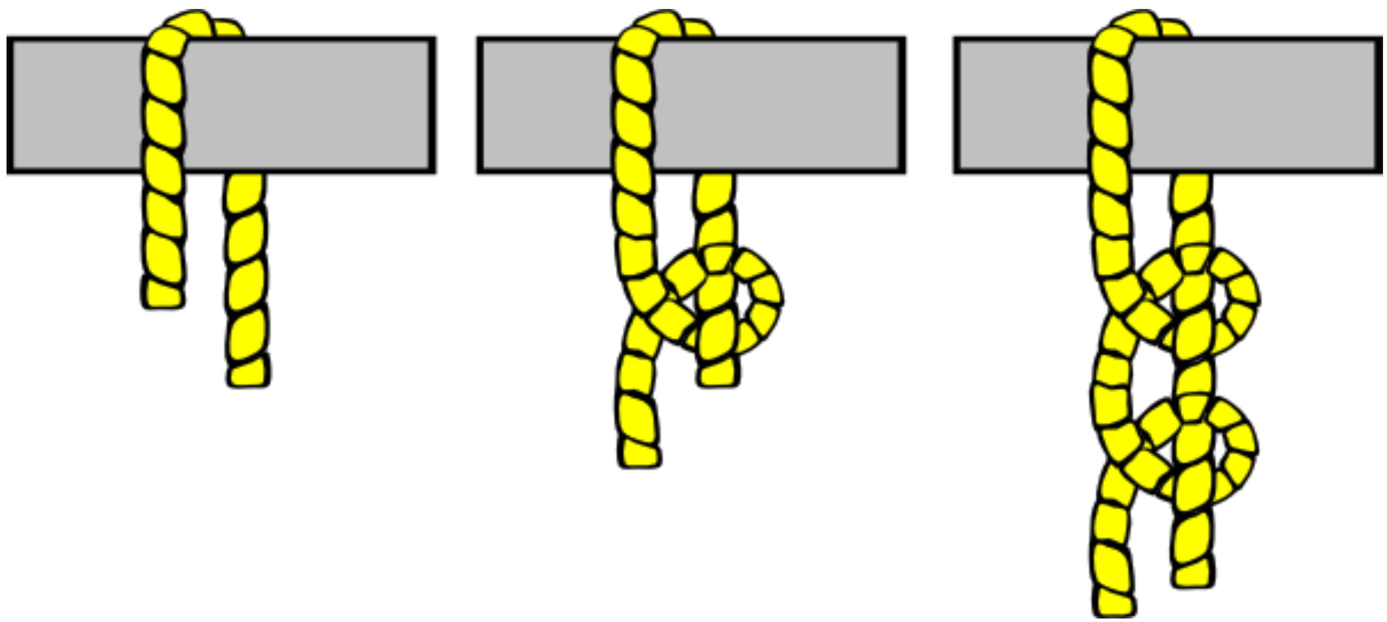
Hardware: Rope - Knots

Half Hitch



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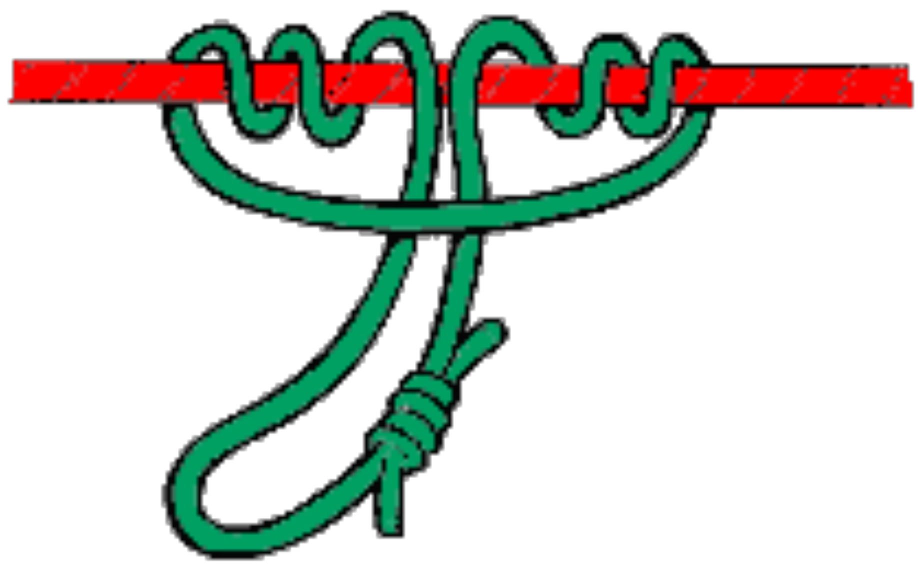
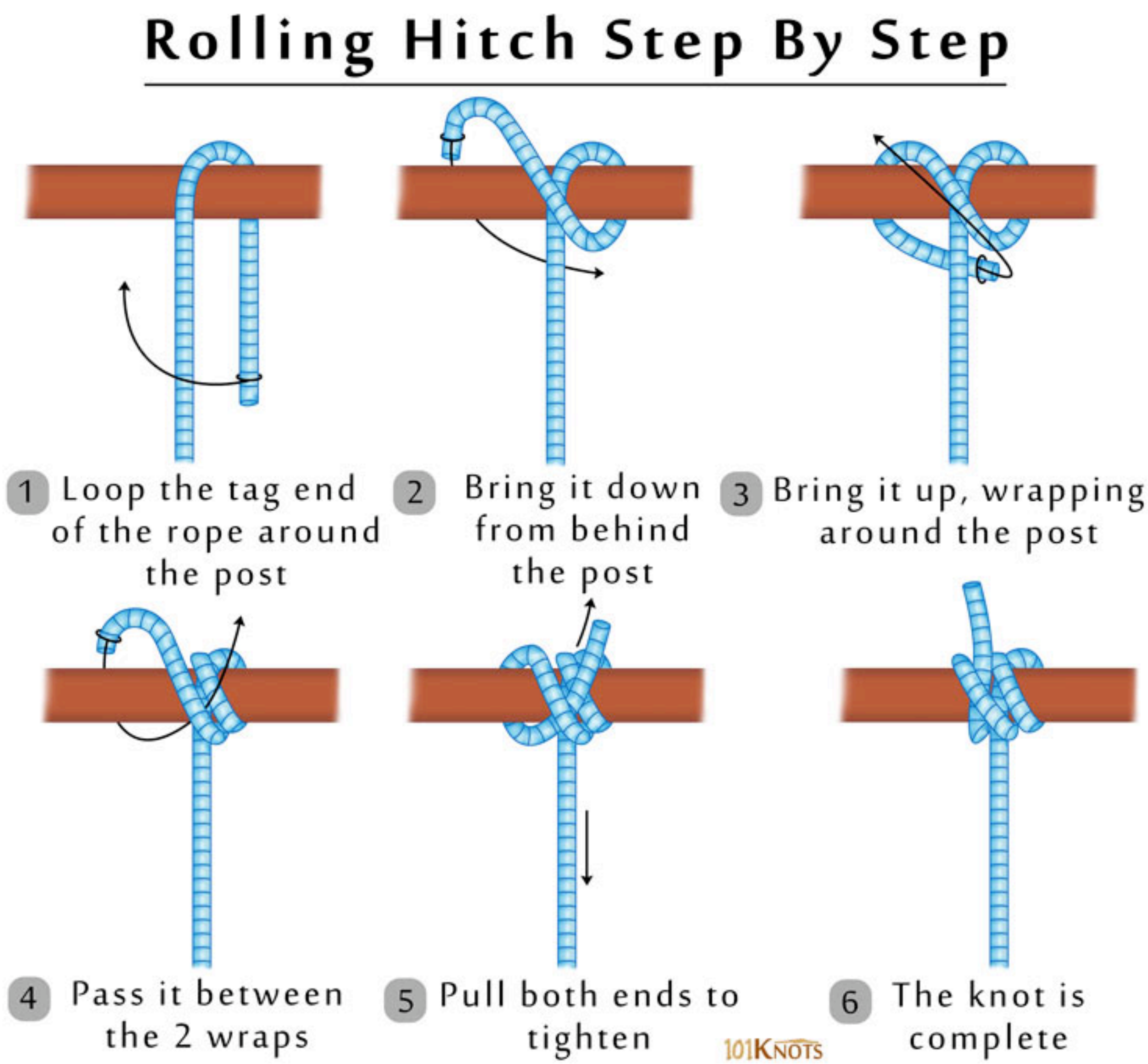
Hardware: Rope - Knots

Prusik Knot



Hardware: Rope - Knots



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Hardware: Wire Rope

- Characteristics of Wire Rope
  - Reserve Strength
  - Flexibility
  - Abrasion Resistance
  - Size
  - Strength

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Hardware: Wire Rope

- Reserve Strength

The inner wires are protected by the outer wires from abrasion and offer a level of reserve strength. However within the entertainment industry the practice has been to remove any wire rope with even one broken wire.

Hardware: Wire Rope

- Flexibility
  - Because wire rope is made of many smaller wires it is extremely flexible.
  - The smaller the wire, the more flexible.
  - The trade off is that smaller wires will fatigue faster.

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Hardware: Wire Rope

- Abrasion Resistance
  - The size and grade of the outer wires effects the abrasion resistance of the wire rope.
  - The larger the wire size, the more material can be removed before it breaks.

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Hardware: Wire Rope

- Size
  - Wire Rope is manufactured oversized and when placed under load will “shrink” to nominal size.
  - Federal regulations allow for a deviation of -0% to +5%

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Hardware: Wire Rope

- Strength
  - Based on material area in cross section.
  - Material determines strength
  - Design factor is 8 to 1 for running wire rope
  - Design factor is 5 to 1 for static

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Hardware: Wire Rope

- Construction
  - Core
  - Classification
  - Grades
  - Rope Lay

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Hardware: Wire Rope

- Core
  - Center strand of wire rope which other strands are twisted around
  - Three types of core
    - Fiber Core (FC)
    - Independent Wire Rope Core (IWRC)
    - Wire strand Core (WSC or SC)

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Hardware: Wire Rope

- Classification
  - The number of wires in each strand, and the number of total strands determines classification
  - 7 x 19
    - 7 Strands including the IWRC
    - Each strand is made from 19 wires

7 x 19

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Hardware: Wire Rope

- Grades
  - Plow Steel
    - Plow Steel (PS)
    - Improved Plow Steel (IPS)
    - Extra Improved Plow Steel (XIPS)
    - Extra Extra Improved Plow Steel (XXIPS)
  - Galvanized Aircraft Cable
  - Stainless steel wire rope
  - Extra Flexible wire rope
  - Rotation resistant wire rope
  - Sash cord
  - Tiller rope

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Hardware: Wire Rope

- Rope Lay
  - Right: Strands rotate clockwise around core
  - Left: Strands rotate counter clockwise around core
  - Regular: Wire rotates around core in the opposite rotation of the strands in the core
  - Lang: Wire and strands rotate in the same direction

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Hardware: Wire Rope

Size	Breaking Strength (Pounds)
3/32”	920
1/8”	2,000
5/32”	2,800
3/16”	4,200
7/32”	5,600
1/4"	7,000
5/16”	9,800
3/8”	14,400
1/2"	19,000

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Hardware: Wire Rope

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Hardware: Wire Rope

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Hardware: Wire Rope

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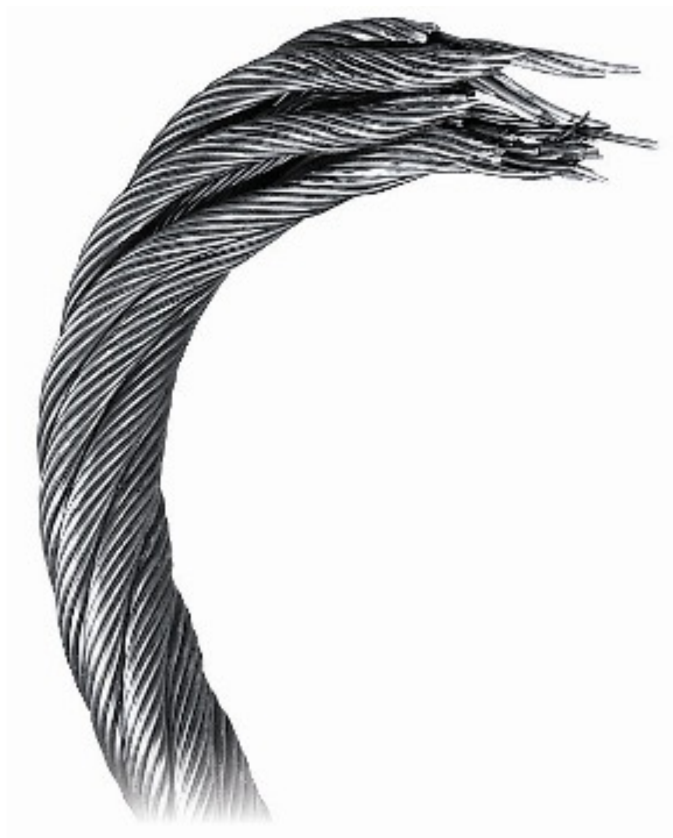
Hardware: Wire Rope



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Hardware: Wire Rope

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Hardware: Wire Rope

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Hardware: Wire Rope

Hardware: Wire Rope

- Terminations
  - Wire rope clip
  - Mechanical
  - Manual swage
  - Temporary

Hardware: Wire Rope

- Wire rope clip
  - 80% efficient
  - Low Cost
  - Reusable
  - Use Forged Clips!

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Hardware: Wire Rope

CROSBY® CLIPS

WARNINGS AND APPLICATION INSTRUCTIONS

G-450
(Red-U-Bolt®)

SS-450
(316 Stainless Steel)

⚠WARNING

- **Failure to read, understand, and follow these instructions may cause death or serious injury.**
- **Read and understand these instructions before using clips.**
- **Match the same size clip to the same size wire rope.**
- **Prepare wire rope end termination only as instructed.**
- **Do not use with plastic coated wire rope.**
- **Apply first load to test the assembly. This load should be of equal or greater weight than loads expected in use. Next, check and retighten nuts to recommended torque (See Table 1, this page).**

Efficiency ratings for wire rope end terminations are based upon the catalog breaking strength of wire rope. The efficiency rating of a properly prepared loop or thimble-eye termination for clip sizes 1/8" through 7/8" is 80%, and for sizes 1" through 3-1/2" is 90%.

The number of clips shown (see Table 1) is based upon using RRL or RLL wire rope, 6 x 19 or 6 x 36 Class, FC or IWRC; IPS or XIP, XXIP. If Seale construction or similar large outer wire type construction in the 6 x 19 Class is to be used for sizes 1 inch and larger, add one additional clip. If a pulley (sheave) is used for turning back the wire rope, add one additional clip.

The number of clips shown also applies to rotation-resistant RRL wire rope, 8 x 19 Class, IPS, XIP, XXIP sizes 1-1/2 inch and smaller; and to rotation-resistant RRL wire rope, 19 x 7 Class, IPS, XIP, XXIP sizes 1-3/4 inch and smaller.

For other classes of wire rope not mentioned above, we recommend contacting Crosby Engineering to ensure the desired efficiency rating.

For elevator, personnel hoist, and scaffold applications, refer to ANSI A17.1 and ANSI A10.4. These standards do not recommend U-Bolt style wire rope clip terminations. The style wire rope termination used for any application is the obligation of the user.

For OSHA (Construction) applications, see OSHA 1926.251.

1. Refer to Table 1 in following these instructions. Turn back specified amount of rope from thimble or loop.

Figure 1

Apply first clip one base width from dead end of rope. Apply U-Bolt over dead end of wire rope – live end rests in saddle (Never saddle a dead horse!). Use torque wrench to tighten evenly, alternate from one nut to the other until reaching the recommended torque.

2. When two clips are required, apply the second clip as near the loop or thimble as possible. Use torque wrench to tighten evenly, alternating until reaching the recommended torque. When more than two clips are required, apply the second clip as near the loop or thimble as possible, turn nuts on second clip firmly, but do not tighten. Proceed to Step 3.

Figure 2

3. When three or more clips are required, space additional clips equally between first two – take up rope slack – use torque wrench to tighten nuts on each U-Bolt evenly, alternating from one nut to the other until reaching recommended torque.

Figure 3

4. If a pulley (sheave) is used in place of a thimble, add one additional clip. Clip spacing should be as shown.

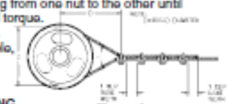

Figure 4

5. WIRE ROPE SPLICING PROCEDURES:

The preferred method of splicing two wire ropes together is to use inter-locking turnback eyes with thimbles,using the recommended number of clips on each eye (See Figure 5).

Figure 5

An alternate method is to use twice the number of clips as used for a turnback termination. The rope ends are placed parallel to each other, overlapping by twice the turnback amount shown in the application instructions. The minimum number of clips should be installed on each dead end (See Figure 6). Spacing, installation torque, and other instructions still apply.

Figure 6

6. IMPORTANT

Apply first load to test the assembly. This load should be of equal or greater weight than loads expected in use. Next, check and use torque wrench to retighten to recommended torque. In accordance with good rigging and maintenance practices, the wire rope end termination should be inspected periodically for wear, abuse, and general adequacy.

Table 1

Clip Size (in.)	Rope Size (in.)	Minimum No. of Clips	Amount of Rope to Turn Back in Inches	*Torque in Ft.Lbs.
1/8	1/8	2	3-1/4	4.5
3/16	3/16	2	3-3/4	7.5
1/4	1/4	2	4-3/4	15
5/16	5/16	2	5-1/4	30
3/8	3/8	2	6-1/2	45
7/16	7/16	2	7	65
1/2	1/2	3	11-1/2	65
9/16	9/16	3	12	95
5/8	5/8	3	12	95
3/4	3/4	4	18	130
7/8	7/8	4	19	225
1	1	5	26	225
1-1/8	1-1/8	6	34	225
1-1/4	1-1/4	7	44	360
1-3/8	1-3/8	7	44	360
1-1/2	1-1/2	8	54	360
1-5/8	1-5/8	8	58	430
1-3/4	1-3/4	8	61	590
2	2	8	71	750
2-1/4	2-1/4	8	73	750
2-1/2	2-1/2	9	84	750
2-3/4	2-3/4	10	100	750
3	3	10	106	1200
3-1/2	3-1/2	12	149	1200

If a pulley (sheave) is used for turning back the wire rope, add one additional clip. See Figure 4.

If a greater number of clips are used than shown in the table, the amount of turnback should be increased proportionately.

*The tightening torque values shown are based upon the threads being clean, dry, and free of lubrication.

rev. 1

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Hardware: Wire Rope

Table 1				
Clip Size (in.)	Rope Size (in.)	Minimum No. of Clips	Amount of Rope to Turn Back in Inches	* Torque in Ft.Lbs.
1/8	1/8	2	3-1/4	4.5
3/16	3/16	2	3-3/4	7.5
1/4	1/4	2	4-3/4	15
5/16	5/16	2	5-1/4	30
3/8	3/8	2	6-1/2	45
7/16	7/16	2	7	65
1/2	1/2	3	11-1/2	65
9/16	9/16	3	12	95
5/8	5/8	3	12	95
3/4	3/4	4	18	130
7/8	7/8	4	19	225
1	1	5	26	225
1-1/8	1-1/8	6	34	225
1-1/4	1-1/4	7	44	360
1-3/8	1-3/8	7	44	360
1-1/2	1-1/2	8	54	360
1-5/8	1-5/8	8	58	430
1-3/4	1-3/4	8	61	590
2	2	8	71	750
2-1/4	2-1/4	8	73	750
2-1/2	2-1/2	9	84	750
2-3/4	2-3/4	10	100	750
3	3	10	106	1200
3-1/2	3-1/2	12	149	1200
If a pulley (sheave) is used for turning back the wire rope, add one additional clip. See Figure 4.				
If a greater number of clips are used than shown in the table, the amount of turnback should be increased proportionately.				

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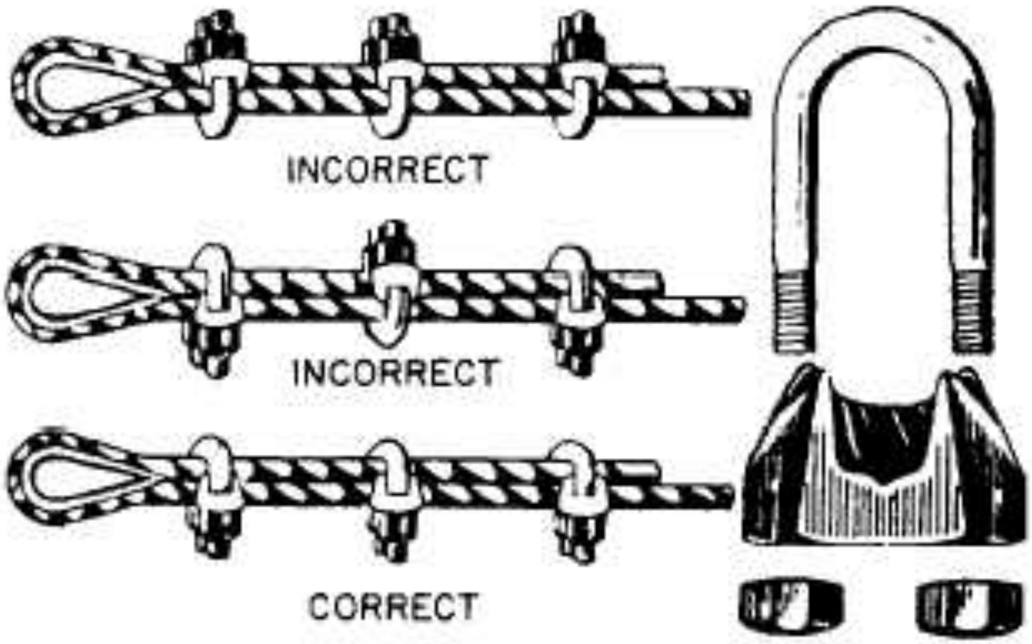
Hardware: Wire Rope



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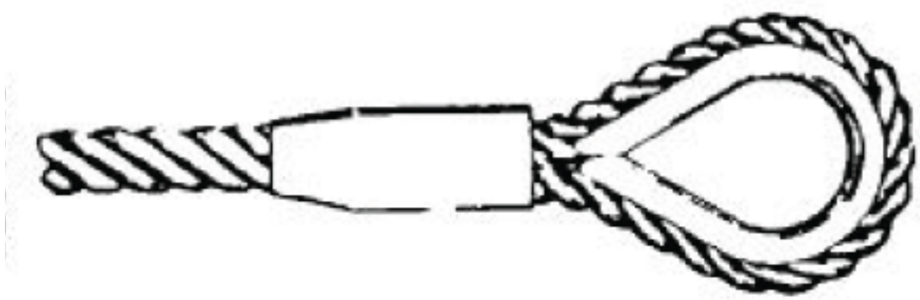
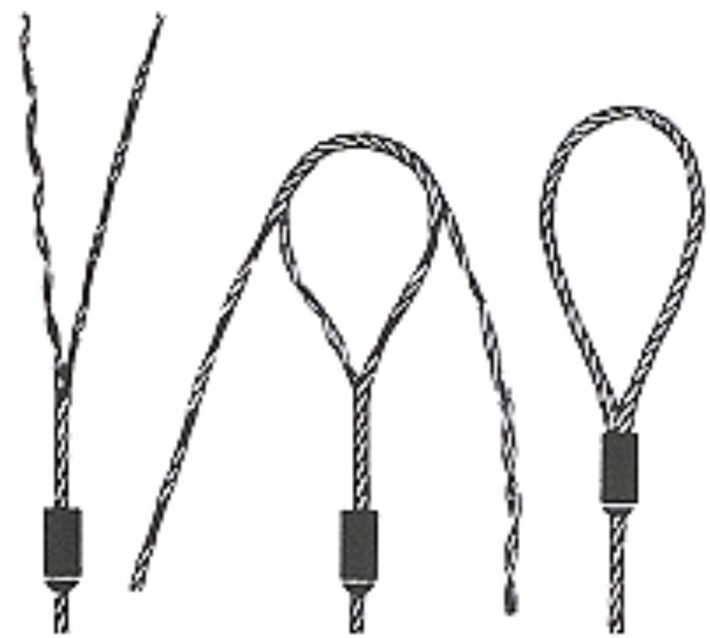
Hardware: Wire Rope

- Fist Grip
  - Can't saddle a dead Horse
  - 80% efficient

Hardware: Wire Rope

- Mechanical
  - Return or Layback Eye
    - 95% efficient
  - Flemish eye
    - 95% efficient
    - Strength is not dependent on fitting only





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Hardware: Wire Rope

- Manual swage
  - 100% efficient (if done correctly)
  - Low cost
  - Flexible

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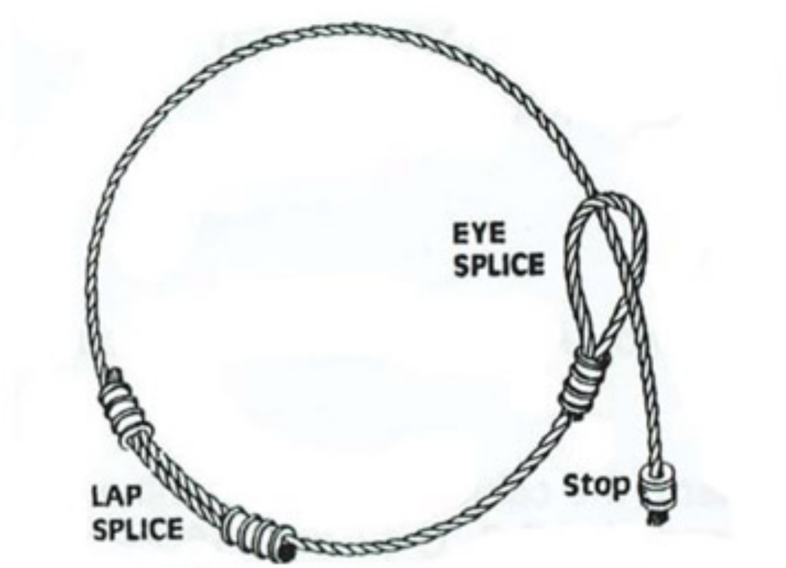
Hardware: Wire Rope



CABLE DIAMETER	ALUMINUM & COPPER	
	OVAL SLEEVES	STOP SLEEVE
1/16"	2	1
3/32"	2	2
1/8"	3	2
5/32"	3	2
3/16"	4	2
7/32"	—	2

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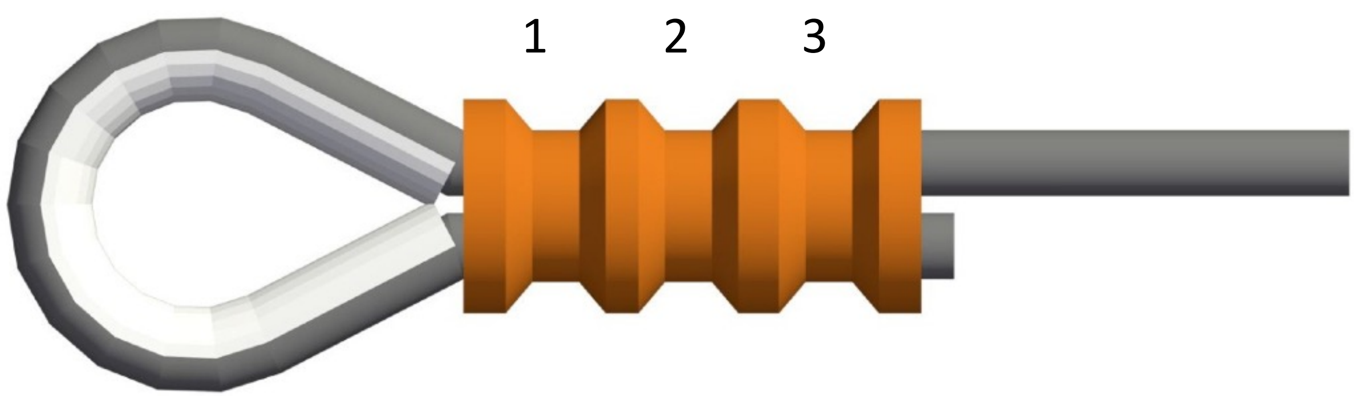
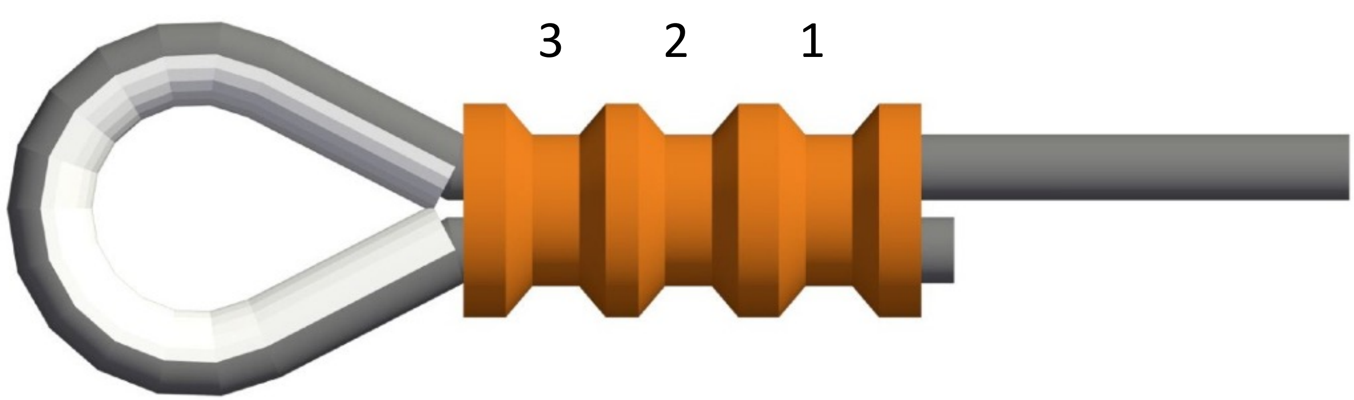
Hardware: Wire Rope

Crimp Order



Hardware: Wire Rope

Crimp Order



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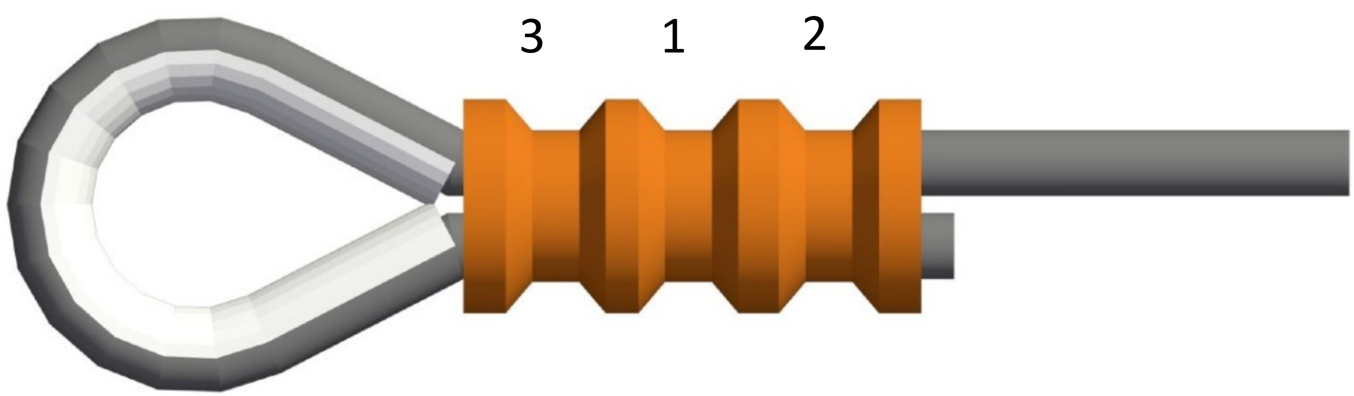
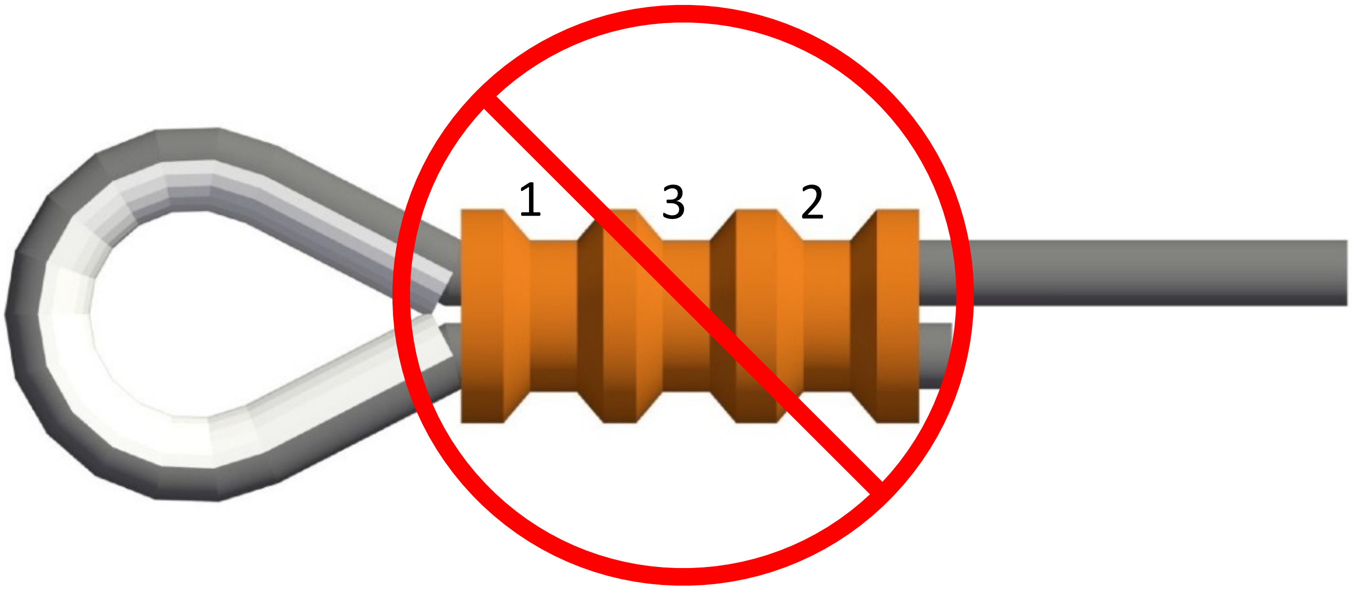
Hardware: Wire Rope

Crimp Order



Hardware: Wire Rope

Crimp Order



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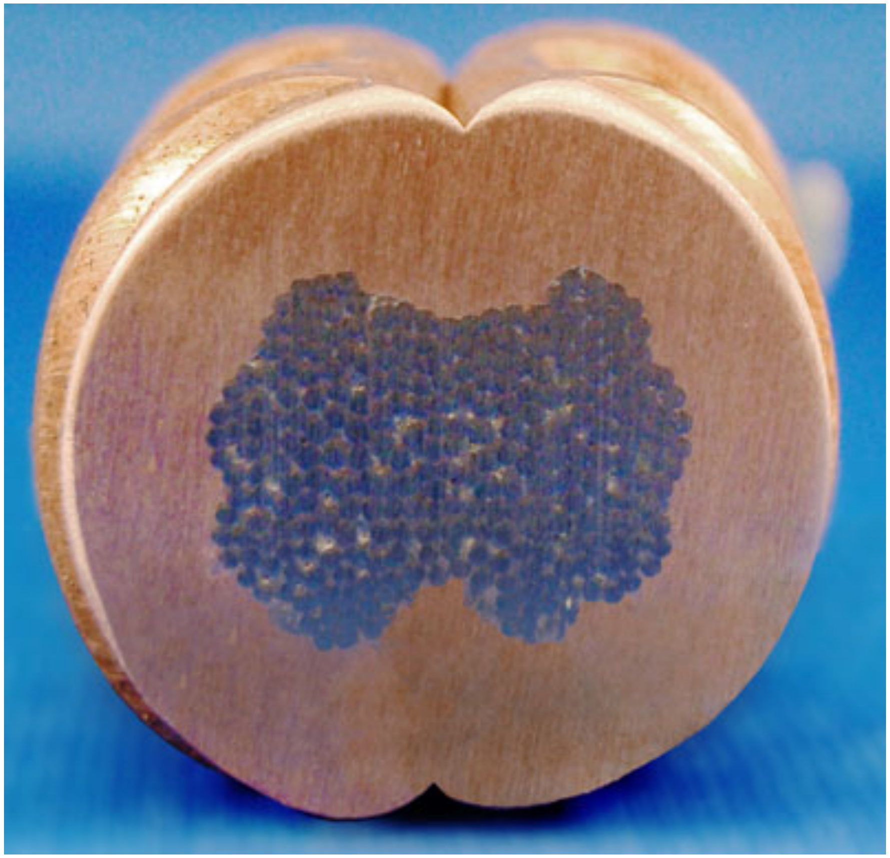
Hardware: Wire Rope



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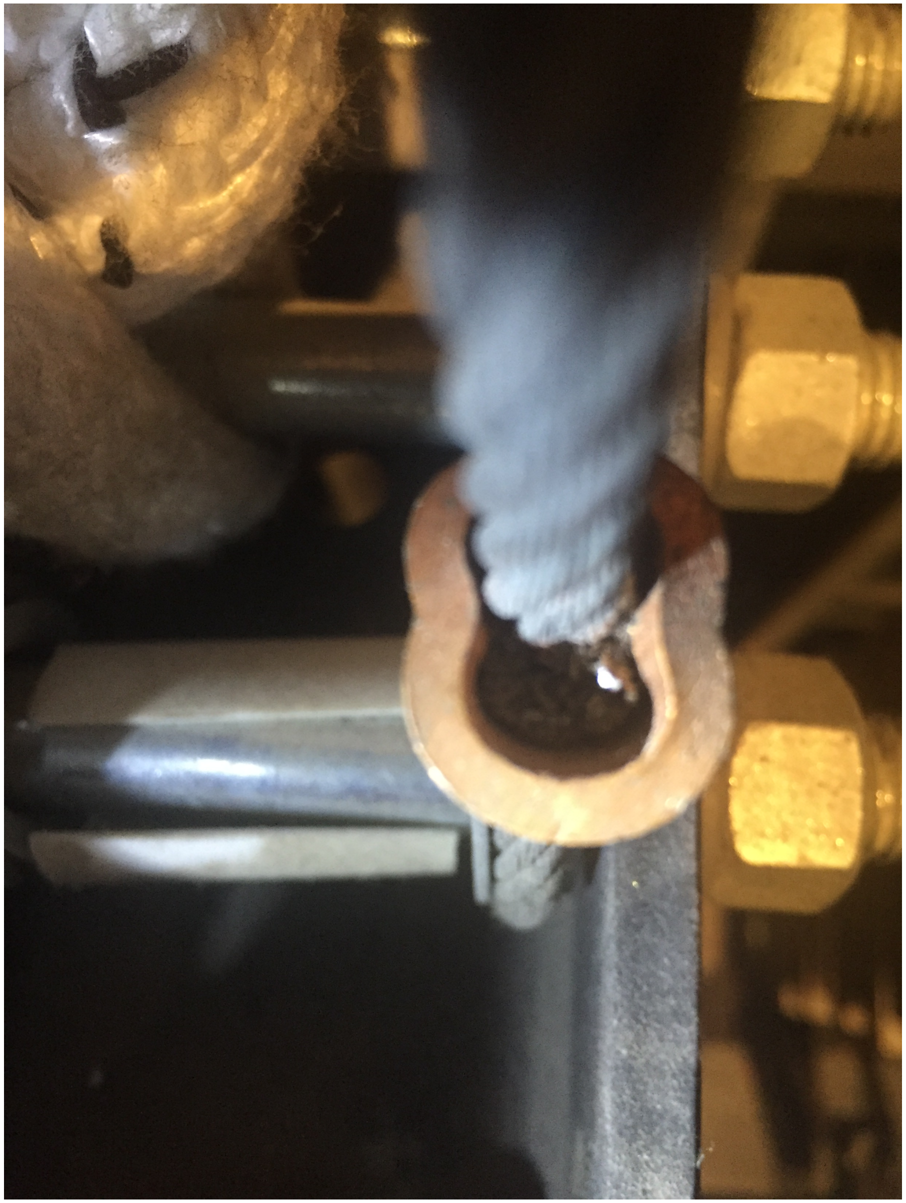
Hardware: Wire Rope



Hardware: Wire Rope

More than one swage fitting?

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Rigging Tools

Felco C7

Rigging Tools

Locoloc #1-SC

Rigging Tools

Locoloc HC-5010-r

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Rigging Tools

GO-NO-GO Guage

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Hardware: Wire Rope

Temporary

- Gliders
  - Reusable
  - 1/16” and 1/8” sizes
  - W.L.L. 250LBS
- Gripples
  - 9 sizes
  - Not rated
- Kwik-loc
  - 4 sizes
  - Varying W.L.L.

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Hardware: Wire Rope

Can I tie a knot in Wire Rope?

Hardware: Wire Rope

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Hardware: Wire Rope

- Burlap should be at least 3 times the bag thickness.
- keep fittings away from hard edges.

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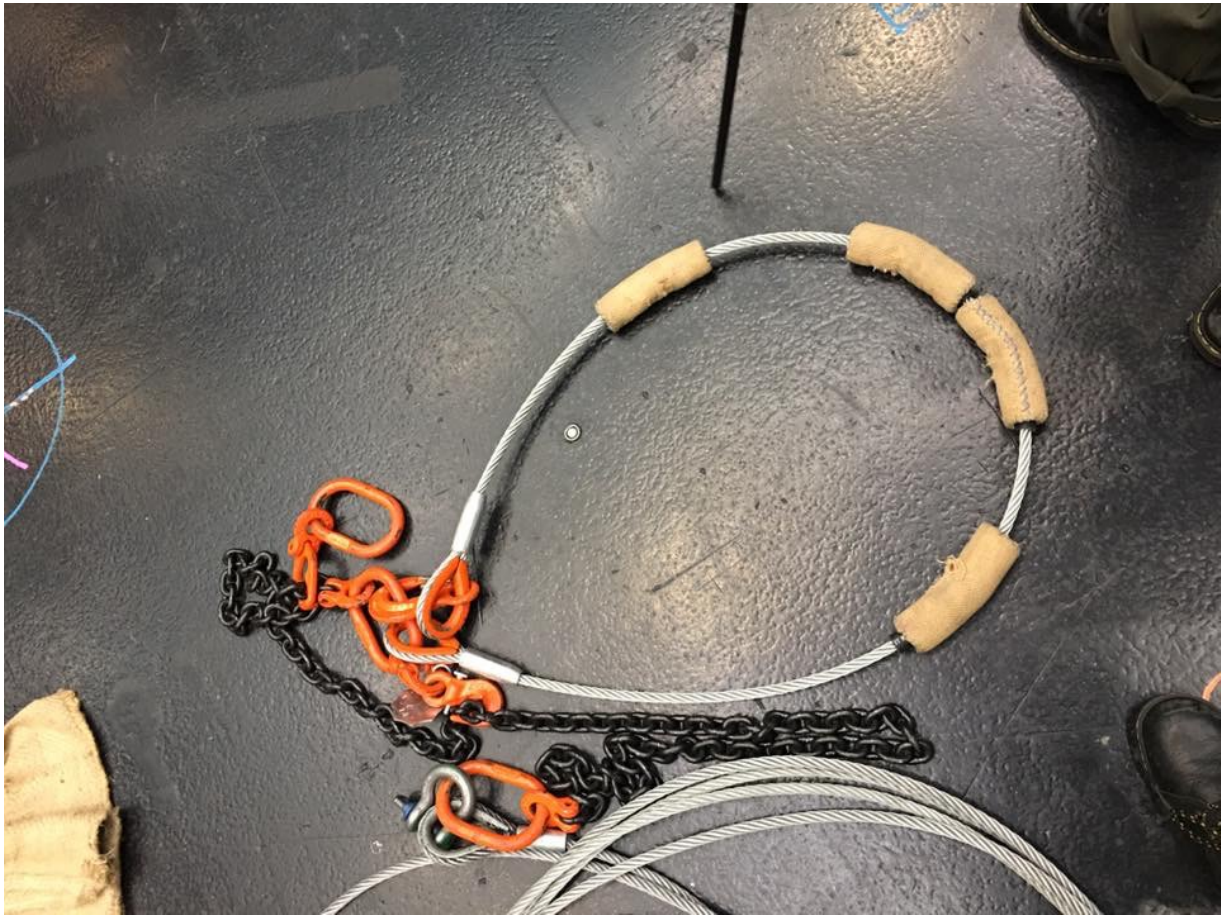
Hardware: Wire Rope



Hardware: Slings

- Synthetic Round Sling
- Steelflex or GACflex wire rope sling
- Wire Rope Slings

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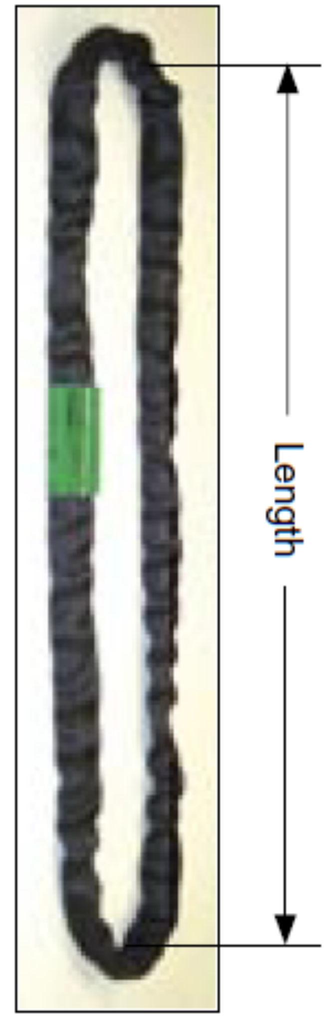
Hardware: Slings

- Synthetic Round Sling
  - Made from polyester fibers
  - Fiber runs in continues loop through sling
  - Jacket protects fibers from abrasion
  - Very flexible
  - Susceptible to environmental and chemical damage
  - Rated for use in temperatures up to 180°
  - Knots reduce strength substantially



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Hardware: Slings

Part #	Color	Vertical (Pounds)	Choker (Pounds)	Basket (Pounds)
EN30	Purple	2,600	2,100	5,200
EN60	Green	5,300	4,200	10,600
EN90	Yellow	8,400	6,700	16,800
EN120	Tan	10,600	8,500	21,200
EN150	Red	13,200	10,600	26,400
EN180	White	16,800	13,400	33,600
EN240	Blue	21,200	17,000	42,400
EN360	Grey	31,000	24,800	62,000
EN600	Brown	53,000	42,400	106,000
EN800	Olive	66,000	52,800	132,000
EN1000	Black	90,000	72,000	180,000

Hardware: Slings

- Steelflex or GACflex wire rope sling
  - Replaces fiber with wire rope
  - Same Strength as fiber slings
  - Not as flexible as fiber slings
  - Rated for use in temperatures up to 400°

Hardware: Slings

- Wire Rope Slings
  - More resistant to abrasion
  - Not as flexible as fiber or steelflex slings
  - Must be protected from sharp edges

Hardware: Slings

Size	Vertical load (Pounds)	Choker (Pounds)	Basket (Pounds)
1/4"	1,300	960	2,600
3/8”	2,800	2,200	5,800
1/2"	5,000	3,800	10,200

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Hardware: Shackles

- Forged steel
- Marked with W.L.L.
- Pin is matched to shackle
- Screw Pin Anchor Shackle
- Entertainment industry uses oversized shackles

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Hardware: Shackles

- Does orientation of the shackle matter?
  - Pin up
  - Pin down
- Keep loads on bow at less than 90°
- Only ONE object on the pin

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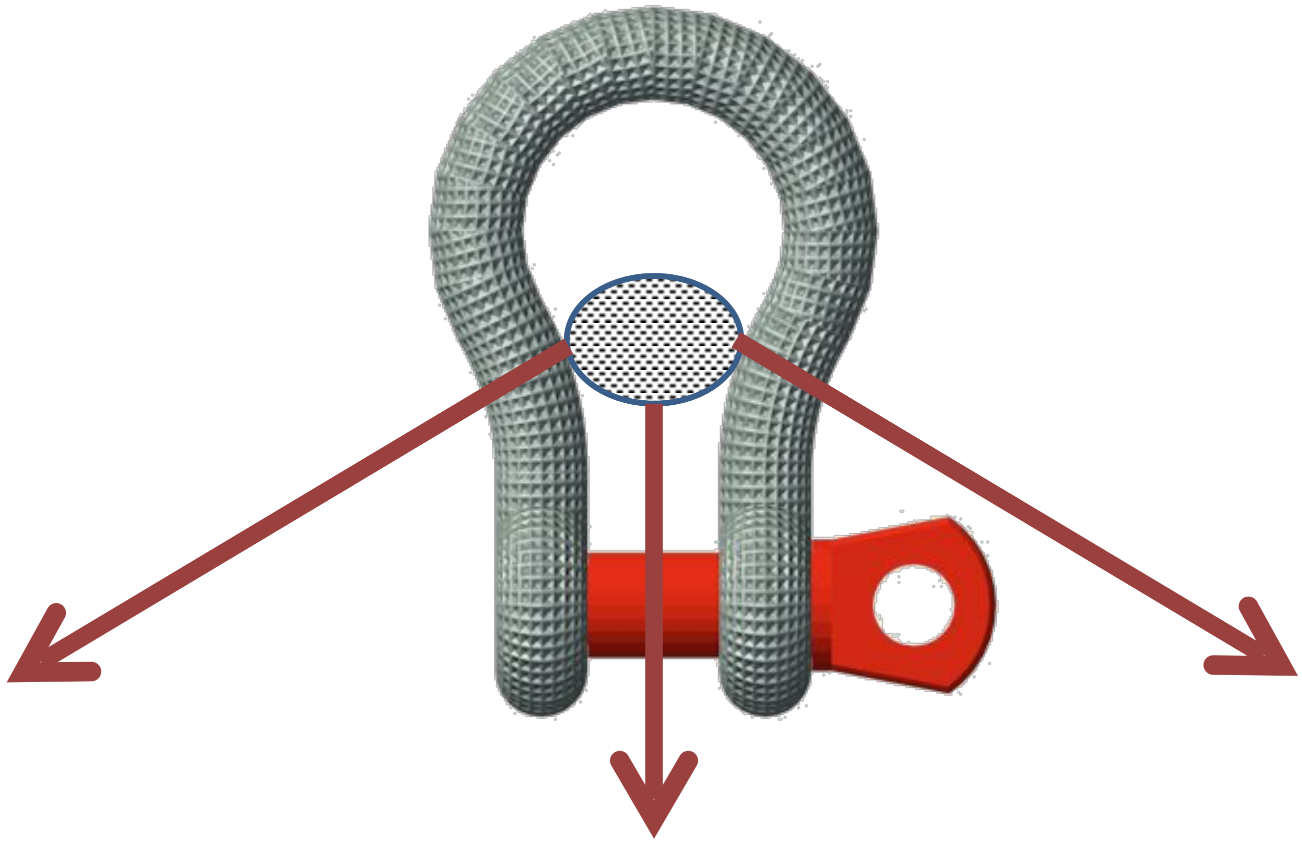
Shackle Wedging



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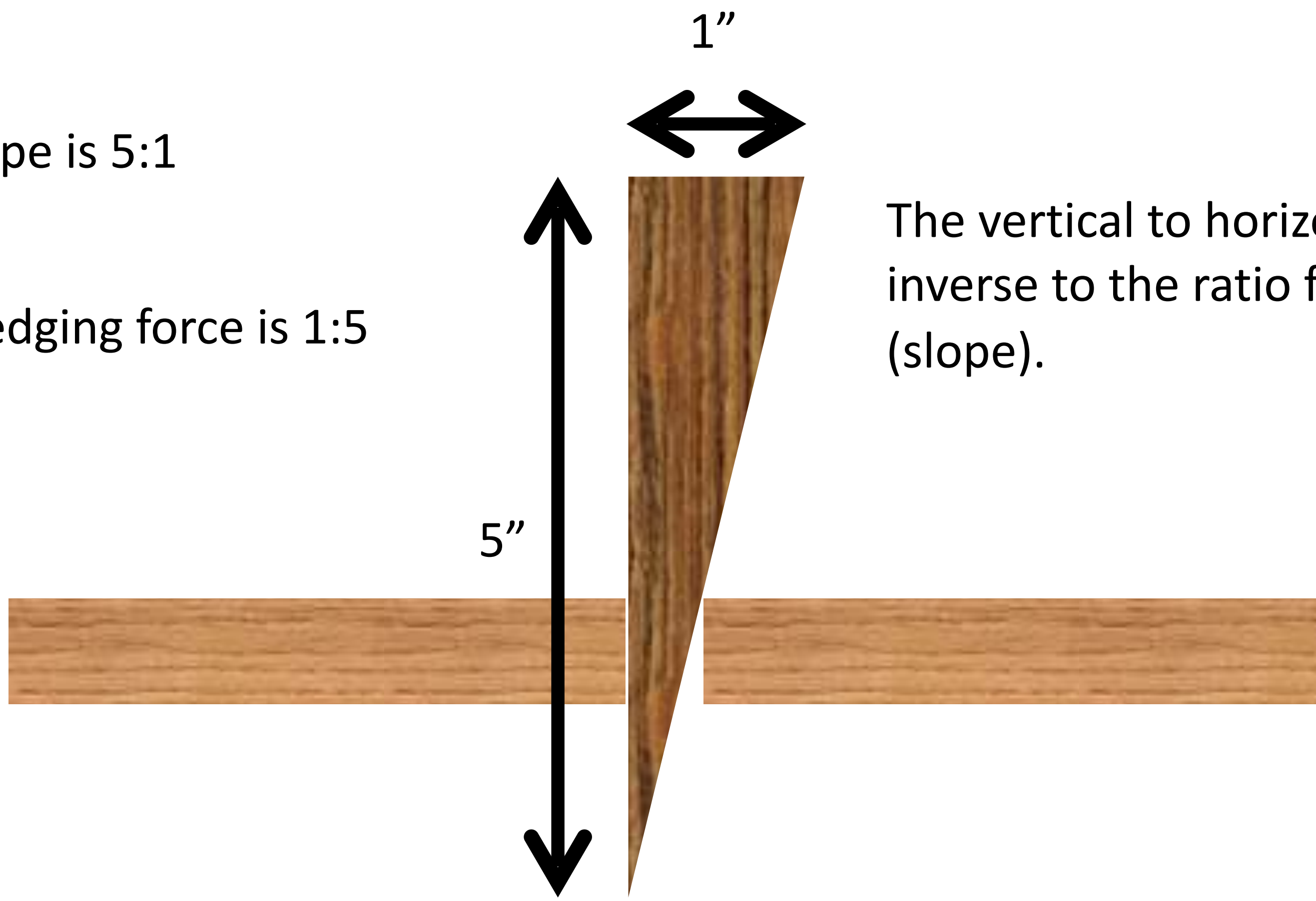
Shackle Wedging

Slope is 5:1

Wedging force is 1:5



The vertical to horizontal force ratio is inverse to the ratio for the distance (slope).

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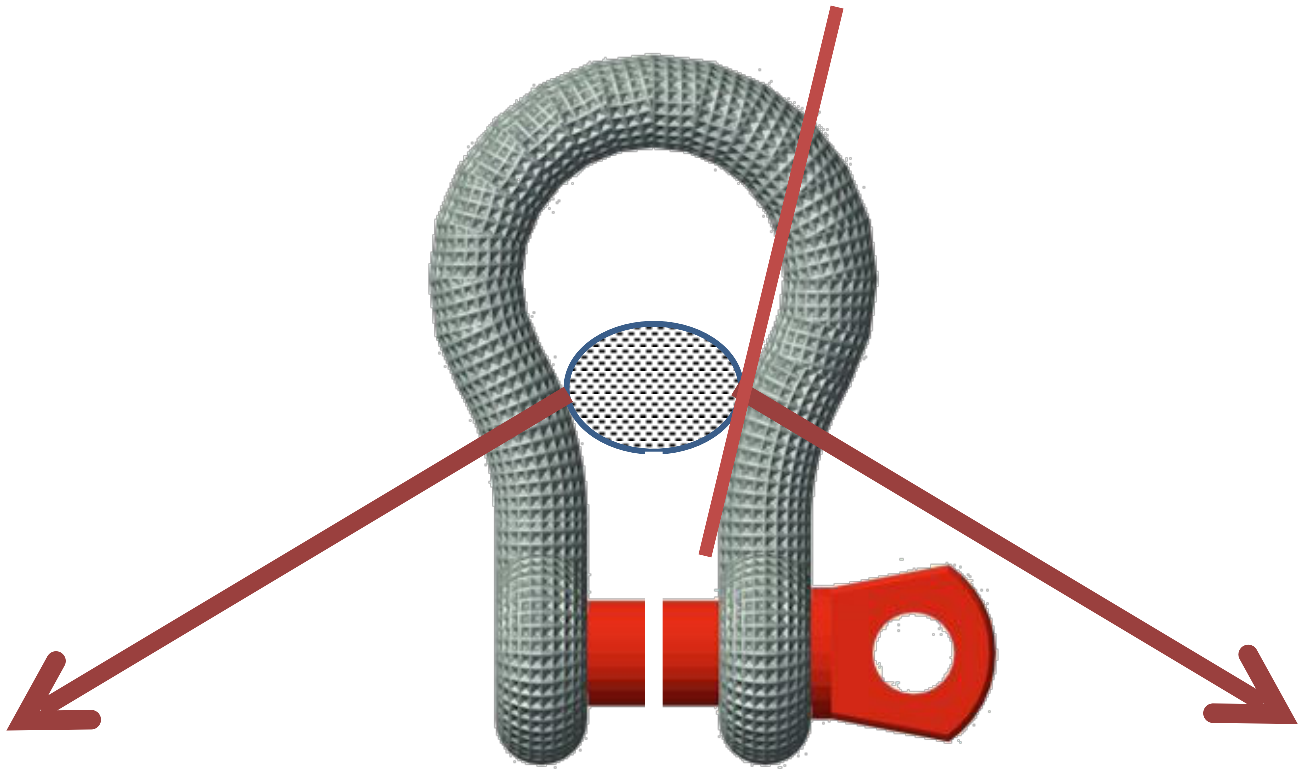
Shackle Wedging



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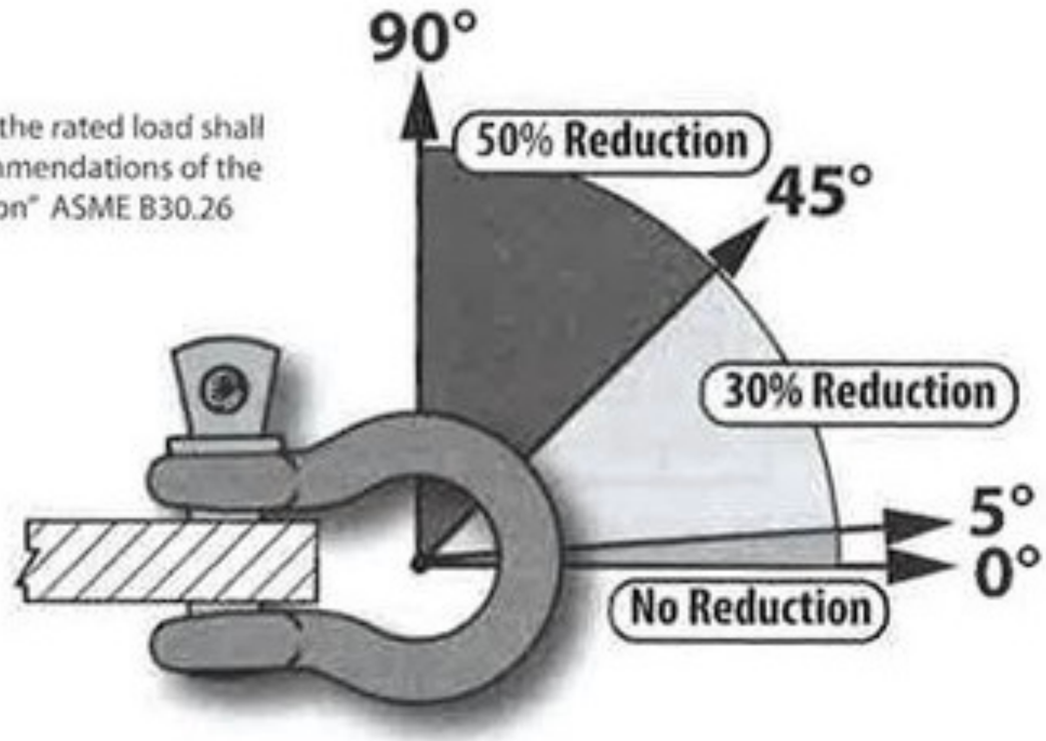
Hardware: Shackles

"If the shackle is to be side loaded, the rated load shall be reduced according to the recommendations of the manufacturer or a qualified person" ASME B30.26



ENTERTAINMENT RIGGING SERVICES, LLC

Hardware: Chain

- Grade 30 Proof Coil Chain
- STAC (Deck) Chain
- Grade 63 Theatrical Chain

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Hardware: Chain

National Association of Chain Manufactures (NACM)

Overhead Lifting: That process of lifting that would elevate a freely suspended load to such a position that dropping the load would present a possibility of bodily injury or property damage.

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Hardware: Chain

- Grade 30 Proof Coil Chain
  - Standard size used in theatres is 1/4”
  - 5/16” or larger is marked every 3 feet

Size	Working Load Limit (Pounds)
3/16”	800
1/4"	1,300
5/16”	1,900
3/8”	2,650
1/2"	4,500
5/8”	6,900

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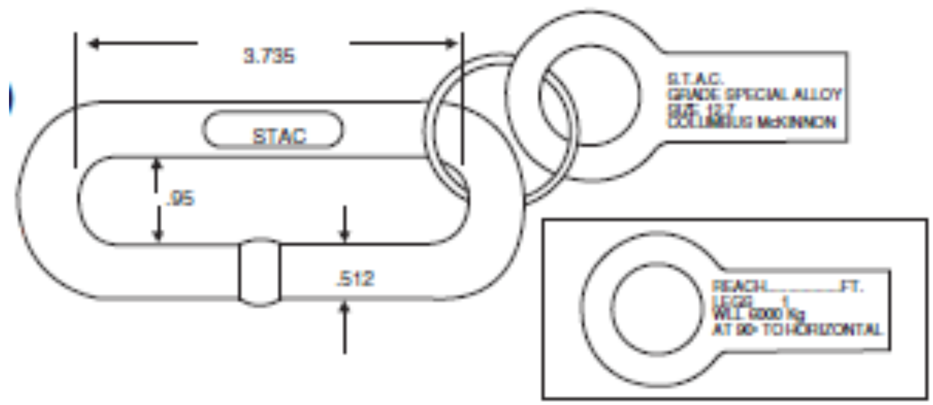
Hardware: Chain

- STAC (Deck) Chain
  - Manufactured by CM
  - Each link is proof tested and marked
  - WLL of 12,000 pounds
  - Made from Grade 80 alloy Steel



Hardware: Chain

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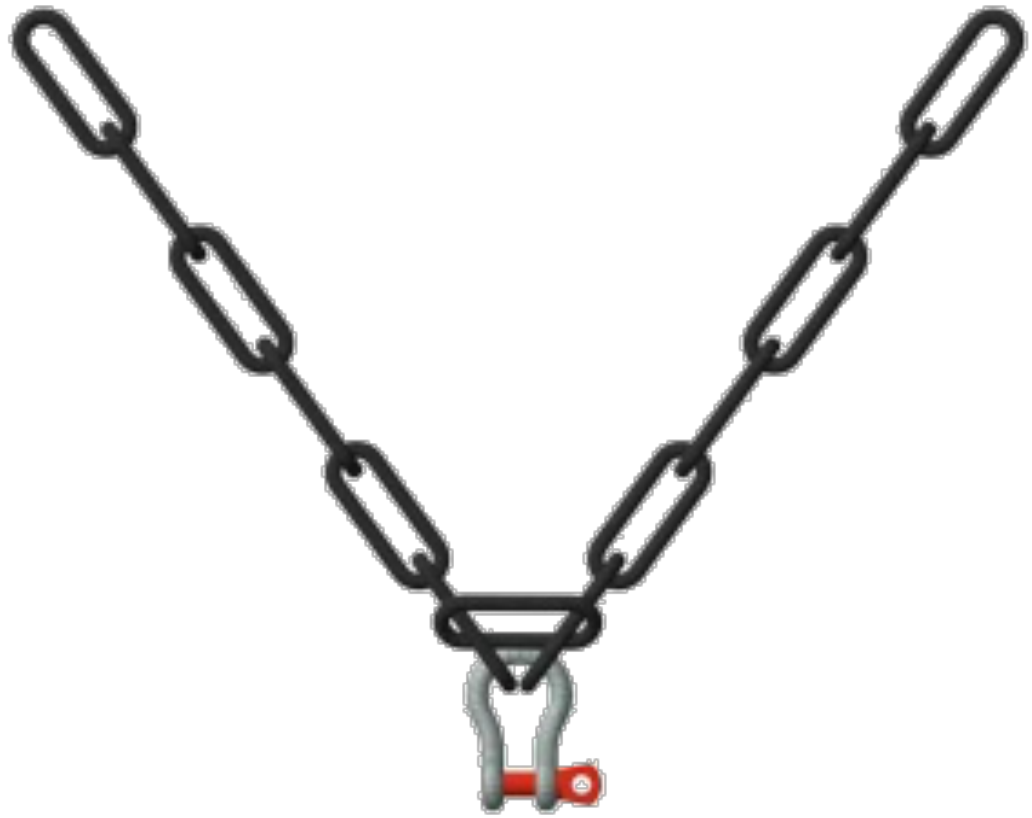
Hardware: Chain



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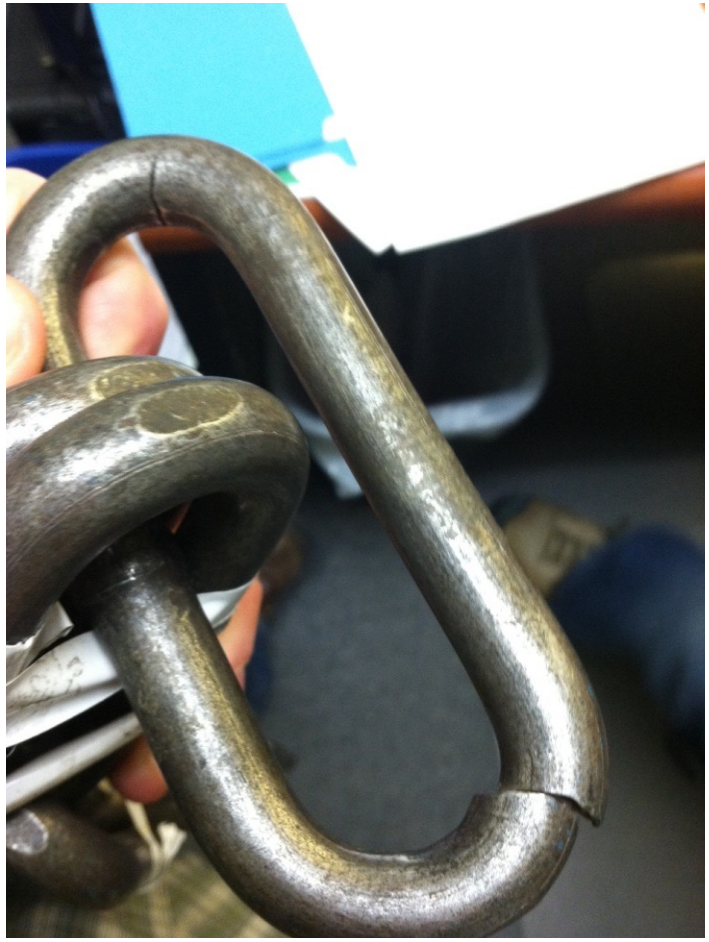
Hardware: Chain



ENTERTAINMENT
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Hardware: Chain

- Grade 63 Theatrical Chain
  - Same size as 1/4“ Proof Coil Chain
  - WLL of 3,250 pounds
  - Proof Tested
  - Made from Grade a steel

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Hardware: Scaffold clamps

WLL = 1100lbs vertically

WLL = ?

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Hardware: Sheaves

- D/d ratio
  - The ratio of the tread diameter to the rope diameter
- Wire rope D/d is 30/1
- Fiber Rope D/d is 8/1

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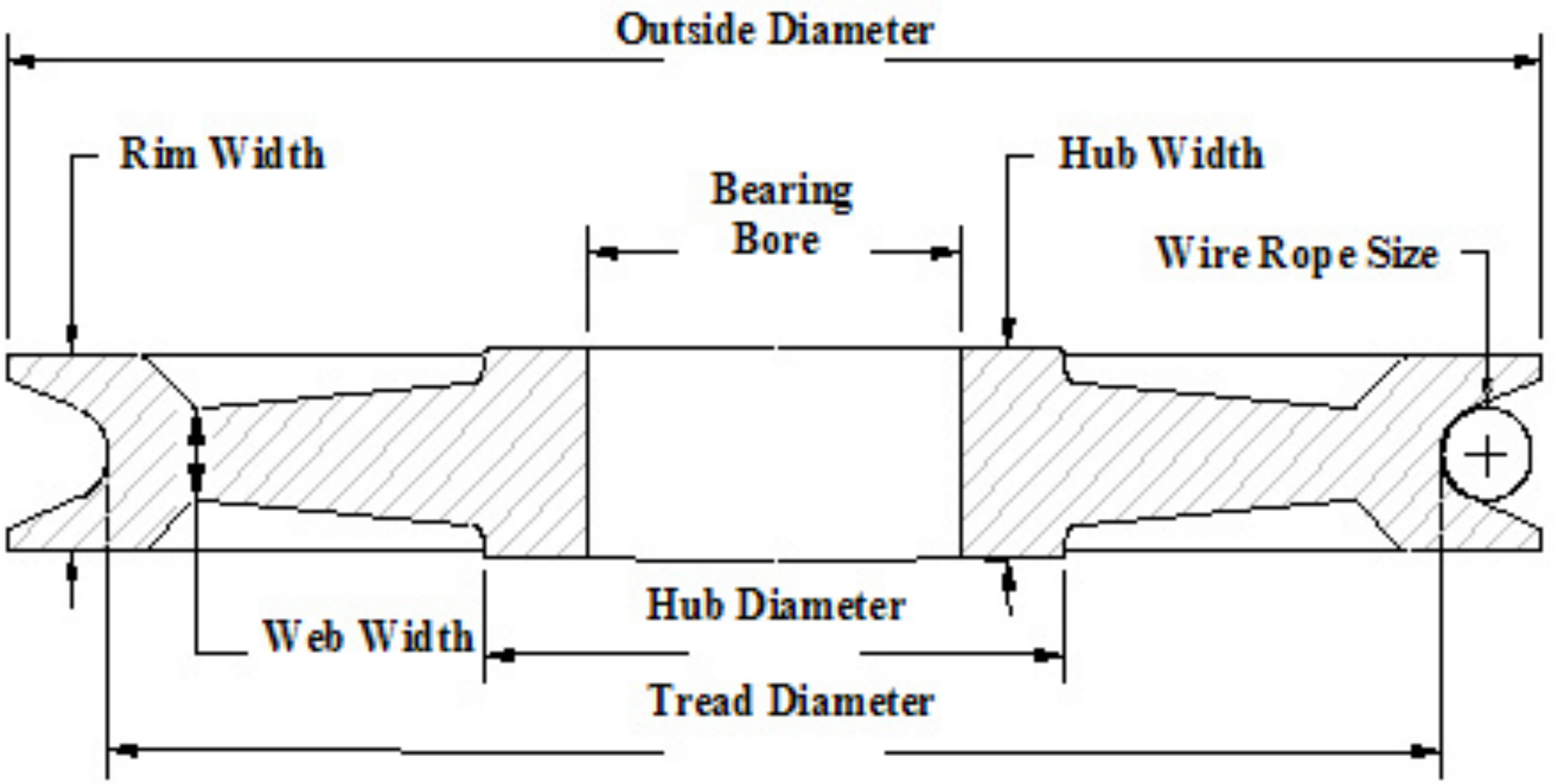
Hardware: Sheaves



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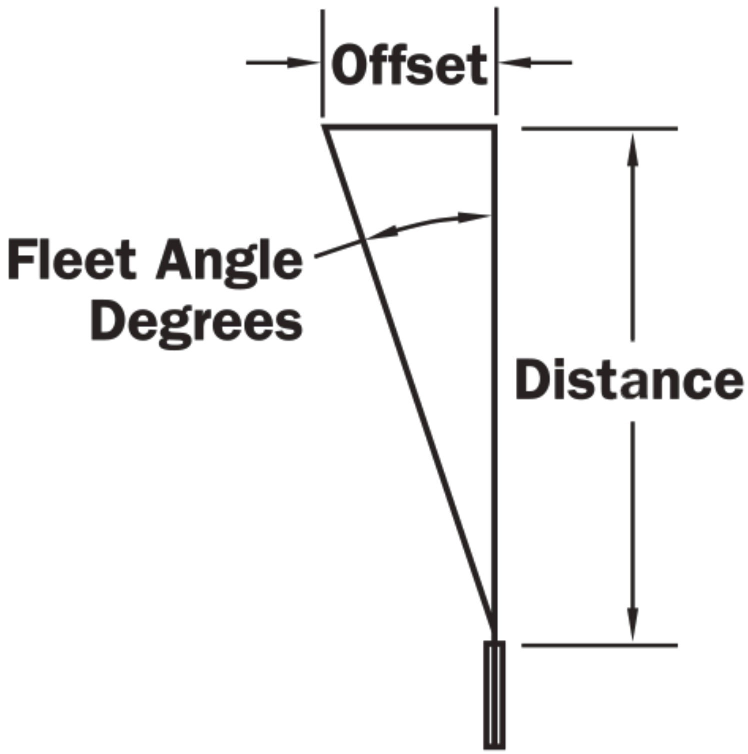
Hardware: Sheaves



- Fleet Angle
  - The angle the rope leaves the sheave at
- Max fleet angle is 1.5°
- Multiply distance in feet by .314 to get offset in inches.

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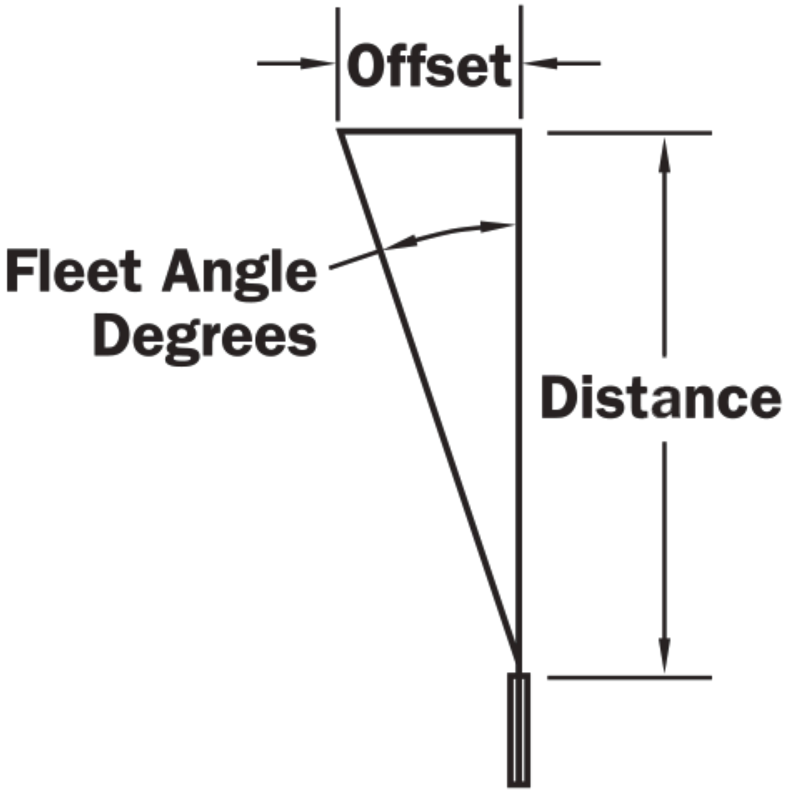
Hardware: Sheaves



- Fleet Angle
  - The angle the rope leaves the sheave at
- Max fleet angle is 1.5°
- Multiply distance in feet by .314 to get offset in inches.

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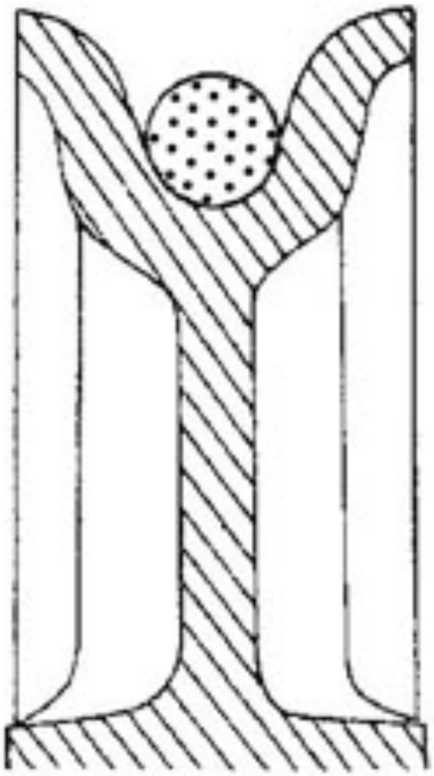
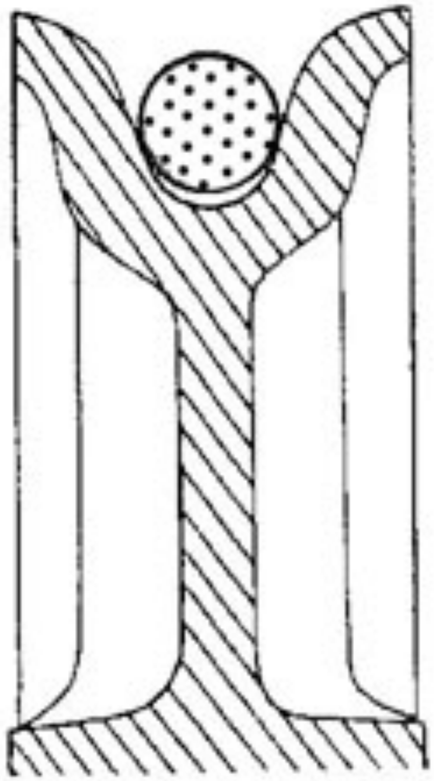
Hardware: Sheaves

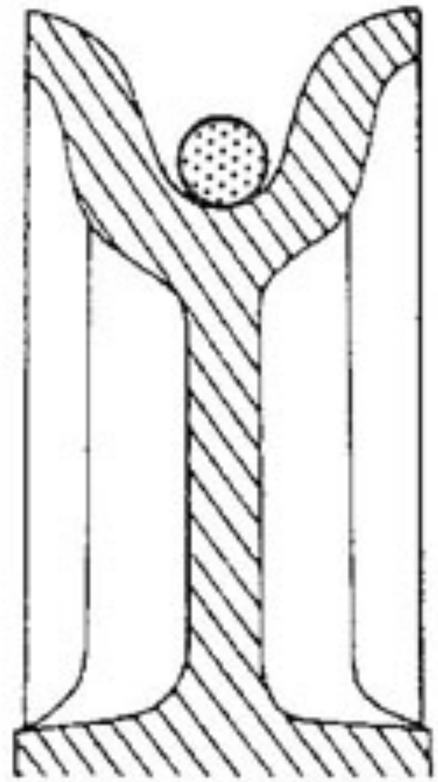
Properly matched rope and sheave



Rope is too large — will pinch



Rope is too small — will flatten



Hardware: Pipe

- Standard pipe used is 1 1/2“ Schedule 40 iron pipe
- 1.9” outside diameter
- 1.61” inside diameter
- ANSI E1.4-20099 section 3.8.1(b)

Battens exceeding one standard pipe length shall be joined using internal splicing sleeves. Threaded couplers shall not be permitted. Spliced battens shall have at least the same overall capacity, deflection, and strength as the component pipe. Battens shall be coated with a rust resistant finish. A minimum of 100 mm (4 inches) at each end of the batten shall be permanently marked with an approved OSHA color, except in architecturally sensitive areas.

ENTERTAINMENT RIGGING SERVICES, LLC

Hardware: Pipe

Span between points	8’	9’	10’	11’	12’	13’	14’	15’
Uniform Strength	83	65	52	43	36	30	25	22
Uniform Deflection	90	62	45	33	25	19	15	11
Point Strength	276	245	221	201	184	170	158	147
Point Deflection	246	194	157	130	109	93	80	70

Load per foot for 1.5” Schedule 40 pipe

From J.R. Clancy iRigging App

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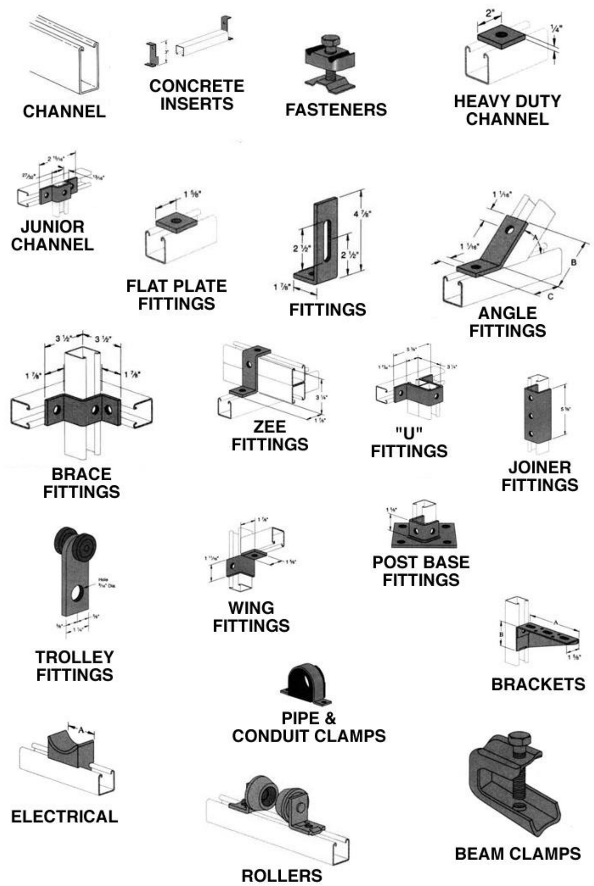
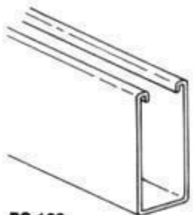
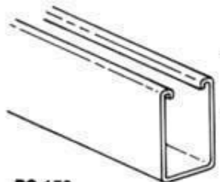
Strut


CHANNEL
CONCRETE INSERTS
FASTENERS
HEAVY DUTY CHANNEL
JUNIOR CHANNEL
FLAT PLATE FITTINGS
FITTINGS
ANGLE FITTINGS
BRACE FITTINGS
ZEE FITTINGS
"U" FITTINGS
JOINER FITTINGS
POST BASE FITTINGS
TROLLEY FITTINGS
WING FITTINGS
BRACKETS
PIPE & CONDUIT CLAMPS
ELECTRICAL
ROLLERS
BEAM CLAMPS

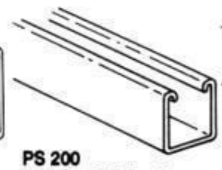
Strut



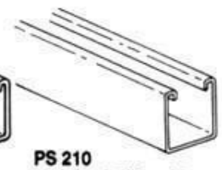
PS 100
1 5/8" x 3 1/4" x 12 ga.



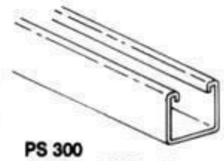
PS 150
1 5/8" x 2 7/16" x 12 ga.



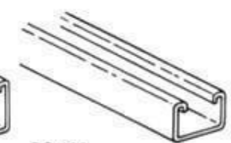
PS 200
1 5/8" x 1 5/8" x 12 ga.



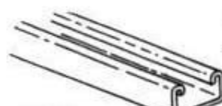
PS 210
1 5/8" x 1 5/8" x 14 ga.



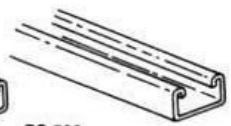
PS 300
1 5/8" x 1 3/8" x 12 ga.



PS 400
1 5/8" x 1" x 12 ga.



PS 500
1 5/8" x 13/16" x 14 ga.

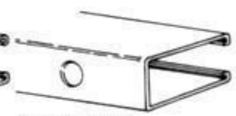


PS 520
1 5/8" x 13/16" x 12 ga.

Channel With Holes
PS 100 H
PS 150 H
PS 200 H
PS 210 H
PS 300 H
PS 400 H
PS 500 H
PS 520 H

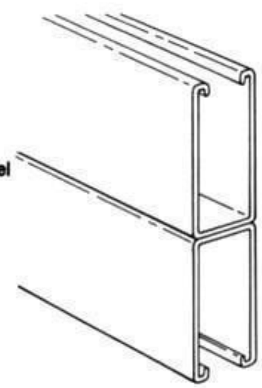
Channel With
Long Slots
PS 100 S
PS 150 S
PS 200 S
PS 210 S
PS 300 S
PS 400 S
PS 500 S
PS 520 S

Channel With
Elongated Holes
PS 100 EH
PS 150 EH
PS 200 EH
PS 210 EH
PS 300 EH
PS 400 EH
PS 500 EH
PS 520 EH



Channel With
Knockouts
PS 100 K06
PS 150 K06
PS 200 K06
PS 210 K06
PS 300 K06
PS 400 K06

Welded Channel
PS 100 2T3
PS 150 2T3
PS 200 2T3
PS 210 2T3
PS 300 2T3
PS 400 2T3
PS 500 2T3
PS 520 2T3



ENTERTAINMENT
RIGGING SERVICES, LLC

Strut

BEAM LOADING – PS 200

Span	Max Allowable Uniform Load	Defl. at Uniform Load	Uniform Loading at Deflection Span/180	Uniform Loading at Deflection Span/240	Uniform Loading at Deflection Span/360
In	*Lbs*	*In*	*Lbs*	*Lbs*	*Lbs*
24	1,690	0.06	1,690	1,690	1,690
36	1,130	0.13	1,130	1,130	900
48	850	0.22	850	760	510
60	680	0.35	650	490	320
72	560	0.50	450	340	220
84	480	0.68	330	250	170
96	420	0.89	250	190	130
108	380	1.13	200	150	100
120	340	1.40	160	120	80
144	280	2.01	110	80	60
168	240	2.74	80	60	40
192	210	3.57	60	50	NR
216	190	4.52	50	40	NR
240	170	5.58	40	NR	NR

This load table is based on a solid channel section.

For concentrated load at center of span, divide uniform load by 2 and multiply corresponding deflection by 0.8.

For Pierced Channels, reduce beam load values as follows:

PS-200-EH	15%	PS-200-S	15%
PS-200-H	10%	PS-200-KO6	5%
PS-200-SB	30%		

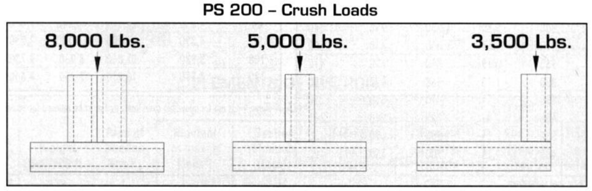
For Extruded Aluminum Channels, reduce beam load values 38%.

COLUMN LOADING – PS 200

Unbraced Height	Maximum Allowable Load at Slot Face	Maximum Column Load Applied at C.G. K = 0.65	K = 0.80	K =1.0	K = 1.2
In	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*
24	3,450	10,750	9,900	8,770	7,730
36	3,050	8,910	7,730	6,370	5,280
48	2,660	7,250	5,980	4,660	3,770
60	2,290	5,890	4,660	3,600	2,940
72	2,000	4,800	3,770	2,940	2,380
84	1,760	4,010	3,170	2,460	1,970
96	1,570	3,450	2,730	2,090	1,650
108	1,410	3,020	2,380	1,800	**
120	1,270	2,680	2,090	**	**

Column loads are for allowable axial loads and must be reduced for eccentric loading.

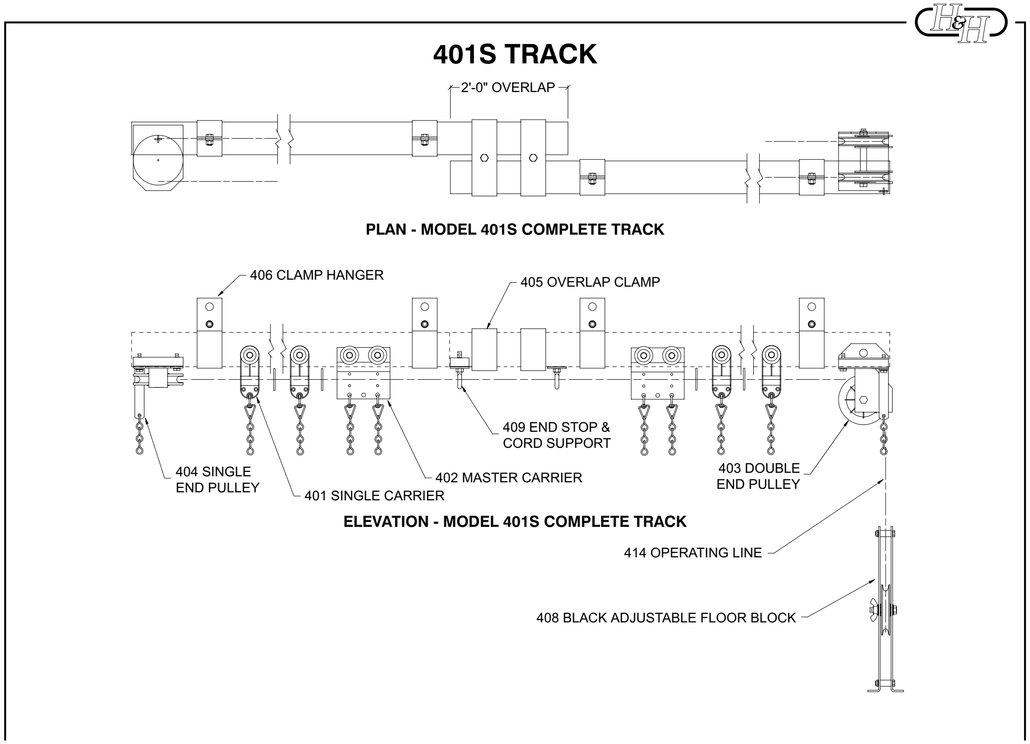
PS 200 – Crush Loads



Resistance to Slip – 1,500 lbs. per bolt when ½" PS NS channel nuts are used.

Pull Out Strength – 2,000 lbs. per bolt when ½" PS NS channel nuts are used.

Traveler Track



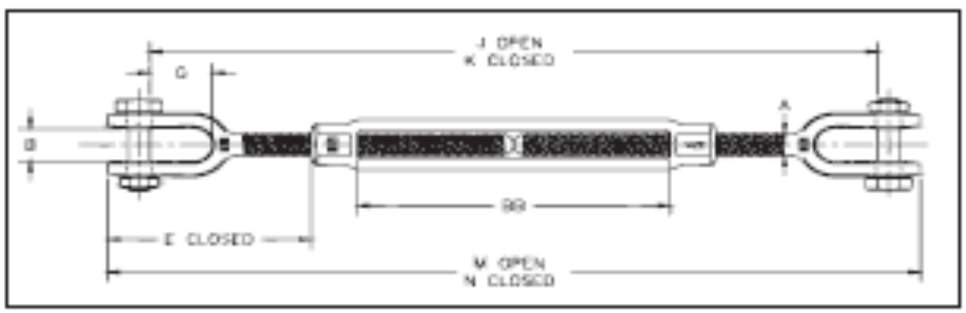
ENTERTAINMENT
RIGGING SERVICES, LLC

Jaw & Jaw Turnbuckles

"QT" Fatigue Rated

HG-228

- End fittings are Quenched and Tempered or Normalized, bodies heat treated by normalizing.
- Hot Dip galvanized steel.
- TURNBUCKLES RECOMMENDED FOR STRAIGHT OR IN-LINE PULL ONLY.
- Forged jaw ends are fitted with bolts and nuts for 1/4" through 5/8", and pins and cotters on 3/4" through 2-3/4" sizes.
- Modified UNJ thread on end fittings for improved fatigue properties.
- Body has UNC threads.
- Meets or exceeds all requirements of ASME B30.26 including identification, ductility, design factor, proof load and temperature requirements. Importantly, these turnbuckles meet other critical performance requirements including fatigue life, impact properties and material traceability, not addressed by ASME B30.26.
- Lock Nuts available for all sizes (see page 178).
- Comprehensive end fitting data provided on page 176.
- Fatigue Rated.



Meets the performance requirements of Federal Specifications FF-T-791b,Type 1, Form 1 - CLASS 7, and ASTM F-1145, except for those provisions required of the contractor. For additional information, see page 426.

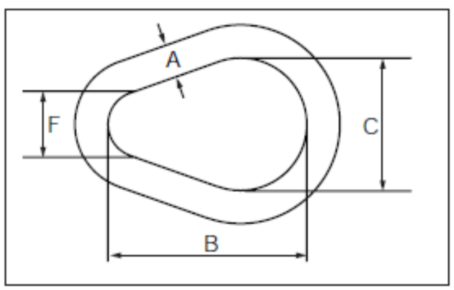
HG-228
Jaw & Jaw

ENTERTAINMENT RIGGING SERVICES, LLC

Miscellaneous Hardware

G-341 / S-341

- Forged carbon steel - Quenched and Tempered.
- Self Colored or Hot Dip galvanized.



G-341 / S-341 Weldless Sling Links

Size (A) (in.)	Stock No.		Working Load Limit Single Pull (lbs.)*	Weight Each (lbs.)	Dimensions (in.)		
	G-341 Galv.	S-341 S.C.			B	C	F
3/8	1013897	1013904	1800	.23	2.25	1.50	.75
1/2	1013913	1013922	2900	.55	3.00	2.00	1.00
5/8	1013931	1013940	4200	1.06	3.75	2.50	1.25
3/4	1013959	1013968	6000	1.88	4.50	3.00	1.50
7/8	1013977	1013986	8300	2.75	5.25	3.50	1.75
1	1013995	1014002	10800	4.35	6.00	4.00	2.00
1 1/4	1014011	1014020	16750	7.60	7.75	5.00	2.50
1 3/8	1014039	1014048	20500	11.30	8.25	5.50	2.75

*Ultimate Load is 6 times the Working Load Limit. Based on single leg sling (in-line load), or resultant load on multiple legs with an included angle less than or equal to 120°.

ENTERTAINMENT RIGGING SERVICES, LLC

Miscellaneous Hardware

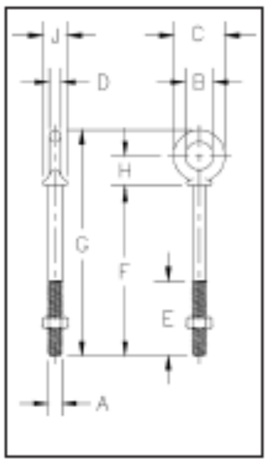
Forged Eye Bolts

"QT" Fatigue Rated QUIC-CHECK®

SEE APPLICATION AND WARNING INFORMATION
Para Español: www.thecrosbygroup.com
On Page 180-181

G-277

- Forged Steel - Quenched and Tempered.
- Fatigue rated at 1-1/2 times the Working Load Limit at 20,000 cycles.
- Working Load Limits shown are for in-line pull. For angle loading, see page 180.
- Meets or exceeds all requirements of ASME B30.26 including identification, ductility, design factor, proof load and temperature requirements. Importantly, these bolts meet other critical performance requirements including fatigue life, impact properties and material traceability, not addressed by ASME B30.26.
- All Bolts Hot Dip galvanized after threading (UNC).
- Furnished with standard Hot Dip galvanized, heavy hex nuts.



G-277 Shoulder Nut Eye Bolts

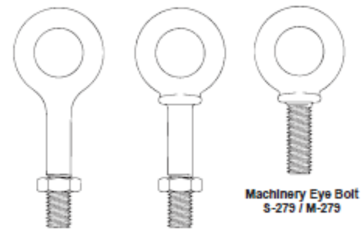
Shank Dia. & Length (in.)	G-277 Stock No.	Working Load Limit (lbs.)*	Weight Each Per 100 (lbs.)	Dimensions (in.)								
				A	B	C	D	E	F	G	H	J
1/4 x 2	1045014	650	6.60	.25	.50	.88	.19	1.50	2.00	2.94	.50	.47
1/4 x 4	1045032	650	9.10	.25	.50	.88	.19	2.50	4.00	4.94	.50	.47
5/16 x 2-1/4	1045050	1200	12.50	.31	.62	1.12	.25	1.50	2.25	3.50	.69	.56
5/16 x 4-1/4	1045078	1200	18.80	.31	.62	1.12	.25	2.50	4.25	5.50	.69	.56
3/8 x 2-1/2	1045096	1550	21.40	.38	.75	1.38	.31	1.50	2.50	3.97	.78	.66
3/8 x 4-1/2	1045112	1550	25.30	.38	.75	1.38	.31	2.50	4.50	5.97	.78	.66
1/2 x 3-1/4	1045130	2600	42.60	.50	1.00	1.75	.38	1.50	3.25	5.12	1.00	.91
1/2 x 6	1045158	2600	56.80	.50	1.00	1.75	.38	3.00	6.00	7.88	1.00	.91
5/8 x 4	1045176	5200	68.60	.62	1.25	2.25	.50	2.00	4.00	6.44	1.31	1.12
5/8 x 6	1045194	5200	102.40	.62	1.25	2.25	.50	3.00	6.00	8.44	1.31	1.12
3/4 x 4-1/2	1045210	7200	144.50	.75	1.50	2.75	.62	2.00	4.50	7.44	1.56	1.38
3/4 x 6	1045238	7200	167.50	.75	1.50	2.75	.62	3.00	6.00	8.94	1.56	1.38
7/8 x 5	1045256	10600	225.00	.88	1.75	3.25	.75	2.50	5.00	8.46	1.84	1.56
1 x 6	1045292	13300	366.30	1.00	2.00	3.75	.88	3.00	6.00	9.97	2.09	1.81
1 x 9	1045318	13300	422.50	1.00	2.00	3.75	.88	4.00	9.00	12.97	2.09	1.81
1-1/4 x 8	1045336	21000	650.00	1.25	2.50	4.50	1.00	4.00	8.00	12.72	2.47	2.28
1-1/4 x 12	1045354	21000	795.00	1.25	2.50	4.50	1.00	4.00	12.00	16.72	2.47	2.28
1-1/2 x 15	1045372	24000	1425.00	1.50	3.00	5.50	1.25	6.00	15.00	20.75	3.00	2.75

*Ultimate Load is 5 times the Working Load Limit. Maximum Proof Load is 2 times the Working Load Limit.

ENTERTAINMENT
RIGGING SERVICES, LLC

Miscellaneous Hardware

FORGED EYE BOLT WARNINGS AND APPLICATION INSTRUCTIONS



Regular Nut Eye Bolt G-291 | Shoulder Nut Eye Bolt G-277 | Machinery Eye Bolt S-279 / M-279

Important Safety Information - Read & Follow

Inspection/Maintenance Safety:

- Always inspect eye bolt before use.
- Never use eye bolt that shows signs of wear or damage.
- Never use eye bolt if eye or shank is bent or elongated.
- Always be sure threads on shank and receiving holes are clean.
- Never machine, grind, or cut eye bolt.

Assembly Safety:

- Never exceed load limits specified in Table I & Table 2.
- Never use regular nut eye bolts for angular lifts.
- Always use shoulder nut eye bolts (or machinery eye bolts) for angular lifts.
- For angular lifts, adjust working load as follows:

Direction of Pull (from In-Line)	Adjusted Working Load
45 degrees	30% of rated working load
90 degrees	25% of rated working load

- Never undercut eye bolt to seat shoulder against the load.
- Always countersink receiving hole or use washers with sufficient I.D. to seat shoulder.
- Always screw eye bolt down completely for proper seating.
- Always tighten nuts securely against the load.

⚠ WARNING

- **Load may slip or fall if proper eye bolt assembly and lifting procedures are not used.**
- **A falling load can seriously injure or kill.**
- **Read and understand both sides of these instructions, and follow all eye bolt safety information presented here.**
- **Read, understand, and follow information in diagrams and charts below before using eye bolt assemblies.**

Shoulder Nut Eye Bolt – Installation for Angular Loading

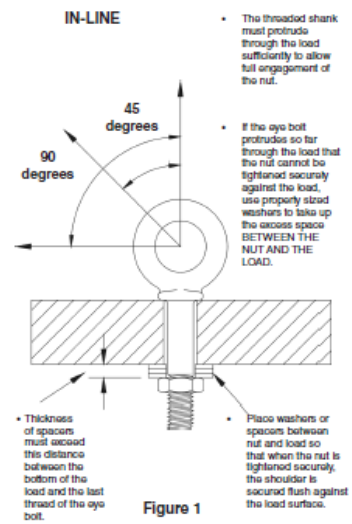


Figure 1

Table 1 (In-Line Load)	
Size (in.)	**Working Load Limit (lbs.)**
1/4	650
5/16	1,200
3/8	1,550
1/2	2,600
5/8	5,200
3/4	7,200
7/8	10,600
1	13,300
1-1/8	15,000
1-1/4	21,000
1-1/2	24,000
1-3/4	34,000
2	42,000
2-1/2	65,000

Table 2 (In-Line Load)	
Metric Size	**Working Load Limit - kg**
m6	200
m8	400
m10	640
m12	1000
m16	1800
m20	2500
m24	4000
m27	5000
m30	6000
m36	8500
m42	14000
m48	17300
m64	29500

rev 6

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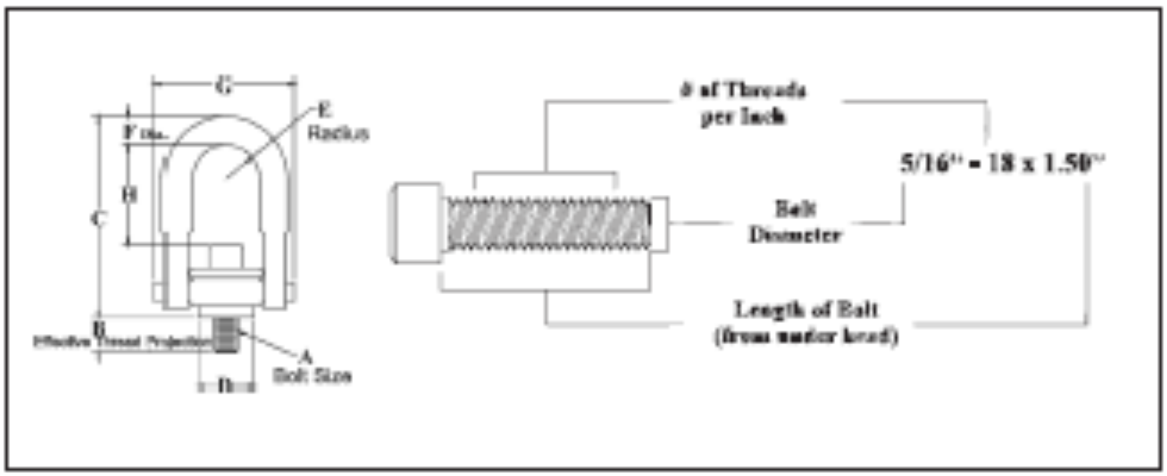
Miscellaneous Hardware

Load Rated Fatigue Rated

SEE APPLICATION AND WARNING INFORMATION
Para Español: www.thecrosbygroup.com
On Page 190-192

HR-125

- Top washer has the following features:
  - The Working Load Limit and Recommended Torque value are permanently stamped into each washer.
  - Washer is color coded for easy identification: Red - UNC thread.
- Individually Proof Tested to 2-1/2 times Working Load Limit.
- Bolt specification is a Grade 8 Alloy socket head cap screw to ASTM A 574. All threads listed are UNC.
- **BOLT SIZE IDENTIFICATION**: The size of the bolt will be stated as in the drawing below. Illustration shows meaning of each dimension given.
- NOTE: For Special Applications, see page 432.
- Frame 2 and larger are **RFID EQUIPPED**.



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Miscellaneous Hardware

Quick Links

- Not often load rated
- Load must be on axis
- Gate can open if used improperly

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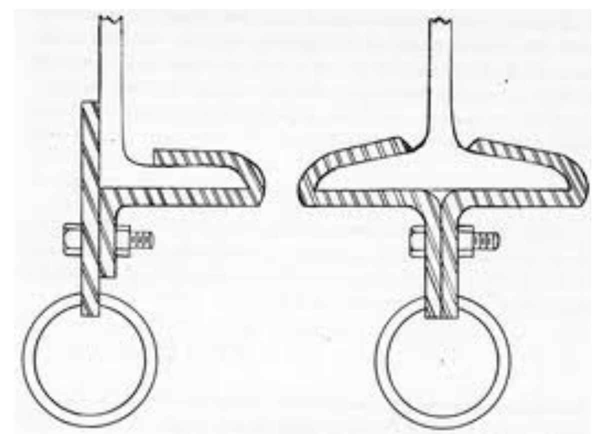
Miscellaneous Hardware

Beam Clamps

- Different Materials
- Rating
- Permanent or portable



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Hardware: Reduction of Strength

What causes a reduction of strength?

- Bending
- Environmental
- Time
- Shock

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Hardware: Reduction of Strength

Bending

D/d	Static Polyester rope
8	100
6	100
5	100
4	88
3	83
2.5	No data
2	No data
1.5	No data
1	No data

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Hardware: Reduction of Strength

Bending

Knot Type	Efficiency percentage
Clove Hitch	75
Clove Hitch with (2) half hitches	65
Figure Eight	64
Square Knot	43
Bowline	50
Eye Splice	85

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Hardware: Reduction of Strength

Environmental

- Rot
- Mildew
- UV light
- Acids
- Alkalis
- Chemicals
- Cuts
- Kinking
- Dirt
- Water

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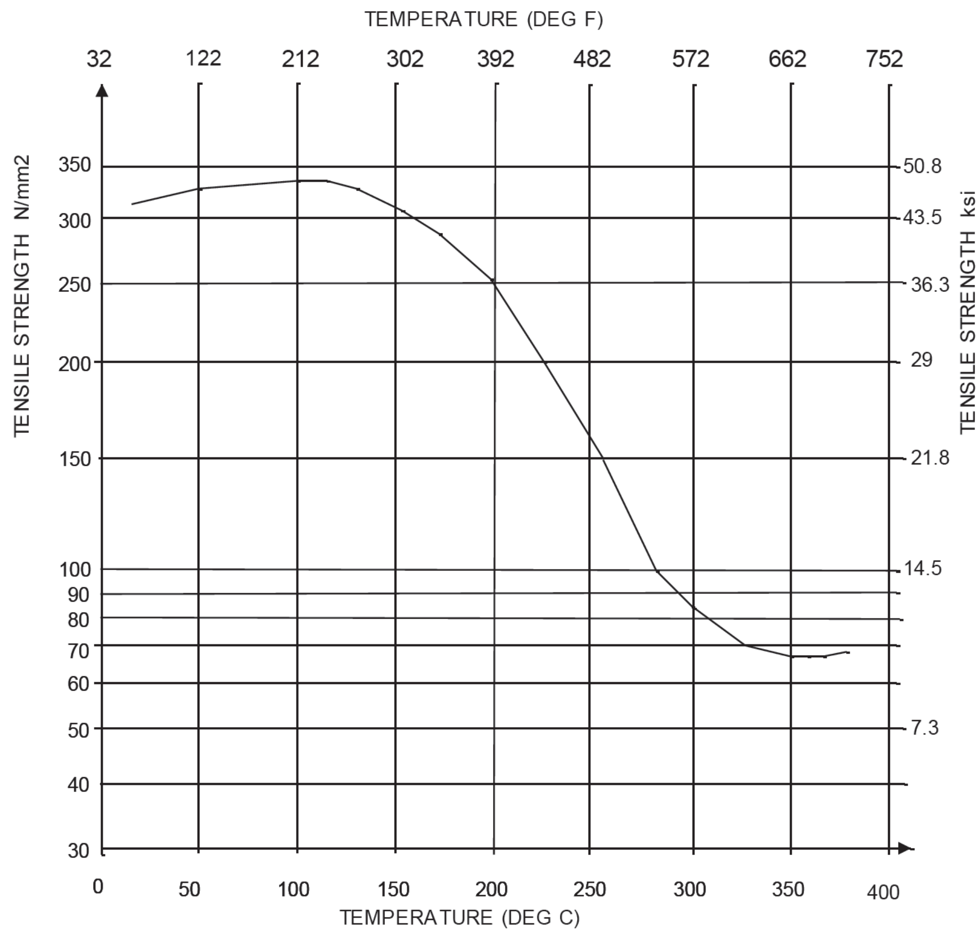
Hardware: Reduction of Strength



GRAPH FOR 6061-T6 ALUMINUM

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Hardware: Reduction of Strength

Steel has a melting point of about 2700°F

Hardware: Reduction of Strength

- Repetitive Fatigue
- Prolonged load
- General wear and tear

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Shock Loads

$$ShockLoadForce = Load(1 + \frac{FreeFallDistance}{StoppingDistance})$$

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Hardware: Reduction of Strength

Shock Loads

- 4000lbs on two 1ton motors
- 5’ GAC safety with a W.L.L. of 2800lbs THROUGH center of truss
- Truss drops 15” before safety takes load
- Truss stops in 1”

$$ShockLoadForce = Load\left(1 + \frac{FreeFallDistance}{StoppingDistance}\right)$$

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Truss

Why Aluminum?

Numerous aluminum alloys

Good corrosion resistance

Readily available

High strength to weight ratio

High conductivity

High cost

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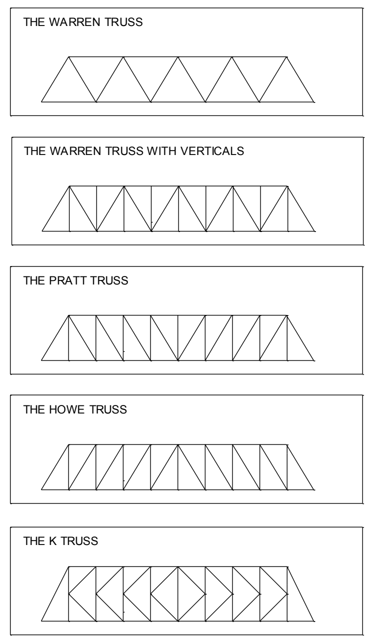
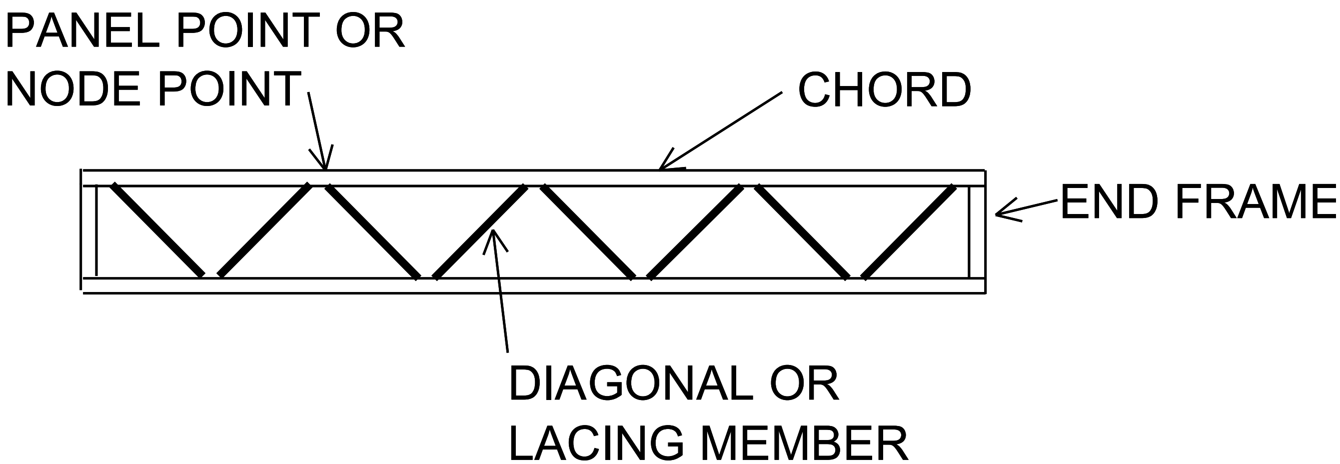
Truss

Types of truss

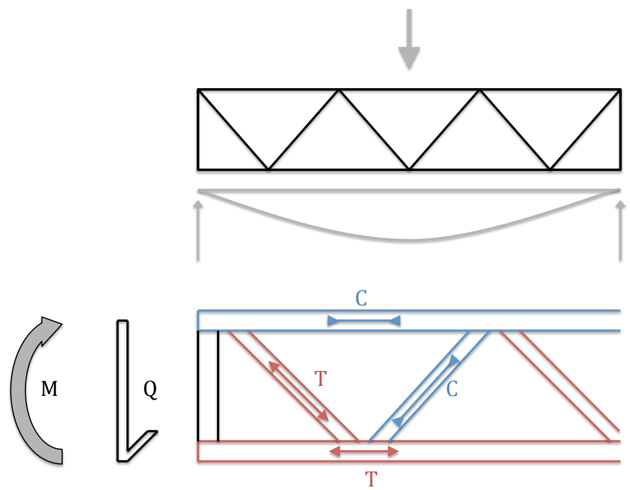


Truss


PANEL POINT OR
NODE POINT
CHORD
END FRAME
DIAGONAL OR
LACING MEMBER

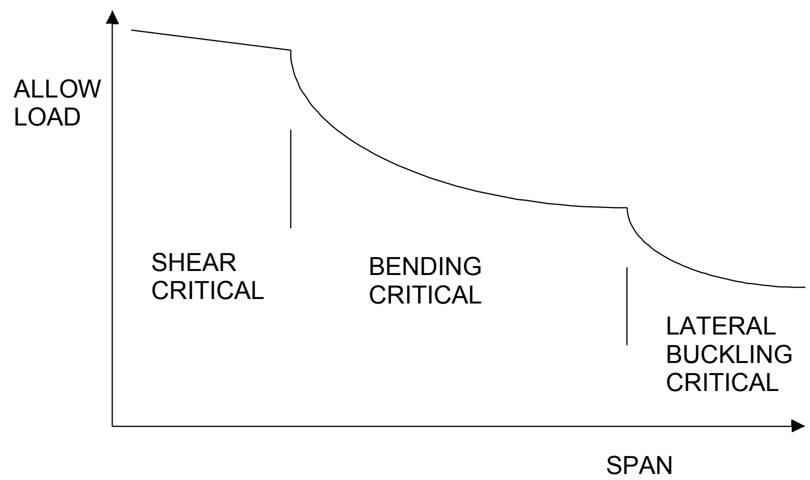
Truss

Bending moment, shear force and axial loads in relation to truss



Truss

Load chart showing effect of lateral buckling



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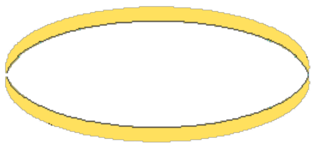
Truss

Lateral buckling

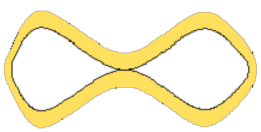
What is tension and compression?



Rubber band at rest

When we pull the rubber band, we put it in…

TENSION



When we push the rubber band, it goes into…

COMPRESSION

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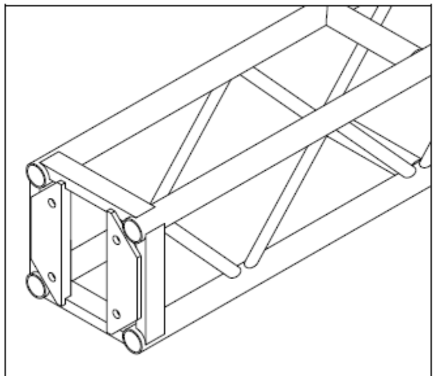
Truss Sizes

JAMES Thomas ENGINEERING

GP 12 x 12

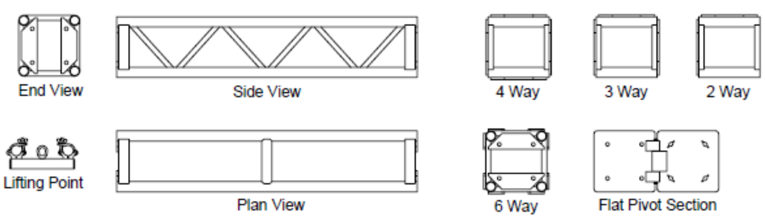
12" x 12" General Purpose truss is manufactured from 2" dia x 0.125" wall and 1" dia x 0.125" wall 6082T6 or 6061T6 Aluminium tubing. Bolts are supplied for assembly of truss elements. This truss is ideal for conference, exhibition, and small venue work. By incorporating suitable sleeve blocks and towers, this truss can be used with our Ground Support System.

PRODUCT CODE	DESCRIPTION	WT lbs
B0700	10' Section	55
B0701	8' Section	46
B0702	5' Section	35
B0703	2' 6" Section	24
B4700	3m Section	55
B4701	2.5m Section	46.5
B4702	2m Section	40.5
B4703	1.5m Section	35
B4704	1m Section	19.5
B4705	2 Way Corner Block	15
B4705A	3 Way Corner Block	17.5
B4706	4 Way Corner Block	19.5
B4707	6 Way Corner Block	26.5
B4708	Flat Plate Hinge Section	14



Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	6140 (2785)	0.276 (7)	4497 (2040)	0.315 (8)
20 (6.096)	3100 (1406)	1.10 (28)	1550 (703)	1.10 (28)
30 (9.144)	1726 (783)	2.21 (56)	864 (392)	2.21 (56)
40 (12.192)	855 (388)	2.96 (75)	428 (194)	2.96 (75)

LOADING FIGURES show maximum loads between supports in addition to the self weight of the truss. Information extracted from the structural report by Broadhurst, Goodwin, and Dunn
suit maximum shear capacity. All loads include 20% overload factor for dynamic effects.



The following slides will refer to the loading charts in the JTE product guide but we will just use the loading data as shown below.

Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	6140 (2785)	0.276 (7)	4497 (2040)	0.315 (8)
20 (6.096)	3100 (1406)	1.10 (28)	1550 (703)	1.10 (28)
30 (9.144)	1726 (783)	2.21 (56)	864 (392)	2.21 (56)
40 (12.192)	855 (388)	2.96 (75)	428 (194)	2.96 (75)

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Truss Sizes

GP 12 x 12

Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	6140 (2785)	0.276 (7)	4497 (2040)	0.315 (8)
20 (6.096)	3100 (1406)	1.10 (28)	1550 (703)	1.10 (28)
30 (9.144)	1726 (783)	2.21 (56)	864 (392)	2.21 (56)
40 (12.192)	855 (388)	2.96 (75)	428 (194)	2.96 (75)

GP 18 x 12

Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	6140 (2785)	0.276 (7)	4497 (2040)	0.20 (8)
20 (6.096)	3100 (1406)	1.10 (28)	1550 (703)	1.10 (28)
30 (9.144)	1726 (783)	2.20 (56)	864 (392)	2.20 (56)
40 (12.192)	855 (388)	2.95 (75)	427 (194)	2.95 (75)
50 (15.24)	425 (193)	3.70 (94)	214 (97)	3.70 (94)

What has changed between the 2 truss sizes?

the change in the geometry allows the truss to span 50' instead of 40'

Notes:

1. **the longest distance shown is the longest <u>CLEAR SPAN</u>**
2. **<u>DO NOT EXCEED THE LONGEST CLEAR SPAN</u>**
3. **capacity does not increase if using a single 5' instead of single 10'**

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Truss Sizes

GP 18 x 12

Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	6140 (2785)	0.276 (7)	4497 (2040)	0.20 (8)
20 (6.096)	3100 (1406)	1.10 (28)	1550 (703)	1.10 (28)
30 (9.144)	1726 (783)	2.20 (56)	864 (392)	2.20 (56)
40 (12.192)	855 (388)	2.95 (75)	427 (194)	2.95 (75)
50 (15.24)	425 (193)	3.70 (94)	214 (97)	3.70 (94)

GP 20.5 x 20.5

Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	5741 (2604)	1.06 (27)	2870 (1302)	1.06 (27)
20 (6.096)	5741 (2604)	1.06 (27)	2870 (1302)	1.06 (27)
30 (9.144)	3715 (1685)	1.57 (40)	1858 (843)	1.57 (40)
40 (12.192)	2643 (1199)	2.44 (62)	1322 (600)	2.44 (62)
50 (15.24)	1911 (867)	3.70 (94)	957 (434)	3.70 (94)

What has changed between these 2 truss sizes?

they both span the same distance, 50’
but note that the GP 20.5 is capable of higher loading than the GP 18 x 12 because we have gone to a deeper and wider truss.

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As you design your system, keep this in mind:

WHAT IS THE LIMITING FACTOR??

Can you hang 500lbs of speakers on the center point of a 40' span of GP 18" x 12"?

GP 15 x 15

Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	9200 (4173)	0.17 (4)	4600 (2086)	0.17 (4)
15 (4.572)	6100 (2766)	0.38 (9)	3050 (1383)	0.38 (9)
20 (6.096)	4500 (2041)	0.67 (17)	2250 (1020)	0.67 (17)
25 (7.62)	3500 (1587)	1.04 (26)	1750 (793)	1.04 (26)
30 (9.144)	2900 (1315)	1.50 (38)	1450 (657)	1.50 (38)
40 (12.192)	2000 (907)	2.67 (67)	1000 (453)	2.67 (67)
50 (15.24)	1300 (589)*	3.75 (95)	650 (294)*	3.75 (95)
55 (16.76)	1000 (453)*	4.13 (104)	500 (226)*	4.13 (104)

GP 18 x 12

Allowable Load Data	Maximum Allowable Uniform Loads		Maximum Allowable Center Point Loads	
Span feet (meters)	Loads pounds (kgs)	Maximum deflection inches (mm)	Loads pounds (kgs)	Maximum deflection inches (mm)
10 (3.048)	6140 (2785)	0.276 (7)	4497 (2040)	0.20 (8)
20 (6.096)	3100 (1406)	1.10 (28)	1550 (703)	1.10 (28)
30 (9.144)	1726 (783)	2.20 (56)	864 (392)	2.20 (56)
40 (12.192)	855 (388)	2.95 (75)	427 (194)	2.95 (75)
50 (15.24)	425 (193)	3.70 (94)	214 (97)	3.70 (94)

smallest GP truss that can be used

***note that 12" SuperTruss could support the load**

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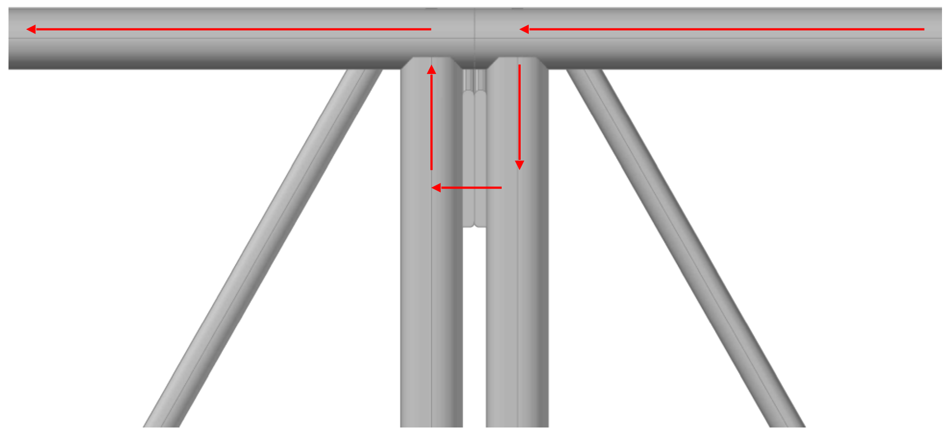
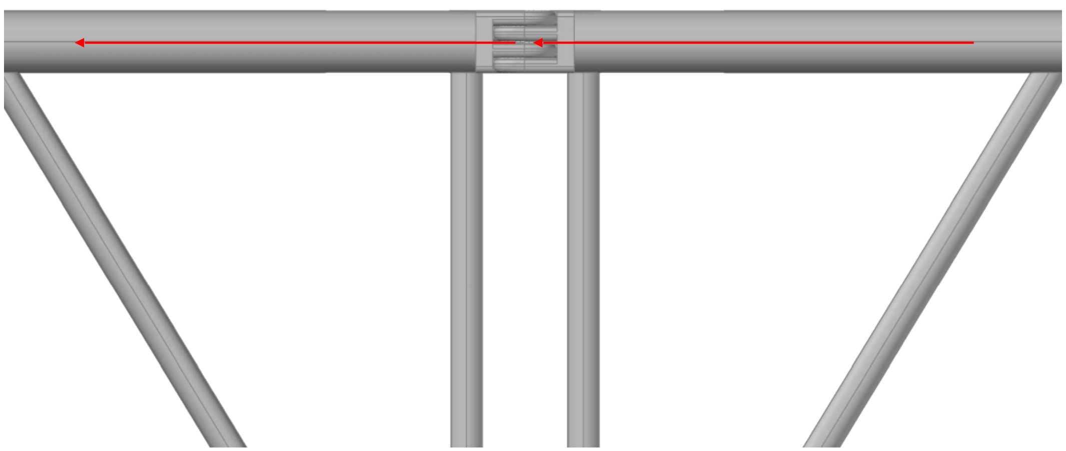
Why is SuperTruss stronger than GP (bolted)?





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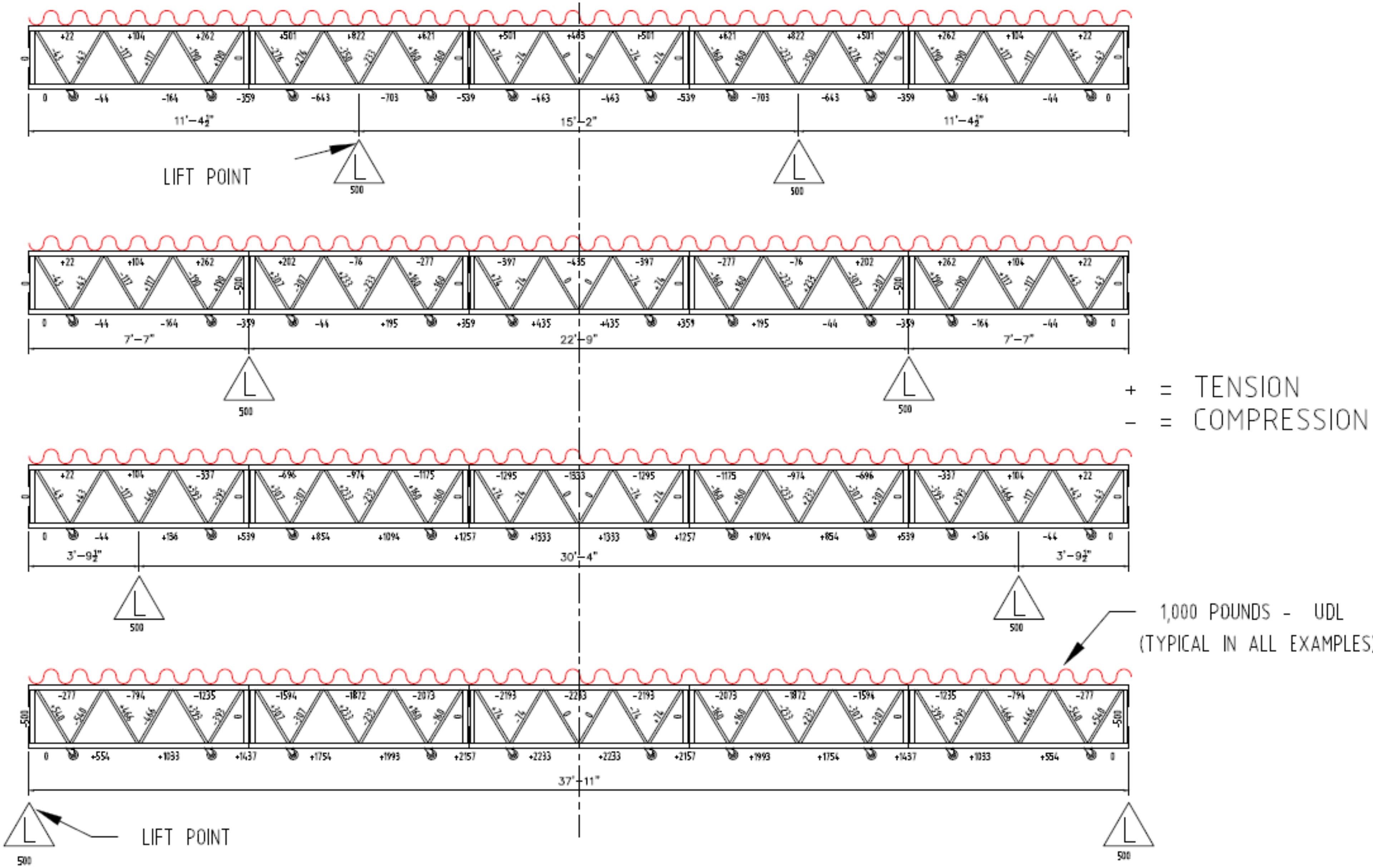

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TRUSS

- Truss Bolts
  - Torquing
  - Direction in horizontal spans and towers
  - Grade
    - 5/8” Grade 8 bolt has a rating of 27,920LBS in sheer, & 36,524LBS in tension
    - 5/8” Grade 5 bolt has a rating of 23,010LBS in sheer, & 29,218LBS in tension
  - Don’t use impact wrench!

TRUSS

Wrapping truss with slings

- Place truss in compression when ever possible
- Always pick truss at a panel point
- It is ok, even sometimes necessary to pick a truss from the top cord

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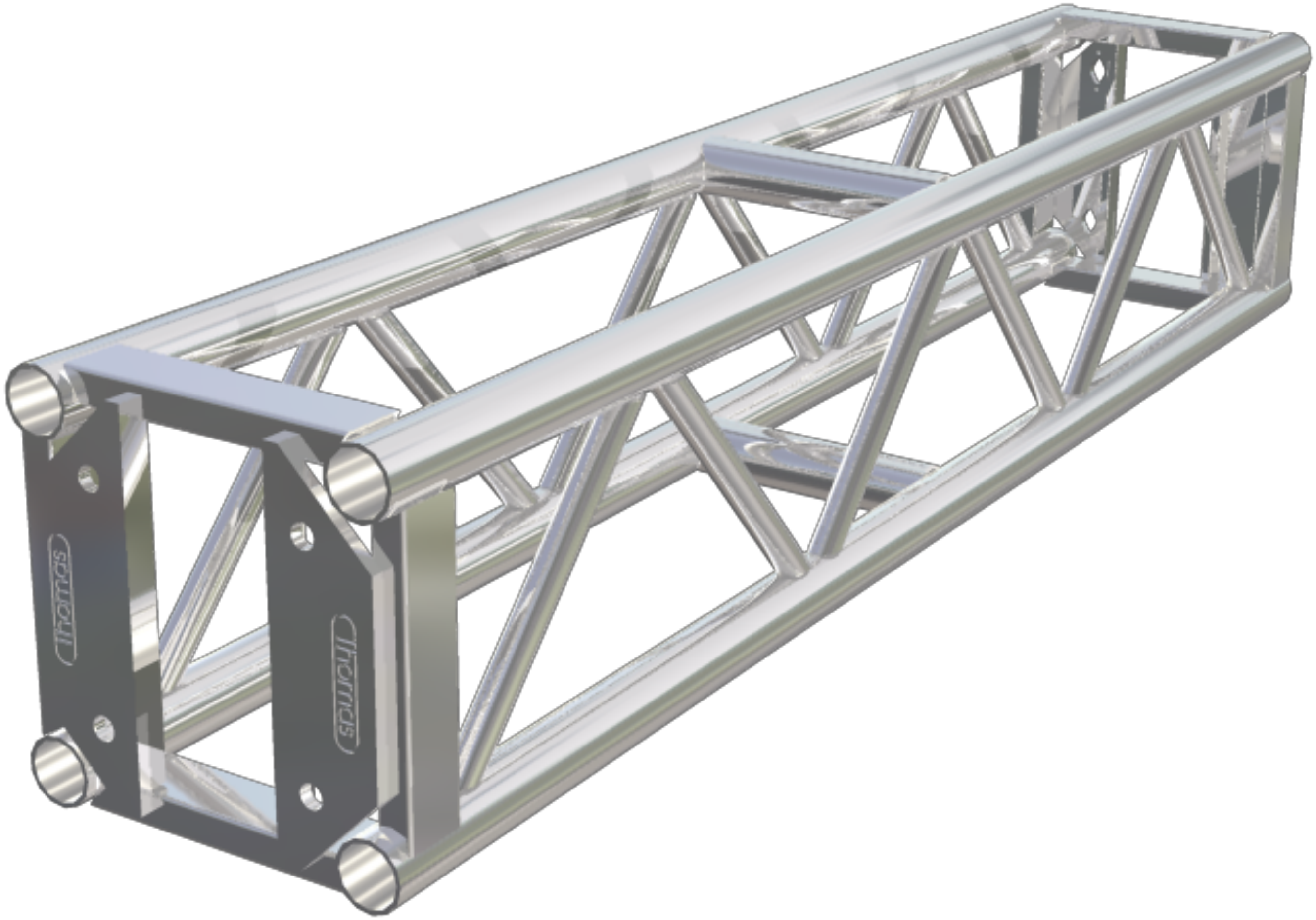
TRUSS



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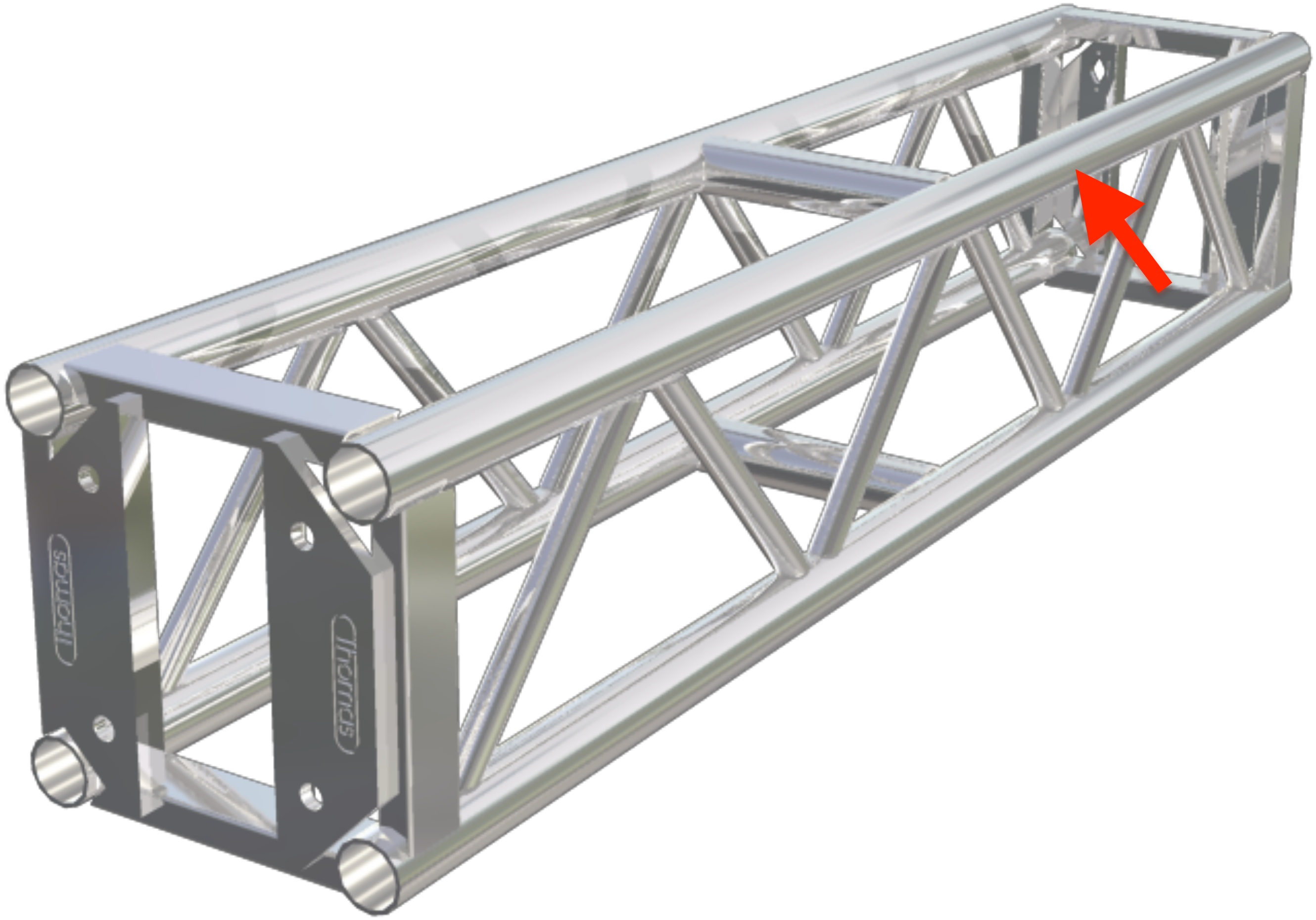
TRUSS



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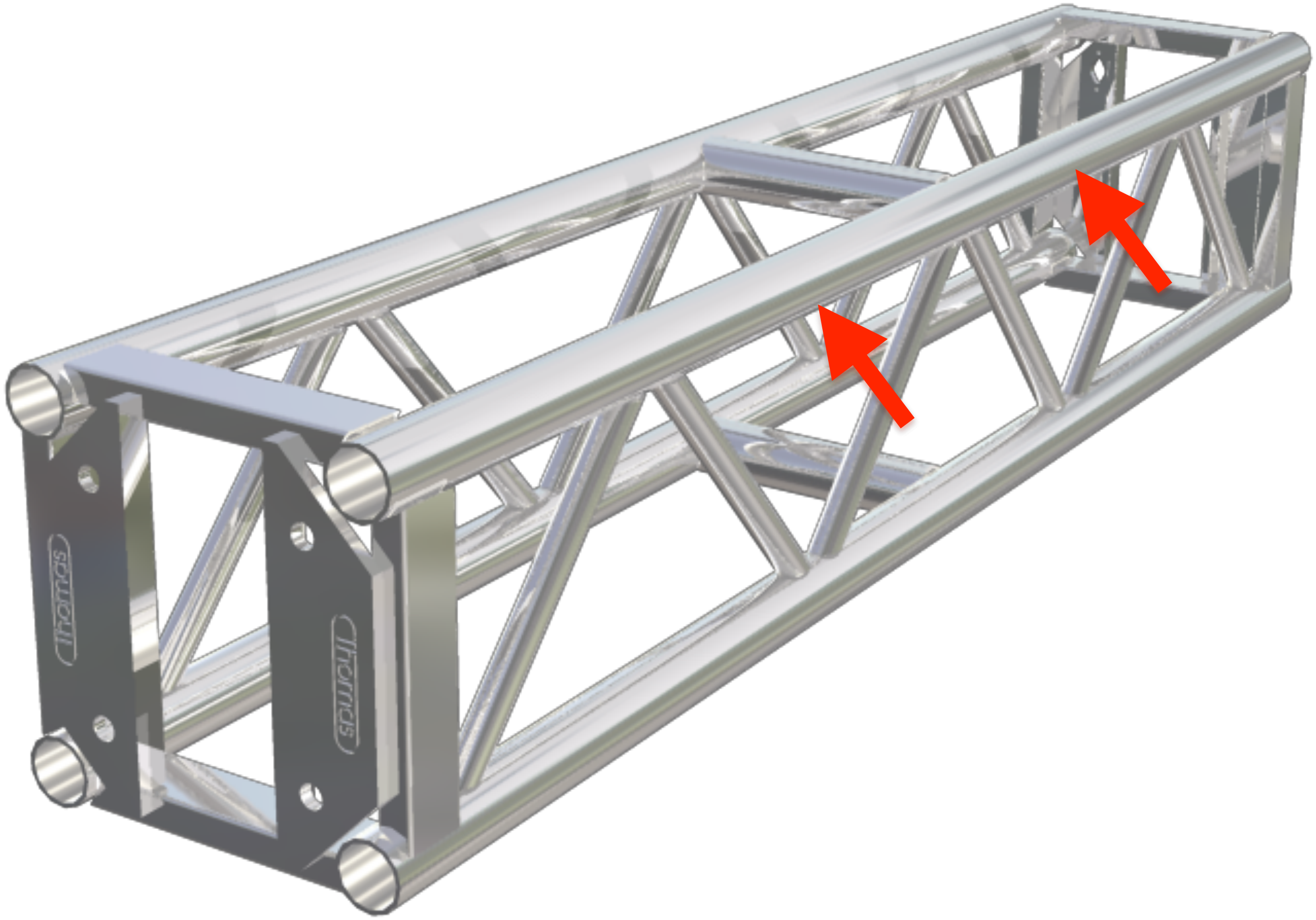
TRUSS



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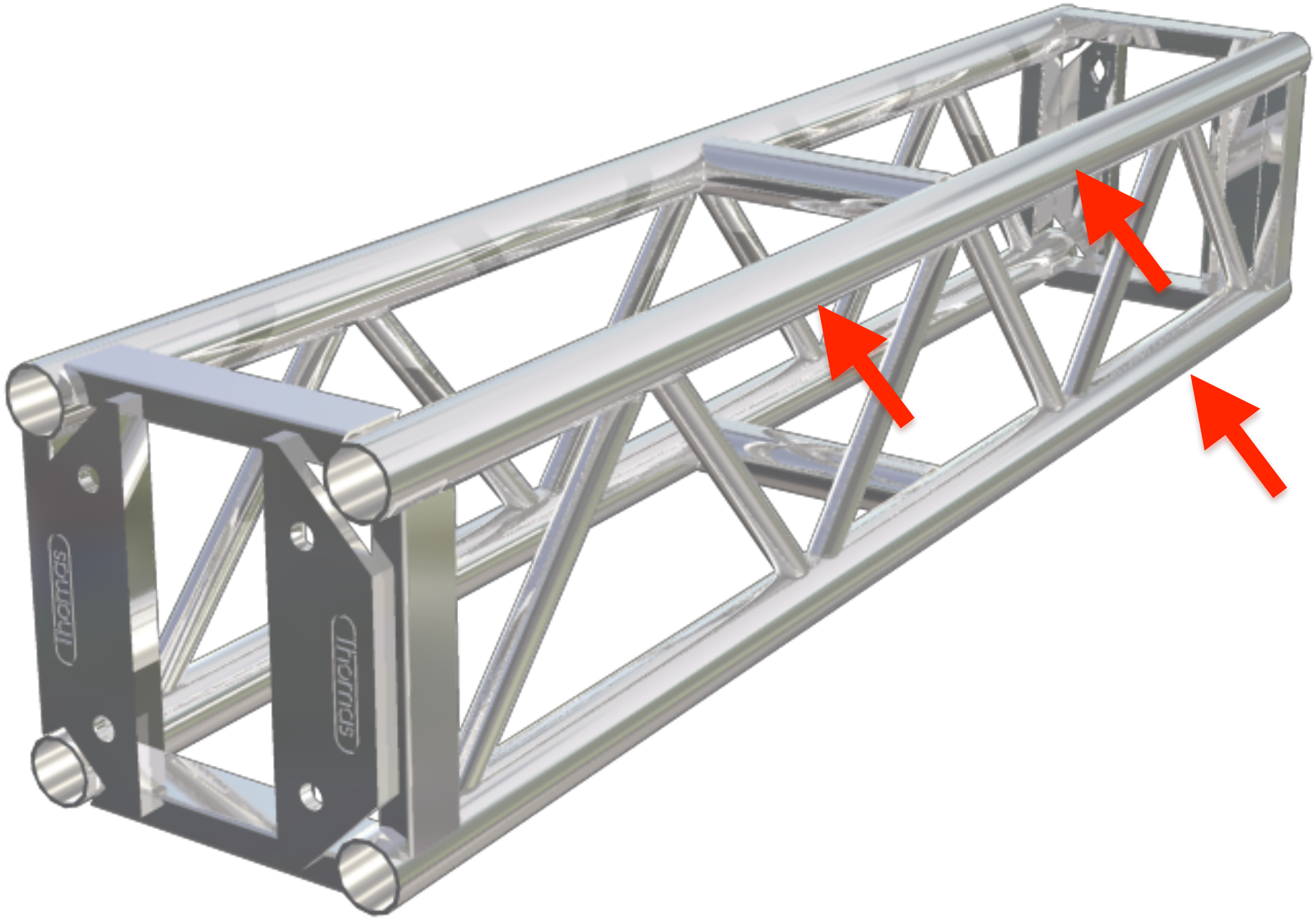
TRUSS



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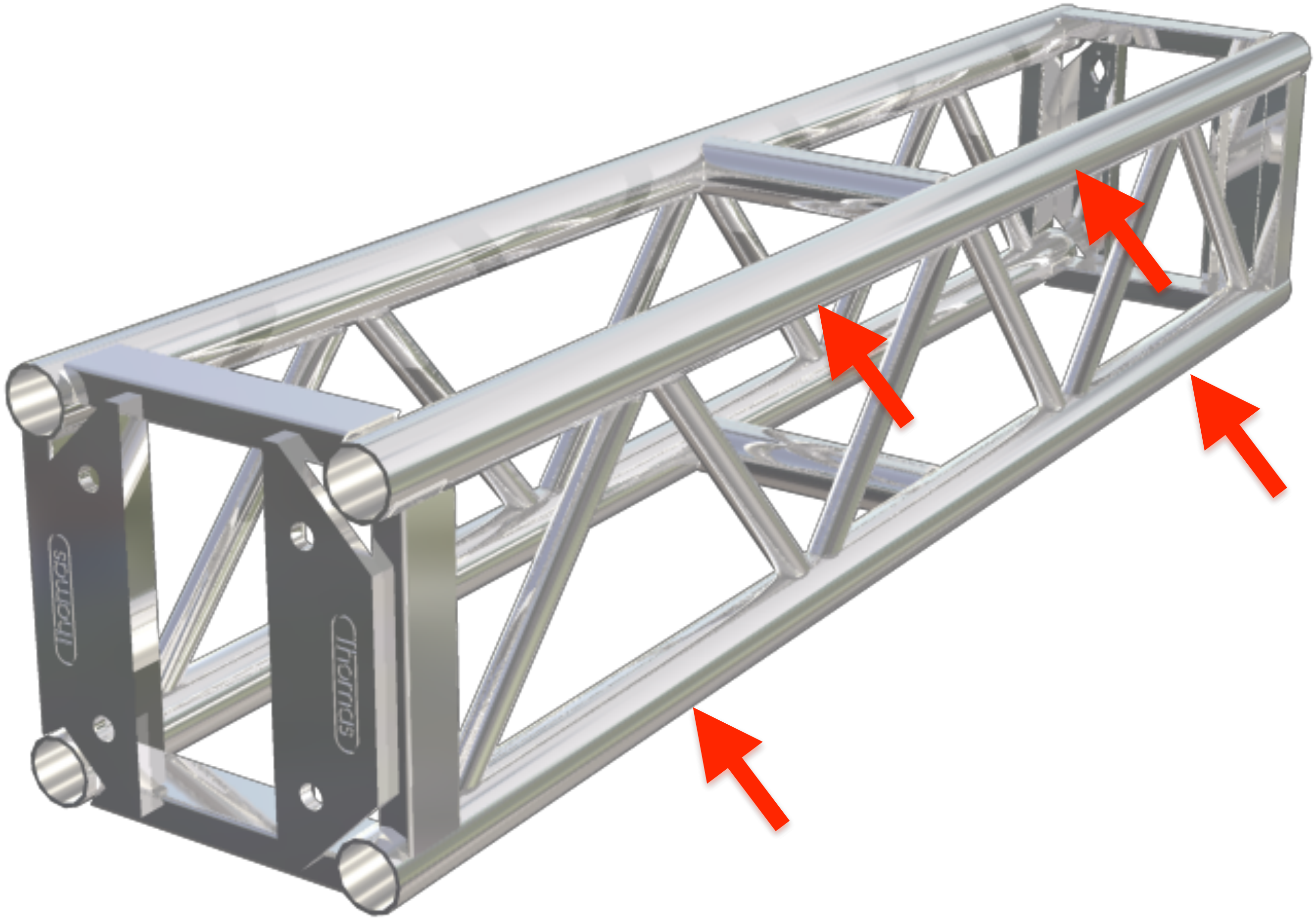
TRUSS



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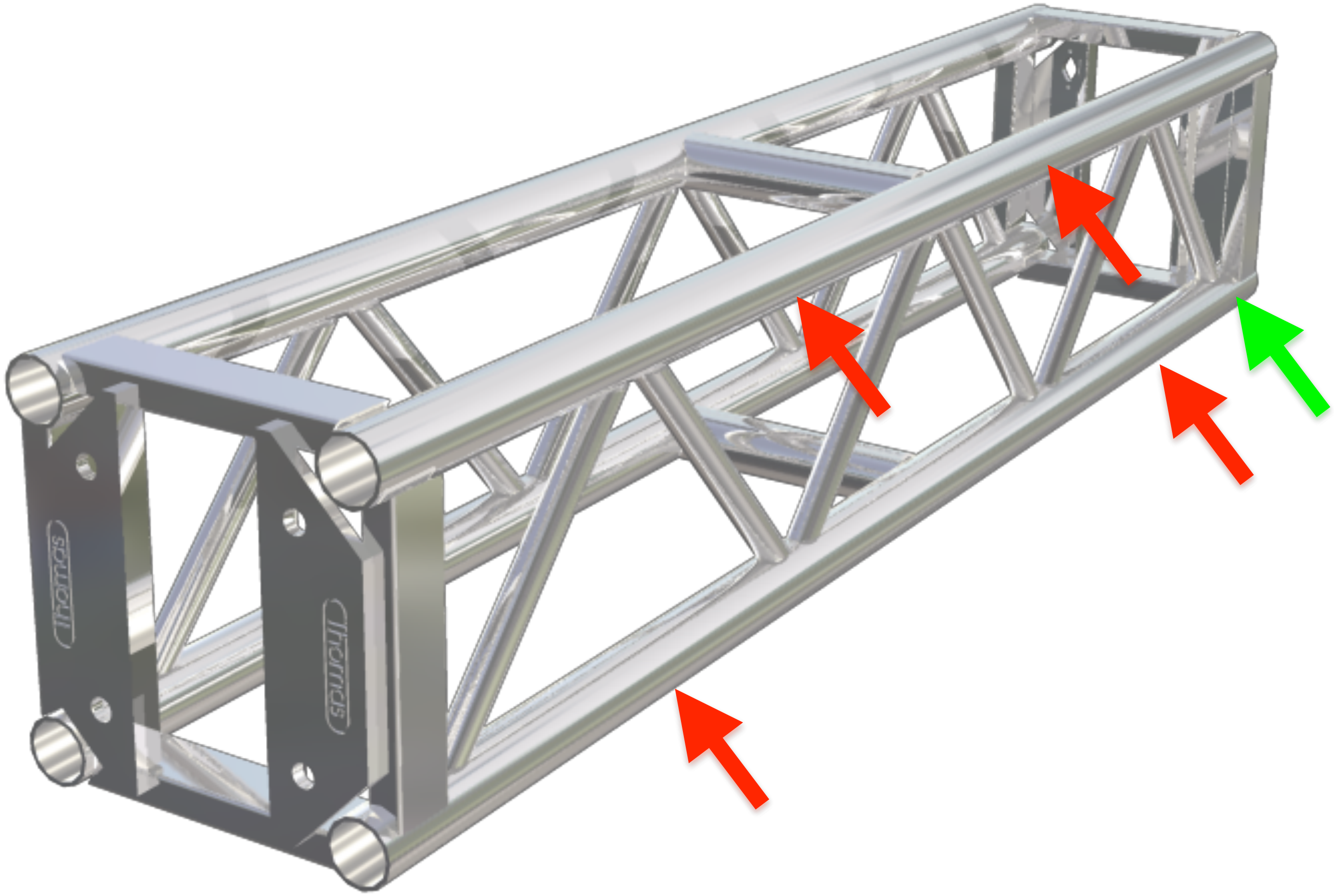
TRUSS



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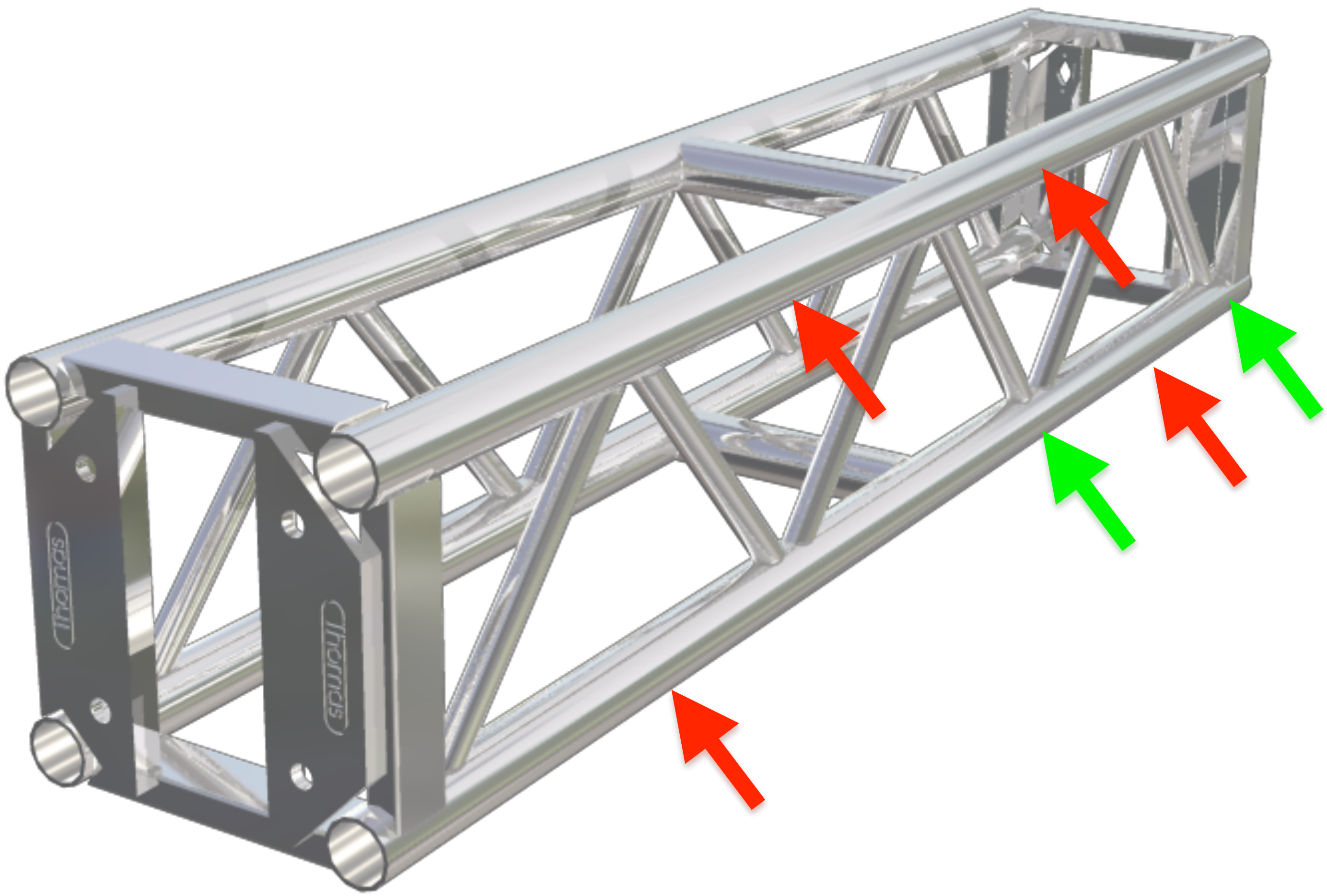
TRUSS



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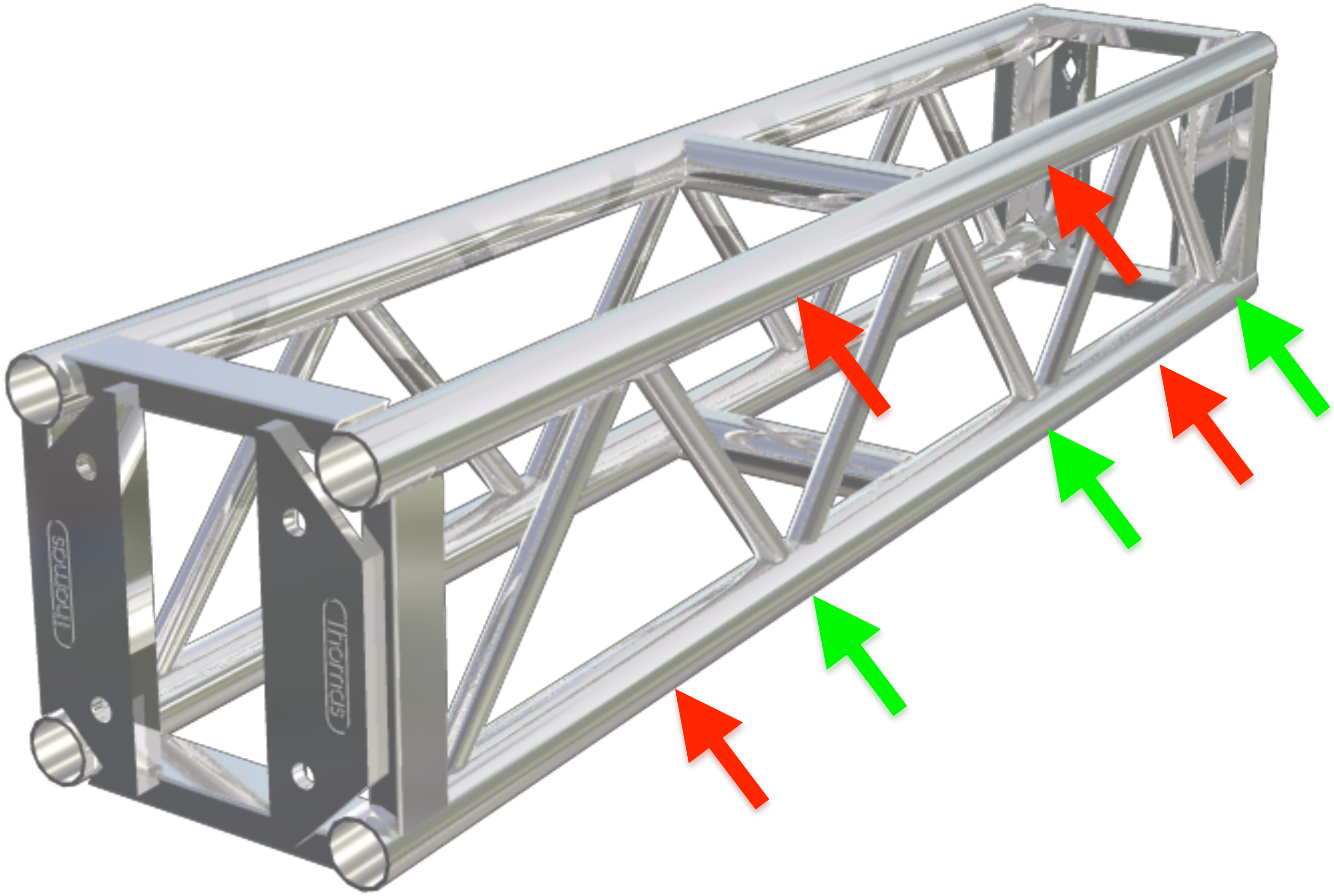
TRUSS



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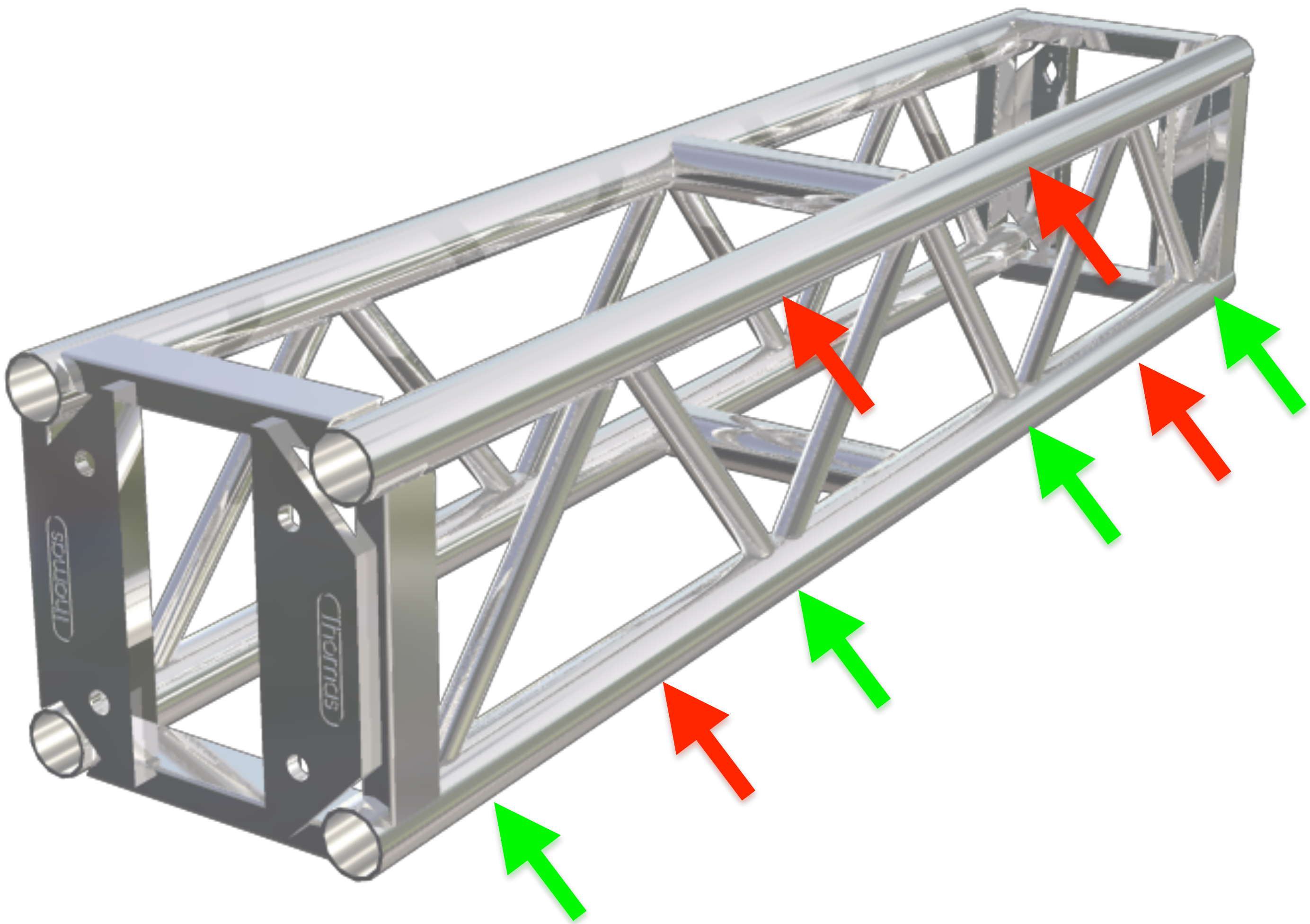
TRUSS



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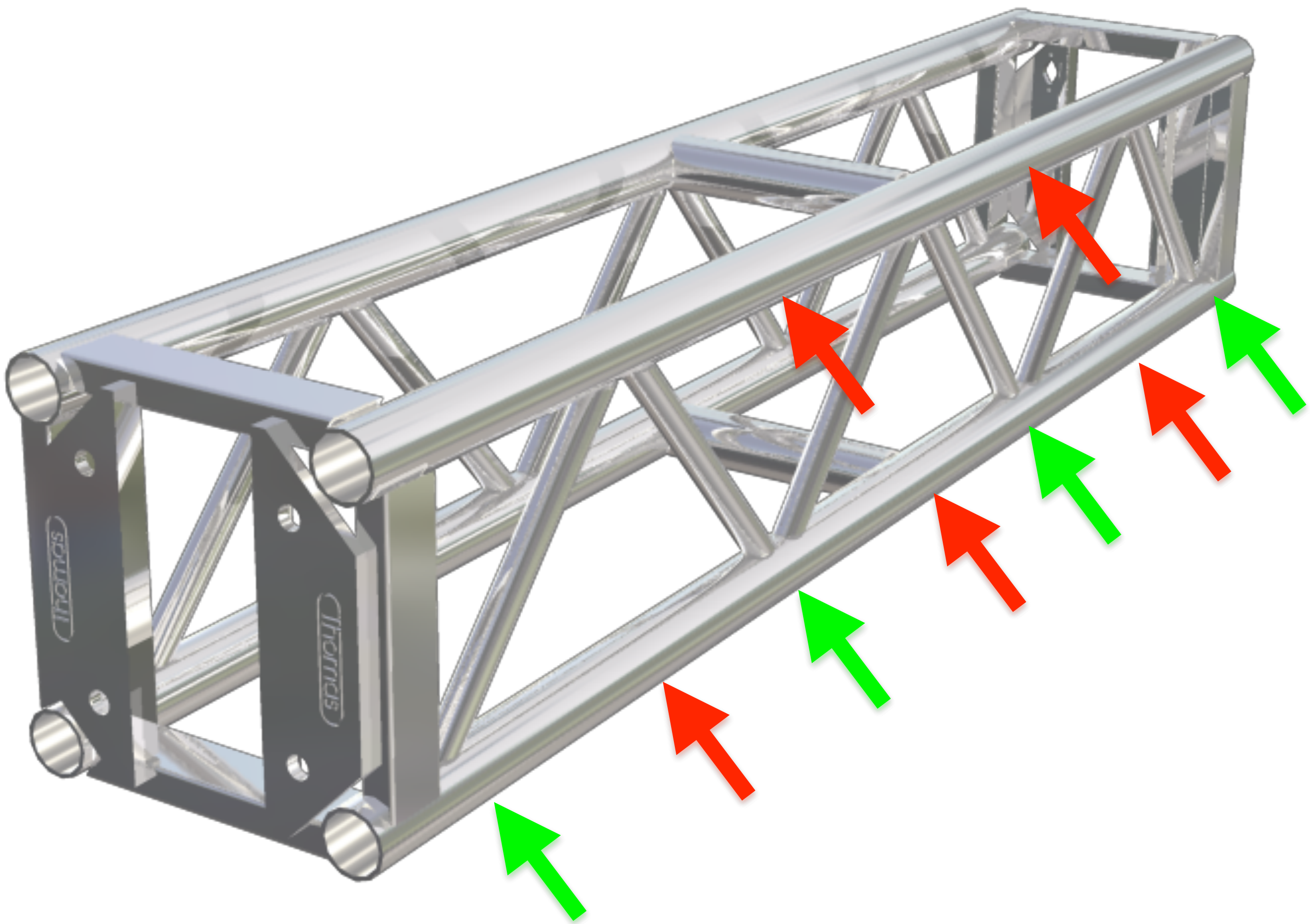
TRUSS



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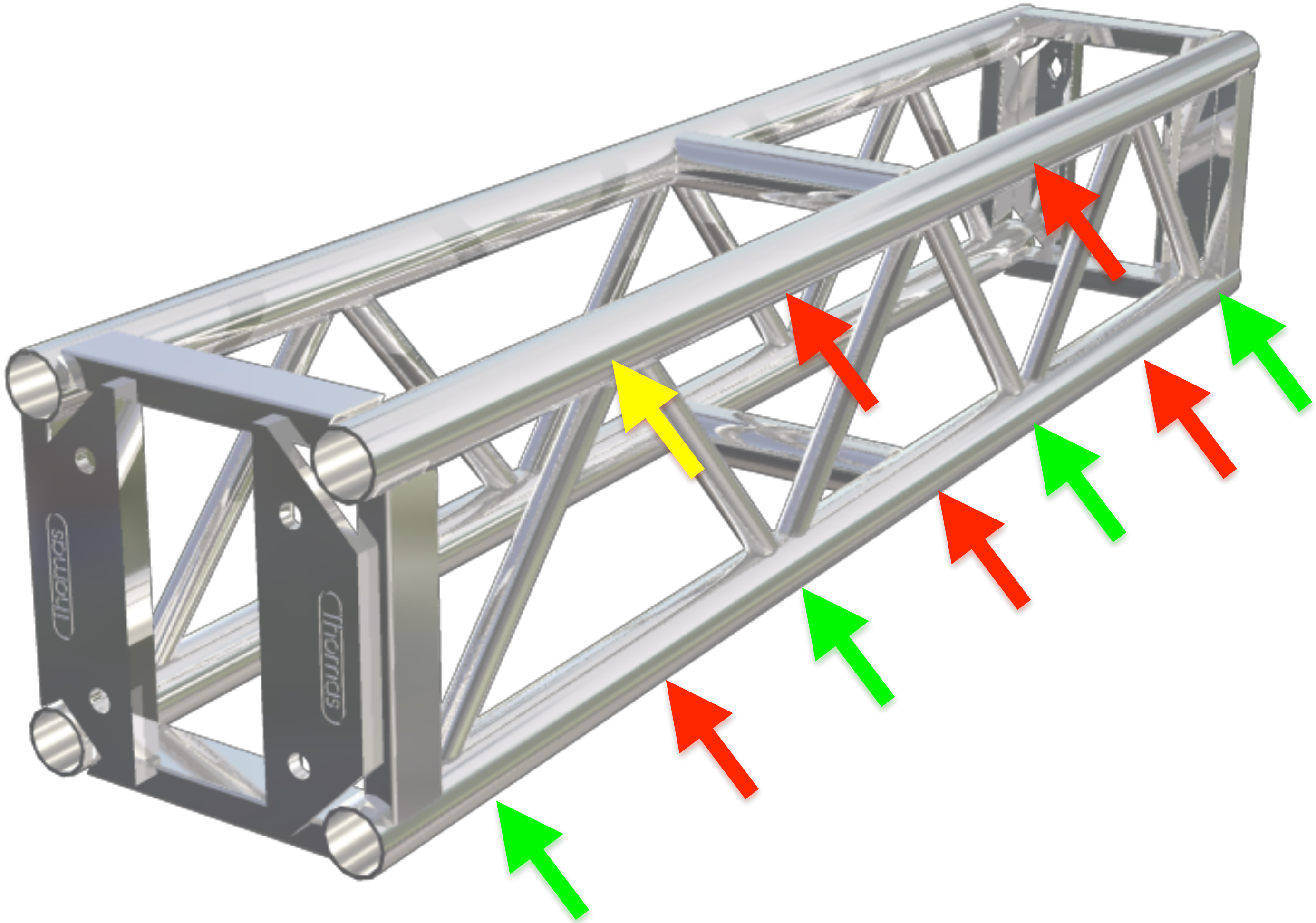
TRUSS



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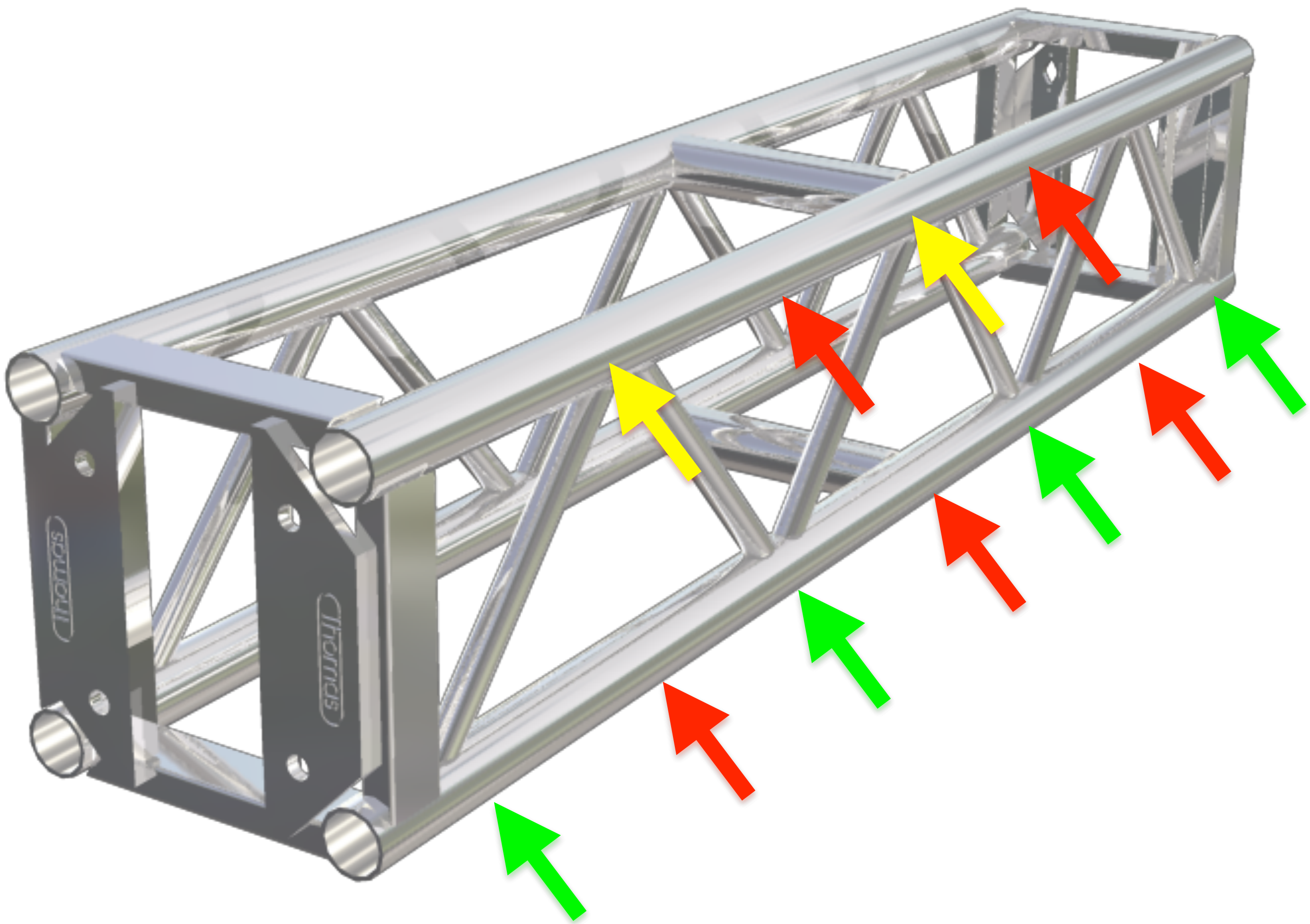
TRUSS



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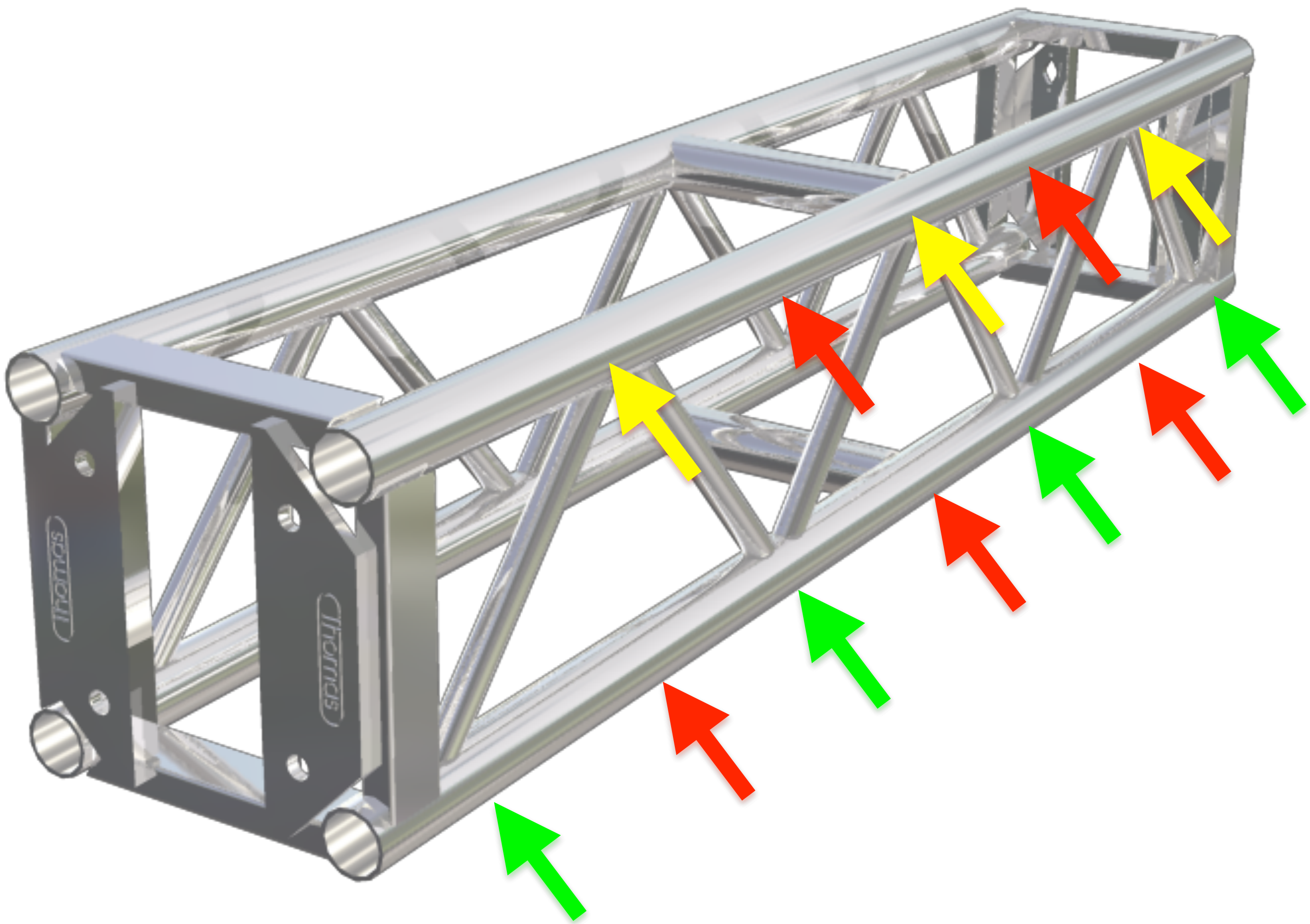
TRUSS



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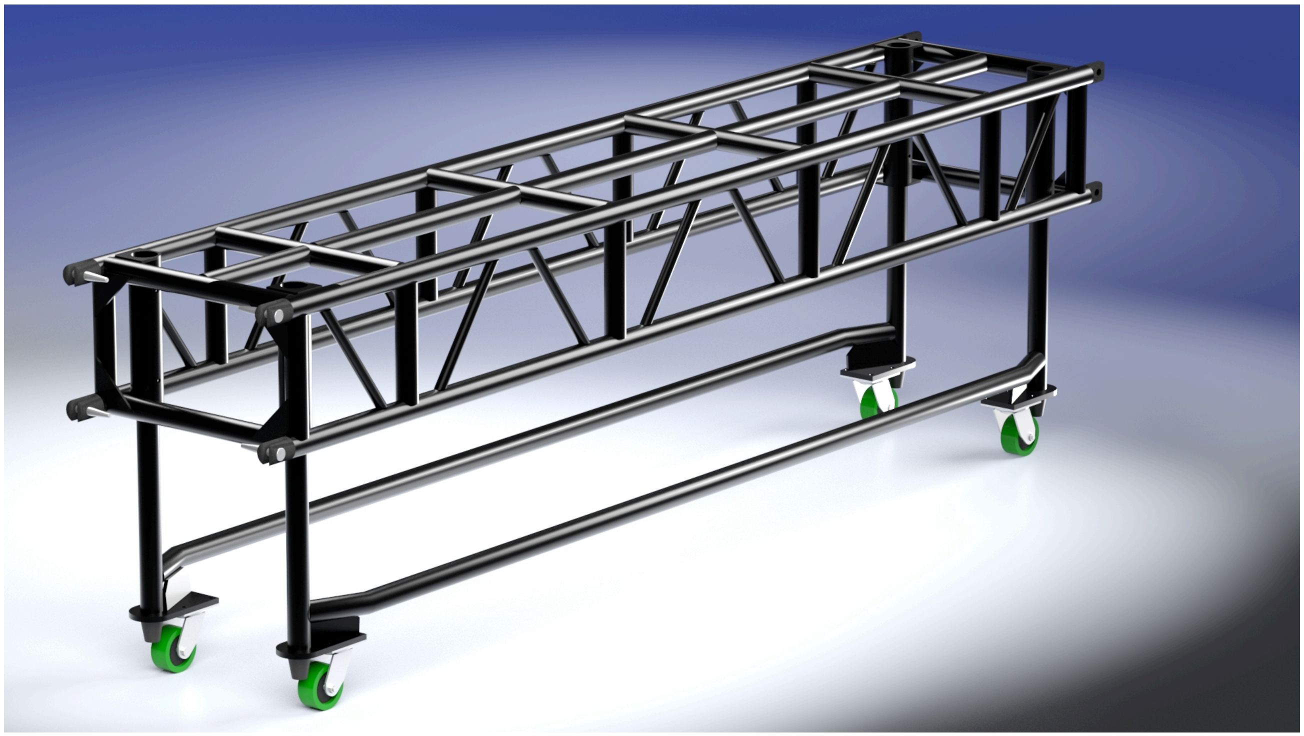
TRUSS



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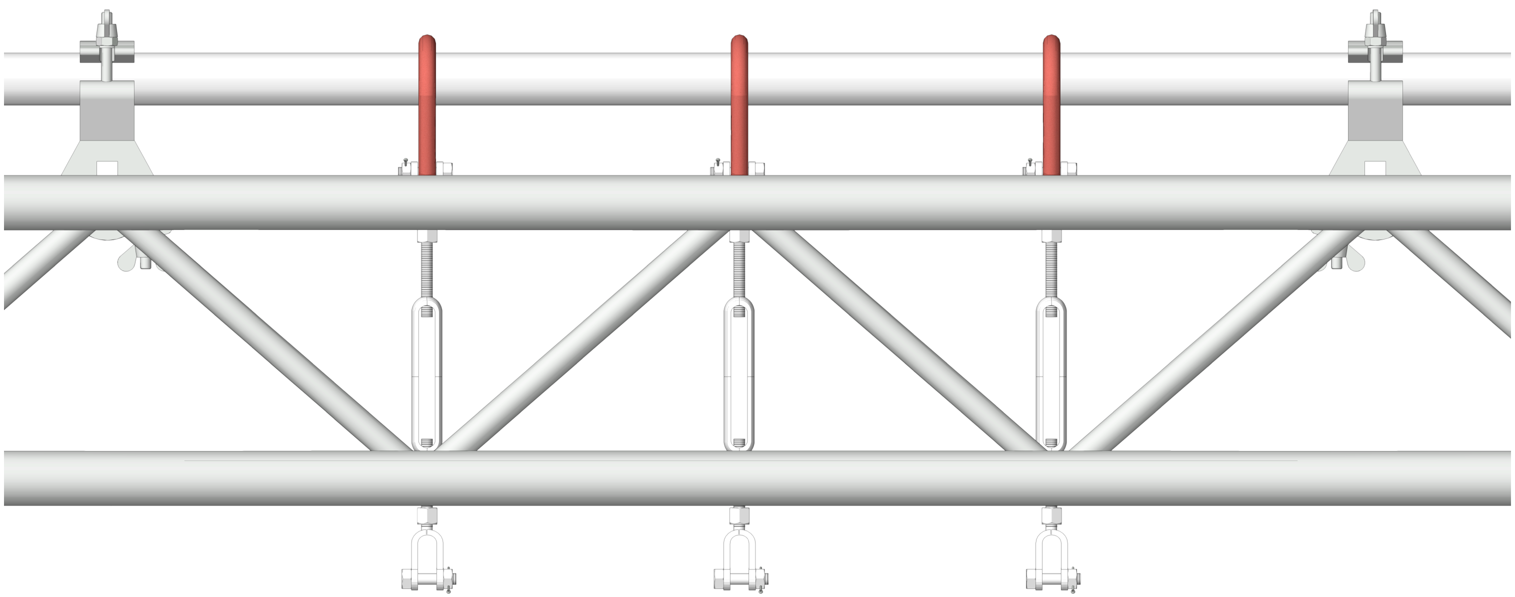
TRUSS



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TRUSS

Lift Points

- Reduce shock load potential
- Increased heat resistance
- May be unstable when used on a single run of truss

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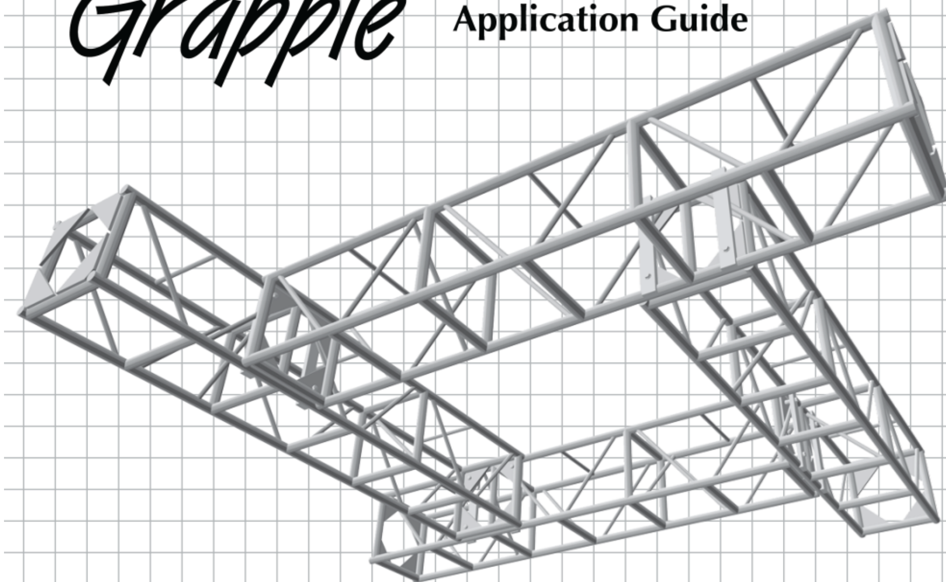
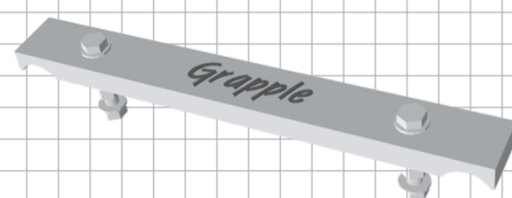
TRUSS

The Grapple™ Application Guide





The Grapple allows you to make inline 90 degree connections between similar trusses anywhere along a perpendicular primary truss. The load capacity of the inline truss will carry 75 percent of the manufacturer's load rating. The primary truss must have point load calculations taken into consideration. The secondary trusses must be supported at both ends. Cantilevering of truss is not recommended.

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TRUSS

Lifting Options

- Chain Hoists
- Counter Weight
- Block and Fall
- Motorized
- Lifts & ground supported structures

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Chain Motors

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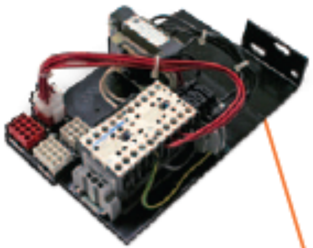
Chain Motors

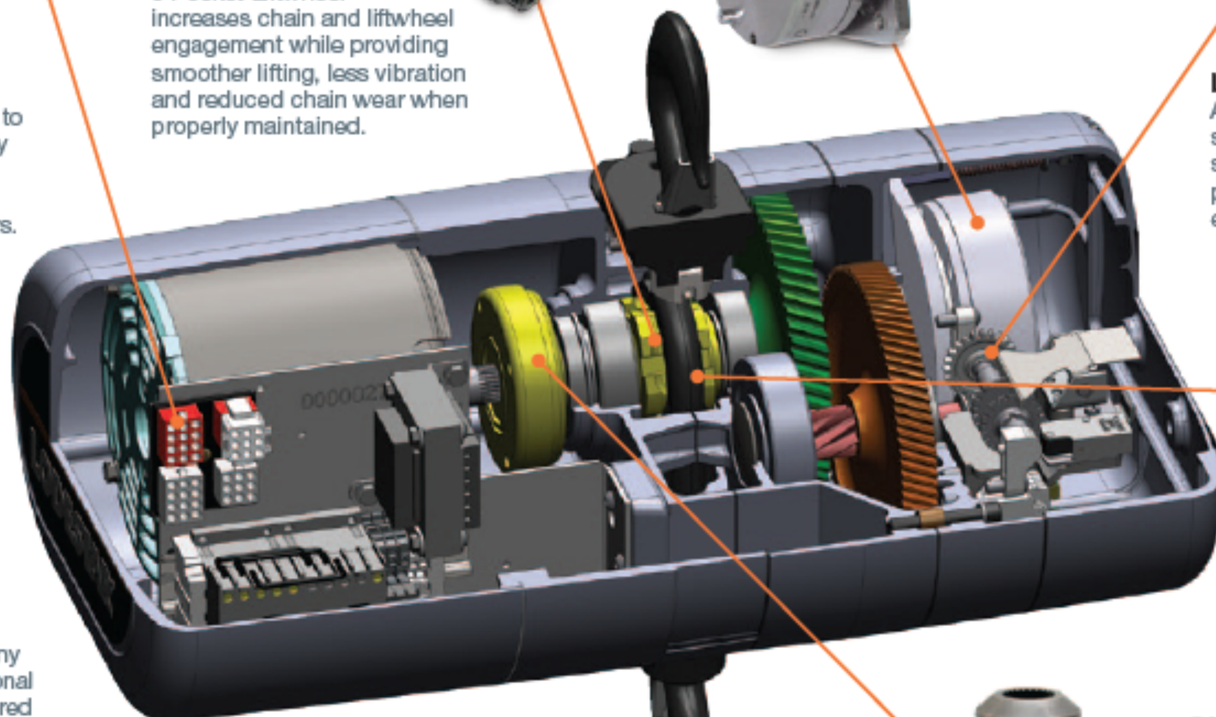


CONTROL PANEL
Provides easy access to controls, plug and play connectors allow for quick voltage change for dual voltage motors. Fuses located on terminal strip (optional).

LIFTWHEEL
5 Pocket Liftwheel increases chain and liftwheel engagement while providing smoother lifting, less vibration and reduced chain wear when properly maintained.

BRAKE
Heavy Duty DC Brake is standard. AC Brake and Double DC Brake are also available.

LIMIT SWITCH
Adjustable screw limit switch that will automatically stop the hook at any predetermined point when either hoisting or lifting.



INTERNAL CHAIN GUIDE
Stamped Steel guide coated for corrosion resistance and quiet operation, while keeping the load chain and liftwheel aligned.

LOAD CHAIN
Sizes available from 1/4 in. to 5/16 in. Meets or exceeds many national and international standards. Manufactured by Columbus McKinnon. 100% proof tested.

CLUTCH
Designed to prevent lifting of excessive overloads. Located outside the gear box. Adjustable and easy to access.

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Chain Motors

- Manufacturer
  - CM
  - Coffing
  - ChainMaster
  - Cyberhoist
  - Pointman

Chain Motors

- Manufacturer
  - CM
  - Coffing
  - ChainMaster
  - Cyberhoist
  - Pointman

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RIGGING SERVICES, LLC

Chain Motors

Chain Motors

Single Brake Vs. Double Brake

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Chain Motors

The manual says not for lifting people.
What do I do?

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Chain Motors

120 YEARS

COLUMBUS MCKINNON CORPORATION
THEATRICAL PRODUCTS DIVISION
140 JOHN JAMES AUDUBON PARKWAY
AMHERST, NY 14228-1197
716/689-5400 FAX: 716/689-5644

DATE: June 5, 1996

TO: CM Entertainment Division Distributors

FROM: Wally Blount

SUBJECT: Fall Protection

****

As you are aware OSHA is vigorously enforcing the use of fall protection equipment in our day-to-day activities. As a result CM is receiving more and more requests concerning our official policy regarding the use of Lodestars in those applications.

CM POLICY STATEMENT FOR LODESTARS USED IN CONJUNCTION WITH FALL PROTECTION EQUIPMENT IN THE ENTERTAINMENT INDUSTRY

If a fall protection system is used in conjunction with Lodestar hoists, the system must be designed and installed by a qualified person such that malfunction or failure of one hoist's load bearing components does not cause load loss and/or overloading of any other hoist(s) in the system. Also the system must be designed such that the static loading of any hoist does not exceed 50% of the rated capacity. Note that in such a system, hoist performance and function must be monitored visually or with the use of load cells.

If you have any questions or need help with an application, please don't hesitate to give me a call.

Yours truly,

COLUMBUS McKINNON CORPORATION

Wally Blount

Wally Blount, Product Manager Hoist
Theatrical Products Division
WRB:cf

cc: All Regional Managers
Territory Managers who have Theatrical Distributors in their Territory
Bulletin Register Groups 2, 3, 5, 7, 11, 17, 21

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RIGGING SERVICES, LLC

Chain Motors

CM POLICY STATEMENT FOR LODESTARS USED IN CONJUNCTION WITH FALL PROTECTION EQUIPMENT IN THE ENTERTAINMENT INDUSTRY

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ENTERTAINMENT RIGGING SERVICES, LLC

Chain Motors

Hoist Standards Explained

Hoist Specification	BS7906 Category B Standard Rigging Hoist	BGV D8 Standard Rigging Hoist	BS7906 Category A	BGV D8+	BS7906 Category A	BGV C1
Use	Static Load with secondary suspension		Static Load without secondary suspension		Dynamic Load without secondary suspension	
Safety Factor	4:1	5:1	8:1	10:1	8:1	10:1
Brake Type	Single	Single	Double	Double	Double	Double
Brake position	Brake may act via the clutch	Brake may act via the clutch	Direct acting Brake required	Direct acting Brake required	Direct acting Brake required	Direct acting Brake required
Electric Limits	Not a requirement	Not a requirement	Top, bottom and two ultimate limits required	Not a requirement	Top, bottom and two ultimate limits required	Top, bottom and two ultimate limits required
Mechanical Chain Stops	Not Essential	Required	Required	Required	Required	Required
Emergency Stop	Not a requirement	Not a requirement	Required	Not a requirement	Required	Required
Secondary suspension	Required	Required	Not a requirement	Not a requirement	Not a requirement	Not a requirement
Controller	Not a requirement	Not a requirement	Desirable	Desirable	Desirable	Required
Clutch	Load Bearing clutch acceptable	Load Bearing clutch acceptable	Load Bearing Clutch NOT acceptable	Load Bearing Clutch NOT acceptable	Load Bearing Clutch NOT acceptable	Load Bearing Clutch NOT acceptable
Overload monitoring – shut down at 120% SWL	Not a requirement	Not a requirement	Not a requirement	Not a requirement	Not a requirement	Required
Underload Monitoring	Not a requirement	Not a requirement	Not a requirement	Not a requirement	Not a requirement	Required on guided loads or multiple group lifts
Incremental encoder	Not a requirement	Not a requirement	Not a requirement	Not a requirement	Not a requirement	Not a requirement

HOIST UK

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Chain Motors

- Load path
  - Motor can be hung at an angle, as long as the load path is in line from hook to hook.
  - DO NOT place more that one object in the hook.
  - DO NOT allow the chassis of the motor to take load.

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Chain Motors

- Control

Chain Motors

- Control
  - Pickle (Single station)

Chain Motors

- Control
  - Pickle (Single station)
  - Motor Controller

ERS
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Chain Motors

- Power

Chain Motors

- Power
  - 120v control

Chain Motors

- Power
  - 120v control
  - single phase vs three phase

ENTERTAINMENT
RIGGING SERVICES, LLC

Chain Motors

- Power
  - 120v control
  - single phase vs three phase
  - Amperage 1 Ton, Model “L”, 1 H.P. @ 16 FPM

ENTERTAINMENT RIGGING SERVICES, LLC

Chain Motors

- Power
  - 120v control
  - single phase vs three phase
  - Amperage 1 Ton, Model “L”, 1 H.P. @ 16 FPM
    - 115 -1-60 = 12.5 Amps

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Chain Motors

- Power
  - 120v control
  - single phase vs three phase
  - Amperage 1 Ton, Model “L”, 1 H.P. @ 16 FPM
    - 115 -1-60 = 12.5 Amps
    - 230 -3-60 = 5 Amps

ENTERTAINMENT RIGGING SERVICES, LLC

Chain Motors

- Power
  - 120v control
  - single phase vs three phase
  - Amperage 1 Ton, Model “L”, 1 H.P. @ 16 FPM
    - 115 -1-60 = 12.5 Amps
    - 230 -3-60 = 5 Amps
    - 460 -3-60 = 2.5 Amps

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Chain Motors

LENGTH OF EXTENSION CORD	THREE PHASE HOISTS MINIMUM WIRE SIZE
UP TO 50 FEET	#16 AWG (1.6 mm)
80 FEET (24.4 M)	#16 AWG (1.6 mm)
120 FEET (36.7 M)	#14 AWG (2.0 mm)
200 FEET (61.0 M)	#14 AWG (2.0 mm)
300 FEET (91.4 M)	#12 AWG (2.7 mm)
For runs beyond 300 Feet contact factory.	

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Chain Motors

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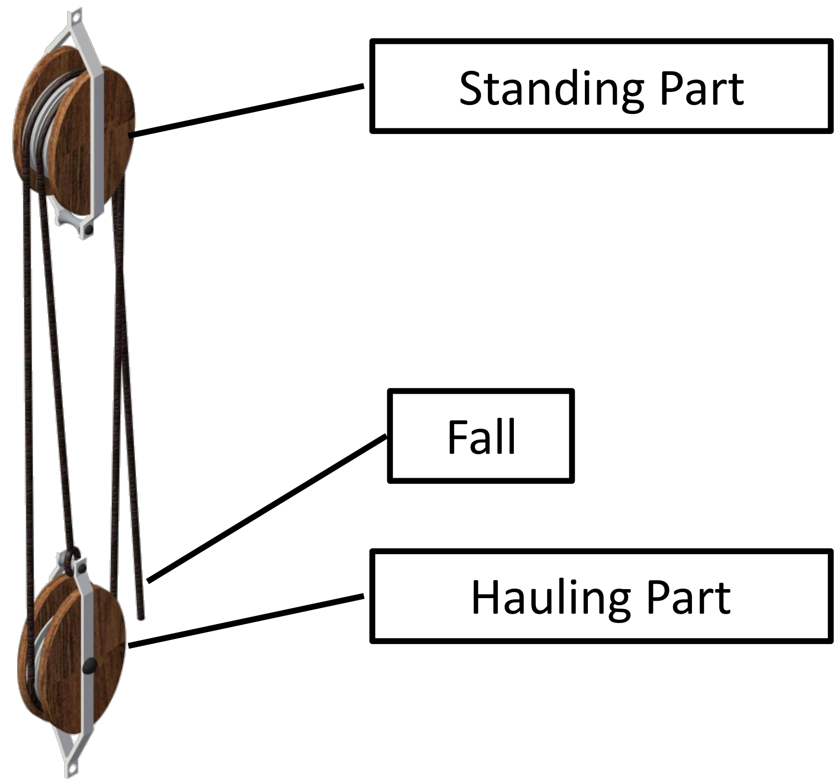
Block and Fall



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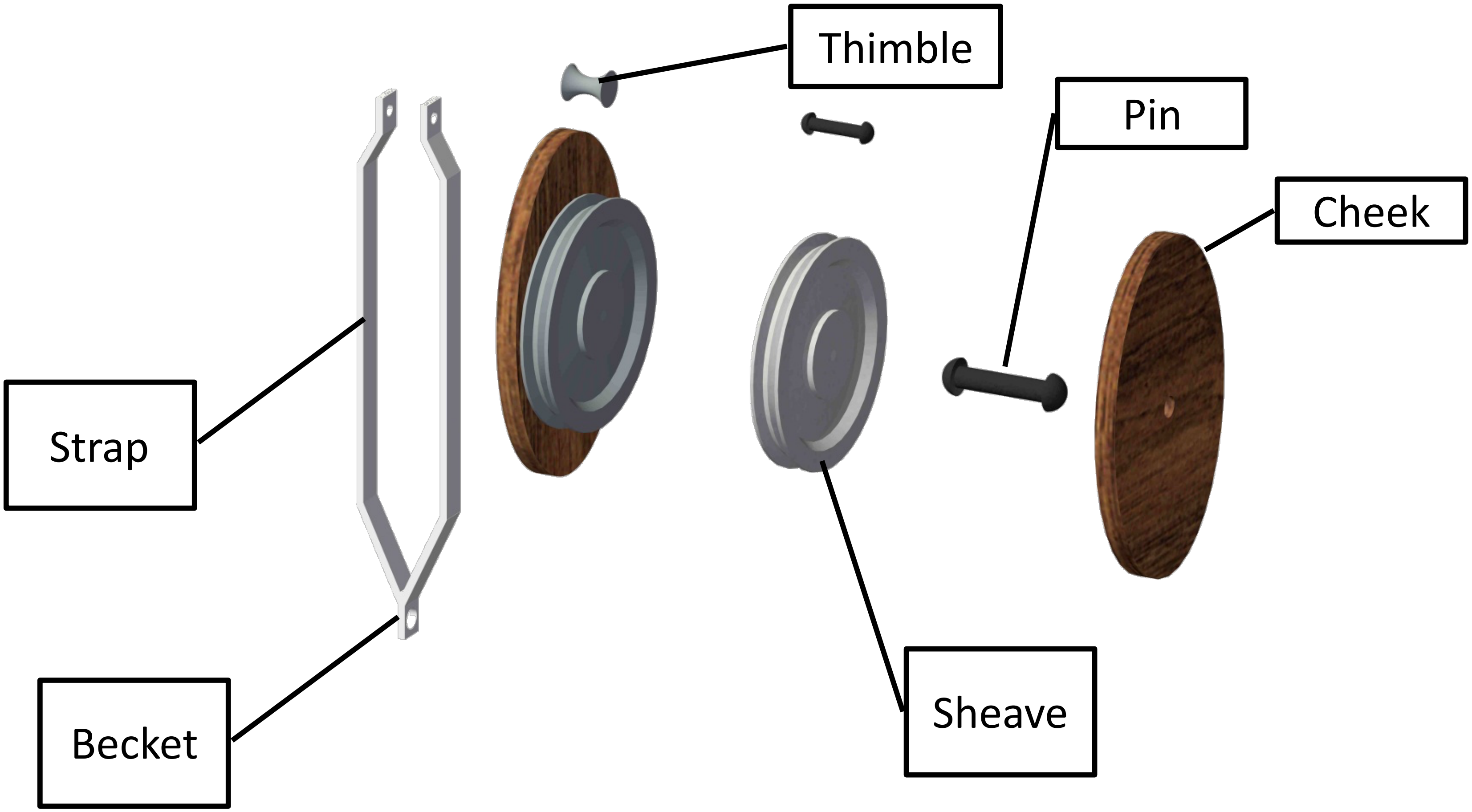
Block and Fall



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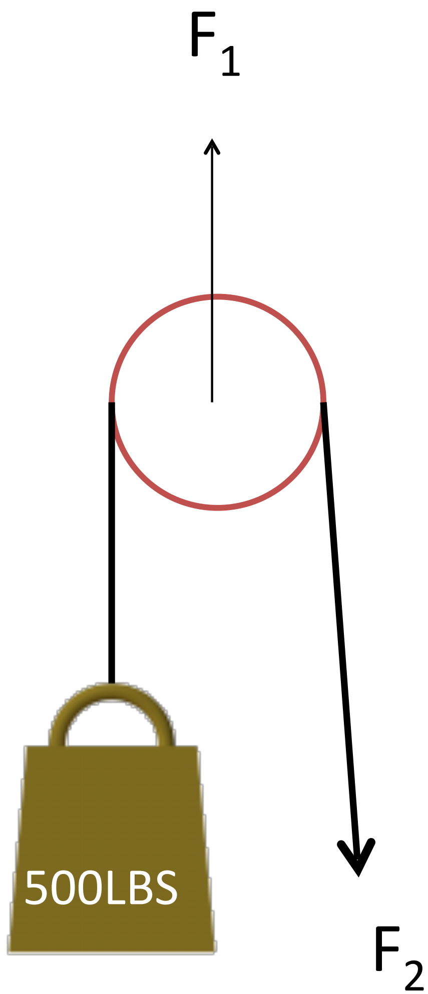
Block and Fall



$$F_1 = \frac{NumberOfLinesOnStandingBlock}{NumberofLinesonRunningBlock}(FA)$$

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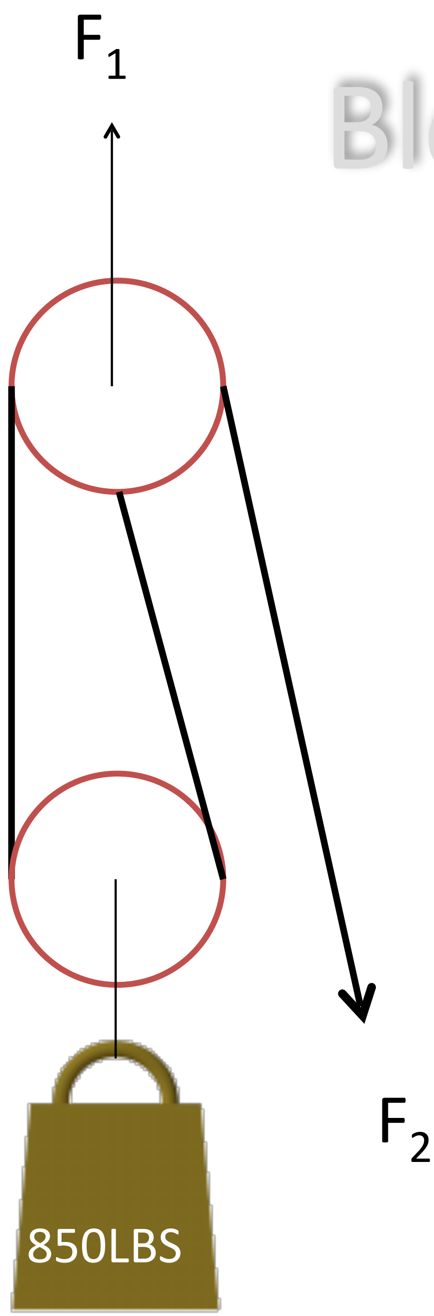
Block and Fall



$$F_1 = \frac{NumberOfLinesOnStandingBlock}{NumberofLinesonRunningBlock}(FA)$$

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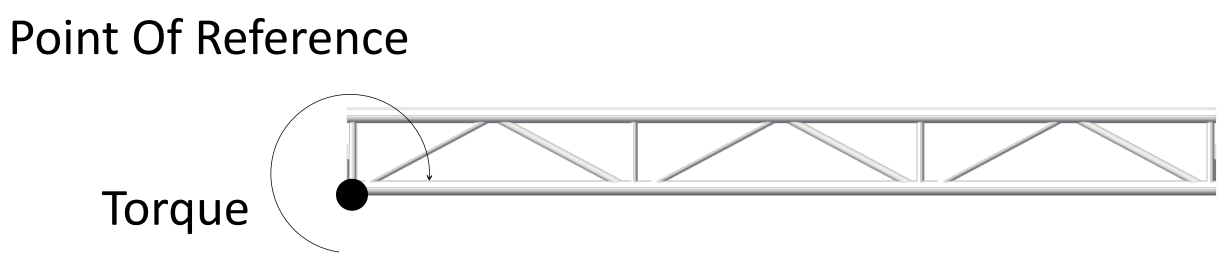
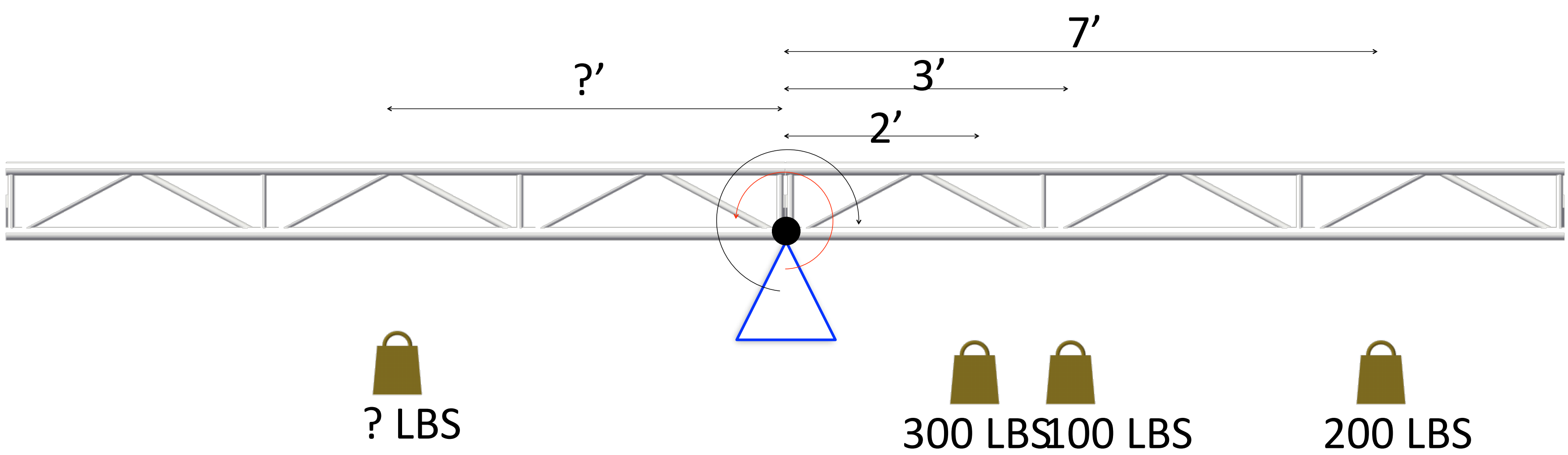
Center of Gravity



Torque = (Force)(Distance)

Center of Gravity



$$(F_{CG})(D_{CG}) = F_1D_1 + F_2D_2 + F_3D_3$$

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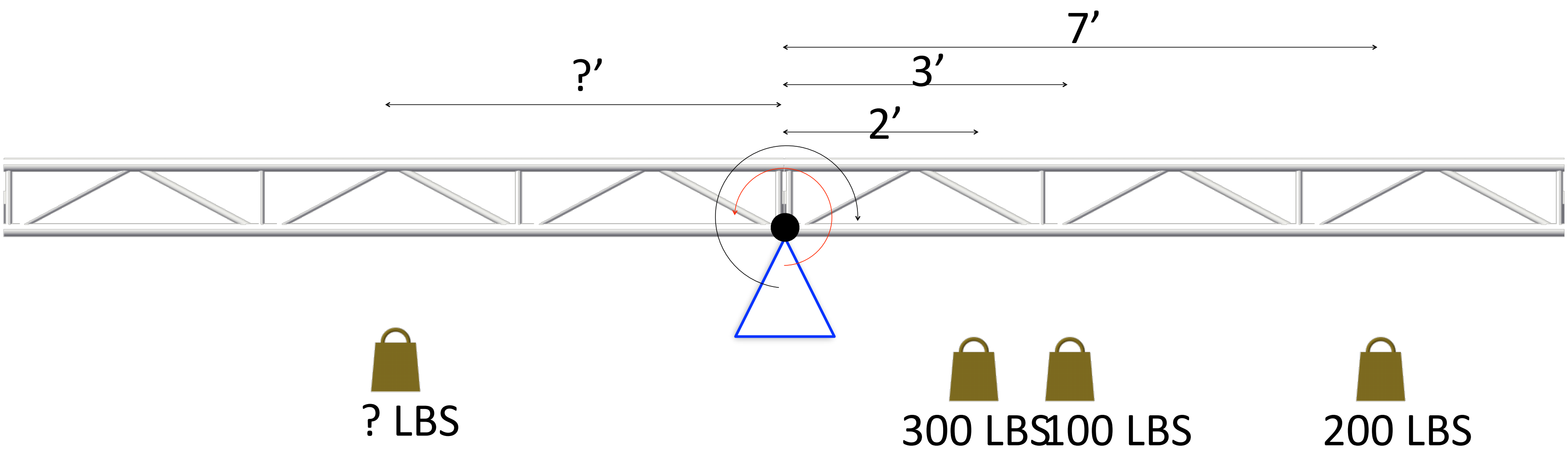
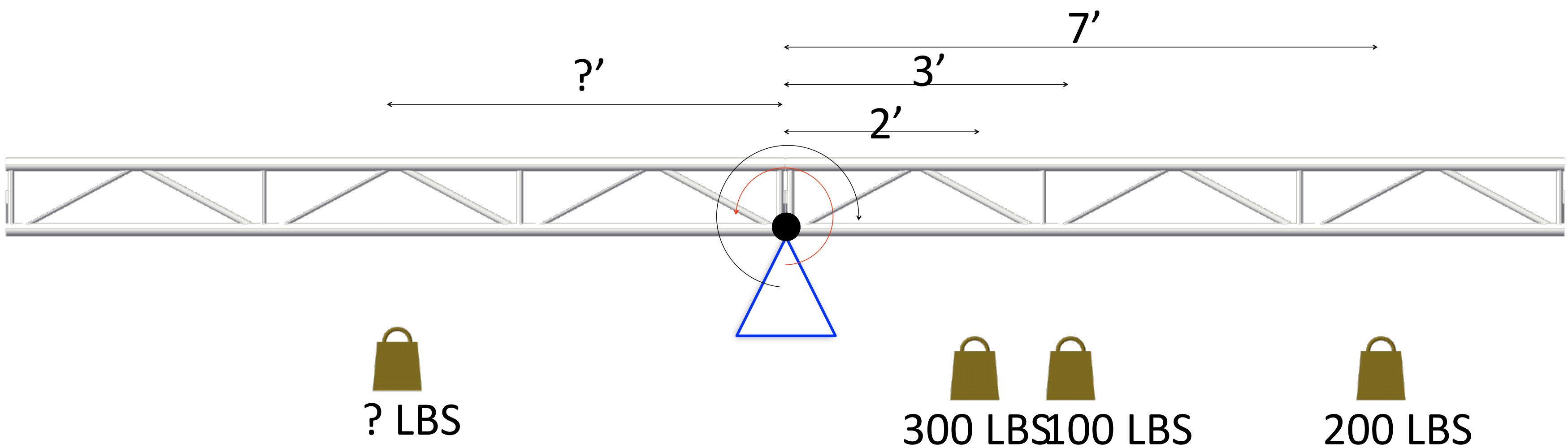
Center of Gravity



$$F_{CG} = F_1 + F_2 + F_3$$

ENTERTAINMENT RIGGING SERVICES, LLC

Center of Gravity



$$(F_1+F_2+F_3)(D_{CG}) = F_1D_1+F_2D_2+F_3D_3$$

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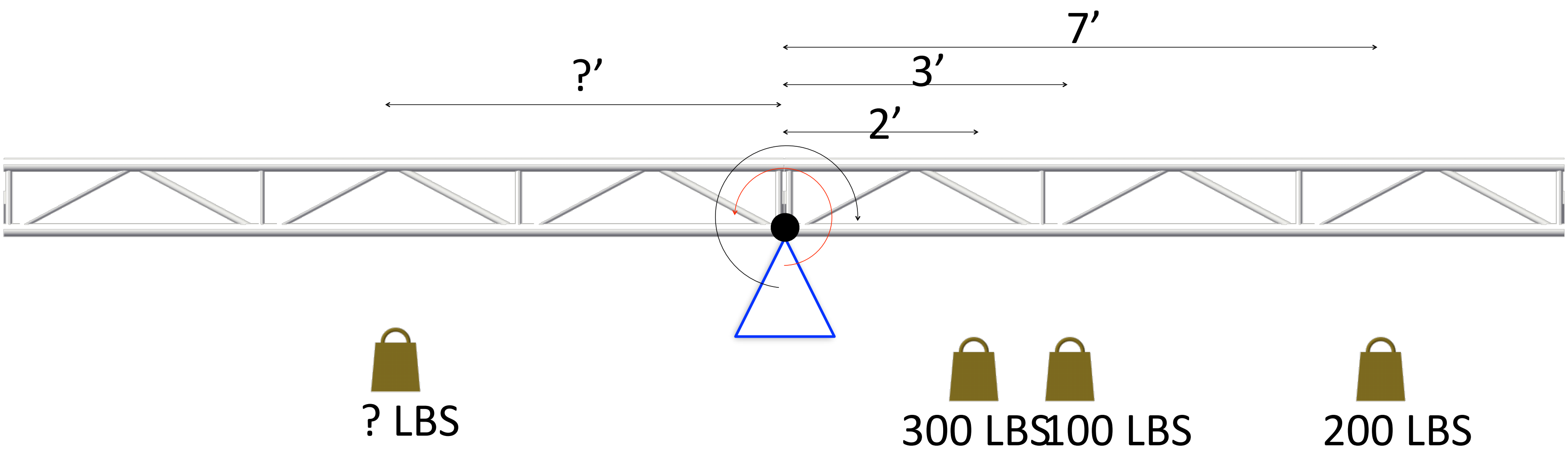
Center of Gravity



$$(D_{CG}) = \frac{F_1D_1+F_2D_2+F_3D_3}{(F_1+F_2+F_3)}$$

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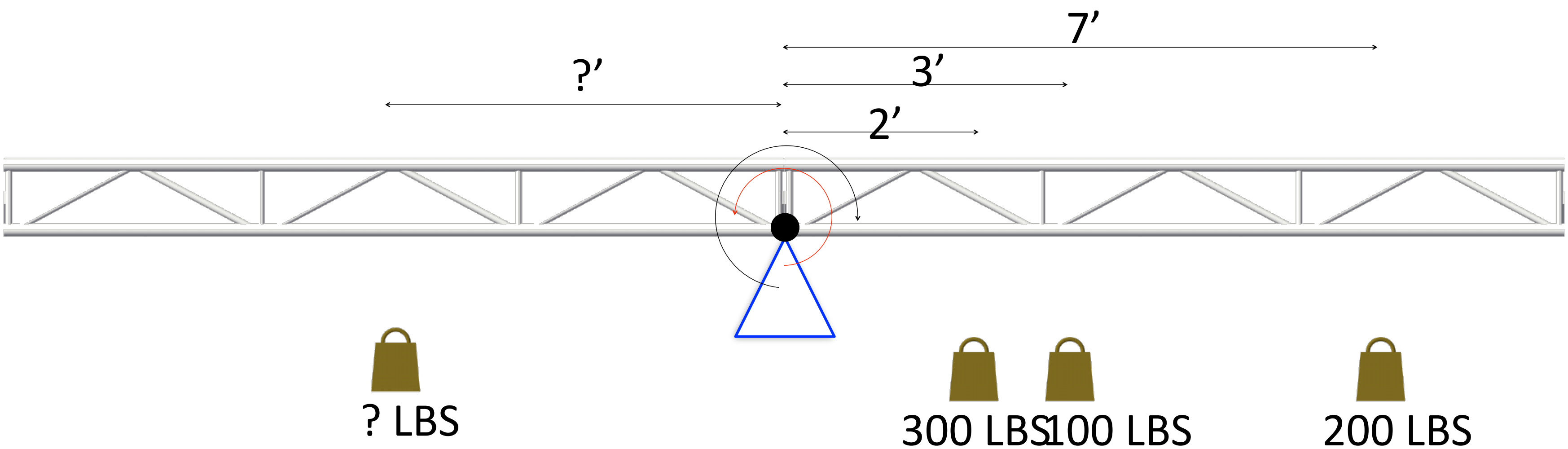
Center of Gravity



$$D_{CG} = \frac{(200)(7)+(100)(3)+(300)(2)}{200+100+300}$$

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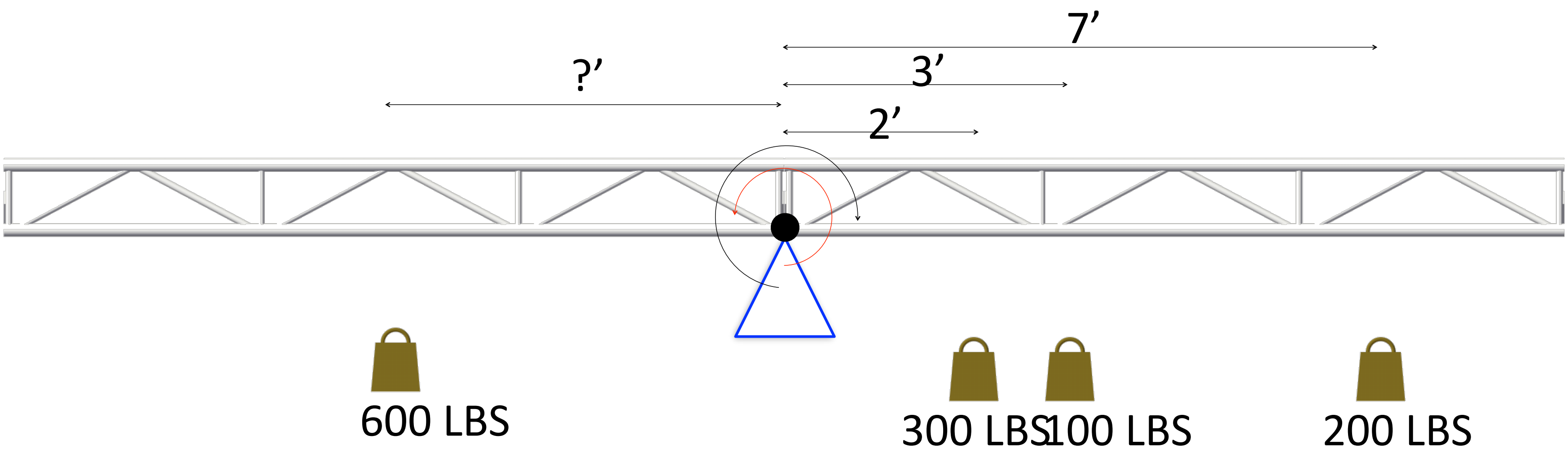
Center of Gravity



$$D_{CG} = \frac{1400+300+600}{600}$$

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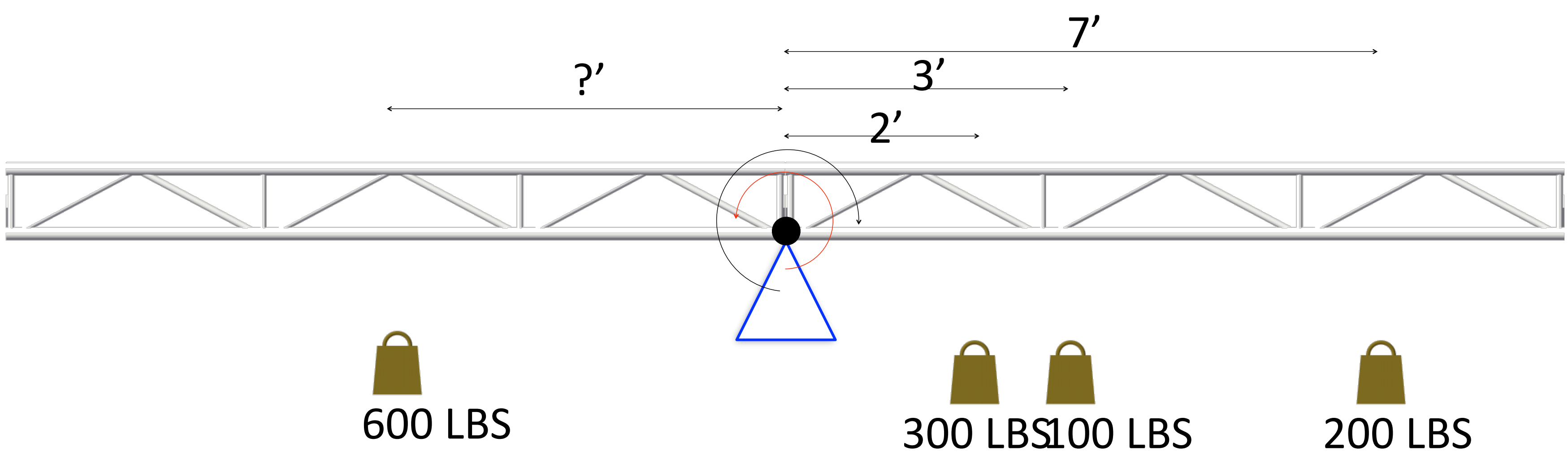
Center of Gravity



$$D_{CG} = \frac{2300}{600}$$

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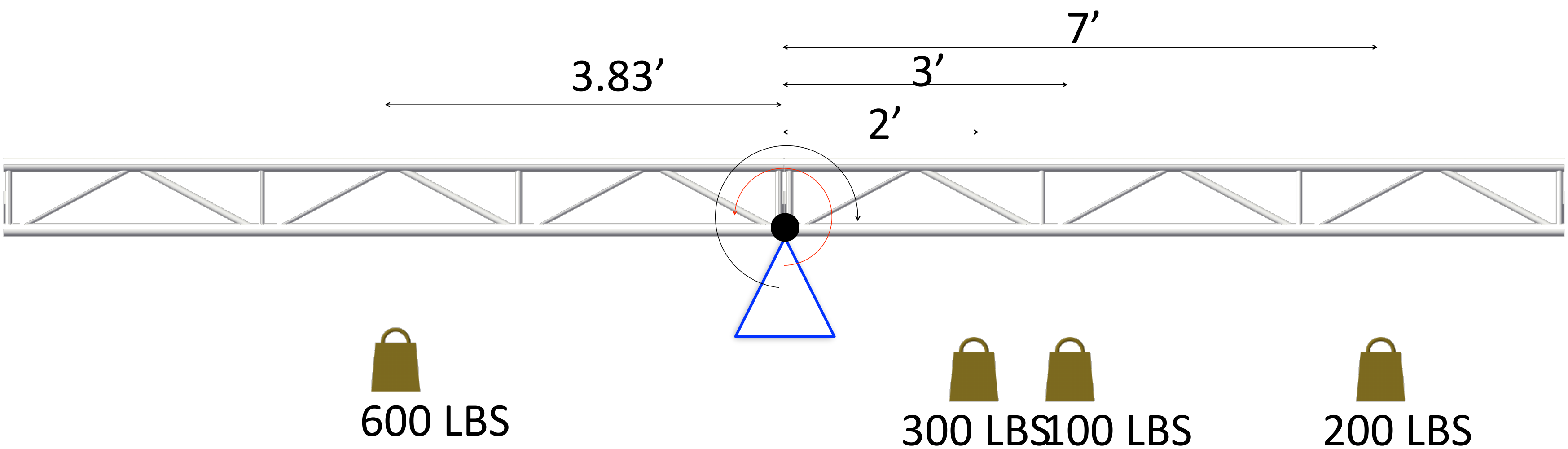
Center of Gravity



$$D_{CG} = 3.83'$$

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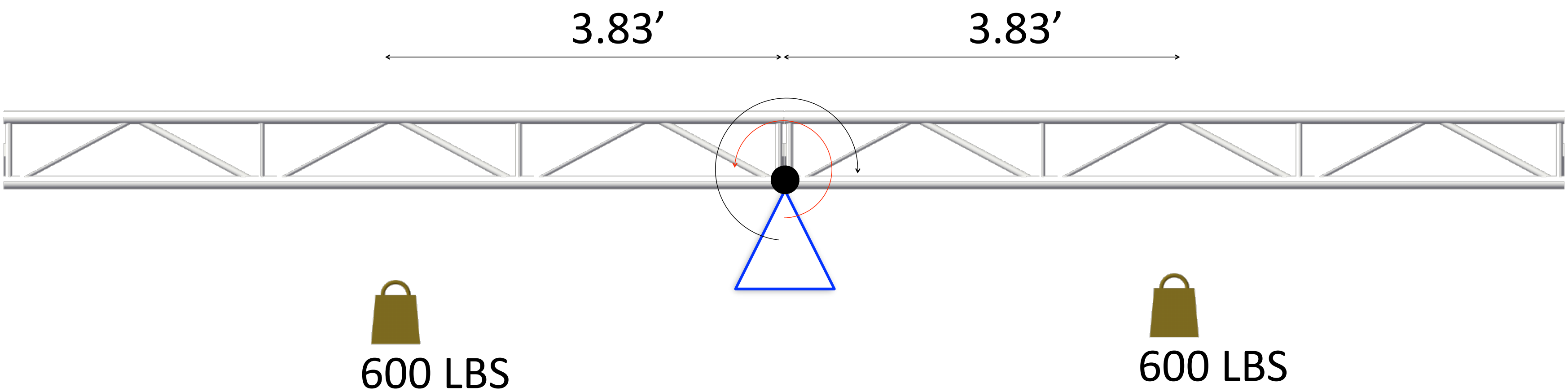
Center of Gravity



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Wind Loads

Wind Speed MPH	10	20	30	40	50	60	70	80	90	100	110	120	130
Wind Pressure (Q_S)	.03	1.0	2.3	4.3	6.5	9.3	12.6	16.4	20.8	25.6	31	36.9	43.3

Height in Feet	Exposure Coefficient C_E	
	Average Location	Location Near Large Body of Water
15	1.06	1.39
20	1.13	1.45
25	1.19	1.50
30	1.23	1.54
40	1.31	1.62
60	1.43	1.73

$$WindForce =$$
$$P = (1.4)(Q_S)(C_E)(AREA)$$

ENTERTAINMENT RIGGING SERVICES, LLC

Wind Loads

- 10’ tall by 30’ wide banner on a truss goalpost.
- Top edge at 25’ from the ground.
- The wind is gusting at 40 MPH.

Wind Loads

Wind Speed MPH	10	20	30	40	50	60	70	80	90	100	110	120	130
Wind Pressure (Q_S)	.03	1.0	2.3	4.3	6.5	9.3	12.6	16.4	20.8	25.6	31	36.9	43.3

Height in Feet	Exposure Coefficient C_E	
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$$P = (1.4)(Q_S)(C_E)(AREA)$$

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Crank Up Lifts

Genie ST-25

Applied Electronics L-16

Applied Electronics L-11

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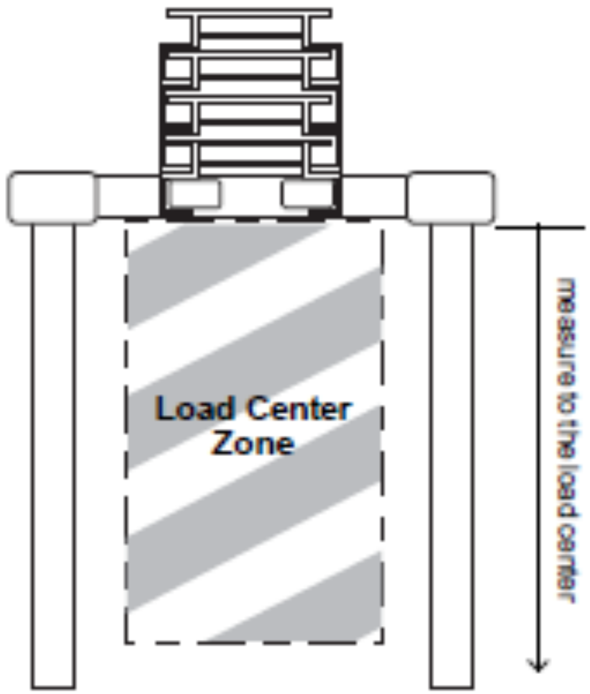
Crank Up Lifts

LOAD CAPACITY CHARTS



See Load Capacity Chart for maximum load centers for adjustable forks.

Maximum Load Center
(measure from the front of the carriage)

Adjustable Forks:	24 in	61 cm

Load Capacity Chart					
Load Center					
Inches		18	20	22	24
cm		46	51	56	61
Model					
ST-20	lbs	800	733	667	600
	kg	363	332	303	272
ST-25	lbs	650	583	517	450
	kg	295	264	235	204

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Pipe and Base

ANSI E1.15-2006 (R2011)

4.1 Acceptable Uses
The following applications of the devices described herein shall be considered acceptable, and within the scope of this document:

A. Mounting of single fixtures*, the weight of which does not exceed 35% of the total assembly weight, or

B. Mounting of small quantities of fixtures, the total combined weight of which does not exceed 50% of the total assembly weight AND where the weights of which are as evenly distributed about the vertical member as is feasible.

C. Attachment of loads under conditions other than that described in A or B above, when used in conjunction with supplemental stabilizing method(s), provided that such applications meet the minimum requirements set forth herein.

D. Use of assemblies
in applications that have been evaluated and deemed acceptable by a qualified person.

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Bad idea!

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Standard Definitions

Reference points

- ***A***(**n**) = Anchorage (n is the anchorage number)
- ***P*** = The point at which the force is applied
- ***O*** = The origin of a force vector
- ***T*** = The termination of a force vector

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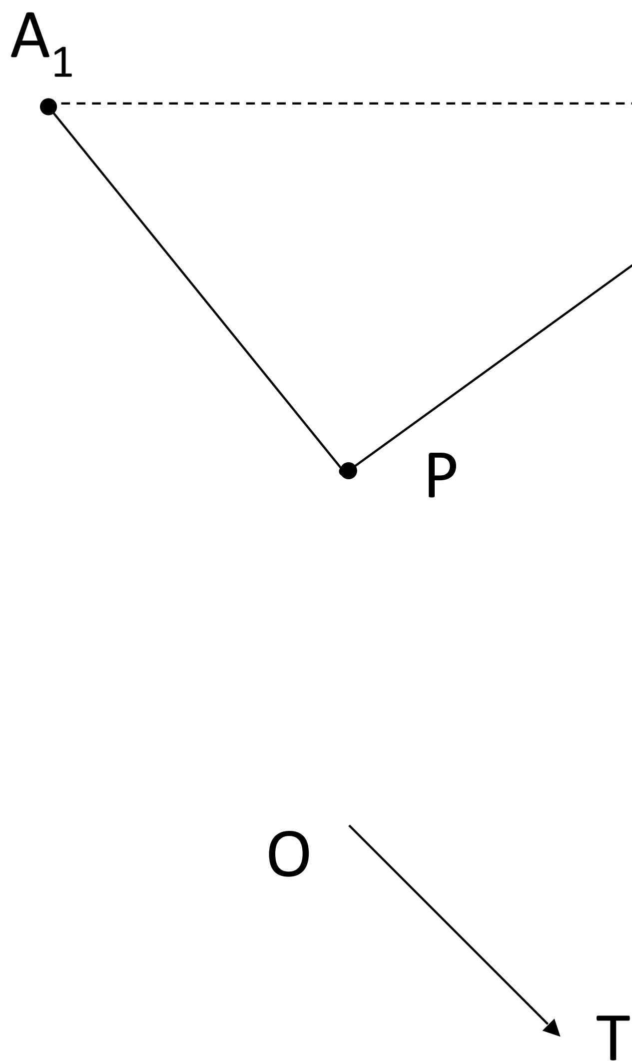

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Standard Definitions

Distances

- ***S*** = The horizontal distance between anchorages. This distance is also commonly referred to as ***Span.***
- ***D***(n) = The horizontal distance from anchorage (n), where (n) is the anchorage number, to the applied force. This form is only used when all distances are horizontal.
- ***DV*** = The vertical distance between the anchorages of a bridle and the bridle point. This form can only be used when all anchorages are at the same height.
- ***DZ*** = An alternative to ***DV***. Used if the Cartesian coordinate system is being used to describe points.

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Standard Definitions

Distances

- ***D***(n)(***x***) = The distance from anchorage (**n**), where (**n**) is the anchorage number, to the applied force in the direction (**x**). The direction ***(x)*** would be one of the following:
  - ***H*** = Horizontal in-line with the bridle leg
  - ***V*** = Vertical
  - ***X*** = In the x-axis
  - ***Y*** = In the y-axis
  - ***Z*** = In the z-axis
  - ***L*** = In-line with the bridle leg

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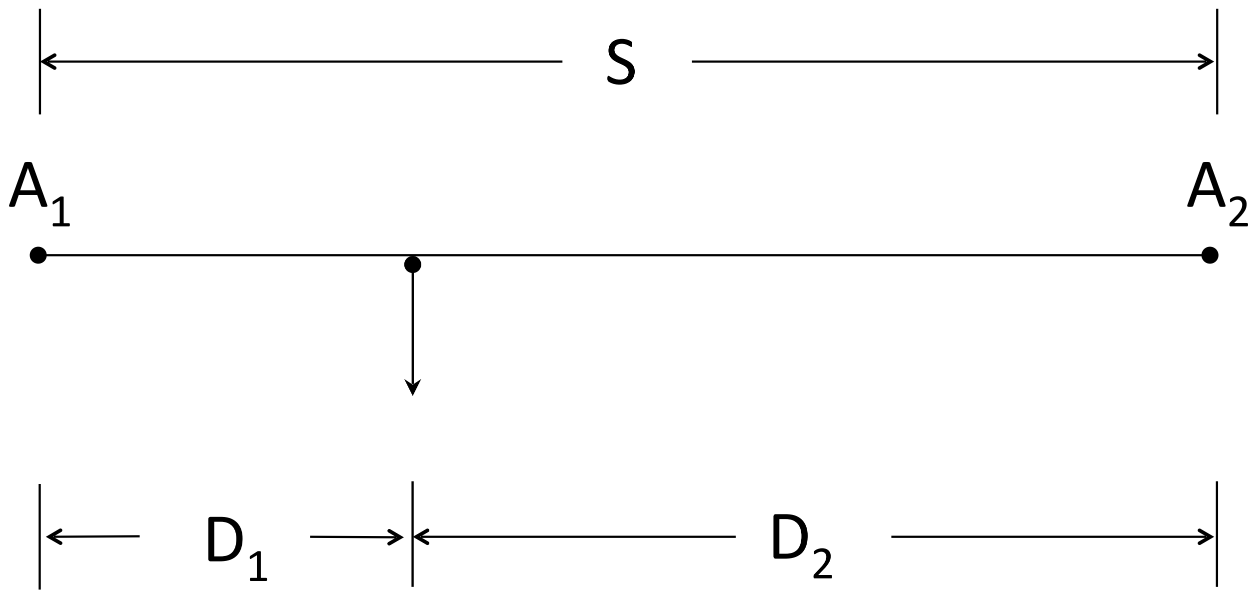
Standard Definitions

Distances



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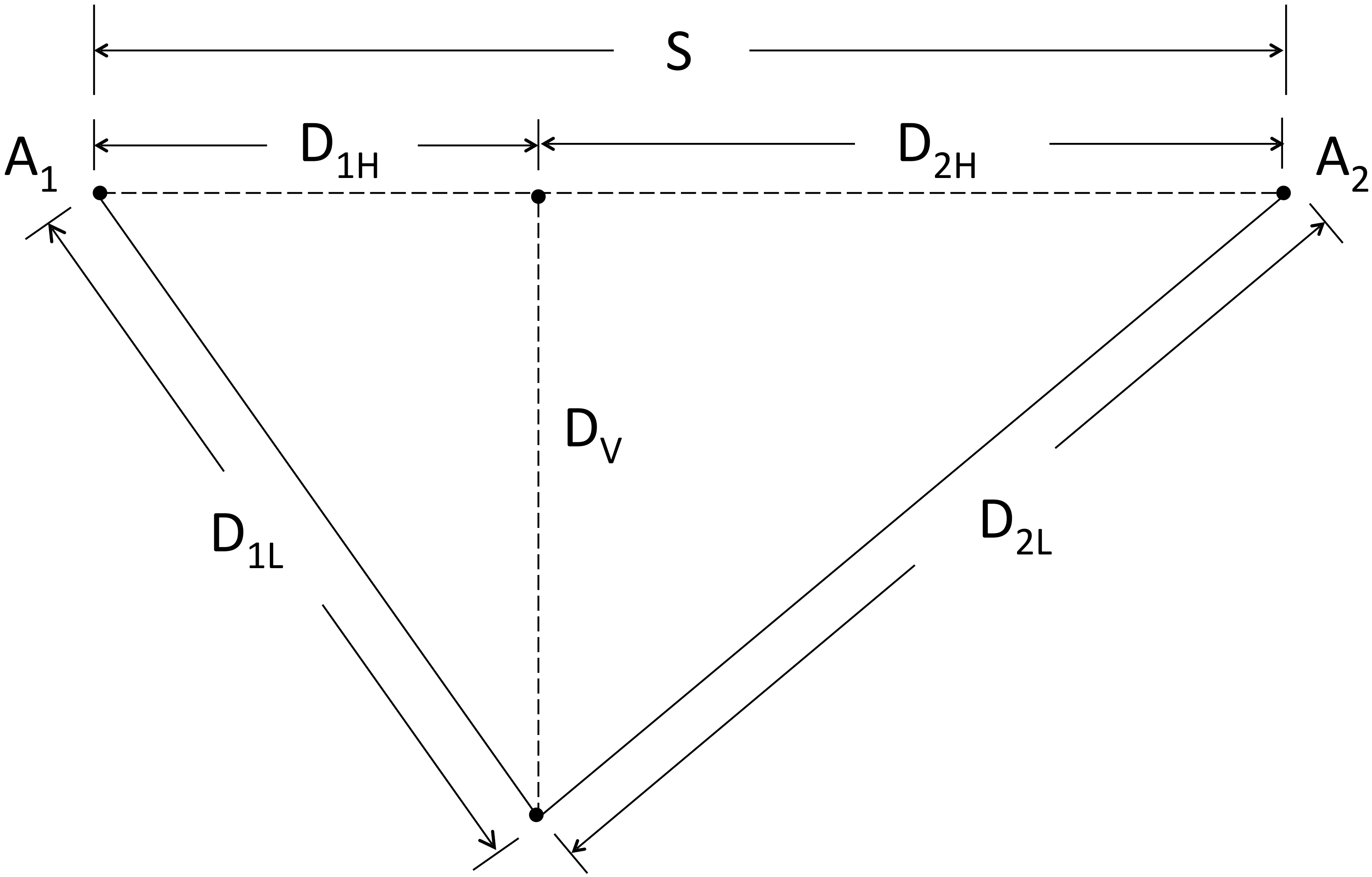
Standard Definitions

Distances



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Forces

- ***FA*** = The applied force
- ***FA(*x*)*** = A component of the applied force in the direction (**x**).
  - The direction (**x**) would be one of the following:
    - ***H*** = Horizontal in-line with the applied force
    - ***V*** = Vertical
    - ***X*** = In the x-axis
    - ***Y*** = In the y-axis
    - ***Z*** = In the z-axis

ENTERTAINMENT
RIGGING SERVICES, LLC

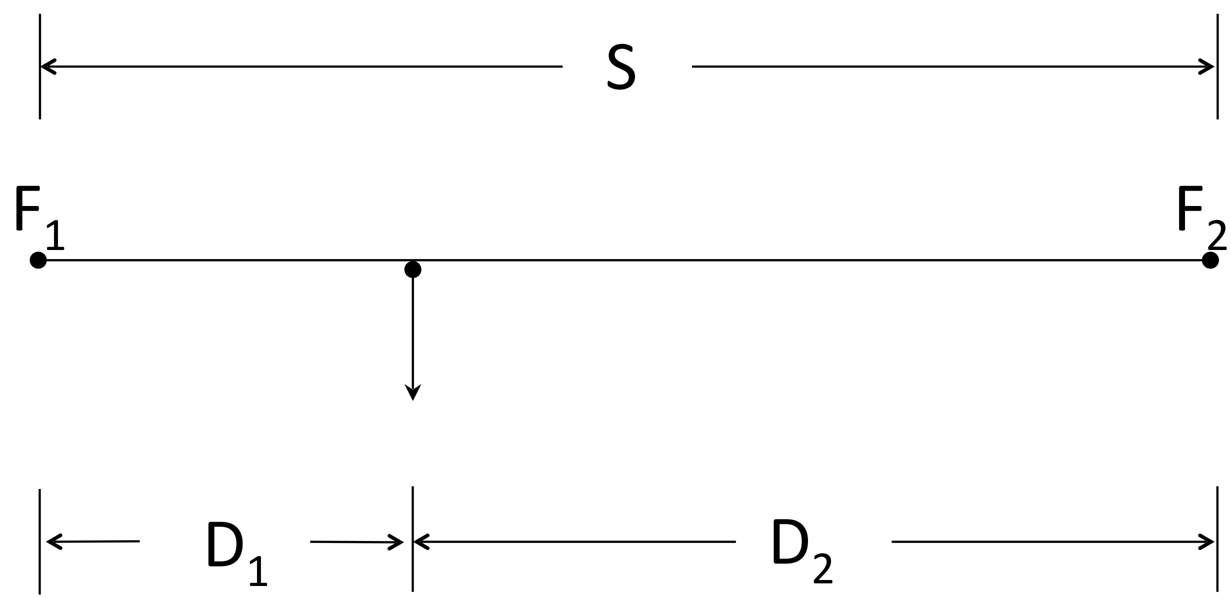
Standard Definitions

Forces

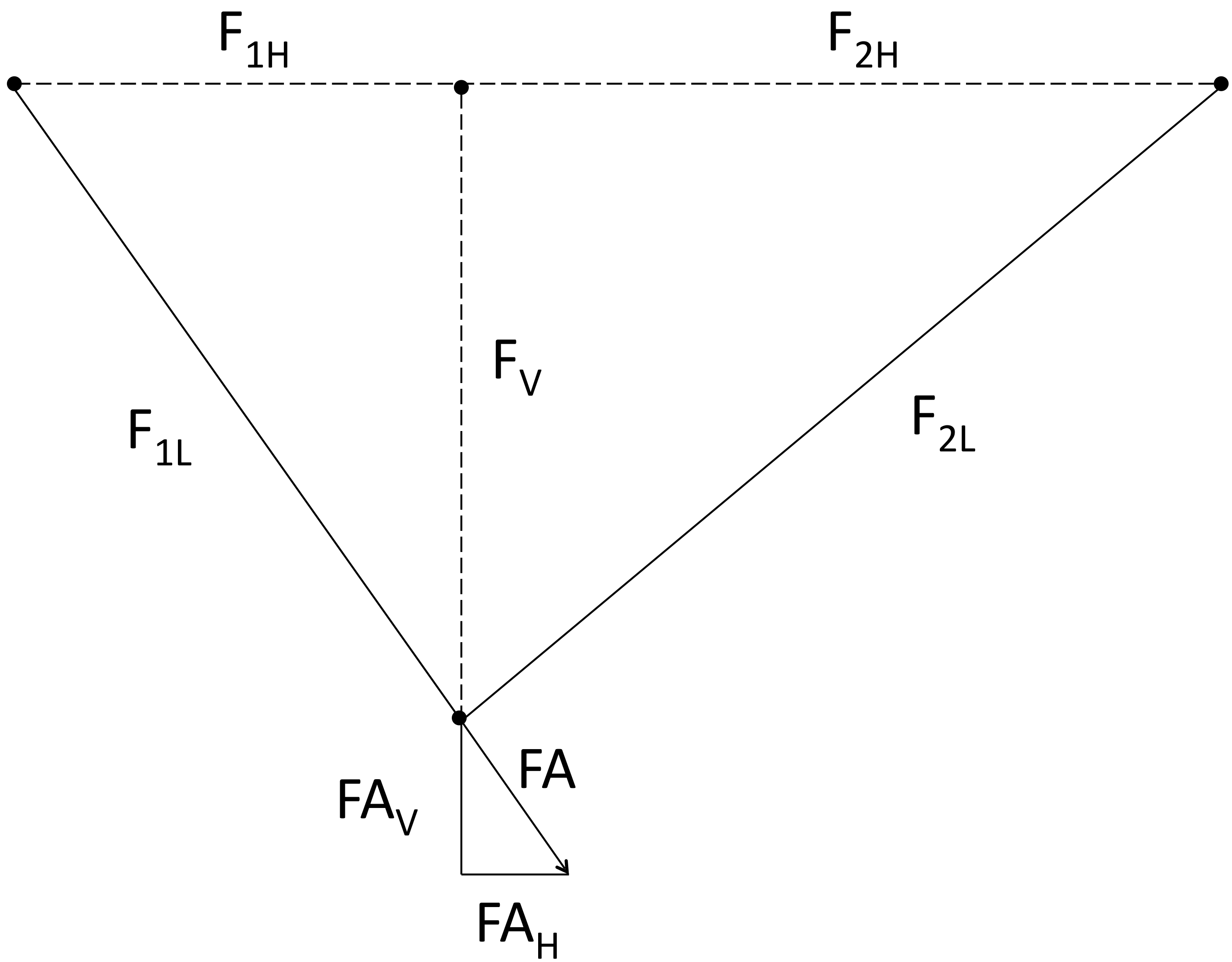
- ***F(n)*** = The vertical force at anchorage (n), where (n) is the anchorage number. This form is used only when all forces being analyzed are vertical.
- ***F(n)(x)*** = The force at anchorage (n), where (n) is the anchorage number, in the direction (x). The direction (x) would be one of the following:
    - ***L*** = In-line with the bridle leg
    - ***H*** = Horizontal in-line with the bridle leg
    - ***V*** = Vertical
    - ***X*** = In the x-axis
    - ***Y*** = In the y-axis
    - ***Z*** = In the z-axis

Standard Definitions

Forces



Forces



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Standard Definitions

Angles

- ***a***(**n**) = The angle between the bridle leg and horizontal at point
- ***A***(**n**), where (**n**) is the anchorage number.
- ***a***(***n***)***r*** = The angle of rotation of the bridle leg around ***A***(**n**), where (**n**) is the anchorage number.
- ***p***(**n**) = The angle between the anchorage and vertical at point ***P***, where (**n**) is the anchorage number.
- ***p*** = the angle between the bridle legs with a base at ***P***.
- ***o*** = The acute angle between ***FA*** and horizontal with a base at ***O***.
- ***or*** = The angle of rotation of the force around ***O***.
- ***t*** = The acute angle between ***FA*** and vertical with a base at ***T***.

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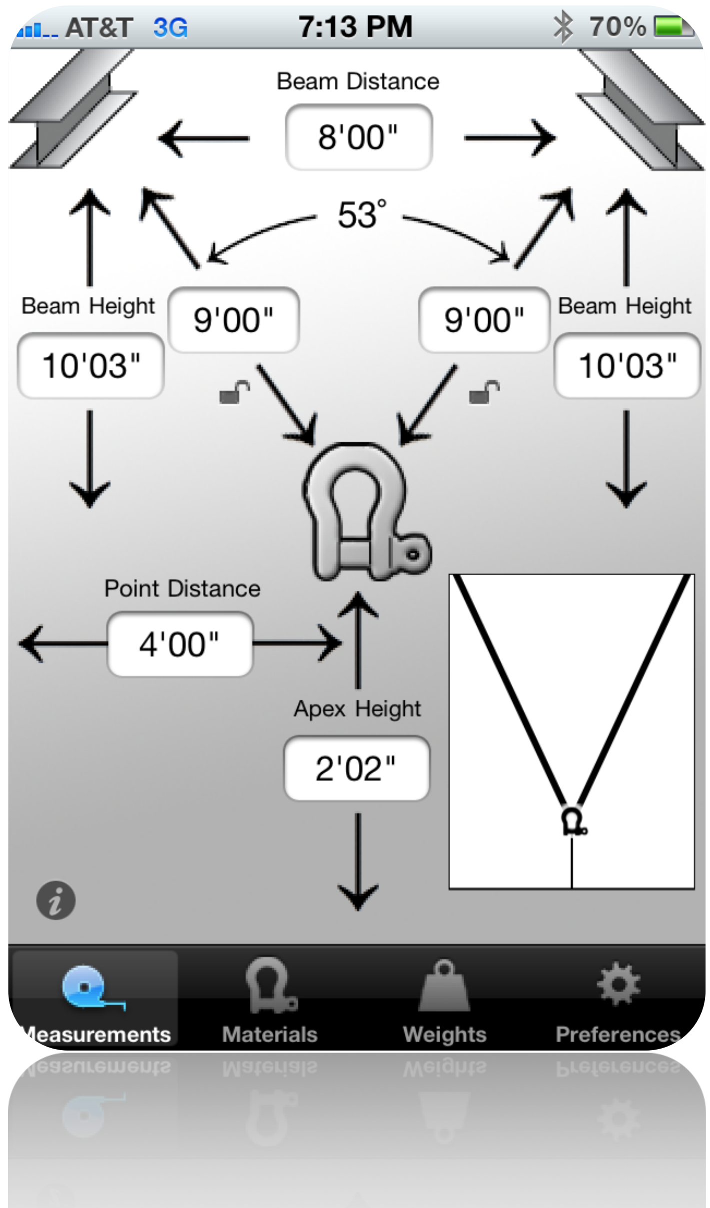
Bridle IPhone App



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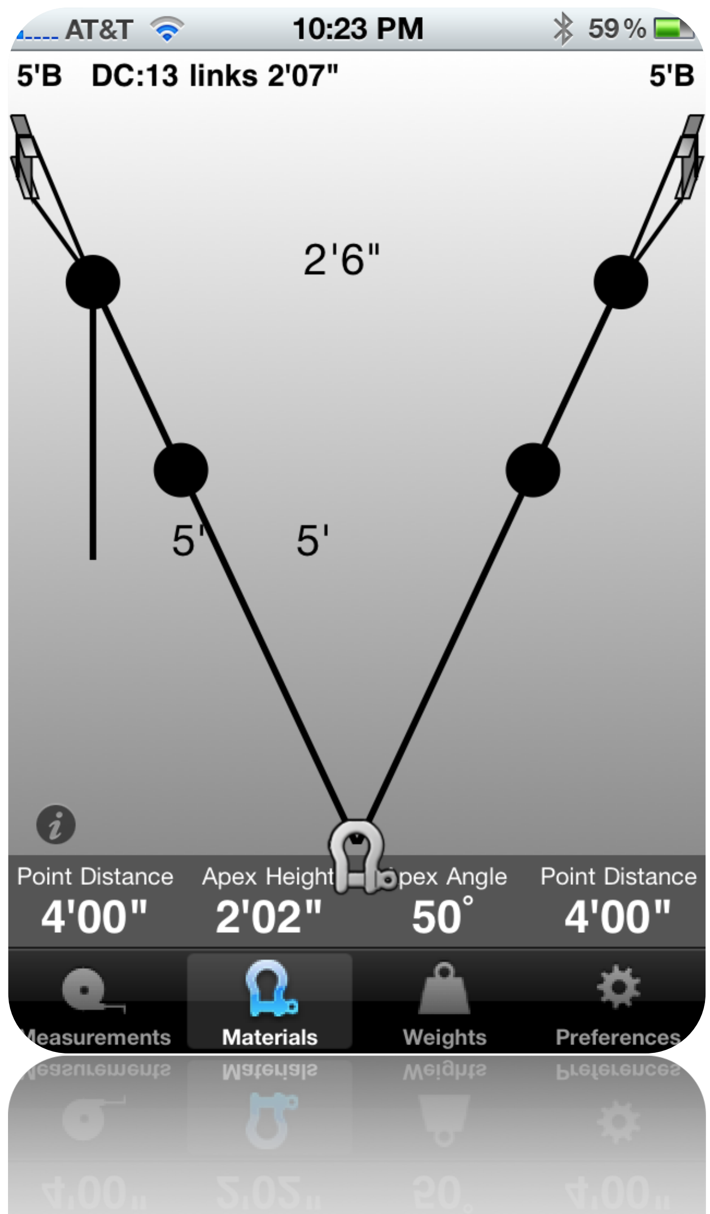
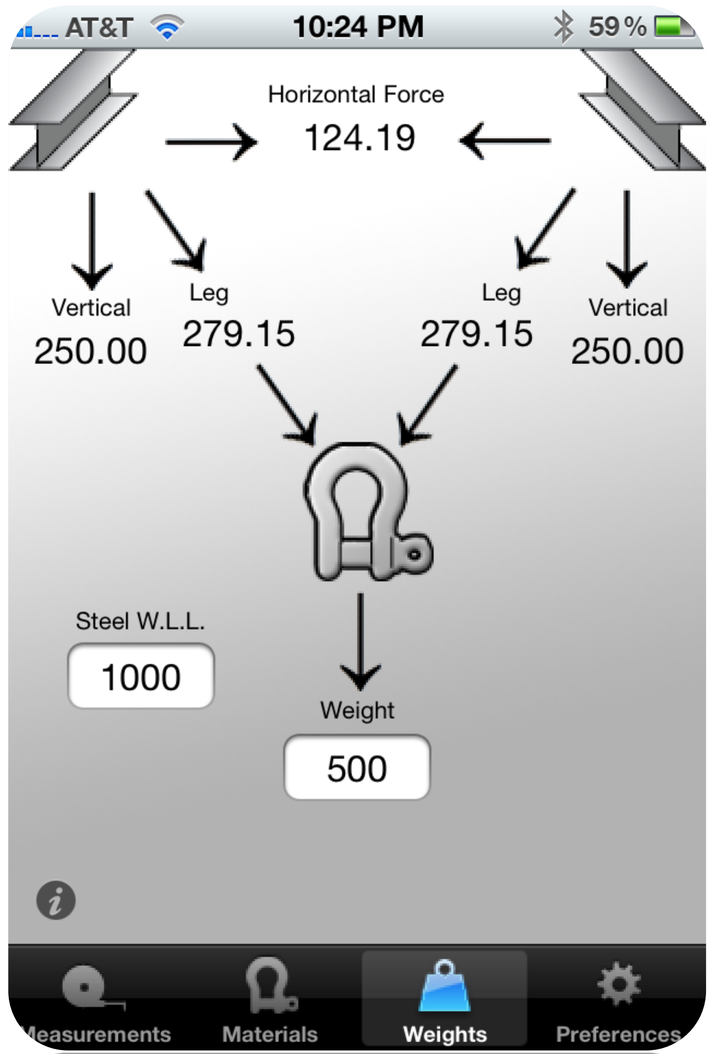
Bridle IPhone App



Bridle IPhone App



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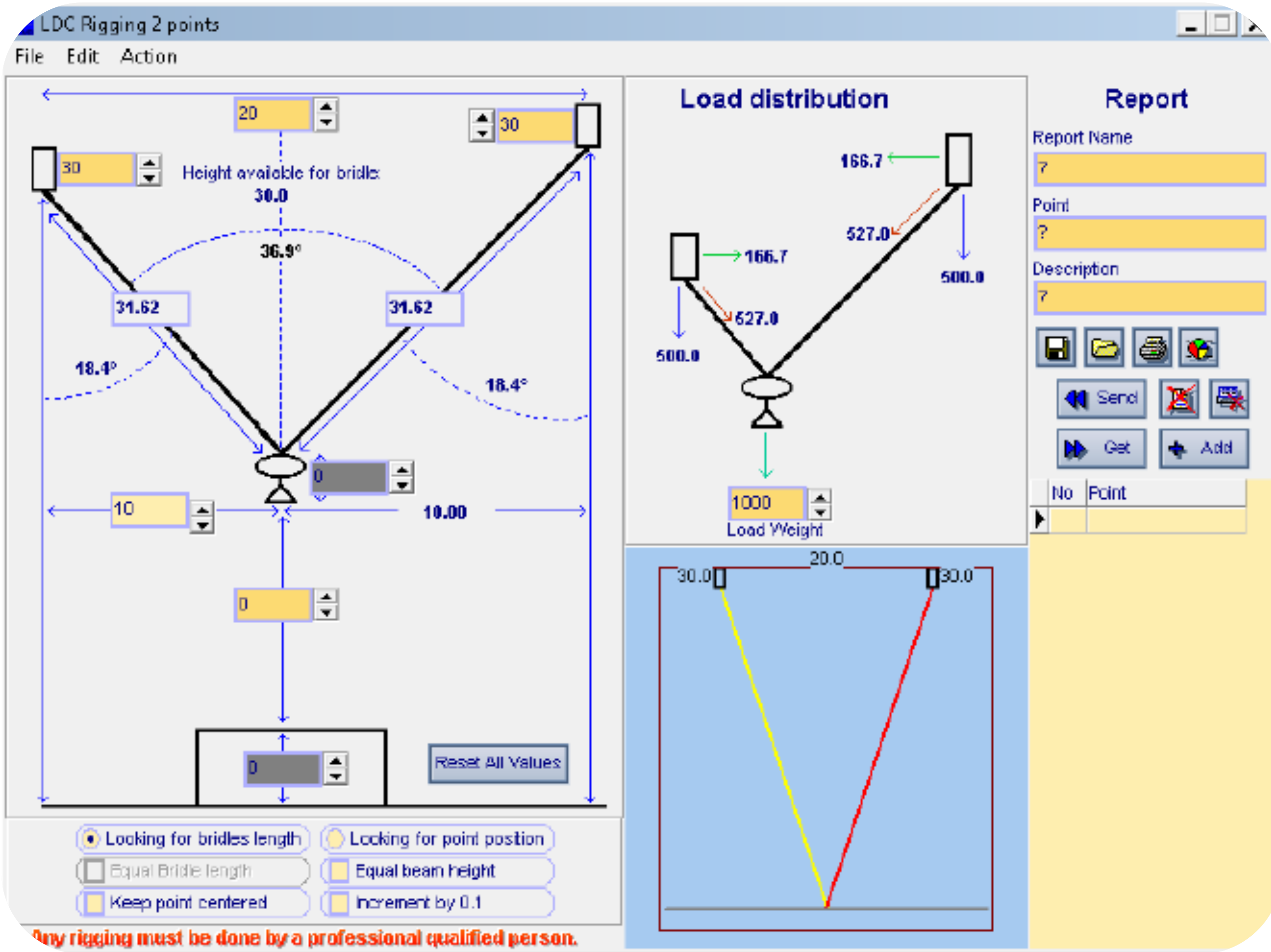
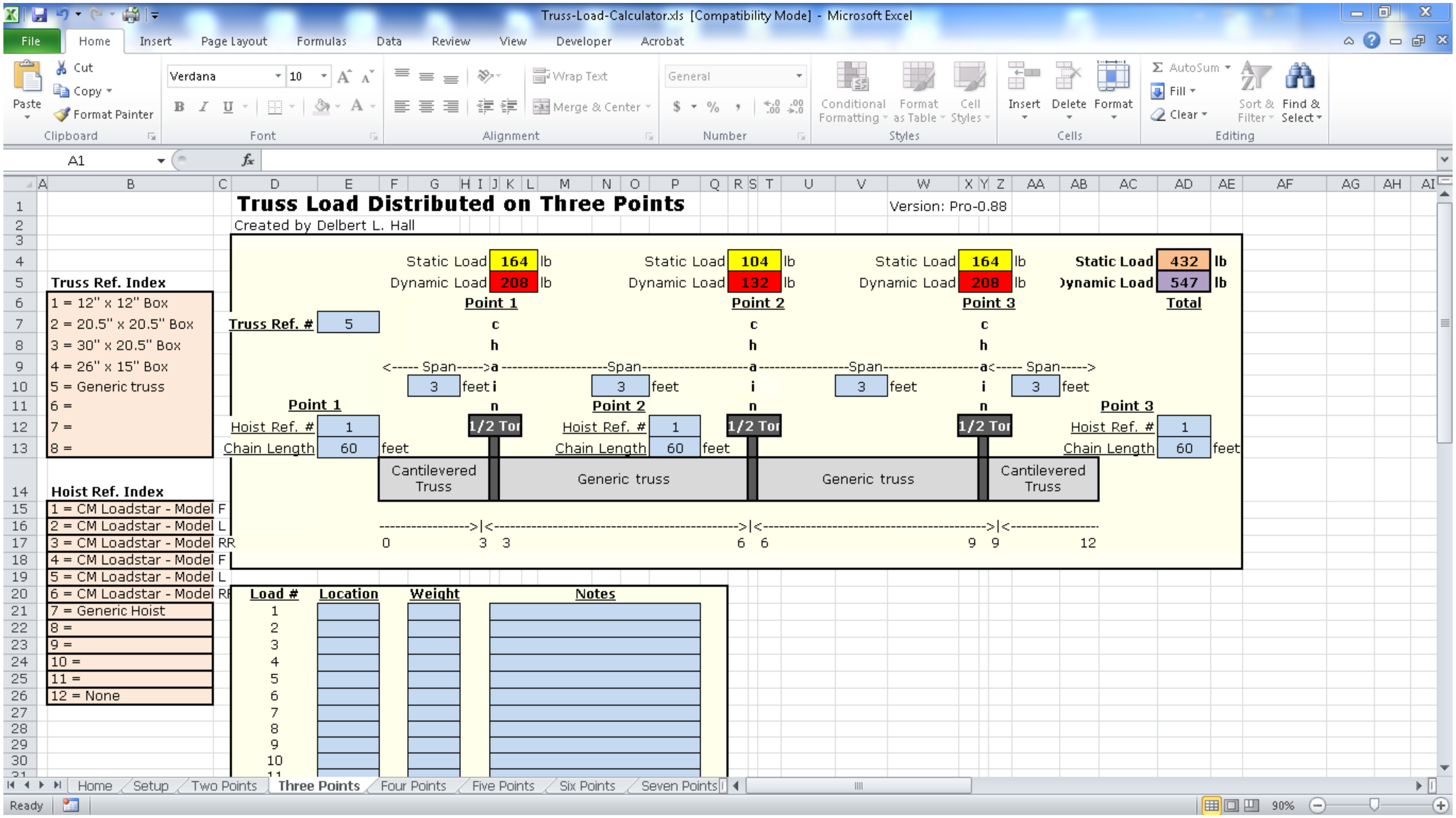
LD Calculator Lite



Dilbert Hall Excel calculators



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Engineering Reports

CLARK | REDER
ENGINEERING

10/19/2015

Advanced Lighting & Production Services
65 Teed Drive
Randolph, MA 02368
Attn: Ethan Gilson

RE: Pan Mass Challenge Lighting Truss
CRE Proj. No.: 15.301.25

Dear Ethan:

Clark Reder Engineering Inc. has completed its structural review of the lighting truss to be installed indoors for the Pan Mass Challenge. The lighting truss is 12"x12" aluminum box truss. The lighting loads and weights are provided on the attached sheets.

CRE has performed an independent structural analysis of the lighting truss to confirm the load reactions to the building structure. Our findings are in agreement with those provided by Ethan Gilson of ALPS. CRE deems that the lighting truss is adequate to support the intended loads.

We trust this information is suitable for your needs at this time. If you have any questions or require any additional information, please do not hesitate to contact our office.

Regards,

Clark-Reder Engineering, Inc.

COMMONWEALTH OF MASSACHUSETTS
JEFFREY M.
REDER
STRUCTURAL
No. [illegible]
REGISTERED
PROFESSIONAL ENGINEER
2015-10-19

Jeffrey M. Reder, P.E.

Clark-Reder Engineering, Inc. • 10091 Mosteller Lane, West Chester, OH 45069-3873 • Phone (513) 851-1223 • Fax (513) 217-9388 •www.clarkreder.com

ENTERTAINMENT
RIGGING SERVICES, LLC

Truss Load Distributed on Six Points

Version: Pro-0.82

Created by Delbert L. Hall

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Total
Static Load (lb)	253	692	387	336	377	252	2,298
Dynamic Load (lb)	321	877	491	426	478	319	2,911
Hoist Ref. #	1	1	1	1	1	1	
Chain Length (feet)	65	65	65	65	65	65	
Chain	1/2 Ton	1/2 Ton	1/2 Ton	1/2 Ton	1/2 Ton	1/2 Ton	

Truss Ref. # 1

Span	Span	Span	Span	Span	Span	Span
2 feet	21 feet	21 feet	21 feet	21 feet	21 feet	3 feet
Cantilevered Truss	12" x 12" Box	12" x 12" Box	12" x 12" Box	12" x 12" Box	12" x 12" Box	Cantilevered Truss
0 – 2	2 – 23	23 – 44	44 – 65	65 – 86	86 – 107	107 – 110

Truss Ref. Index

1 = 12" x 12"
2 = 20.5" x 20.5"
3 = 30" x 20.5"
4 = 20" x 15"
5 = Generic
6 =
7 =
8 =

Hoist Ref. Index

1 = 1/2 Ton, 16 fps
2 = 1 Ton, 16 fps
3 = 2 Ton, 16 fps
4 = 1/2 Ton, 32 fps
5 = 1 Ton, 32 fps
6 = 2 Ton, 32 fps
7 = Generic
8 =
9 =
10=
11=
12=

Load #	Location	Weight	Notes
1	24	168	Cross Truss 1
2	5.667	52	MAC Q
3	11	13	Aura
4	14	13	Aura
5	19.333	52	MAC Q
6	23	118	Cross Truss 2
7	25	20	Leko
8	32.833	13	Rush
9	33.5	72	Spectra/MAC
10	34.25	20	Leko
11	42	20	Leko
13	46	20	Leko
14	53.833	13	Rush
15	54.5	20	Spectra
16	55.25	20	Leko
17	63	20	Leko
18	67	20	Leko
19	74.833	13	Rush
20	75.5	20	Spectra
21	76.25	20	Leko
22	84	20	Leko
23	88	20	Leko
24	95.833	13	Rush
25	96.6	20	Spectra
26	97.25	20	Leko
27	105	20	Leko
28	30	52	MAC Q
29	90	52	MAC Q
30			

Ticket Side Truss

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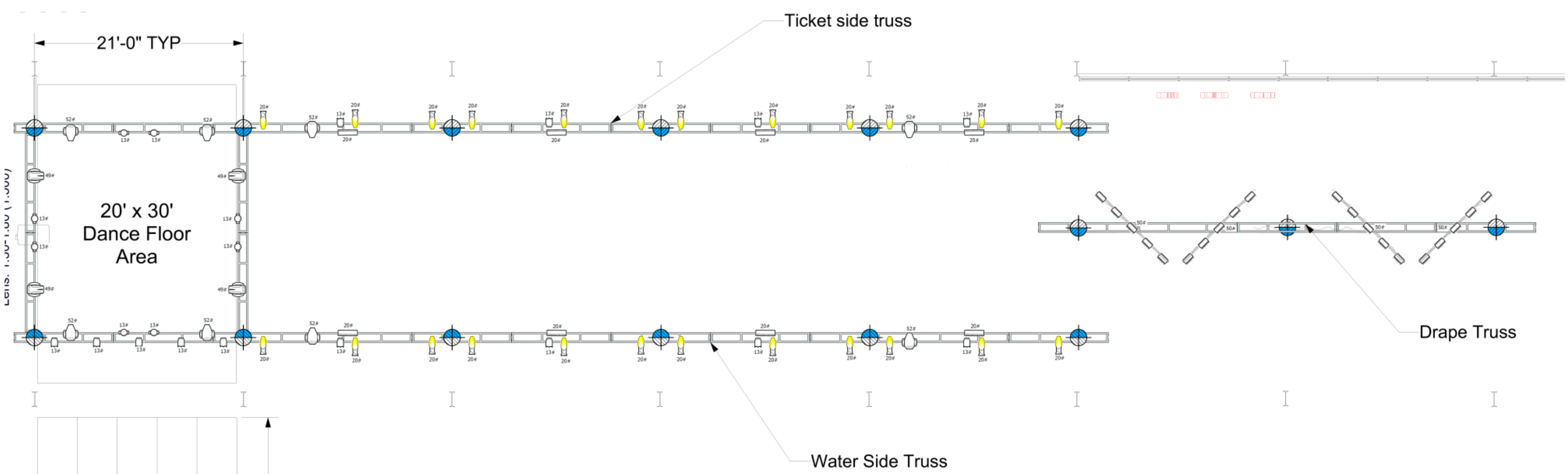
Engineering Reports



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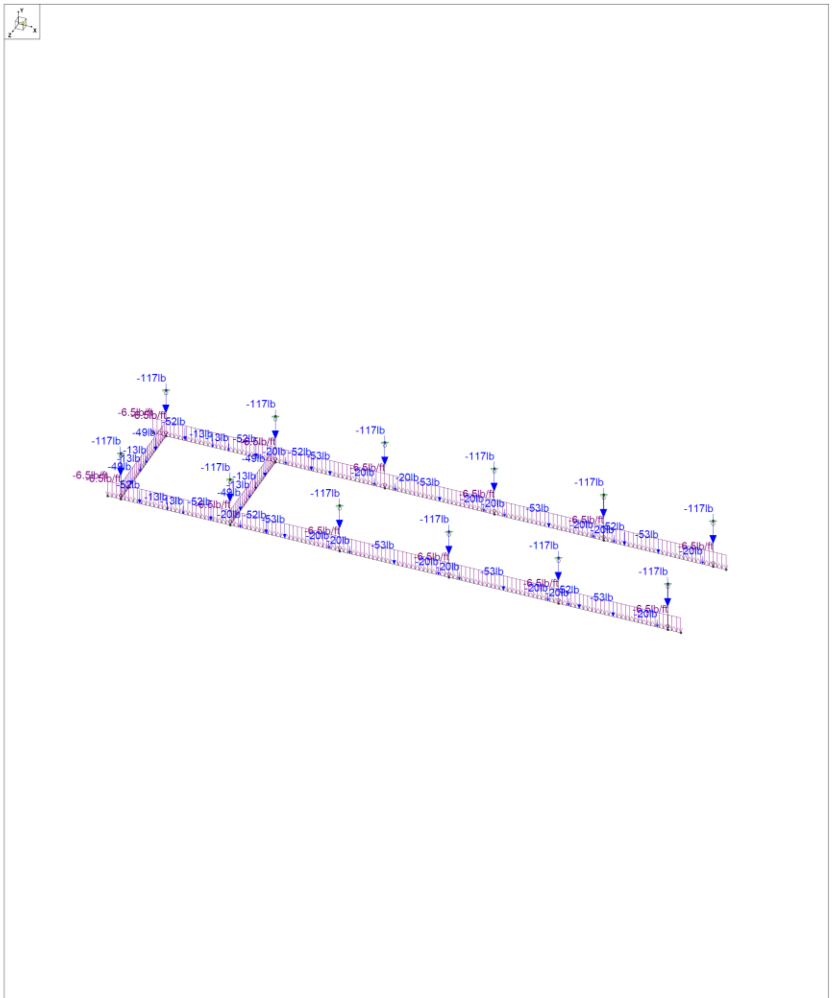
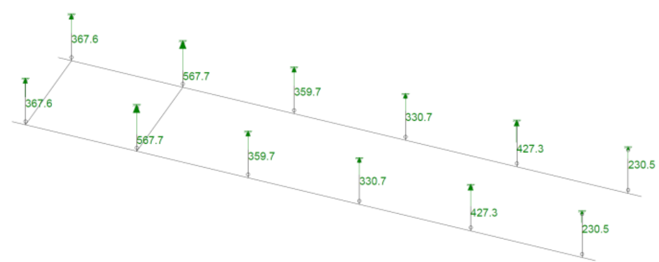
Engineering Reports



Loads: BLC 1, Dead Load

Clark Reder Engineering I...		SK - 2
JMR		Oct 19, 2015 at 10:20 AM
		r1.r3d

Engineering Reports



Results for LC 1, DL+LL
Y-direction Reaction Units are lb and lb-ft

Clark Reder Engineering I...		SK - 1
JMR		Oct 19, 2015 at 10:20 AM
		r1.r3d

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Vector Solutions to Simple Bridles

- Vectors offer an alternative to Algebra
- Helps to visualize the forces
- Slower to calculate loads
- Not as Accurate

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Vectors

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Vectors

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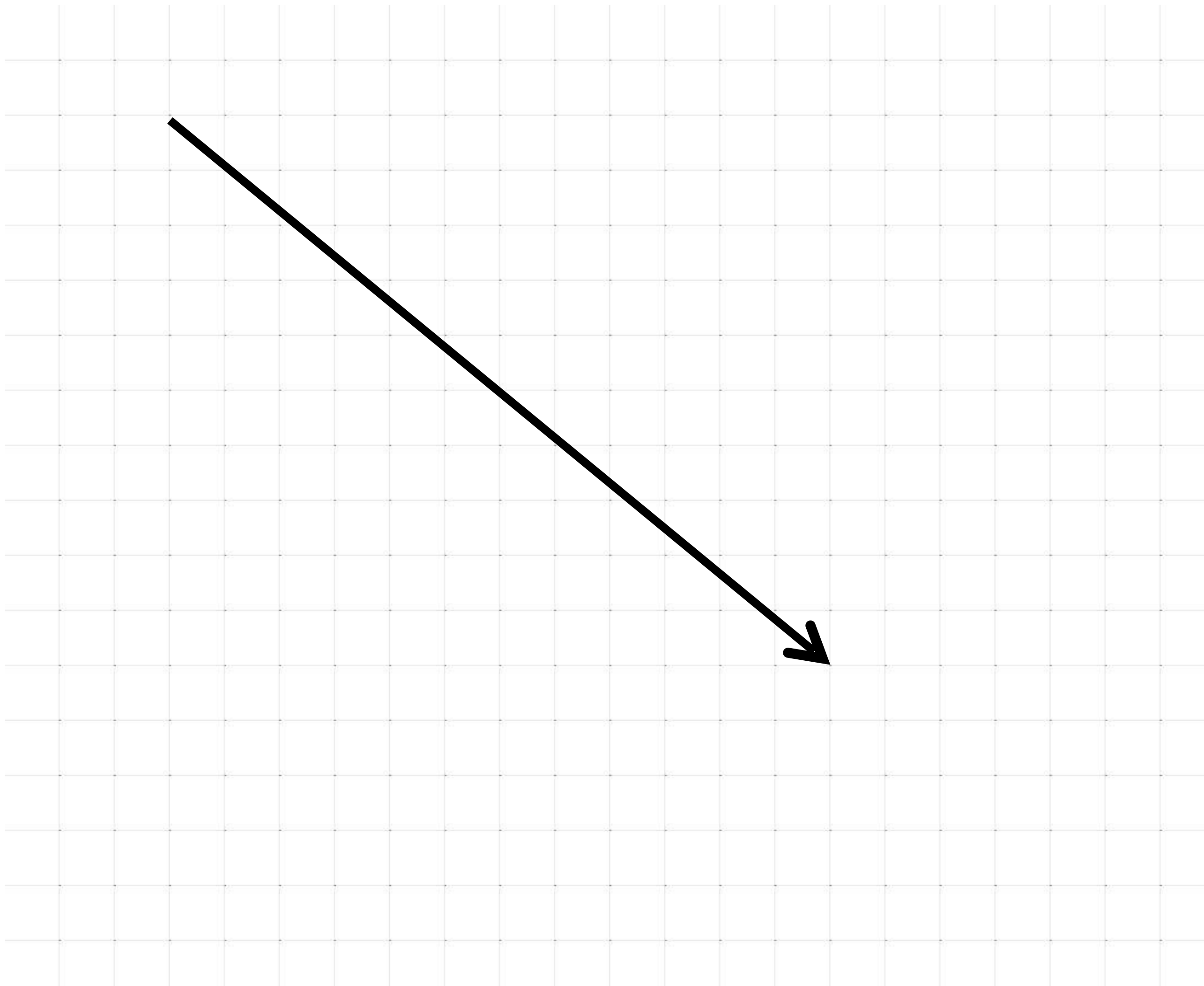
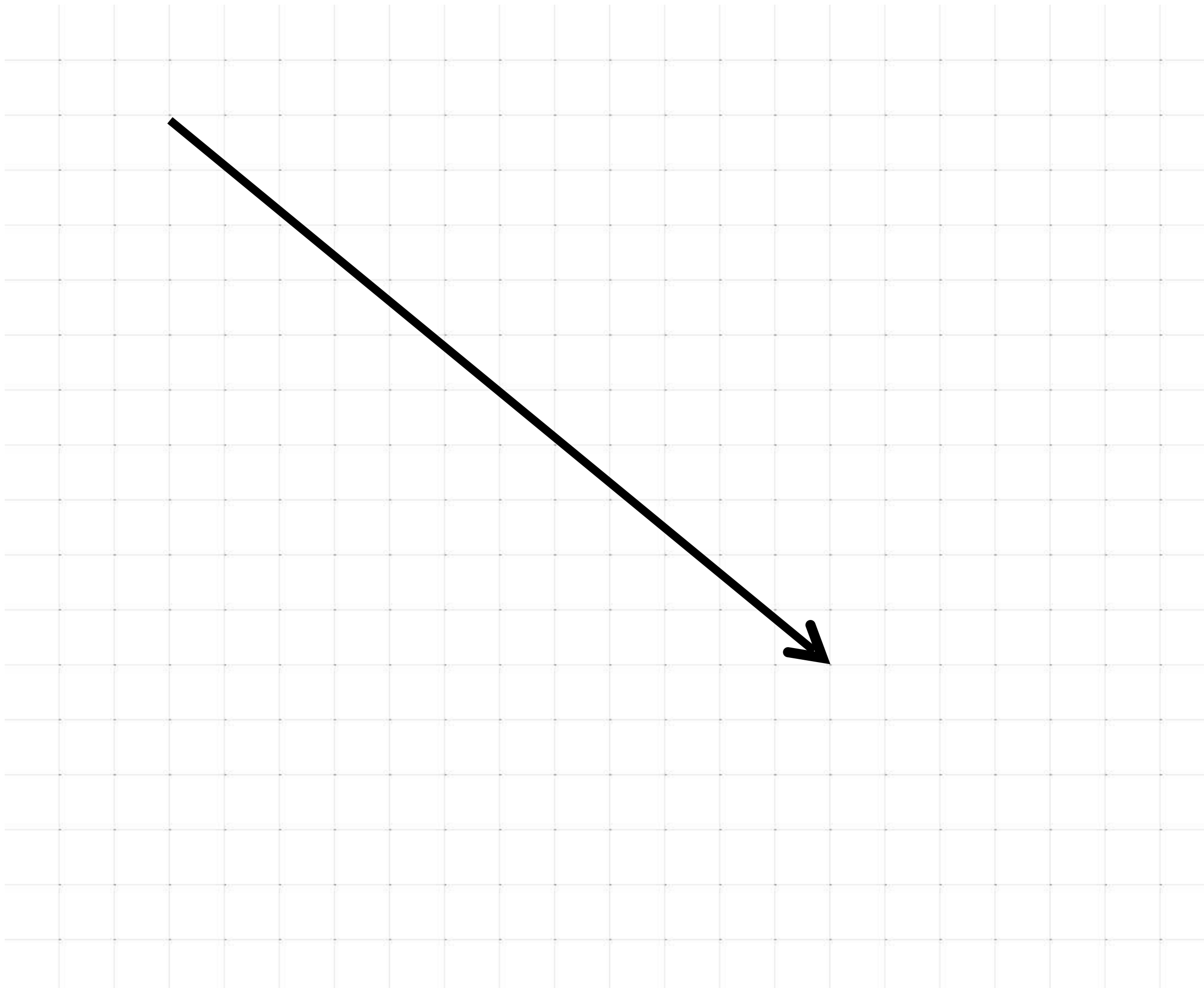
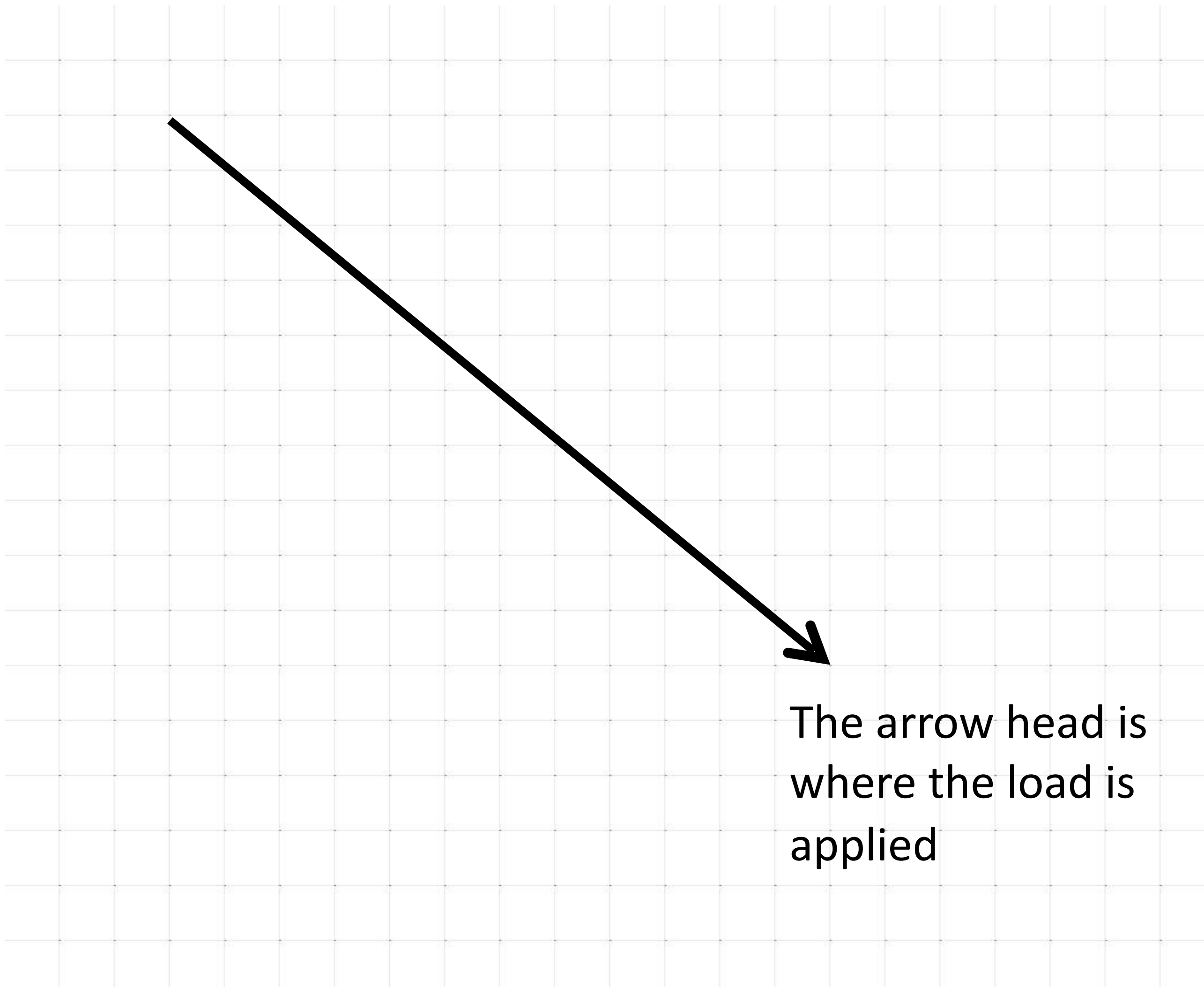
Vectors



Vectors



Vectors



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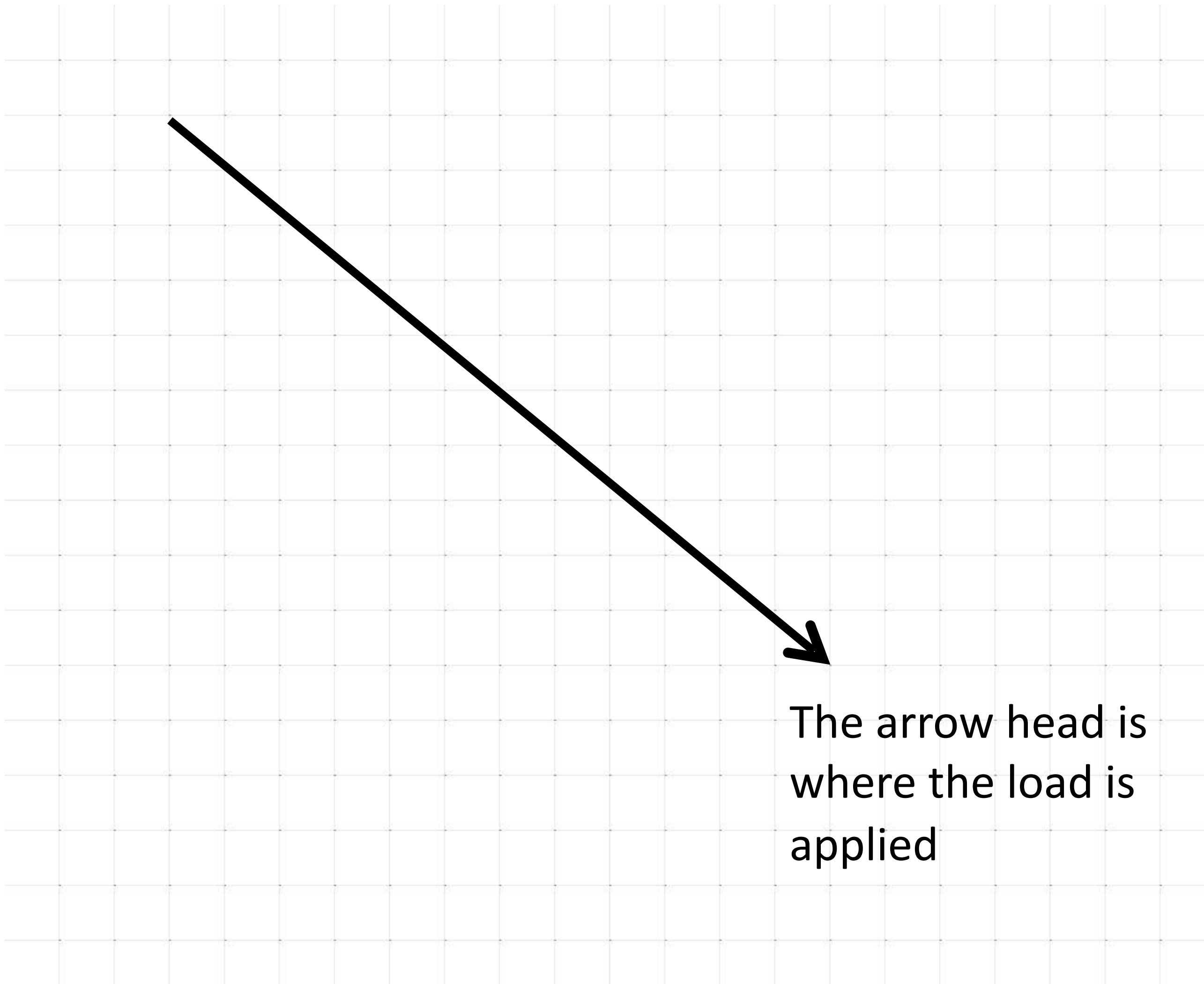
Vectors



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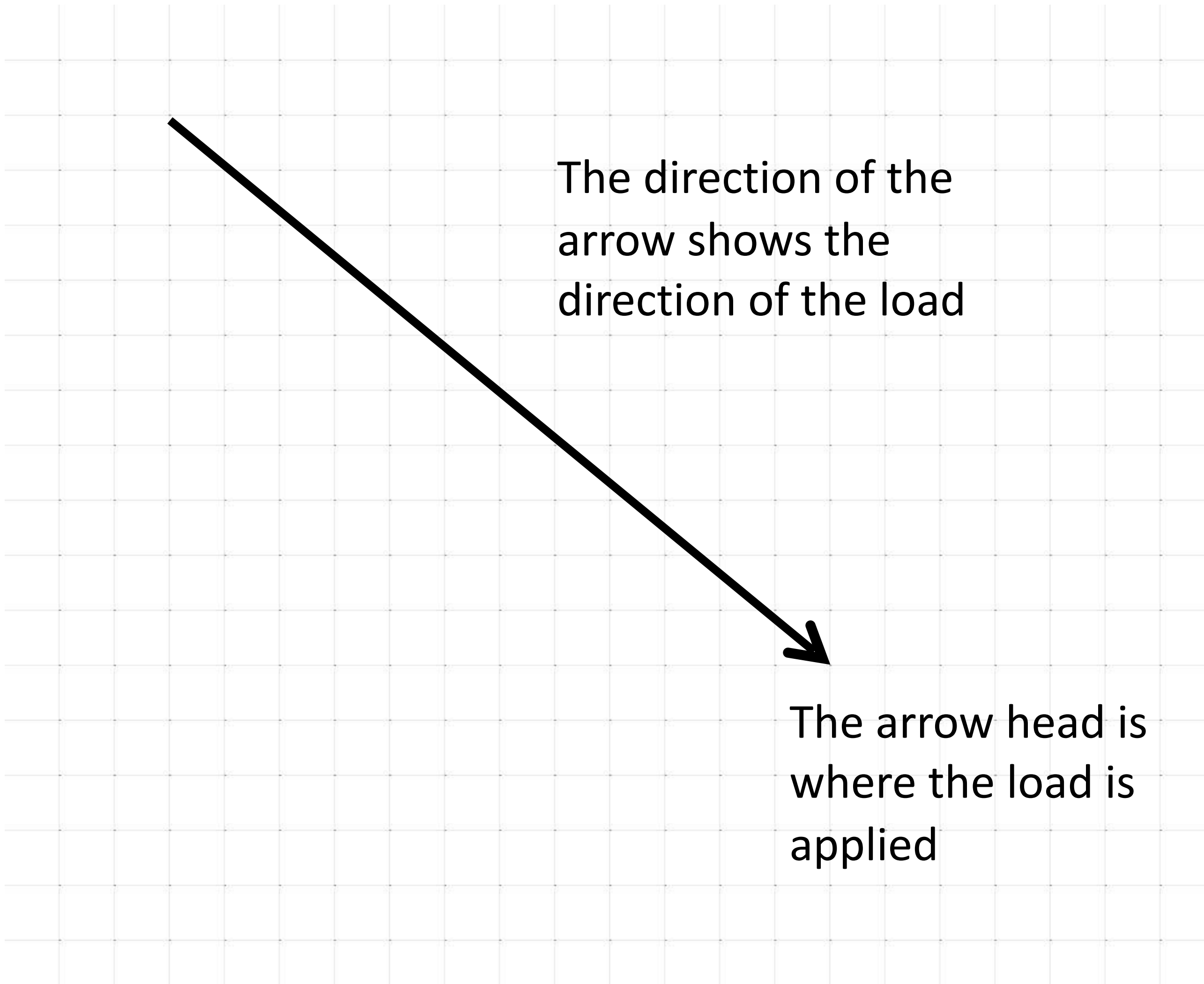
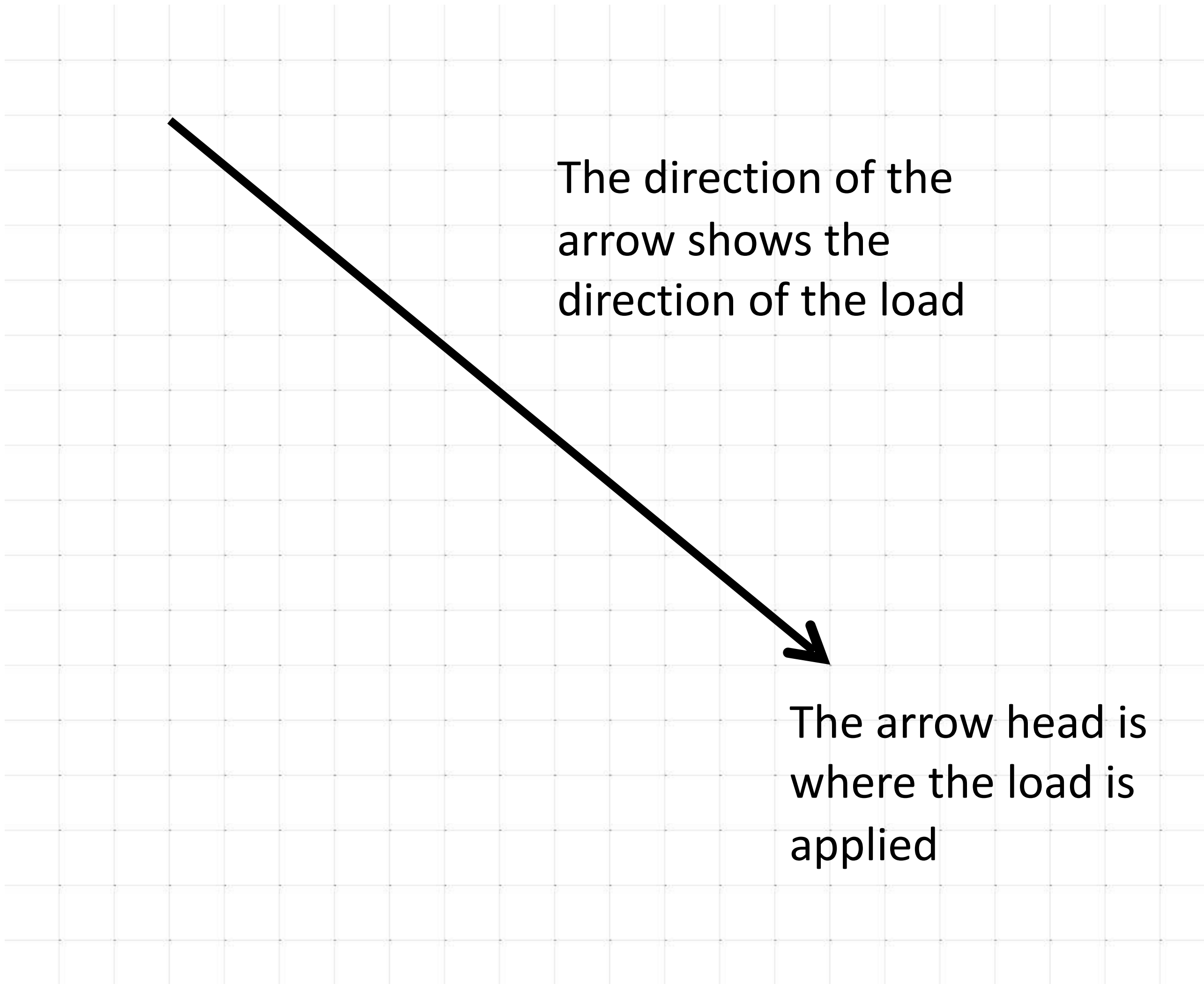
Vectors


The direction of the arrow shows the direction of the load
The arrow head is where the load is applied

Vectors



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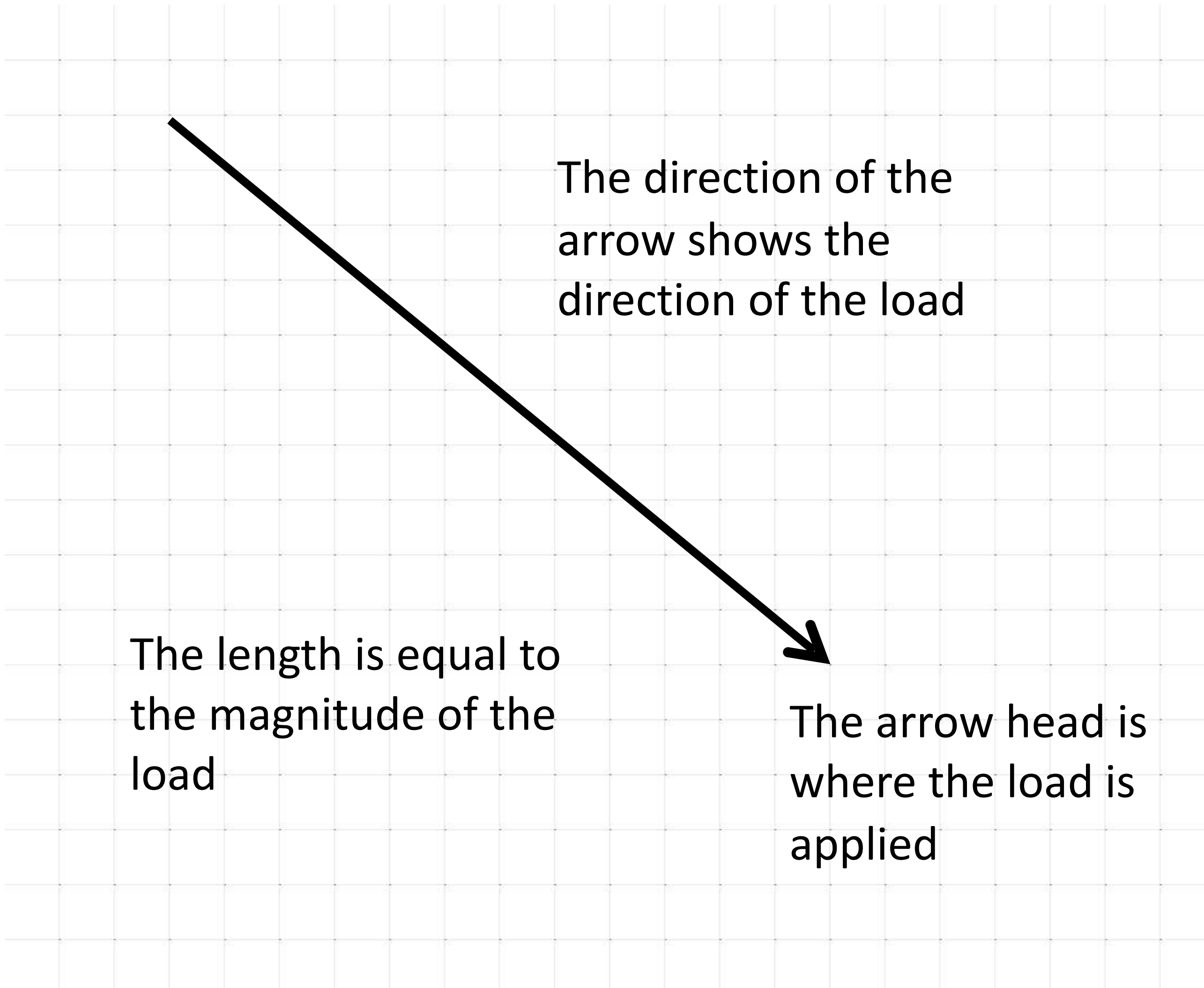
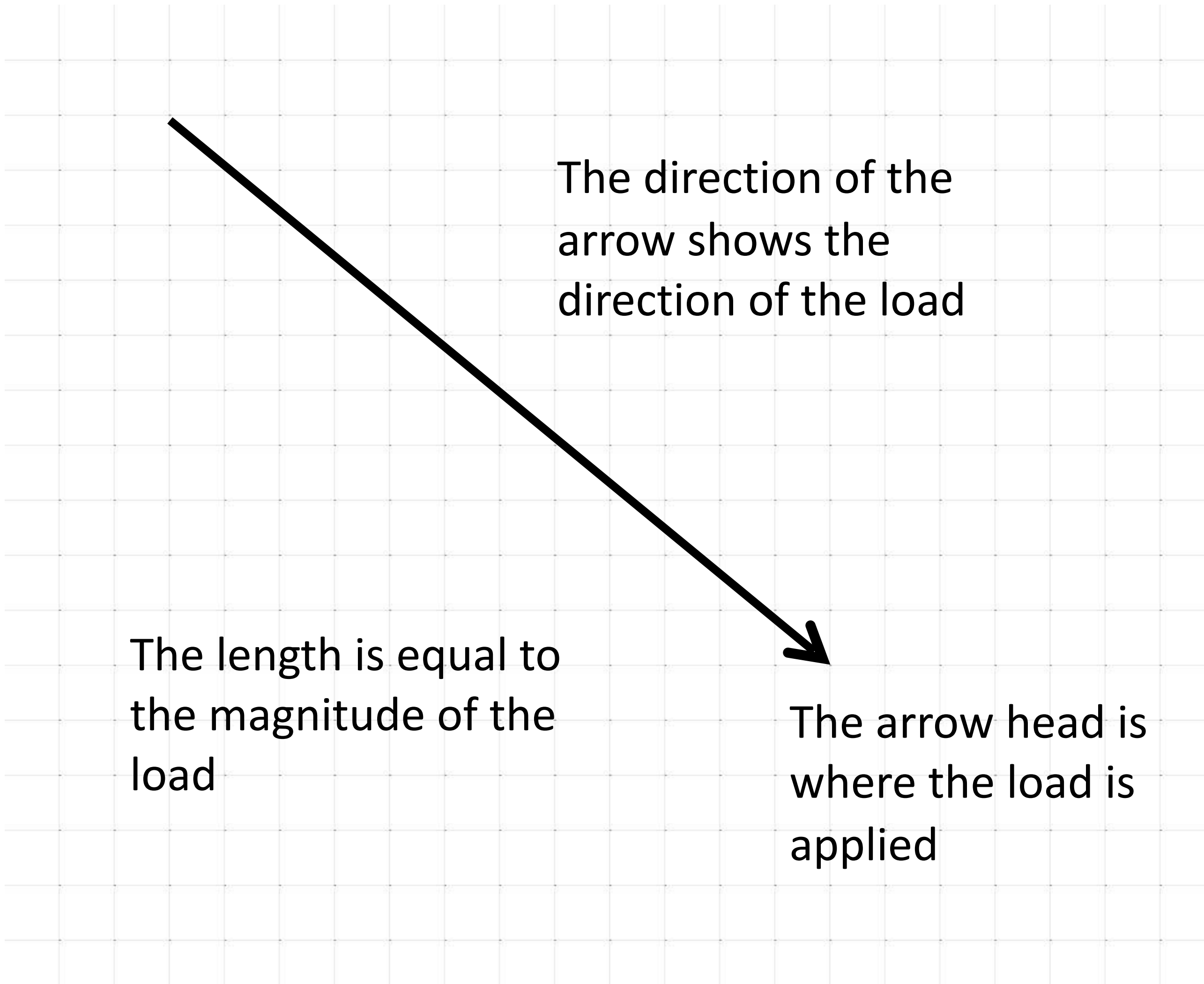
Vectors


The direction of the arrow shows the direction of the load
The length is equal to the magnitude of the load
The arrow head is where the load is applied

Vectors



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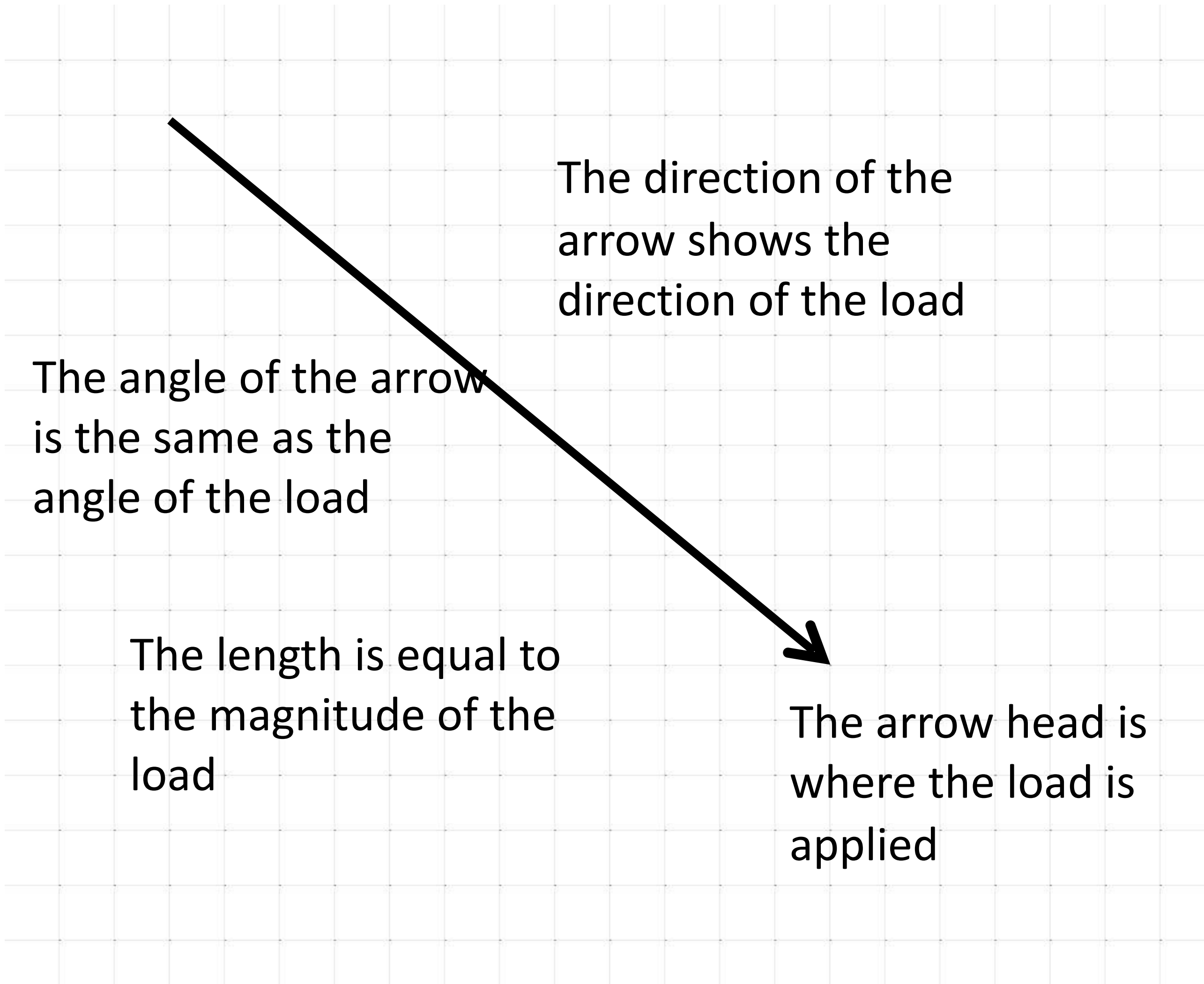
Vectors



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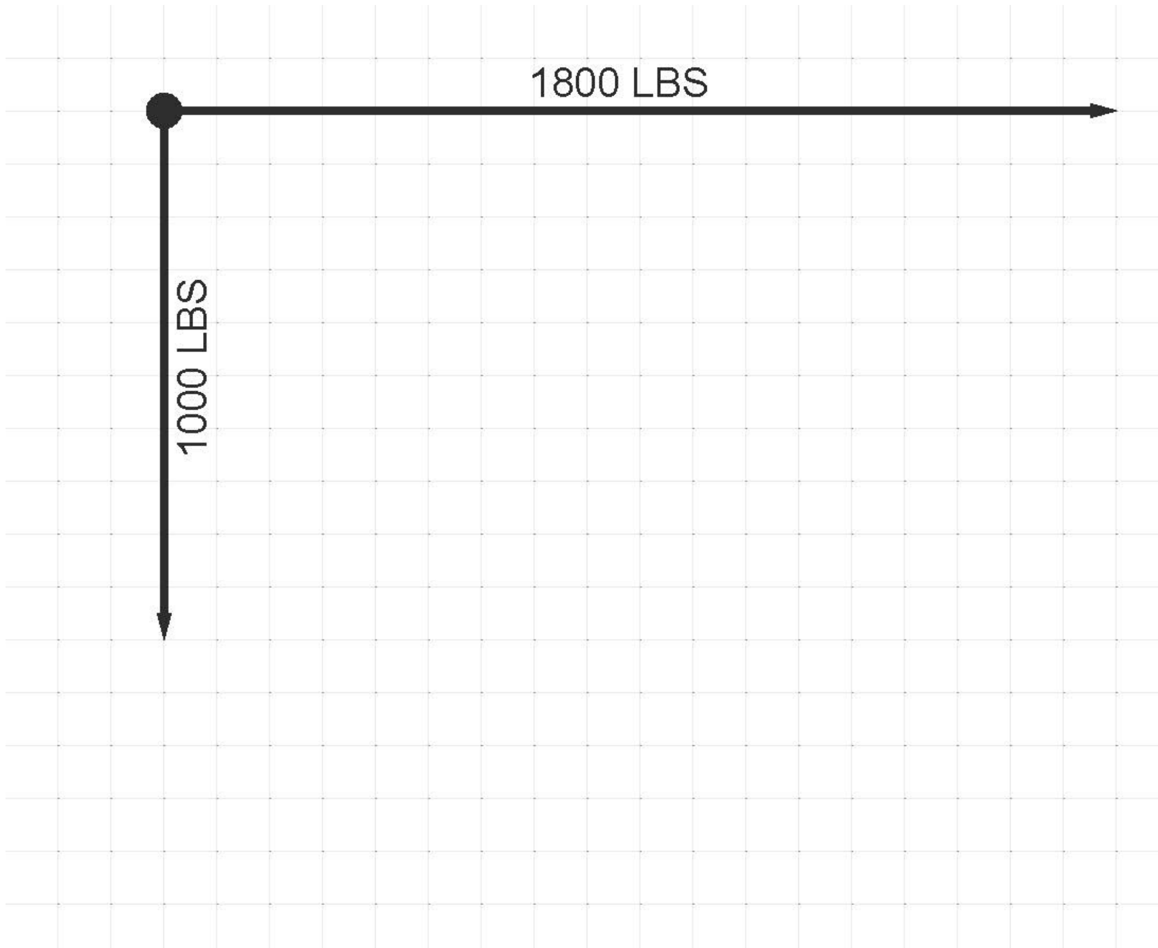
Vector Problem 1



Draw the vector loads

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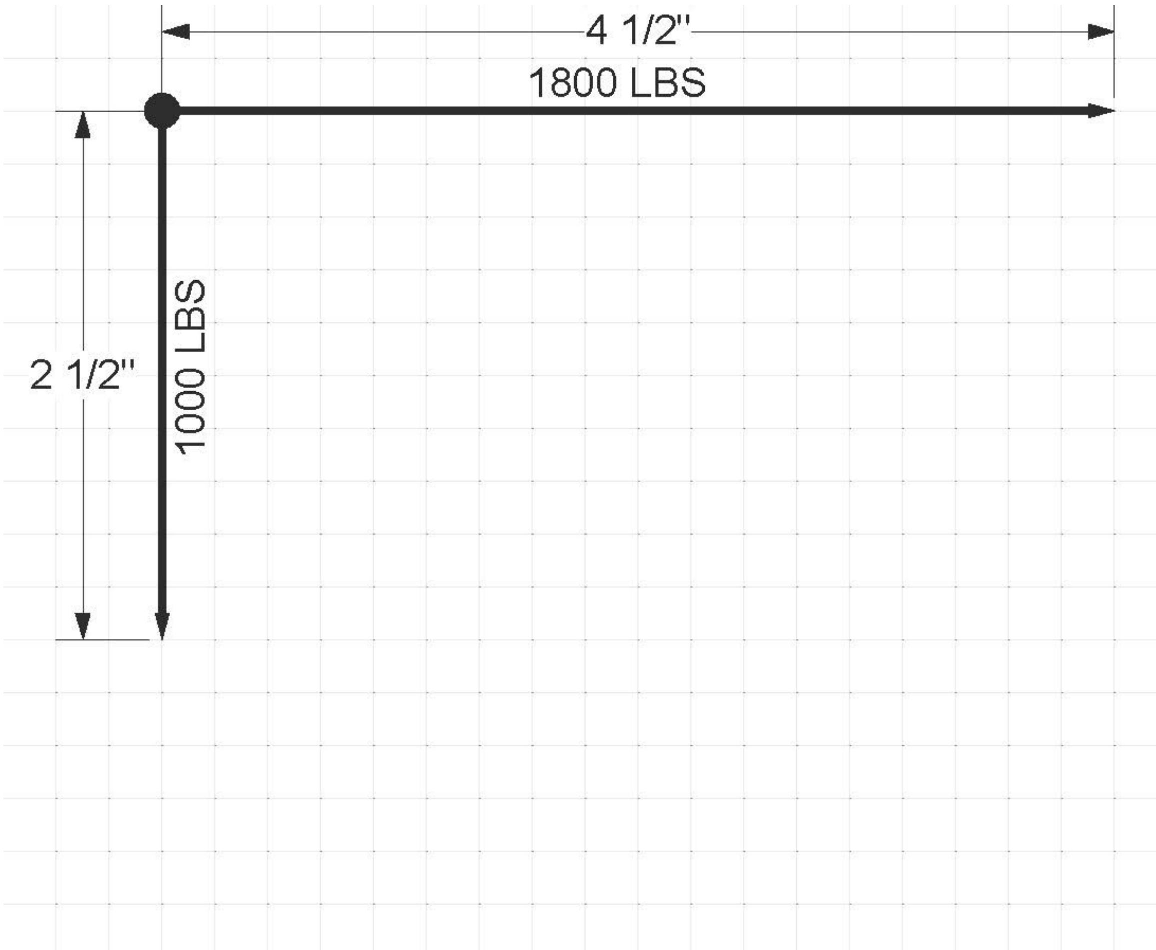
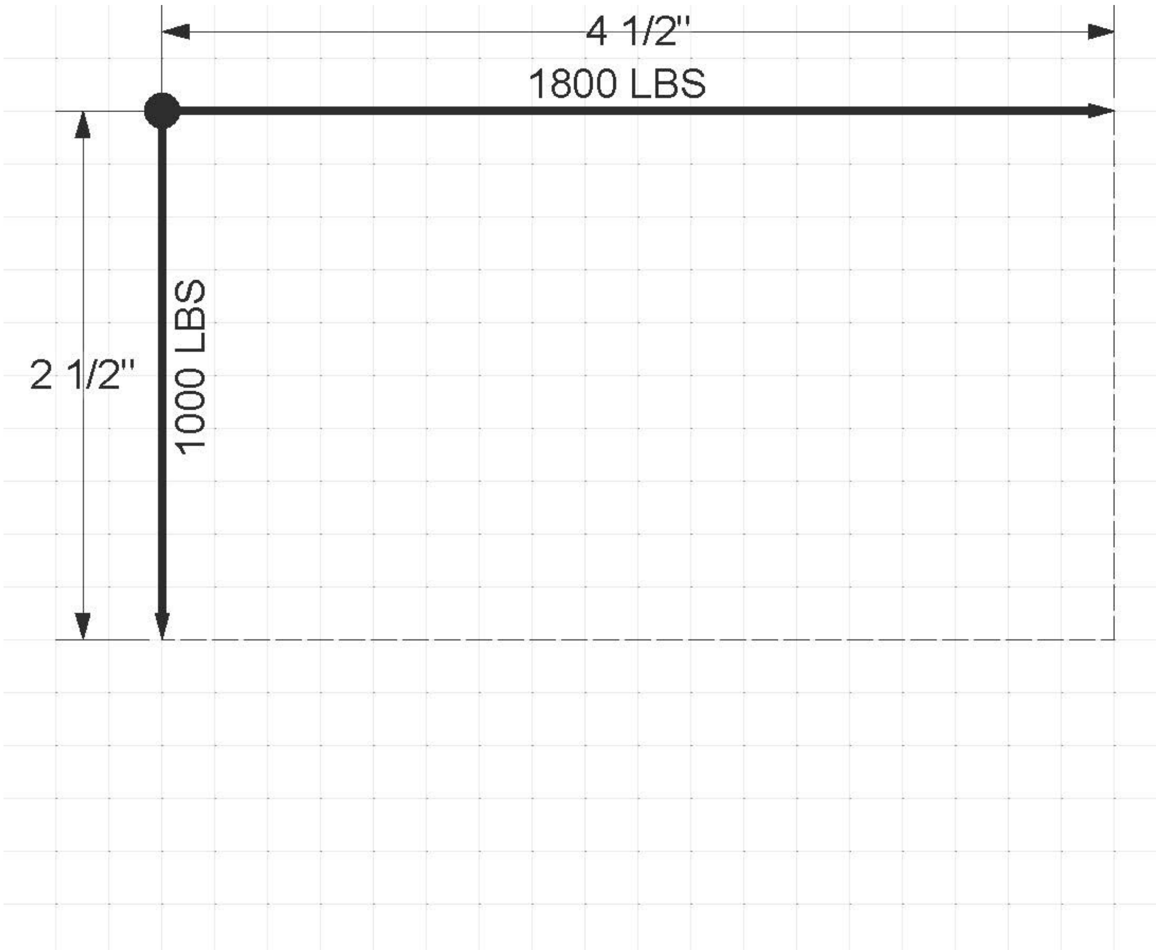
Vector Problem 1



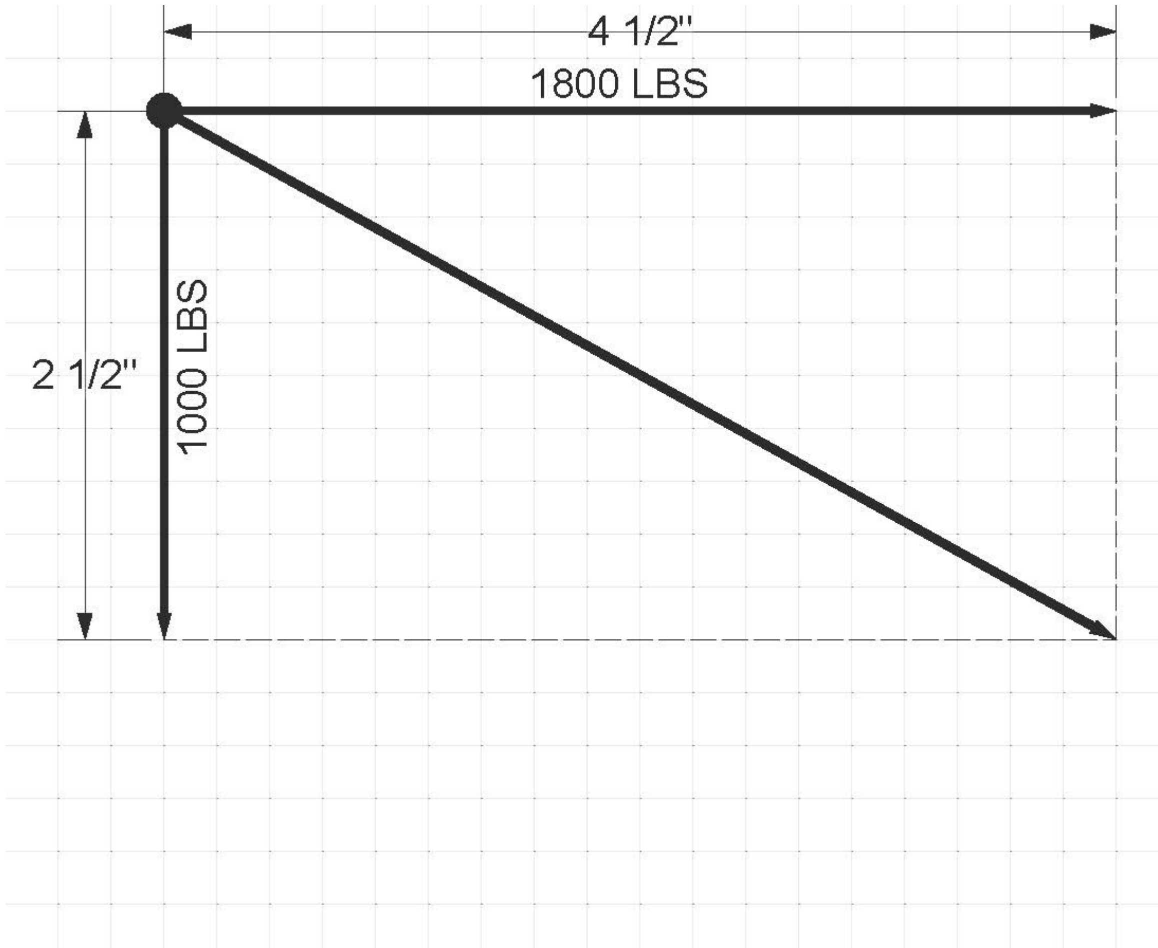
Scale is 100lbs equals ¼"

Vector Problem 1



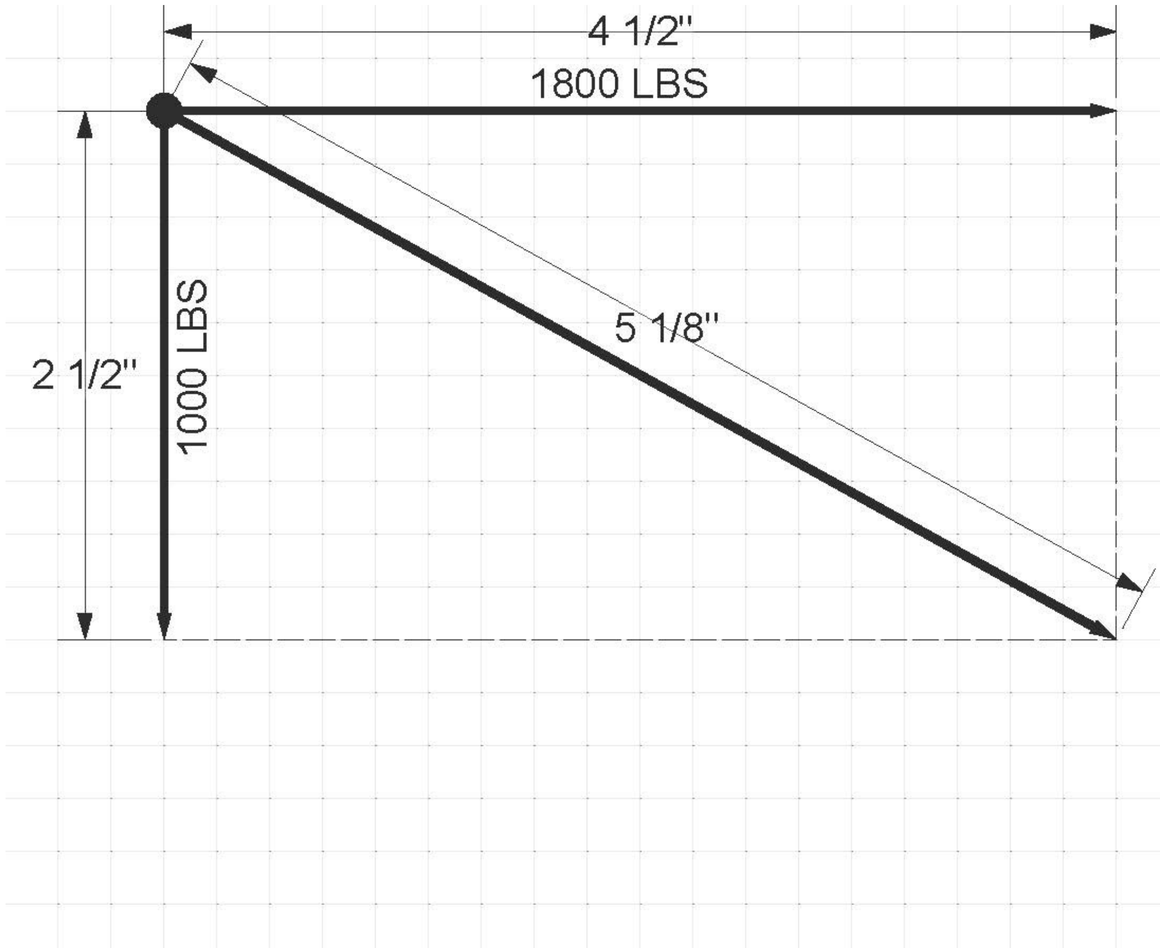
Connect the arrow heads

Vector Problem 1



Draw the resultant vector loads

Vector Problem 1



Measure the vector loads

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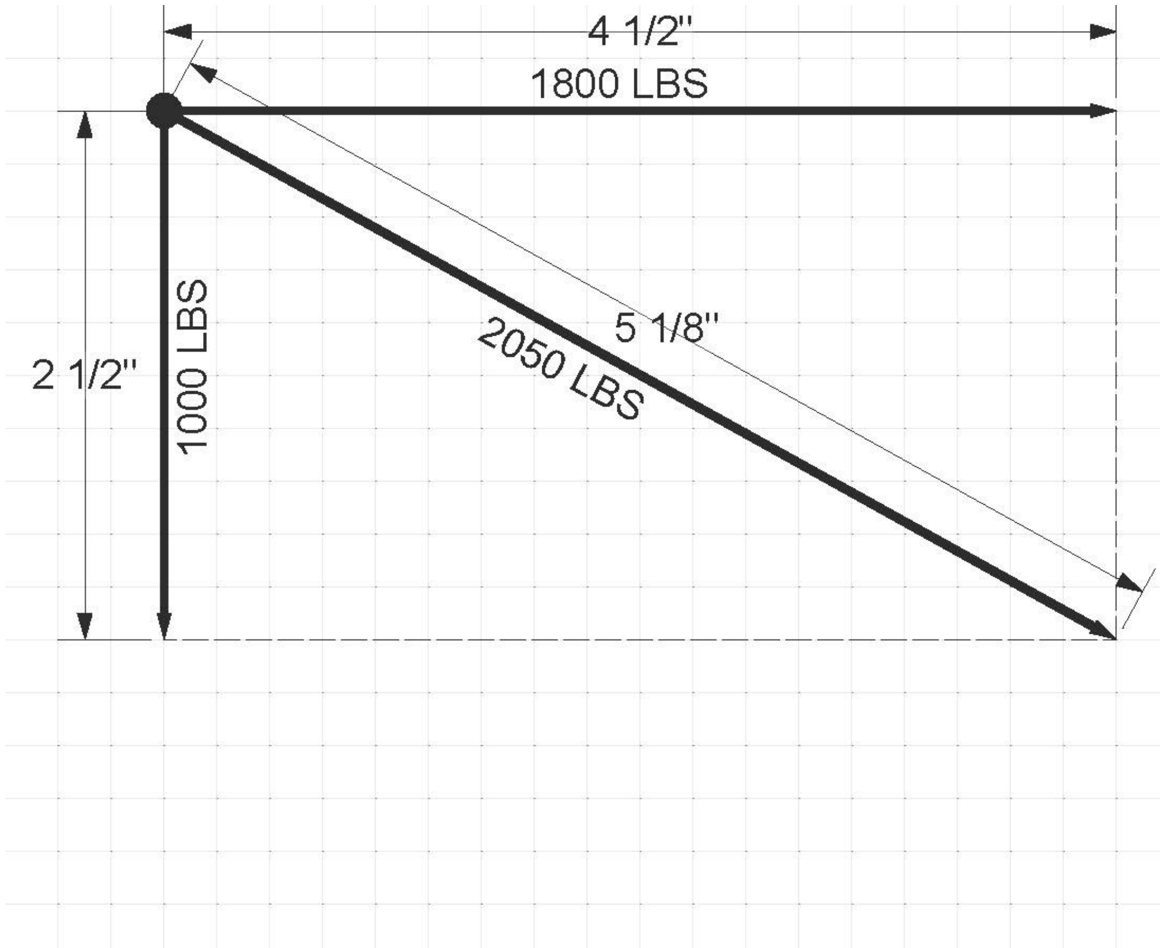
Vector Problem 1



Calculate the vector loads using the scale

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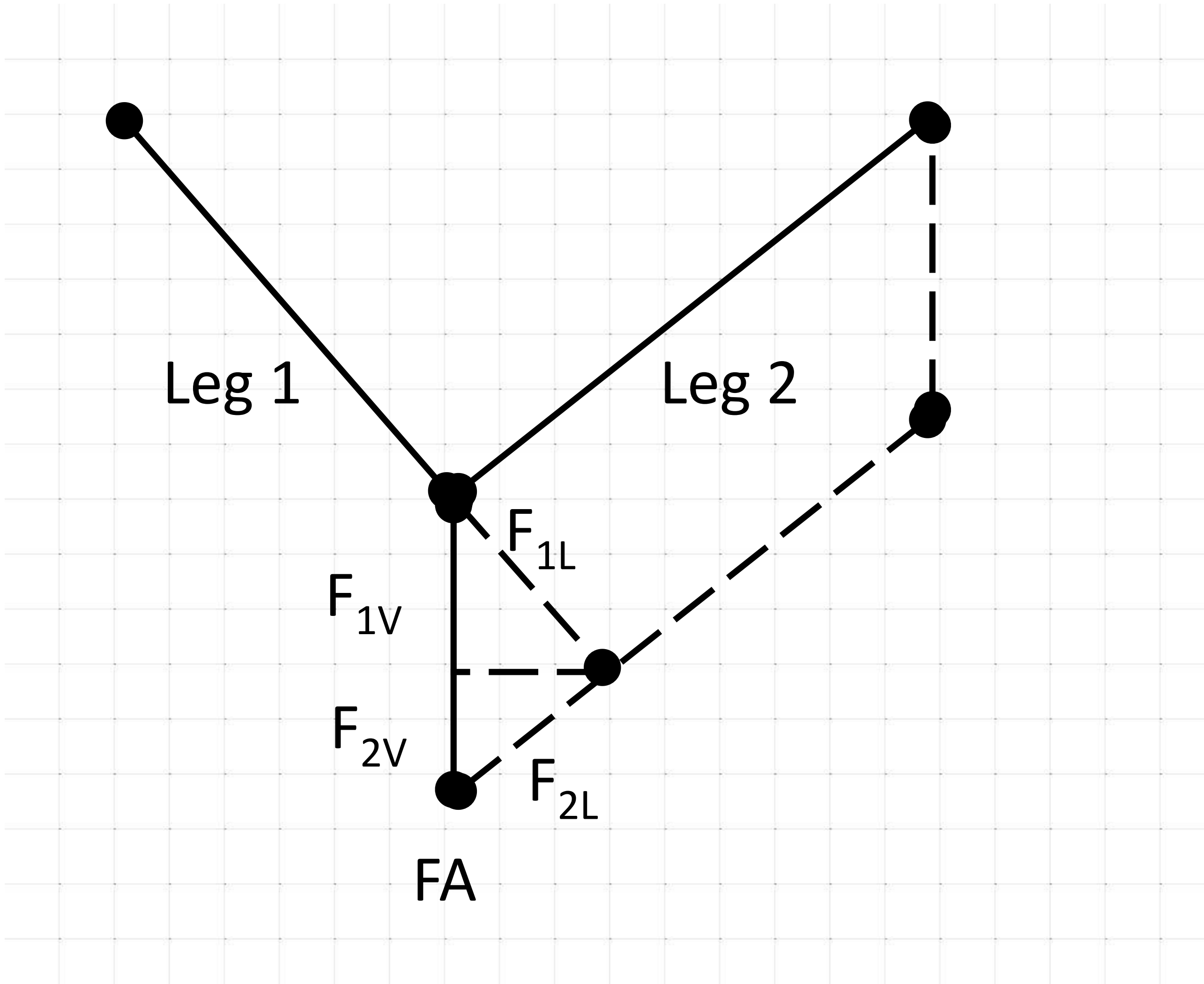
Vector Problem 1



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Load Cells

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Load Cells

Resistive Strain Gauge Load Cells - How They Work? Load cells are traditionally built using resistive bonded foil strain gauges. Strain gauges are essentially resistors built using standard semiconductor etching techniques and are bonded to a metallic member such as a cantilever beam or diaphragm.

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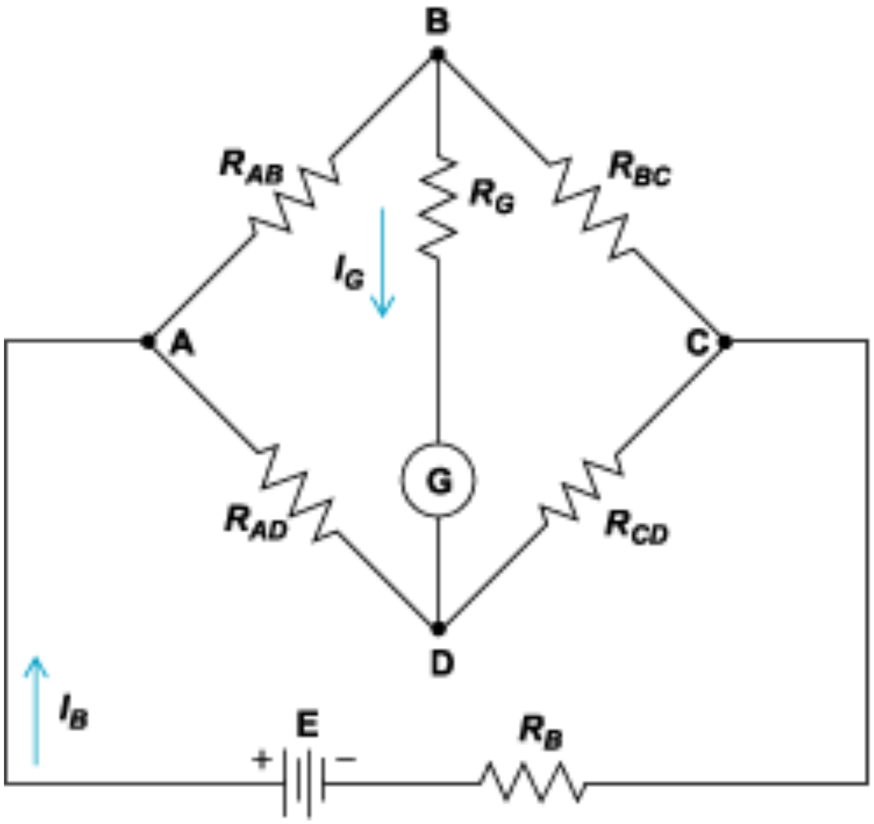
Load Cells



Usually at least four strain gauges are configured in a Wheatstone Bridge configuration with four separate resistors connected as shown in what is called a Wheatstone Bridge Network. An excitation voltage - usually 10V is applied to one set of corners and the voltage difference is measured between the other two corners. At equillibrium with no applied load, the voltage output is zero or very close to zero when the four resistors are closely matched in value. That is why it is referred to as a balanced bridge circuit.

Load Cells

When the metallic member to which the strain gauges are attached, is stressed by the application of a force, the resulting strain - leads to a change in resistance in one (or more) of the resistors. This change in resistance results in a change in output voltage. This small change in output voltage can be measured and digitized after careful amplification of the small millivolt level signals to a higher amplitude 0-5V or 0-10V signal.

These load cells have been ins use for many decades now, and can provide very accurate readings but require many tedious steps during the manufacturing process.

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Ground Rigging 101

- Ground rigging responsibility
  - Attach(detach) chain to rig steel
  - Attach(detach) Chain Bag
  - Run motor in/out
    - PAY ATTENTION!
    - Stop running motor if you are distracted.

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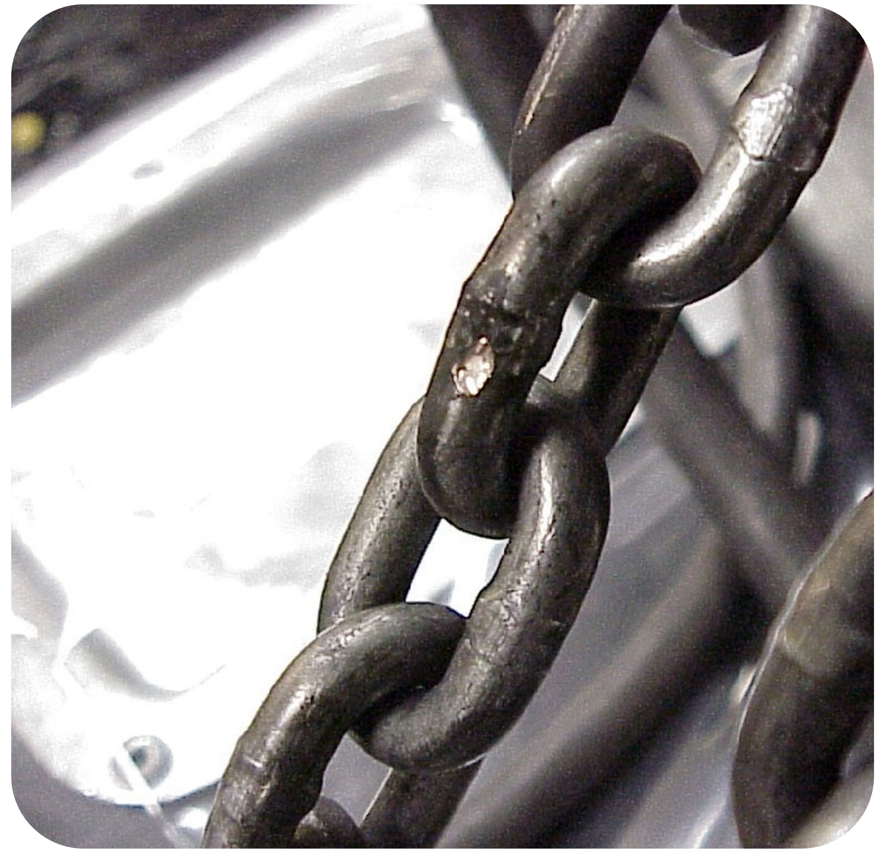
Chain Motors



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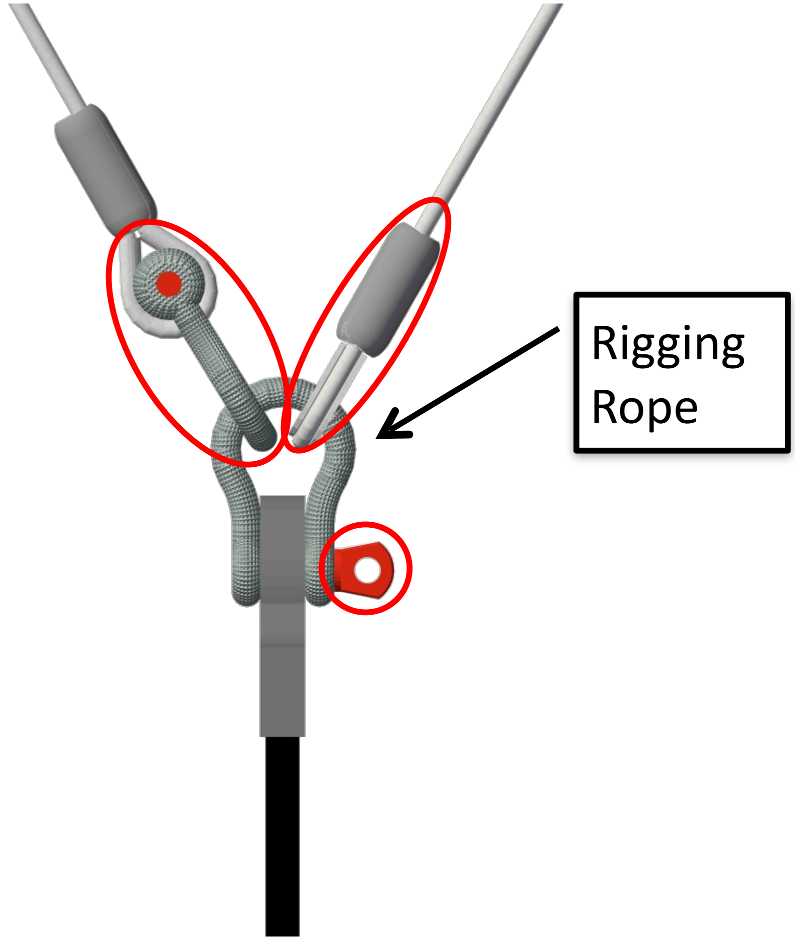
Ground Rigging 101

"PRESS"

- PIN
- ROPE
- STEEL
- SECOND SHACKLE



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Ground Rigging 101

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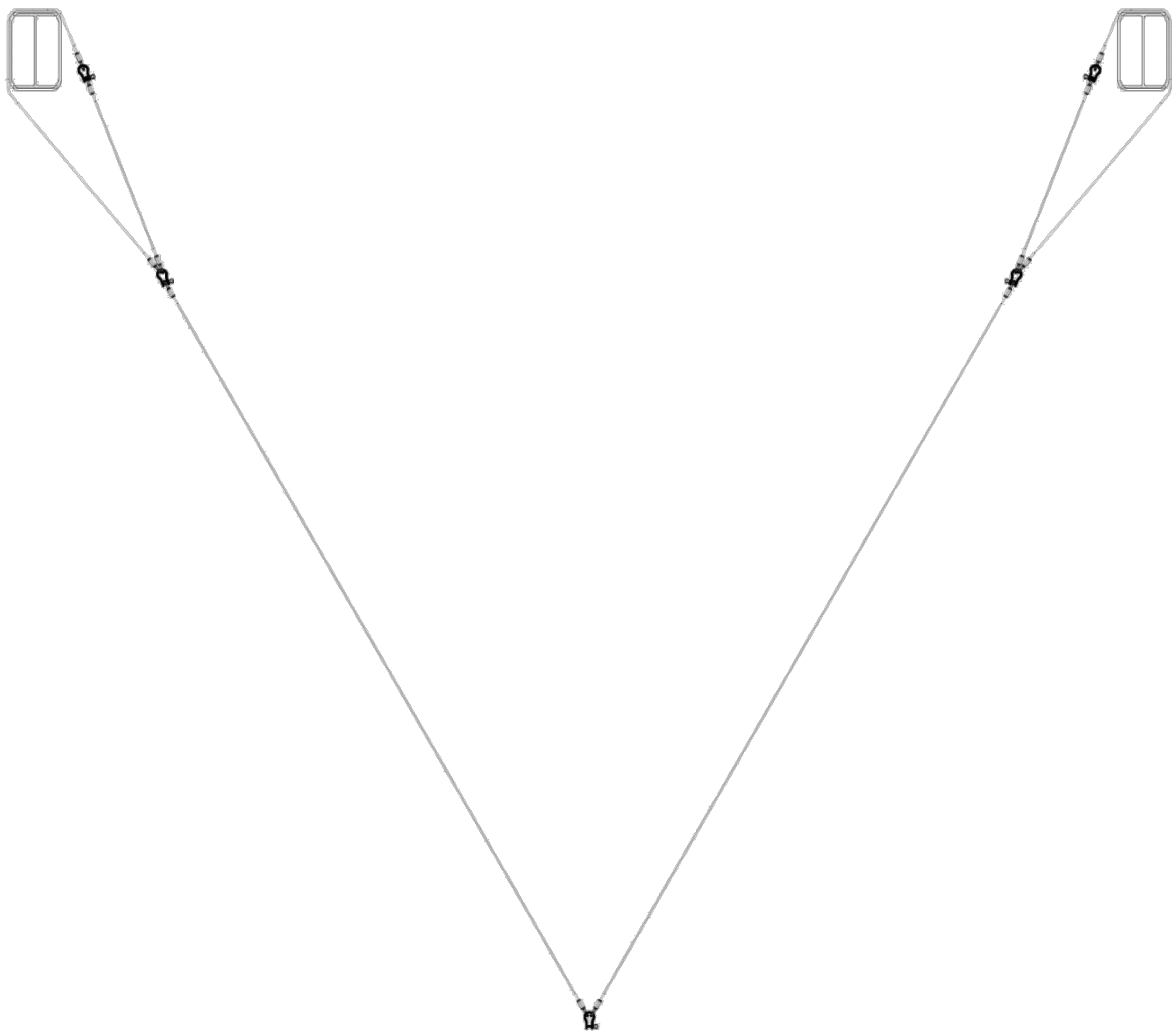
Ground Rigging 101



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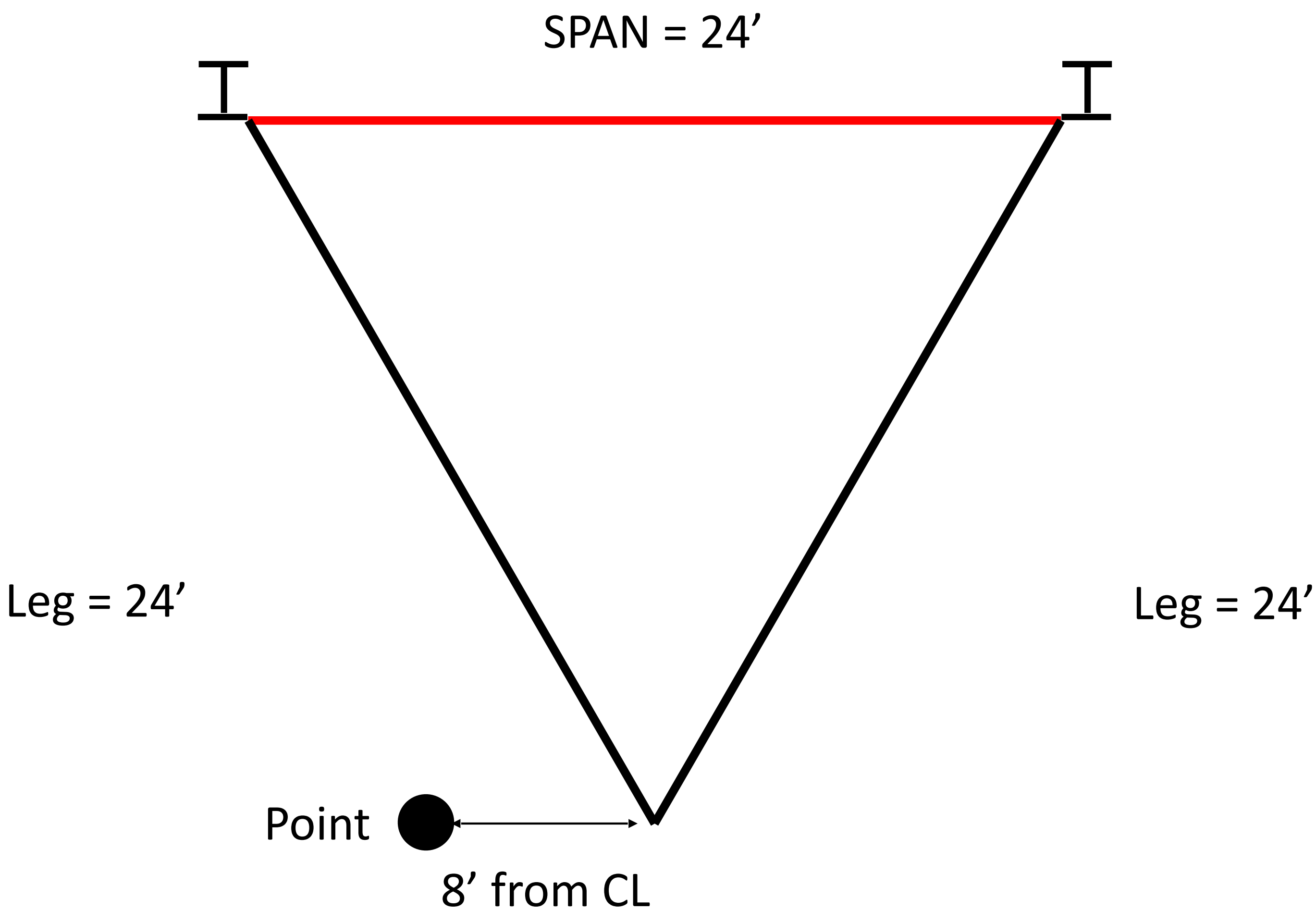
Ground Rigging 101



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Ground Rigging 101

One leg Adjustment Method

- If legs are equal to span, a 1 to 1 correspondence (roughly, because we are only modifying one leg)
- If the legs are 2 times the span, it’s a 2 to 1 correspondence
- If the legs are HALF the span, it’s a .5 to 1 correspondence. (This is to flat of a bridle, but is mentioned as an example.)
- So if a leg is 70% of a span, any adjustment will move the point 70% of the adjusted distance.
- This works with unequal legs as well.

- Smaller adjustments are better.
- Be mindful of limits.
- When adding add no more that 80% of the Range (half the span width)
- When subtracting, no more than 100% of the range.

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Ground Rigging 101

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Ground Rigging 101

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Ground Rigging 101

1T 2T 1/2T 1/4T

Lighting Audio Video PFAS

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Rigging Tools

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Rigging Tools

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Rigging Tools

Rigging Tools

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Rigging Tools

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Rigging Tools

ETCP Sample Questions

1. Given the following information, what is the total static load?

• 40' 20" lighting truss at 9 lb/ft, suspended by
two 1-ton chain hoists with 60' chain weighing 148 lb each
• 17 PARs weighing 9 lb each
• 4 Studio SpotsR weighing 60 lb each
• 3 multicables which weigh .5 lb/ft (one running full length of the truss, one running 20', and the third running 5' onto the truss, all three multis run off the left end of the truss and drop 20' to the floor)

A. 1,045.5 lb
B. 1,111.5 lb
C. 1,310.5 lb
D. 1,424.5 lb

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ETCP Sample Questions

2. Which of the following are two main responsibilities of the ground rigger?

1. Coil cable.
2. Assemble rigging points.
3. Tie on rope.
4. Tighten shackles.

A. 1 and 2 only
B. 1 and 4 only
C. 2 and 3 only
D. 3 and 4 only

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ETCP Sample Questions

3. Which of the following factors most affect the load-bearing capacity of a truss on a given span?

A. height and material
B. height and width
C. width and material
D. height and length

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ETCP Sample Questions

1. A designer has specified a 3,600 lb video wall hanging from two points over the heads of the audience. Which of the following calculations shows the best eyebolt selection?
*Ultimate loads are 4 times catalog WLLs.

A. 3,600 lb / 2 x 8 / 4 = 3,600 lb (select ¾" eyebolt: WLL* 5,200 lb)
B. 3,600 lb x 8 / 4 = 7,200 lb (select 7⁄8" eyebolt: WLL* 7,200 lb)
C. 3,600 lb / 2 x 8 = 14,400 lb (select 1¼" eyebolt: WLL* 15,200 lb)
D. 1,800 lb / 2 x 8 / 4 = 1,800 lb (select ½" eyebolt: WLL* 2,200 lb)

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ETCP Sample Questions

2. Which of the following is the best sequence when loading a counterweight batten?
1. Load the counterweight arbor.
2. Attach the load to the batten.
3. Add or subtract weight from the arbor.
4. Slowly raise the batten.

A. 2, 4, 1, 3
B. 2, 1, 4, 3
C. 4, 2, 1, 3
D. 1, 2, 3, 4

ETCP Sample Questions

3. Which of the following would be used to attach sandbags to hemp rigging lines?
1. a sunday
2. a knuckle buster
3. trim chain
4. a trim clamp

A. 1 and 2 only
B. 1 and 4 only
C. 2 and 3 only
D. 3 and 4 only

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Reference Material

- Stage Rigging Handbook
  - Jay O. Glerum
- Entertainment Rigging
  - Harry Donovan
- Rigging Math Made Simple
  - Dilbert L. Hall
- Entertainment Rigging for the 21st Century
  - Bill Sapsis
- Bridle Dynamics for Production Riggers
  - Fred Breitfelder
- PLASA Protocol: Confusion Vs. Clarity
  - Rocky Paulson
- USITT: Fall Protection for Arena Shows
  - Rocky Paulson
- The Crosby Group Catalog
- Columbus McKinnon Catalog