Engineering Design I

Shop Crane Project

Milestone 1 Submission

Team 11

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Introduction:

This report presents the design and analysis of a shop crane with a lifting capacity of 1 ton, developed as part of our Engineering Design course project. The crane is designed to lift and move heavy loads safely and efficiently, adhering to the given specifications of a 1700 mm horizontal reach and a lifting range from 110 mm to 2000 mm.

The design process involved identifying key components, selecting appropriate materials, and performing detailed stress and stability analyses to ensure the crane's structural integrity and performance. Emphasis was placed on optimizing the design for strength, durability, and ease of operation while maintaining cost efficiency.

The crane's structure is primarily composed of steel members, chosen for their high strength-to-weight ratio, weldability, and availability. A hydraulic cylinder is employed as the lifting mechanism to provide precise and reliable load handling. Mobility is achieved through the use of wheels, carefully selected to support the load and facilitate smooth movement across different surfaces.

This report details the conceptual design, material selection, structural analysis, and verification methods employed to ensure the crane's safety and functionality. Additionally, we discuss considerations for manufacturing, assembly, and testing to validate the design under real-world conditions.

By adhering to engineering principles and safety standards, this shop crane aims to meet the demands of practical industrial applications while serving as an educational exercise in applied engineering design.

Literature Review:

- ### General Design of Shop Cranes

During our research, we examined a variety of shop cranes with differing features. These included cranes with 4 or 6 wheels for mobility, foldable and non-foldable frames, and models with varying load capacities. Some cranes featured extendable booms for greater reach, while others had fixed booms for simplicity. Additionally, we observed that cranes employed different lifting mechanisms, such as chain hoists or winches, in place of hydraulic jacks. For our design, we chose hydraulic jacks due to their simplicity, reliability, and ability to handle heavy loads with minimal operator effort.

The T1001Z crane was selected as a reference for its compact, foldable design and versatile lifting range. This research informed the development of a design that balances functionality and practicality while leveraging the advantages of hydraulic lifting systems.

- ### Material Selection

A572 Grade 70 steel was chosen as the primary material due to its high yield strength and tensile properties, making it suitable for handling heavy loads. Research into material properties and applications highlighted its effectiveness in structural components where strength and durability are critical. Comparisons with alternative materials further validated this choice.

- ### Hydraulic Jack Selection

An 8-ton hydraulic jack was chosen to provide significant overcapacity, enhancing safety and durability under load. Research into hydraulic systems emphasized the importance of proper jack placement to minimize stress on the crane’s structure while ensuring efficient load transfer.

Capacity and Overall Dimensions:

Here, we define the needed requirements for our project:

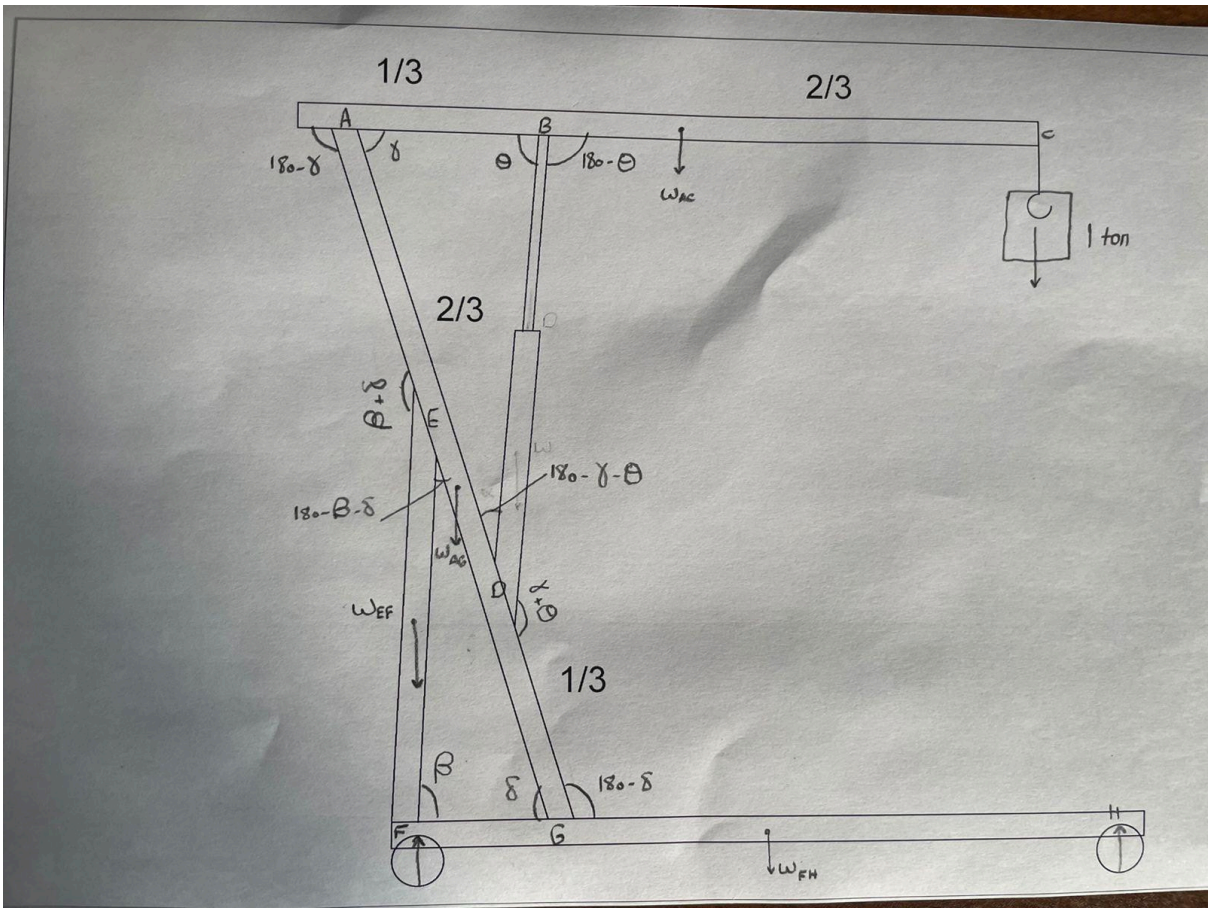
Lifting Capacity: 1 ton (1000 kg)

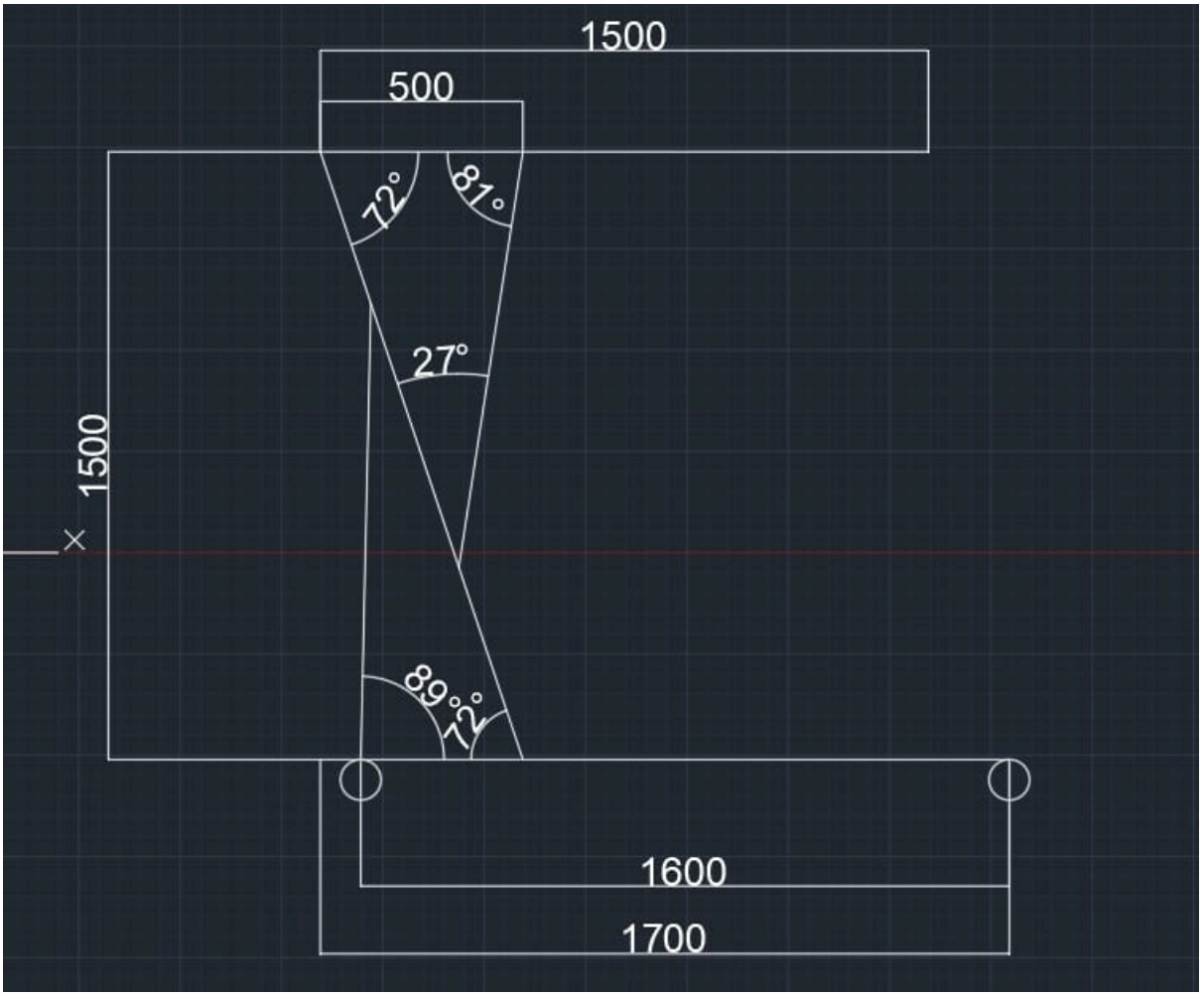
Horizontal Length: 1700 mm

Lifting Range: From 110 mm to 2000 mm

Other considerations: Stability, safety factor, mobility, and ease of assembly.

Initial Design:



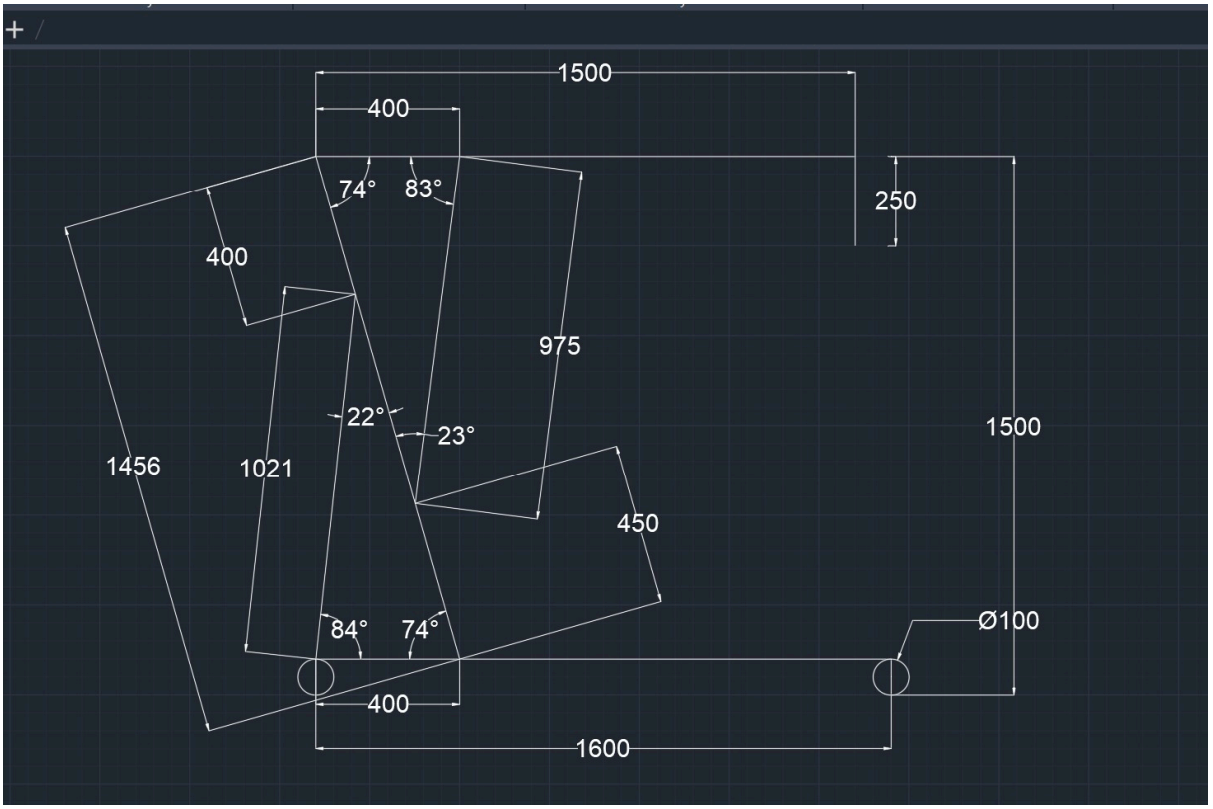


This was a very early draft in our troublesome crane design journey.

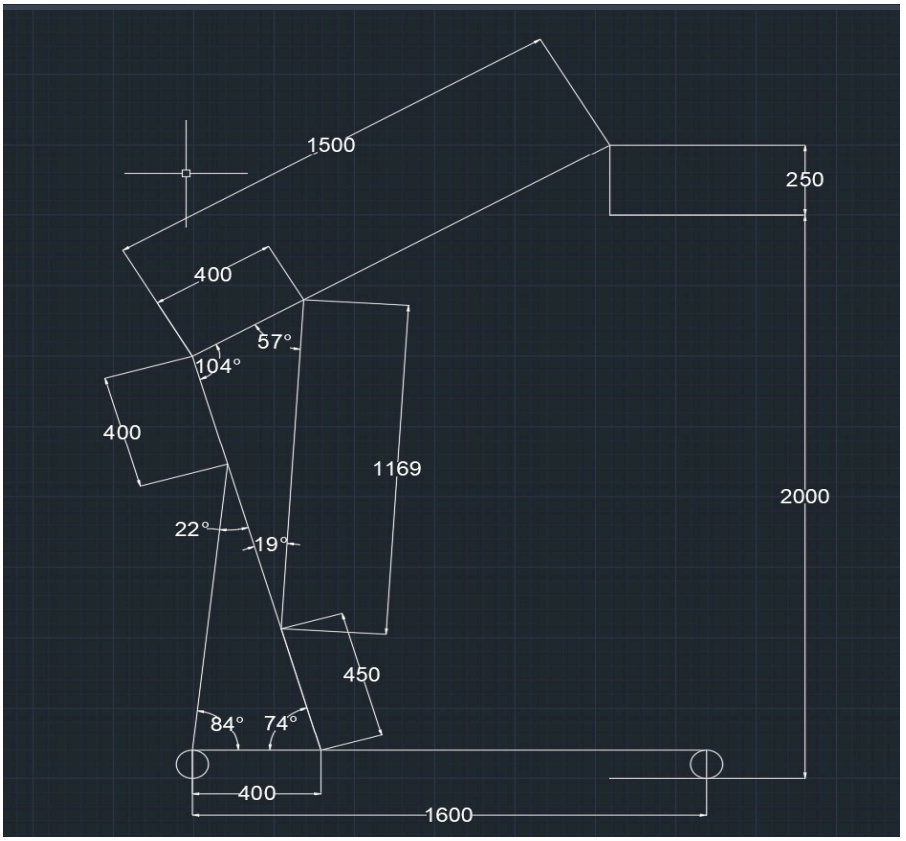
Initially, we didn’t consider the hook length and we still hadn’t reached the exact positions for support points.

A major problem we faced during our design was finding a geometry that would accommodate the hydraulic cylinder while also reaching the specified requirements.

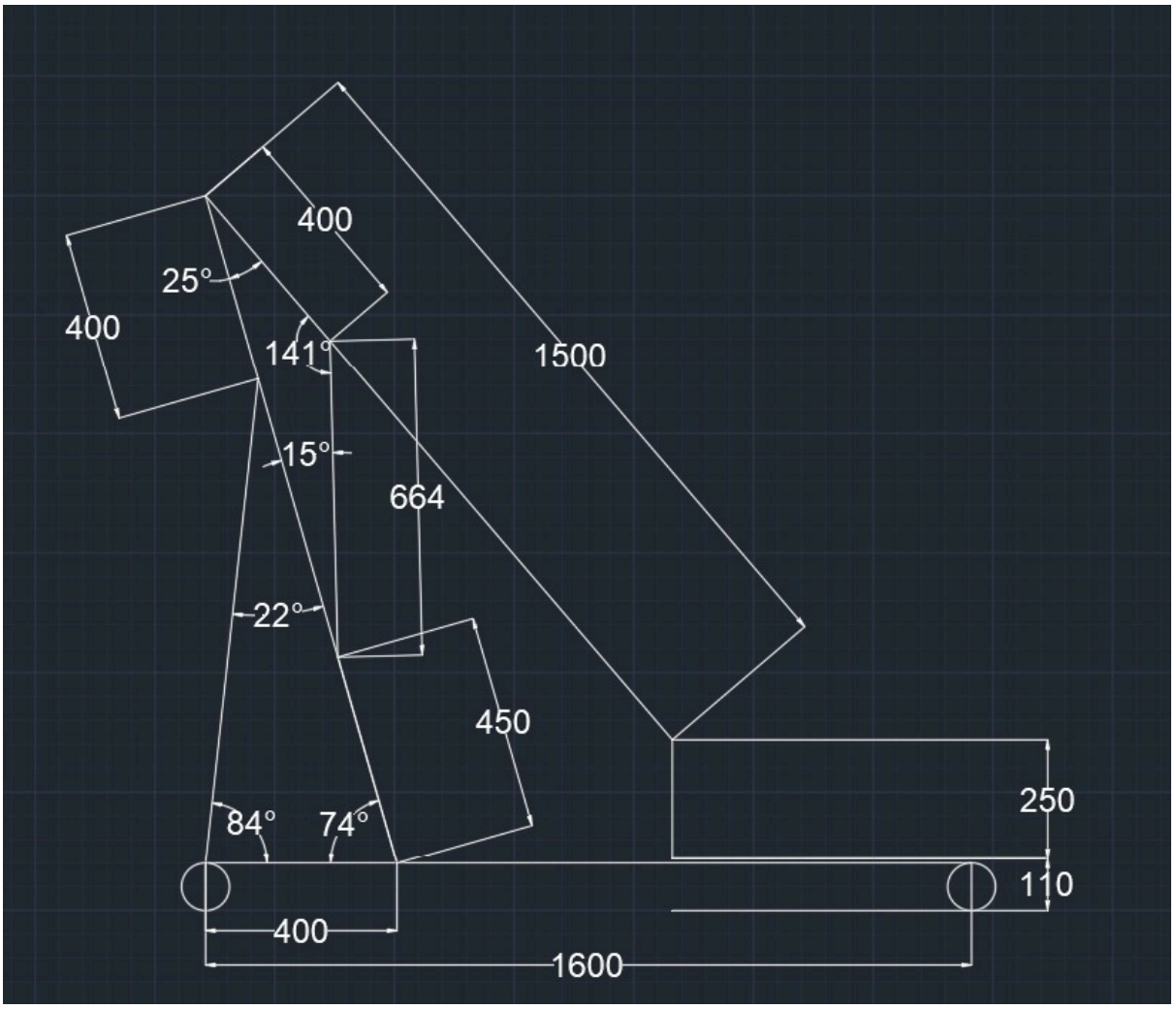
Final Design and Motion Study:



Crane at Horizontal Position



Crane at Upper Position



Crane at Lower Position

Hook length considered for our design is 250 mm.

Max Hydraulic cylinder Length = 1169 mm.

Min Hydraulic cylinder Length = 664 mm.

Hydraulic Jack Selection:

After research, we found that the most common range of hydraulic jacks used in shop cranes with similar requirements were 8 Ton hydraulic jacks to provide sufficient lifting capacity.

We found a hydraulic cylinder from VEVOR that fits our geometry needs

e.g. max and min hydraulic cylinder previously specified

Amazon link for the Hydraulic Cylinder:

https://www.amazon.com/VEVOR-Hydraulic-Ram-Ton-Cylinder/dp/B0CY2FTRTD?dib=eyJ2IjoiMSJ9.OXfKFSDgKgSSbGB0dvP8b0B_-iXuSvHgB-1pZ9s-dEHW5pmFkRrVb9fKtPnmTaYbrd-3uLnsWfPdMt2tglgjamZf59Pj0cPxzS3UOKUnRr-32_DuAxBDYYJ0D7OKS20jOA3hgwTJ8ITxUu-Hx4TMfeV4jr6Rf0kemwsz8foishu92TRXCSEMsaY6lebl7ddnbrE3Gns7J32ukd3VTYgvJ9zVTxuIkX72QPOkXhuxOdY.Siy14zfIQHgvL467MMPHif-XxHBPu_8oRlP7Jf6sffU&dib_tag=se&keywords=vevor%2Bhydraulic%2Blong%2Bram%2Bjack&qid=1731701585&sr=8-3&th=1

Wheels Selection:

From our force analysis, we found that the maximum load on the wheels occurred for the front wheels at the horizontal position at which the load carried by a single wheel is approximately 4600 N which is equivalent to 1034 lb.

From our research, we found a set of wheels with a capacity of 1200 lb per wheel which are suitable for our purposes.

To increase the factor of safety, an additional two wheels could be used for a total of 6 wheels instead of 4.

Amazon web link:
https://www.amazon.com/Toolbox-Phenolic-Capacity-Swivels-CasterHQ/dp/B07M93

NS9N?crid=162GDK9TN22OR&dib=eyJ2IjoiMSJ9.6wgQZUV5eBoiyFmGAMW_EzKv7Dv_YxsYNKfdTkO6EqG9LKL3F9diwZpZcqSAWwzkoN3K_H3KGRz9l0GbWTLb8AZ8BHoS8BXnujYAyZ924f4Ch-5Rupp5HJAa0gG2IpknCvVdV_TbrJbfLvWCm4RvRf_vUQJMWkQZuX6USUb_Bp6Jehpmql9hg_6zFjDKn40QfeD1-WgjTdeZ3qLSu-6zH5Tx85YhrkNcD6ZfV1FvAnU.qQ8oPcrnCYtGr3qBx1gJVOC8jfpQm4Jgz-nr_ORh9CE&dib_tag=se&keywords=heavy+duty+toolbox+caster+set&qid=1732399310&sprefix=heavy+duty+toolbox+caster+set%2Caps%2C201&sr=8-11

Wheels

6" x 2" Heavy Duty Toolbox Caster Set of 4 with Phenolic Wheels, 4,800 lbs Capacity per Set of 4, 2 Swivels with Locking Brakes and 2 Rigid Casters, CasterHQ Brand

Visit the CasterHQ Store

4.5 out of 5 stars 91 ratings

Amazon's Choice in Plate Casters by CasterHQ

Price: $129.99 + $118.26 shipping

$310.46 Shipping & Import Fees Deposit to Egypt Details

Available at a lower price from other sellers that may not offer free Prime shipping.

- WHEEL DIAMETER: 6" | WHEEL TREAD WIDTH: 2"
- LOAD CAPACITY: 1,200 LBS /EA / 4,800 LBS PER SET OF 4
- TOP PLATE SIZE: 4" X 4-1/2" | BOLT HOLE SPACING: 2-5/8" X 3-5/8" (Slotted to 3" x 3")
- OVERALL HEIGHT: 7-1/2" | BEARING TYPE: ROLLER BEARING
- MOUNTING BOLT SIZE: 3/8" (Mounting Hardware Not Included)