Topics For Discussion

- Section 1: *Introduction and Needs Assessment*
- Section 2: *Project Goals & Design Process*
- Section 3: *Technical Specification*
- Section 4: *Final Design*
- Section 5: *Prototype Demonstration*
- Section 6: *Q & A*
Section 1

Introduction and Needs Assessment

Presented by:
Trent Lucier
&
Trevor Deming
Introduction

- **Objective**: To design a hand truck that will utilize a compact lifting device.
  - Researched numerous lifting devices to find an optimal choice
  - Constructed models in Working Model
  - Final model in Solidworks for design layout
  - Verified conclusions with Strength of Materials formulae

- Finding a reasonable lifting device to provide optimal lift height proved to be the bulk of our research.
Every year numerous parcel service employees injure their lower back due to repeated heavy lifting.

This results in loss of productivity for the parent company and loss of income for the employee.
Problem

- Find a way to lift an object off the ground to ease the stress on the operator of a standard hand truck.

- Reducing the stress on the back of the operator would improve productivity.
Section 2

Project Goals & Design Process

Presented by:
Jonathan Sheanon
&
Trevor Deming
Project Goals

- The goal of this project is to redesign a hand truck to:
  - Lift a 100 pound package
  - Lift said package 30 inches off the ground
  - Remain stable during the whole lifting procedure

- The hand truck must also be portable, defined as:
  - Being easily stored inside of a mid sized delivery truck
  - Less than 80 pounds in weight
  - Stable as to allow any able body person to maneuver and handle the hand truck without falling over.
  - The lifting mechanism is confined to the framework of the hand truck
Method of Design

1 – To pick a method of lifting, that would enable multiple lifts and is light

2 – Use working model and statics to verify needed lifting capacity

3 – Model the components in Solidworks to design component location and Alignment

4 – Build prototype in the projects lab with available materials and machinery

5 – To have a working prototype
## Design Matrix

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<th>Weight</th>
<th>Versatility</th>
<th>Sustainability</th>
<th>Capacity</th>
<th>Durability</th>
<th>Practicality</th>
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**Total Components:**

- **Cost:** 8
- **Weight:** 21
- **Versatility:** 10
- **Sustainability:** 13
- **Capacity:** 26
- **Durability:** 11
- **Practicality:** 11
- **Total:** 100
Mechanism Matrix

Design Matrix Created To Identify Best Solution To lift A load With Previous Design Criteria In mind

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Section 3

Technical Specifications

Presented by:
Trent Lucier
&
Jonathan Sheanon
**The Mechanical Advantage**

- **Definition**: The purpose of a machine is to create a mechanical advantage that will facilitate your ability to move an object against resistive forces. Mechanical advantage (MA) means that the output of the machine is greater than the input. MA is the output divided by the input. There are three types of mechanical advantage: force, distance and speed.

- The Law of Conservation of Energy requires that in gaining a mechanical advantage, it will cost you in another factor. For example, increasing output force may cost you by requiring an increase in distance traveled.

- We are reversing the Mechanical Advantage and creating a Mechanical Disadvantage to reach our desired lifting height.
The effort force with a lifting wheel can be calculated as
\[ F = \frac{W \cdot d}{D} \quad (1) \]
where
\[ F = \text{effort force (lbf)} \]
\[ W = m \cdot a = \text{weight of body (lbf)} \]
\[ d = \text{wheel inner diameter (ft)} \]
\[ D = \text{wheel outer diameter (ft)} \]
\[ m = \text{mass of lifted body (lbm)} \]
\[ a = 32.2 \text{ ft/s}^2 - \text{acceleration of gravity} \]

\[ F = (120 \text{lbf}) \cdot (32.2 \text{ ft/s}^2) \cdot (0.666 \text{ ft}) / (0.166 \text{ ft}) \]
\[ = 1576 \text{ lb ft/s}^2 \]
Verifying Solution

\[ \sum M = 0 \text{ lb} \cdot \text{in.} \] where \( M \) is the moment arm shared by both pulleys.

\[ (P \times 1 \text{ in}) - (-100 \text{ lb} \times 4 \text{ in.}) = 0 \text{ lb} \cdot \text{in.} \]

\[ (P \times 1 \text{ in}) - 400 \text{ lb} \cdot \text{in.} = 0 \text{ lb} \cdot \text{in.} \]

\[ F \times 1 \text{ in} = 400 \text{ lb} \cdot \text{in.} \rightarrow F = \frac{400 \text{ lb} \cdot \text{in.}}{1 \text{ in.}} \]

\[ F = 400 \text{ lb} \]

This value represents the minimum applied force required to lift a 100 lb package.

However, after testing the solution in a Working Model we accounted for additional losses.

The minimal applied force was actually 405 lb.
Bearing Load - The force exerted on the Bearings during operation. The bearings function to withstand the applied forces during a lift.

\[ R_A + R_B = 438.31 \text{ lb} = 0 \text{ lb}; \text{Due to symmetry the reaction will be equal.} \]

\[ 2R - 438.31 \text{ lb} = 0 \text{ lb} \rightarrow R = \frac{438.31 \text{ lb}}{2} = R_A = R_B = 219.155 \text{ lb} \]
Utilizing Distortion Energy theory, We knew that:

\[\sigma' = \left[ \left( \frac{1399.209}{d^2} - 9 \right)^2 + \left( 9 - \frac{594.615}{d^2} \right)^2 + \left( \frac{594.615}{d^2} - \frac{1399.209}{d^2} \right)^2 \right]^{\frac{1}{2}}\]

\[\sigma' = \frac{3887.97 \text{ lb in}}{d^2}\]

\[n = \frac{Yield}{\sigma'} = \frac{30000 \text{ lb}}{3887.97 \text{ lb in}}\]

\[d = .75 \text{ in}\]
Design - Hand truck

- 1 1/4 inch Schedule 80 Tubing
- 2" Pneumatic Piston With 750lb Max Lift
- DPT Approved Carbon Fiber Compressed Air
- Solid Diamond Plate Lifting Carriage
- Solid Tires for Added Lifting capacity
Grainger Double Action Piston

- Air Inlet: ¼ in NPT Fitting
- Power Stroke: 10 in Stroke
- 2 in diameter bore
- Max Pressure: 250 Psi
- Max Capacity: 785 lb
Pulley Assembly

- Machined out to reduce weight
- Set Screws to insure tight fit on shaft
- Machined Keyway for added strength when under torque
Animation
Problems Encountered

- Clean and precise cuts for clean welds
- Fastening cable to pulleys
- Lifting track had binding issues
- Controller needs adjustment to hold load in upright position
- Needling valves to control speed of lift
Section 5

Prototype Demonstration

Presented by:
GROUP THREE
References


  Path: http://www.school-for-champions.com/science/machines_advantage.htm

  Path:http://www.engineeringtoolbox.com/lifting-wheel-d_1306.html


Questions?