Educational Solar Tracking System

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April 25, 2014

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Presentation Overview

- Introduction
- Problem formulation
- Engineering Analysis
- Final design
- Prototype fabrication
- Cost analysis
- Conclusion

Introduction

- Normal high efficiency solar tracking systems are not effective for teaching purposes

- Sponsor
  - Dr. Tom Acker
    - Professor of Mechanical Engineering
    - Director of NAU’s Sustainable Energy Solutions Group

- Testing Environment
  - Will be tested using fixed solar panels at NAU.

Problem Formulation

- Need
  - Current solar tracking systems are intimidating to students.
  - Systems are expensive.
  - Unreliable
  - Hard to maintain

- Goal
  - Design and build a system that enables students to experience the fundamentals of solar tracking systems.

Objectives/Constraints

Constraints

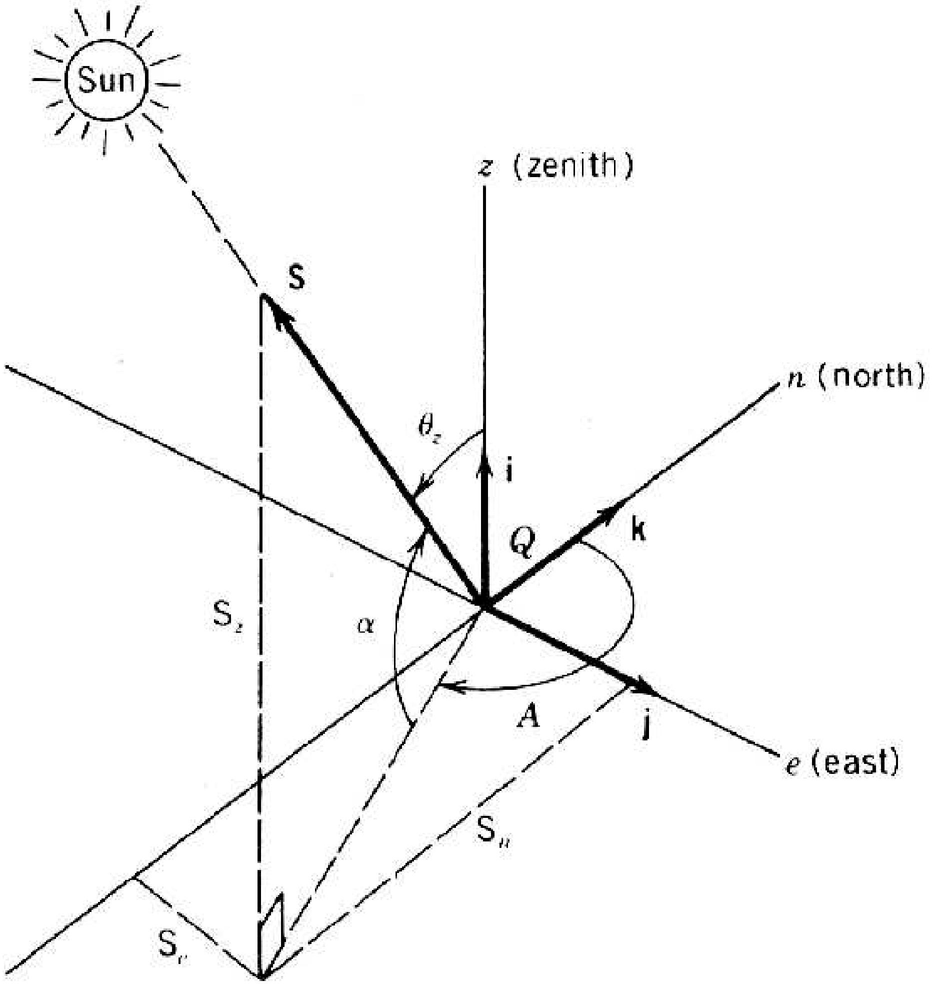
- The team must stay within a reasonable budget.
- Limited space available for testing and solar tracking system operation.
- Weather in Flagstaff, AZ.
- Good but limited building abilities and processes available to the team.

Objectives

- The system must be inexpensive to produce.
- System must have a relatively good efficiency.
- Design must be low maintenance.
- System must have a good build quality.
- Educational

Solar Tracking Angle Analysis

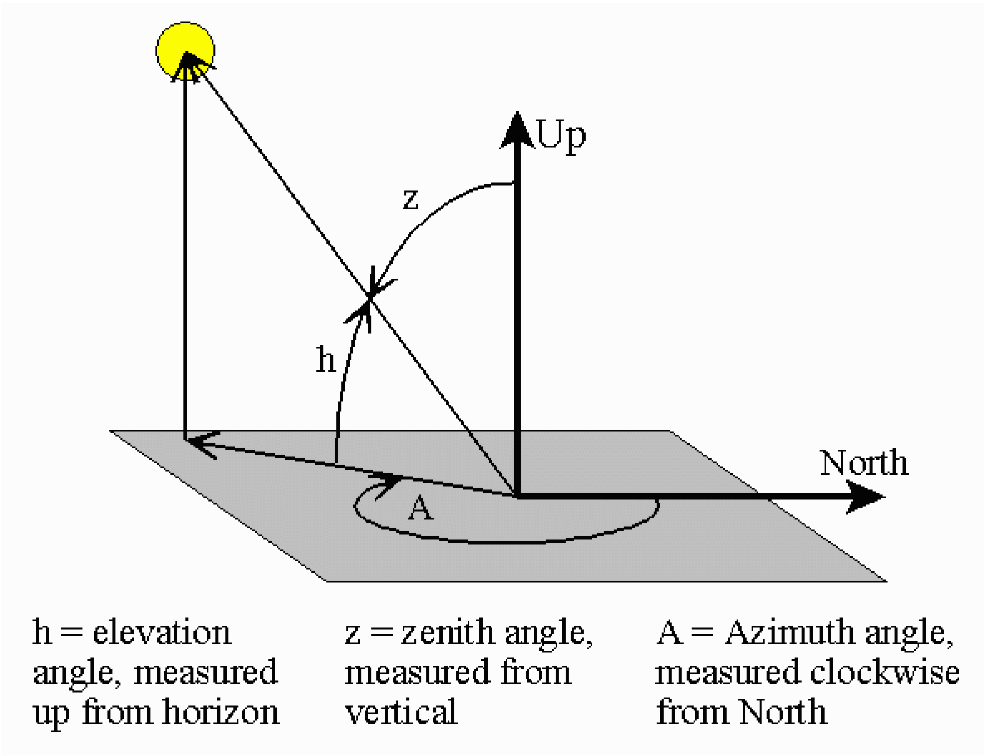
- Most important angles
  - Solar azimuth (γ)
  - Angle of Incidence (Θ)
  - Panels slope angle (β)
- Tracking systems are supposed to
  - Minimize angle of incidence (Θ)
  - Maximize angle of incident beam radiation



Solar Tracking Angle Analysis Cont'd

- Knowns
  - Flagstaff at latitude of 35 degrees
  - Fixed slope angle of 36 degrees
- Matlab Program
  - Based on desired day of the year
  - Θ (angle of incidence)
  - ϒs (Azimuth angle)
  - Θz (Zenith angle)

North-South Axis slope tracking



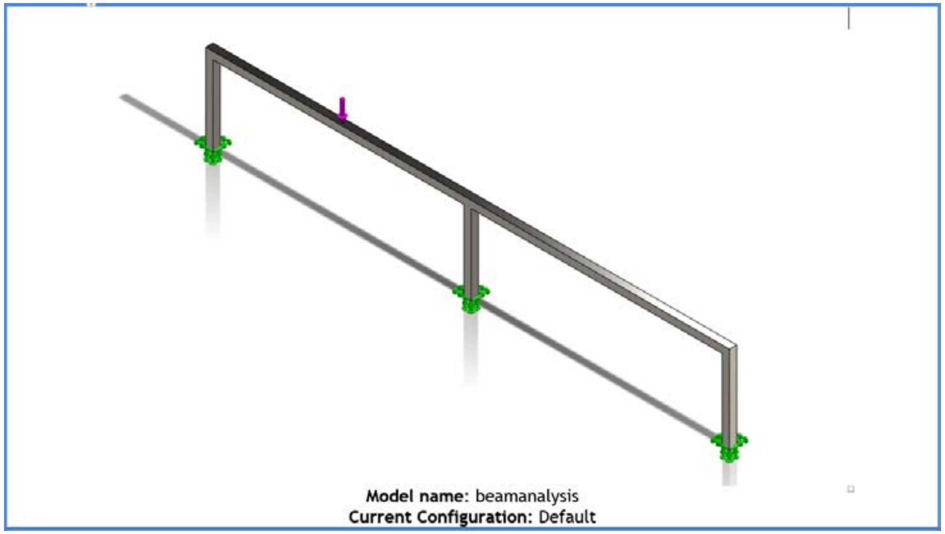
http://capsis.cirad.fr/capsis/help_en/samsaralight J

Torque Analysis

- The Torque was calculated using :
  - $T = F_c \times \frac{D}{2}$
  - $Torque = 300\ Ib \cdot in$

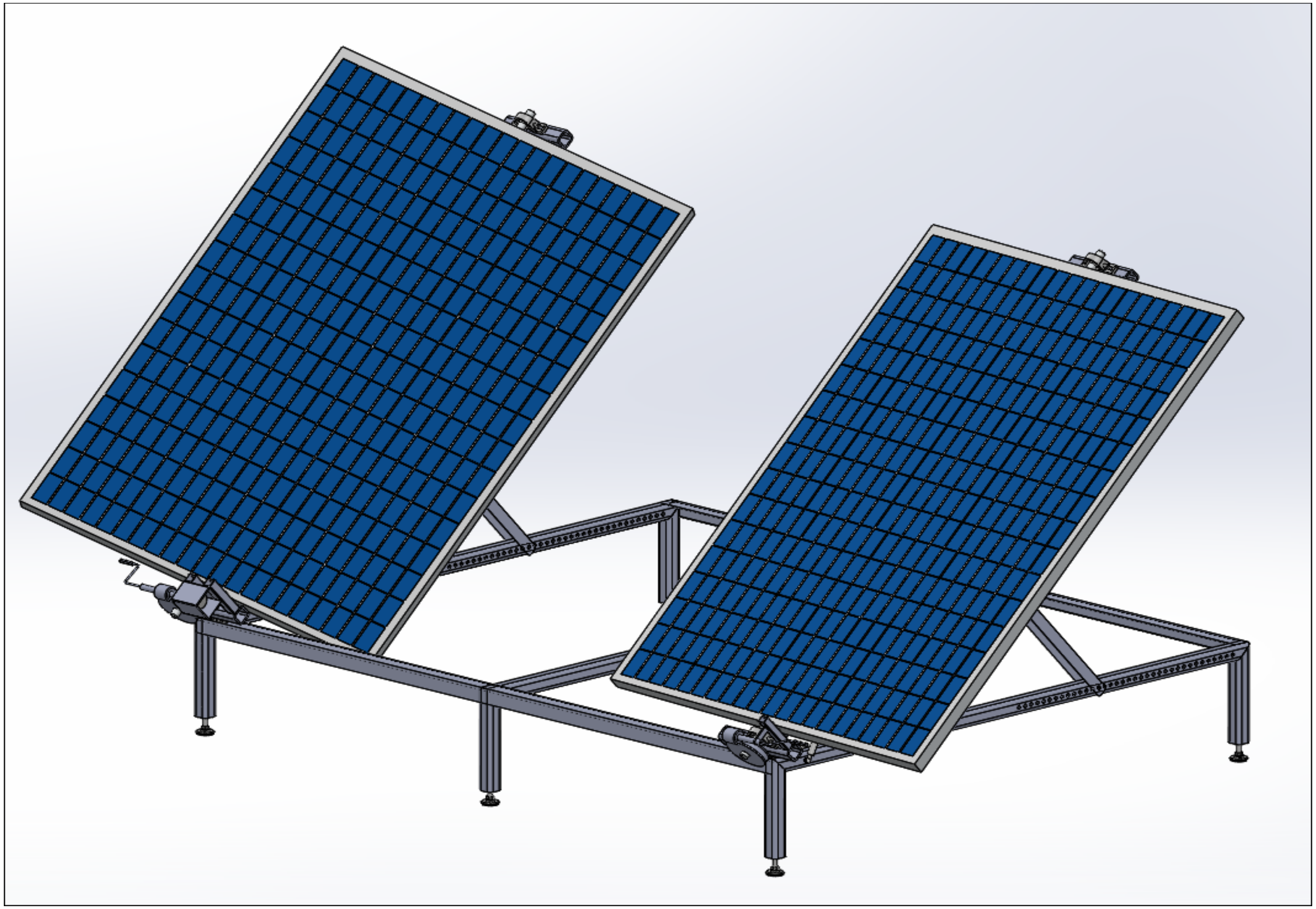
- Finding the desired Motor using Full-load Torque equation
  - $T \times 4 = \frac{HP \times 5252 \times 8.851}{rpm}$
  - $\frac{HP}{rpm} = 0.026$

Beam Stress Analysis



- Max load 105 pounds
- Max stress 3200 psi
- Yield Strength is 51000 psi
- Min Factor of Safety is 15.94
- Max Displacement 0.014 inches

Final Design



Prototype Fabrication

- Four Phases of Construction
  - Base frame
  - Angle support
  - Solar panel box
  - Motor housing and manual crank

Base Frame

- 8ft by 6ft rectangle
  - 1”x1” square tubing
  - 1.5”x1 angled bar
- The square tubing has 18 holes drilled along their length
- Hydraulics for ease of movement
- Adjustable feet
  - 4”x4”

Angle Support

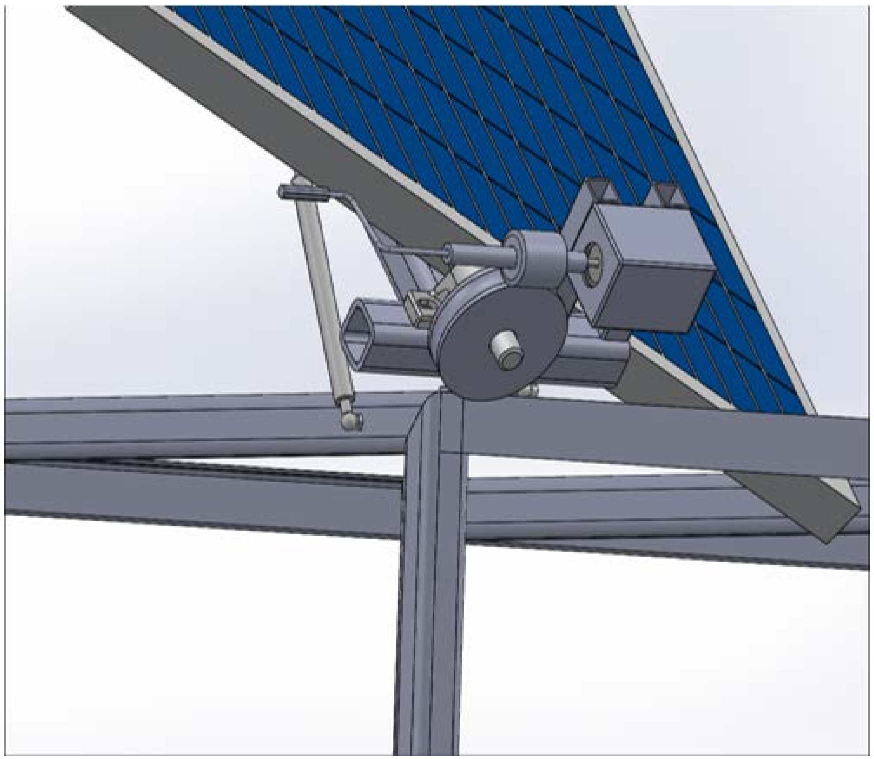
- Frames for solar panels 4ft by 6ft
  - Angled bar
  - 1 inch steel shafts for bearings

- Holds the Solar panel at different angles
  - 1”x1” square tubing
  - 1”x36” steel plates

Frame Connections

- 2 Heavy duty door hinges
  - Welded to top frame
- Hydraulic stabilizers

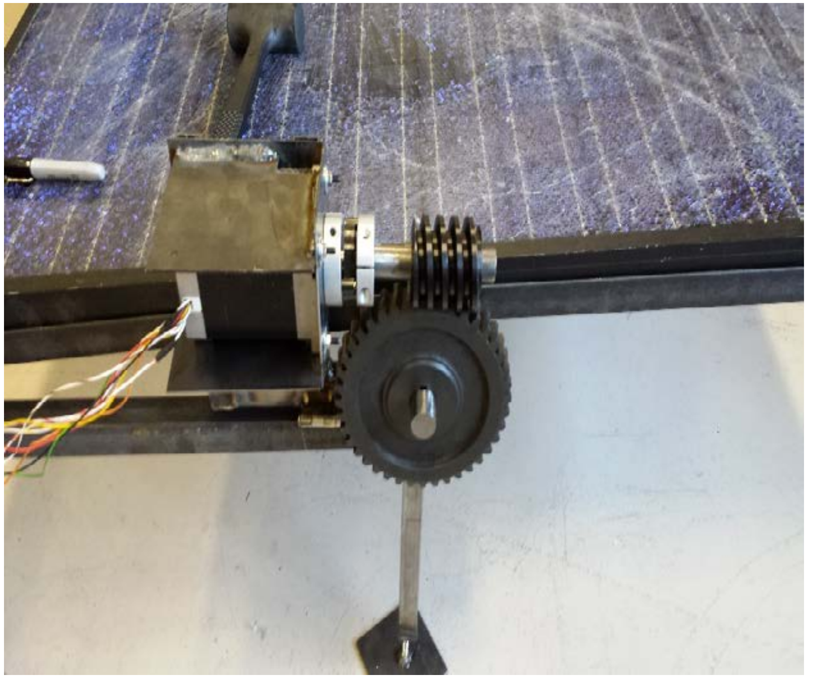
Motor and Gear Design



- Worm and Gear system
- Left side manual crank
- Right side automated system
  - Stepper motor provides the precise control over the rotation angle.

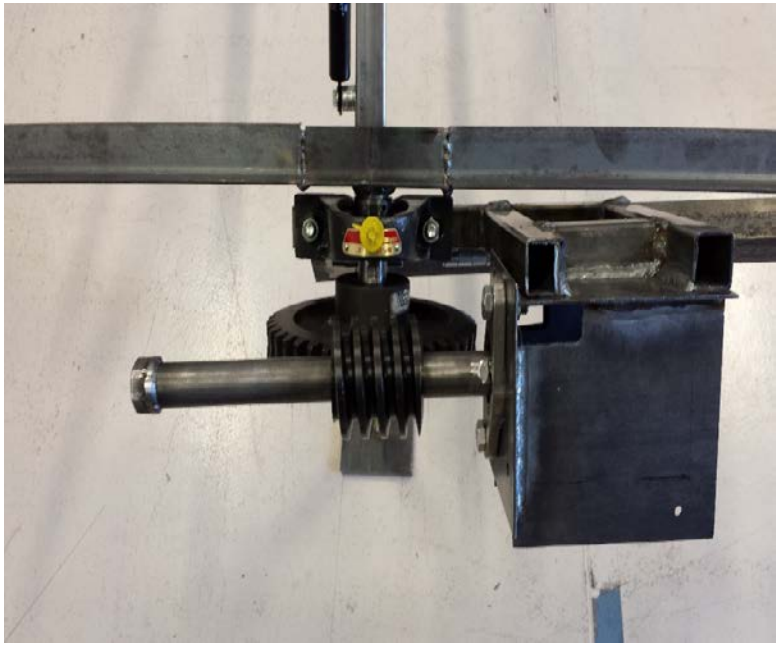
Motor and Control

- Motor case
  - 5mm bolts
- Coupling between motor and shaft
- STR-8 and Arduino board is used to send signals to the drive
- Separate power supply for motor and control system



Crank Housing and Shaft

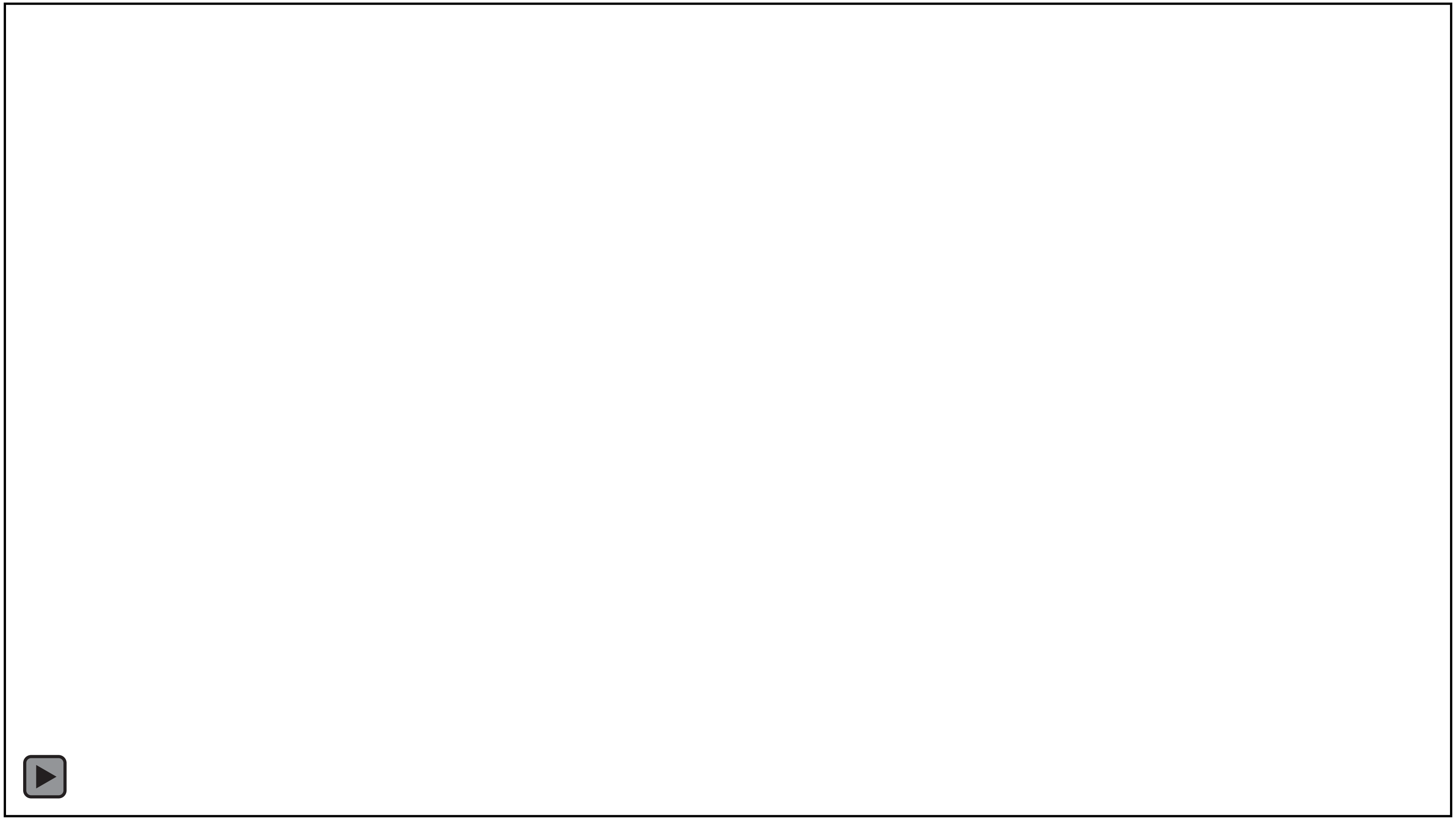
- Same motor case on the hand crank side
- Crank shaft
- Keyways cut into shafts to hold worm gears
- Ability to upgrade to automatic system



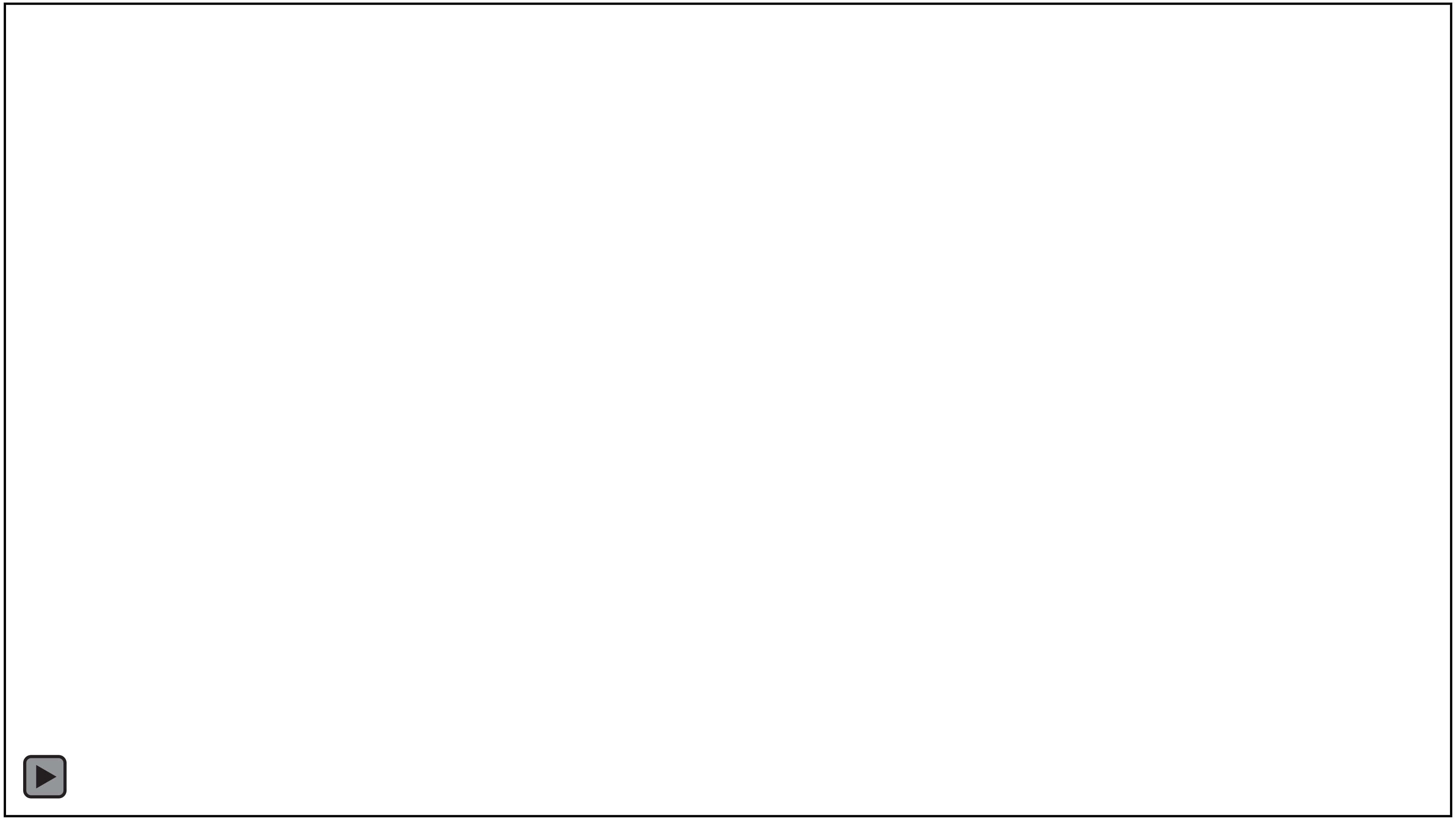
Testing and Results

- 18 holes for North- South tracking.
- Change the hole position every 10-15 days.
- Motor rotates clockwise for a full rotation , and the solar panel rotates 2.5 degrees every 15 minutes.
- Solar panel rotates from 30 degrees to 150 degrees.
- https://www.youtube.com/watch?v=_X1lucYdSRc
- https://www.youtube.com/watch?v=hjXubvmJOAs&feature=youtu.be

Manual tracking test



Automated tracking test



Cost Analysis

Resource	Cost	Justification
1.25” x 1.25” Angle Bar	$98.09	Framework of solar panel tray
1” x 1” Square Tubing	$180.00	Framework of tracking system base
1” Solid Steel Rod	$13.71	Connected to bearings to turn solar panels
Motor and Control Panel	$597.00	Standalone system used to control tracking system
Worm and Spur Gear	$311.92	Used to rotate panels
Bearings	$311.92	Solar panel shafts rotate on them
Hardware	$20.00	Connections where not suitable for welding
Total	$1532.64	

Conclusion

- We constructed a solar panel array capable of tracking the sun both manually and automatically.
- Using FEA to analyze the beam stresses and we calculated torque and maximum solar incidence angle (θ), materials for the frame were chosen.
- The frame, angle supports and housing were constructed out of materials we selected.
- Using a worm and gear system the solar panels move freely.
- Using stepper motor, STR-8 control system, Arduino board and power supply for automatically tracking.
- The solar panel array cost approximately $1500.

References

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Questions?