Static Equilibrium*

A Mechatronics

Demonstration Project

By

Robert Gandolfo

And

Paul Friedman
Abstract

The intent of this project is to provide a visual demonstration of a standard static equilibrium problem that high school physics students are responsible for. The use of servomotors, sensors and basic programming further demonstrates how concepts of physics, mechanical engineering, electrical engineering and computer programming are interrelated and interdependent. This project provides students with a model of a real world problem in which concepts they are learning in school are applied.
STATIC EQUILIBRIUM

- STANDARD PHYSICS PROBLEM
- NO MOTION
- $\Sigma$ FORCES = 0
- $\Sigma$ TORQUE = 0
SENSORS & DRIVES

- TWO SERVO MOTORS
- ROTARY POTENTIOMETER
- SLIDE POTENTIOMETER
- LOAD CELL
- LEAD SCREW
ELECTRONICS

- TWO ADC 0831 CHIPS
  - SENSE VOLTAGE
- BREADBOARD
  - RESISTOR/CAPACITOR
- PARALLAX BS2 CHIP
- PBASIC CODE
ELECTRICAL SCHEMATIC

ADC 0831

Vdd

Incline sensor

Offset

Vdd

P3

Vdd

P4

P5

Vdd
LOAD CELL

- FlexiForce #A101
- 0.01 ?F
- 220 ?
- Vdd

Diagram:
- P13
- FlexiForce #A101
- 220 ?
- 0.01 ?F
- Vdd
OPERATION

• **INPUT**
  - BOOM ANGLE $\theta$ (5 TO 55 DEG)
  - SLIDE WEIGHT POSITION
  - 17 TO 22 CM FROM PIVOT

• **FEEDBACK**
  - BOOM ANGLE
  - SLIDE POSITION
  - CABLE TENSION

• **CALCULATE**
  - CABLE ANGLE
  - REACTION FORCES
CALCULATIONS

- $\sum \tau = 0$
- $\sum \tau = T \cdot L_3 \cdot \sin(\alpha + \theta) - W_1 \cdot L_1 \cdot \cos \theta - W_2 \cdot L_2 \cdot \cos \theta - W_3 \cdot L_3 \cdot \cos \theta$
- $\sum F_x = 0$
- $\sum F_x = F_H - T \cdot \cos \alpha$
- $\sum F_y = 0$
- $\sum F_y = F_V - W_1 - W_2 - W_2 + T \cdot \sin \alpha$
APPLICATIONS

• MODEL
  – ELBOW
  – KNEE
  – CRANE
  – BRIDGE
  – BACKHOE
THANK YOU!

- Sang Hoon Lee
- Yvonne Lee
- Saul Harari
- Hong Li
- Imran Ahmed
- NSF (022749)
- Prof. V. Kapila