RoboJackets

FIRST - IGVC - BATTLEBOTS - ROBOCUP

2008 TE Sessions Supported by

CATERPILLAR®

NATIONAL INSTRUMENTS™

Rockwell Automation

The George W. Woodruff School of Mechanical Engineering

Georgia Tech College of Computing

Introduction to Robotics

and

Structures

www.robojackets.org

Info

- Sponsors
  - Caterpillar
  - Rockwell Automation, National Instruments
  - College of Computing
- Key Contacts
  - Andy Bardagjy– andyb@gatech.edu
  - Stefan Posey – stefan.posey@gatech.edu
- Every Tuesday 5pm – 7:30pm

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About This Year

- Basic
  - Ways to build, how to build, and how to succeed.
- Advanced – Special Topics
  - CAD, Topics in Robotics, Controls, etc.
- Lectures and notes (pdf)
  - http://www.robojackets.org (click on TE Sessions)

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TE Session Final Competition

- When: November 8, 2008 @ 10 AM
- Where: Klaus Advanced Computing Building

- Food will be provided
  - College of Computing

TE Schedule

Basic

– Intro to Robotics & Structures	09/09
– Mechanical Power Trans	09/16
– Drive Types	09/23
– Manipulation & Fluid Power	09/30
– Fabrication, Safety, and Elect	10/07
– Introduction to LabVIEW	10/14
– LabVIEW 2	10/28
– LabVIEW 3	10/30
– LabVIEW and Compact Rio	11/04

Advanced / Special

– Advanced Robotics
– Advanced Robotics II
– Manipulation
– Autodesk Inventor

INTRODUCTION TO ROBOTICS

What is a robot?

- Characteristics
  - Detects surroundings / environment
  - Make decisions based on surroundings
- Basic Idea – A vehicle / platform that can compete tasks with out human interaction.
  - Autonomous capabilities and Sensors

Roots and History

- 3^{rd} century BC first automated device
- 1920 – word robot first used
- 1941 – Asimov coins robotics
- 1963 – 1^{st} pallet robot
- Science Fiction
  - Kitt, Cylons, RoboCop, T1000, Data

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Laws of Robotics

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Applications

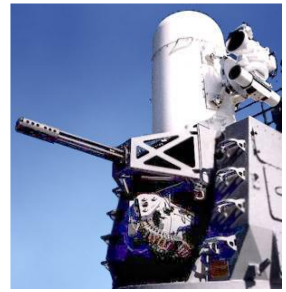
- Commercial / Industrial
- Government / Military
- Research
- College Competitions

App: Commercial / Industrial

- iRobot
  - Roomba
- KUKA
- FANUC
- EPSON

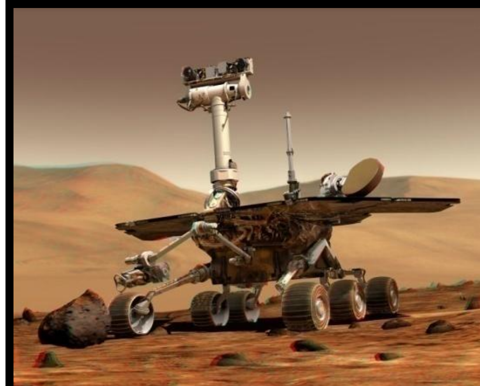
App: Government / Military

- Defense
  - Phalanx CIWS
- UAV
  - Surveillance
  - Communication
- Rescue
- Bomb Disposal

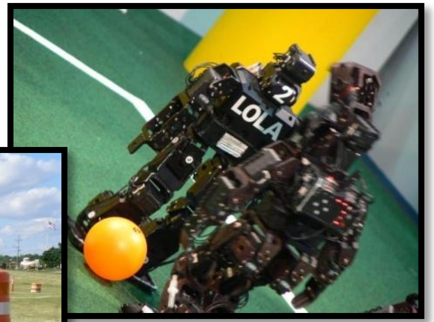


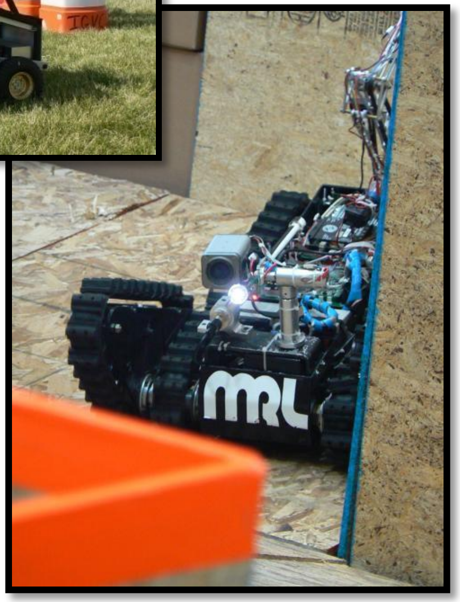

App: Research

- NASA
  - Rovers, Landers, Satellites
- DOD
  - DARPA
- Georgia Tech
  - Robotics and Intelligent Machines
    - http://robotics.gatech.edu
  - BORG Lab, IMDL, UAV Lab, etc
  - GTRI

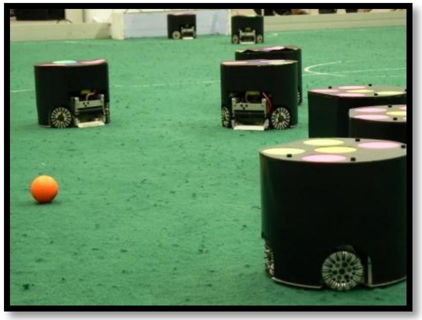


App: College Competitions





- FIRST* (mentor)
- RoboCup
  - Small Size*
  - Medium
  - Humanoid
- BattleBots*
- AUVSI
  - IGVC* – Ground
  - AUVC – Underwater
  - IARC – Arial
- IEEE
- More



Note * = RoboJackets Team

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MATERIALS & STRUCTURES

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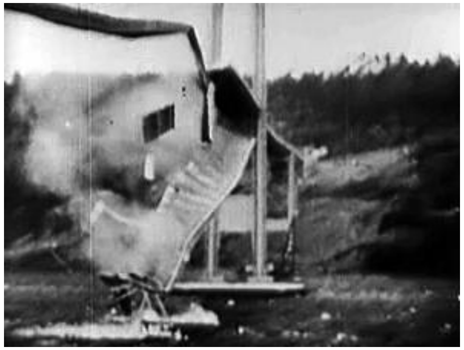
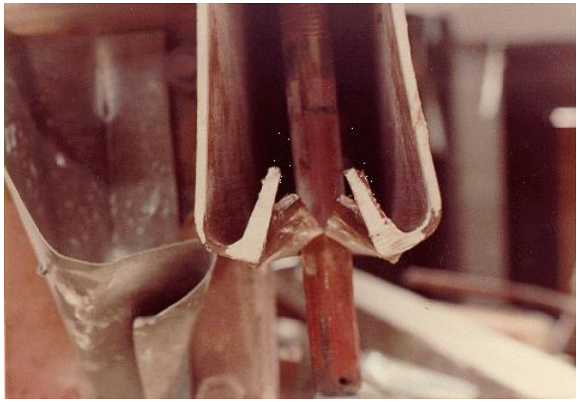
Mechanical Basics

Motivation:

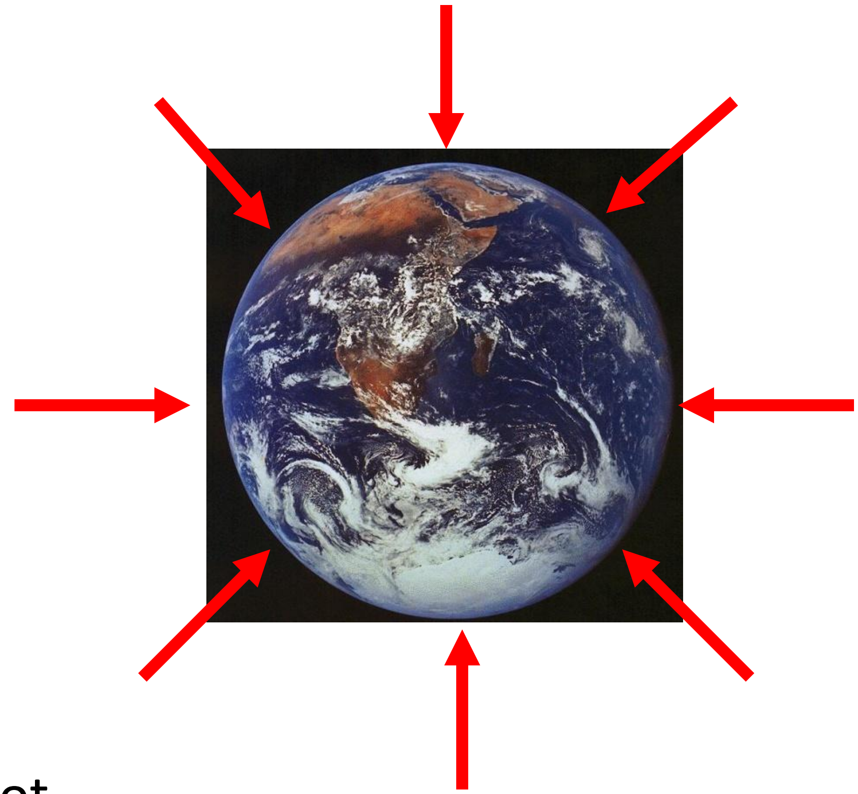
– Strong structures can fail catastrophically
– Geometry of design can contribute to or prevent failures
– Material selection can also be crucial





Forces

- Gravity
  - Its everywhere
- Isaac Newton
  - 2nd Law F=ma
  - a = acceleration
    - From gravity
      - 32.2 ft/s^2 , 9.81 m/s^2
    - From motors
    - From hitting another robot
  - m = mass of object (lb$_{mass}$, kg)



Forces

- Weight
  - On Earth, $a = 9.81\ m/s^2$
    - $F = 1\ kg \times 9.81\ m/s^2 = 9.81\ N$
  - On the Moon, $a = 1.6\ m/s^2$
    - $F = 1\ kg \times 1.6\ m/s^2 = 1.6\ N$
  - In outer space, $a \approx 0\ m/s^2$
    - $F = 1\ kg \times 0\ m/s^2 = 0\ N$
- Same mass different weight

Stresses

- Materials Bend (not ridged)
  - Everything deforms before it breaks
    - Elastic
      - Stretches a lot before it breaks
      - Rubber (Rating → Durometer)
    - Brittle
      - Not much stretching before breaking occurs
      - Will have cracks (glass)
- Stress
  - Force / Area (psi, Pa)

Stresses

Area

Cross-section through force

Circular

pi * (radius)^2

Rectangular

L * H

Stress:

Tension

Compression

Stresses

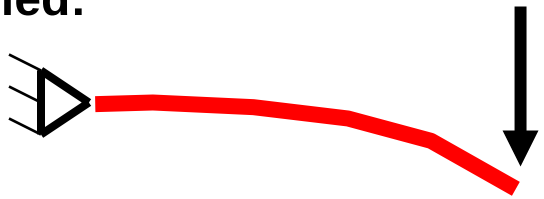
Materials Bend

Everything stretches before it breaks

Single Point Bending

Cantilever Beam:

Force Applied:



Deflection:

End of beam deflects in direction of force

If deflection is large enough, stresses will cause beam to permanently deform

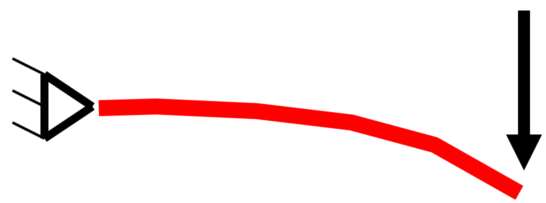
Stresses

Example

Single Point Bending

Cantilever Beam, length of 0.5m:

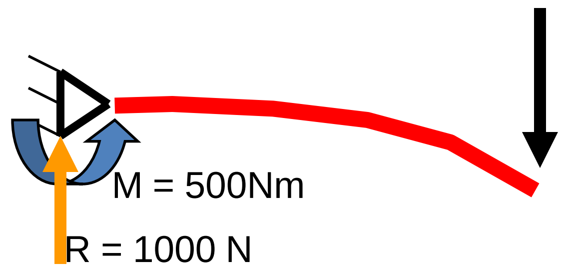
Force of 1000N Applied:



Reactions

Moment

Force



Thoughts:

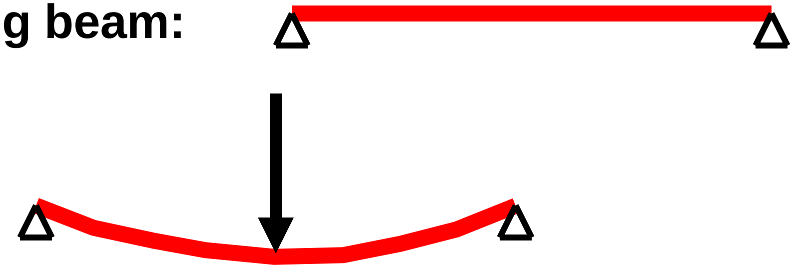
Large deflections can occur without damage
Large moments may be difficult to resist
Cantilevered loads can be avoided

Stresses

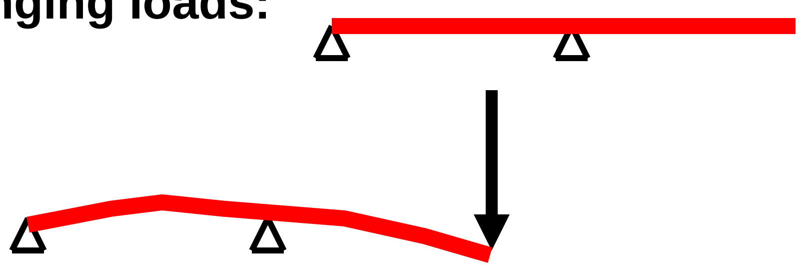
Bending

Two Point Bending

Spanning beam:



Overhanging loads:



Deflection:

End of beam deflects in direction of force

Middle of beam rises in direction opposite of force

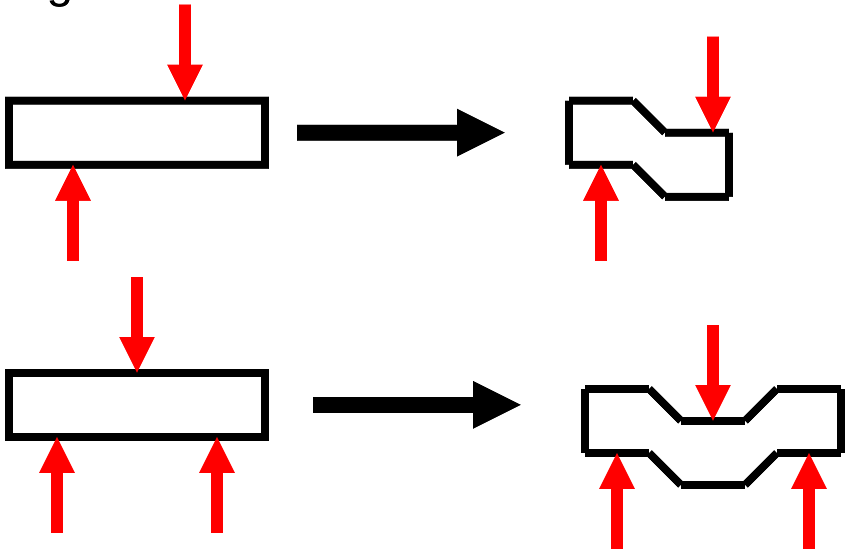
Shear Stress

Shear

While bending results in tension and compression

Shear loads produce different stresses

Single and double shear:



Double shear setups reduce load on pins by 1/2

Materials - Steel

- Traits
  – Strong and heavy
- Steel is a combination of Iron and Carbon
  – Carbon Steel or Stainless? Various grades:
    - Carbon
      – **Low carbon:** more flexible, yields at lower stress (AISI 1006 – 1020)
      – **High carbon:** more brittle, yields less before failure (AISI 1060+)
    - Stainless
      – Stainless resists oxidation (rust), difficult to work with & $$$
      – 304, 304L, and 316 are most common

Materials - Aluminum

- Traits
  - Light, but weaker than steel
  - More expensive than steel
  - Limited flexibility
- Many grades
  - Common (6061, 2024)
    - Good fit for most applications.
  - Special Stuff (7000s, 4000s)
    - Higher strength, corrosion resistant, ultra-light, etc.
- Fatigue
  - When repeatedly flexed & stressed, cracks will develop, and the piece WILL fail

Materials - Plastics

- Plastics
  - Light, Flexible, Cheap, easy to machine
- Wide range available, what type?
  - HDPE: High Density Polyethylene
    - Flexible, white or black
  - Polycarbonates (Polycarb): Lexan
    - Very flexible, clear sheets
  - Acrylics: Plexiglas, etc
    - Brittle, clear sheets
  - Delrin: Acetal resin
    - Slick, low friction, many colors

Material Selection

Based on component properties

- Axles & Drive Components
  - Steel can withstand fatigue and stresses
  - Aluminum or plastics will wear and fail to quickly
- Frame
  - Aluminum beams will be easy to cut and drill, stay lightweight
  - Steel will be very strong and easily weldable
- Arms
  - Aluminum is lighter than steel, and with good design, will be strong
  - Steel is strong, but too heavy to be an arm
- Body Panels
  - Aluminum and steel are both too heavy
  - Polycarbonates work well.
  - Acrylics can, but think about shattering.

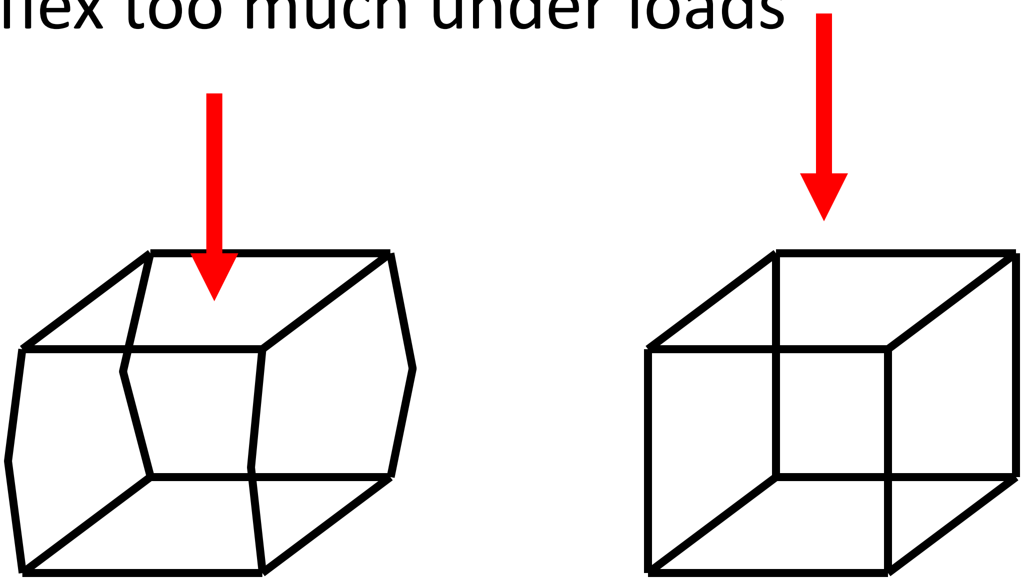
Additional Info on Materials

- http://www.matweb.com/
- http://www.mcmaster.com/
  - Go to Raw Materials & browse

How to Build a Box

(A ok one)

- **What makes a box ok?**
  - Should be able to support weight
  - Should be light
  - Shouldn't flex too much under loads



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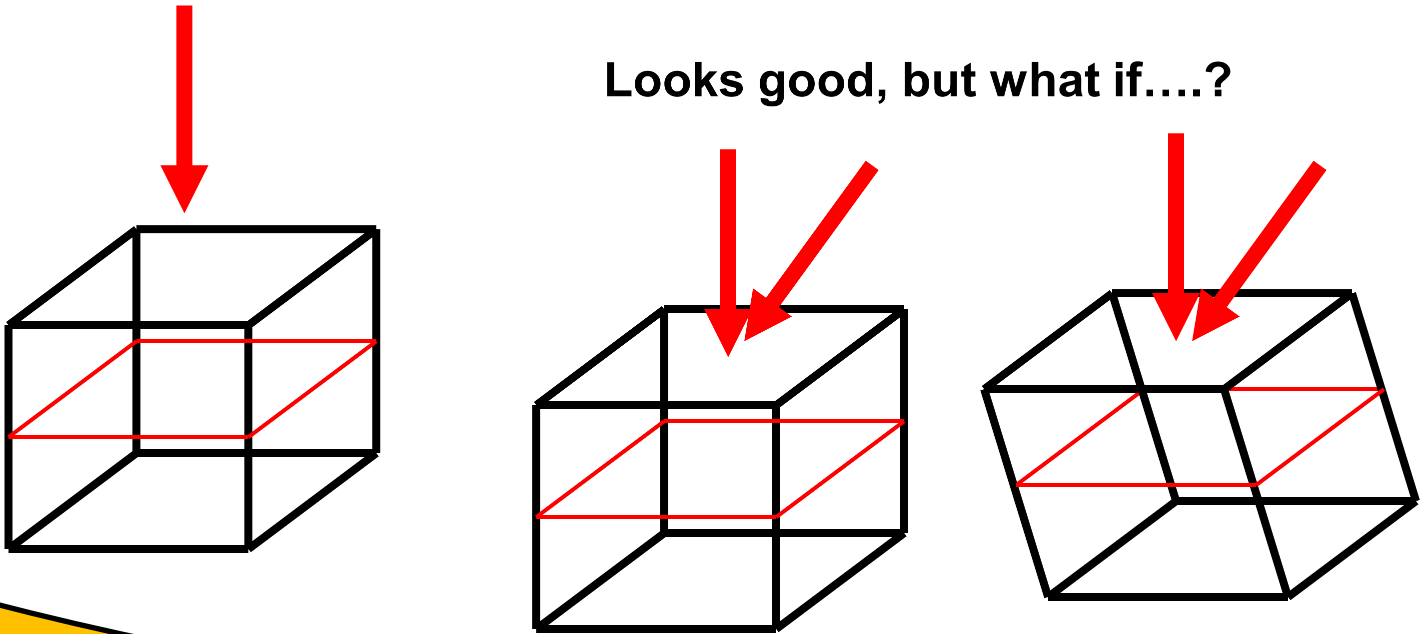
How to Build a Box

(A better one)

- **What makes a box better?**
  - Members spanning sides can prevent buckling
  - Shouldn't flex too much under side loads



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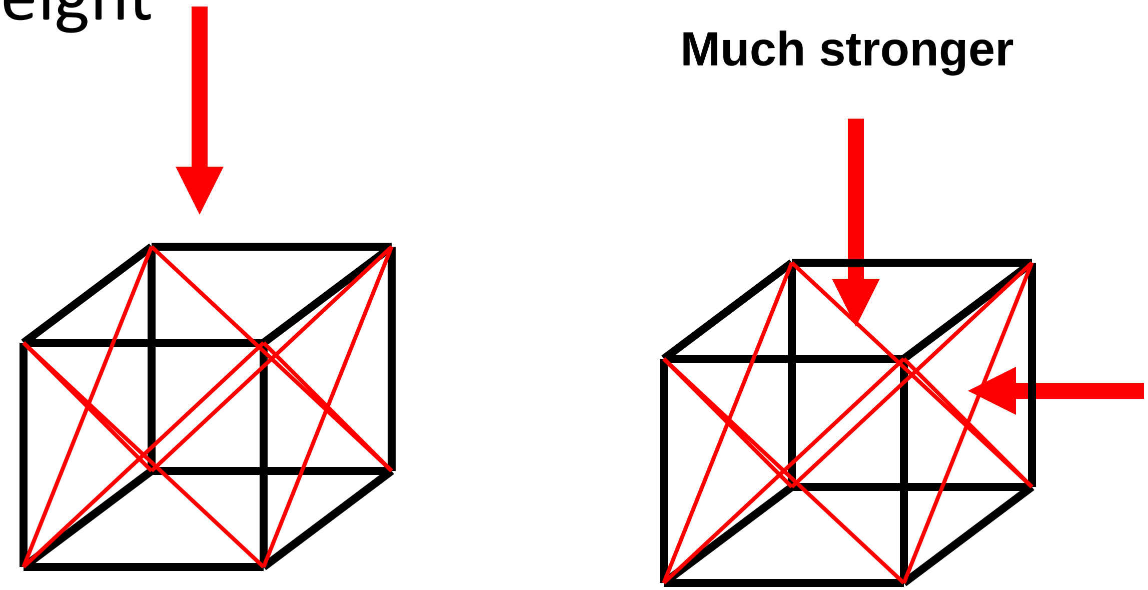
How to Build a Box

(An even better one)

- **What makes a box even better?**
  - Members spanning corners are best
  - An X shape is preferable, but not always an option due to weight



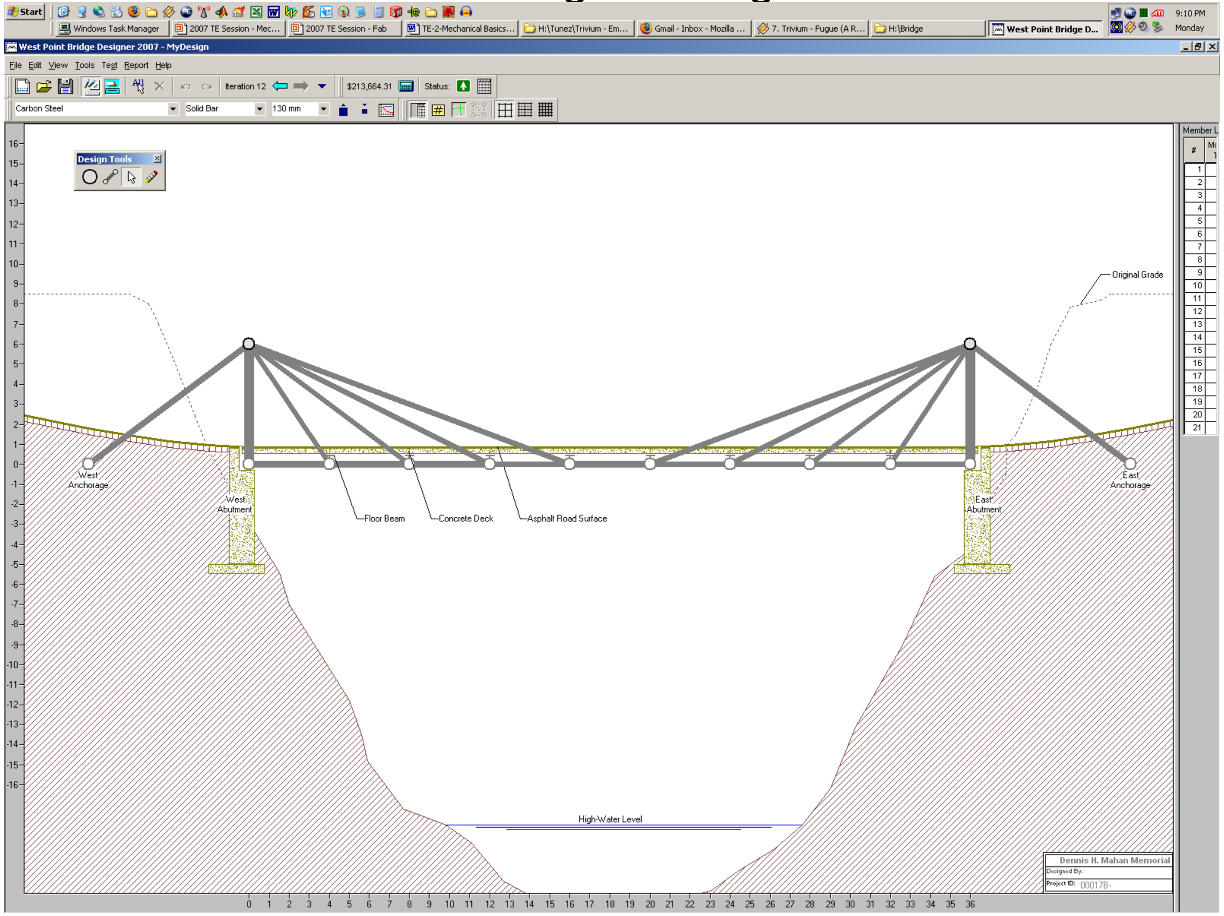
Activity

- Build a cantilevered structure to support as many coins as possible
  - In the event of a tie the team with the most left over will win
  - For every ½ ft of length = multiplier to coin #
  - Materials
    - 1 Box of Straws
    - 1 Role of tape
    - 10 sheets of copy paper

Try This At Home

West Point Bridge Designer®
Free download

Design a bridge or watch it fail



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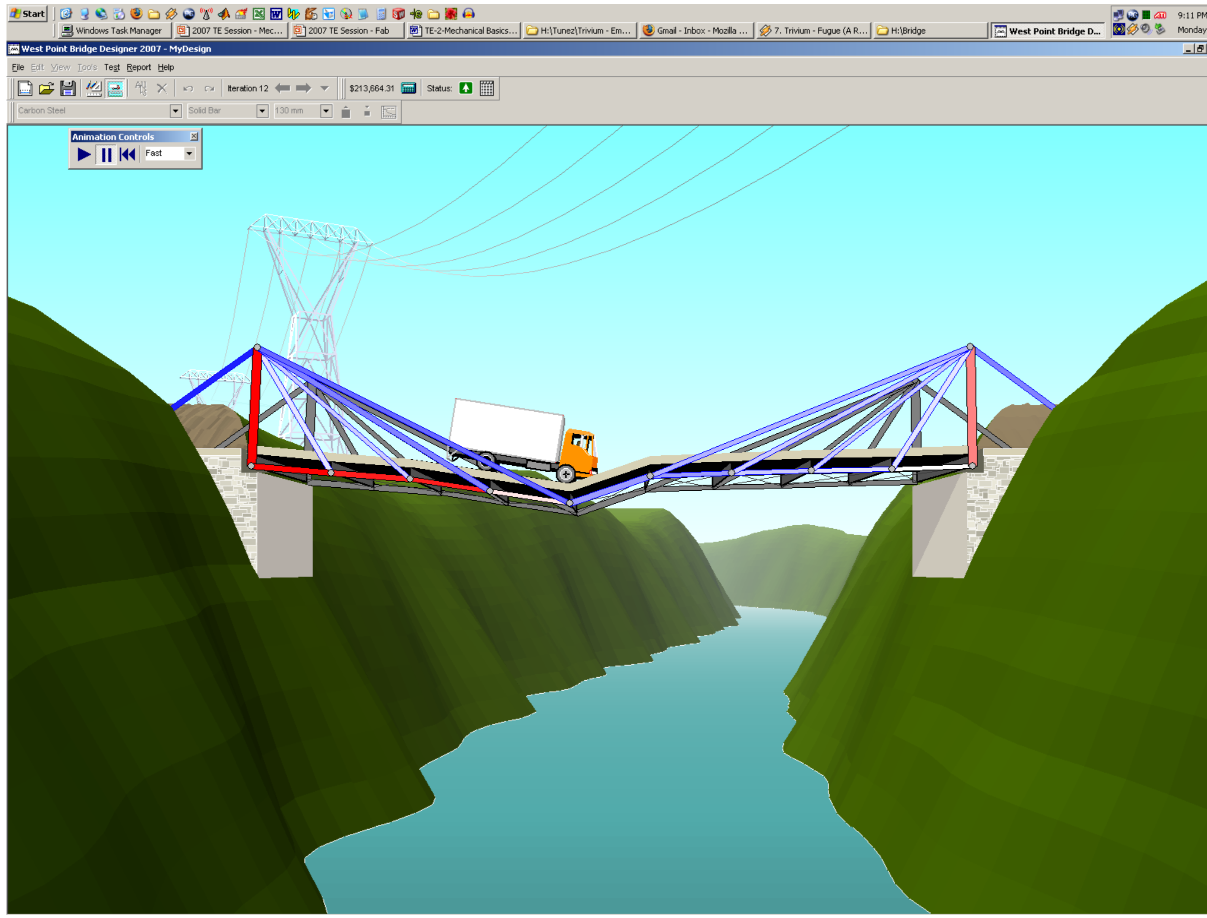
Try This At Home

West Point Bridge Designer®

Run a real simulation on it   Watch the beams stretch and



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