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Project 4 – Baja Front Suspension

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Mentor: Dr. Bob Allen

Sponsor: Olivet SAE Baja Racing Team

- student-led group, the Olivet SAE (Society of Automotive Engineers) Baja racing team (leader Jordan Houser and headed by Dr. Bob Allen)
- Martin D. Walker School of Engineering


ONU SAE Baja Racing Team

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SAE Baja Racing

- Need
- Problem
- Goals
  - Improve Durability/Strength
  - Improve Handling/Control
  - Increase strength-to-weight ratio
- Control Arm
  - Vertical motion of wheel relative to chassis

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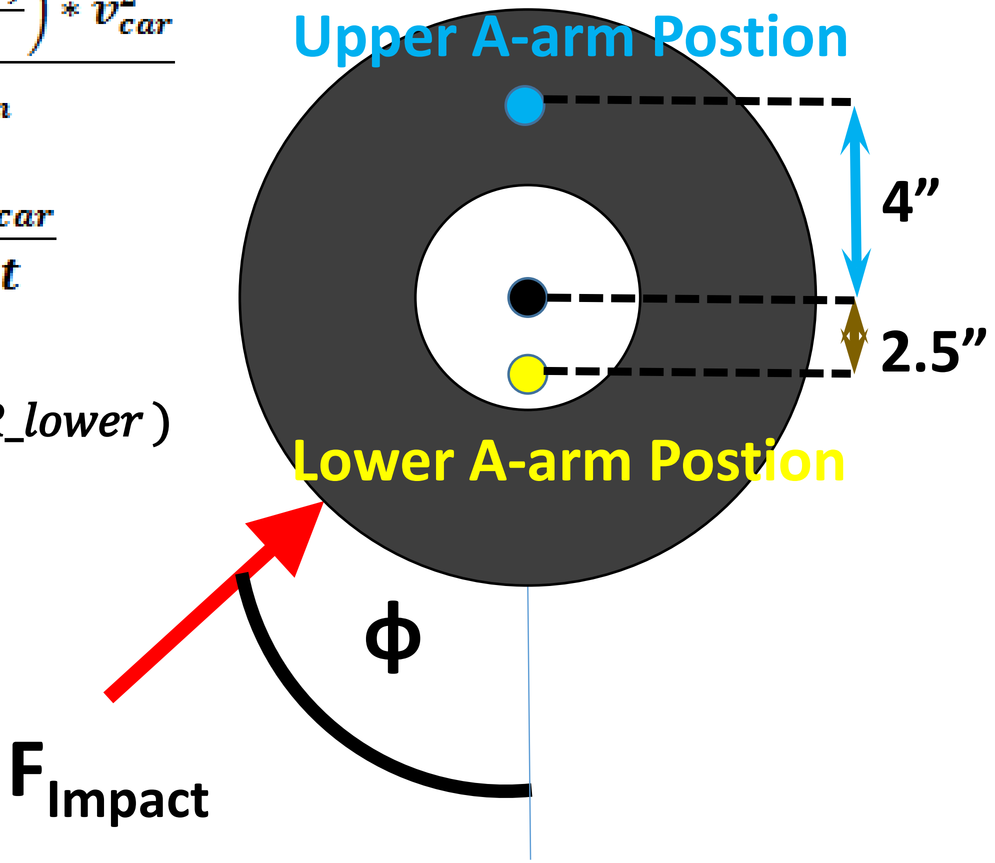
Problem Approach

- Assuming:
  - W_{car}=400lb MAX
  - W_{driver}=240lb MAX (vary)
  - g=32ft/s^2
  - 2.5” +/- 2in tire deflection (vary)
  - Φ=90° (vary)
  - 2-Dim (actually 3-D)
  - MAX tire pressure 36psi (vary)
  - R=10”, Tire thickness=4.5”
  - 3ft fall
  - All energy from 3ft fall is translated to torque in A-arm

$$F_{impact} = \frac{\frac{1}{2} * \left(\frac{(W_{driver} - W_{car})}{g}\right) * v_{car}^2}{\Delta_{tire\ deflection}}$$

$$F_{impact} = m * \frac{\Delta v_{car}}{\Delta t}$$

$$T_{impact} = F\_impact * (R\_upper - R\_lower)$$



Note: Many uncertainties due to variation in many variables

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Constraints and Requirements

- Constraints
  - Manufacturing
    - Tech. Center
  - Costs ~$1000 budget
    - At approximately $500 in material costs
  - Materials
    - Metals-particularly steel due to welding capabilities
  - Geometry
    - Allow shock to pass through
  - Competition Rules
    - Stay within SAE car width requirement of 65" MAX
  - Need to exceed last years strength of old control arm
    - Failed at estimated 69 lb*ft torque/ 410 lb impact force

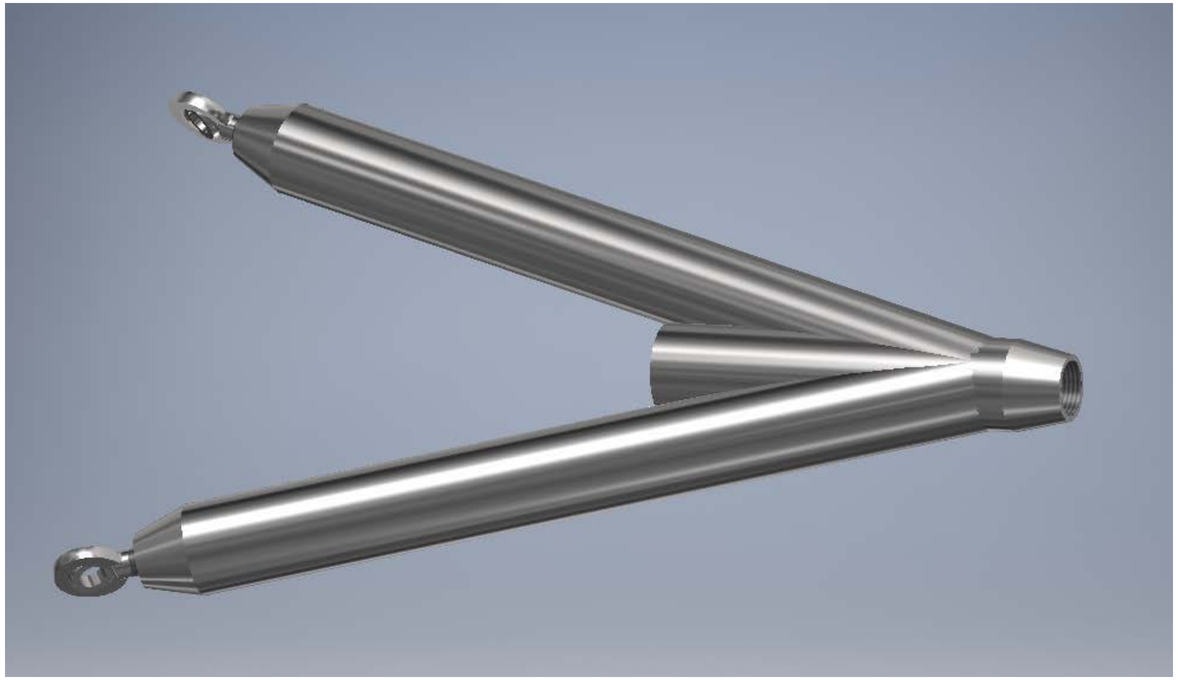
- Requirements
  - Perform in various terrains (mud, gravel, off-road conditions…etc.)
  - Withstand 3ft falls, clear a 12" boulder

Alternative Design 1: Last years design

- Intial changes to last year’s geometry
  - 1” OD to 1.25” OD
- Pros
  - Easy to Manufacture
  - Large shock clearance
  - Simple design
  - Easy to adjust at tie rod ends
- Cons
  - Weak geometric strength
    - Induced bending at 90° bends
    - Poor transmission of forces

Alternative design 2

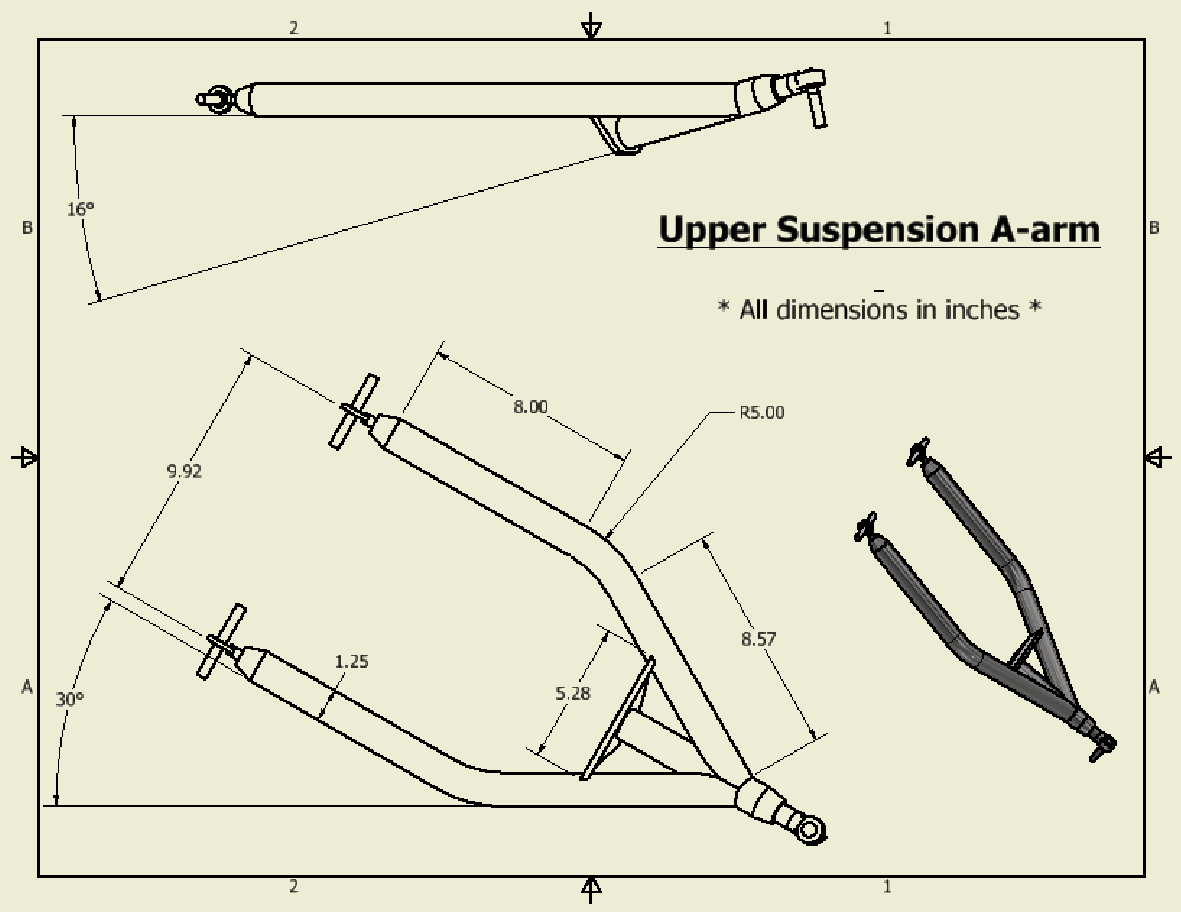
- Intial changes to last year’s geometry
  - 1” OD to 1.25” OD
- Pros
  - Strong Geometry
    - Good transmission of forces
  - Light weight
  - Simple design
- Cons
  - Difficult to Manufacture
    - Complex angles
  - Low Shock Clearance if any
  - Induces bending at tie rod ends
  - Difficult to adjust at tie rod ends

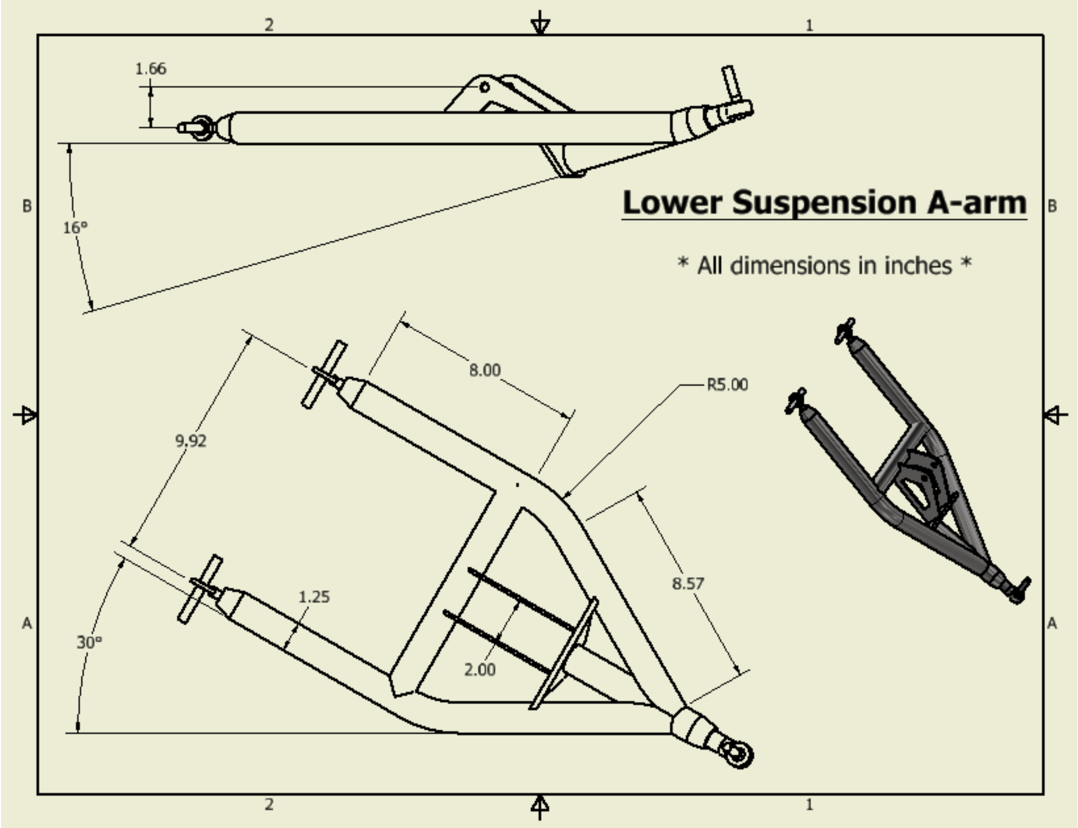


Alternative Design 3

- Intial changes to last year's geometry
  - 1" OD to 1.25" OD
- Pros
  - Strong Geometry
    - Good transmission of forces
  - Light weight
  - Simple design
  - Large shock clearance
  - Easy to adjust at tie rod ends
- Cons
  - Difficult to Manufacture
    - Complex angles

Selection of final design & Information





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Stress and Area Moment of Inertia

- Final design increases moment of inertia and reduces stress experienced by material

$$\sigma = \frac{Mz}{I}$$

$$I = \frac{\pi(R^4 - r^4)}{4}$$

<u>1" O.D. tubing:</u>

$$I = 0.021\ in^4$$

<u>1.25" O.D. tubing:</u>

$$I = 0.043\ in^4$$

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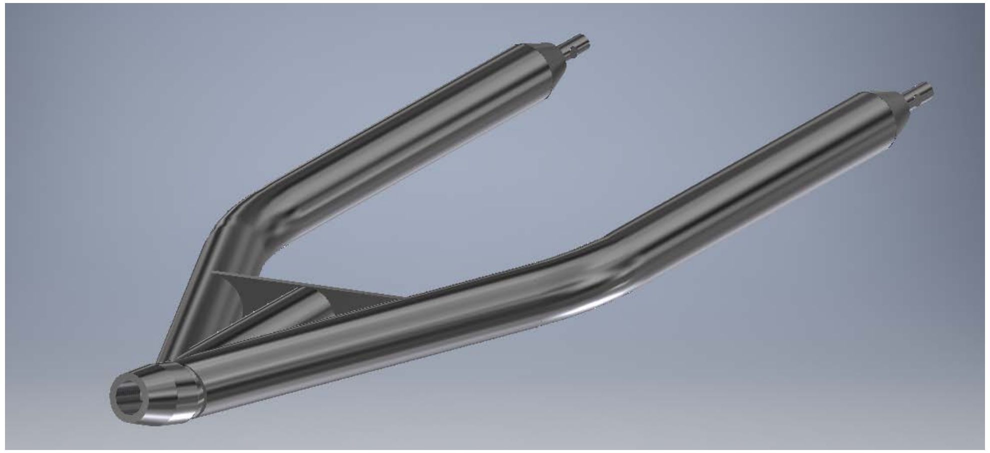
Material Selection

- Mild Carbon steel – strong with use of a lot of material, makes component heavy
- **4130 chromoly steel** – stronger, can use less material and create lighter component
- Aluminum – lightest, not as strong, harder to manufacture (welding especially), not as good with fatigue

Manufacturing

- Challenges
  - Stability, consistency, complex angled machining
- Solutions
  - 2 jigs, tolerance control, redesigned ball joint connector
- Repeatability
  - Consistent bends +/- 0.5 deg., lengths, cuts, welding stability



Mounted Suspension Arms

- Images of suspension mounted and going through full 8” of vertical travel with no binding

- Mention at the spindle the angle does not change through the full 12” of travel - constraint for the constant camber

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Testing

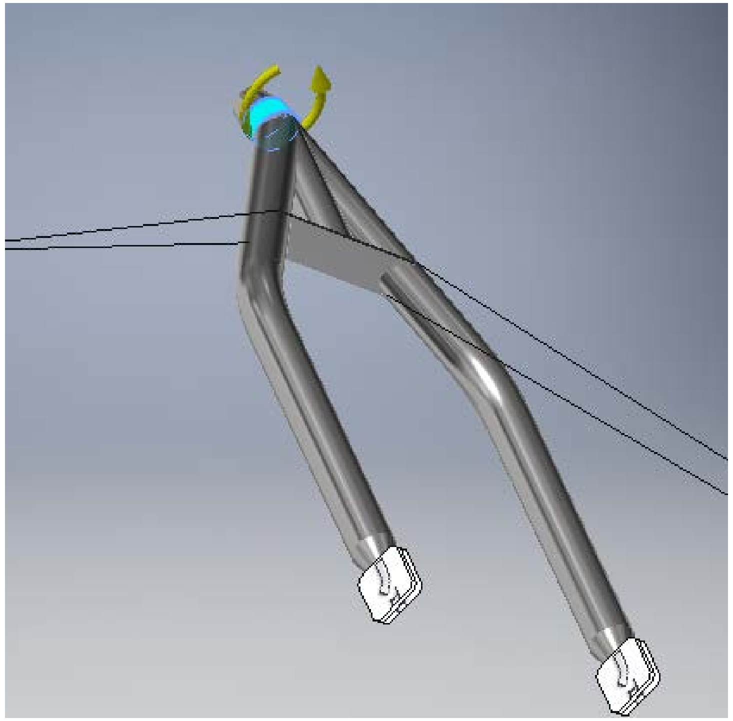
- Testing Apparatus
  - Mounted at two rod ends
  - Ball joint supported but free to rotate
  - Torque applied at ball joint mount
  - No measurable deflection of test stand mounting points

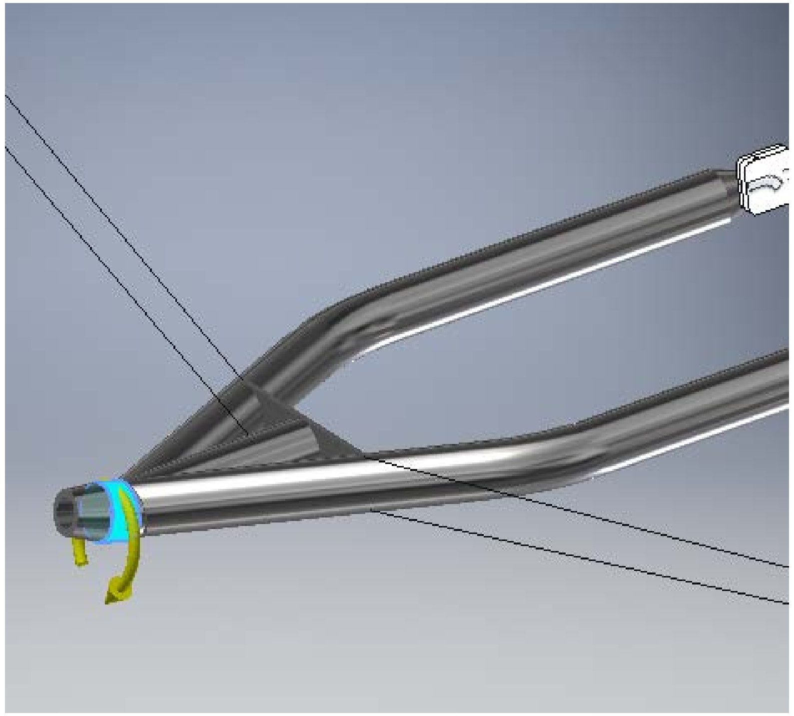
Obtaining Data

- Torque application
  - Torque applied in10lb increments
  - Force applied at the end of a torque arm by operator
  - Force measured by scale operator stands on
- Measurements
  - Deflection measured at 1 inch increments along control arm

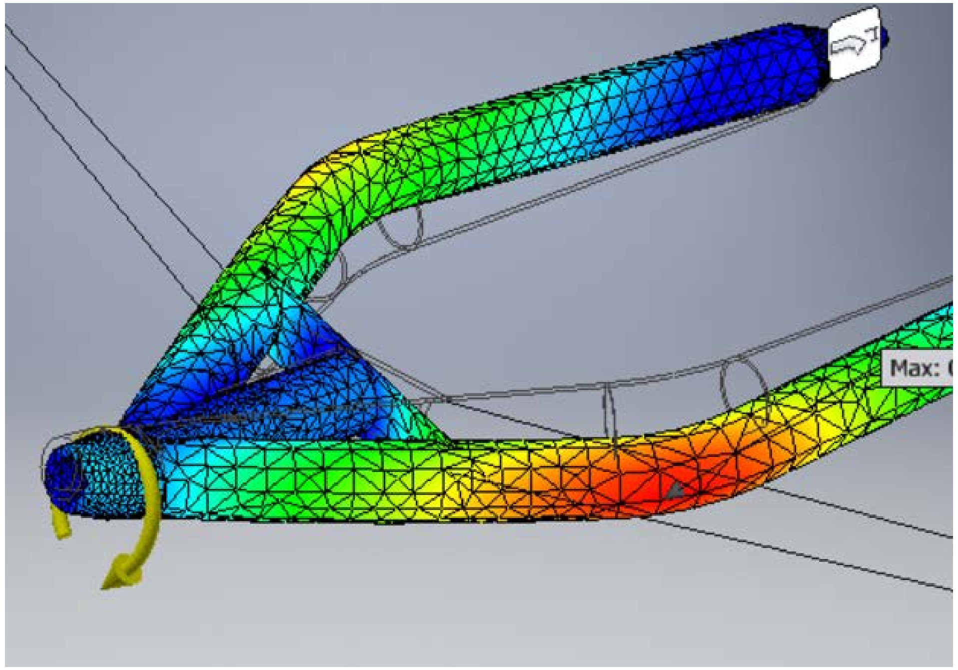
Computer Modeling

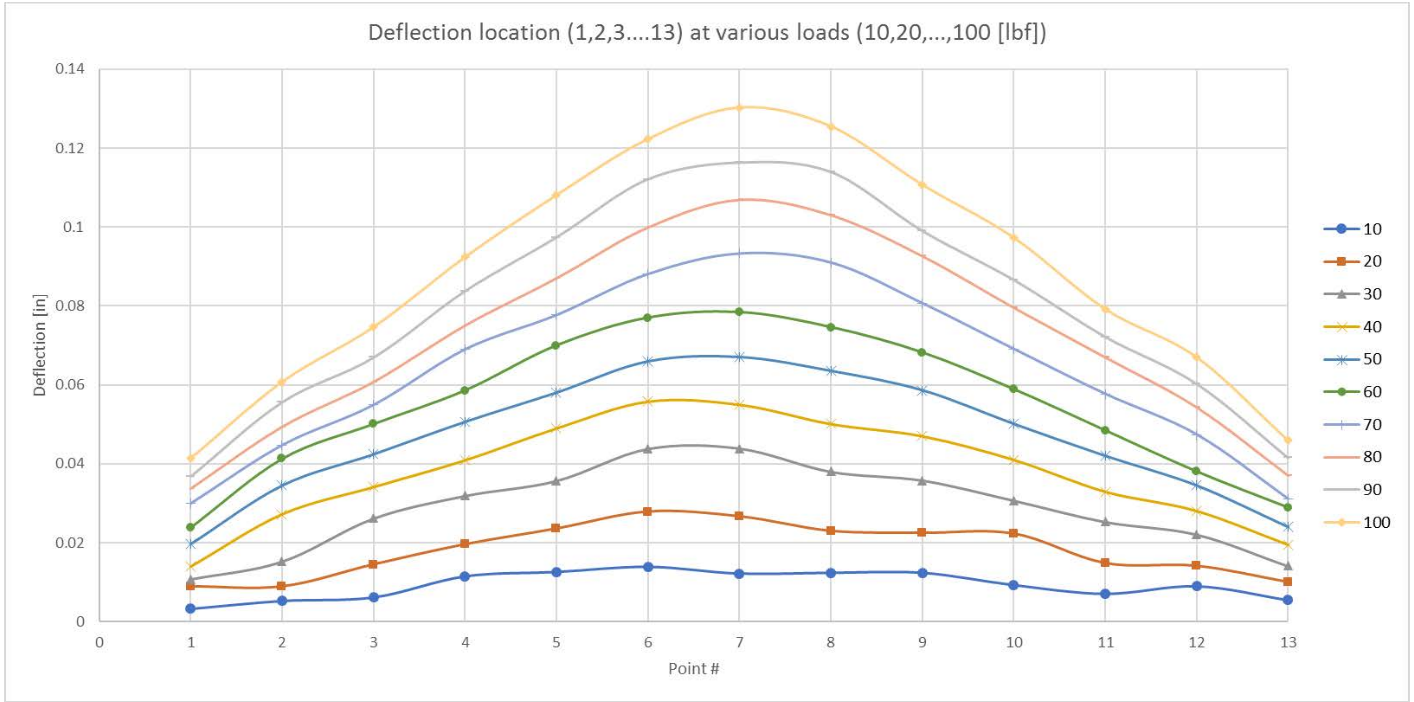
- Torque applied at end of ball joint mounting piece.
- Two rod ends are fixed constraints – represents being mounted to a rigid chassis.
- Challenges with modeling complexity and imperfections of physical model.





Results



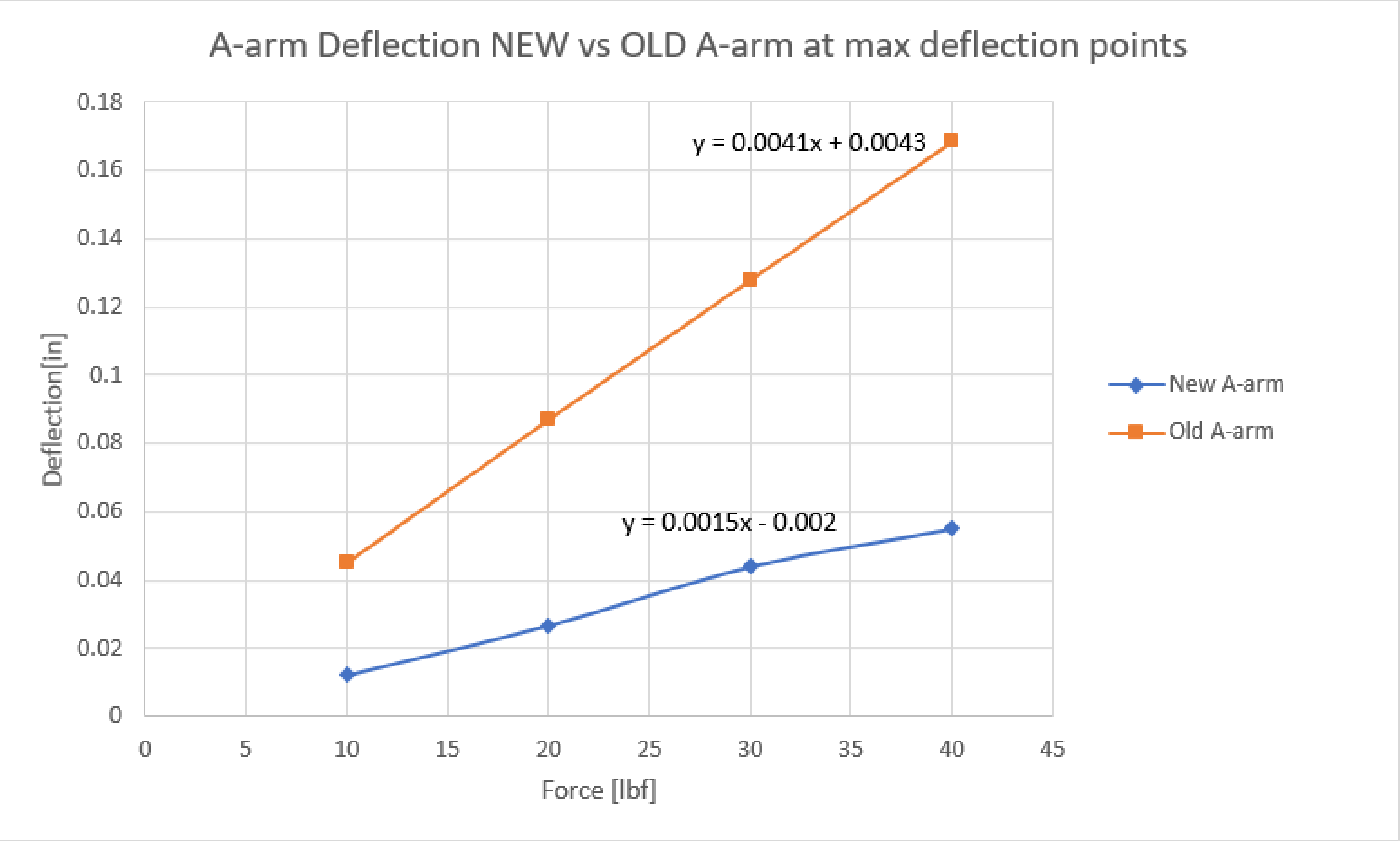


- Yield of old design: 69 lb-ft
- Weight of old design: 2.1 lb

- Yield of new design: 330 lb-ft
- Weight of new design: 2.8 lb

Effect on Performance

- More rigid control arm offers better handling
- Driver has more control over exact placement of wheel



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Questions?

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Thank You!