2012 BAJA SAE TEAM

Suspension Team
- Tyler Shaner
- Andrew Ghosn
- Sean Watson

Drivetrain Team
- Dustin Breon
- Justin Puakea
- Ross Leventhal
BAJA HISTORY

1976- Mini Baja competition created at USC (South Carolina)
1978- Subdivided in East, West, and Midwest
2006- Renaming of competition and events (BAJA SAE)
2012- BAJA SAE Wisconsin June 7th - 10th

Day 1
  • Registration
  • Engine Check

Day 2
  • Technical Inspection
  • Design Judging
  • Brake Test

Day 3
  • Maneuverability
  • Acceleration
  • Mud Bog
  • Hitch Pull
  • Suspension and Traction

Day 4
  • Endurance Event
FRONT SUSPENSION
FRONT SUSPENSION

Unequal length A-arms

- Track
  - 60 in.
- Travel
  - 6.9 in. Compression
  - 3.8 in. Droop

Custom Shocks

- Valves, Springs, and Length
- Adjustable
  - Hi/Lo Rebound
  - Hi/Lo Compression
  - Preload
ABS BUSHINGS

- Increased Strength
- Lower Cost
- Easier Manufacturing
- Lighter Weight
SUSPENSION JIG
SUSPENSION JIG

- Aluminum CNC Jig
- Increased Manufacturing Accuracy
# UPPER A-ARM FEA

## Material Properties

<table>
<thead>
<tr>
<th>Model Reference</th>
<th>Properties</th>
<th>Components</th>
</tr>
</thead>
</table>
| ![Image](image1.png) | **Name:** AISI 4130 Steel, annealed at 865C  
**Model type:** Linear Elastic Isotropic  
**Default failure criterion:** Max von Mises Stress  
**Yield strength:** 4.6e+008 N/m$^2$  
**Tensile strength:** 5.6e+008 N/m$^2$  
**Elastic modulus:** 2.05e+011 N/m$^2$  
**Poisson's ratio:** 0.285  
**Mass density:** 7850 kg/m$^3$  
**Shear modulus:** 8e+010 N/m$^2$ | SolidBody 29(Sweep5)(Upper Aarm) |

**Curve Data:** N/A

## Loads and Fixtures

<table>
<thead>
<tr>
<th>Fixture name</th>
<th>Fixture Image</th>
<th>Fixture Details</th>
</tr>
</thead>
</table>
| Fixed-1      | ![Image](image2.png) | Entities: 2 face(s)  
Type: Fixed Geometry |

### Resultant Forces

<table>
<thead>
<tr>
<th>Components</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>Resultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction force(N)</td>
<td>-0.481445</td>
<td>2807</td>
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<tr>
<td>Reaction Moment(N-m)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Load name | Load Image | Load Details |
|--------------|------------|--------------|
| Force-1      | ![Image](image3.png) | Entities: 1 face(s)  
Type: Apply normal force  
Value: 1500 lbf |
1” X 0.035”

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement1</td>
<td>URES: Resultant Displacement</td>
<td>0 mm Node: 173</td>
<td>15.222 mm Node: 123</td>
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</tbody>
</table>

Upper Arm Study 1 Displacement-Displacement

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress1</td>
<td>VON: von Mises Stress</td>
<td>132.809 N/m² Node: 16695</td>
<td>1.12235e+009 N/m² Node: 1402</td>
</tr>
</tbody>
</table>

Upper Arm Study 1 Stress-Stress

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Strain1</td>
<td>ESTRN: Equivalent Strain</td>
<td>6.7935e+010 Element: 4796</td>
<td>6.02664e+002 Element: 7956</td>
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Upper Arm Study 1 Strain-Strain

1” X 0.049”

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
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<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement1</td>
<td>URES: Resultant Displacement</td>
<td>0 mm Node: 173</td>
<td>15.6342 mm Node: 123</td>
</tr>
</tbody>
</table>

Upper Arm Study 1 Displacement-Displacement

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress1</td>
<td>VON: von Mises Stress</td>
<td>137.802 N/m² Node: 16695</td>
<td>1.12235e+009 N/m² Node: 1402</td>
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</tbody>
</table>

Upper Arm Study 1 Stress-Stress

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
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Upper Arm Study 1 Strain-Strain
1” X 0.065” 4130 STEEL
LOWER A-ARM FEA

Material Properties

<table>
<thead>
<tr>
<th>Model Reference</th>
<th>Properties</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Name: AISI 4130 Steel, annealed at 865C</td>
<td>SolidBody 30 (Cut-Sweep3) (Lower Aarm), SolidBody 34 (Boss-Extrude8) (Lower Aarm)</td>
</tr>
<tr>
<td></td>
<td>Model type: Linear Elastic Isotropic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Default failure: Max von Mises Stress</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yield strength: $4.6 \times 10^8$ N/m²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tensile strength: $5.6 \times 10^8$ N/m²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elastic modulus: $2.05 \times 10^1$ N/m²</td>
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</tr>
<tr>
<td></td>
<td>Poisson's ratio: 0.285</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mass density: 7850 kg/m³</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shear modulus: $8 \times 10^1$ N/m²</td>
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Curve Data: N/A

Loads and Fixtures

<table>
<thead>
<tr>
<th>Fixture name</th>
<th>Fixture Image</th>
<th>Fixture Details</th>
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</thead>
<tbody>
<tr>
<td>Fixed-2</td>
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<td>Entities: 3 face(s) Type: Fixed Geometry</td>
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</tbody>
</table>

Resultant Forces

<table>
<thead>
<tr>
<th>Components</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>Resultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction force (N)</td>
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<td>Reaction Moment (N-m)</td>
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<td>0</td>
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</tbody>
</table>

Load name | Load Image | Load Details |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Force-5</td>
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<td>Entities: 1 face(s), 1 plane(s) Reference: Front Plane Type: Apply force Values: ..., ..., -0.224809 lbf</td>
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</table>
1" X 0.065" 4130 STEEL
OPTIMUM K SUSPENSION GEOMETRY
REAR SUSPENSION
REAR SUSPENSION

- Trailing link connects frame to wheels
- Camber links control camber
- Toe link changes toe throughout travel
WHEEL TRAVEL

- Vertical Travel
  - 6 in compression
  - 6 in droop
- 2 Degrees of Rear Steering
TAB AND SLOT CONSTRUCTION

- Increases manufacturing accuracy
- Reduces jig complexity
The new Gaged GX-9
  - Initial Drive 3.85:1
  - Final Drive 0.9:1

Performance Tuned specifically for 10Hp Briggs Motor due to reverse helix shoes
BRIGGS MODEL 20

Torque Curve

Torque (ft-lbs)
00 2400 2800 3200 3600 4000
12.0 12.5 13.0 13.5 14.0

REVOLUTIONS PER MINUTE

(N·m)
16.3 16.9 17.6 18.3 19.0
<table>
<thead>
<tr>
<th>Engine rpm</th>
<th>Eng. torque</th>
<th>Eng. HP</th>
<th>CVT low rpm</th>
<th>CVT high rpm</th>
<th>CVT Low Torque</th>
<th>CVT High Torque</th>
<th>low rpm</th>
<th>high rpm</th>
<th>Gearbox Low Torque</th>
<th>Gearbox High Torque</th>
<th>low mph</th>
<th>high mph</th>
<th>Pass/Fail</th>
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<tbody>
<tr>
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<tr>
<td>2200</td>
<td>13.60</td>
<td>5.66</td>
<td>571.43</td>
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<td>12.33</td>
<td>103.90</td>
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<td>86.31</td>
<td>7.73</td>
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<td>3000</td>
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<tr>
<td>3200</td>
<td>13.40</td>
<td>8.20</td>
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<td>51.59</td>
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<td>507.94</td>
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<td>539.68</td>
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<td>571.43</td>
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<tr>
<td>4000</td>
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<td>77.18</td>
<td>11.04</td>
<td>47.22</td>
<td>Green</td>
</tr>
</tbody>
</table>

This spreadsheet is a basic representation of the forces acting on the mini baja vehicle as it travels uphill. The values in blue can be changed to the approximate final values desired. The gearbox low torque should be greater than the forces acting downhill. The vehicle weight entered should include the driver.
GEAR SELECTION

Tapered Lock Timing Gears

- Internal buffers eliminate backlash and vibration
- Will NOT slip or Vibrate loose thus increasing reliability.
- Easily Adjustable
GEAR SIZING

- Recent calculations show that a single belt drive system is not possible due to a 9” tall x 20” long subframe size constraint; therefore, a dual belt drive system with the following pulley sizes will be used.

- 2.75” to 6.75” reduced to 2.75” to an 8” output gear = 7:1 Gear Ratio
SUBFRAME

Integrated Motor Mount/Gear Box Housing
- Allows Motor and Gear to be removed simultaneously as one assembly
- Reduces maintenance
GEARBOX

- The exterior casing houses Gears, Bearings, and Shafts.
- This design for the 2012 Baja is only going to weigh 14 lbs.
GEARBOX VS. BELT DRIVE

Some advantages that come from a CNC gearbox include:

- Reduced “slack” (i.e. there is no flexing of belt tensioners, & belt stretch) these two aspects of a belt drive system causes slight acceleration lag.

- The friction resistance is greater in a belt drive system as well.

- The Gearbox significantly reduces resistance by having direct contact of metal gears.
GEARBOX VS. BELT DRIVE MAINTENANCE

CNC Gearboxes maintenance includes

- Changing grease and gear casing fluids approximately every 50 to 100 hours

Belt Drive System maintenance includes

- Nearly impossible to seal; therefore, dirt and small debris can damage the rubber belts, & wear pulleys unless the belt drive system is cleaned after every use.

- Water can also get inside the belt system causing the belt to slip and having to repair it before continuing the competition.
COST ANALYSIS

Desired Targets would be a primary issue to resolve prior to manufacturing a Baja for pleasure vs. competition

- Baja’s with a belt drive system can be constructed for approximately $10,000 including parts and labor
- Baja’s with a gearbox can increase price to roughly $12,500
- The belt drive is a sufficient system for a Baja competition; however, the gearbox design will definitely give the customer an advantage.
- For a real world application and cost difference the Baja with a belt drive system would be more practical for the recreational Baja.
QUESTIONS