# SOLAR VEHICLE PROJECT

# MECHANICAL SYSTEMS NOTES

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Professor Patrick J. Starr
Mechanical Engineering Dept.
Univ. of Minnesota
612-625-2315

## INTRODUCTION

This packet is intended to help us get started on the design of the 2005 U of M solarcar. It includes 20 separate handouts that are briefly described in the following table of contents. Some material is from notes that were prepared for an experimental course in Vehicle Dynamics and Design, some is from student reports, and some is from notes to the Borealis mechanical team. The Borealis II Structural Report is included, as well as some "hardware" notes regarding the NGM wheel, rod ends, tubing properties, aircraft fasteners, bearings and snap rings.

These handouts are just the first step. Most of you will need to delve deeper into selected topics. Some handouts only describe what is to be achieved, but the details of how are not included, since they are very specialized methods. However, I do have further information and assume you will see me as soon as you decide "who will be doing what". Some 2003 team alumni are also preparing independent study reports on these methods, and they should be completed soon.

## PACKET CONTENTS: BRIEF DESCRIPTIONS AND PAGES



This handout shows how to estimate loads at the bottom of tires for cornering, braking and bump for a three wheeled vehicle, including estimates for the 1987 GM Sunraycer. These loads are used to trace forces through the suspension members. Note the information that is needed to make the estimates.

This handout describes some "packaging issues" regarding the components of a double A-arm suspension as used on the solarcars and FSAE cars, which are discussed in later handouts with specific dimensions. It also shows how Free Body Diagrams of statics can be used to trace forces from the bottoms of tires through the suspension elements. The diagrams are used to show "what holds the car up". A comparison of two spring locations on an A-arm is shown, and utilizes methods from "DEFORM", including a table of properties of tubing. You show review statics for ways of recognizing directions of forces, two-force members, and force and torque sums. Also, review "DEFORM" for stress computations for:

- members in tension: can adjust area.
- slender columns in compression: can adjust l/r.
- members in bending: can adjust moment of inertia.

Also, recognize that most suspension members and brackets can initially be treated as "beams", having shear and moment diagrams.



This handout describes the geometry of the double A-arm suspension, including a discussion of "Roll Centers", which utilizes some methods of ME 3222. There are pages taken from two references that focus upon race cars rather than solarcars, but the description of the geometry is valuable. Later handouts will focus upon solarcar issues.

This handout describes some of the issues to be resolved in designing a double A-arm suspension for a solarcar, including aerodynamic concerns, packaging and "no scrub" geometry. The diagram on page 67 shows the final dimensions for the BI front suspension. Much effort goes into determining these values, but when they are nailed down, component detailing can begin. Lesson: create the equivalent of "page 67 " ASAP!

5. No Scrub Suspension Geometry: The Finishing Touch (page 73 )

This describes an additional feature to include in suspension geometry to achieve no-scrub motion. It discusses what is to be accomplished, but not how. The "how" will require further analysis. Travis Lee is preparing a report to illustrate the "how".

6. Steering Issues (page 80 )

This handout describes Ackerman steering geometry and a simple view of how it can be approximated. It also includes a description of Bump Steer and a start on how it is avoided. Further analysis will be needed to show how to eliminate Bump Steer. Brian Hall is preparing a report on the "hows" for good Ackerman geometry and Bump Steer.

7. Chassis Components and Construction, Aurora 4 (page 85)

ME 5190 Report, Ryan Giada, March 22, 1999. Note the detailed CG analysis with two battery weights. Only two drawings are needed.

8. Borealis I Chassis Design Notes (page 97)

This handout is a memo to the Borealis I Mechanical Team with a sketch and some notes that show a concept for the chassis. The dimensions are based on a detailed drawing from the Aero team which is included. Note that a swing arm suspension is shown. (This memo moved the Mech Team off of square one).

9. Evaluation of the Borealis II Chassis (page 101)

The Borealis I body had an upper and lower portion that were separated by a seamline about half-way up on the body exterior like a clamshell. This caused the top of the body, where the array is, to have very low torsional rigidity. For BII, we wanted the upper body to extend to the bottom plane and wrap-around to enhance torsional rigidity, like the Aurora 2-4 cars. At the front, this meant "wrapping" the nose below the battery box, if the box was located where it was on BI. So we examined means to move the battery box rearward and move the nose forward and trying to not move the CG rearward. This handout consists of two memos to the team to describe these issues.

10. Borealis Front Uprights: Some Considerations (page 112)

These are notes to the Mechanical Team of Borealis which outlines some details that needed to be examined as the front suspension took shape. We were still considering a lower A-arm that had one "leg" that was parallel to the axle line, like the Aurora cars, so a wide cavity would be required in the upright if the legs were to be two-force members.

11. New Suspension Layout for Borealis (page 131)

These are notes to the Borealis Mechanical and Aero teams regarding changing the lower A-arm design from the Aurora style, which had a "leg" parallel to the axle line, to a more conventional "A" shape. There is a weight (length) comparison and some discussion of mounting concepts.



A series of memos to the Mech Team that accompanied the development of the BII swing arm rear suspension. The BI rear suspension was a complex, rearward facing double A-arm arrangement with a long-stroke shock/spring unit acting over the axle, which required chassis structure back to the axle line. We tried to simplify this for BII. Note the level of detail required: the body-chassis dimensions interact with suspension dimensions.



This memo describes the topics to include in the structural report and the various loading conditions for crash analysis.



This was prepared by the Mechanical Team in 2003. Many of the sections were adapted from earlier reports. There are some errors in the analysis of the rear suspension loads and stresses.

These were provided by NGM company and the wheels were used in Aurora 3, 4 and Borealis vehicles.

16. Rod End Data (page 220)

Pages from catalog 1093 from the Aurora Bearing Company, one of our sponsors.

17. Properties of Tubing (page 223)

Weights, areas, moments of inertia and radius of gyration data for steel tubing. The geometric based properties: (area, moment of inertia, etc.) apply to any material.

18. Aircraft Nut and Bolt Data (page 226)

Descriptions and dimensions of many of the fasteners used in our solarcars, from the Coast Fabrication catalog.

19. Bearing Data (page 230)

A few pages from the SFK bearing catalog for the BII front hub bearings. It shows the kind of information available for bearings, including load data and dimensions.

20. Snap Ring Data (page 232)

A few pages showing snap ring dimensions, hole sizes, loads, groove dimensions, etc. The part numbers are "fairly" universal.