21 Recommended Practices

What are the recommended practices in debugging a model?

What's in this module:

Crawl-walk-run

- Try to understand the mechanism from a physical standpoint.
- Use building blocks of concepts that have worked in the past.
- Add enhancements to the model while testing periodically.
- Build kinematic models before building dynamic models.
- Use motions to check models before applying forces.
- Use motions which start with zero velocity.
- Verify enhancements to a complex model on a simpler model first.

Modeling Practices: Parts

Geometry associativity errors

Geometry may be added to the wrong part.

Mass properties

- Using imported CAD-created geometry (IGES, STL, and so on) can yield inaccurate mass properties.
- Ensure inertia matrix is realistic.
- Use aggregate mass for a quick check of system mass and inertia.
- Use the Table Editor to do a quick check and potentially fix individual part masses and inertia.
- Small part mass and inertia lead to unrealistically high frequencies.

Initial velocities

Check to see that part initial velocities are consistent (look in the .out file).

Dummy parts

- Whenever possible, avoid using them.
- If absolutely needed, constrain all six DOF and assign a mass of 0.0 (not 1e-20).

Design configuration

- Build a model close to assembled position.
- Build a model close to a stable equilibrium position, if possible.

Modeling Practices: Constraints

Fixed joints

- Not needed, since two or more parts can be combined or merged into a single part.
- An extra part with a fixed joint adds unnecessary equations to your system.
- When locking a part to ground, enormous torque may develop due to large moment arms.
- If absolutely needed, then add fixed joints at the center-of-mass (cm) location of lightest part.
- If locking a part to ground, consider assigning a very large mass/inertia to it so it can behave like ground.

Note: Whenever possible, avoid using fixed joints.

Universal joints

When a universal joint is at 90^o, you get a singular matrix.

Motion

- Motion elements should only be functions of time.
- Do not use motion (functions) as a function of variables (or states).

Note: Avoid redundant constraints.

Spring-dampers

- Ensure that the marker endpoints (DM(I,J)) are never superimposed.
- Watch out for springs with very stiff spring constants.
- Watch out for springs with no damping.

Bushings

Watch out for bushings with large rotations.

Modeling Practices: Run-time Functions

Function Builder

- Assists in building functions.
- Assists in function verification.
- Has function plot capability.

Velocity

Make sure velocities are correct in force expressions. For example, in the damping function: -c*VX(i, j, j, _), the fourth term is missing.

Splines

- Approximate forces with smooth, continuous splines.
- Extend the range of spline data beyond the range of need.
- Cubic splines (CUBSPL) work better on motions than Akima.
- Akima splines (AKISPL) work better on forces than Cubic.
- The Akima interpolation method is faster and can be defined as a surface, but its derivatives are generally discontinuous.

IMPACTs/BISTOPs

- Do not use 1.0 for exponent on IMPACT or BISTOP functions.
- Models with IMPACTs/BISTOPs should have slight penetration in design position when doing statics.

Measures

- Set up measures of your run-time functions.
- Set up measures of components of your run-time functions.
- Ensure that your function will not try to divide by zero.

Modeling Practices: Run-time Functions

Contacts

- Do not use 1.0 for exponent on IMPACT or BISTOP functions.
- Models with contacts should have slight penetration in design position when doing statics.

Tires

- Models with tires should have slight penetration in model position when doing statics.
- If only rear tires penetrate, the static position could be a "handstand."

Units

- Use consistent units throughout the model (time, mass, stiffness, damping, and so on).
- Choose units (mass, force, time, and so on) that do not require using very large or very small numbers.
- Be wary when your model contains numbers like 1e+23 or 1e-20.
- Use appropriate units—when modeling large models such as an aircraft landing on a runway, length units of millimeters may not be appropriate. Conversely, when modeling small models such as a power window switch (made up of small moving parts), using length units of meters may not be appropriate.
- Use reasonable time units—high frequencies may be better modeled with time units of milliseconds rather than seconds.

Gravity

- Check magnitude and direction.
- Check for multiple gravity elements.

Debugging Tips

Model verify

- Lists number of moving parts, number of each type of constraint.
- Lists Gruebler's count and actual DOF count.
- Lists redundant constraints.
- Reports misaligned forces/force elements, joints, and so on.
- Helps identify and eliminate causes for input warning (don't ignore).

Model topology

- Text or graphical model topology.
- Table Editor provides spreadsheet-like overview of model content.

Icon feedback

Broken icon in design configuration probably means incorrectly defined joint or force.

Table Editor

Convenient way to inspect and modify models (particularly large ones).

Interactive simulation

By default, is turned on.

Debugging Tips...

Model display update

As ADAMS performs the simulation, you have the option to get immediate graphical feedback of the simulation at every:

- Output step
- Integration step
- Iteration

Icons visible during simulation

This may help you monitor behavior of model components.

Subroutines

- Check for their existence.
- While debugging a model, eliminate user subroutines so that they are not the source of the error.

Gravity

Turning gravity off can accentuate modeling errors and make debugging easier.

Debugging Tips...

Statics

- When applicable, perform an initial static first.
- If static solution fails:
    - Turn on **Model display update = at every iteration** to provide additional insight.
    - Identify and eliminate the undesired static configuration—there could be more than one static configuration and ADAMS could be finding the undesired one.
- Check to see if there are any floating parts.
- Check the signs of applied forces.
- Experiment with Alimit/Tlimit/Maxit/Stability.
- Check if impacts are initially in contact; if not, they should be.
- Running an initial dynamic simulation can help you determine why the model is not finding static equilibrium.

Dynamics

- If integrator fails to **start-up**:
  - Check sign and magnitude of forces.
  - Look at accelerations to understand what is happening.
  - Perform initial static analysis first.
  - Try a quasi-static simulation.
  - Try changing integrator parameter - HINIT.
  - Try a different integrator.
- If integrator fails in the **middle of a simulation**:
  - Look at animation and plots until failure, to understand simulation.
  - Decrease integrator parameter - HMAX.
  - Do not let the integrator step over important events.
  - Short duration events, such as an impulse can be captured by setting the maximum time step, HMAX, to a value less than the impulse width.
  - Use HMAX so ADAMS/Solver acts as a fixed-step integrator
  - Decrease error.
  - Try a different integrator.
- If integrator takes **very small steps**:
  - Look for sudden changes in force and motion input.
  - Rescale model to get more uniform numbers.

Velocities at time=0

Check initial velocities using the .out file.