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Suggested Technique for Constraining a Model in Static Equilibrium

This document is valid for the following Pro/MECHANICA mode:
Independent

Introduction

There are many dynamic systems which require Pro/MECHANICA Motion as well as Pro/MECHANICA Structure for design simulation. A four bar linkage is a simple example where both motion and static analysis can be implemented. Figure 1 illustrates a four bar linkage model.

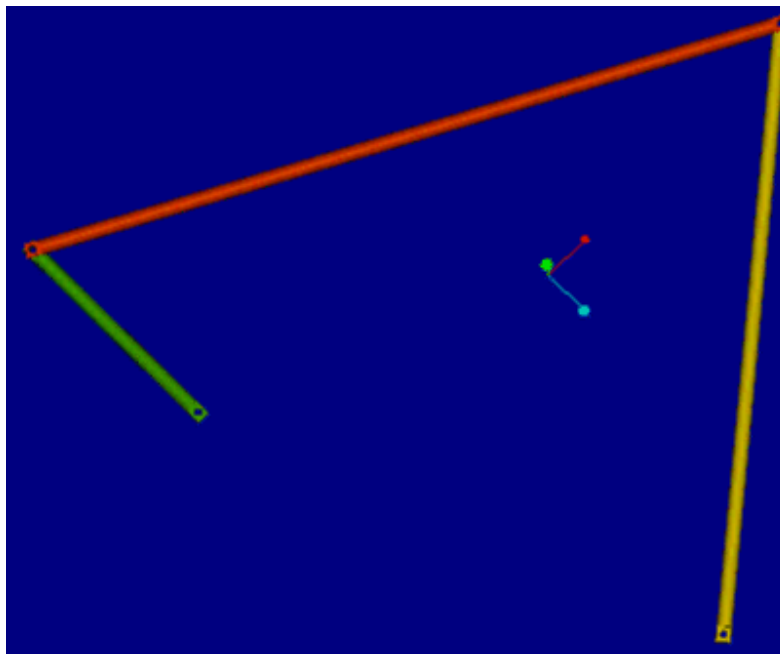


Figure 1

The dynamic forces at any instant in time on the driver arm must be balanced. This is an important principle, known as D'Alembert's principle, which can be derived from Newton's second law. In words, D'Alembert's principle states that "*the reverse effective forces and torques and the external forces and torques on a body together give statical equilibrium*". The challenge is to apply proper constraints in Pro/MECHANICA Structure to analyze the effects of these forces on the driver.

The following is a basic procedure for transferring a model from Motion into Structure and applying constraints for a model in static equilibrium. This suggested technique will make use of the independent Pro/MECHANICA Motion and Pro/MECHANICA Structure packages.

Procedure

1. Transfer the mechanism from Pro/ENGINEER to Pro/MECHANICA Motion and perform an assembly and motion analysis. Figure 2 illustrates the model after being assembled with joints in Pro/MECHANICA Motion.

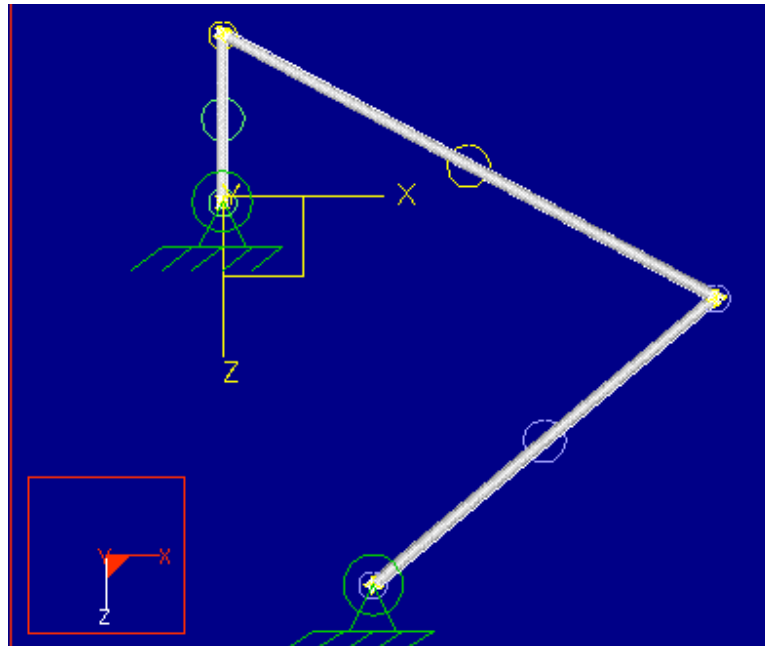


Figure 2

2. After completing a motion analysis, the assembly and loads can be transferred over to Pro/MECHANICA Structure. In this case, the driver is chosen as the current part for the analysis. The driver with the appropriate loads is illustrated in Figure 3.

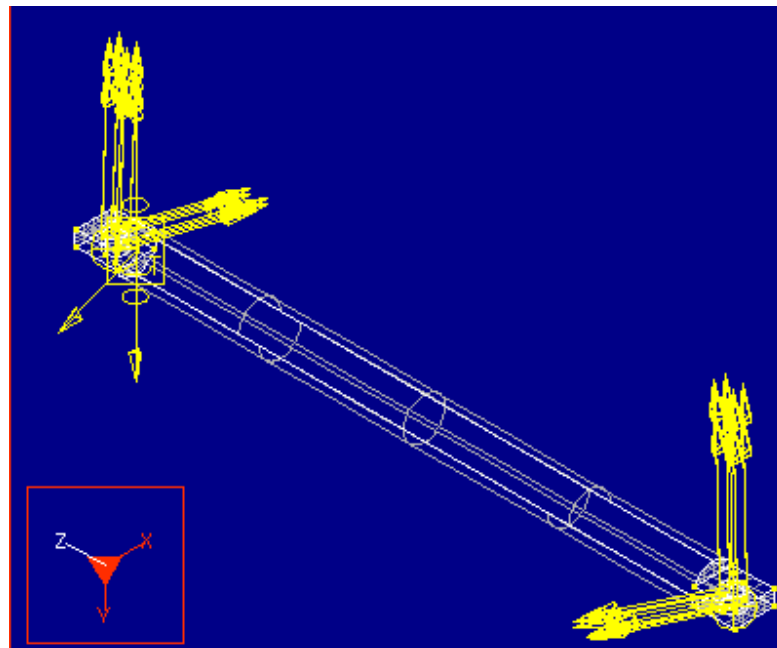


Figure 3

3. To constrain the model choose a plane and constrain a point on that plane in the X, Y, and Z translations. It is beneficial to create a coordinate system on the plane where the pin would pass and constrain it at the origin as illustrated in Figure 4.

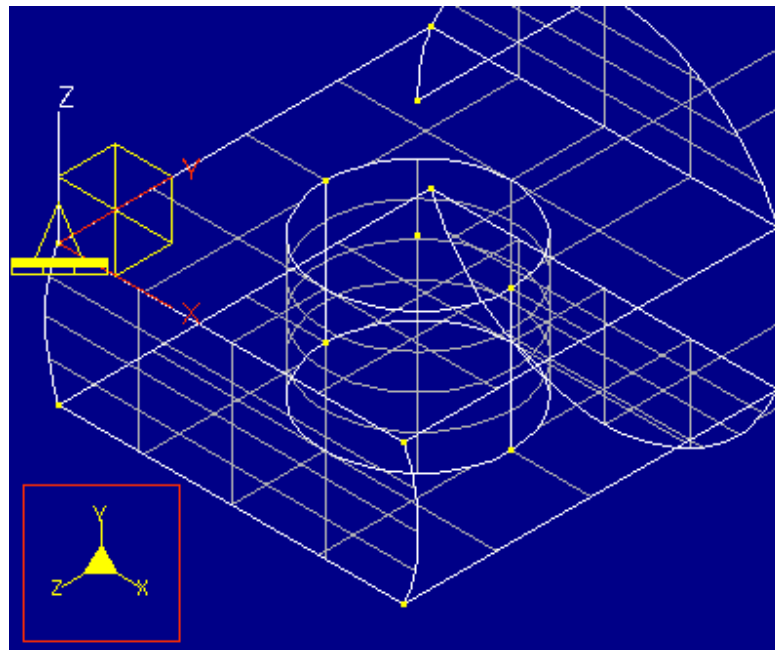


Figure 4

4. Select another point on the plane which lies along an axis and constrain it in all translations except for the component that passes through this axis. This will remove the rotations about the Y and Z axis. Figure 5 illustrates a point chosen, in this case along the X axis.

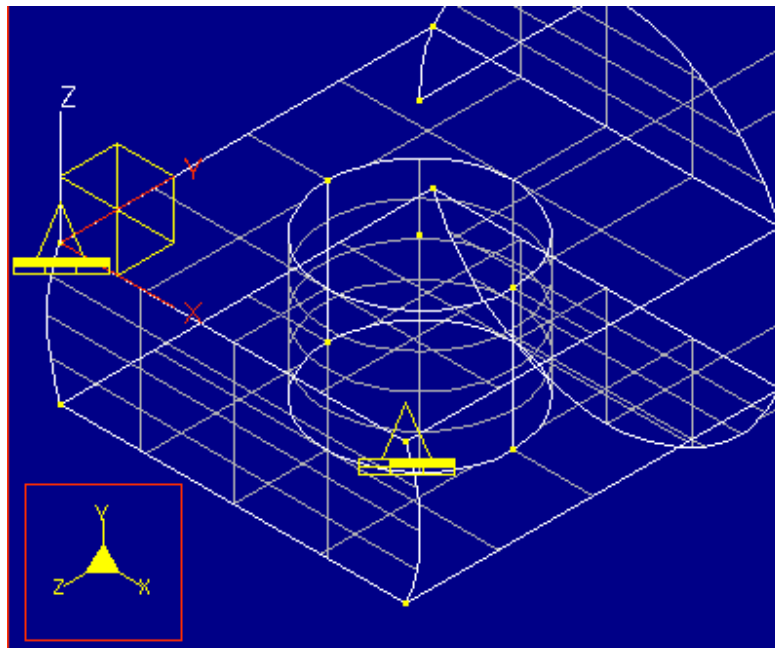


Figure 5

5. Select a third point anywhere on that plane and constrain it in the axis that is perpendicular to it. This is the final constraint needed, as shown in figure 6. This constraint removes the rotation about the X axis.

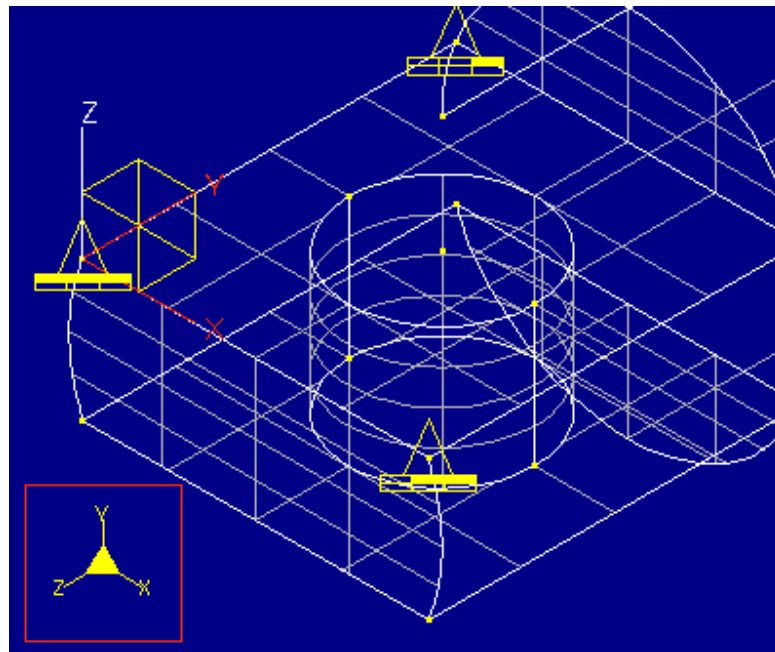


Figure 6

6. Figure 7 shows a portion of the model meshed via AutoGEM. The magenta arrows show the load distribution of the reaction forces that the pin on the ground exerts on the driver linkage.

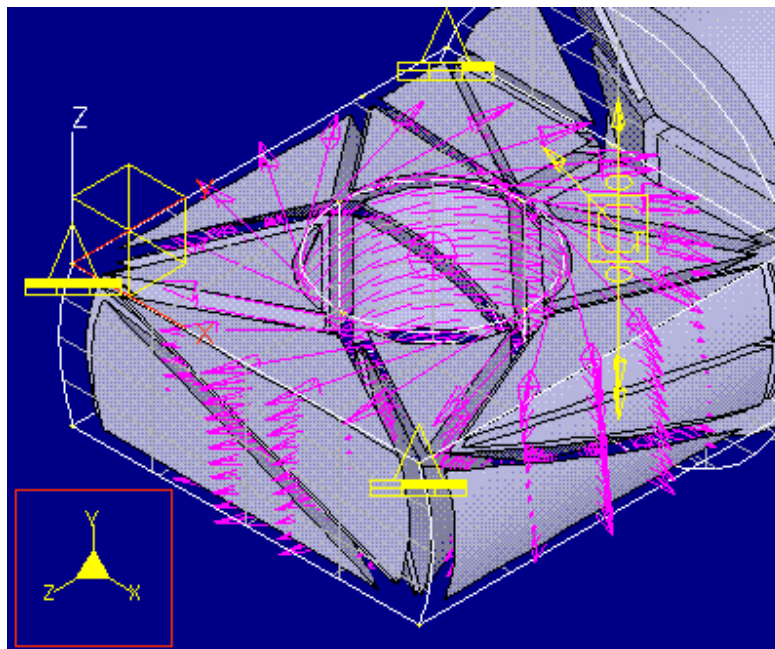


Figure 7

In order to transfer the loads from Motion to Structure select **Model, Loads, MEC/M Load**. Then select the instant in time to transfer the loads from the Motion analysis.

7. Following the same procedure as in the previous (Figure 7) a second set of constraints can be set up at the other end of the driver linkage to be used to verify the results. Figure 8 below has the fully meshed and constrained end with the magenta forces for a ball joint shown.

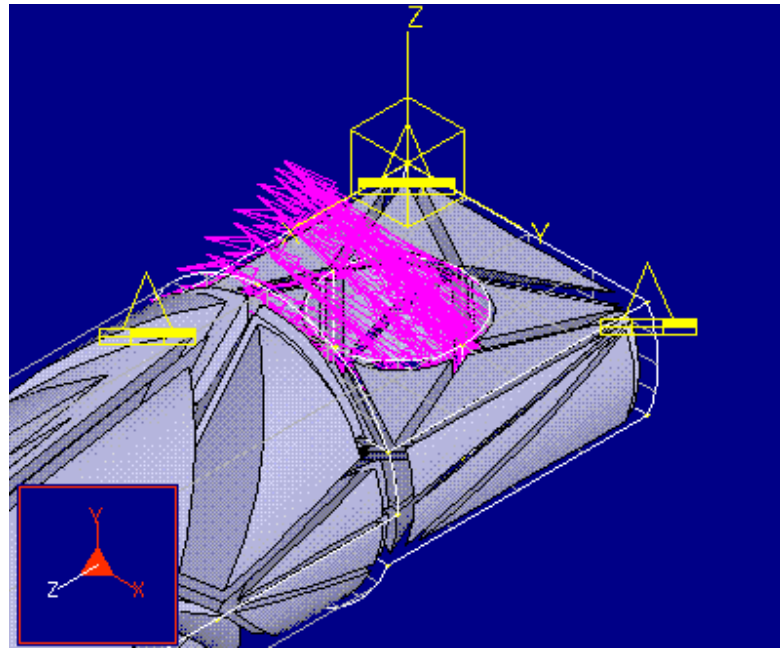


Figure 8

8. Comparing the one static analysis with the first constraint set active (Figure 9) to another static analysis with the second constraint set active (Figure 10) demonstrates that the technique of constraining a free body adds no singularities and that the constraints can be placed anywhere on the model provided they are in one plane.

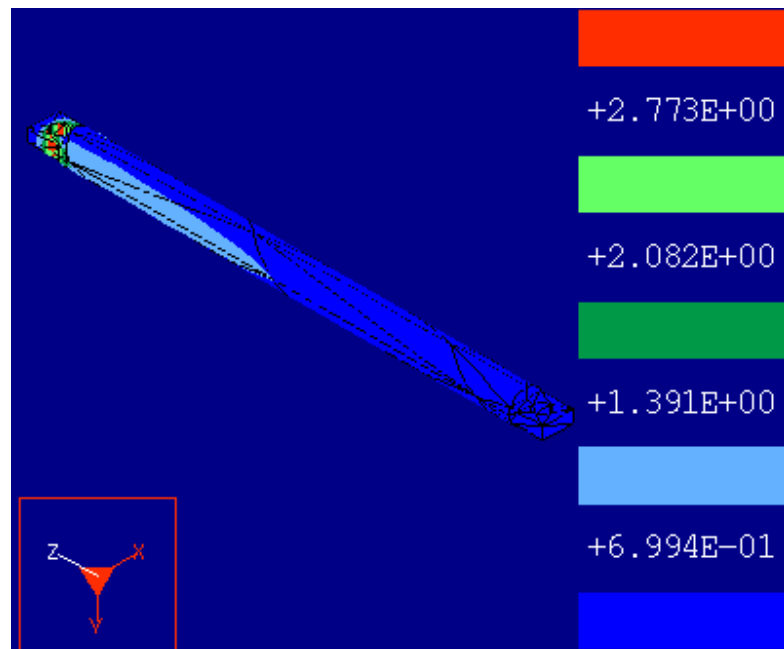


Figure 9

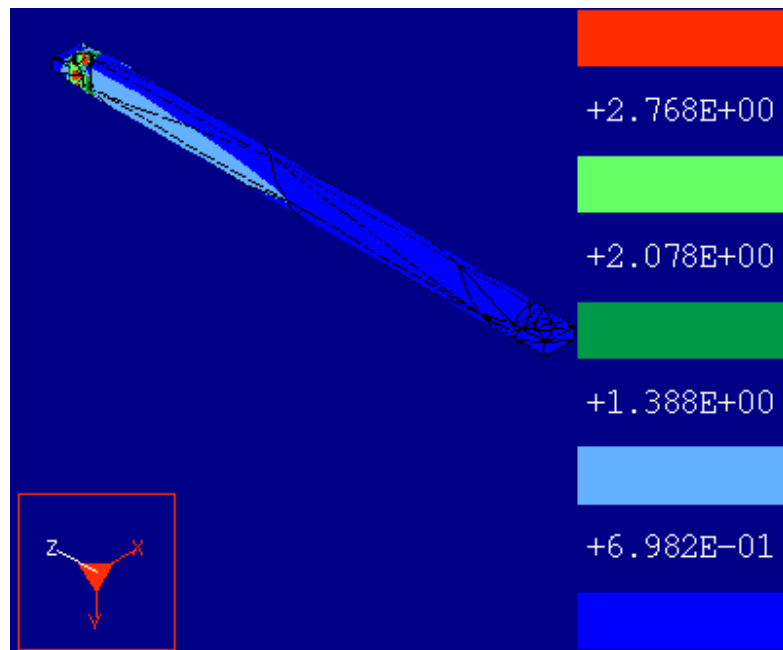


Figure 10