Mechanism analyses

MEC-E1060

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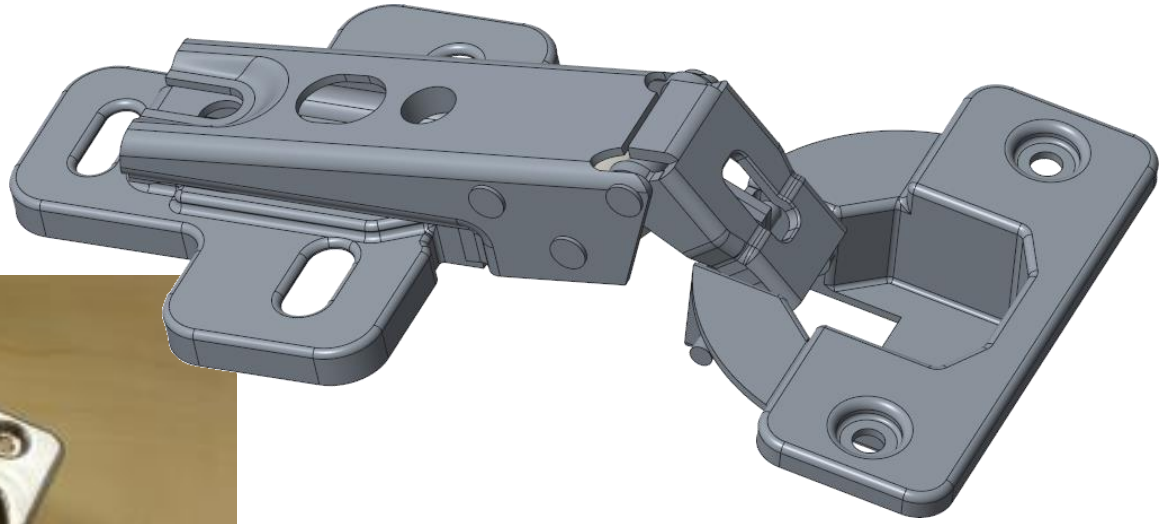
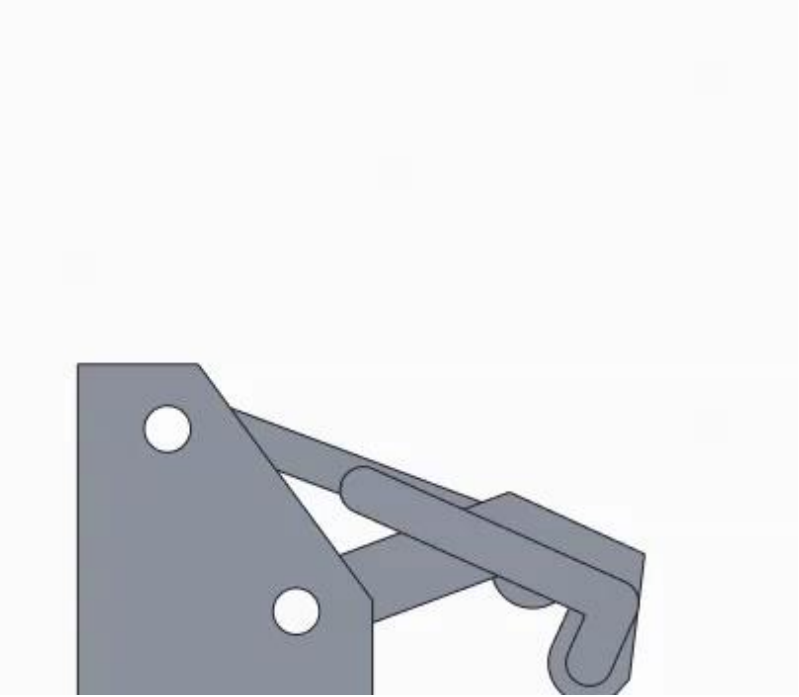
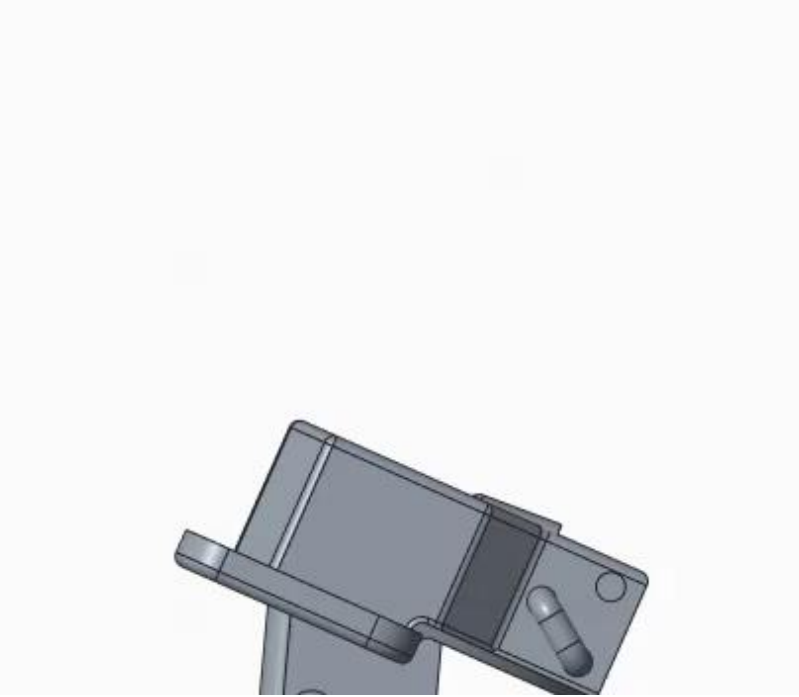
14.9.2020

Real Mechanism and Detailed Model



Simplified and Detailed Model



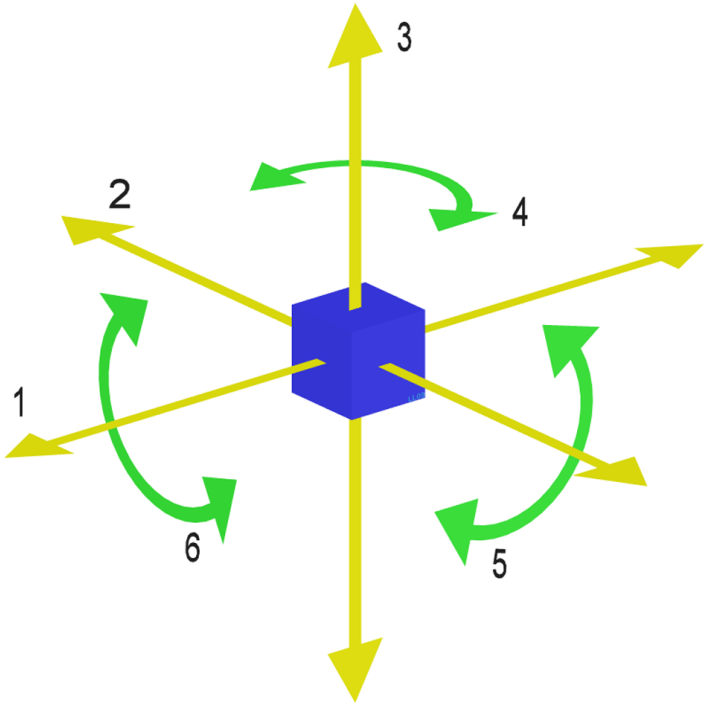


Degrees of Freedoms

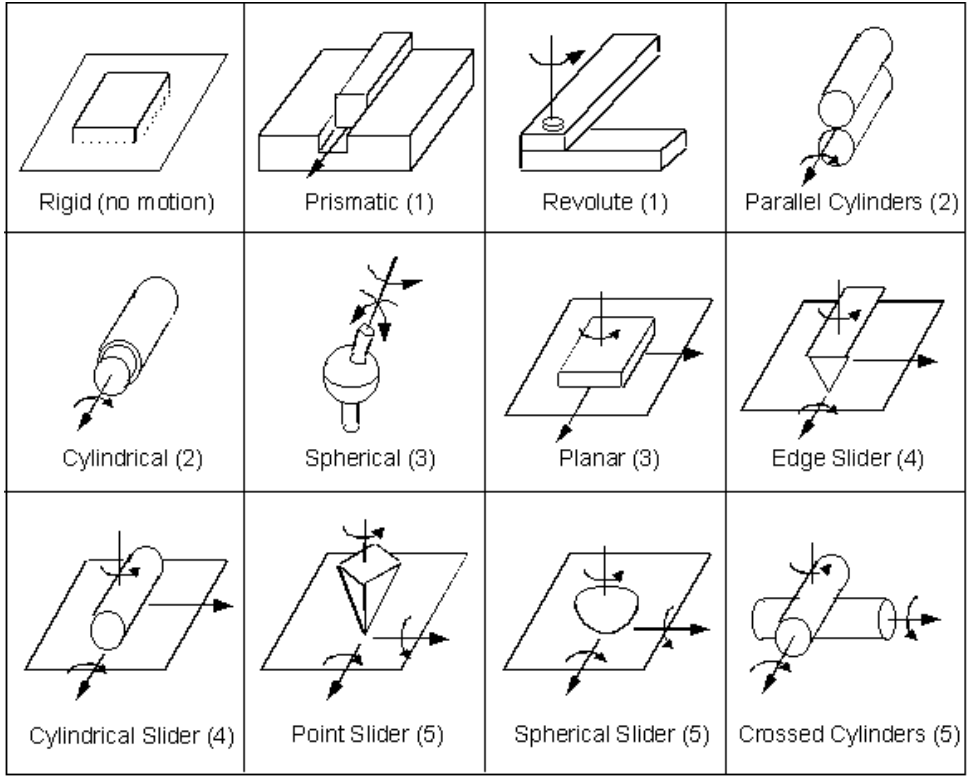
DoFs

Object in 3D world

- 3 translations
- 3 rotations



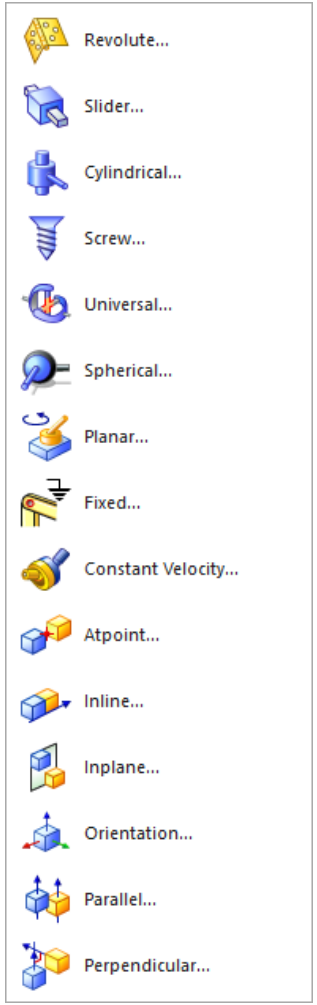
Joints


Rigid (no motion)
Prismatic (1)
Revolute (1)
Parallel Cylinders (2)
Cylindrical (2)
Spherical (3)
Planar (3)
Edge Slider (4)
Cylindrical Slider (4)
Point Slider (5)
Spherical Slider (5)
Crossed Cylinders (5)

Joints in NX Motion

Low kinematic pairs are recommended

Symbol in NX	Name of the joint	Amount of DoFs	Description	Joint level
	Revolute (hinget joint)	1 rotation	Rotation around its axis. "A door hinge."	1
	Slider (prismatic joint)	1 translation	Moves along its axis.	1
	Cylindrical	1 rotation and 1 translation	Can both rotate and move along its axis. "A hydraulic piston".	2
	Screw	1 rotation or 1 translation	Can rotate or move along its axis.	1
	Spherical (ball joint)	3 rotations	Fixes joint location but allows all rotations. "A ball inside a ball."	3
	Planar	1 rotation and 2 translations	Can slide and rotate along its attachment plane. "A coffecup on a table."	3



Mobility of the Mechanism

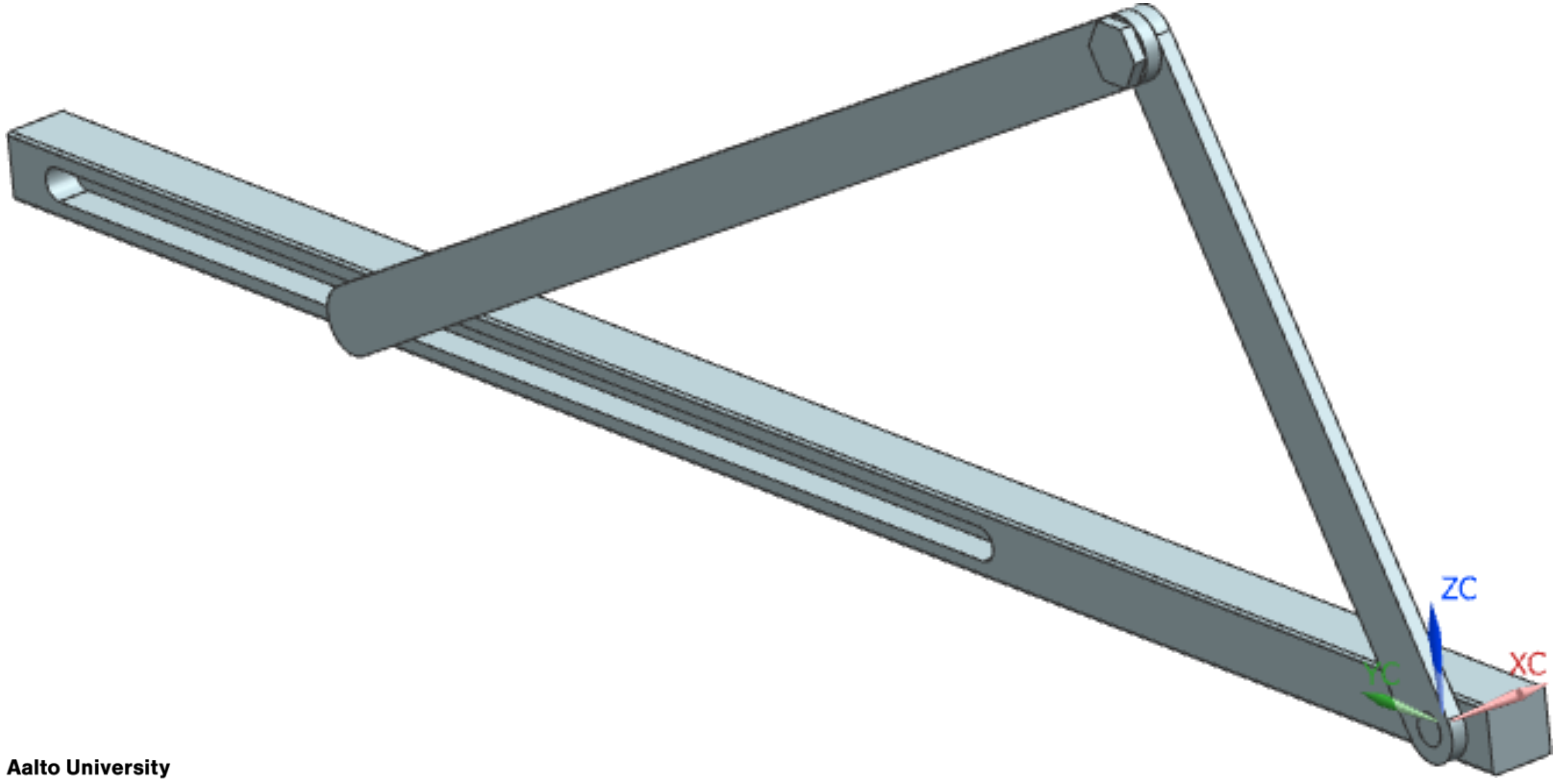
General case

Can be calculated using Kutzbach criteria

$$M = 6 \times (n - 1) - 5 \times j_1 - 4 \times j_2 - 3 \times j_3 - 2 \times j_4 - 1 \times j_5$$

- Where n is the amount of members
- j_N is the amount of N DoF joints

Example: Crank-Slider Mechanism



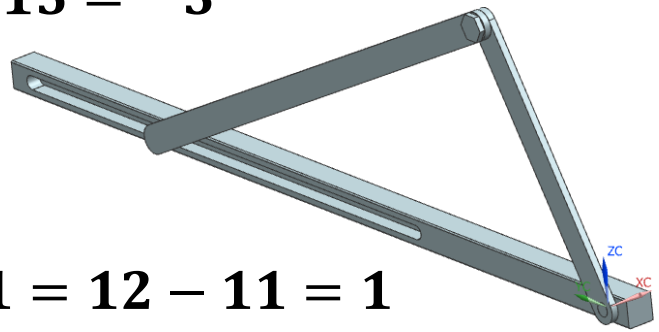
Example: Crank-Slider Mechanism

$$M = 6 \times (n - 1) - 5 \times j_1 - 4 \times j_2 - 3 \times j_3 - 2 \times j_4 - 1 \times j_5$$

If two revolute (j_1) and one prismatic (j_1) joints

$$M = 6 \times (3 - 1) - 5 \times 3 = 12 - 15 = -3$$

- → Over-constrained mechanism



If one revolute, one cylindrical (j_2) and one edge slider (j_4)

$$M = 6 \times (3 - 1) - 5 \times 1 - 4 \times 1 - 2 \times 1 = 12 - 11 = 1$$

- → One degree-of-freedom mechanism

Mechanism Analyses

MBS Model Process

NX Assembly to place parts

NX Motion

- to create joints and define links (moving bodies)
- to define the input to the model (driver)
- to create gears, belts, external forces etc.
- to plot results, or export to MS Excel
- to create animations

Motion Navigator

Original assembly

Simulation element

Links (usually parts from assembly)

- Ground as fixed

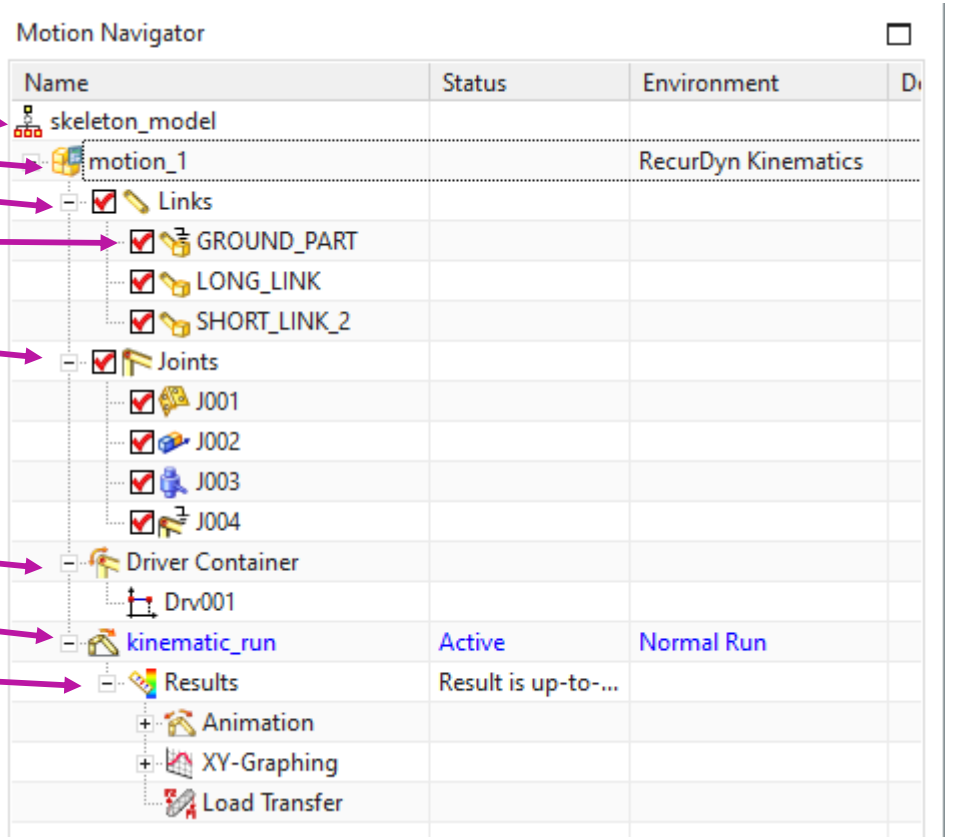
Joints

- Revolute (1 DOF)
- Inline (4 DOFs, edge slider)
- Cylindrical (2 DOFs)
- Fixed (0 DOF, ground part)

Drivers (forced movement)

Solution (simulation run)

Results



Kinematic simulation

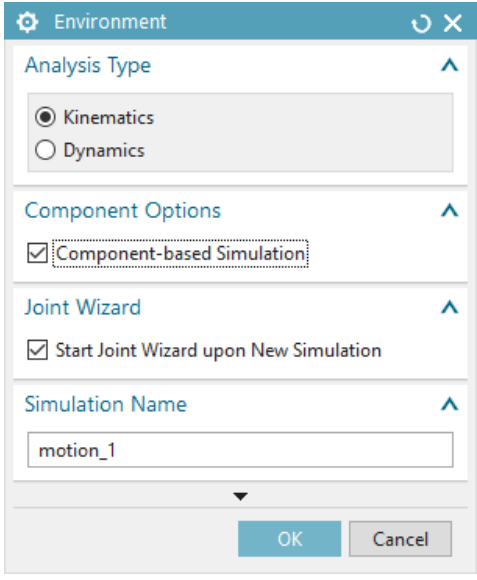
Calculates the movement of the joints

Needs to have 0 DOF

- 1 DOF mechanism and one Driver (forced movement)

No need for geometries

- Skeleton model is enough



Dynamic simulation

Additional to kinematic simulation, calculates forces

Each link (body) needs to have geometry

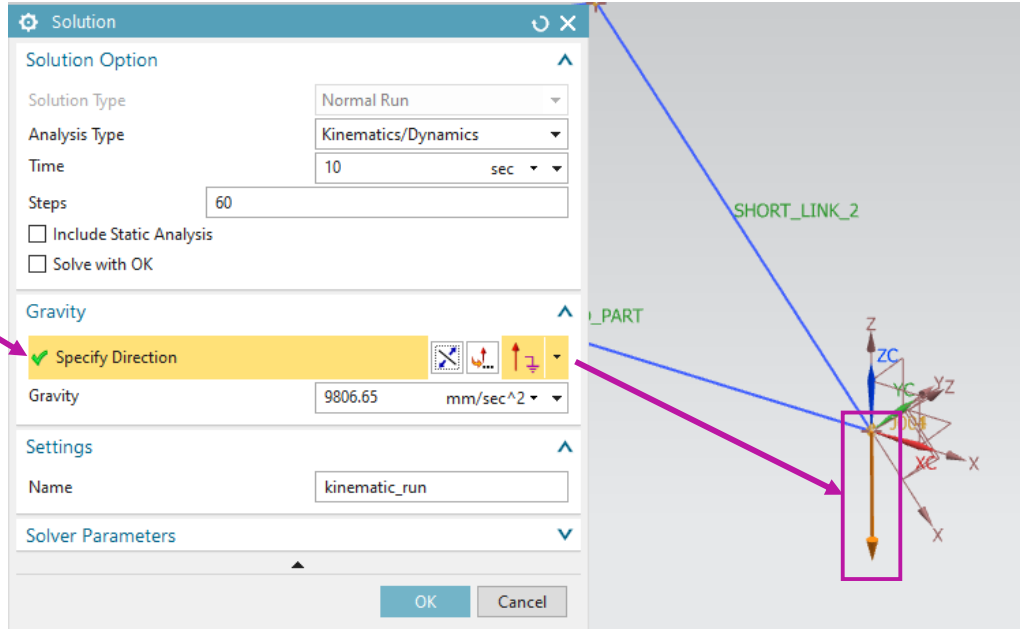
- Weight and Center of mass

Gravity is included by default

- Check direction!

Can have DOF >= 0

- Zero is recommended for this course



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