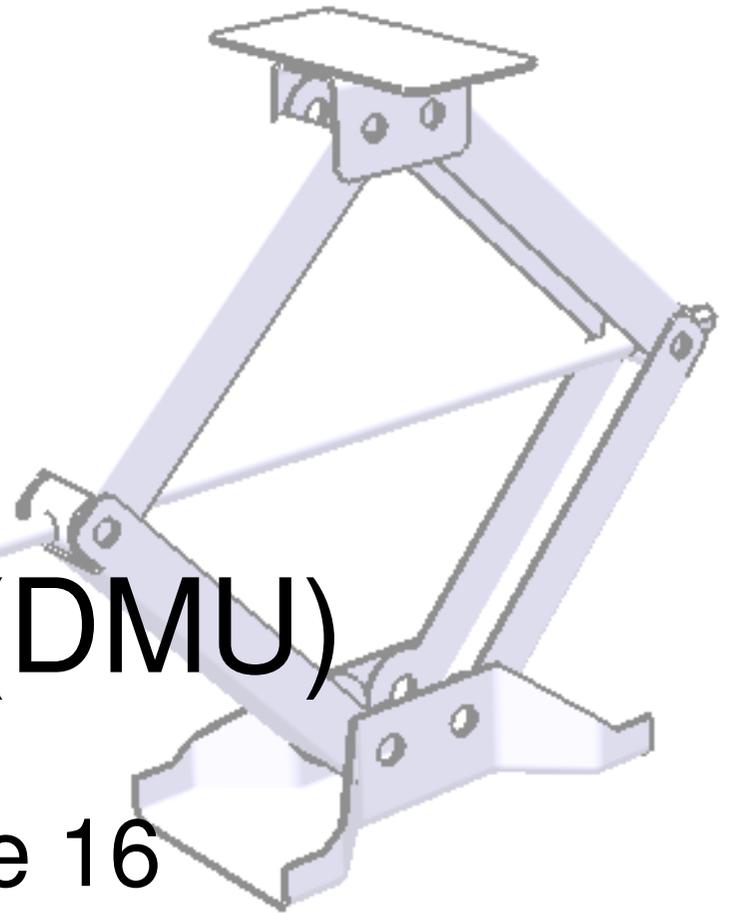
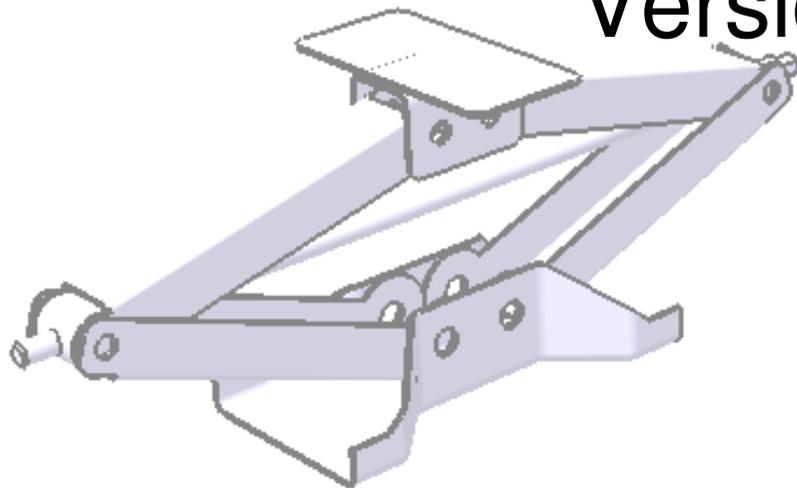


CATIA V5 Digital Mockup (DMU)

Version 5 Release 16

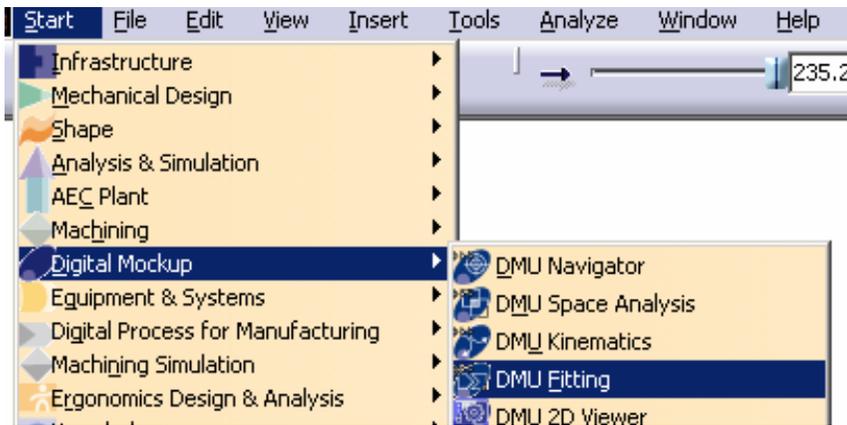


DMU Fitting

DMU Kinematics

DMU Fitting

Simulate part motions for assembly and maintainability issues



Toolbars



- A. **DMU Simulation:** Key tools for DMU Fitting
- B. **DMU Check:** Measure Interference, distance, detect Clash while moving
- C. **Manipulation:** Manipulate model or Compass while creating a track
- D. **Recorder:** Record or modify the track
- E. **Player:** Play the track

General Process

Open an Assembly Document



Create a Track



Move a Component



Record the Track



Repeat creating tracks for other components



Create a Sequence of Tracks



Create a Simulation



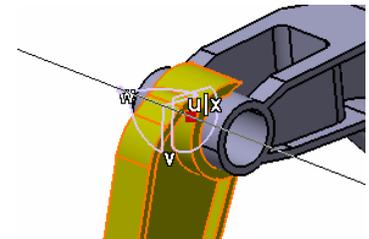
Analyze the results and modify the design if necessary

Using DMU Manipulation Toolbar to change the position of the Compass:-

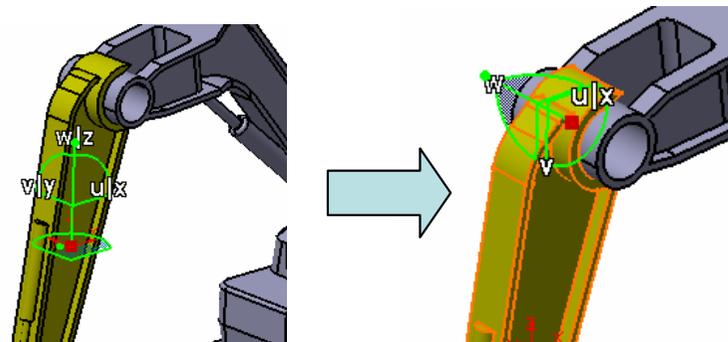
- 1) "Detach" the Compass from the selected Part (it will be gray)



- 2) "Snap" the Compass onto a new position



- 3) "Attach" the Compass again (it will be Green)



Detect Clashes automatically during the part movement:-

Three modes are available:

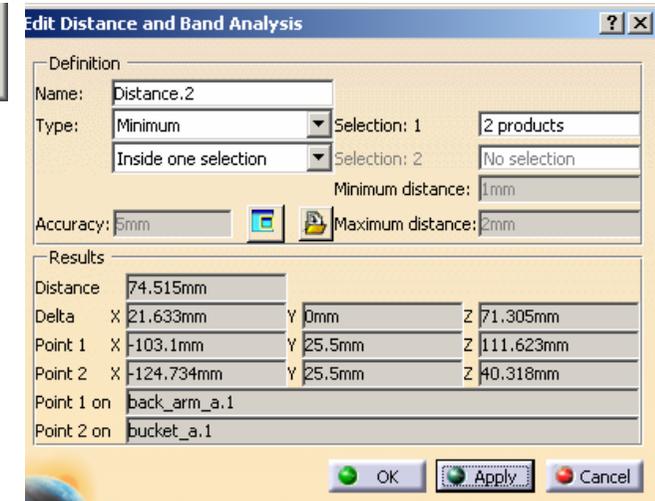
- (1) **On** (default mode), which deactivates clash detection
- (2) **Off**, which highlights in the geometry area products in collision while playing a simulation
- (3) **Stop**, which stops the simulation when the first clash is detected.



On/ Off/ Stop

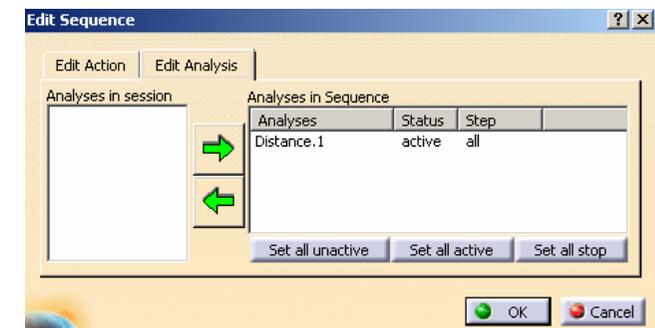
Measure distances AFTER a simulation:-

- Click "Distance" icon
- Select two components
- Click "Apply" to get the minimum distance



Measure distances DURING a simulation:-

- After "Distance.1" is created, double-click "Sequence.1" on the tree
- Select the Tab Page " Edit Analysis"
- Put "Distance.1" on the list called "Analyses in Sequence"
- Set it Active



Exercise 1

(1) File Open:-

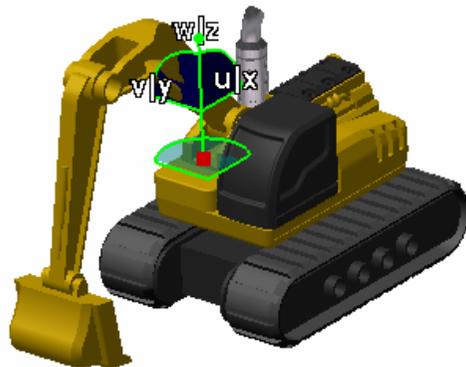
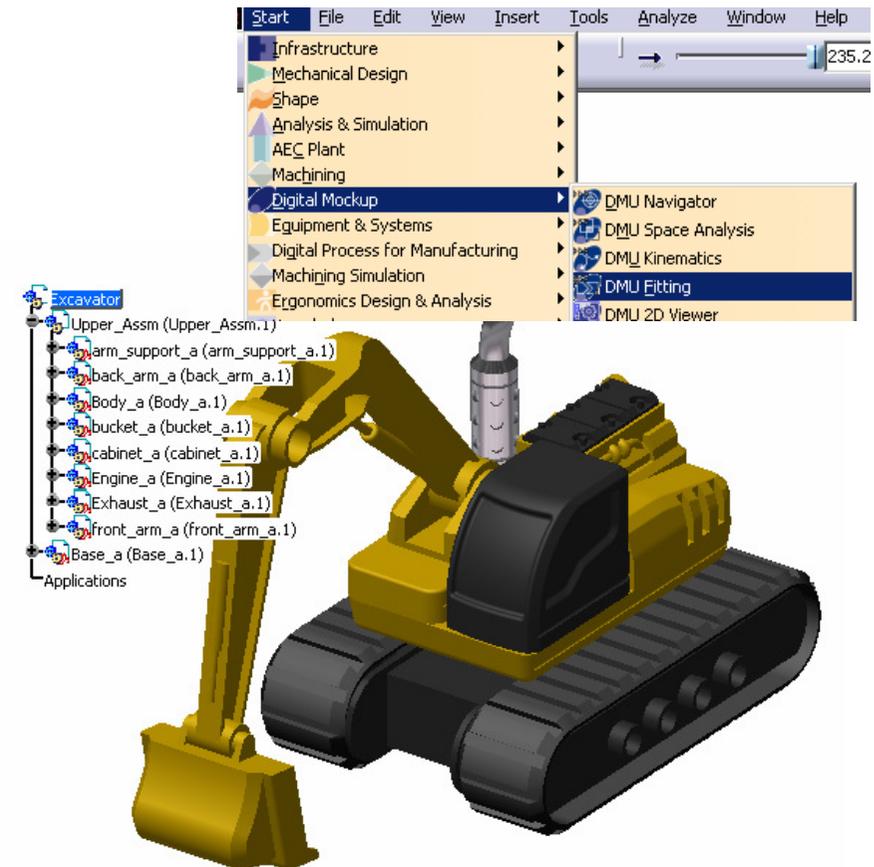
- File/Open/Excavator_a.CATProduct

(2) Change workbench to DMU Fitting:-

- If the current workbench is not “DMU Fitting”, select “**Start/Digital Mockup/ DMU fitting**” on the top menu to change. (otherwise, it needn't change)

(3) Make the 1st Film:-

- Click “**Track**” icon
- Select Upper_Assm(Upper_Assm.1) on tree
- (The Compass will be snapped onto the assembly and it will turn GREEN)

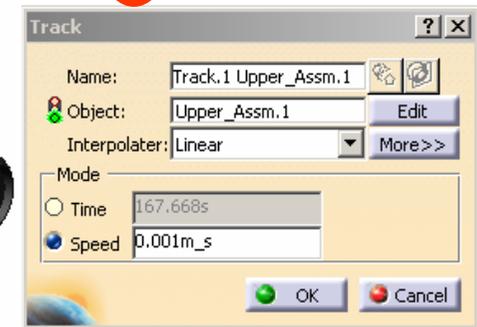
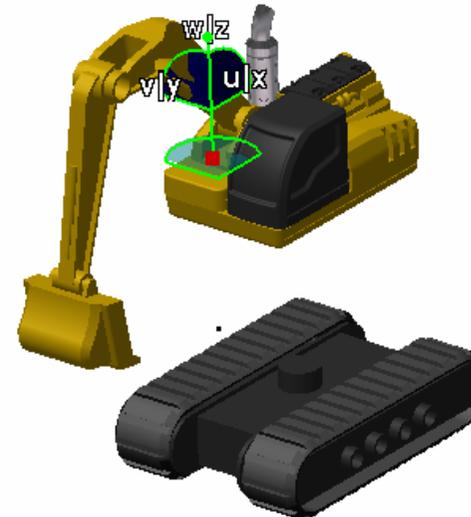


A- 5

Exercise 1

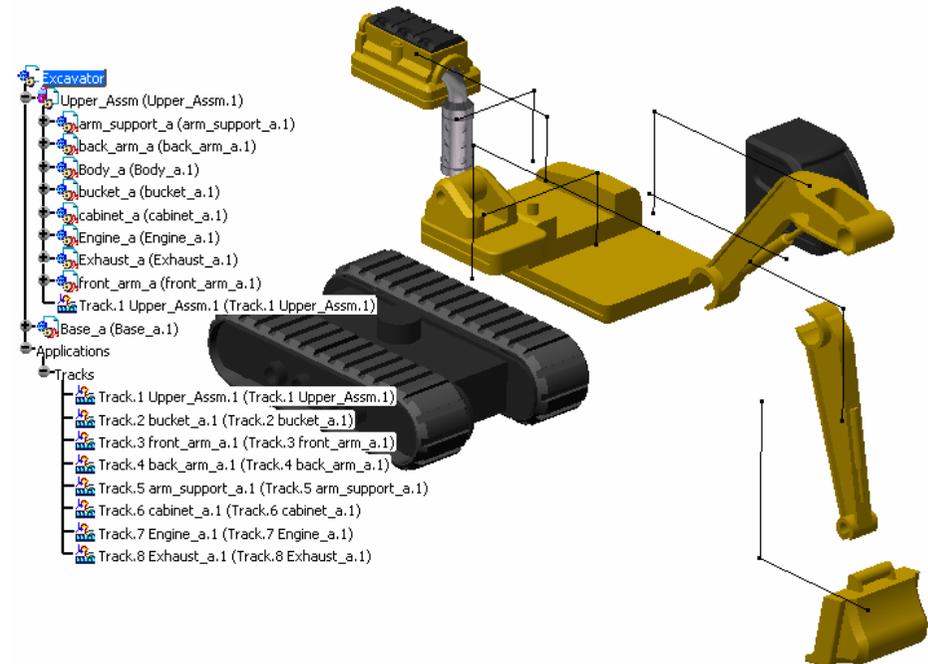
(3) Cont' :-

- Drag the upper assembly out by Compass
- Then Click “Record(Insert)” icon to record the new position
- Drag the assembly to another position
- Click “Record(Insert)” icon again
- Click ok complete



(4) Repeat Step 3 to make the remaining Films for the below components:-

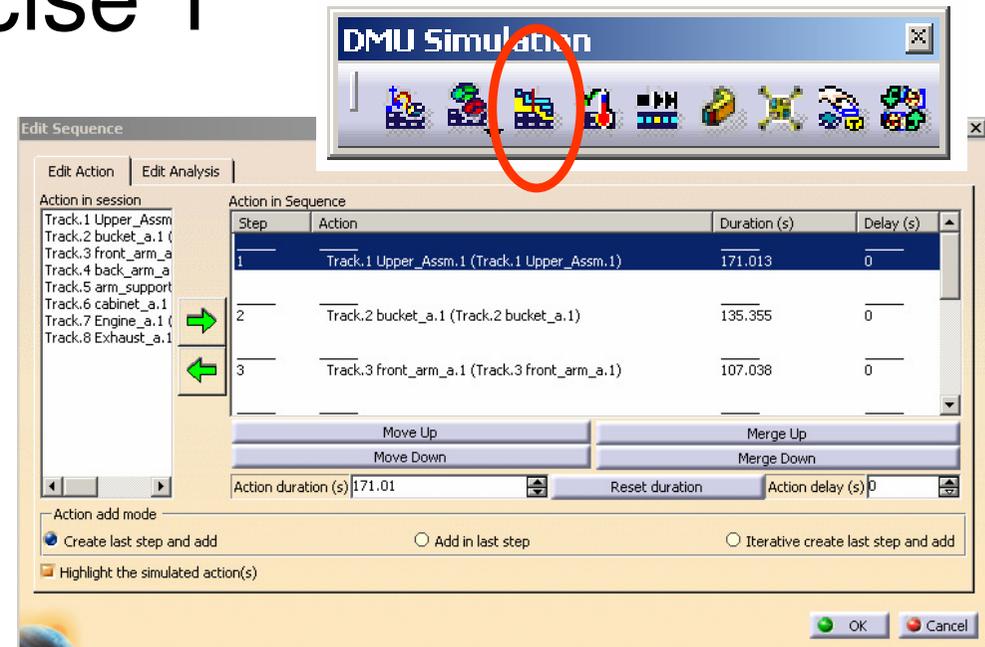
- Bucket
- Front_Arm
- Back_Arm
- Arm_Support
- Cabinet
- Engine
- Exhaust



Exercise 1

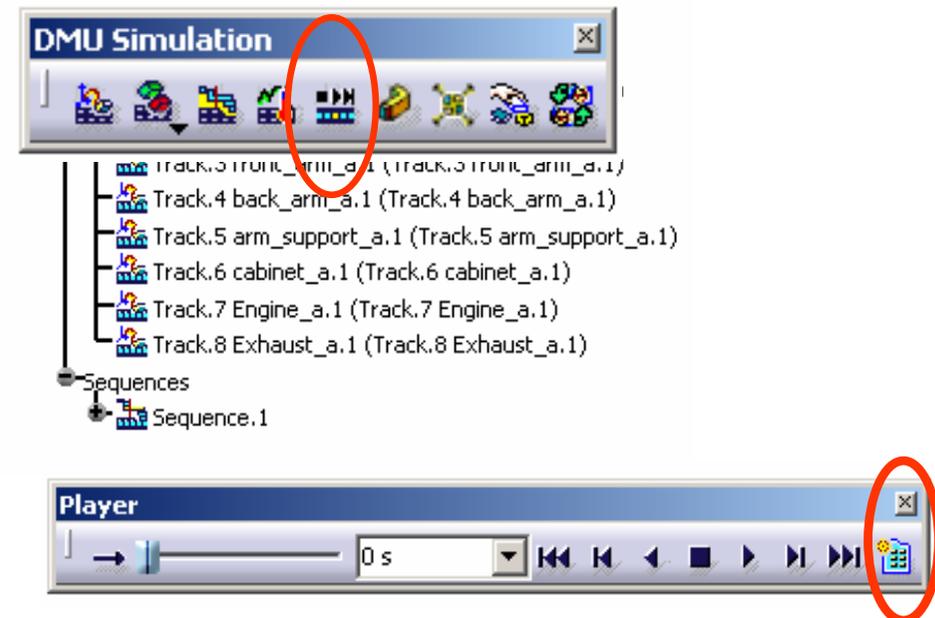
(5) Create a Play Sequence of the films:-

- Click “**Edit Sequence**” icon
- Select Track.1 under the list of “Action in session”
- Click 
- Select Track.2, then 
- ...Repeat the steps until all Tracks are inserted



(6) Play the Sequence of films:-

- Click “**Simulation Player**” icon
- Select Sequence.1
- (The Player is activated on top of the screen)
- Click “**Parameters**” icon
- Enter 5s as Sampling Step (Run the simulation faster)
- Click 



Exercise 1

(6) Cont' :-

- Click “**Change Loop Mode**” icon to run the simulation continuously
- Click “**Stop**” icon to stop
- Click “**Simulation Player**” icon again to exit

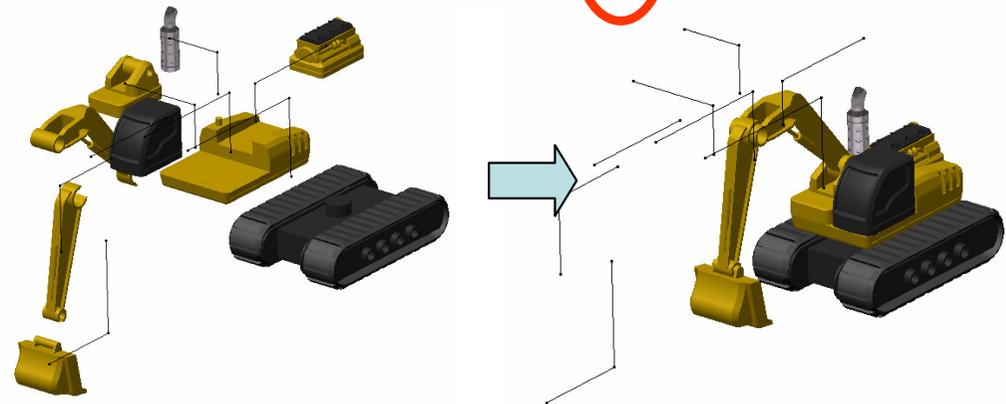


Change Loop Mode

Stop

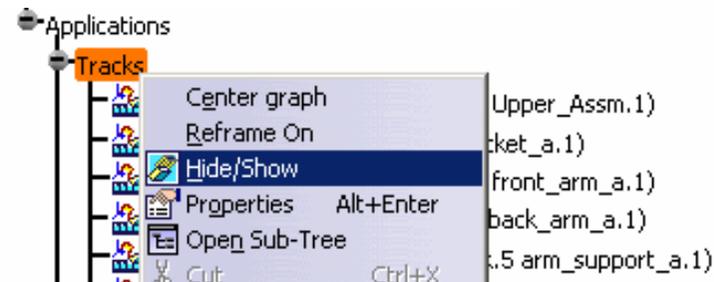
(7) Reset the positions:-

- Click “**Reset Position**” icon
- (all components will be back to their original positions)



(8) Hide all Track Lines on screen:-

- Right-Click “Tracks” on the tree
- Select “Hide/Show”

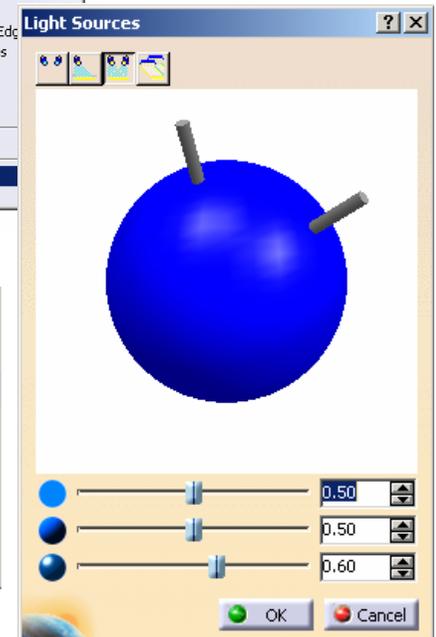
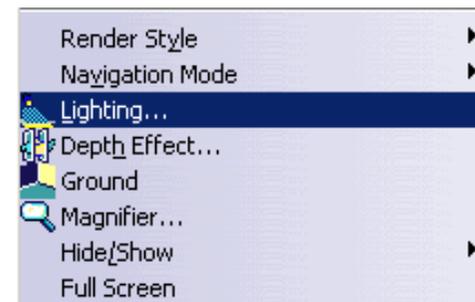
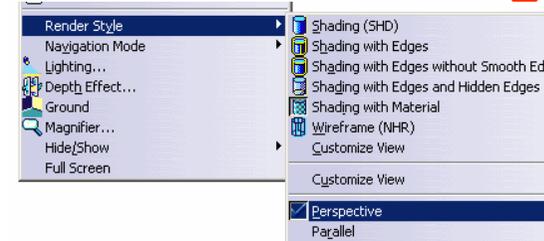
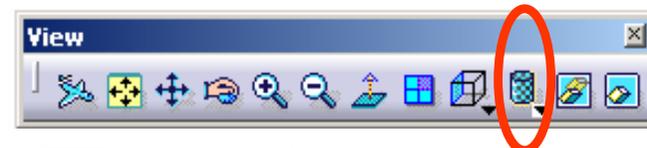
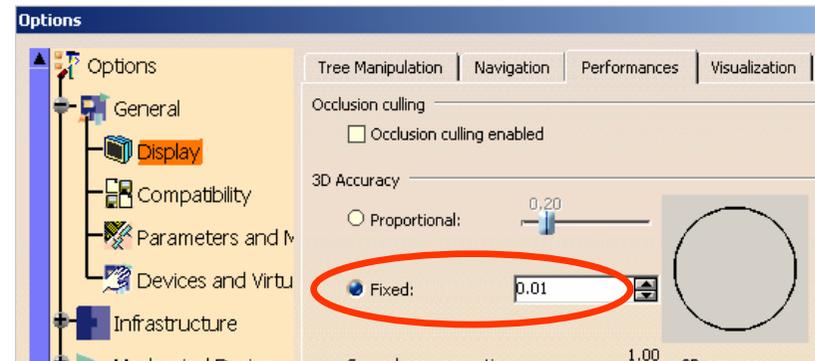


A- 8

Exercise 1

(9) Refine Environment Settings (optional):-

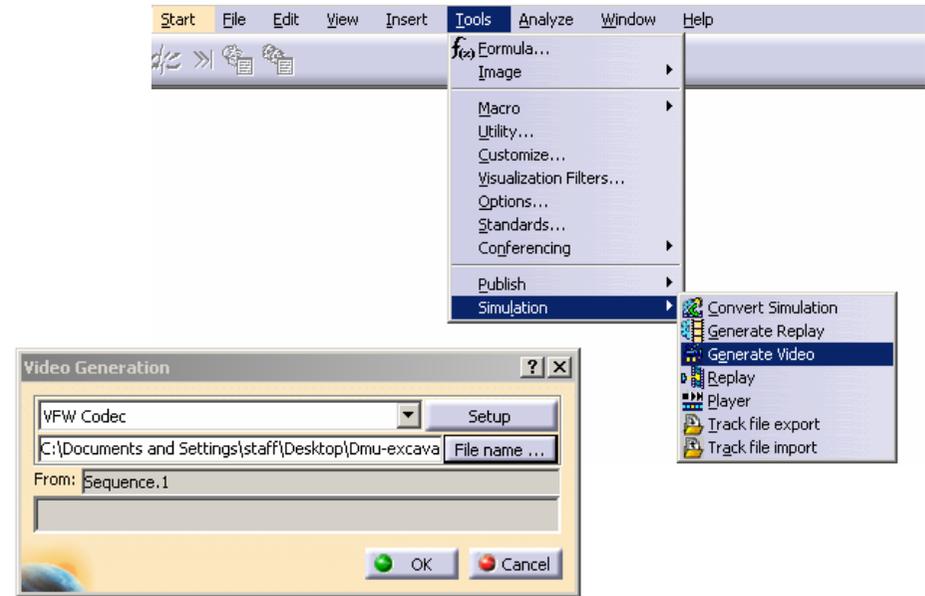
- To improve the resolution, select **“Tools/options.../General/Display/Performances/3D Accuracy/Fixed”** on the top menu and change it to 0.01 (smallest value)
- Change the shading mode to **“Shading with Material”**
- Select **“View/Render Style/Perspective”** on the menu
- Select **“View/ Lighting...”** and then select **“Two Lights”**
- To Hide Compass, Deselect **“View/ Compass”** on the top menu
- To Hide Tree, Deselect **“View/ Specifications”** on the top menu



Exercise 1

(10) Export Simulation into AVI format

- Click “**Tools/Simulation/Generate Video**” on the top menu
- Select Sequence.1 on tree
- Select “**VFW Codec**” as default
- Click “**Setup**” button and select “**Cinepak Codec by Radius**” as Compressor
- Click “**File name...**” to define the destination of the exported file and the file name
- Click ok to complete

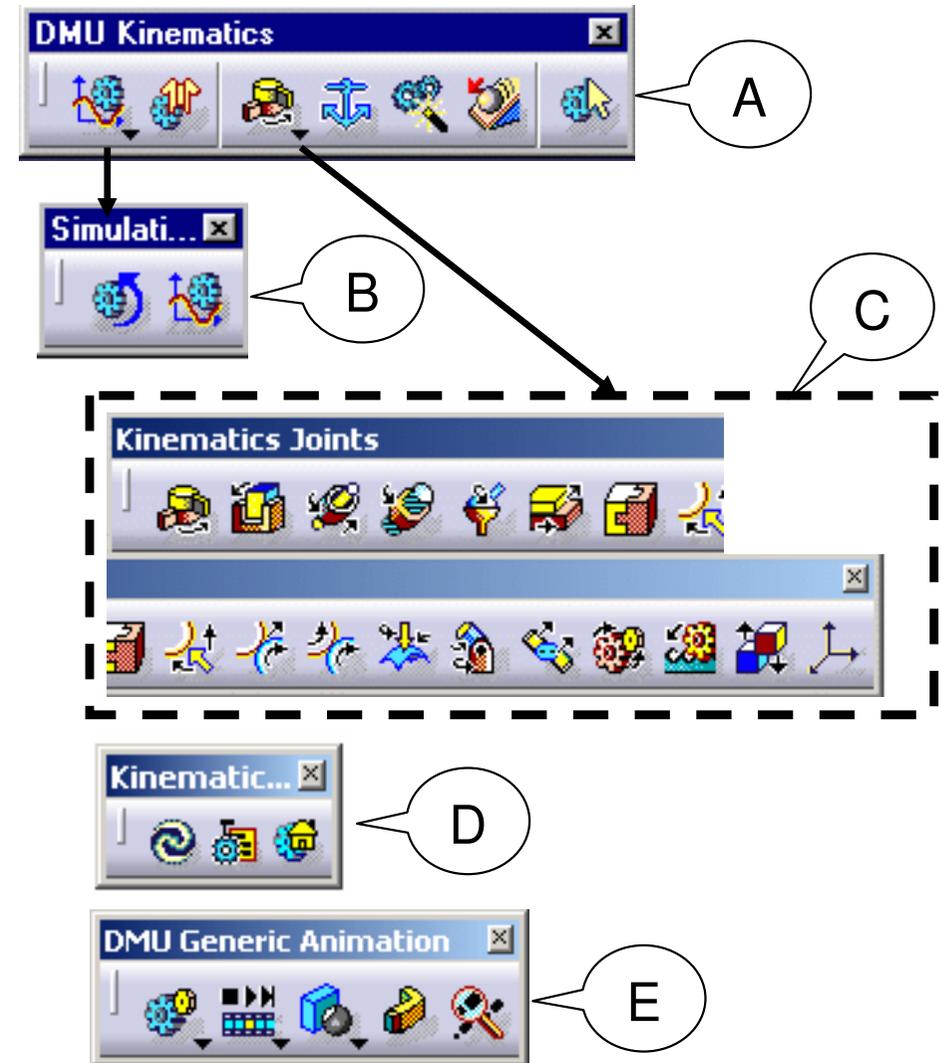
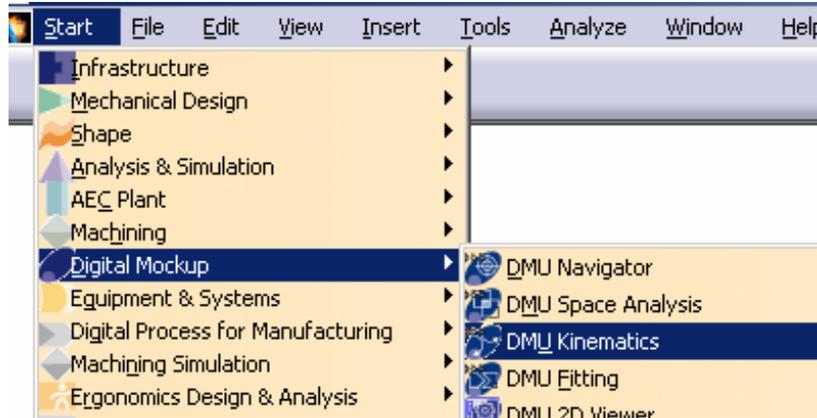


(Remark: During the conversion, we can manipulate the geometry by mouse)

END of Exercise 1

DMU Kinematics

Simulate the mechanism of an assembly



- A. DMU Kinematics:** Key tools for DMU Kinematics
- B. Simulation:** Make Simulation with commands
- C. Kinematics Joints:** Create Joints between components
- D. Kinematics Update:** Restore or Update positions of components
- E. DMU Generic Animation:** Record or Export Simulation into other format

General Process

Open an Assembly Document



Delete all Constraints & Create Joints manually

-Or-



Convert Constraints into Mechanism



Browse the Mechanism with Commands



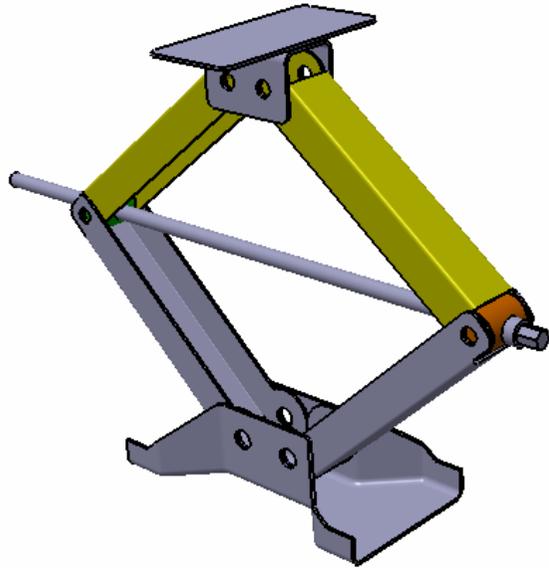
Create a Simulation



Analyze the results and modify the design if necessary

JOINT TYPE	DEGREES OF FREEDOM	COMMAND TYPE	DIRECT MANIPULATION	
Revolute 	1 Rotation	Angle	YES / Left-mouse button	
Prismatic 	1 Translation	Length	YES / Left-mouse button	
Cylindrical 	1 Rotation 1 Translation	Length + Angle	Length: Left-mouse button	Angle: Left-Mouse button + Middle-Mouse button
		AND/OR		
		Angle or Length	YES / Left-mouse button	
Spherical 	3 Rotations	–	NO	
Planar 	2 Translations 1 Rotation	–	NO	
Rigid 	–	–	NO	
Roll Curve 	1 Rotation 1 Translation	Length	NO	
Slide Curve 	2 Rotations 1 Translation	–	NO	
Point Curve 	3 Rotations 1 Translation	Length	NO	
Point Surface 	2 Translations 3 Rotations	–	NO	
U Joint 	1 Rotation	–	NO	
Gear joint 	1 Rotation	Angle1 or Angle2 (exclusive)	YES / Left-mouse button	
Rack Joint 	1 Rotation or 1 Translation	Length1 or Angle2 (exclusive)	YES / Left-mouse button	
Cable Joint 	1 Translation	Length1 or Length2	YES / Left-mouse button	
Screw Joint 	1 Rotation or 1 Translation	Angle or Length (exclusive)	YES / Left-mouse button	
CV Joint 	–	–	NO	

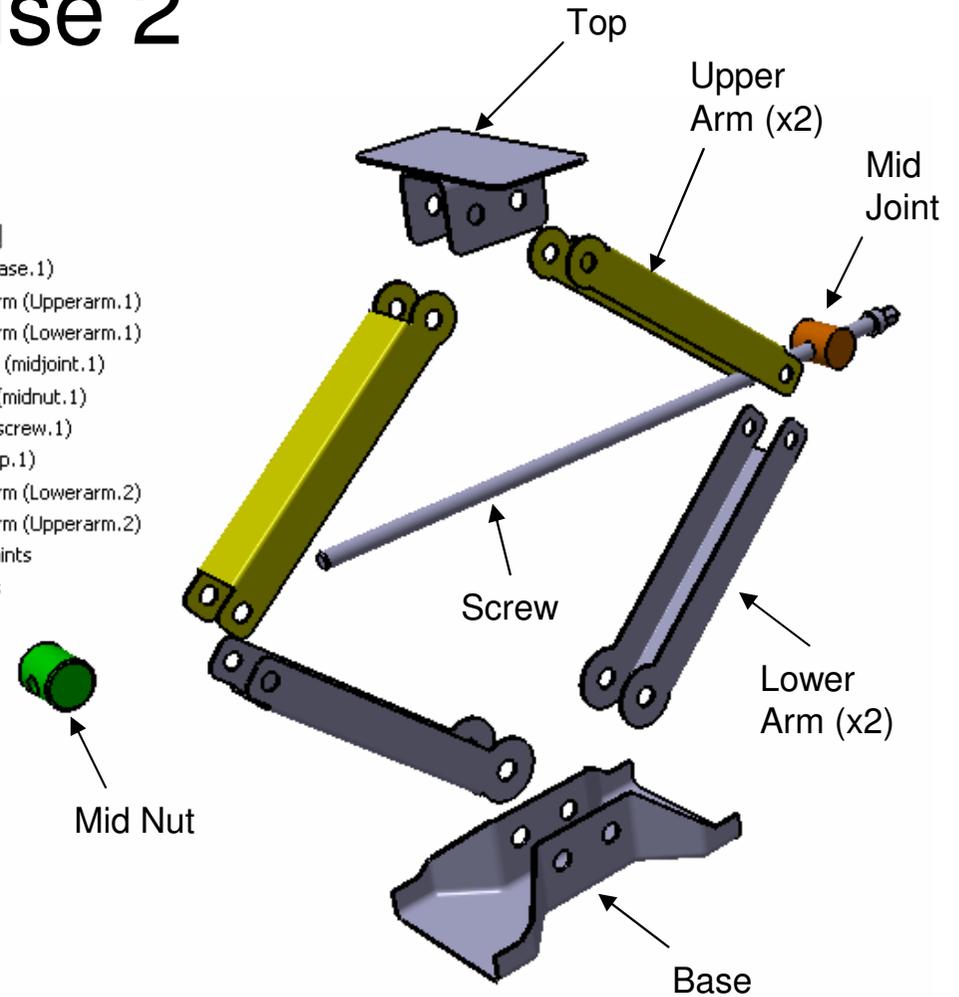
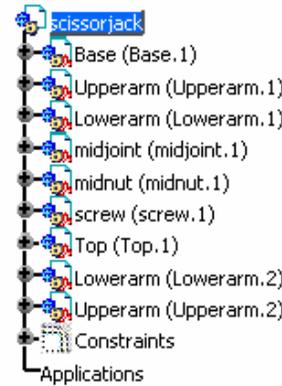
Exercise 2



Scissor Jack

- Create Kinematic Joints
- Simulate the mechanism with command
- Study the mechanism behavior (Displacement and Speed)

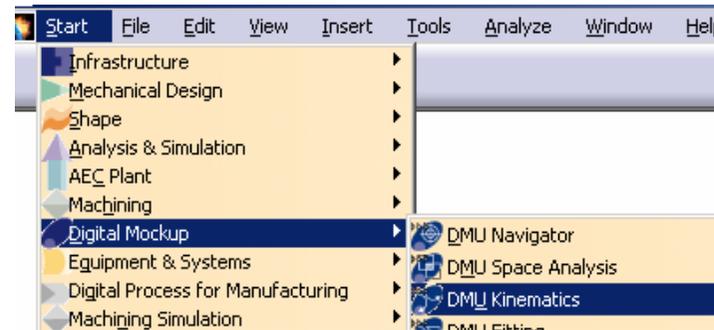
- (1) File/Open/
Scissorjack_a.CATProduct



Exercise 2

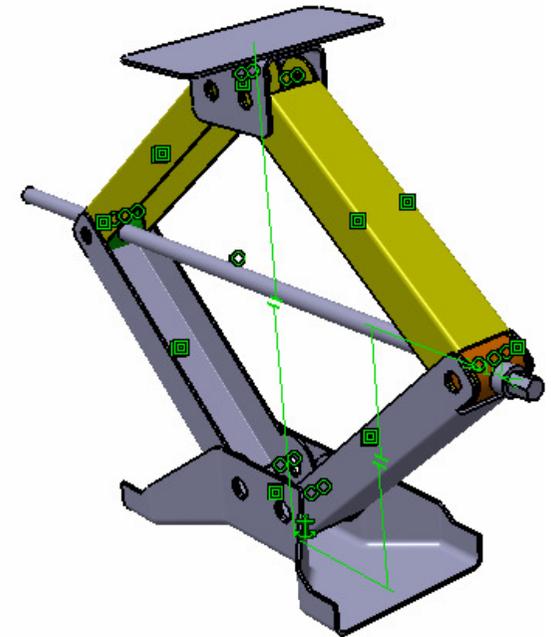
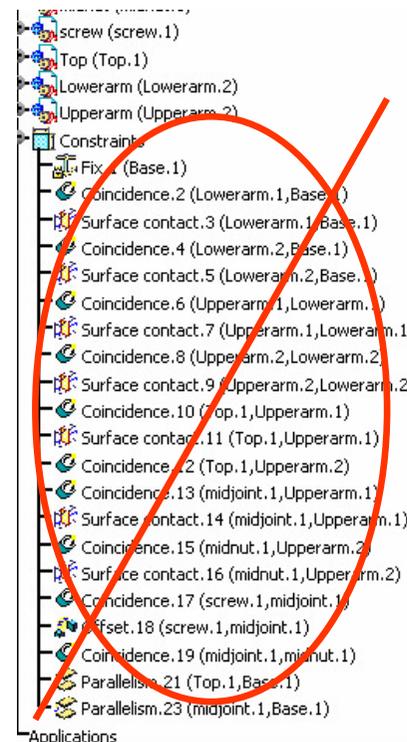
(2) Change workbench to DMU kinematics:-

- If the current workbench is not “DMU kinematics”, select “**Start/Digital Mockup/DMU kinematics**” on the top menu to change. (otherwise, it needn't change)



(3) Delete all Constraints:-

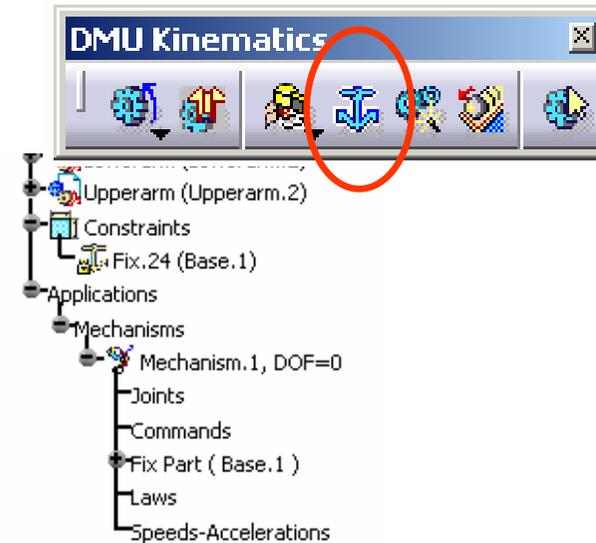
- Right-Click on “**Constraints**” on the product tree and then select “Delete”
- (We are going to create kinematic joints manually. Once a joint is created between two parts, the corresponding constraints will be made automatically between them. To prevent redundancy, we need to delete all the constraints, which were made on the “Assembly Design” workbench, before creating joints.)



Exercise 2

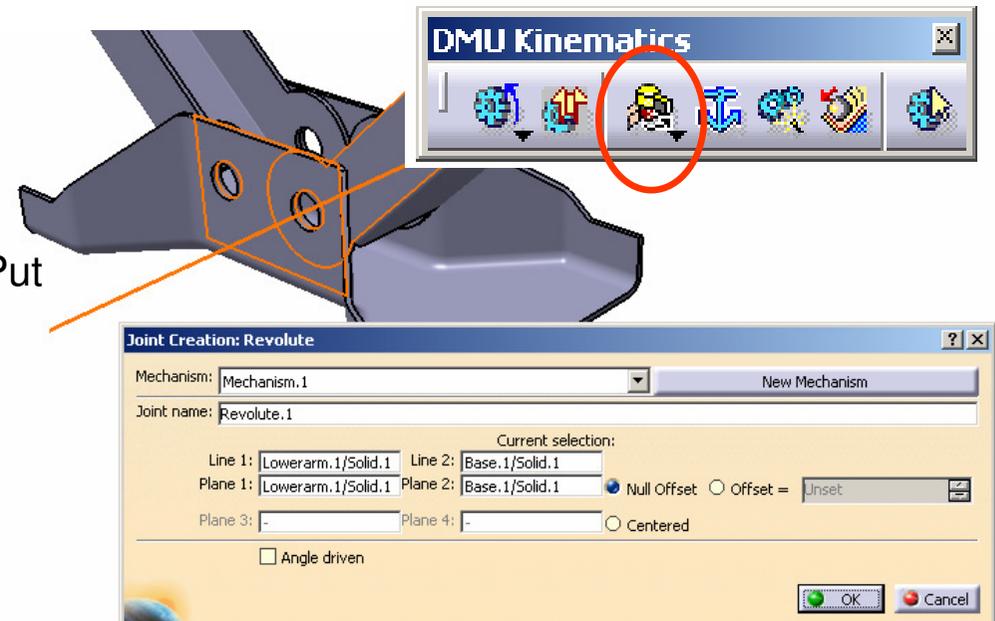
(4) Fix “Base” in place:-

- Select “**Fixed Part**” icon
- Click “**New Mechanism**” icon on the pop-up window
- Click ok to accept the default name
- Select “**Base**” (by clicking “Base” on tree or clicking on the geometry directly)
- (A Fix Constraint is created automatically, and at the same time, a fixed part is defined in Mechanism.1)



(5) Create a Revolute joint between Right Lower Arm and Base:-

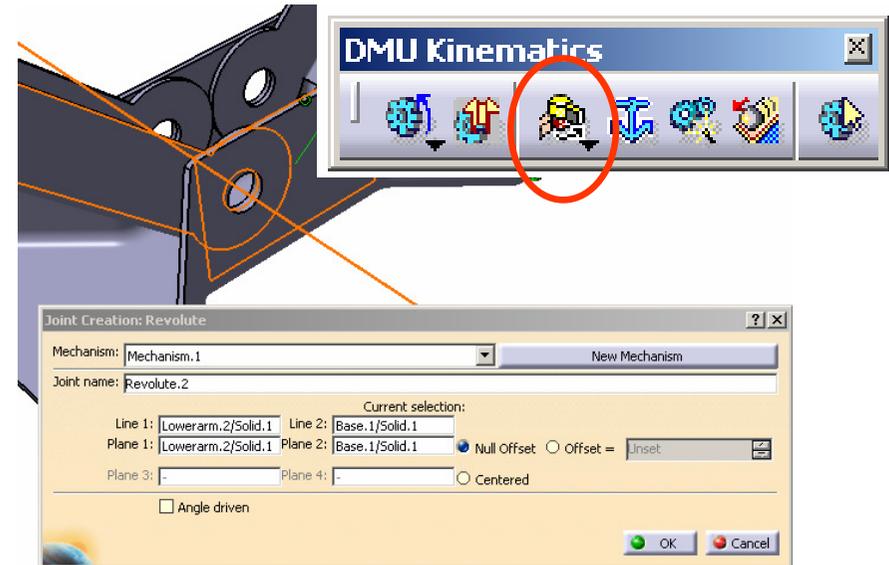
- Select “**Revolute Joint**” icon
- Click Axis of LowerArm and then Axis of Base (Put the mouse cursor onto the cylindrical surface to get its axis)
- Click Face of LowerArm and then Face of Base
- Click ok to complete



Exercise 2

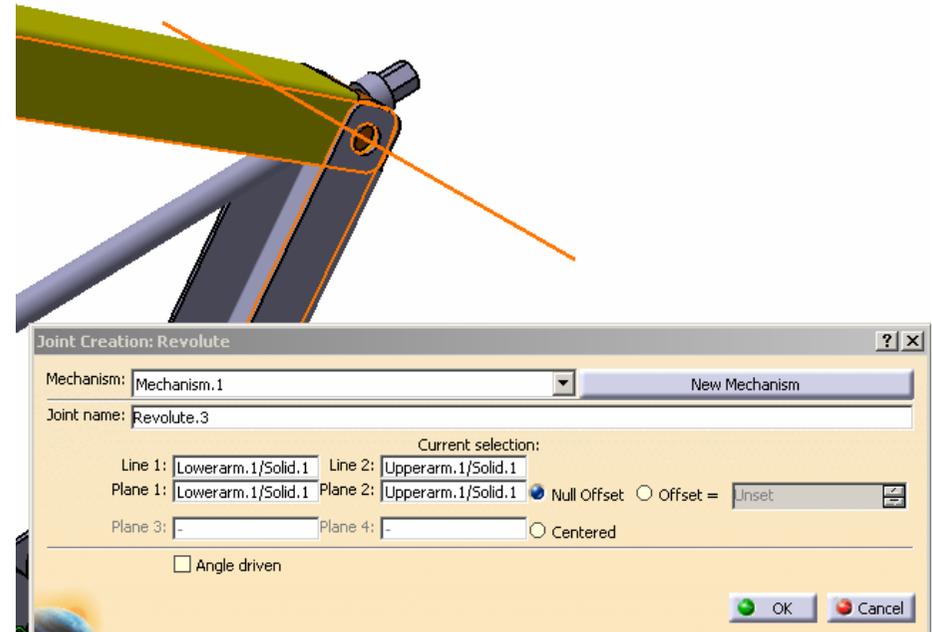
(6) Create a Revolute joint between Left Lower Arm and Base:-

- Select “**Revolute Joint**” icon
- Click Axis of LowerArm and then Axis of Base
- Click Face of LowerArm and then Face of Base
- Click ok to complete



(7) Create a Revolute joint between Right Lower Arm and Right Upper Arm:-

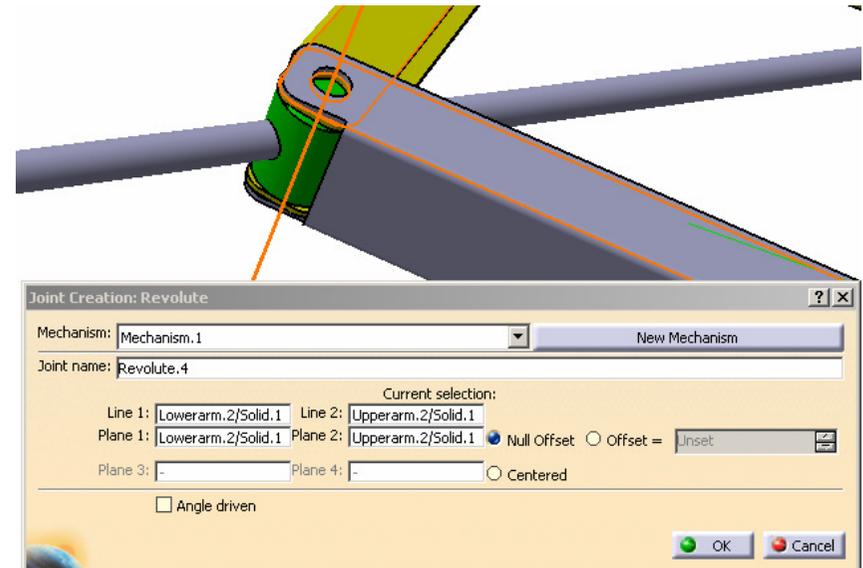
- Select “**Revolute Joint**” icon
- Click Axis of LowerArm and then Axis of UpperArm
- Click Face of LowerArm and then Face of UpperArm
- Click ok to complete



Exercise 2

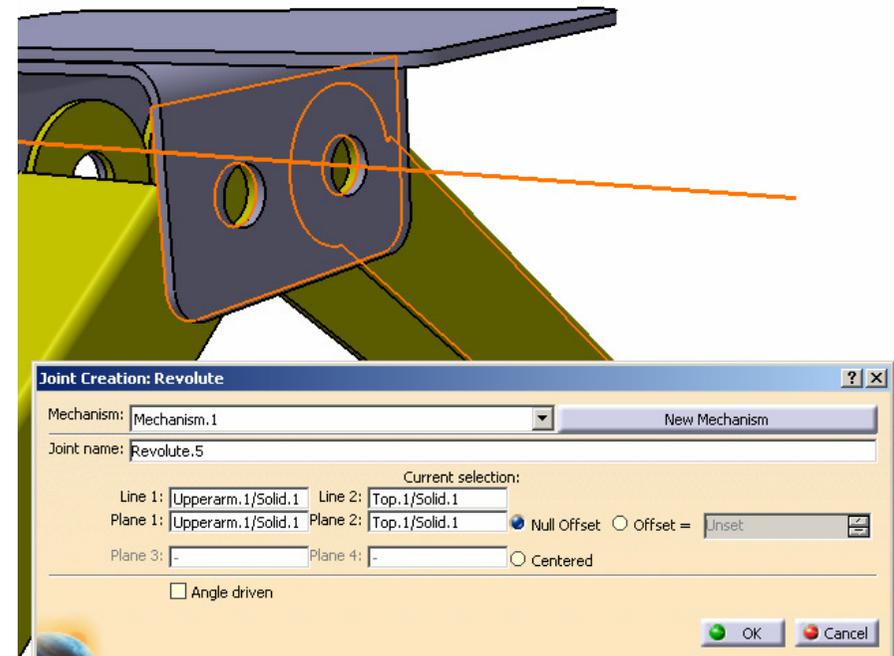
(8) Create a Revolute joint between Left Lower Arm and Left Upper Arm:-

- Select “**Revolute Joint**” icon
- Click Axis of LowerArm and then Axis of UpperArm
- Click Face of LowerArm and then Face of UpperArm
- Click ok to complete



(9) Create a Revolute joint between Right Upper Arm and Top:-

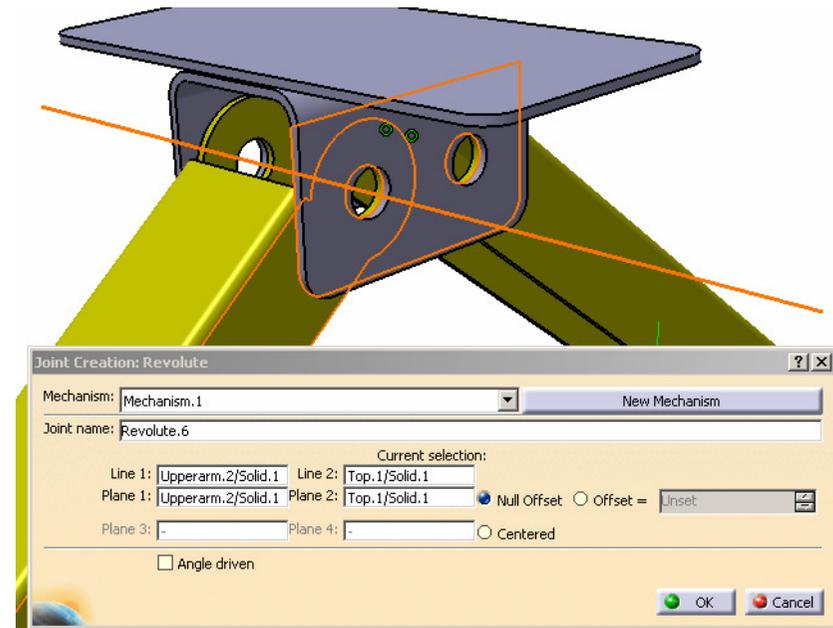
- Select “**Revolute Joint**” icon
- Click Axis of UpperArm and then Axis of Top
- Click Face of UpperArm and then Face of Top
- Click ok to complete



Exercise 2

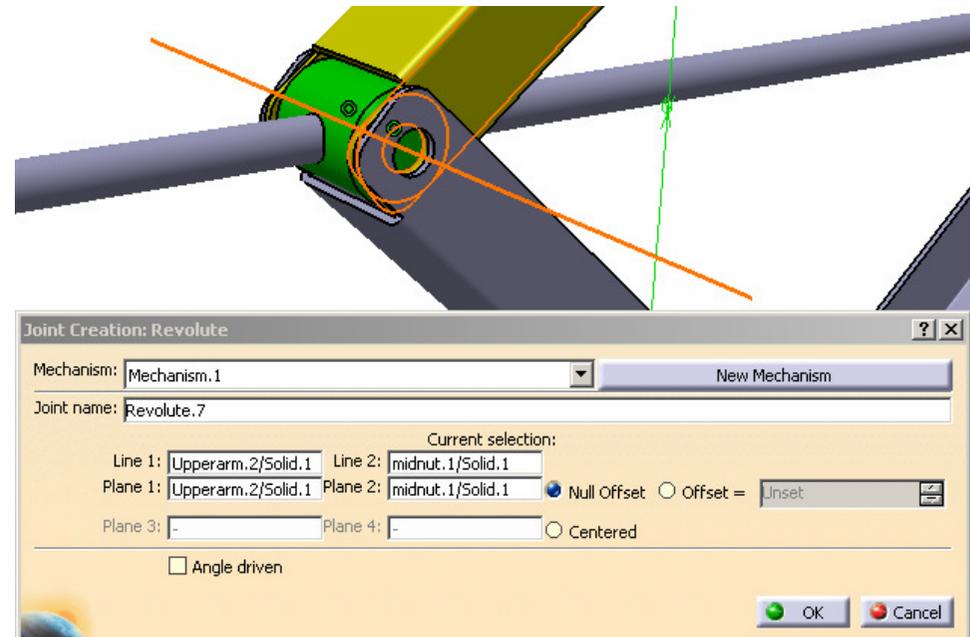
(10) Create a Revolute joint between Left Upper Arm and Top:-

- Select “**Revolute Joint**” icon
- Click Axis of UpperArm and then Axis of Top
- Click Face of UpperArm and then Face of Top
- Click ok to complete



(11) Create a Revolute joint between Left Upper Arm and Mid-Nut:-

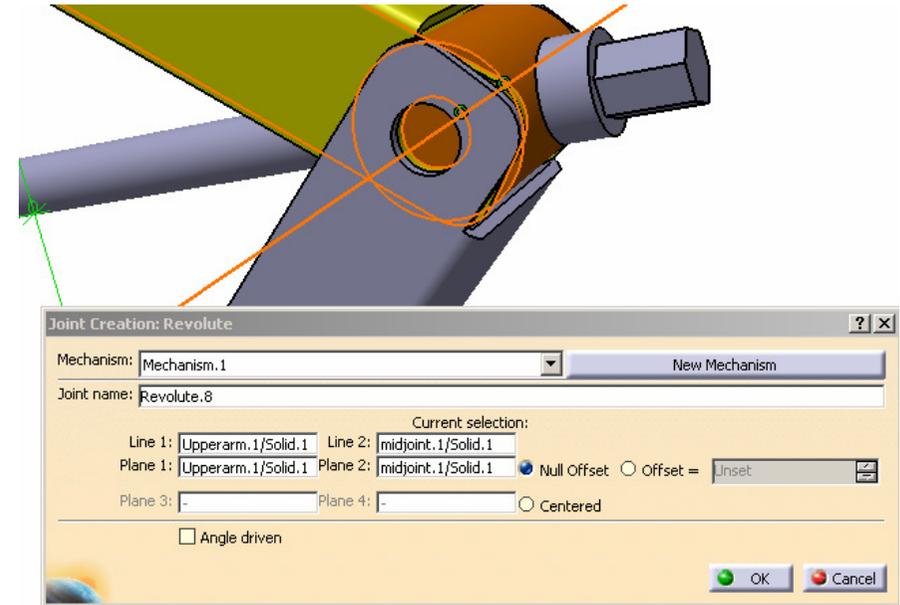
- Select “**Revolute Joint**” icon
- Click Axis of UpperArm and then Axis of MidNut
- Click Face of UpperArm and then Face of MidNut
- Click ok to complete



Exercise 2

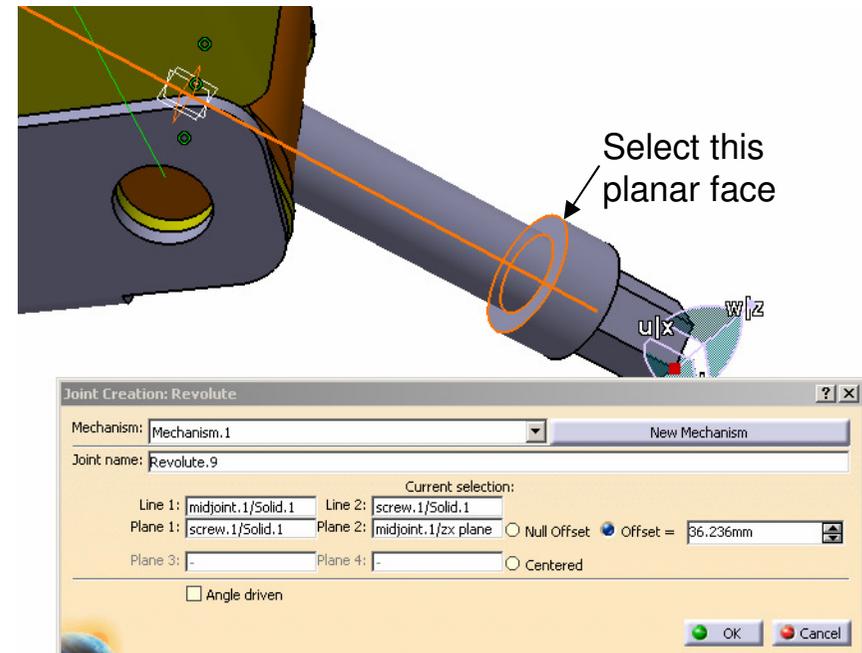
(12) Create a Revolute joint between Right Upper Arm and Mid-Joint:-

- Select “**Revolute Joint**” icon
- Click Axis of UpperArm and then Axis of Midjoint
- Click Face of UpperArm and then Face of MidJoint
- Click ok to complete



(13) Create a Revolute joint between Mid-Joint and Screw:-

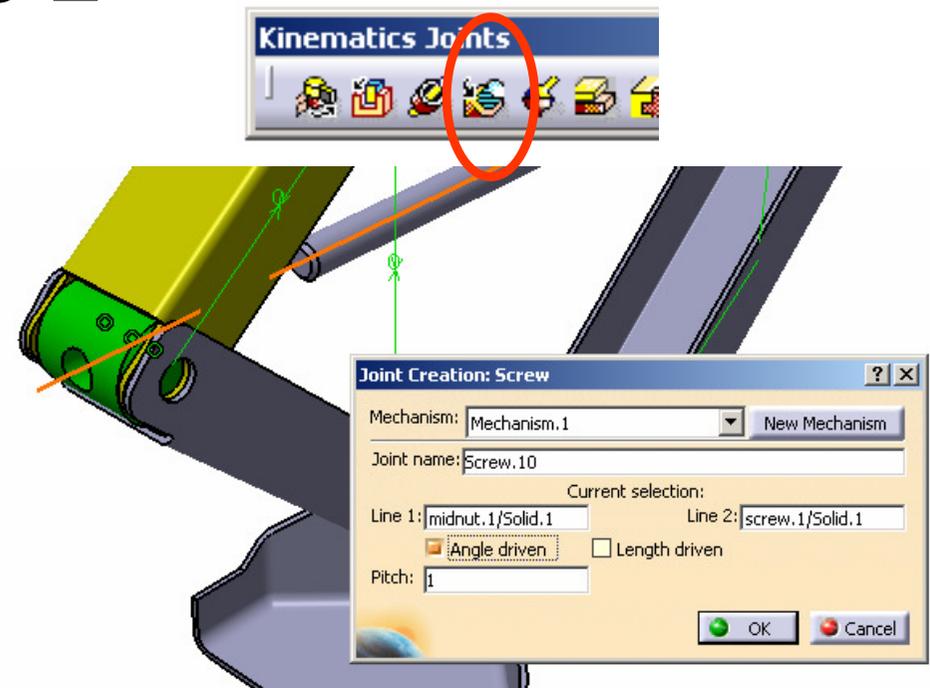
- **Drag** the Screw out of the hole **by Compass**
- **Show** xy-plane, yz-plane & zx plane of Mid-Joint
- Select “**Revolute Joint**” icon
- Click Axis of Mid-Joint and then Axis of Screw
- Click zx Plane of Mid-Joint and then Face of Screw
- Enter 10mm as Offset
- Click ok to complete
- **Hide** xy-plane, yz-plane & zx plane



Exercise 2

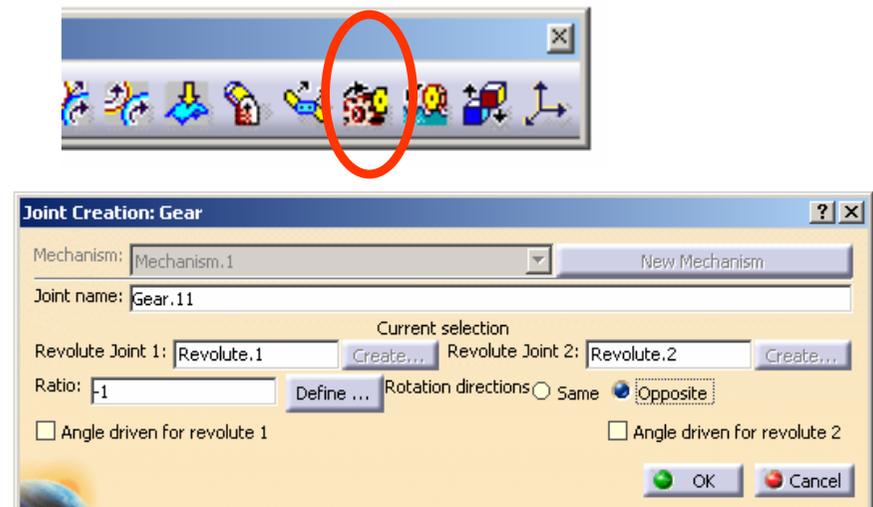
(14) Create a Screw joint between Mid-Nut and Screw:-

- Drag the Screw out of the hole by **Compass** again so that we can see the screw hole
- Select "**Screw Joint**" icon
- Click Axis of MidNut and then Axis of Screw
- Select "**angle driven**" option
- Enter 1 as **Pitch**
- Click ok to complete



(15) Create a Gear joint between Right Lower Arm and Left Lower Arm:-

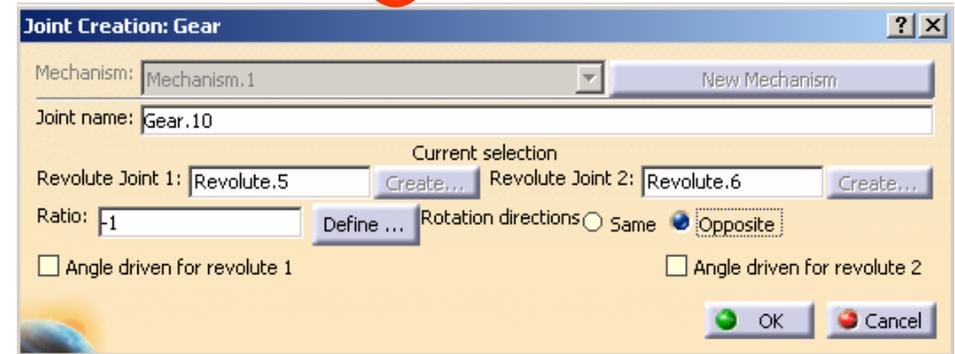
- Select "**Gear Joint**" icon
- Select Revolute.1 and then Revolute.2
- Select **Opposite** as **Rotation Directions**
- Click ok to complete



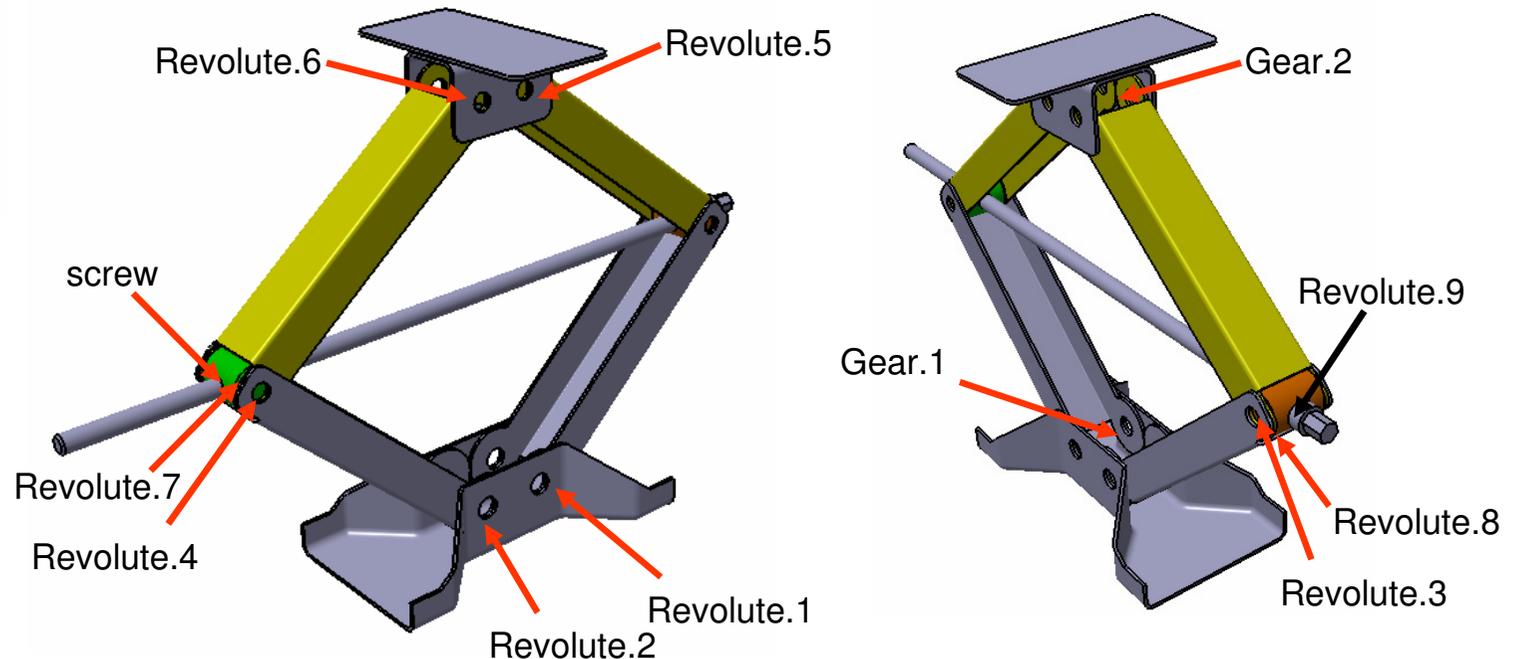
Exercise 2

(16) Create a Gear joint between Right Upper Arm and Left Upper Arm:-

- Select “**Gear Joint**” icon
- Select Revolute.5 and then Revolute.6
- Select **Opposite** as **Rotation Directions**
- Click ok to complete



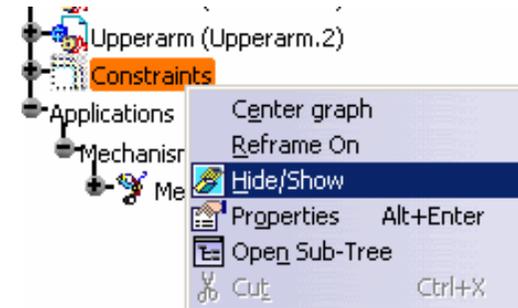
(Finally, a window pops up, saying that the mechanism can be simulated)



Exercise 2

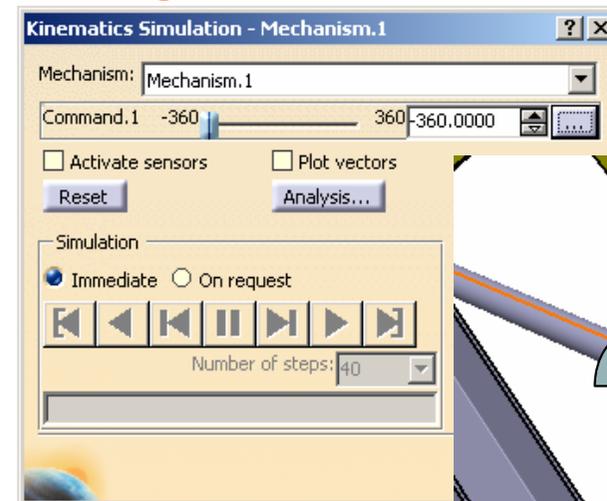
(17) Hide all Constraints:-

- Right-Click on “**Constraints**” on the product tree and then select “**Hide/Show**”



(18) Simulate the Mechanism:-

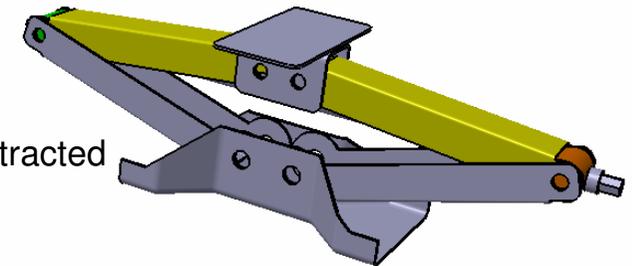
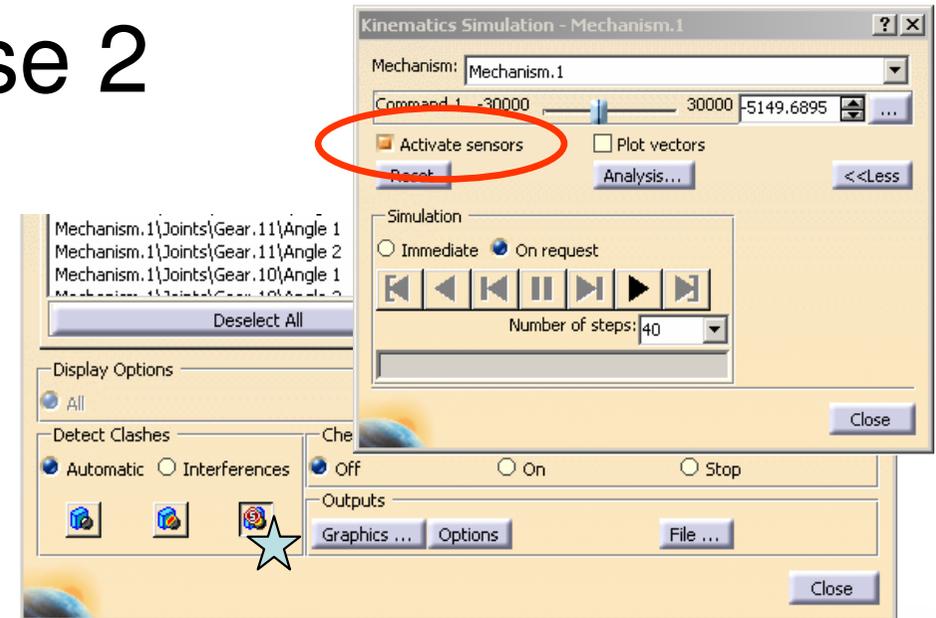
- Select “**Simulation with Commands**” icon
- Click “...” button next to Command.1
- Enter -30000 as Lowest Value
- Enter 30000 as Highest Value
- Click ok to confirm
- Select “Immediate” Simulation
- Put the mouse cursor onto the screw (double-arrow appears)
- Press and Hold the Right Button to rotate the screw (The whole mechanism moves)



Exercise 2

(19) Get the Smallest Height of Scissor Jack:-

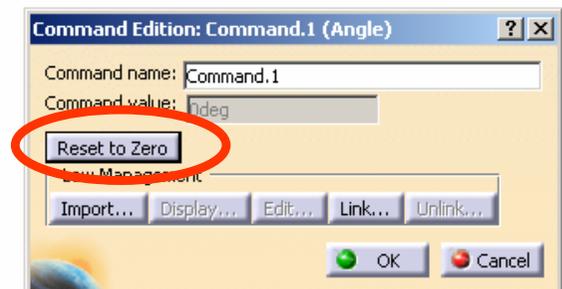
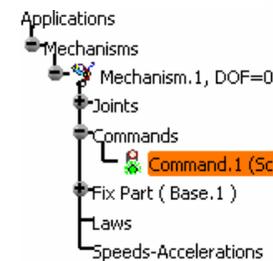
- Select “**Activate Sensors**” option (another menu pops-up)
- Select the third button “Stop when Clash” 
- Select “On Request” Simulation
- Select 40 as Number of steps
- Adjust Command.1 to -30000 (lowest value)
- Click “Play” icon 
- (The mechanism moves until the clash occurs; When Command.1 is ~21000, it stops)
- Select “Close” on both menus



It is now fully contracted

(20) Reset Command.1 to Zero:-

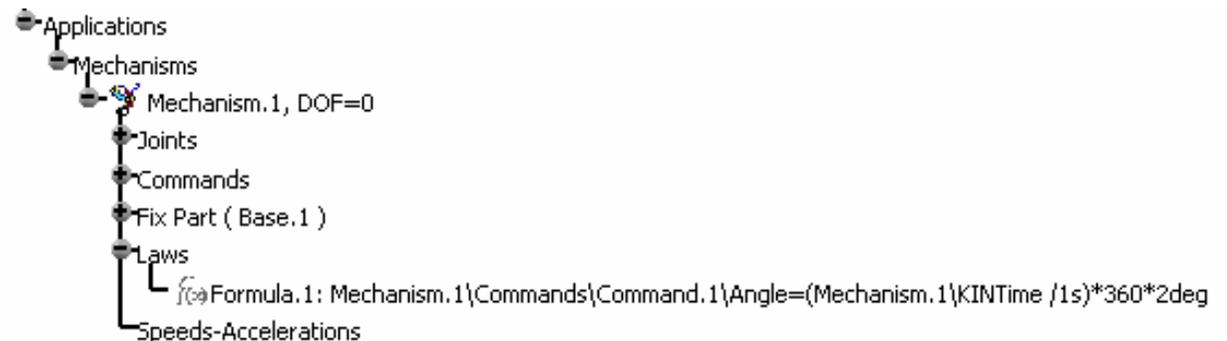
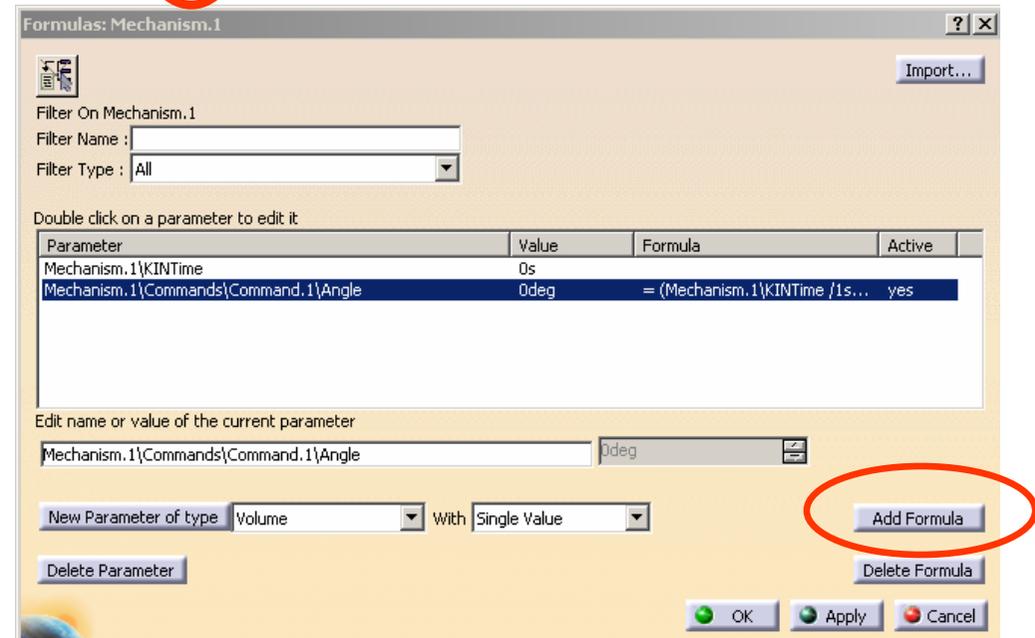
- Double-Click Command.1 on tree
- Click “**Reset to Zero**” button
- Click ok to complete
- (Now when Command.1=0 deg, the scissor jack is the shortest)



Exercise 2

(21) Define the relation between Command.1 and Time:-

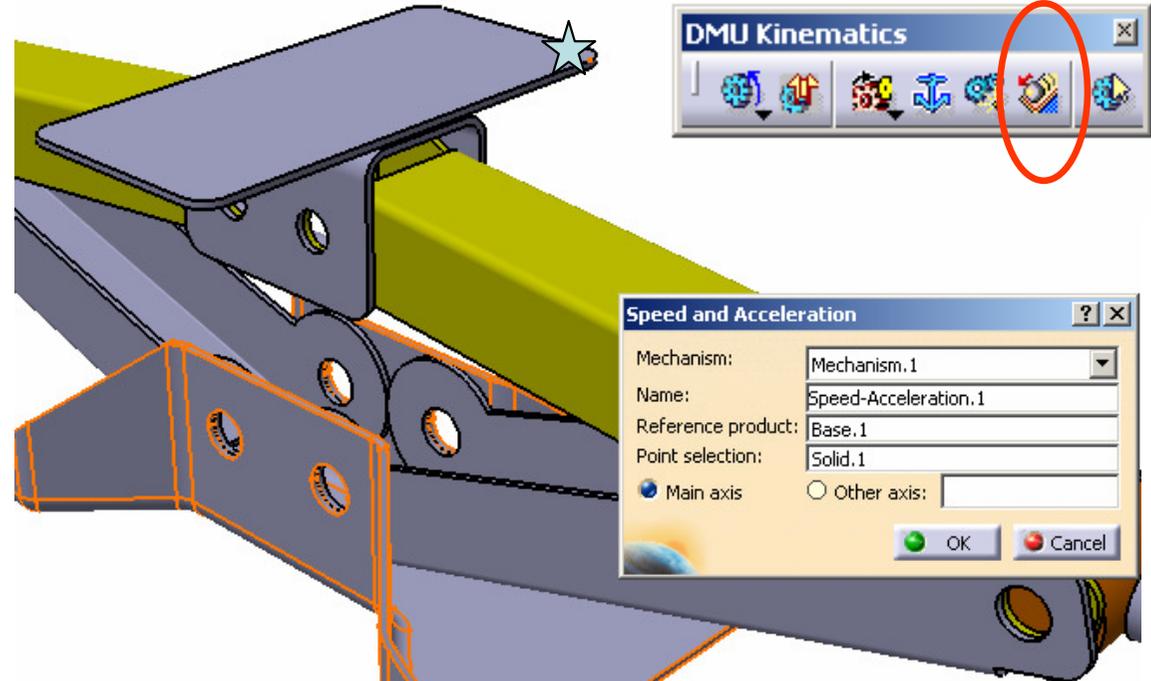
- Click “**Formula**” icon
- Click Mechanism.1 on tree
- (Two related parameters are sorted out: “Mechanism.1\KINTime” & “Mechanism.1\Commands\Command.1\Angle”)
- Select “Mechanism.1\Commands\Command.1\Angle”
- Click “Add Formula” button
- Enter $(\text{Mechanism.1}\backslash\text{KINTime} / 1\text{s}) * 360 * 2\text{deg}$
- Click ok
- Click ok again
- (The formula is now stored under Mechanism.1)



Exercise 2

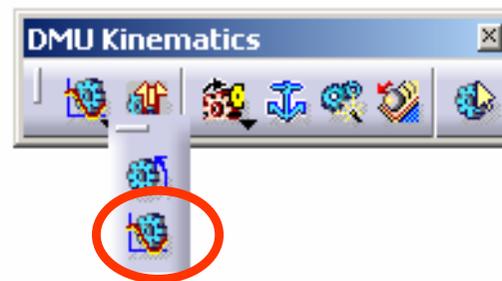
(22) Define a Sensor:-

- Click “**Speed and Acceleration**” icon
- Select Base as Reference Product
- Select any endpoint  of the Top face as Point Selection
- Select “Main axis”
- (Remark: “Main Axis” is the axis system of the Product, which is also the axis system of Base (1st component))
- Click ok to complete



(23) Run the Simulation with Formula:-

- Click “**Simulation with Laws**” icon



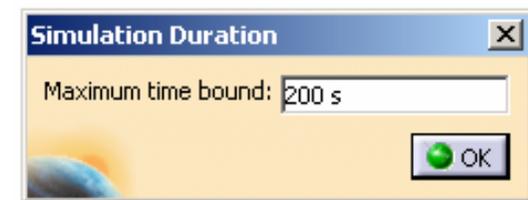
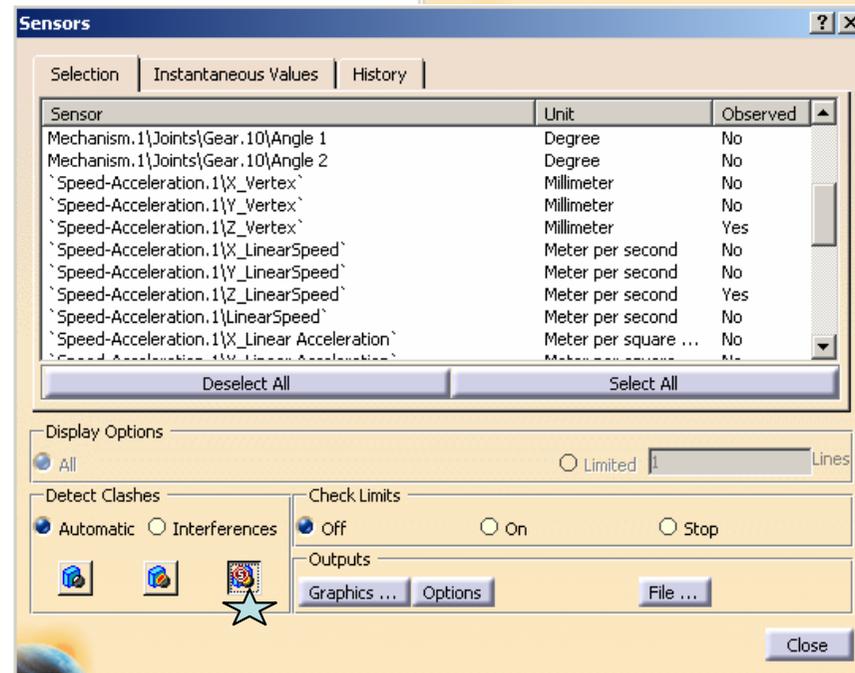
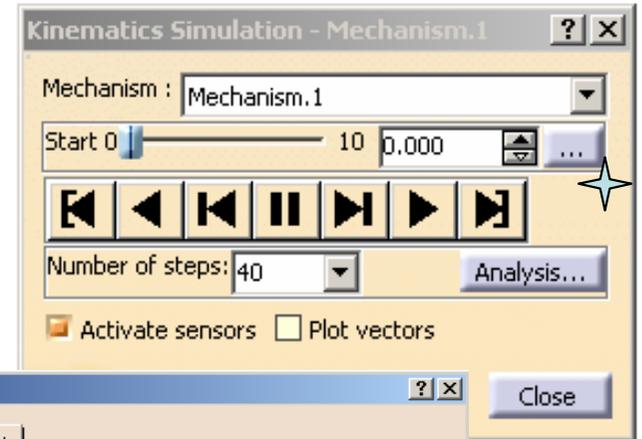
Exercise 2

(23) Con't:-

- Select “**Activate Sensors**”
- Select “Speed-Acceleration.1\z_vertex” and “Speed-Acceleration.1\z_LinearSpeed”
- Click “Stop when Clash” button 

- Click “...” button 
- Enter 200s as Maximum time bound
- Click ok
- Click  button

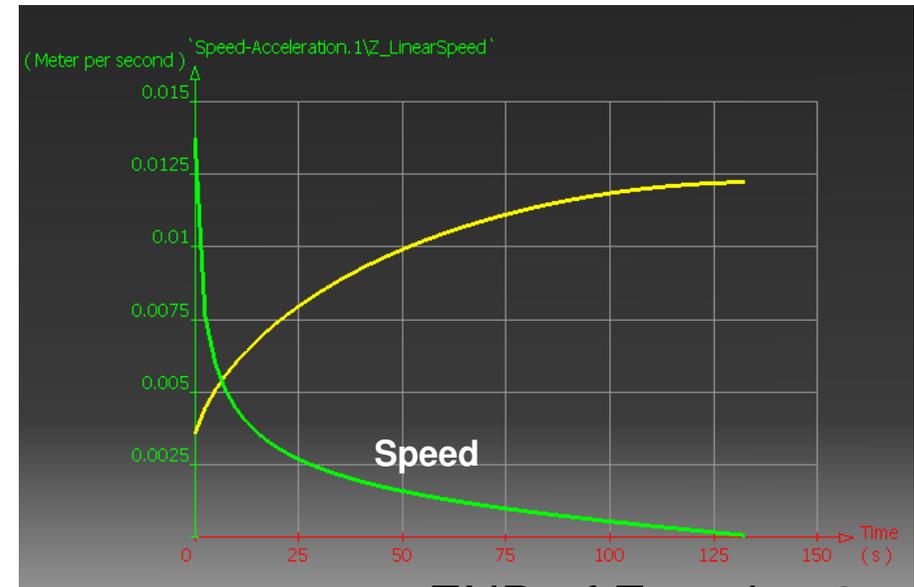
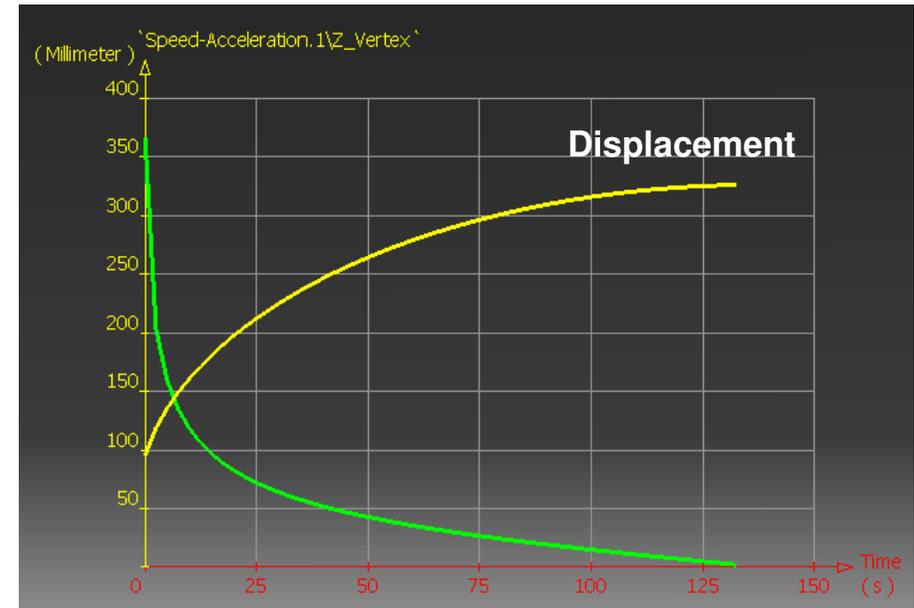
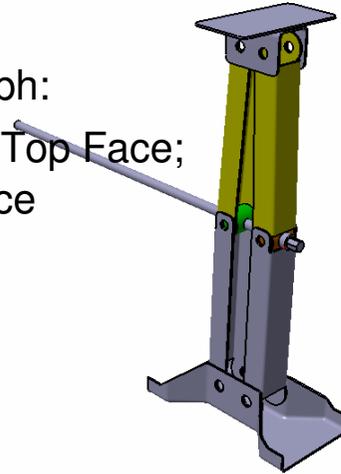
(The mechanism moves, but stops at ~130s when clash is detected)



Exercise 2

(24) Study Results:-

- Click “**Graphics...**” button
- We get two curves on the graph:
Yellow – Displacement of the Top Face;
Green – Speed of the Top Face
- Smallest Height = 95mm
- Largest Height = 326mm
- Range = $(326-95) = 231$ mm
- Total Time (from Full contraction to Full Extension) = 133sec (assuming the angular speed of the screw is 2 rev/sec)



(25) Restore original positions:-

- Click “**Reset Positions**” button



A- 27

END of Exercise 2