This tutorial builds on the experience of working with mechanisms provided in the MECHANISMS tutorial. It is essential that you have completed and fully understand that tutorial before you progress on these more advanced functions.

Two new functional areas are covered here. First the concept of using gears and drivers to power mechanisms is covered. Secondly a novel use for mechanism in preparing assembly instructions is demonstrated. The whole tutorial is based around the mechanism shown in Figure 1 which is a simple wash/wipe assembly for the rear window of a hatchback car.

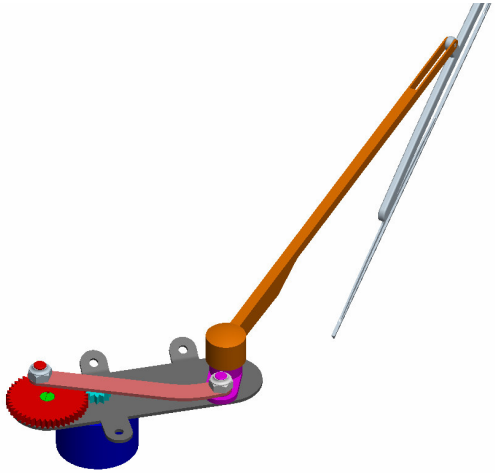
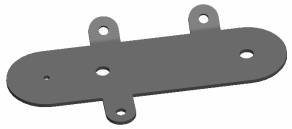
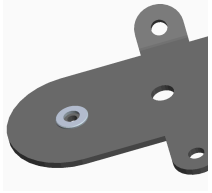
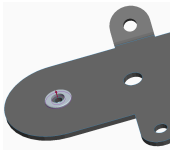
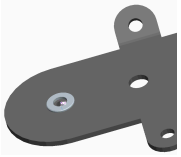
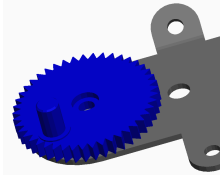
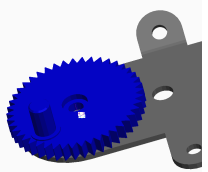
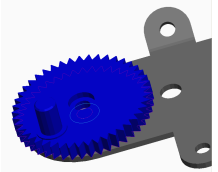
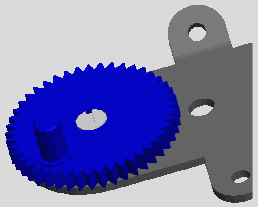
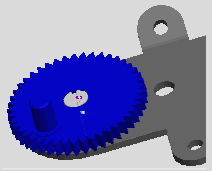
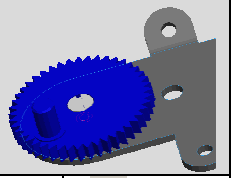
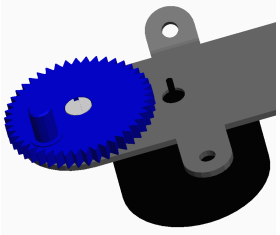
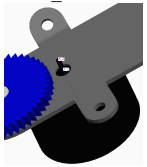
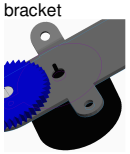
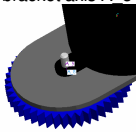


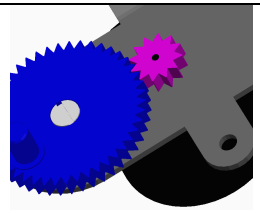
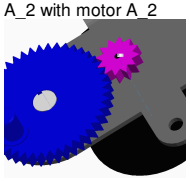
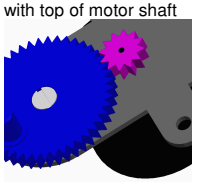
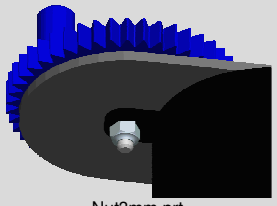
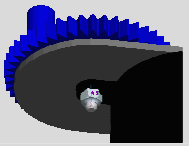
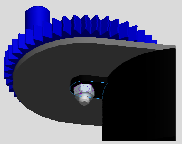
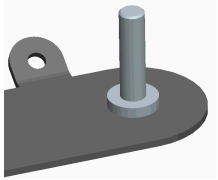
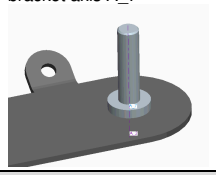
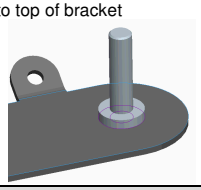
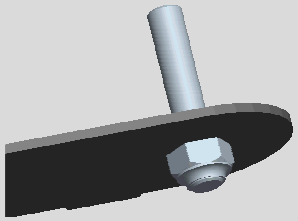
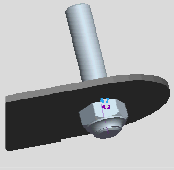
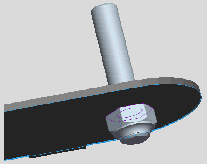
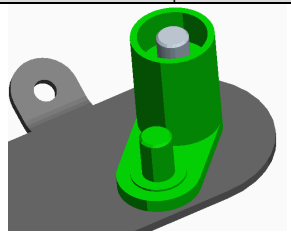
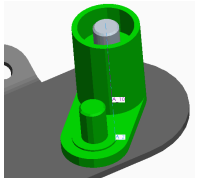
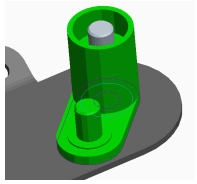
Figure 1 : Wash/Wipe Mechanism

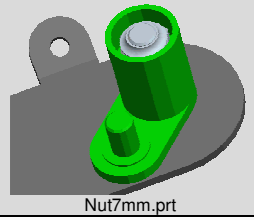
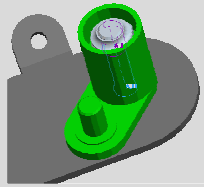
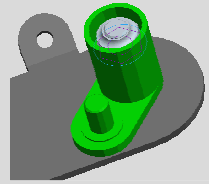
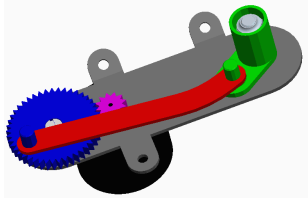
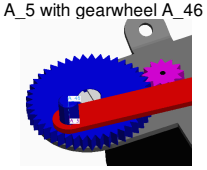
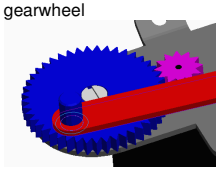
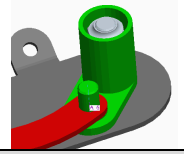
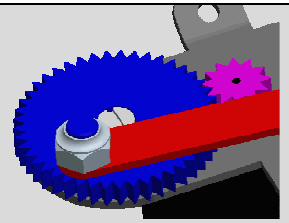
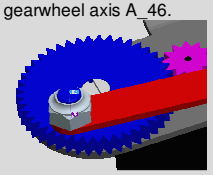
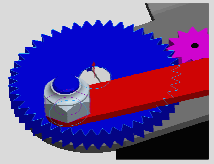
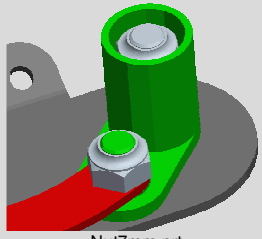
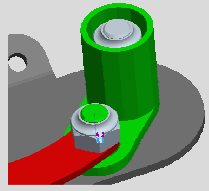
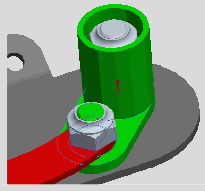
Mechanism Review

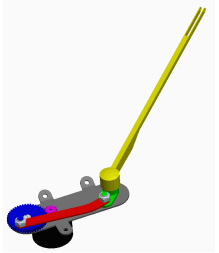
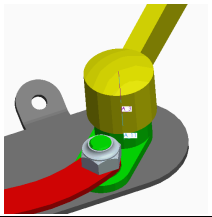
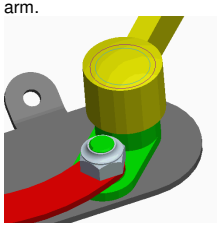
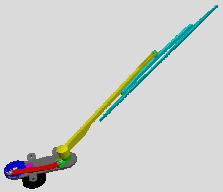
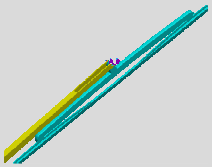
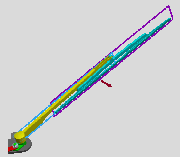
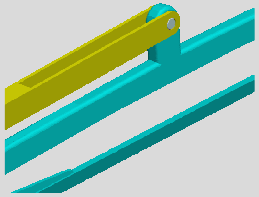
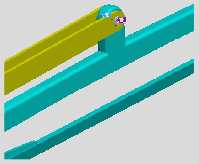
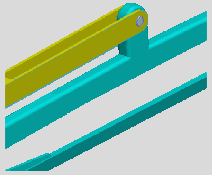
By way of review we will go through the process of assembling the mechanism. This uses the techniques already shown in the MECHANISMS tutorial and so instructions will be brief. If you need to, refer back to the earlier tutorial.

Create a new empty assembly file called *wipermechanism* and assemble the mechanism in the following order using the joint properties described in this table. Some assembled pairs (marked assembly only) do not require a joint and should be assembled in the normal way. The steps with a grey background can be omitted without affecting the function of the mechanism if you are short of time.

Part for assembly	Joint	References		
		Reference 1	Reference 2	
 Bracket.prt	None	None	None	
 Washer.prt	Assembly only	Mate face surface of washer to face surface of bracket 	Align washer axis A_3 to bracket axis A_8 	
 Gearwheel.prt	Pin Joint	Axis alignment – gearwheel A_2 with washer A_3 	Translation – base of gearwheel with top of washer 	
 Gearshaft.prt	Assembly Only	Align gearshaft axis A_2 to bracket axis A_8 	Mate face surface of gearshft to face surface of bracket 	
 Motor.prt	Assembly Only	Align motor axis A_2 to bracket axis A_6 	Mate face surface of motor to underside of bracket 	and align motor axis A_5 to bracket axis A_8 

 Pinnion.prt	Pin Joint	Axis alignment – pinion A_2 with motor A_2 	Translation – top of pinion with top of motor shaft 
 Nut3mm.prt	Assembly Only	Align nut3mm axis A_2 to motor axis A_5 	Mate base surface of nut3mm to underside of motor bracket 
 Axle.prt	Assembly Only	Align axle axis A_2 to bracket axis A_7 	Mate base surface of axle to top of bracket 
 Nut7mm.prt	Assembly Only	Align nut7mm axis A_2 to bracket axis A_7 	Mate base surface of nut7mm to underside of motor bracket 
 Arm.prt	Pin Joint	Axis alignment – arm A_10 with axle A_2 	Translation – base of axle with top of step on axle shaft 

 Nut7mm.prt	Assembly Only	Align nut7mm axis A_2 to arm axis A_10 	Mate base surface of nut7mm to top of arm 
 Longarm.prt	Pin Joint	Axis alignment – longarm A_5 with gearwheel A_46 	Translation – bottom of longarm with top of step on gearwheel 
Create a second joint in the same part using the + button	Cylinder Joint	Axis alignment – longarm A_6 with arm A_6 	
 Nut7mm.prt	Assembly Only	Align nut7mm axis A_2 to gearwheel axis A_46. 	Mate base of nut7mm with step on gearwheel with 2.5 offset. 
 Nut7mm.prt	Assembly Only	Align nut7mm axis A_2 to arm axis A_6. 	Mate base of nut7mm with top surface of arm with 2.5 offset. 

 Wiper.prt	Assembly Only	Align wiper axis A_3 to arm axis A_11. 	Mate inside surface of wiper with top surface of arm. 
 Blade.prt	Assembly Only	Align blade axis A_8 to wiper axis A_9. 	Mate front datum plane of blade with front datum plane of wiper. 
 Pin.prt	Assembly Only	Align pin axis A_2 to wiper axis A_9. 	Mate front surface of pin with end surface of wiper. 

If you have assembled the mechanism correctly you should now be able to enter mechanism mode (APPLICATION > MECHANISM) and drag the wiper blade to flex the mechanism using the MECHANISM > DRAG  . If the mechanism does not flex you will need to check each of the assembly steps for accuracy – particularly check that you have selected the axis of the correct body at each stage.

Gears

You may notice as you drag the mechanism that the pinion gear on the motor does not move. There is no connection between the two gears. A connection can be created using MECHANISM > GEARS and pressing the NEW button. The dialog in Figure 2 will be shown.

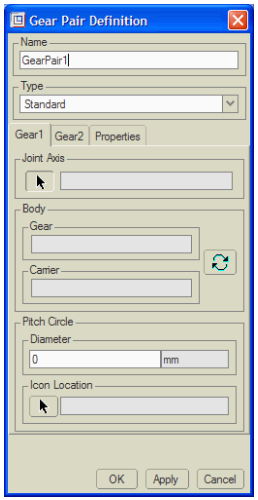


Figure 2 : Gears Dialog

You now have to define the two gears. First pick the joint axis – the yellow arrow symbol – at the centre of the large gearwheel. Click on the Gear2 tab and pick the joint axis for the pinion gear. On the properties tab change the Gear Ratio to user defined. The gearwheel (Gear1) has 42 teeth and the pinion (Gear2) has 12 teeth so enter these values in the boxes.

Exit the dialog and try dragging the mechanism to check that the gears now mesh correctly.

Drivers

Of course with a real wiper you don't move it by dragging the wiper! You turn on the motor. The equivalent in Mechanism is to define a driver to turn the gear on the motor. One type of driver – called a servo motor - can be created using MECHANISM > SERVO MOTORS and pressing the NEW button. The dialog in Figure 3 will be shown.

Like gears you first have to select the axis of the motor so pick the yellow arrow at the centre of the pinion. On the profile tab you can define how quickly the motor turns. Change the specification from position to velocity and enter a value into the A pane below Magnitude. This value specifies the speed of rotation of the motor in degrees per sec. This motor turns at 120rpm or 2 rev per second or 720 deg per sec so enter 720 as the value. This means each wipe takes 3.75/2 or just under 2 secs.

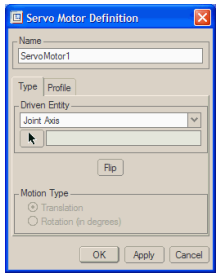


Figure 3 : Servo Motor Dialog

To see the motor in operation it is necessary to define an Analysis using MECHANISM > ANALYSES and creating a New analysis. First define the graphical display parameters. Enter the values shown in Figure 4. Also click on the Motors tab and press the  or  button to add the motor definition to the analysis. When this is done you should be able to press the RUN button at which point the motor will run and the mechanism will be flexed through its full range of movement – you should see the movement on the screen.

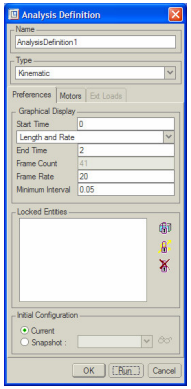


Figure 4 : Analysis Definition

Assembly Simulation

One novel use of mechanisms is to simulate the steps undertaken in the process of assembling the components together. To achieve this is a different set of joints would be needed than those used in the mechanism so it is necessary to save the assembly simulation as a different file from the mechanism simulation. So to start open the *wipermechanism* assembly and choose FILE > SAVE AS and enter a new name such as *wiperassembly*. You will notice that the file that is open in front of you now is still *wipermechanism* so choose FILE > CLOSE WINDOW then FILE > OPEN and locate the newly created *wiperassembly* file. This is of course currently identical to the original assembly file.

Now we need to modify this file to simulate the assembly. Basically each part in the assembly needs to be defined by a joint which allows the part to move along the direction it will be assembled.

For example the second part in the assembly is the washer. Originally this was assembled without a joint at all. It now needs to be assembled with a joint that allows the washer to move along the axis of the washer – this type of joint is called a cylinder (you could also use a slider but that also restricts rotation which is not necessary). This modification (using EDIT DEFINITION) is shown in Figure 5.

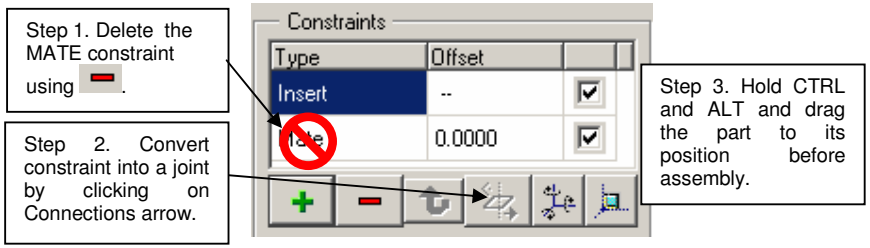


Figure 5 : Modifying the Washer

Other parts, such as the gearwheel already have a joint defined but the joint is the wrong type and can be changed e.g. the pin joint can be changed to a cylinder joint).

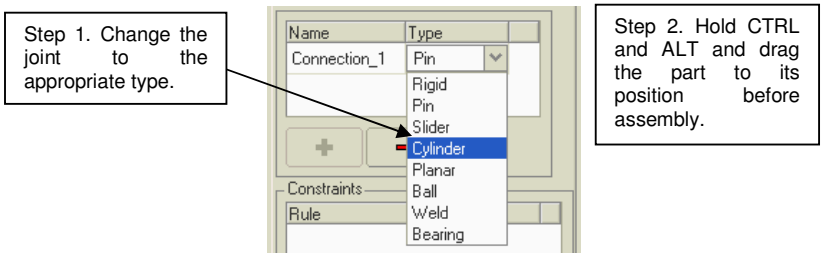
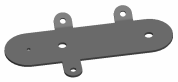
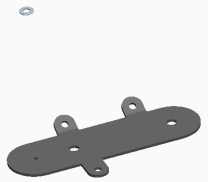
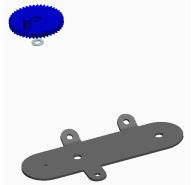
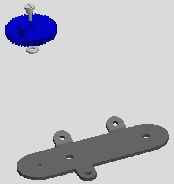
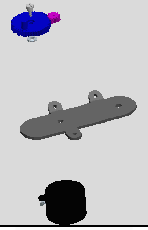
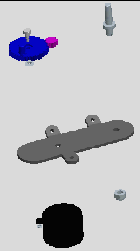
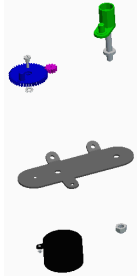
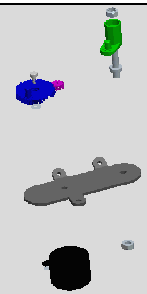
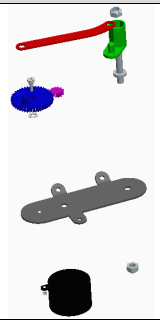
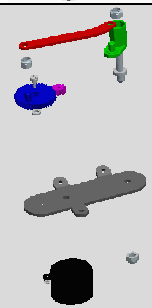
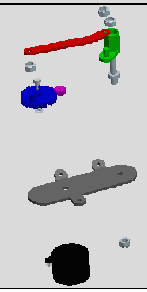


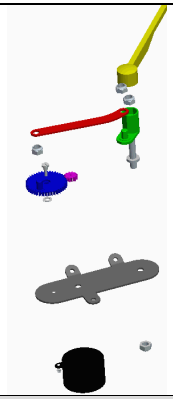
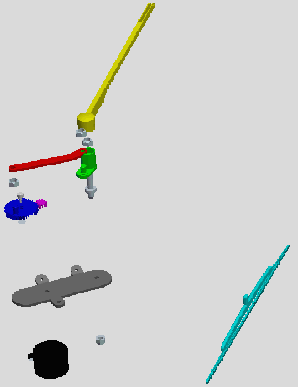
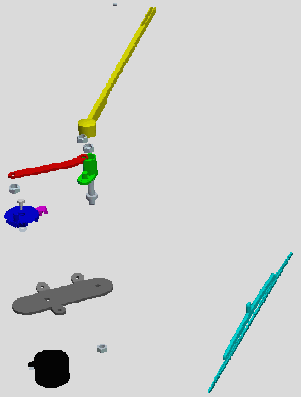
Figure 6 : Modifying the Gearwheel

So to prepare the current model into an assembly simulation you need to go through each part in turn, right click on the name in the feature tree and choose EDIT DEFINITION then create or change the joint type. Finally, drag the part to a position away from the assembly – in the position where it would start the assembly process. Close the assembly dialog and move on to the next part. The following table describes the joints for each part.

Part Name	Modification	Result
Bracket.prt	No Change	
Washer.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	
Gearwheel.prt	Convert PIN joint to CYLINDER. Move to starting position.	
Gearshaft.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position	
Motor.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	

Pinion.prt	Convert PIN joint to CYLINDER. Move to starting position.	
Nut3mm.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	
Axle.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	
Nut7mm.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	
Arm.prt	Convert PIN joint to CYLINDER. Move to starting position.	

Nut7mm.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	
Longarm.prt	Convert PIN joint to CYLINDER at both ends. Move to starting position.	
Nut7mm.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	
Nut7mm.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	

Wiper.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	
Blade.prt	**NOTE THIS IS DIFFERENT TO ALLOW THE BLADE TO SLIDE INTO POSITION.** Delete the ALIGN constraint. Convert to PLANAR joint. Move to starting position.	
Pin.prt	Delete the MATE constraint. Convert to CYLINDER joint. Move to starting position.	

The assembly should now have all the joints defined and the parts in their starting positions. Now we have to create an animation. You did this in the MECHANISM tutorial but we will review and introduce some new functions now.

Creating an Animation

To define an animation choose APPLICATION > ANIMATION. (You may get a warning message about invalid servo motors because the servo motor defined earlier is no longer valid – this can be ignored) The screen will change with the important addition of an area below the main graphics window. This is where the timeline editor will appear. A timeline defines what events happen and at what time they start/stop. But what are these events and how do we define them? In simple terms an event is a mechanism position. The model can be dragged to different positions and a snapshot taken of the model in that position. Here is how…

Choose the  icon or the ANIMATION > SNAPSHOT command. The Drag Dialog shown in Figure 6 will appear.

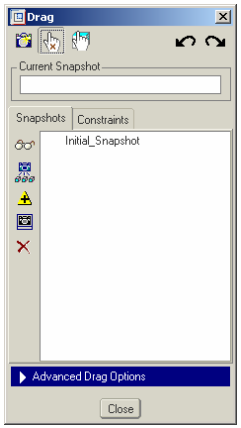


Figure 6 : The Drag Dialog

You can use the camera icon  at the top of the dialog to take snapshots of the 'mechanism' in its current position. Do this now to save a snapshot of the 'mechanism' in its starting position. This will be saved under the name Snapshot1.

We now have to create a snapshot with each component in its assembled position. You could use the drag icon  to position each part in its assembled position but there are some more accurate functions we can use.

The CONSTRAINTS tab provides functions to control the position of components. There are functions similar to assembly functions such as MATE and ALIGN but these are temporary constraints only. Choose the MATE icon  now and pick the top surface of the bracket and the bottom surface of the washer. The washer should snap to the correct assembled position. You may find that some of the other parts move as well due to the internal relationships. You can use the drag icon  to reposition these other parts to their original position at which point you can use the camera icon  again to take another snapshot of the 'mechanism' after the washer is assembled. This will be called Snapshot2.

This basic procedure needs to be repeated for every part if the assembly. Some of the parts (the Blade) may require MATE  and/or ALIGN  functions to correctly position them. Don't forget after each position is defined to take a snapshot. When the 'mechanism' is fully assembled you should have 17 snapshots or events defined that need to be turned into an animation. Close the Drag dialog.

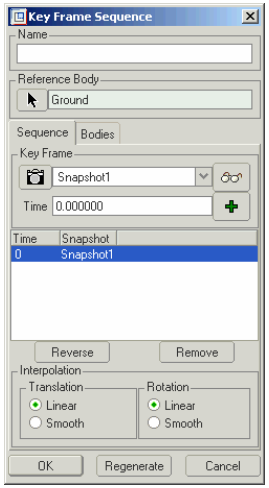


Figure 7 : Key Frame Editor

Press the icon or choose ANIMATION > KEY FRAME SEQUENCE. Choose NEW and the Keyframe Sequence Editor dialog appears (see Figure 7). Type Assembly in the name field. Below Keyframe Snapshot1 should be listed and time 0.000. In the dialog press to add this Snapshot1 to the animation. Then select Snapshot2 from the list and change the time to 1 and press again (The time of 1 sec could be set to the actual time that this part of the assembly takes). Repeat this process fro each of the 17 snapshots defined. Press OK. You should see the Assembly animation appearing in the timeline. You can right click on the timescale at the bottom of the screen and choose EDIT TIME DOMAIN to change the overall time (to 16 secs) and frame rate of the animation period.

Now in the animation toolbar press or ANIMATION > START to generate all the intermediate frames between the snapshots. Once generated you can press or ANIMATION > PLAYBACK to play the sequence using the Animate dialog which has controls like a video recorder.

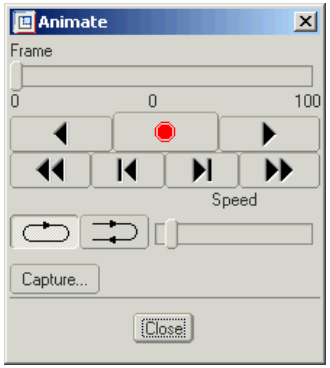


Figure 8 : Animate Dialog

In the Animate dialog the CAPTURE option can be used to capture an MPEG movie from the sequence which can be replayed in Media Player.

Notice that position of the mechanism and the view that you are looking at the mechanism from is independent so you can look at the mechanism from any viewing position before playing the animation. It is normal to zoom in on the centre of the assembly – in this case the bracket – so that the parts 'appear' from of the screen as they are assembled.

However you may wish to change the view during the animation – this is possible using the ANIMATION > VIEW @ TIME or icon. First though you have to define the views that you want using the VIEW > VIEW ORIENTATION > REORIENT command (use the mouse to get the view you want then press type in a meaningful name then press SAVE).

Create two views now one called CLOSEUP which is zoomed into the motor end of the bracket and one called FAR which shows the whole assembly. Now you have the views you need choose ANIMATION > VIEW @ TIME or icon. Choose CLOSEUP as the name and a time of 0 then press the apply button. Choose CLOSEUP again and a time of 12 then press the apply button. Choose FAR and a time of 14 then press the apply button. Close the dialog. In the timeline at the bottom of the screen a second line should have appeared with the view names. Now in the animation toolbar press or ANIMATION > START to generate all the intermediate frames between the snapshots and then or ANIMATION > PLAYBACK to play the sequence. The animation should start with a close-up then after 12 secs zoom out.

Review

So what should you have learnt?

- How to assemble mechanisms using different joint types.
- How to create gears and motors
- How to simulate the assembly process.
- How to create and save animations.
- How to change the view during an animation.

Any problems with these? Then you should go back through the tutorial – perhaps several times – until you can complete it without any help.