



The Wheels Modifier

A Plug-in for CARRARA 4 & 5

Version 0.4

Apply the **Wheels** modifier to any vehicle in Carrara and it will automatically spin the wheels in the correct direction and steer the front wheels as the vehicle moves around the scene. This will potentially save a lot of production time and takes the difficulty out of estimating and manually entering many key frames to achieve the same effect. If the motion of the vehicle needs to change then no editing is required since the Wheels modifier works out the details frame by frame.

To install the modifier extract the contents of the compressed zip package into the Carrara\Extensions sub-folder. To remove the Wheels modifier Carrara 4 users must delete the Wheels.mcx and Wheels.dta files from the ..\Extensions\ folder. Carrara 5 users must delete the Wheels.mcx, Wheels.dat and Wheels.txt files.

Once installed, apply the Wheels modifier by selecting the vehicle, opening out the Properties tray and then on the Modifiers card hit the + icon and choose 'Wheels' from the list of modifiers.

This manual contains a detailed overview of how the modifier functions and its user interface then covers several examples explaining how to setup a variety of vehicles.

Overview

The vehicle object or grouped assembly of parts that make up the vehicle must be aligned, without any rotation, to lie on the XY plane and face either in the Y axis with the wheel axels aligned in the X axis or with the vehicle facing in the X axis and the wheels aligned in the Y axis. If the vehicle model is not so aligned to face in either the X or Y axis, or if the wheels have been rotated into position during its assembly, then groups can be used to correct this. Refer to the [Problematic Setups](#) section below.

All the wheels should be child objects or groups and parented to the vehicle assembly or grouped with it so that they move when the whole vehicle does. Wheels that are made of separately modelled parts with tyres, rims, hubs etc must be grouped together as a whole wheel. Wheels sharing the same axel can be grouped together but front wheels that will steer should really be separate objects using separate wheels modifiers. Front and rear wheels must be different objects - they cannot be in the same mesh or primitive in order to spin around individual axels. Front and rear wheel objects or wheel groups must have unique names in the scene hierarchy but they can share the same master object. The hot point of a wheel or grouped wheels must be located in the centre of each wheel or their axel. Front wheels which will turn with steering should have the hot point placed at the end of the stub axel to be more accurate rather than in the dead centre of the wheel.

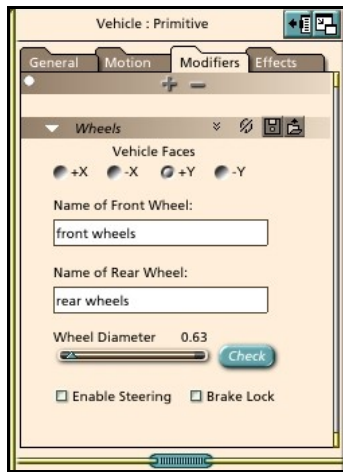
The Wheels modifier will normally need to be added to the vehicle twice, however one instance can be used to spin front and rear wheel groups with common axels. Setting the vehicle up with a Wheels modifier for each side of the car will give more accurate results when the car is turning - in which case the left and right side wheels will need to have unique names as well as being separate objects. You can add any number of Wheels modifiers to the same vehicle and to different vehicles in the same scene. Once you apply the modifier and name the wheel objects you will no longer be able to freely rotate those wheels using the standard rotation tool.

During each frame of animation the Wheels modifier calculates out how much to spin the wheels in the right direction. This is done by using the input diameter to work out the wheel circumference and then dividing that into the distance travelled, in a forward or reverse direction, since the last frame. The change in the facing orientation of the vehicle in the XY plane since the last frame and the current forward or reverse direction of the car is used to work the steering. If the wheel diameter is too large then the wheels will spin slower and if its too small then the wheels will spin faster than they should. There is no real physics or traction so whether the vehicle is driving along the road, flying in the air or rolling over, the wheels will spin based on the distance travelled.

It is not recommended that you apply Carrara Physics directly to a vehicle with the Wheels modifier. Substitute a duplicate 'stunt' car instead and use a Track modifier to get the vehicle to follow its motion. You will need to disable the tracking while the physics is calculating then save the tweener data and disable physics for the scene.

The Wheels Modifier User Interface

The modifier parameters are detailed as follows:



The *Vehicle Faces* option tells the modifier which direction is forward for the vehicle assembly. This must be correct so that it can work out when the car is moving forward, in reverse or sideways and spin the wheels the correct way round.

Type in the exact unique object or group name into the *Name of Front Wheel* text field. Steering is only ever applied to a front wheel. If the vehicle has more than one axel then type the object or group name into the *Name of Rear Wheel* field. If either of the text name fields are blank or the object is not found they are ignored by the modifier.

The *Wheel Diameter* must be entered exactly in scaled units in order for the modifier to work out accurately how many turns the wheel makes every time its circumference is travelled in the scene. Use the *Check* button to get the modifier to automatically find the diameter, this looks for a front wheel first then a rear wheel if it cannot find one or the name is blank. The *Check* button uses the wheel height or scaled *Z* size not the size of the mesh. The *Wheel Diameter* slider can be animated to simulate the effect of loss of traction on a wet road or during a skid.

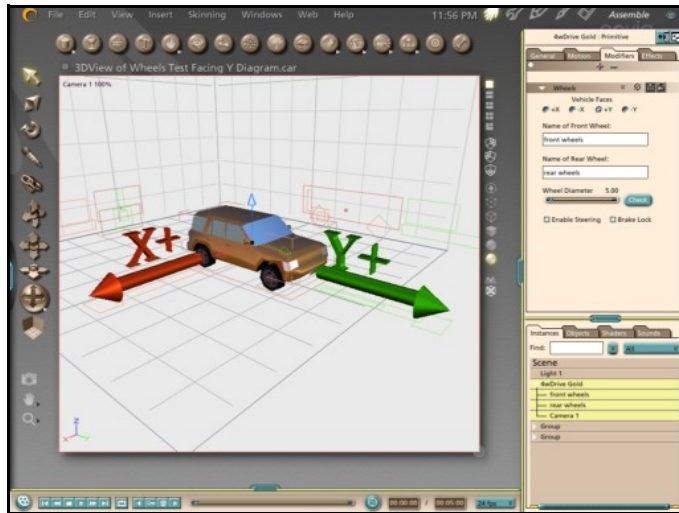
Check the *Enable Steering* box and then the modifier will automatically steer a front wheel around its hot point. Note that changing this parameter will create a key frame.

Check the *Brake Lock* box during the animation of a skid to stop the wheels from spinning. Changing this parameter will create a key frame. This will not stop the vehicle from steering as it corners if steering is enabled.

Simple Vehicle Setup

The simplest vehicles that do not require steering are easy to setup and get started with. In this example both the 'front wheels' and 'rear wheels' objects are two separate vertex meshes which are children of the parent vehicle object.

With the properties tray open select each wheel object and click on the [HP->Obj] button to make sure that the hot points are in the middle of the wheels. Select the vehicle and check that all of the vehicle rotation parameters are set to zero in order to make sure that the facing parameter is properly put in. Make sure the Current Time value is rewound back to zero so as not to enter accidental key frames.



Switch to the Modifiers card then hit the + icon and choose 'Wheels' from the list of modifiers.

Set the *Vehicle Faces* axis to match the direction in which the vehicle would move if it were to drive off straight ahead. In this example the vehicle will be driving in forward gear when it moves in the direction of the positive Y axis.

Click on the name fields and type in the name of the front wheels object and the separate rear wheels object.

Hit the *Check* button and the modifier will work

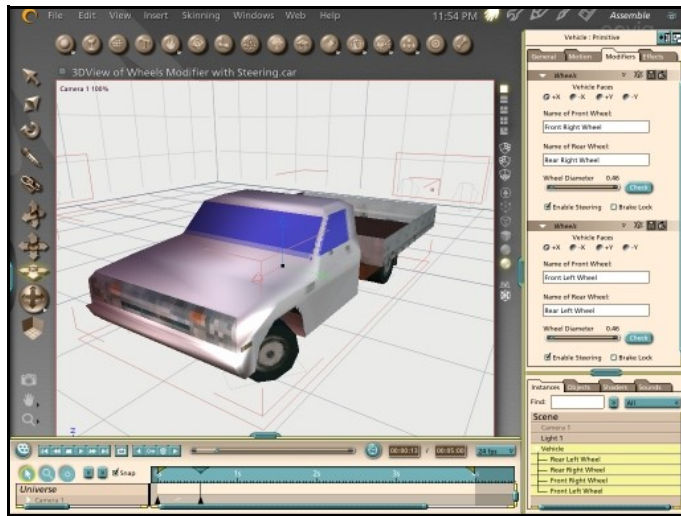
out the wheel diameter.

Leave the *Enable Steering* and *Brake Lock* options un-checked.

Now go forward a few seconds in time using the controls on the sequencer tray. Take a top view and move the car a short distance ahead in the Y axis. Rewind the time and hit play and watch the wheels spin as the vehicle moves. Position the camera up close alongside the car at time zero and then make the vehicle its parent to get the best view and run the animation again. If the wheels move too fast to see then edit the key frame value and move the vehicle over a shorter distance or longer time.

Vehicle Setup with Steering

In this example the vehicle is facing in the positive X axis and has four separate wheel objects. The hot point of each front wheel is moved inwards for more realism because they should not turn about their exact centre. The details of the rack and pinion, suspension and the steering knuckle and stub axle have not been included in this basic vertex model though.



The wheels modifier is applied twice to the vehicle. In both modifiers the *Vehicle Faces* direction is +X. The *Name of Front Wheel* and *Name of Rear Wheel* fields are filled with the names of all the four different wheel objects respectively - one modifier with the left side wheels and the other with the right. The *Check* button is clicked in each modifier to find out the wheel diameter. Most importantly tick the *Enable Steering* box. Do not forget to set the vehicle up at zero time.

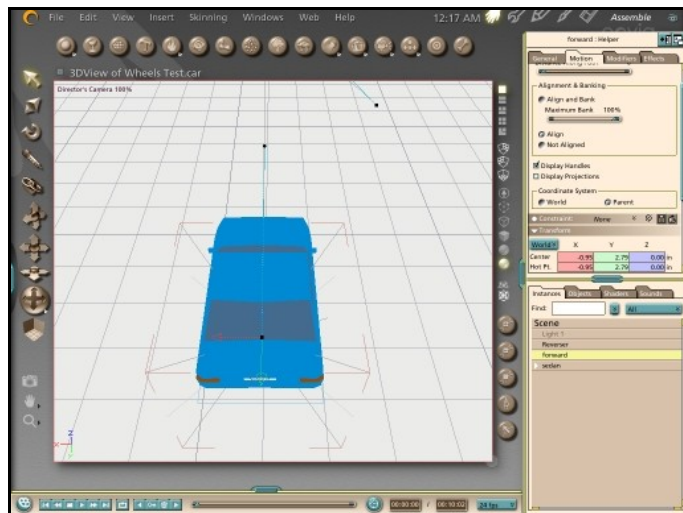
Unless a very tight turn is made quickly or over a short distance then the steering effect will

not be so noticeable. Go ahead half a second in time and make the car move a half length forward in +X and +Y and turn it 90°. Position the camera so that the front wheels can be seen, parent it to the vehicle and then play the animation. Use the time scrubber and the mouse to control the animation speed and watch the wheels turn and steer.

Note that whenever the vehicle is repositioned in the scene or rotated during editing that the wheels will turn. The front wheels may steer around oddly when using the rewind and forward buttons or the time scrubber. This is because the modifier uses the previous position and orientation of the vehicle to apply the steering. If many frames are skipped over then that previous orientation might be miles away or at the start of a U-turn so the wheels will steer around a full 180°. This is only temporary and the rotation of the wheels are not stored as key frames but worked out frame by frame. When the animation is played from start to finish it will be all right. However if only a partial section of a movie is rendered to file, say from 10:00 seconds to 20:00 seconds then the very first frame will have an unpredictable result. To get around this limitation render a single extra frame at the start and then remove it later when the final movie is put together. Also the steering is always straight on the first frame at time zero because it has no previous frame to compare with.

Working with Motion Paths

Vehicles are best animated by using motion paths - especially when driving around obstacles or corners. The vehicle can be aligned to the path to make turning easy and the speed is easy to control by using the *Distance Along Path* slider. By adjusting the course of a motion path and using the Wheels modifier almost no key frames are required. However there are a few tricks involved in getting motion paths to work.



Check the hot point of the vehicle itself. It should be in the lateral centre but somewhere closer to the rear wheels for a rear wheel drive car. Setting the vehicle hot point at ground or road level ($Z=0$) helps to make things simpler so that when the motion path is drawn it will all be at road level. The first point on a motion path traces out from the object's hot point. The motion path drawing tools will place all of the points onto the currently selected grid - which should be the XY plane. When the vehicle follows the motion path the hot point of the vehicle will jump onto the path and if the path is at $Z=0$ ground level then the vehicle will be buried into the

ground unless its hot point is at ground level. Also if the vehicle is driven up a slope it will be much easier to match a point to the road surface rather than estimating how high above the road to place it.

When a motion path is drawn tick the *Align* option to get the vehicle to stay pointing where the path is going. Carrara can't guess which way the user actually wants an object to be aligned on a motion path so it uses the orientation of the vehicle relative to the angle of the first spline handle. If the vehicle is facing in the negative Y axis then the first spline handle must also lie that way. If the vehicle is rotated arbitrarily in the first frame make sure the first spline handle is aligned with the front facing of the vehicle. If the vehicle starts by driving straight ahead in any direction then the first spline handle will be right on the motion path. If the vehicle is going to reverse down the path then the first spline handle must point to the back of the vehicle instead.

At the end of the animation set the distance along path slider and use a tweener to control the speed or put in key frame values to set where the vehicle should be on the path at what time.

To make a vehicle start by driving forward along a motion path and then stop and reverse requires a little trick. The vehicle can't change how it aligns itself with the direction of the motion path, but it can track the position and rotation of one target helper that is aligned forward then switch in the middle of the animation and track to a different target helper that is orientated in reverse. The first spline handle on the path of the forward target helper must be aligned to point in the same axis that the vehicle faces. The first spline handle on the path of the reverse direction target helper must be aligned with the opposite axis to the vehicle or be rotated 180° about the Z axis. The reverse motion path must have its starting point intersecting at the location on the forward motion path where the switch will take place. Add two Track modifiers to the vehicle. These must come first in the modifier list otherwise they will be processed after the Wheels modifier and be a frame behind the vehicle. Drag and drop the modifiers to move them higher up the modifier list. The target helper objects must also come before the vehicle in the scene hierarchy. Track the vehicle to the target helper with the forward motion path first. When it reaches the point in time where it switches into reverse gear set the distance along path slider for the forward target to the end and for the reverse target helper set the distance along path slider to its start. At the same frame disable the tracking of the forward target on the vehicle and enable tracking for the reverse target. A discrete tweener or key frames before and after the change over frame will be needed.

Problematic Vehicle Setups

If the geometry used to create the vehicle is rotated into position during its assembly then this complicates matters. Meshes imported from other modeling software might have the wheels lying flat on the XY plane, with the axel running though the Z axis. In a different case the wheel parts may have all been made using the spline modeler and have their axel aligned with the Y axis but an imported or vertex modeled vehicle may also face in the Y axis. All of these problems are easily overcome by grouping the parts. If all of the vehicle's pieces are gathered together into one group there should not be a problem with the facing. In cases where the vehicle is assembled but the parent body was rotated to fit then simply select it and group it - the group will have no rotation and work. Similarly if the wheels have been put together from many parts into a group and moved into position without rotation there should be no problem - otherwise simply select each wheel and then put it into a new group which is orientated with the world axes. If the wheels rotate around completely the wrong axis when the Wheels modifier is applied then make sure to rewind back to zero and check if the wheel objects have any kind of rotation set and if this is required for them to be assembled in the right position then group each wheel and change the modifier to name the new groups instead.

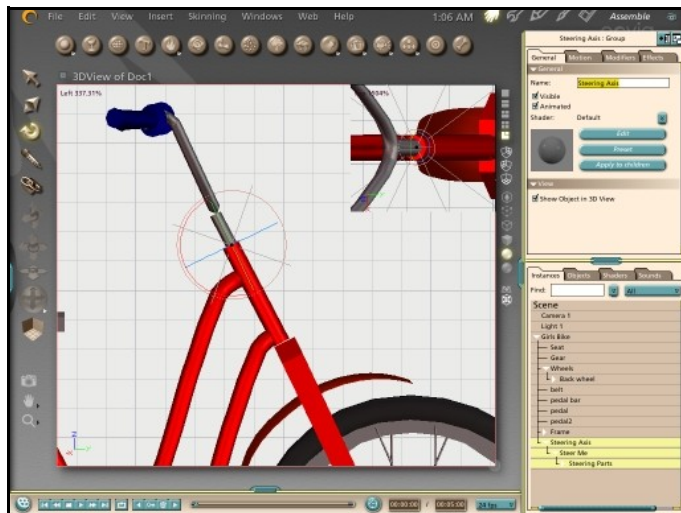
Where the wheels have been assembled on one side of the vehicle and then fitted on the other side by using a duplicate with symmetry operation this should not cause a problem with the vehicle facing, spin or steering.

Complicated Vehicle Setup

With a properly modeled motorbike or push bike the steering is 'castered'. The handle bars attached to the steering tube, need to turn the fork into which the front wheel is fitted - but these rotate around a slanted axis. The Wheels modifier always rotates the named front wheel about its local Z axis. In such cases an extra group at the correct angle and a target helper object in the right place are all that is needed to get the steering to work.

This example uses the 'Girlbike' from the Carrara 4 content CD which is found in the Transport folder. Although it takes a little time to setup consider how long it would take to accurately make all the parts move as the bike moves around freely by using manual rotations and key frames. The Wheels modifier, with some target helpers, can do everything except make the gear chain turn round.

This assembled whole bicycle group faces forward in the positive Y axis. Both the front and back wheels are already in separate groups with their axels align with the X axis so they are ready for the Wheels modifier to use. The hierarchy of this bike needs to have some parts re-arranged into suitable groups so that all of the parts which will steer are gathered together. The handlebars, fork, front fender and one of the pieces named Frame 2 (which is actually the steering tube) are selected and put into a new group 'Steering Parts' to which the assembled front wheel is parented.



If the new group were rotated about the Z axis now then the steering tube will not rotate inside the head tube as it should. To get all the steering parts to rotate on a slanted axis first insert a new target helper object into the scene. Use the side and top views and position the new target in the middle of the frame cylinders at the point where the steering tube fits into the head tube. Name the new target something like 'Steer Me'. With that steering target selected put it into a new group and call it 'Steering Axis'. Using a side view rotate the new 'Steering Axis' group, containing the target, until the Z axis is aligned with the steering tube and head tube. Drag the

group containing all the steering parts (handlebars, fork and wheel etc) onto the 'Steer Me' target to make it their parent. When the target is rotated about its local Z axis because it is now inside the correctly orientated group it will rotate about the slanted axis and so will all the steering parts attached to it. Make sure that the top 'Steering Axis' group is dragged into the bike so that its all assembled together again.

Select the whole bike group and apply the Wheels modifier. Set the first modifier up to get both the wheels to spin. Set the facing as +Y, name the Front wheel and Back wheel groups, then hit the check button to find the diameter. Do not enable the steering option for the wheels because it's the handlebars and fork that turn. Add a second Wheels modifier, set the facing as +Y and name the front wheel as the 'Steer Me' target. Ignore the diameter and leave it as the default because the brake lock option must be ticked to prevent the handlebars, fork and wheel from spinning around the X axis like a wheel when the bike moves. Tick the enable steering box. Now when the bike is moved around the scene the wheels will turn and the handle bars will steer.

Add a third Wheels modifier to the bike to make the pedals work as well. This isn't so straight forward because the pedal bars need to spin round but the pedals themselves should stay more or less flat and remain parallel with the road. Add a target helper object for each of the pedals, positioned right over the hot point of the pedal, then parent the target helper to the pedal bar, giving each a unique name like 'right pedal tracker'. Track each of the pedals to their target helper in X,Y and Z but do not track rotation. Apply the extra Wheels modifier to the bike and again set the facing as +Y. Leave the front wheel name blank and put the pedal bar object in as the rear wheel name. Look at the value used for the actual wheel

diameter in the first modifier and type this value in for the pedals rather than using the check button. This way the pedals will turn round at the same rate as the wheels. Adjust the wheel size using a discreet tweener during an animation to make a gear change. Increasing the wheel size parameter will make it appear as though a lower gear is used and decreasing it a higher gear.

In Carrara 5 users with Poser figures can really have some fun with the modifier now. Carrara 4 and 5 users can apply this method to any suitable figure with skin and bones and inverse kinematics. Both of the hands can use IK and track to the handlebars and both feet track to the pedals and this will do all the work of animating the cyclist.

Import the figure into Carrara 5 using the 'Native Importer' mode and the *Import IK Chains* option must be ticked. The default Poser 'favoured IK angles' for most figures are in poorly 'memorised' positions and figures tend to spread their knees out rather than bending them. These could be easily adjusted and saved in Poser - *however Carrara 5 seems to ignore them*. Therefore the joint constraints of the thighs may need adjusting to severely limit rotation in the Y and Z axes and increase the rotation in the X axis to allow the knees to raise higher and get good results. Constraints can be animated though so there is some flexibility in Carrara to set the right IK for the right movement.

Scale the figure to be in proportion with the bike and move them into position sitting on the seat. Drag the figure onto the bike in the scene hierarchy to make it a child so that when the parent bike moves the sitting figure moves with it. The figure must be the last object in the bike group hierarchy so that they will respond to the final position of the bike parts controlled by the Wheels modifier each frame. Using the IK target objects, move the hands into position on the handlebars and the feet onto the pedals. The IK target objects can be rotated to get the hands and feet at the right angles.

For the best results apply track modifiers to each of the figure's IK targets. Since these will track hot point to hot point and the hot point for the hands is at the wrist rather than in the palm then more target helper objects must be added. Insert a new target helper, name it 'right handlebar hold' and move it into position right on top of where the hot point of the right hand is. Now add a track modifier to the right hand IK target and track that to the 'right handlebar hold' in X,Y and Z. In the hierarchy list, drag the new target helper onto the handlebar itself so that as a child it moves and maintains its distance when the handlebars steer, thus keeping the hand that tracks it holding onto the handlebar. Use the same method for the other hand and then for both the feet, the hot point for them is at the ankle. The advantage of using a track modifier rather than parenting the IK targets directly is that the track can be disabled and then the figure is free to move away from the bike. If the figure's legs do not animate smoothly check the constraint settings for the thighs.



Tips and Tricks

- Use the modifier for a 2-wheeled cart and simply leave the *Name of Front Wheels* field blank.
- When using the modifier on a tractor or vehicle where the wheels are different sizes, apply a second wheels modifier to the larger rear wheel.
- Add an extra Wheels modifier to get a steering wheel turn as the vehicle does. Since the modifier always turns a wheel around its Z axis an additional target object and group aligned with the steering column will be required. Refer to the [complicated vehicle setup example](#) above for guidance. Adjust the wheel diameter slider to get the steering ratio correct.
- Because names are used rather than relying on the scene hierarchy, wheels don't necessarily have to be children of the parent or move with the vehicle. For example use the Wheels modifier to have a falling counterweight spin a master gear.
- Animate the wheel diameter slider to trick the modifier into spinning the wheels faster or slower and simulate traction. Since the modifier overrides any other rotation it is not possible to make the wheels spin on the spot for when the vehicle is stuck in the mud or doing a burnout. Get around this for now by putting each wheel into a group and then use the group name in the wheels modifier instead. Make sure to set the hot point of the parent group to the centre of the wheel. The wheel will spin round properly when its parent does but you can then freely spin the wheel inside the group.

Planned Improvements

- Version 1.0 release for Carrara 5 will have name buttons and invoke the scene dialog to select the wheels rather than naming them.
- Version 1.0 may include pre-calculation for when the render animation does not commence at 0:00 time.
- To include a traction override user slider so that the wheels can be spun faster, slower or without the car moving.
- To have each steered wheel not turn exactly in parallel, using the tangent curve of the hot point of the turning vehicle, but their own tangent to the curve.
- To allow the user to set a degree of maximum wheel lock for when the car is made to spin out of control, currently there is no limit
- To include a steering override so the user can adjust the initial or stationary position of the front wheels
- A later version to implement suspension with collision detection when going over bumps in the road.

Support

Sparrowhawke3D is an amateur project so I can't make any promises regarding support, however I'm keen to improve my simple practical plug-ins and share them with the Carrara community.

The Wheels modifier plug-in is absolutely free, you can use it in any project, commercial or otherwise. You may not repackage and sell the modifier.

For comments, feedback and suggestions email me, Jeremy@Sparrowhawke3D.com.