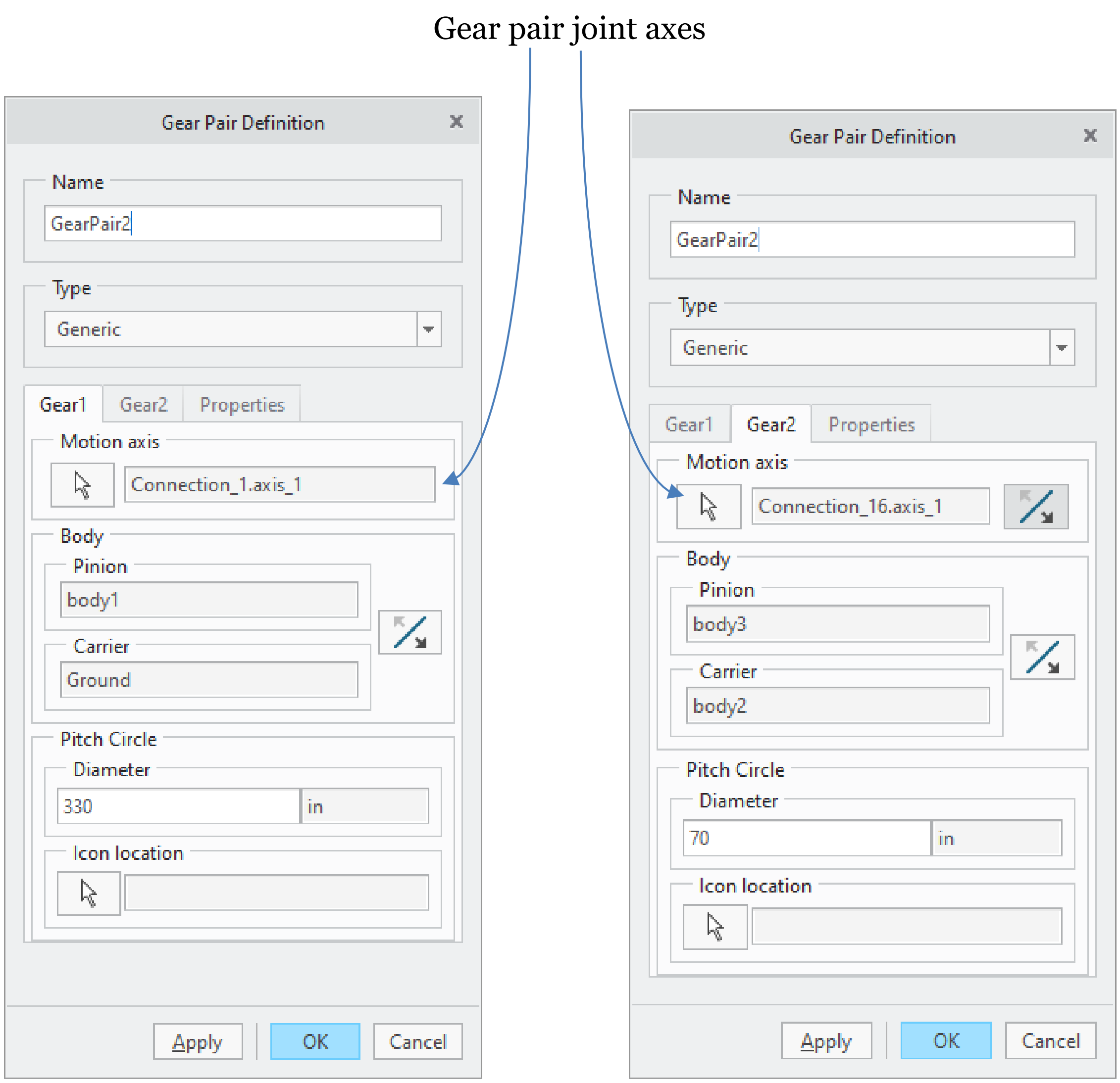
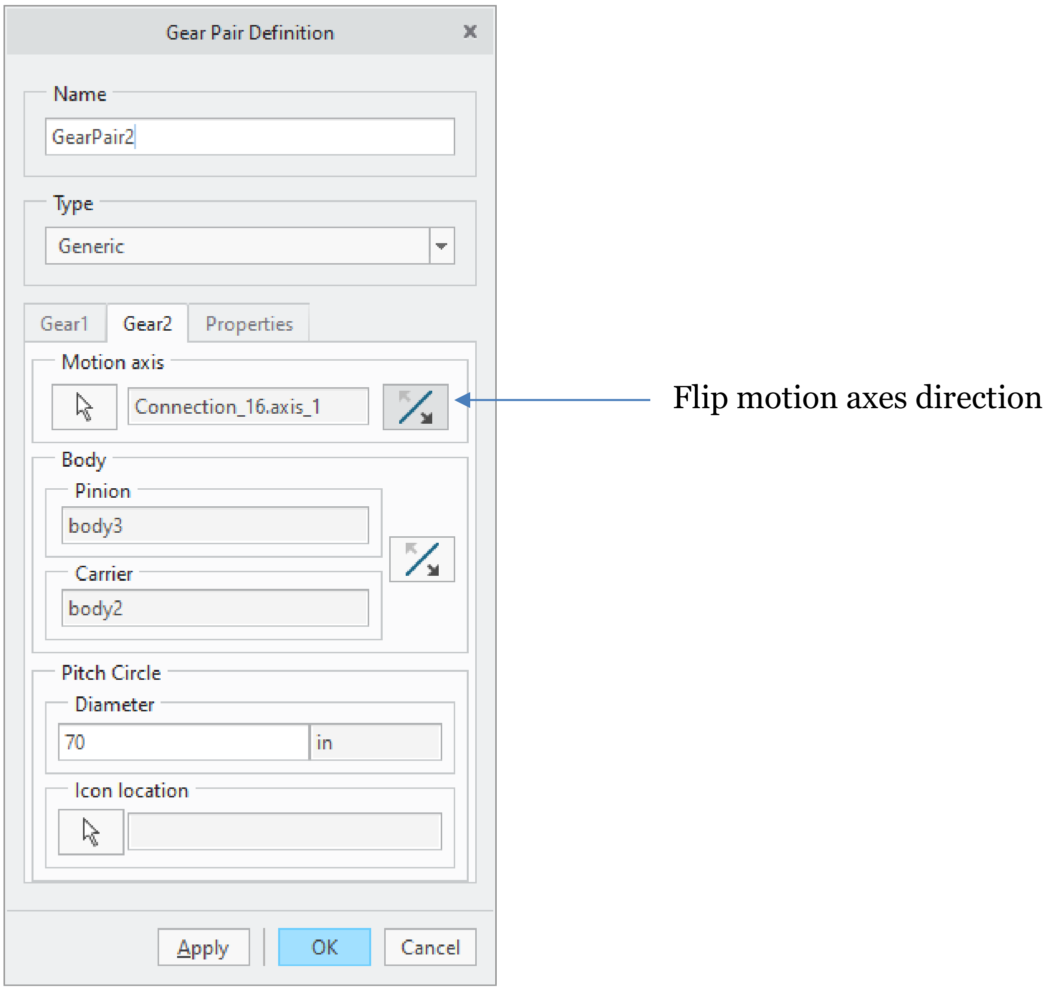
Using Common Carrier Body for Modeling Gears in Creo Mechanism

In Creo Mechanism Gears are modeled as joint axis constraints. This means that a gear pair constrains the two joint axes of the gear pair to move in a certain way with respect to one another. It should be noted that gears are not modeled as contact constraint acting between gear teeth.[1]



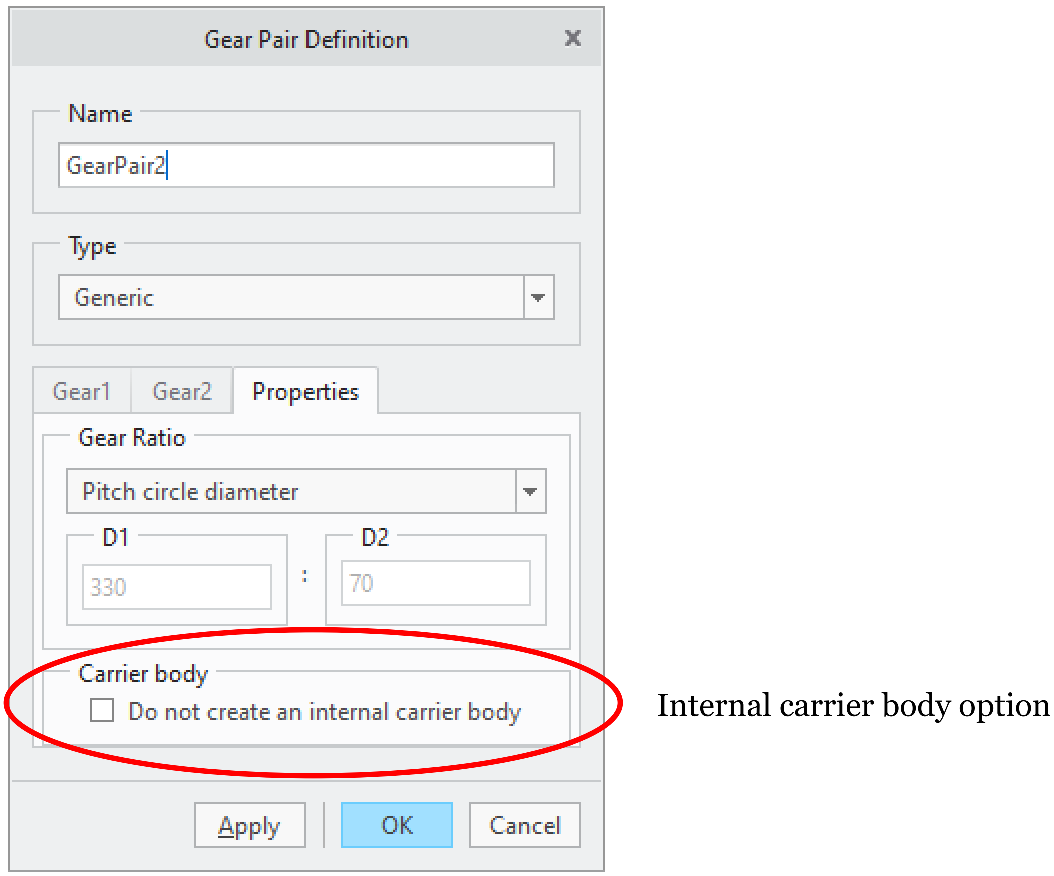
[1] Creo Mechanism does ask for gear tooth parameters such as helix angle, bevel angle, etc., if the user chooses a non-generic gear type. However, these parameters are merely used to calculate gear forces from the gear axis constraint forces. The presence of these parameters does not mean that gear teeth are modeled in Creo Mechanism.

In the real world of course gears are not joint axis constraints, but involve teeth in contact. The Creo Mechanism model of the gear therefore represents a simplification of the real physical phenomenon of gear teeth in contact. As with any such idealized model of a physical phenomenon, sometimes adjustments are needed to the model to adequately represent the actual phenomenon. Creo Mechanism allows for several such adjustments to be made in the gear model. For example, one such adjustment allows the user to flip the direction of the Gear2 motion axis, depending on which direction the gear movement is desired.

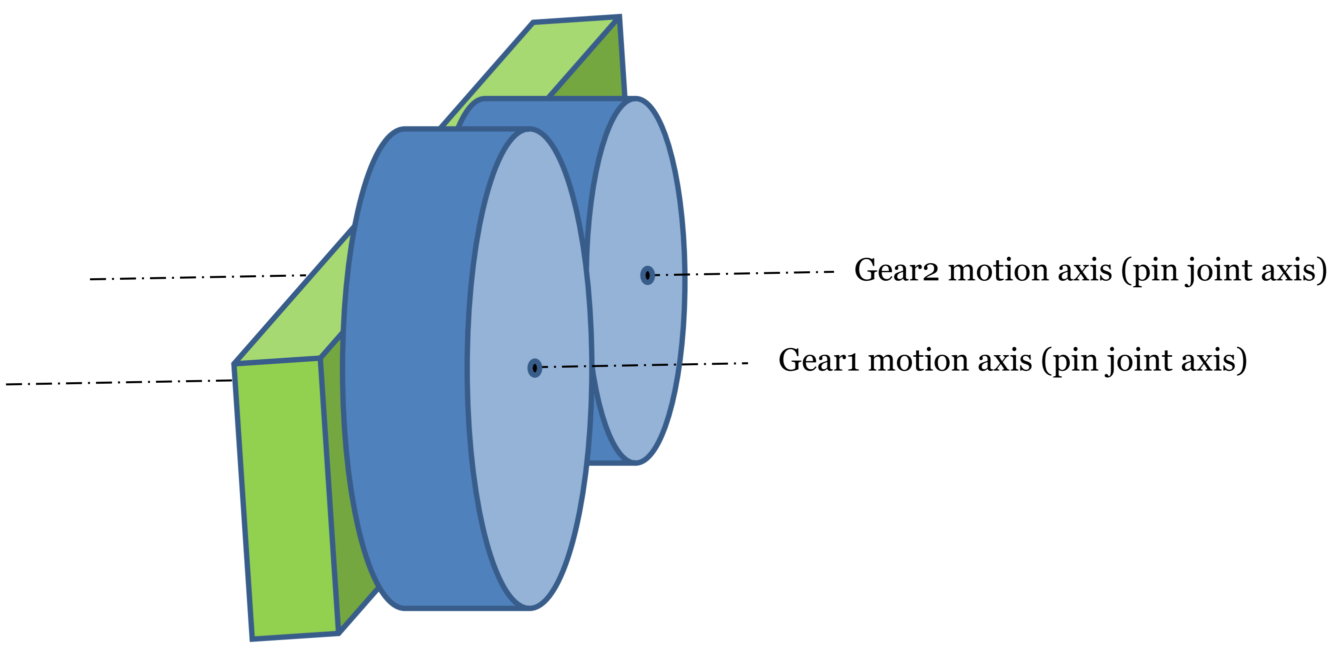


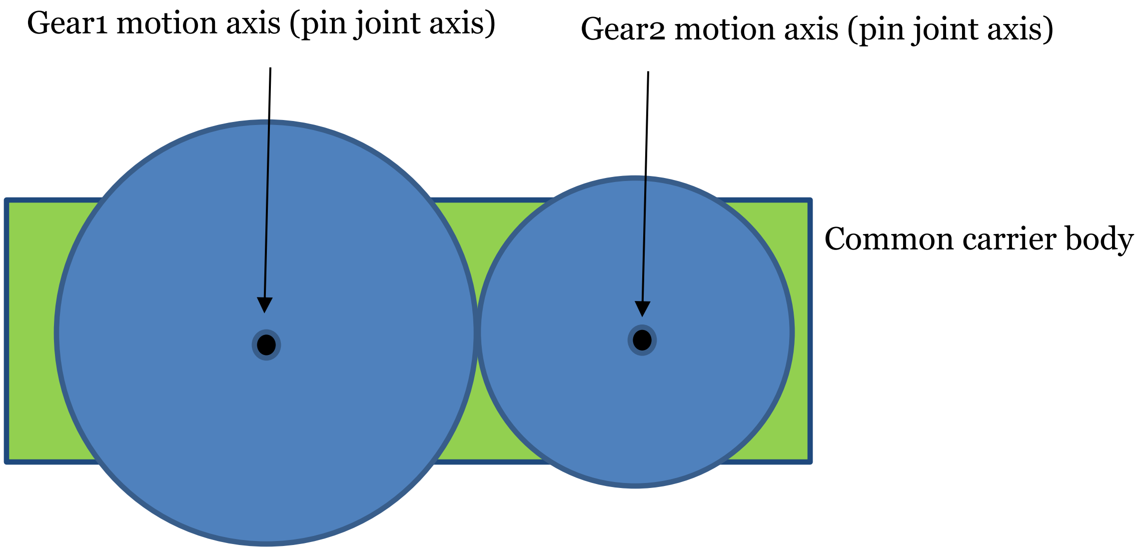
Another very important adjustment that the user can make in the gear model is to allow or disallow the creation of an internal common carrier body. It is seen that proper use of this adjustment makes the model in question work better. The option to allow or disallow the creation of an internal carrier body appears in the Gear Pair Definition dialogue. The box is unchecked by default (meaning that an internal carrier body will be created if there is no user-created common carrier body).

The rest of this document is devoted to explaining this “internal carrier body” option.

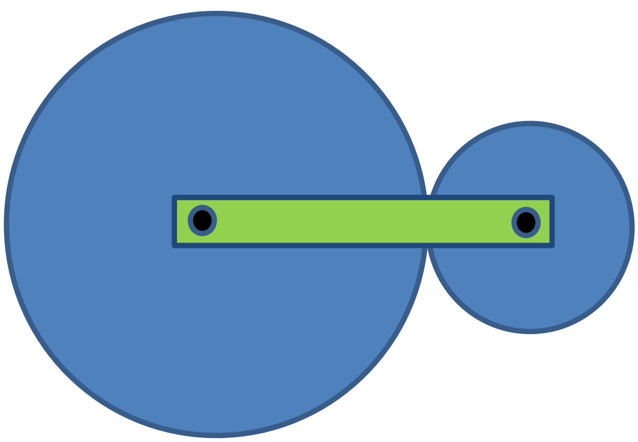


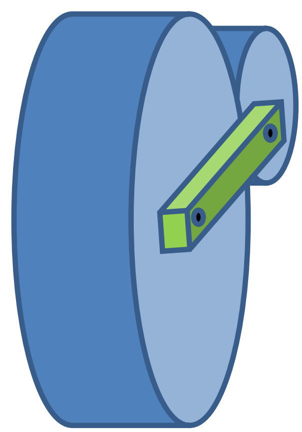
Consider the gear model below in Creo Mechanism. Two views of the model are shown below. Note that teeth are not necessary since gears are modeled in Creo Mechanism as motion axis constraints.





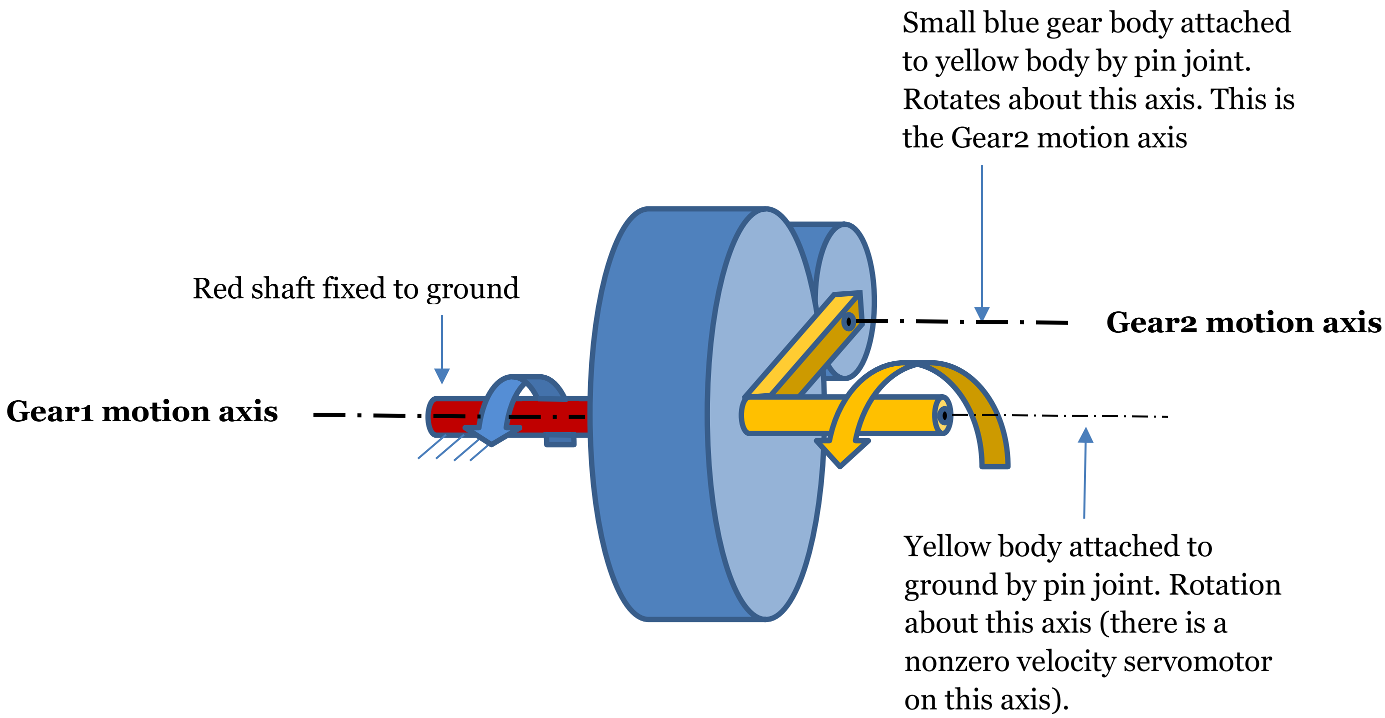
In the example shown above it is clear that this carrier body (the green body) is the same for both the gear bodies. Another gear model is shown in the figures below.



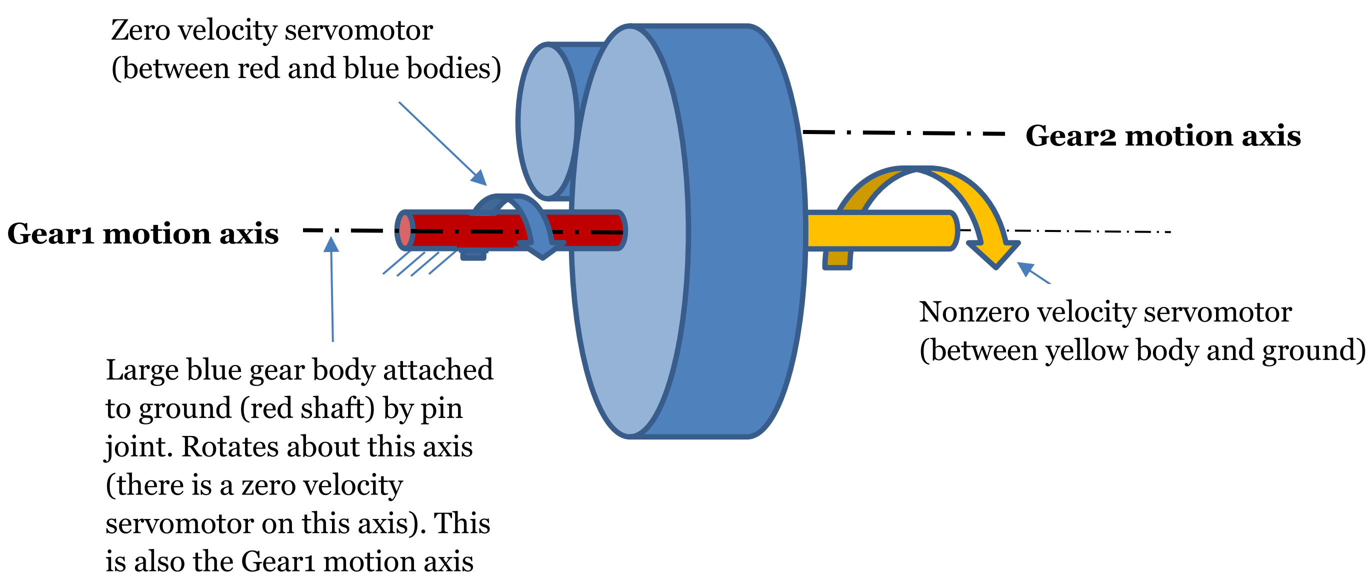


The above two models are very similar in terms of having a common carrier body (the green body in both cases). The gear model in Creo Mechanism behaves as one would expect from observing actual physical gears in the real world.

Now, consider a different gear model shown below (2 figures showing 2 views).



Two views of the same model above and below



In the above model:

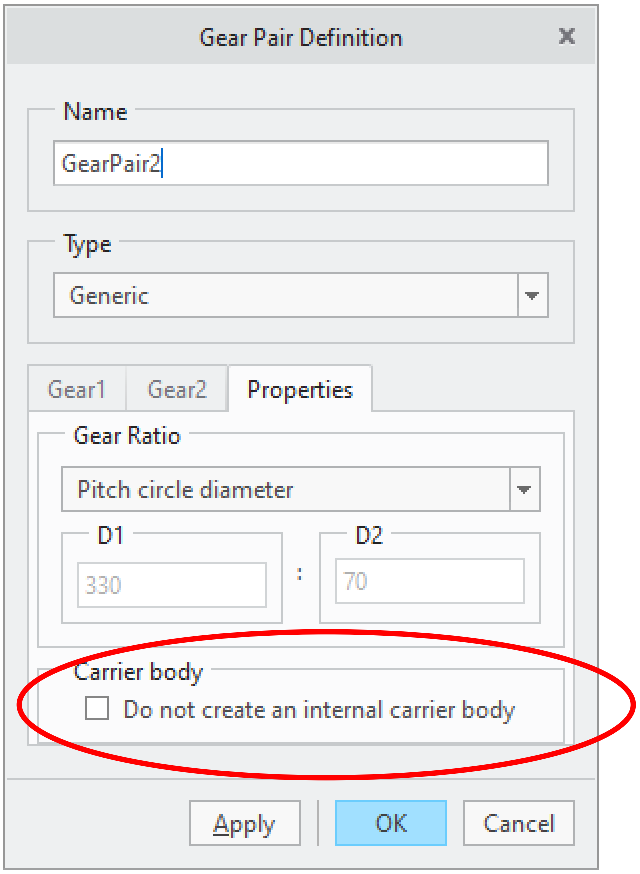
- The two blue bodies represent gear bodies, which in the real world would have teeth.
- The two gear motion axes are:
  - Gear1 motion axis is the pin joint axis between the larger blue body and the ground-fixed red shaft.
  - Gear2 motion axis is the pin joint axis between the smaller blue body and yellow body.
- The carrier bodies for the two gears are not the same. For Gear1 the carrier body is the ground-fixed red shaft. For Gear2 the carrier body is the yellow body, which is connected to the ground by a pin joint.
- The gear ratio is the ratio of the diameters of the two blue bodies.
- A zero velocity servomotor is applied to the pin joint axis between the larger blue body and the ground-fixed red shaft.
- A non-zero velocity servomotor is applied to the pin joint axis between the yellow body and the ground.

Suppose the gear pair is modeled as a simple ratio between the two gear motion axes, i.e, in the form

Gear2 motion axis velocity = (gear ratio) x (Gear1 motion axis velocity)

What will happen if an analysis is run? Since the Gear1 motion axis has zero velocity (because of the zero velocity servomotor), the Gear2 motion axis will also have zero velocity. This means that there will be no relative motion between the small blue gear body and the yellow body. This behavior is not right, because in a real-life gear pair of this configuration we would expect the Gear2 motion axis to have non-zero velocity when the yellow body is rotated by the non-zero velocity servo motor.

Because of this kind of problems with the idealized gear model, Creo Mechanism has the option of creating a internal common carrier body if there is no user created common carrier body for a gear pair. By default, this a common carrier body is created if a common carrier body does not already exist. However, the user can check the “Do not create internal carrier body” option, which means that an internal common carrier body will not be created even if there is no user-created common carrier body.



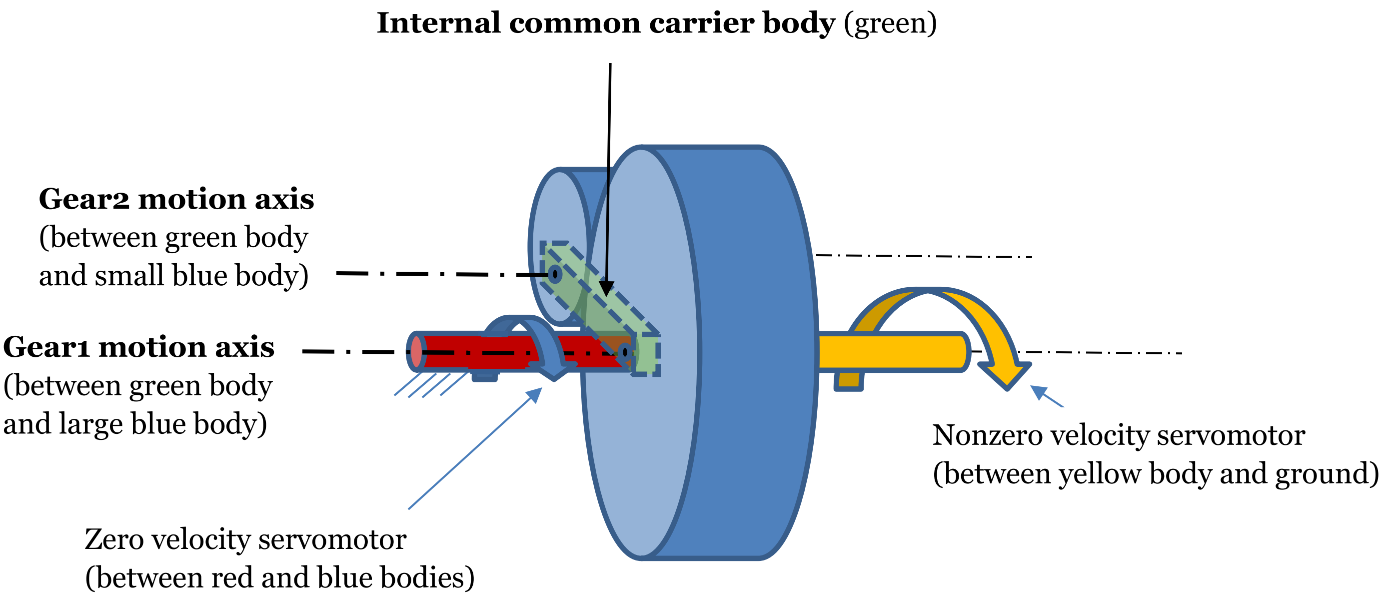
Internal carrier body option

When an internal carrier body is created, a new body is created that serves only a kinematic function (its inertial effects are negligible). New joints are created that connect the internal carrier body to each of the two gear bodies. These new joints are defined such that the axes of these new joints coincide with the user-defined gear motion axes. The motion of the gear bodies with respect to the internal common carrier body is now used to enforce the gear constraint. So, for the gear constraint,

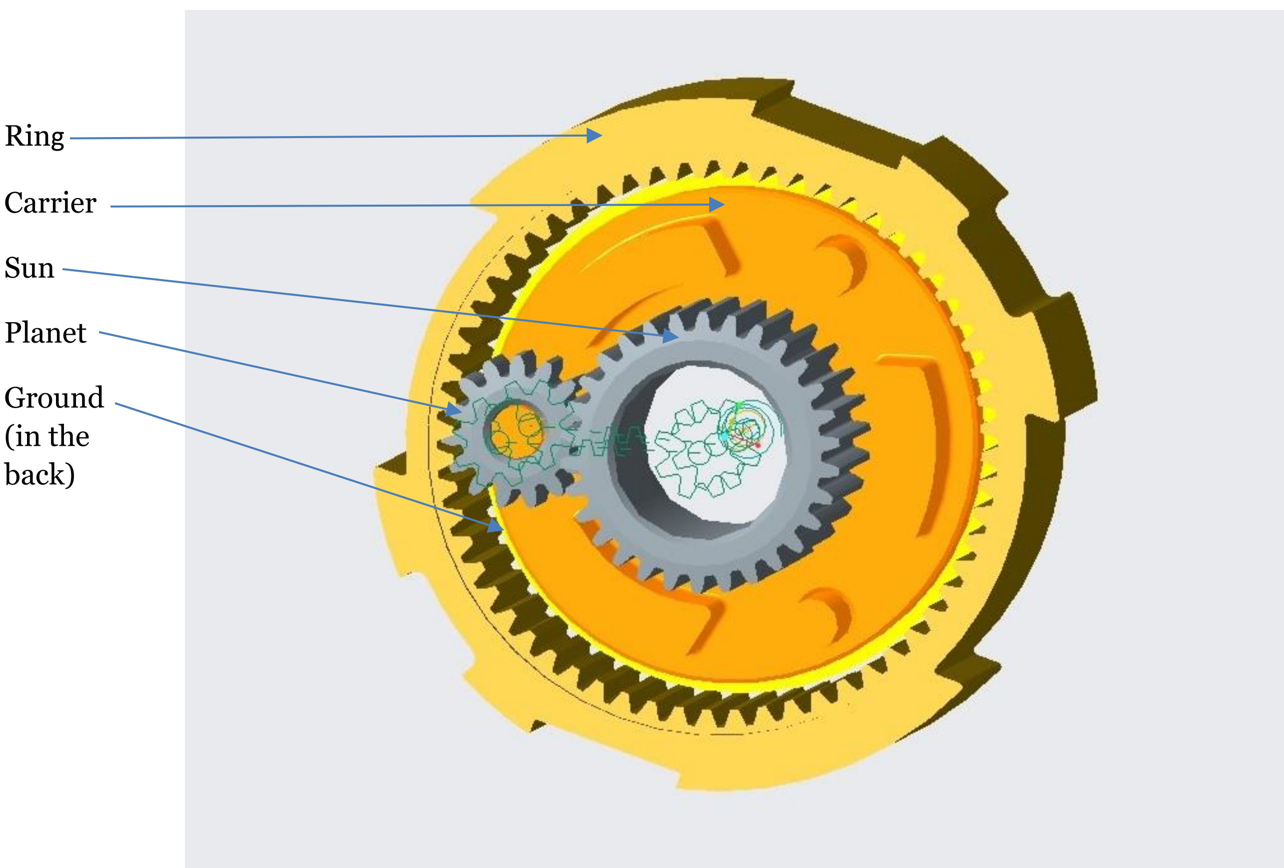
Gear2 motion axis velocity = (gear ratio) x (Gear1 motion axis velocity)

Gear1 motion axis velocity is now the velocity of the Gear1 body with respect to the internal common carrier body, while the Gear2 motion axis velocity is now the velocity of the Gear2 body with respect to the internal common carrier body.

When the internal common carrier body is used, the above model behaves as one would expect from observing a real-life toothed gear pair.



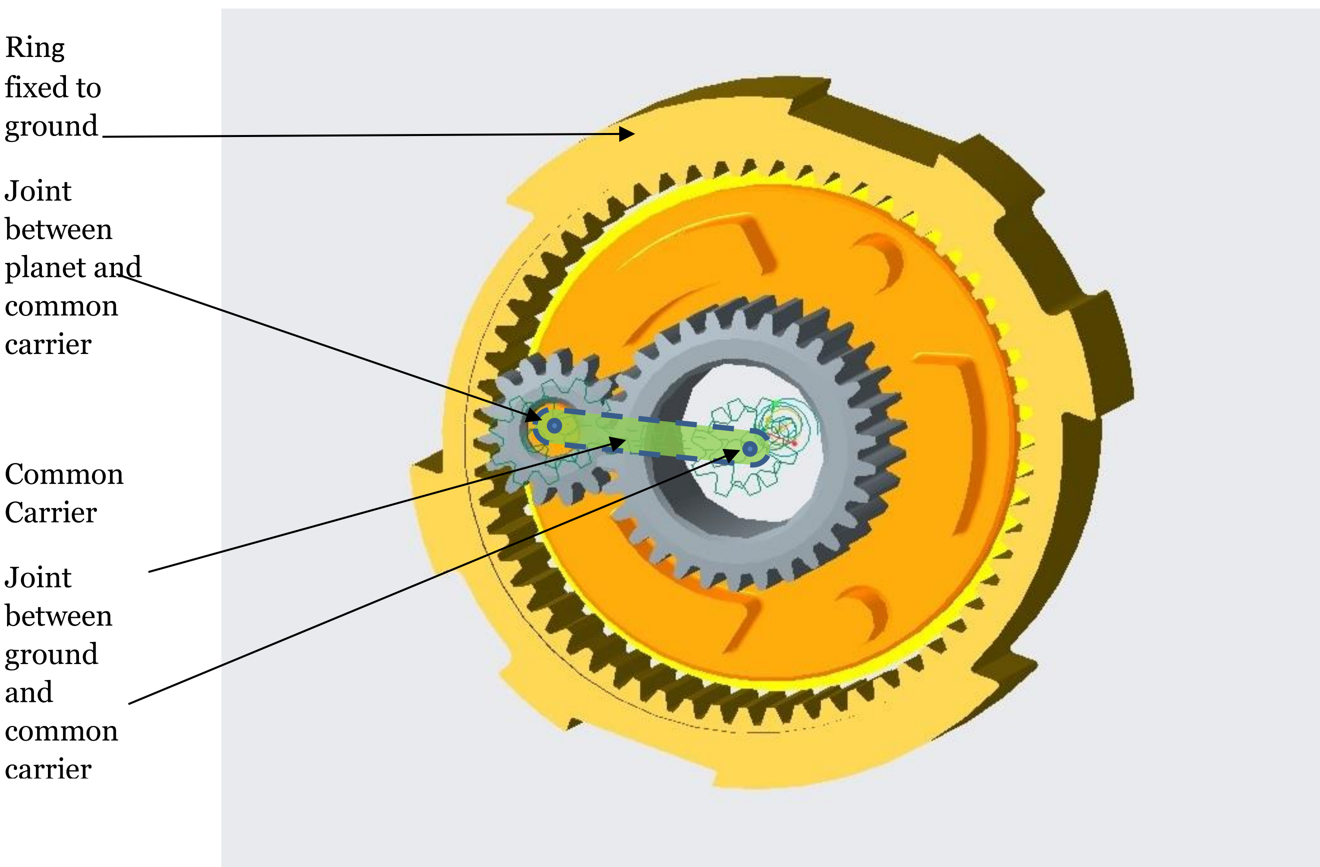
Consider the planetary gear model shown below.



Creo Mechanism analyses are run for two different configurations:

1. Configuration 1: The ring is fixed to the ground by a zero velocity servomotor. The carrier body is free to rotate.
2. Configuration 2: The carrier body is fixed to the ground by a zero velocity servomotor. The ring is free to rotate.

In both the above configurations, there is no user-defined common carrier body for either of the two gear pairs in the model. So, by default, Creo Mechanism creates an internal common carrier body for each gear pair. For configuration 1 this is exactly what is required. With the internal common carrier body, the behavior of the model is as expected. However, for configuration 2, the behavior is not as expected. This is because of the internal common carrier body.



In the above model, the sun is driven by a non-zero velocity servomotor. The sun drives the planet through one set of gears. The internal carrier body does not cause any problem in this set of gears. But there is a second set of gears, which also does not have a user-defined common carrier body. The internal carrier body that is introduced by default in the second gear pair is as shown above (green body). It is evident that if the planet to rotates, the gear constraint will cause the internal carrier body (green body shown above) to rotate about the joint connecting it to the ground. In Configuration 2 where the carrier body is fixed to the ground, it is clear that any attempt to rotate the internal carrier body about its joint with the ground will cause the analysis to fail. In order for the analysis to run currently in Configuration 2, the " Do not create internal carrier body" must be checked. In addition, in Configuration 2 the Gear2 motion axis direction needs to be flipped. After these modeling changes are made, the analysis runs properly and shows the same motion as real-life toothed gears.