Gears App

Modeling a Compound Planetary Gearset

https://drivetrainhub.com

Overview

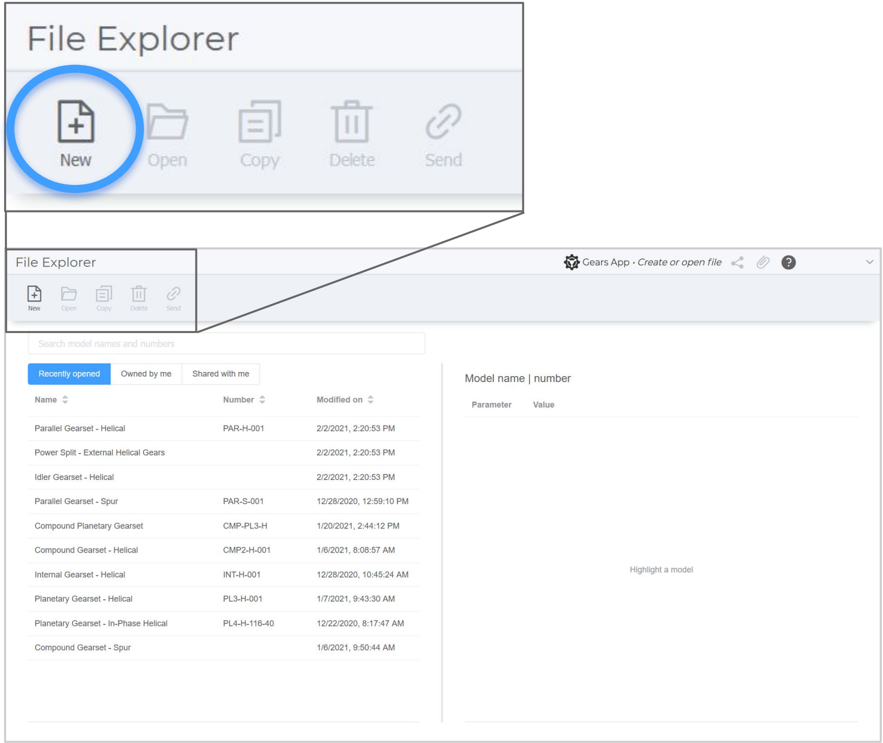
Learn how to model a compound planetary gearset and simulate its powerflow.

Table of Contents

MODELING

Create Model

1. In a web browser, open [Gears App](#).
2. By default, the **File Explorer** will open to manage any existing models.
3. Create a new model by clicking the **New** ribbon button.
4. Once the new model opens, click the **Model Info** ribbon button to edit the model *name*.



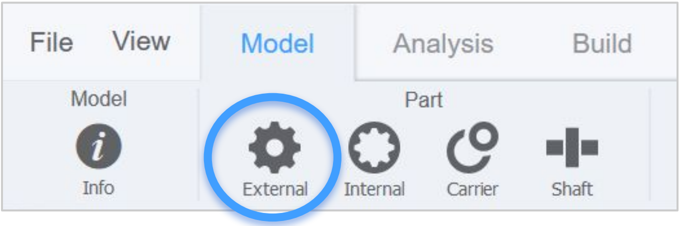
TIP: Firefox or Chrome internet browser is recommended.

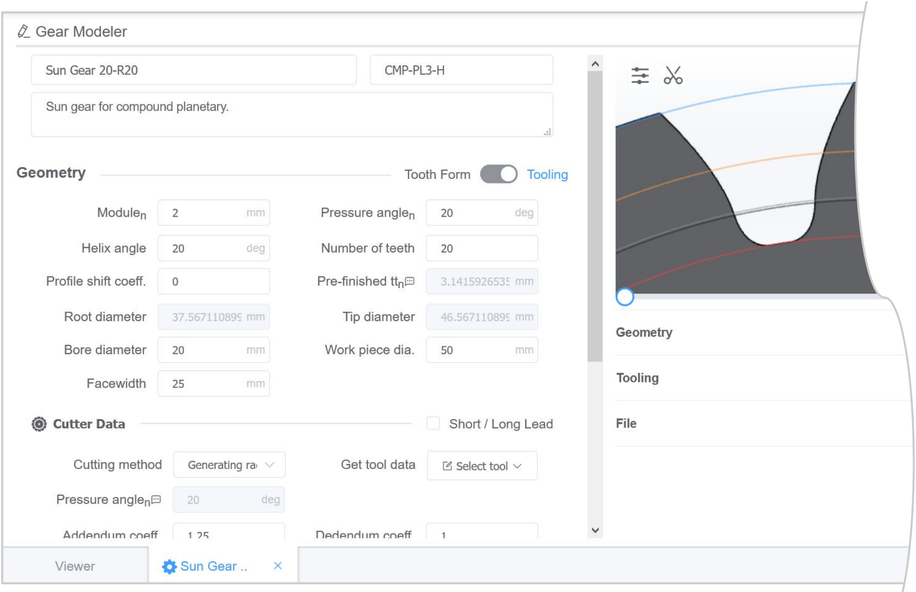
Create Gears

1. To create a new gear, from the **Model** ribbon tab, click the **External** button.
2. A new **Gear Modeler** tab opens.
3. Define the *Sun Gear* as specified on slide 7 and click ✓ to accept.
4. Repeat these steps for the *Planet Pinion* and *Planet Wheel*, per slide 8. Three (3) instances of each gear will be used, as shown later.

HINT: Every gear created is automatically added to the Gear Library, an organization-wide collection of gears.

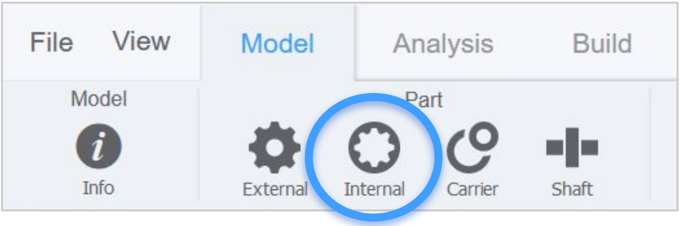
TIP: To insert a gear previously created, go to the Gear Library, find the gear, and click **Insert**.

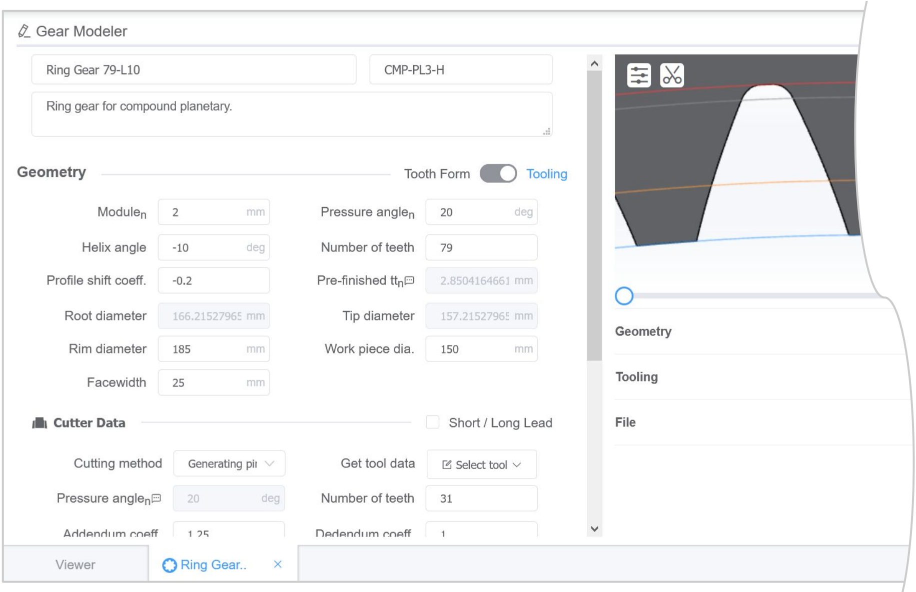




Create Ring Gear

1. To create a new gear, from the **Model** ribbon tab, click the **Internal** button.
2. A new **Gear Modeler** tab opens.
3. Define the *Ring Gear* as specified on slide 7 and click ✓ to accept.





HINT: Every gear created is automatically added to the Gear Library, an organization-wide collection of gears.

TIP: To insert a gear previously created, go to the Gear Library, find the gear, and click **Insert**.

Gear Geometry

HINT: See our notebook on planetary gears for help calculating valid tooth counts in a planetary gearset.

Name	Sun Gear	-
Module$_n$	2	mm
Pressure angle$_n$	20	deg
Helix angle	20	deg
Number of teeth	20	-
Profile shift coeff.	0	-
Bore diameter	20	mm
Work piece dia.	50	mm
Facewidth	25	mm

Cutter Data

Cutting method	Rack generation	-
Pressure angle$_n$	20	deg
Addendum coeff.	1.25	-
Dedendum coeff.	1.00	-
Protuberance size	0	mm
Protuberance angle	0	deg
Tip radius coeff.	0.25	-

Name	Ring Gear	-
Module$_n$	2	mm
Pressure angle$_n$	20	deg
Helix angle	-10	deg
Number of teeth	79	-
Profile shift coeff.	-0.2	-
Rim diameter	185	mm
Work piece dia.	150	mm
Facewidth	25	mm

Cutter Data

Cutting method	Pinion generation	-
Pressure angle$_n$	20	deg
Number of teeth	31	-
Addendum coeff.	1.25	-
Dedendum coeff.	1.00	-
Protuberance size	0	mm
Protuberance angle	0	deg
Tip radius coeff.	0.25	-

Gear Geometry

HINT: See our notebook on planetary gears for help calculating valid tooth counts in a planetary gearset.

Name	Planet Wheel	-
Module$_n$	2	mm
Pressure angle$_n$	20	deg
Helix angle	-20	deg
Number of teeth	37	-
Profile shift coeff.	0	-
Bore diameter	20	mm
Work piece dia.	85	mm
Facewidth	25	mm

Cutter Data

Cutting method	Rack generation	-
Pressure angle$_n$	20	deg
Addendum coeff.	1.25	-
Dedendum coeff.	1.00	-
Protuberance size	0	mm
Protuberance angle	0	deg
Tip radius coeff.	0.25	-

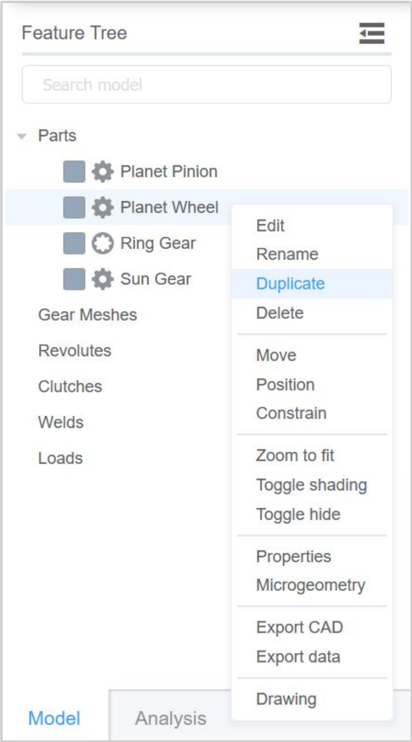
Name	Planet Pinion	-
Module$_n$	2	mm
Pressure angle$_n$	20	deg
Helix angle	-10	deg
Number of teeth	19	-
Profile shift coeff.	0	-
Bore diameter	20	mm
Work piece dia.	45	mm
Facewidth	25	mm

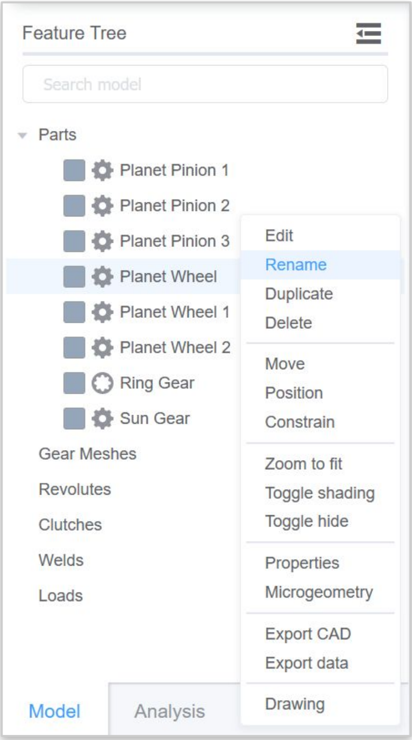
Cutter Data

Cutting method	Rack generation	-
Pressure angle$_n$	20	deg
Addendum coeff.	1.25	-
Dedendum coeff.	1.00	-
Protuberance size	0	mm
Protuberance angle	0	deg
Tip radius coeff.	0.25	-

Duplicate Planets

1. Add two (2) more instances of *Planet Wheel* to the model by right-clicking it in **Feature Tree** and select *Duplicate*.
2. Notice the duplicate planet gears appear in the **Feature Tree**.
3. For clarity, rename each planet by right-clicking it in the **Feature Tree** and select **Rename** as shown on right.
4. Also create two (2) more instances of *Planet Pinion* and rename each.

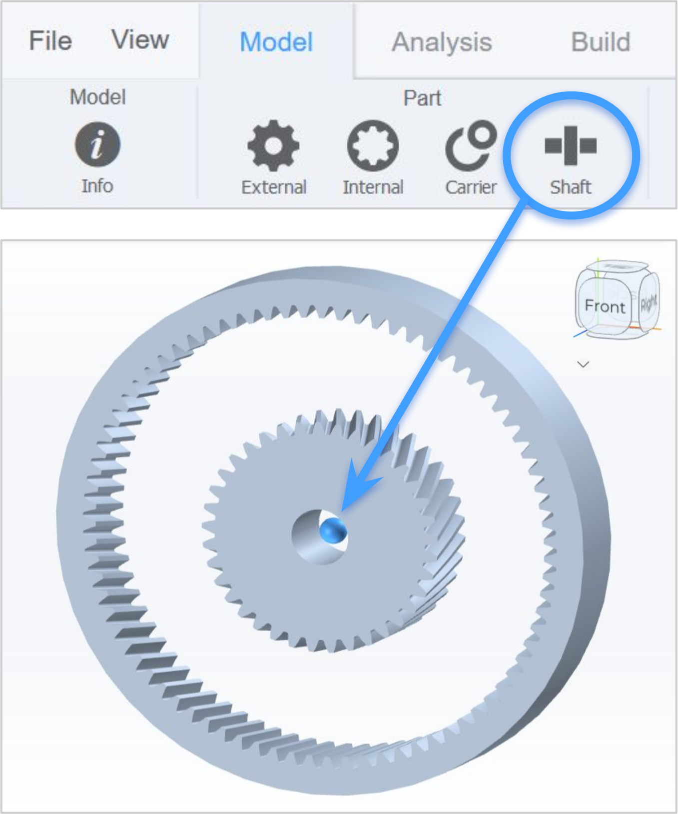




HINT: Duplicate gears reference the same library gear. Changes to any instance of the gear affect all references.

Create Shafts

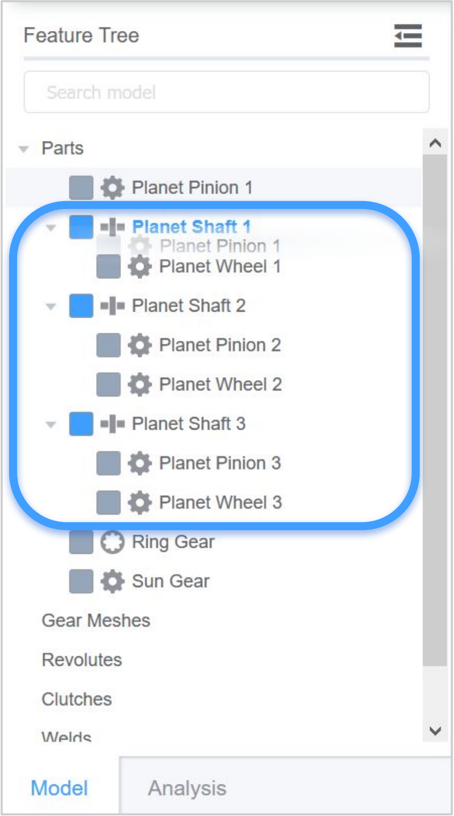
1. To create a new shaft, from the **Model** ribbon tab, click the **Shaft** button.
2. A new shaft is added to the model, as shown in **Feature Tree** and **3D Viewer**.
3. Add two (2) more shafts to the model.
4. For clarity, you may rename each shaft by right-clicking it in the **Feature Tree** and select **Rename**.
    a. Planet Shaft 1
    b. Planet Shaft 2
    c. Planet Shaft 3



HINT: Shafts are conceptual with no geometry to edit. A shaft origin is represented by a sphere in 3D Viewer.

Create Subassemblies

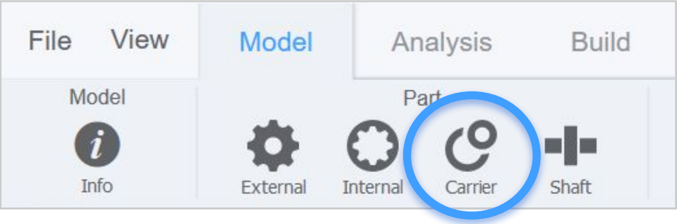
1. To create a planet subassembly, we will add planet gears to a shaft.
2. In the **Feature Tree**, drag-and-drop a *Planet Wheel* onto its respective *Planet Shaft*.
3. Repeat above for the *Planet Pinion*.
4. Repeat for each planet subassembly.

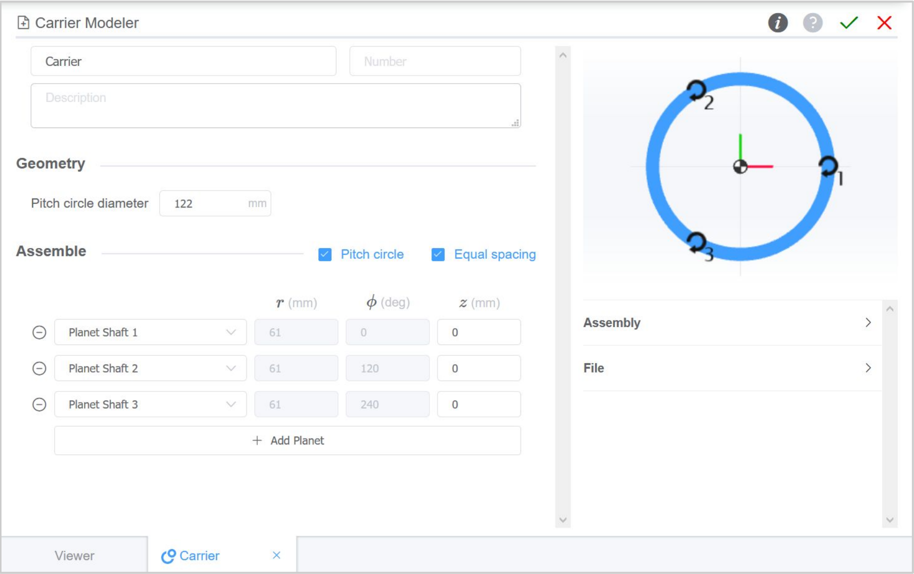


HINT: By default, gears are positioned at the shaft origin.

Create Carrier

1. To create a carrier, from the **Model** ribbon tab, click the **Carrier** button.
2. A new **Carrier Modeler** tab opens.
3. Specify a *name* and optionally a *number* and *description*.
4. Specify a *pitch circle dia* of 122mm.
5. Click the **Add Planet** button three times and select each *Planet Shaft* from the dropdown menus.
6. Click ✓ in upper right to create carrier.



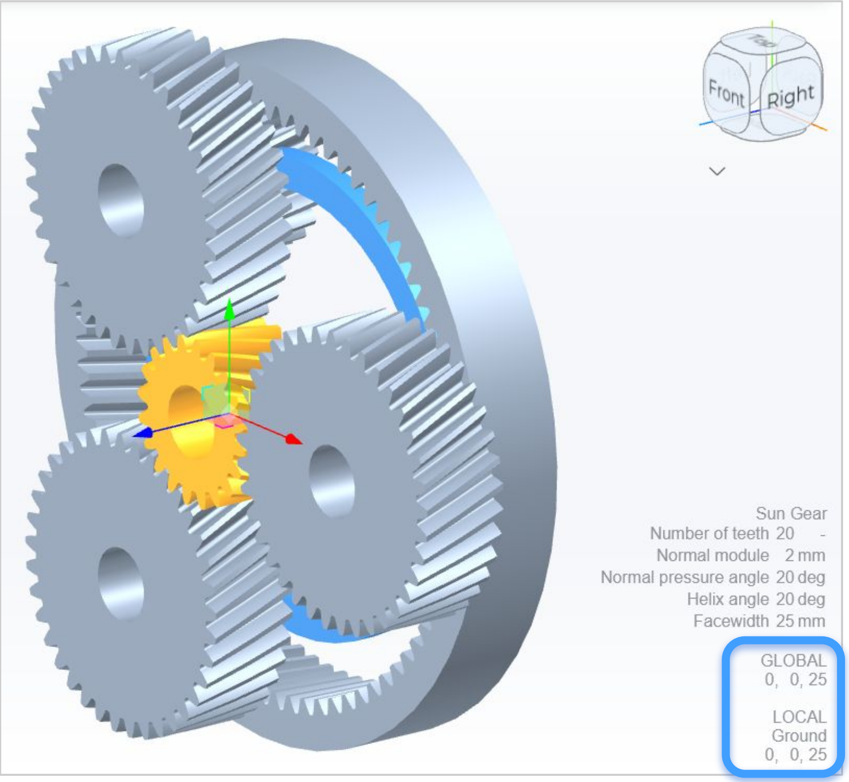


HINT: Carriers are rotational reference frames with eccentrically mounted parts.

Position Gears

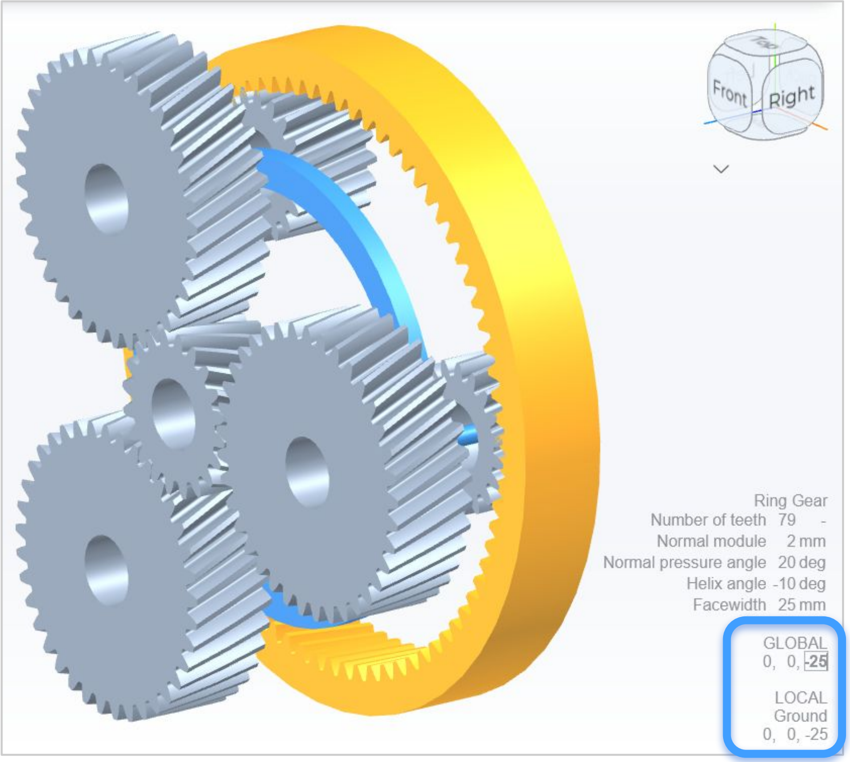
1. Right-click the *Sun Gear* in **3D Viewer**, and select **Move**.
2. A triad appears at the gear origin.
3. Drag its z-axis (blue) to 25mm per the display in lower right.
4. Repeat this for each *Planet Wheel.*
5. Press Esc to exit the move tool.

HINT: The *Move* tool uses increments of 0.5mm to interactively position a part in the *3D Viewer*.



Position Gears

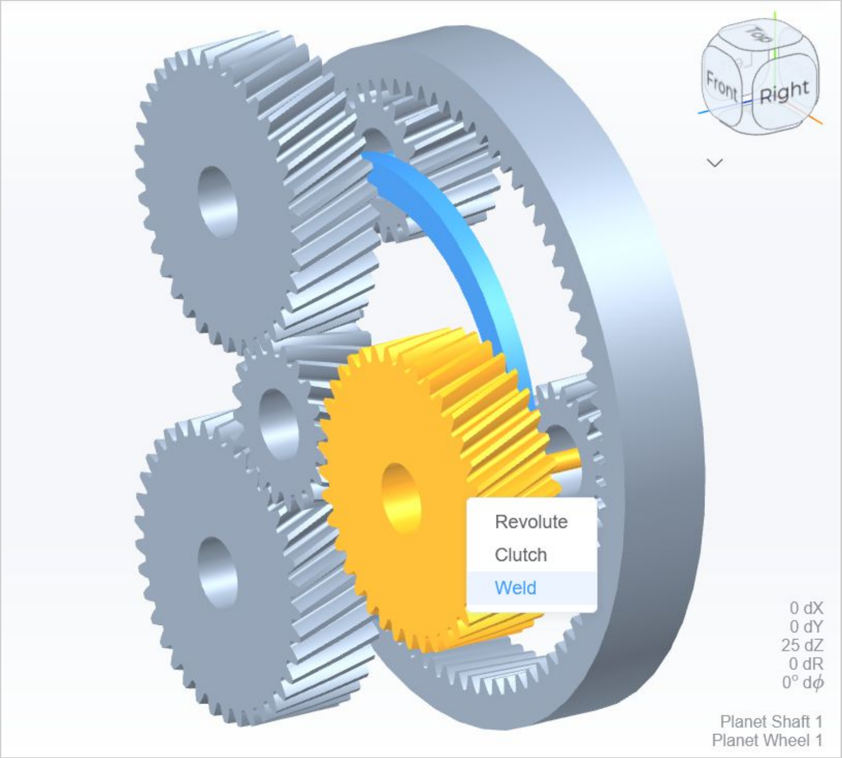
1. Click the *Ring Gear* in **3D Viewer**, and notice the display in lower right.
2. Select the GLOBAL z-coordinate field and set its value to -25mm.
3. Press Enter to accept the value and observe the updated view.
4. Repeat this for each *Planet Pinion*.



TIP: Ctrl + click two gears in 3D Viewer to see valuable information in the bottom right, including if the gears are “meshable” and the center distance for no backlash.

Constrain Planets

1. Since each gear is rotationally free, we need to add *Weld* constraints between each shaft and its gears.
2. From the **3D Viewer**, Ctrl + click a *Planet Shaft* and its *Planet Wheel*, then right-click for constraint options, and select **Weld**.
3. Repeat above for the *Planet Pinion*.
4. Repeat for each planet subassembly, resulting in six (6) *Weld* constraints.

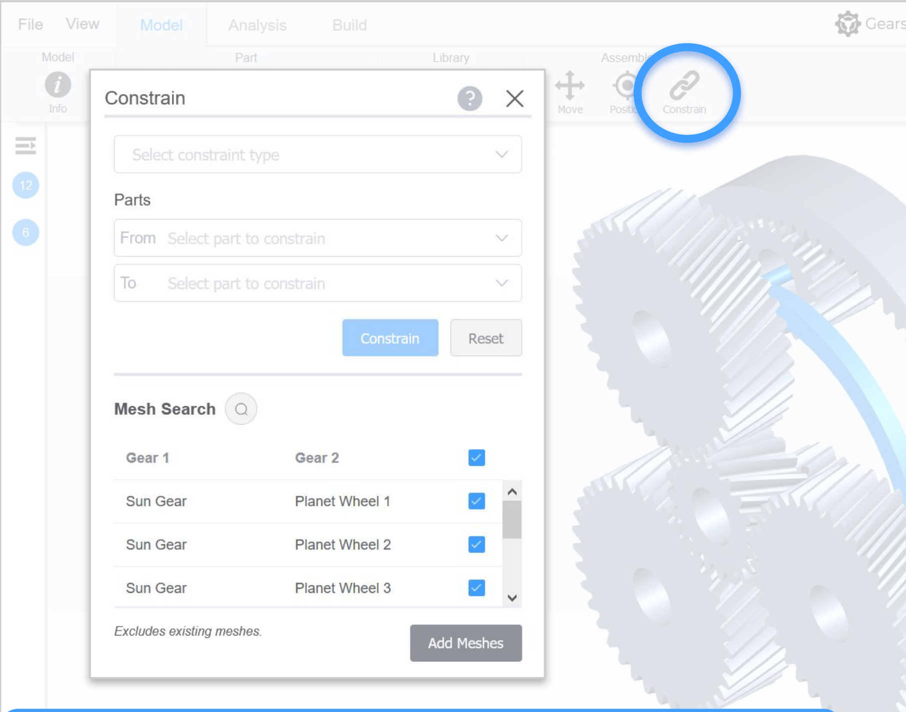


HINT: Alternatively, use the Constrain dialog to choose the constraint type and parts from the dropdown menus.

TIP: To deselect any selected parts, press Esc.

Mesh Gears

1. From the **Model** ribbon tab, click the **Constrain** button to open dialog.
2. Click the **Mesh Search** button to automatically identify gears to mesh.
3. Confirm the selected gears to mesh, then click **Add Meshes**.
4. Exit the dialog.



TIP: Ctrl + click two gears in 3D Viewer, then right-click to see options to constrain them.

HINT: Every component is considered to be rotationally unconstrained unless specified otherwise.

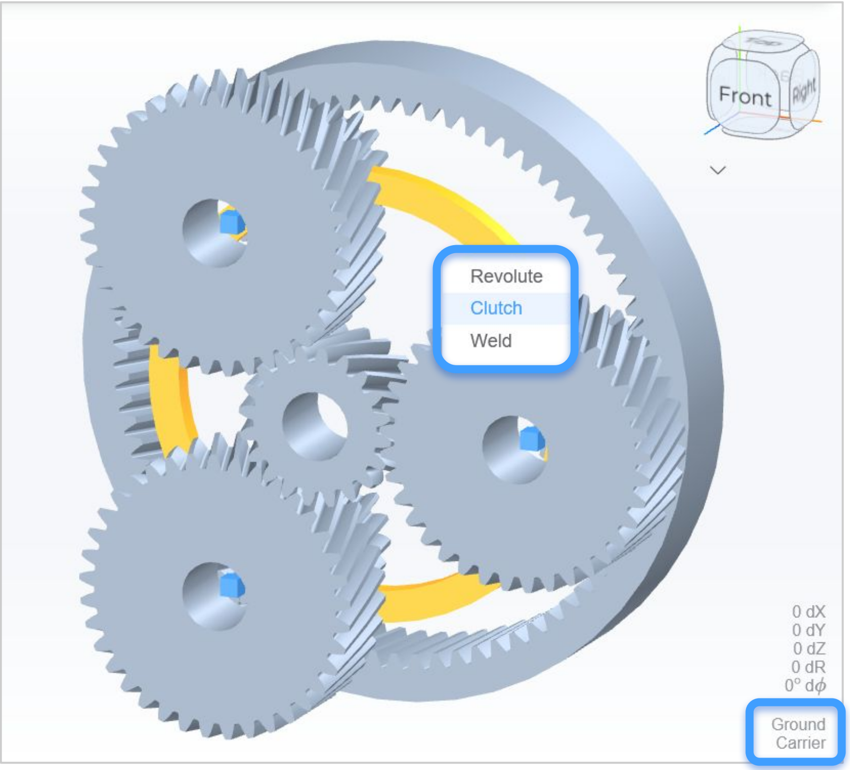
HINT: Alternatively, choose the constraint type and gears from the dropdown menus, then click **Constrain**.

Add Clutches

1. To simulate numerous powerflows, we must define *Clutch* constraints to conditionally constrain parts.
2. In the **3D Viewer**, Ctrl + click the **Ground* and *Ring Gear*, then right-click and select **Clutch**.
3. Repeat for **Ground* and *Carrier*.
4. No other constraints are required.

***TIP:** To select the *Ground* reference frame, Ctrl + click the background within 3D Viewer.

HINT: Alternatively, use the Constrain dialog to choose the constraint type and parts from the dropdown menus.



TIP: To deselect any selected parts, press Esc.

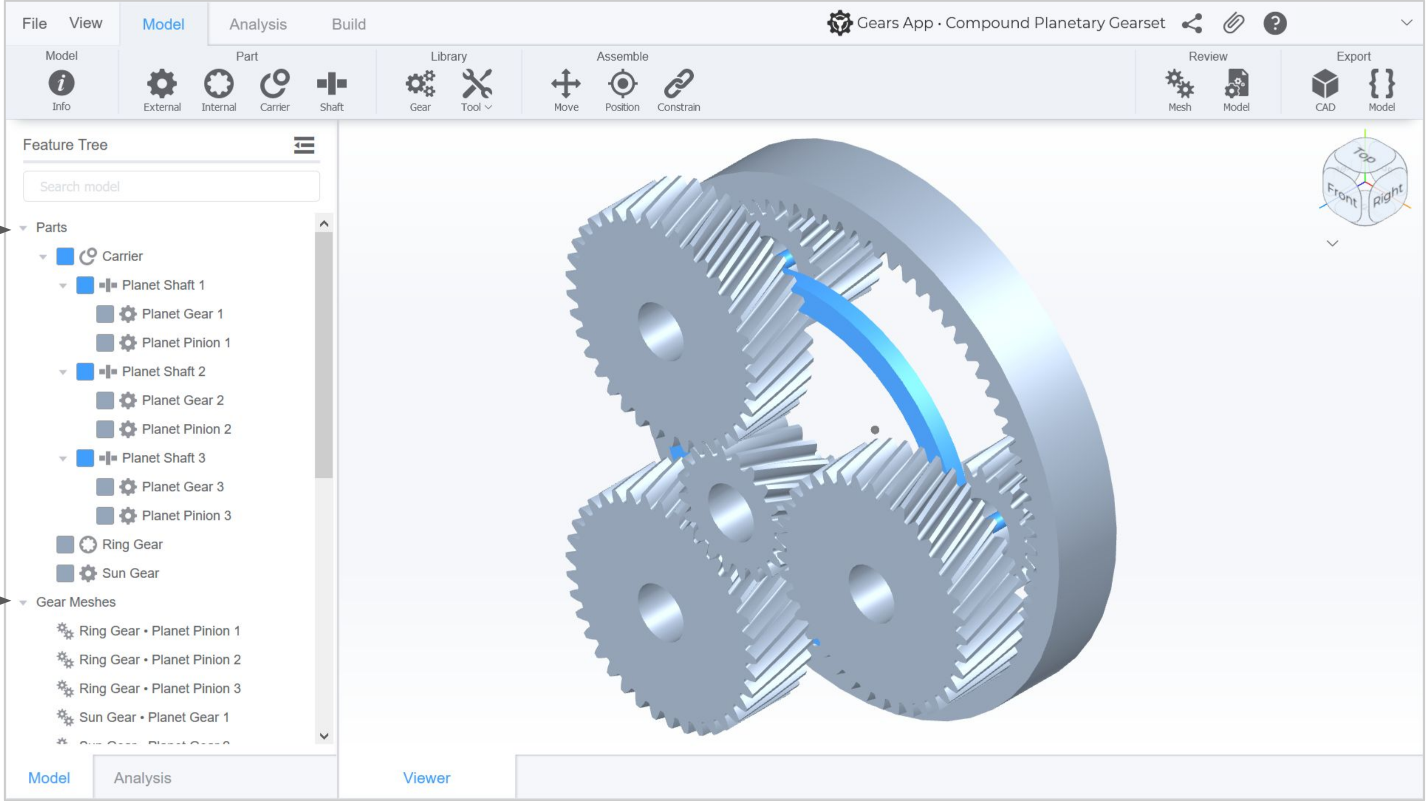
Review Model

Your model should look like the one below, possibly with different part names.

(1) carrier
(3) shafts
(8) gears

(6) meshes

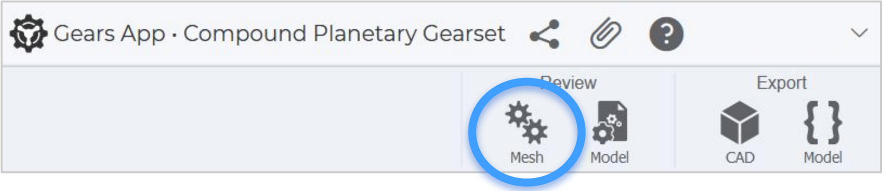
(2) clutches
(6) welds

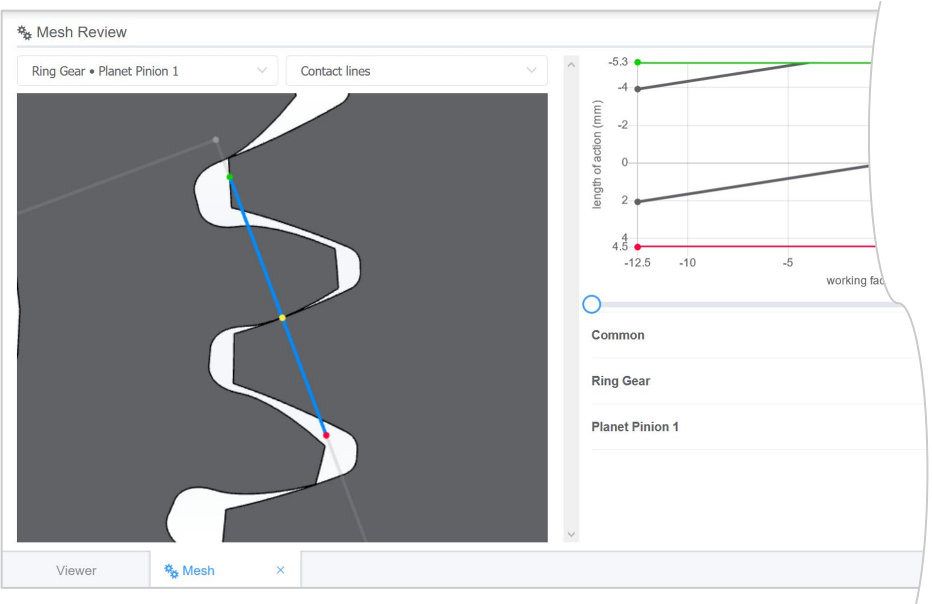


Review Mesh

1. From the **Model** ribbon tab, click the **Mesh** button to open tab.
2. Select a *gear mesh* from the dropdown to examine it.
3. Select a *plot type* from dropdown.
4. Interactively review gear mesh and plot by **scrolling with mouse** in the gear or plot areas.
5. Notice the gear mesh parameters available in the lower right quadrant.

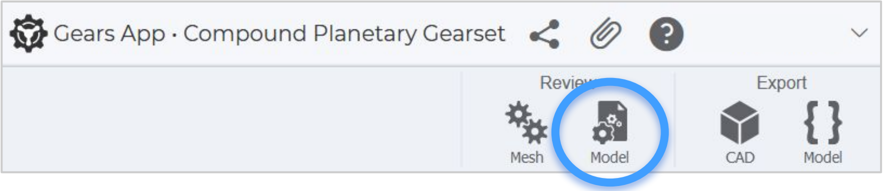
TIP: Right click a gear mesh from the Feature Tree and select Review Mesh to achieve the first two steps above.

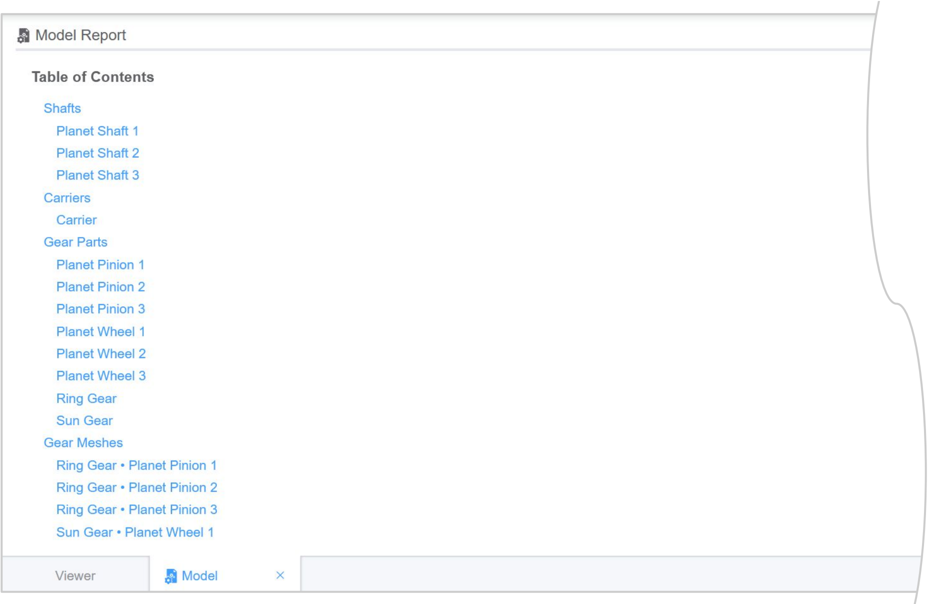




Reporting

1. From the **Model** ribbon tab, click the **Model** button to open a report tab.
2. Modeling report is auto-generated.
3. Review data for each part, including assembly, constraints, and geometry.
4. Review data for each gear mesh, including common and individual gear parameters.



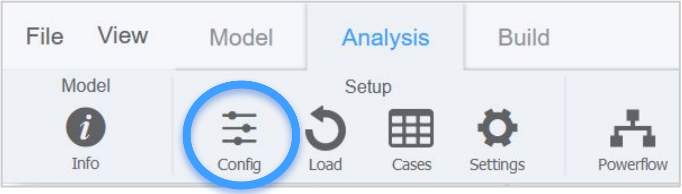


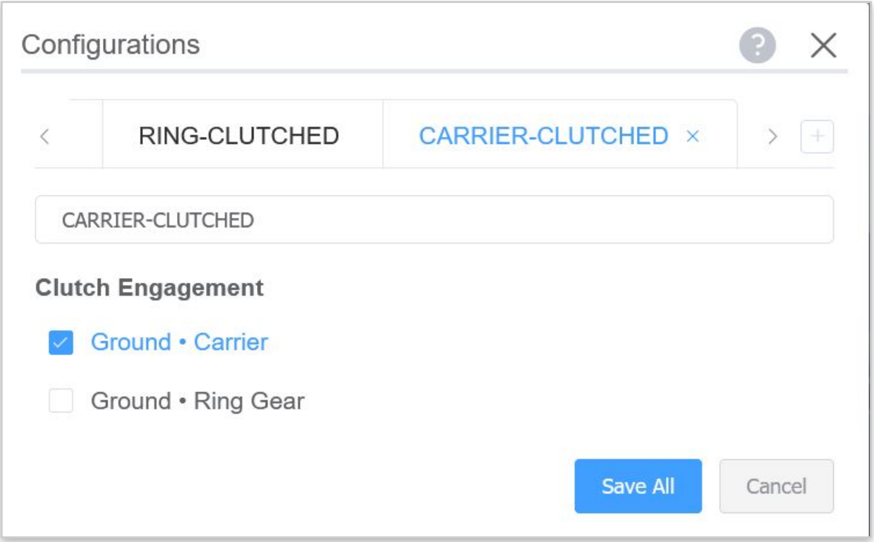
HINT: Alternatively, click the File dropdown and choose Model Report to auto-generate the report.

ANALYZING

Configurations

1. From the **Analysis** ribbon tab, click the **Config** button to open dialog.
2. A default configuration is added. Rename it as **UNCLUTCHED**.
3. Add a configuration by clicking [+] near upper right. Rename it as **RING-CLUTCHED** and select the *Ground • Ring Gear* checkbox.
4. Add another configuration, rename it **CARRIER-CLUTCHED**, and select the *Ground • Carrier* checkbox.
5. Click the **Save All** button.





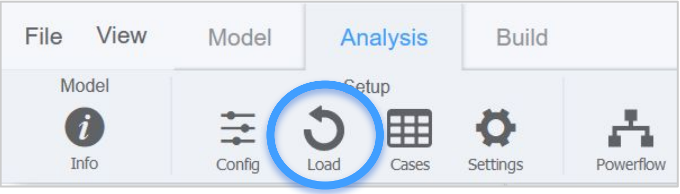
HINT: To define a load case, as shown later, a configuration must be defined even if no clutches were used.

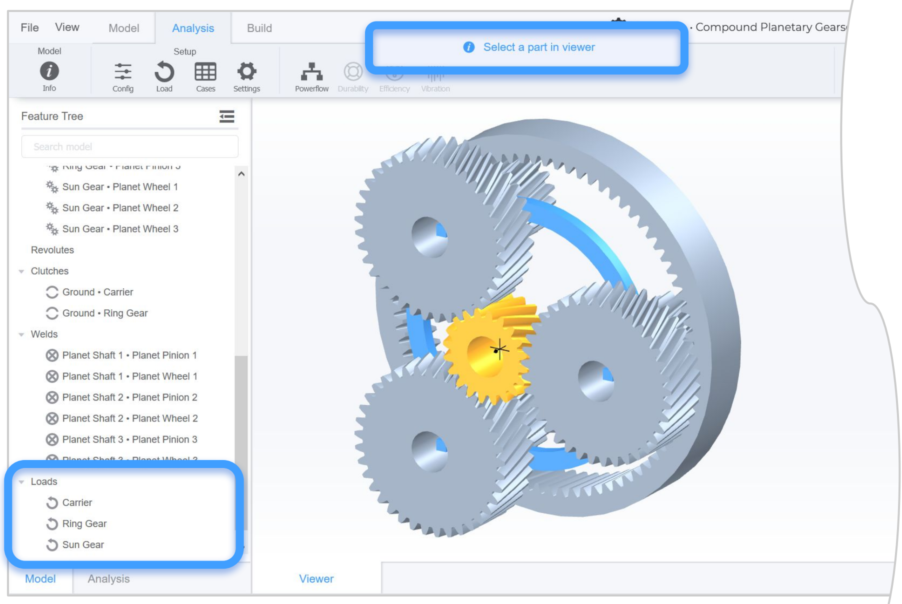
System Loads

1. To torsionally constrain the model, we must define the system loads.
2. From the **Analysis** ribbon, click the **Load** button.
3. Per the notification message, select a part in the **3D Viewer**.
4. Click the *Sun Gear* to add a load.
5. Repeat for the *Ring Gear* and *Carrier*.

HINT: To cancel the creation of a load, press Esc.

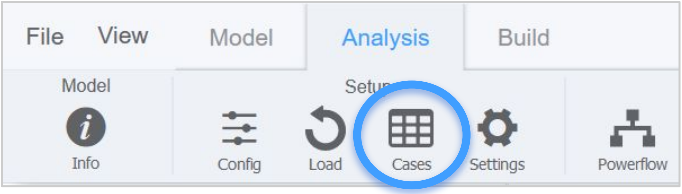
HINT: At *least* 1 input and 1 output load must be defined to torsionally constrain the system with balanced powerflow.

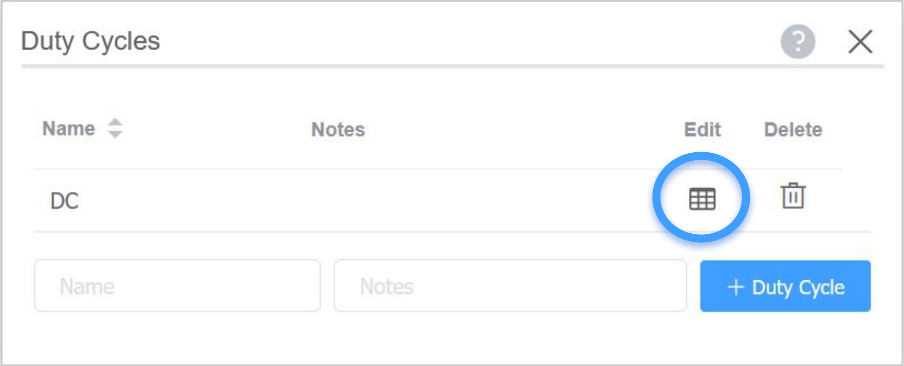




Duty Cycle

1. From the **Analysis** ribbon tab, click the **Cases** button to open dialog.
2. Specify a duty cycle with name *DC* and click **+ Duty Cycle** button.
3. To add load cases to the duty cycle, click its **Edit** button.

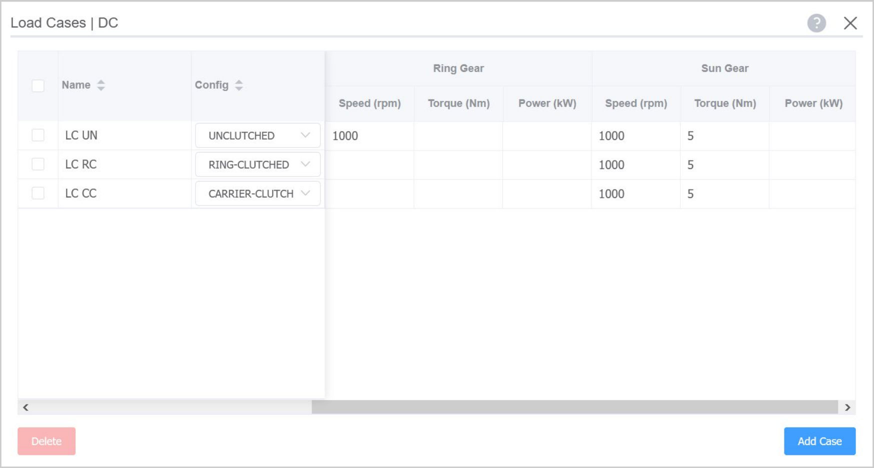




HINT: A *duty cycle* is a collection of *load cases*, i.e. discrete loads, preferably binned from real-world time series data.

Load Cases

1. Click the **Add Case** button to add a load case. Add three (3) cases.
2. Edit the table of cases to define the load conditions for the model.
3. On completion, exit the dialog.

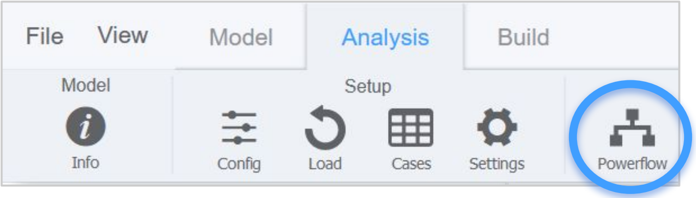


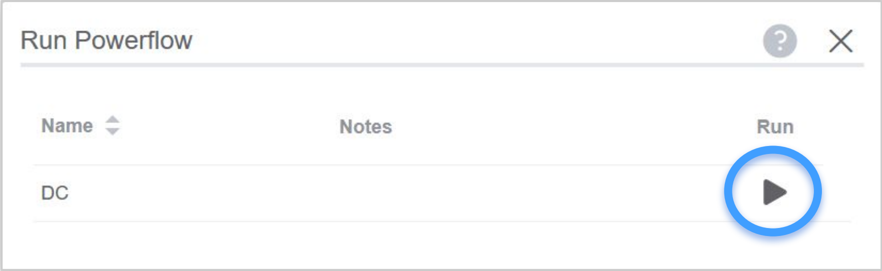
TIP: To edit the load cases of a duty cycle, double click the duty cycle in the Feature Tree on Analysis tab.

Name	Config	Hrs	Carrier			Ring Gear			Sun Gear		
			rpm	Nm	kW	rpm	Nm	kW	rpm	Nm	kW
LC-UN	UNCLUTCHED	100				1000			1000	5	
LC-RC	RING-CLUTCHED	100							1000	5	
LC-CC	CARRIER-CLUTCHED	100							1000	5	

Run Powerflows

1. From the **Analysis** ribbon tab, click the **Powerflow** button to open dialog.
2. Click the **Run** ▶ button next to the duty cycle to simulate.
3. If the model has been properly defined, it will successfully solve.
4. If it failed to solve, review the prior steps in this tutorial.





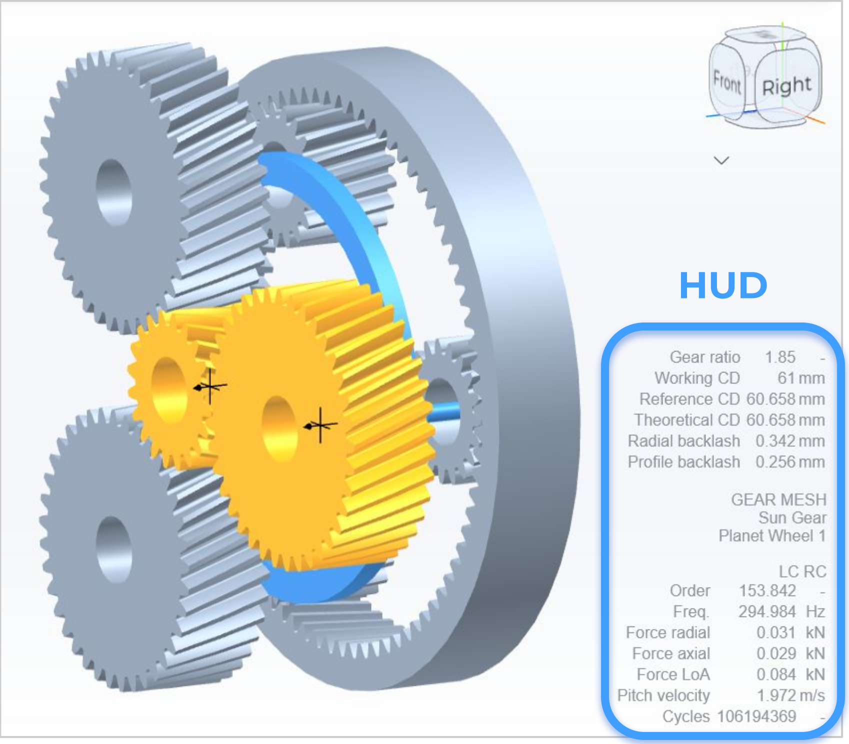
TIP: Run a duty cycle or load case from the Feature Tree by right clicking it in the *Powerflows* tree and clicking **Run**.

HINT: If the model is modified, outdated results will automatically update when accessing results.

HINT: Notice the load cases in the Feature Tree show × when unsolved and when solved.

Results & Animation

1. To interactively review powerflow results, a load case must be *set*.
2. From the **Analysis** tab of **Feature Tree**, double click a load case in the *Powerflows* tree to *set* it.
3. Select a gear or gear mesh in **Feature Tree** to display certain results in HUD.
4. From the **Analysis** ribbon tab, click the **Animate** button to start animation.



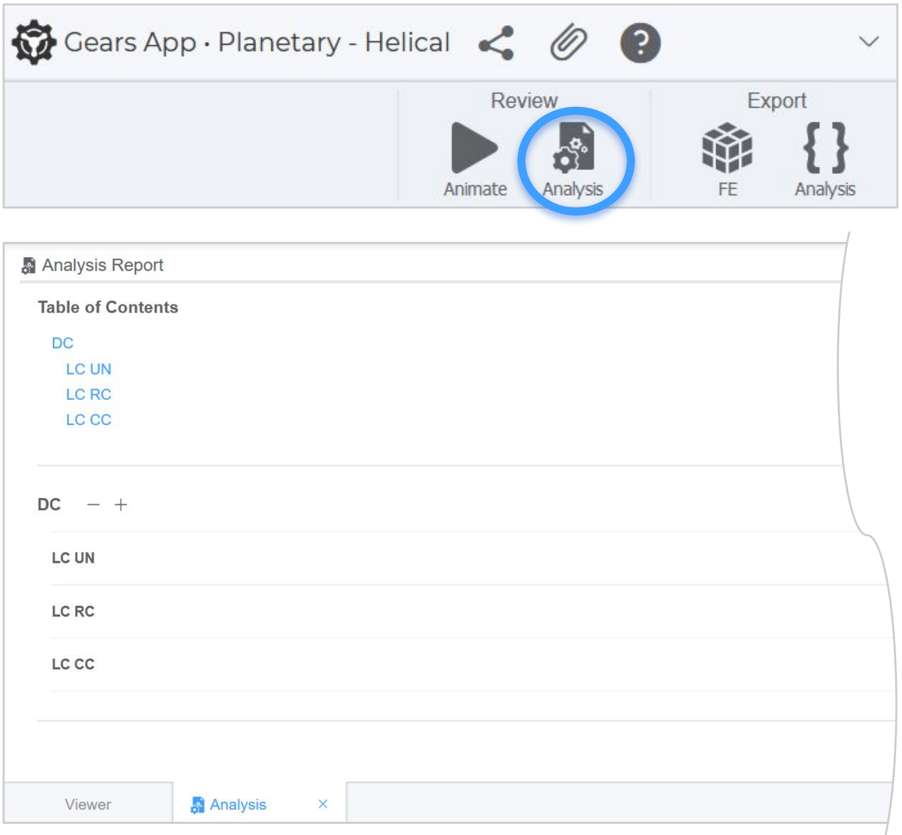
TIP: Animate a load case from the Feature Tree by right clicking it in the *Powerflows* tree and clicking **Animate**.

TIP: With a load case set, view results for a gear by selecting it in the 3D Viewer.

HINT: Gear or gear mesh *order*, as shown in HUD, is based on the reference part in Settings, from the Analysis ribbon.

Reporting

1. From the **Analysis** ribbon tab, click the **Analysis** button to open a report tab.
2. Analysis report is auto-generated.
3. Review load case results for the gears and gear meshes, including angular velocities, torques, forces, and frequencies.



HINT: Alternatively, click the File dropdown and choose Analysis Report to auto-generate the report.

INTEGRATIONS

EXPORTS, CONSULTING, & MANUFACTURING

Export Data

Need to evaluate your gears in other software?

Learn how to export data to work with CAD, FE, and other software. Leverage the fully web-based ecosystem of the Gears App to streamline your gear design development.

See tutorial: *Model Data and Exports*

Design Review

Need an expert to review your design?

Learn how to request services to conduct a design review with independent consultants from our global network at Drivetrain Hub.

See tutorial: *Consulting and Manufacturing*

Manufacturing

Need to build your gear system?

Learn how to create mockups with our additive manufacturing service, and efficiently communicate with qualified global manufacturers to prototype and mass produce your gears.

See tutorial: *Consulting and Manufacturing*

What Next?

- ➔ Sign up and start using Gears App.
- ➔ Keep learning with the Tutorial Series.