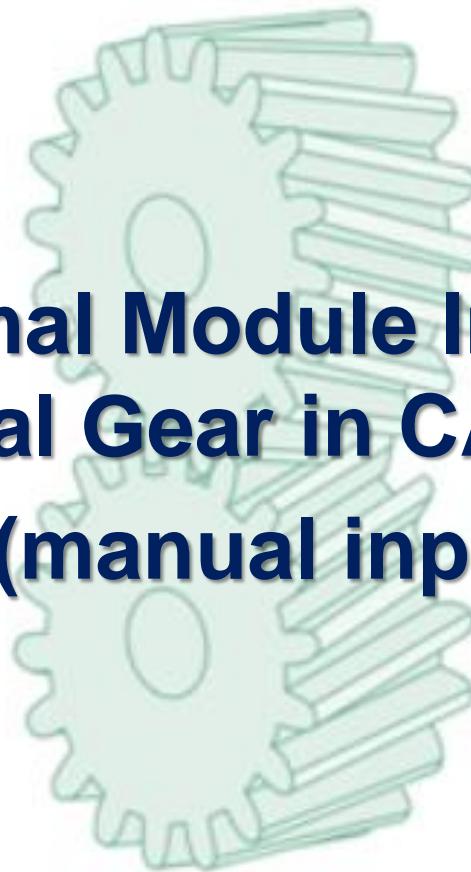
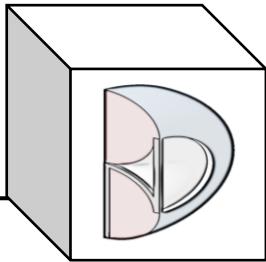


# BND TechSource



## **Normal Module Involute Helical Gear in CATIA V5 (manual input)**





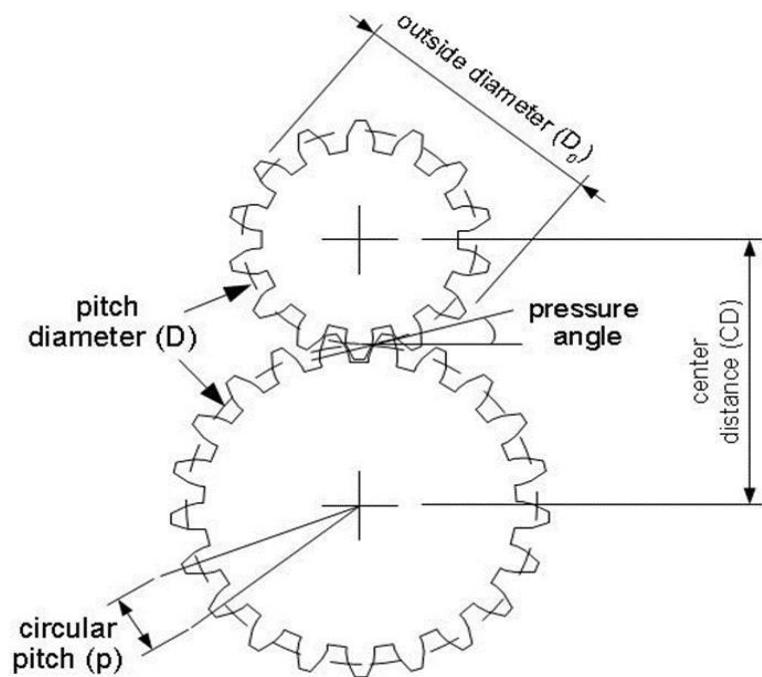
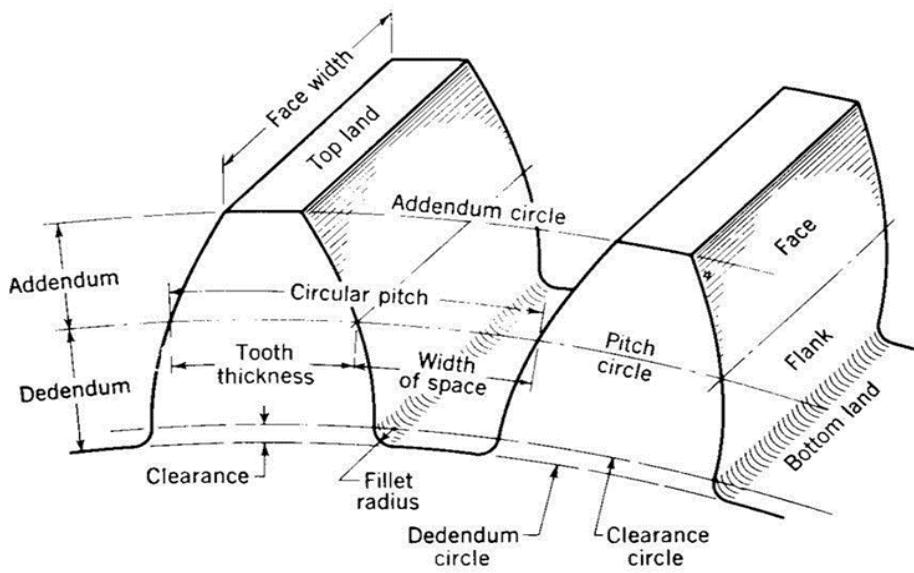
# BND TechSource

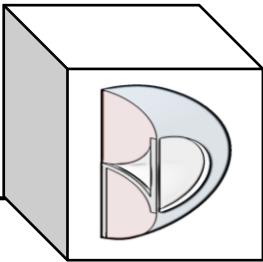


## NORMAL MODULE INVOLUTE HELICAL GEAR

- This is step by step guide of how to create an involute helical gear using CATIA V5.
- This document assumes that you know basic gear geometry.

### GEAR NOMENCLATURE



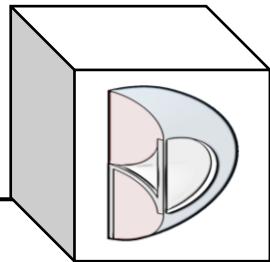


# BND TechSource



## *NORMAL MODULE INVOLUTE HELICAL GEAR*

- Helical gears are one type of cylindrical gears with slanted tooth trace. Compared to spur gears, they have the larger contact ratio and excel in quietness and less vibration and able to transmit large force. A pair of helical gears has the same helix angle but the helix hand is opposite.
- When the reference section of the gear is in the normal plane, by tilting the hobbing tool, the spur gear hobbing machine and hobbing tool can be used to produce helical gears. Because of the twist of teeth, their manufacturing has the disadvantage of more difficult production.
- While spur gears do not generate axial thrust forces, because of the twist in the tooth trace, helical gears produce axial thrust force. Therefore, it is desirable to use thrust bearings to absorb this force. However, combining right hand and left hand helical gears making double helical gears will eliminate the thrust force.
- Helical gears are often used in automotive transmissions by replacing spur gears.



# BND TechSource

## NORMAL MODULE INVOLUTE HELICAL GEAR

- Helical gears can be classified into two groups by the reference section of the gears being in the rotating plane (**transverse module**) and normal plane (**normal module**).
- If the reference section is in the rotating plane (*transverse module*), the center distance is identical to spur gears as long as they are the same module and number of teeth. This allows for easy swapping with spur gears. However, in this case, they require special hobbing cutters and grinding stones, leading to *higher production cost*.
- On the other hand, if the reference section is in the normal plane (*normal module*), it is possible to use spur gear hobbing tools and grinding stones. However, the same module and number of teeth in spur gears no longer match the center distance of helical gears, and *swapping becomes very difficult*. In addition, the center distance is usually not an integer.

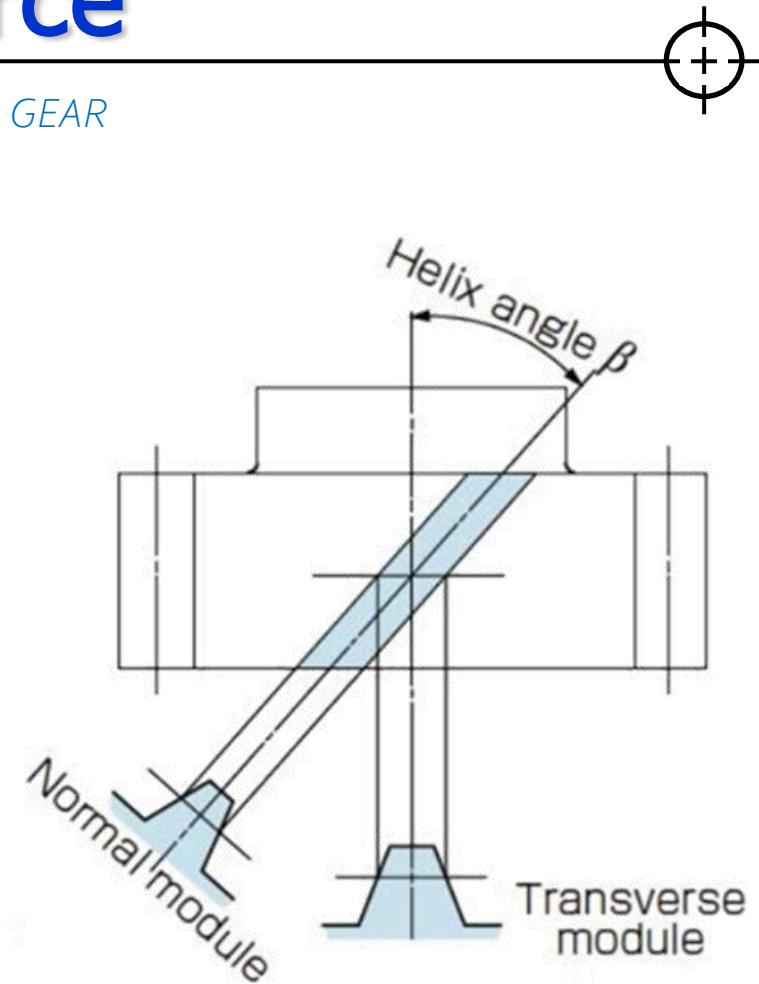
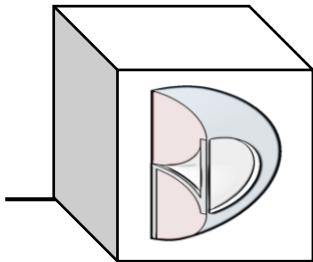


Fig. 2.9 Right-handed Helical Gear



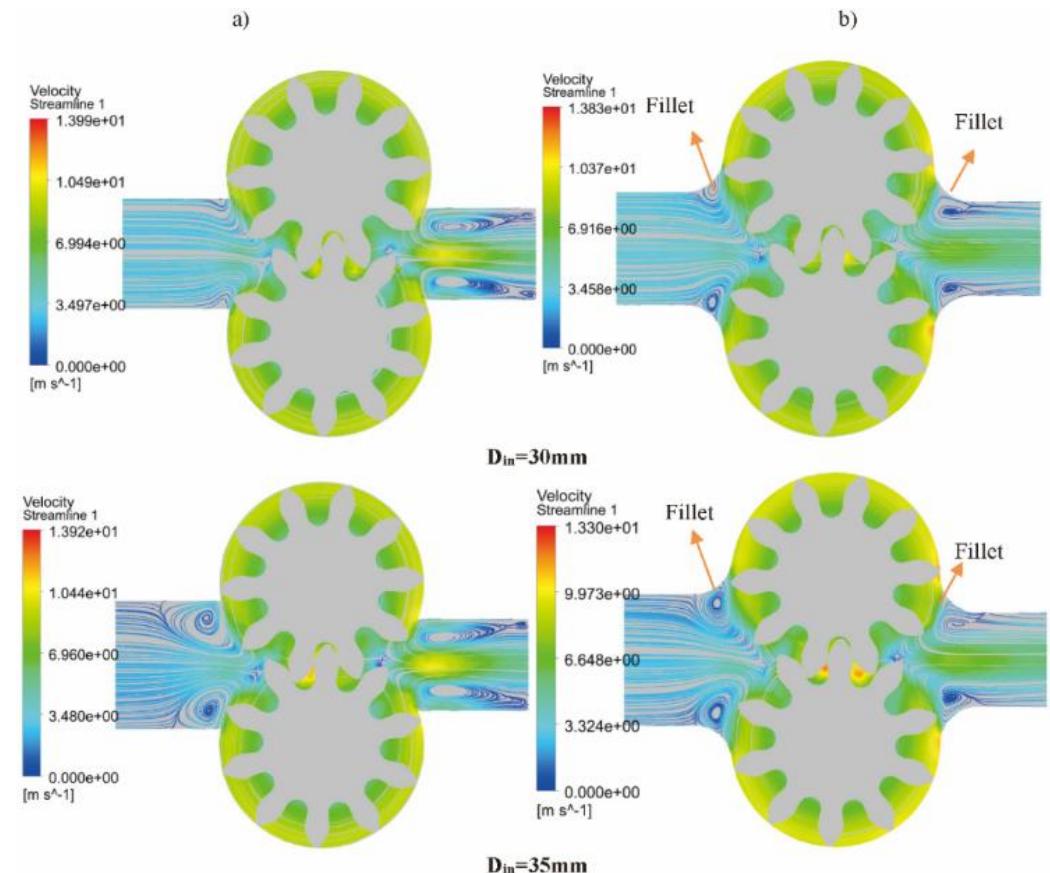
# BND TechSource

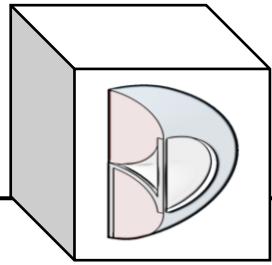


## MODELLING AN INVOLUTE

Q: Why would you spend the extra time to model an involute gear tooth profile?

A: CFD (Computational Fluid Dynamics). Take for example an external, positive displacement oil pump with helical gears. For CFD to accurately simulate the flow of the pump, the gears must be modeled as they will be manufactured.



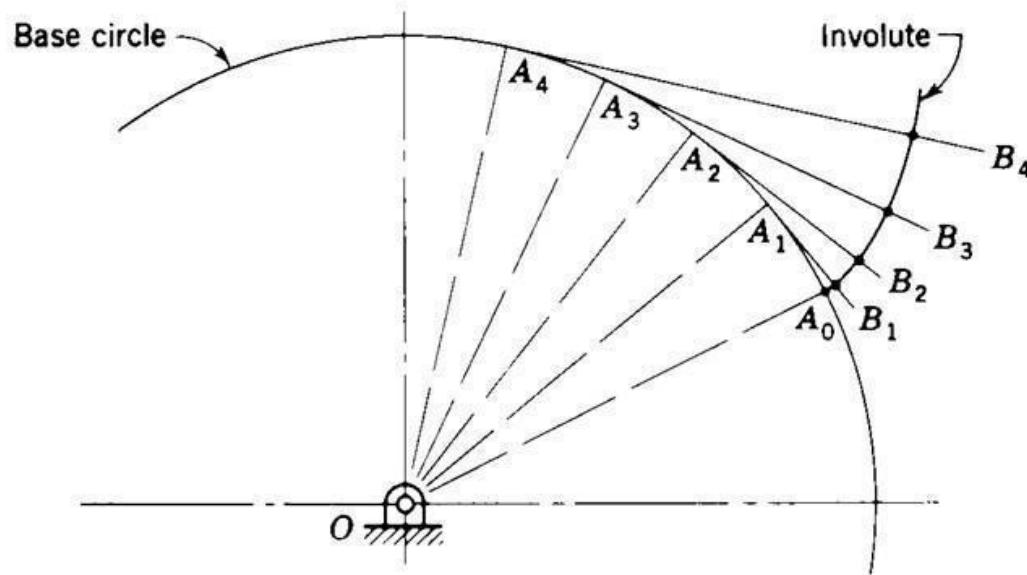


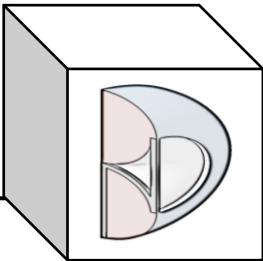
# BND TechSource



## MODELLING AN INVOLUTE

- Most CAD systems don't support the exact creation of involute curves.
- They must be represented using splines through a series of points.
- Of course the distance between the points will have a direct correlation to the accuracy of the spline.



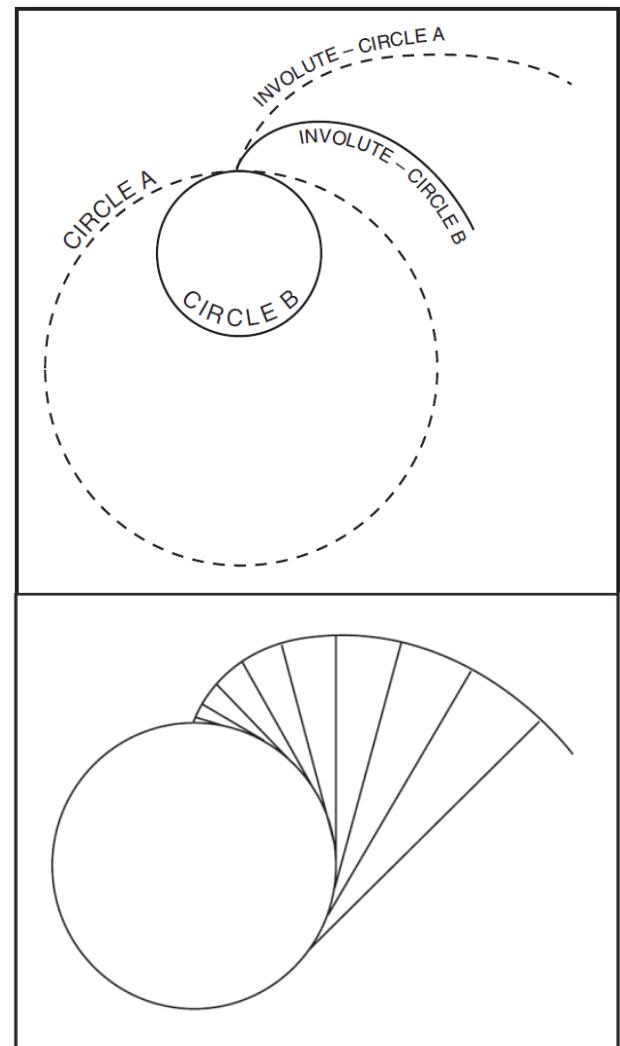


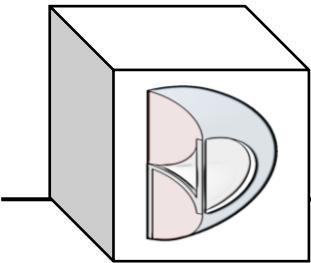
# BND TechSource



## HELICAL GEARS INVOLUTE FORM

- Gear teeth could be manufactured with a wide variety of shapes and profiles. The involute profile is the most commonly used system for gearing today.
- An involute is a curve that is traced by a point on a taut cord unwinding from a circle, which is called a **BASE CIRCLE**. The involute is a form of spiral, the curvature of which becomes straighter as it is drawn from a base circle and eventually would become a straight line if drawn far enough.
- An involute drawn from a larger base circle will be less curved (straighter) than one drawn from a smaller base circle. Similarly, the involute tooth profile of smaller gears is considerably curved, on larger gears is less curved (straighter), and is straight on a rack, which is essentially an infinitely large gear.





# BND TechSource

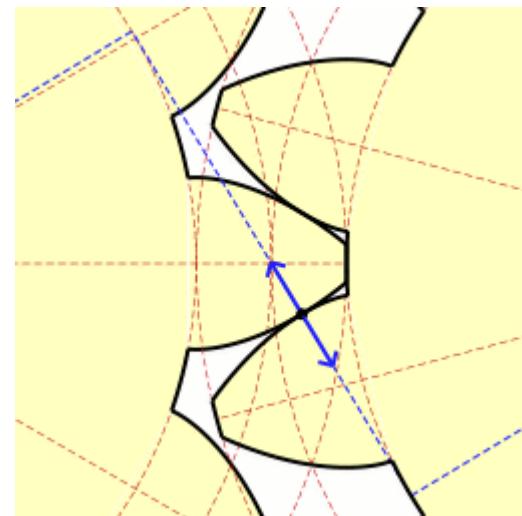


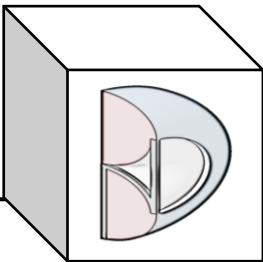
## HELICAL GEARS INVOLUTE FORM

- Involute gear tooth forms and standard tooth proportions are specified in terms of a basic rack which has straight-sided teeth, for involute systems.



- Two involute gears, the left driving the right: Blue arrows show the contact forces between them; (1) downward force applied by the left gear and (2) upward resistance by the right gear. The force line (or line of action) runs along the long leg of dashed blue line which is a tangent common to both base circles.





# BND TechSource

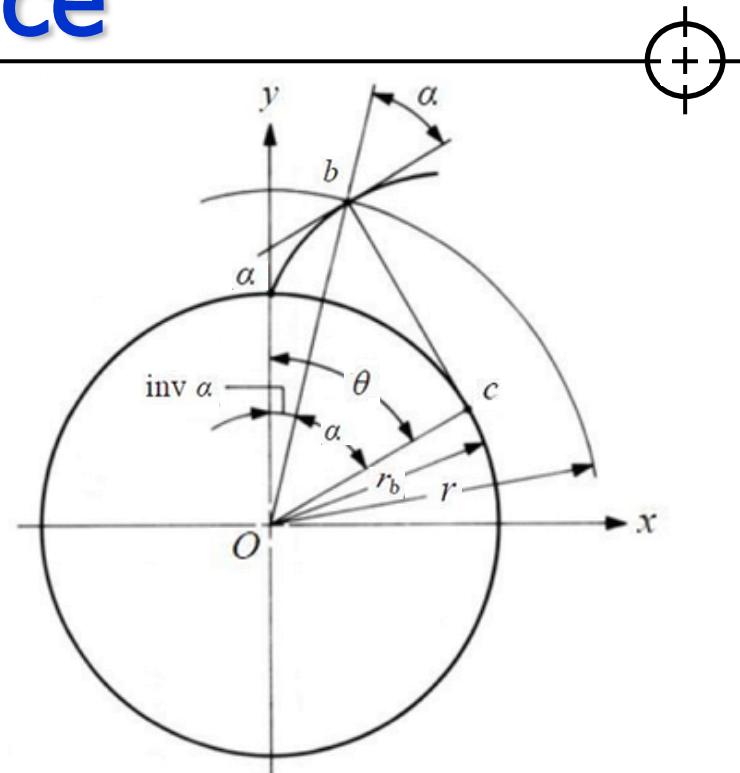
## HELICAL GEARS INVOLUTE FORM

The definition of involute curve is the curve traced by a point on a straight line which rolls without slipping on the circle. The circle is called the base circle of the involutes.

inv  $\alpha$  stands for Involute Angle (Involute  $\alpha$ ). The units for inv  $\alpha$  is radians.  $\theta$  is called involute rolling angle.

$$\text{inv } \alpha = \tan \alpha - \alpha \quad (\text{radians})$$

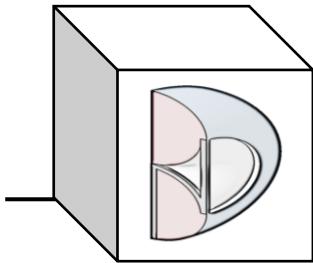
With the center of the base circle O at the origin of a coordinate system, the involute curve can be expressed by values of x and y as follows:



$$\alpha = \cos^{-1} \frac{r_b}{r}$$

$$x = r \sin(\text{inv } \alpha)$$

$$y = r \cos(\text{inv } \alpha)$$



# BND TechSource



## HELICAL GEAR TOOTH INVOLUTE FORM

Some basic nomenclature and formulae:

Fw -Face width // length parameter [Fw = 100mm]

m -module // length parameter [m = 8mm]

z -number of teeth // real parameter [z = 11]

Npa -Normal pressure angle // angle parameter [Npa = 20 deg]

Ca -Cylinder helix angle // angle parameter [Ca = 8deg]

s -symmetry angle // angle parameter [s = 90deg/z]

Tpa -Transverse pressure angle // angle parameter [Tpa = atan(tan(Npa)/cos(Ca))]

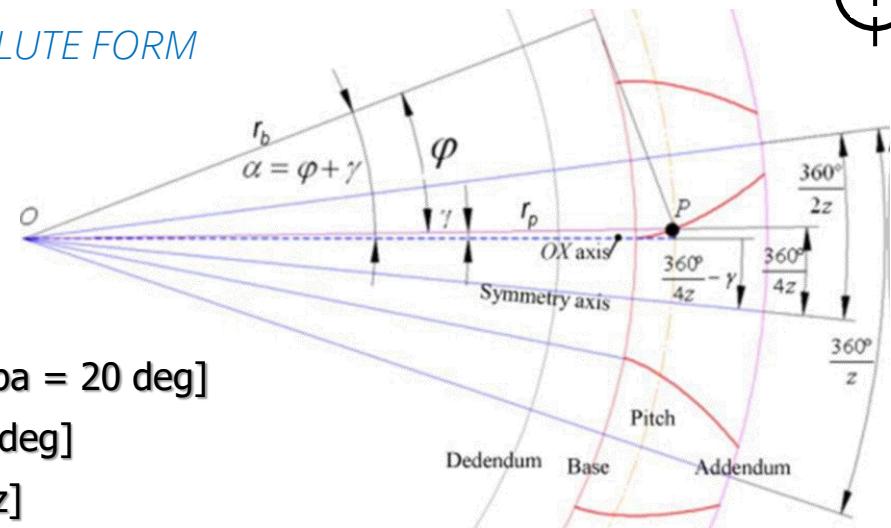
Pd -Pitch diameter // length parameter [Pd = (z \* m)/cos(Ca)]

Bd -Base diameter // length parameter [Bd = Pd \* cos(Tpa)]

Ad -Addendum diameter // length parameter [Ad = Pd+(2\*m)].....(no profile shift)

Dd -Dedendum diameter // length parameter [Dd = Pd-(2.5\*m)].....(no profile shift)

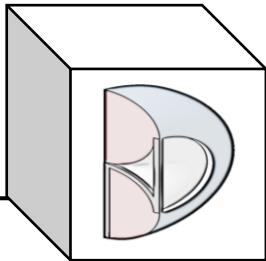
tr -tooth radius at dedendum circle // length parameter [tr = 0.375\*m]



The parametric equations for involute curve points in CATIA:

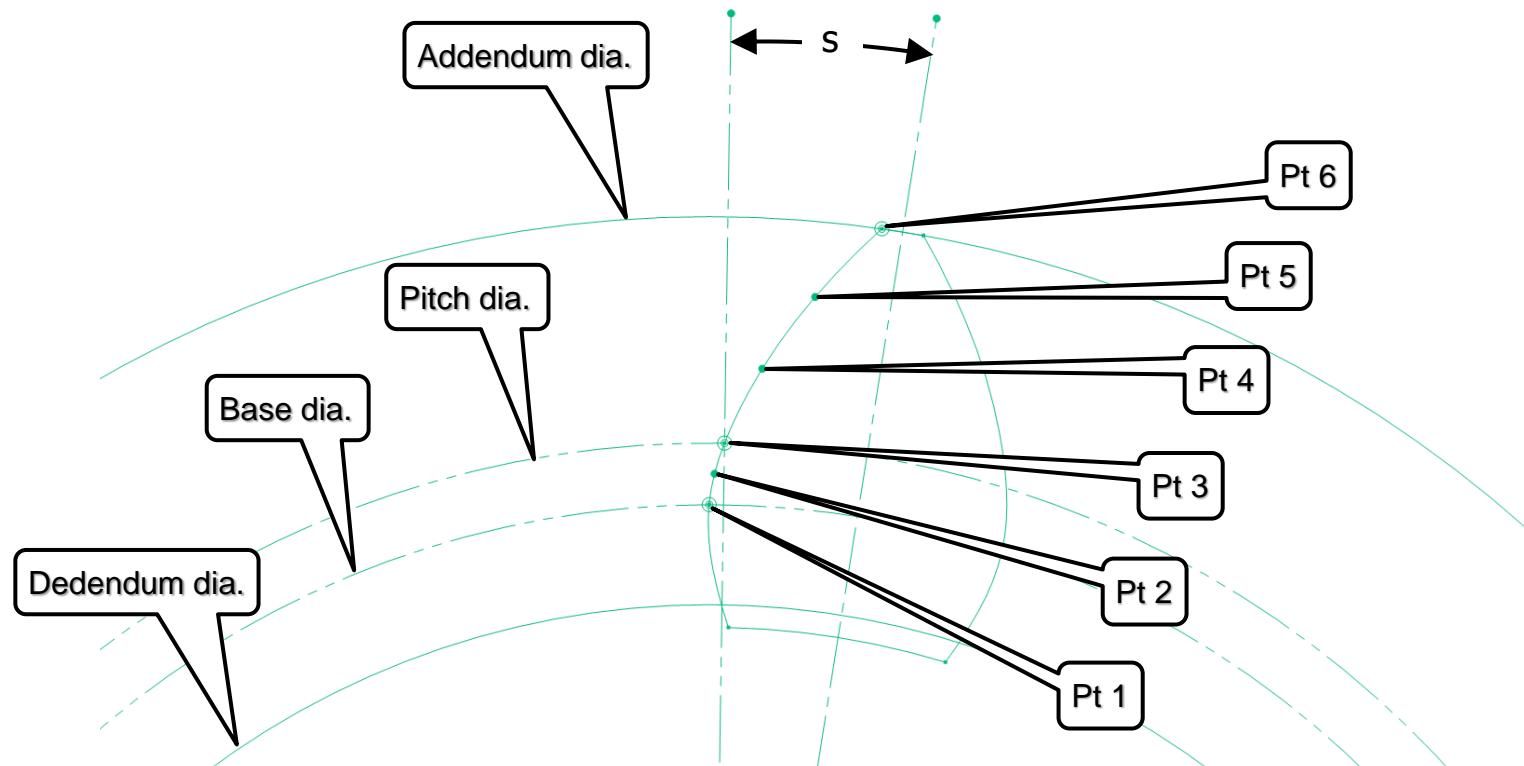
$$x=r*\sin((\tan(\text{acos(`r(Pt1)`/r))}-(\text{acos(`r(Pt1)`/r))))$$

$$y=r*\cos((\tan(\text{acos(`r(Pt1)`/r))}-(\text{acos(`r(Pt1)`/r))))$$

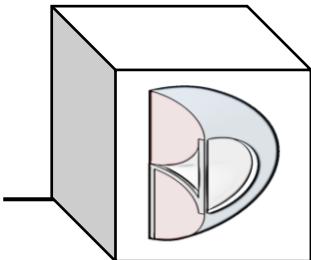


# BND TechSource

## HELICAL GEAR TOOTH INVOLUTE POINTS



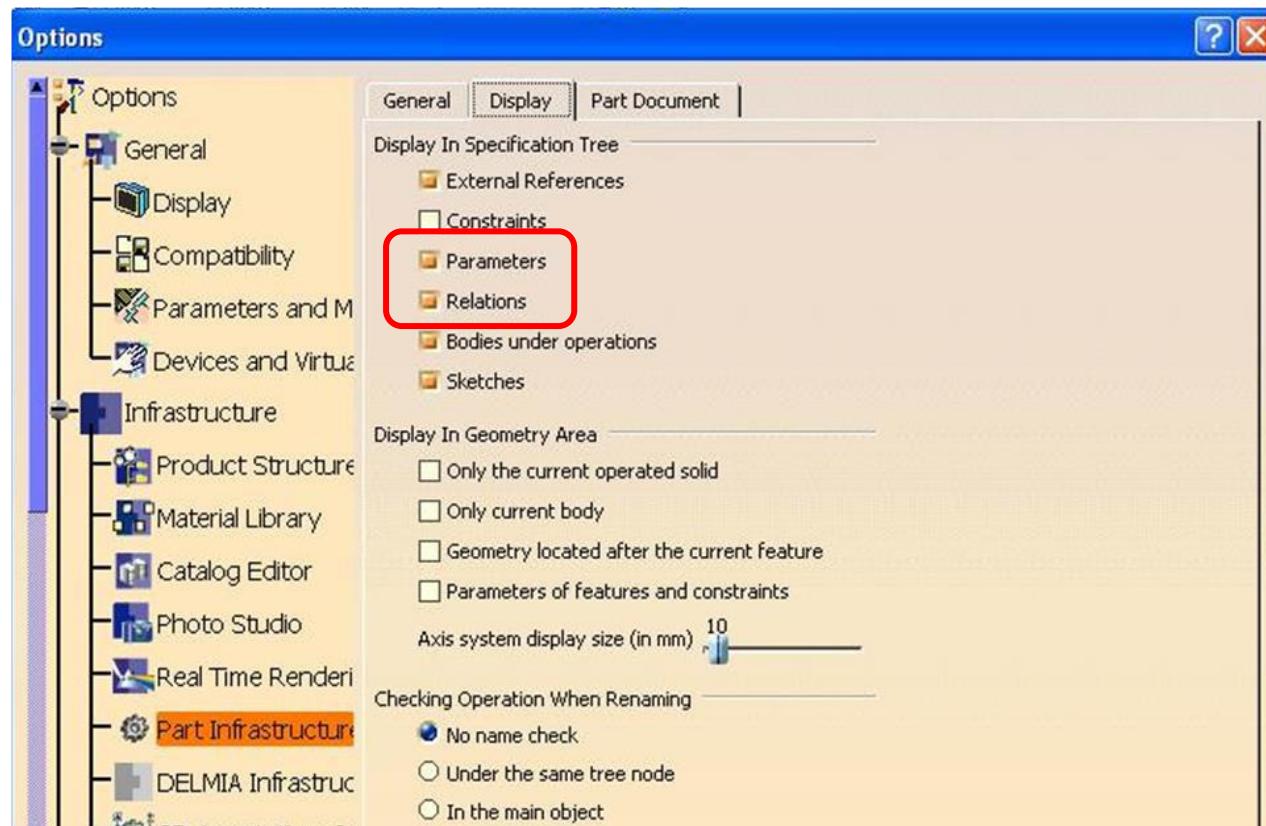
Point	r (formula)	r (mm)	$\alpha$ (radians)	inv $\alpha$ (radians)	x (mm)	y (mm)
Pt 1	[Base] Br	41.705	0.0000	0.0000	0.000	41.705
Pt 2	(Pr+Br)/2	43.069	0.2523	0.0055	0.237	43.068
Pt 3	[Pitch] Pr	44.432	0.3522	0.0153	0.681	44.427
Pt 4	Pr+(Ar-Pr)*.33333	47.770	0.5094	0.0492	2.348	47.712
Pt 5	Pr+(Ar-Pr)*.66667	51.107	0.6163	0.0920	4.697	50.891
Pt 6	[Addendum] Ar	54.444	0.6982	0.1410	7.652	53.904

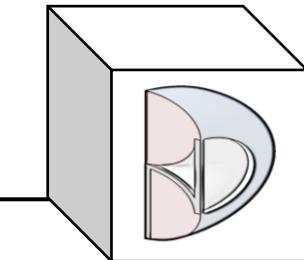


# BND TechSource



- When you start CATIA, go to TOOLS->OPTIONS->Infrastructure->
- Part Infrastructure and in Display select “Parameters” and “Relations”.

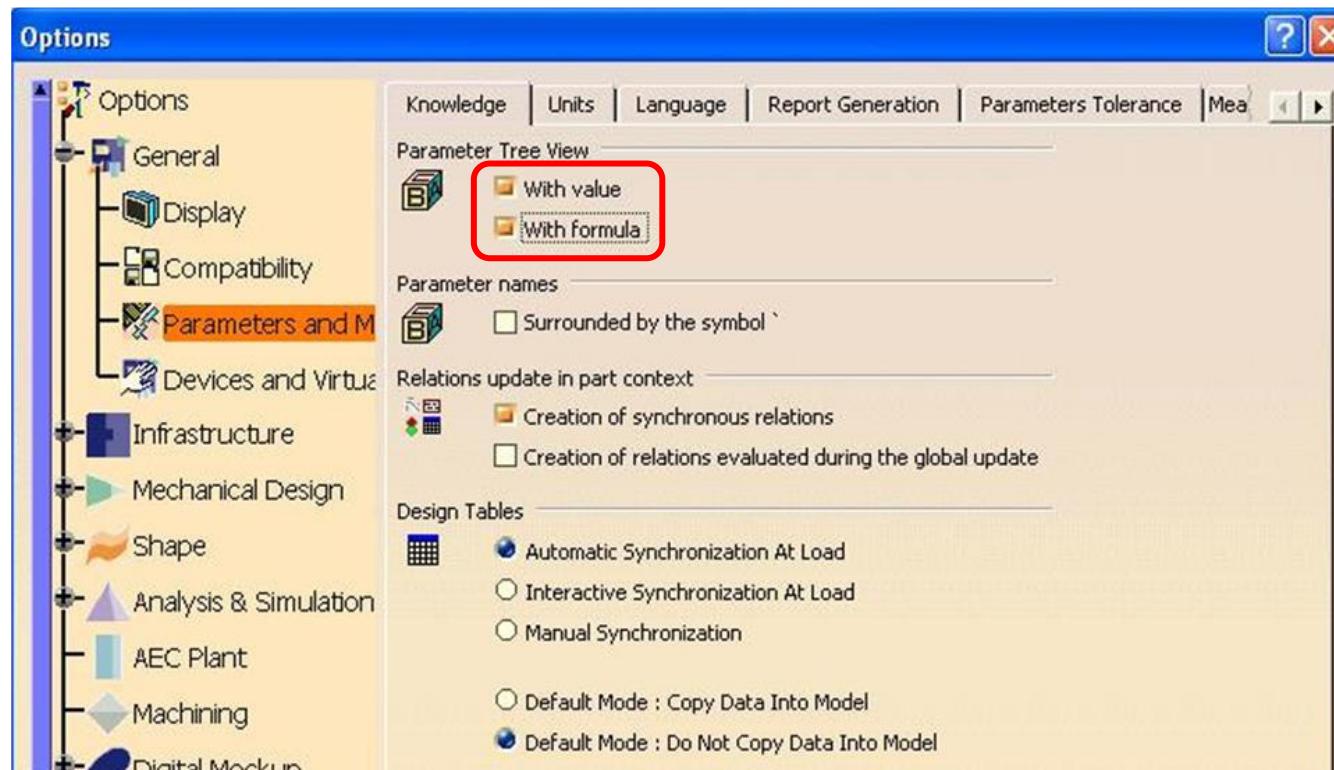


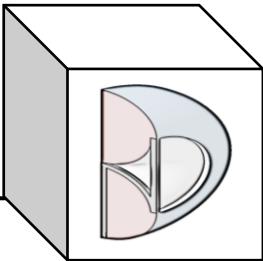


# BND TechSource



- Then in Options->General in Parameters and Measures select “With Value” and “With Formula” in Parameters Tree View.



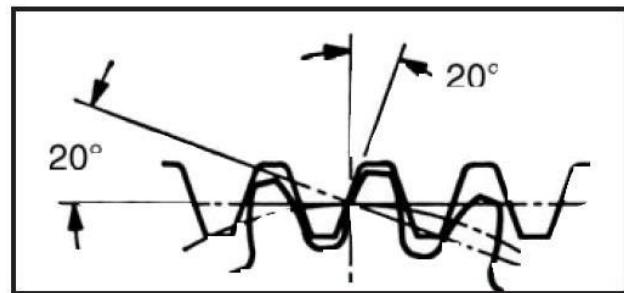
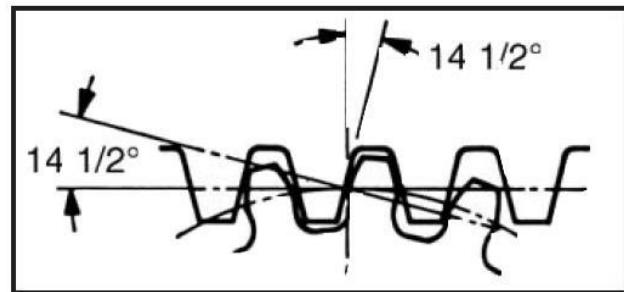


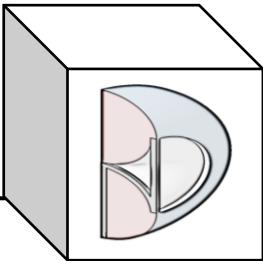
# BND TechSource



## PRESSURE ANGLE

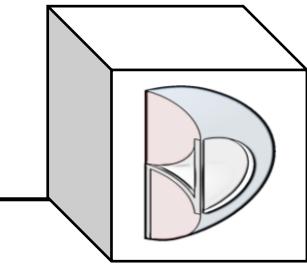
- Pressure angle is the angle at a pitch point between the line of pressure which is normal to the tooth surface, and the plane tangent to the pitch surface. The pressure angle refers to the angle when the gears are mounted on their standard center distances.
- Standard pressure angles (PA) are  $14\frac{1}{2}^\circ$  and  $20^\circ$ . While  $20^\circ$  PA is generally recognized as having higher load carrying capacity,  $14\frac{1}{2}^\circ$  PA gears have extensive use. The lower pressure angle results in less change in backlash due to center distance variation and concentricity errors. It also provides a higher contact ratio and consequent smoother, quieter operation provided that undercut of teeth is not present.





## BACKLASH

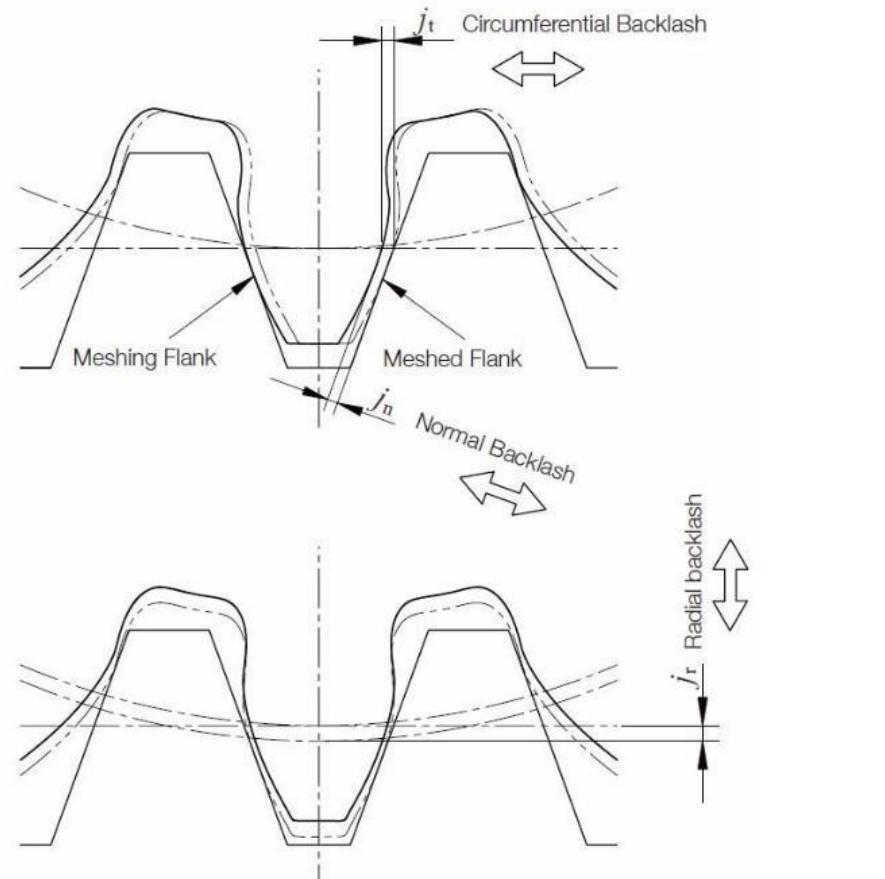
- Backlash, a clearance between mating gear teeth, is built into speed reducers to let the gears mesh without binding and to provide space for a film of lubricating oil between the teeth. This prevents overheating and tooth damage.
- For smooth rotation of meshed gears, backlash is necessary. Backlash is the amount by which a tooth space exceeds the thickness of a gear tooth engaged in mesh. Backlashes are classified in the following ways:
  - 1) Circumferential Backlash ( $j_t$ ) – Circumferential Backlash is the length of arc on the pitch circle. The length is the distance the gear is rotated until the meshed tooth flank makes contact while the other mating gear is held stationary.
  - 2) Normal Backlash ( $j_n$ ) – The minimum distance between each meshed tooth flank in a pair of gears, when it is set so the tooth surfaces are in contact.
  - 3) Angular Backlash ( $j_\theta$ ) – The maximum angle that allows the gear to move when the other mating gear is held stationary.
  - 4) Radial Backlash ( $j_r$ ) – The radial backlash is the shrinkage (displacement) in the stated center distance when it is set so the meshed tooth flanks of the paired gears contact each other.
  - 5) Axial Backlash ( $j_x$ ) – The axial backlash is the shrinkage (displacement) in the stated center distance when a pair of bevel gears is set so the meshed tooth flanks of the paired gears contact each other.

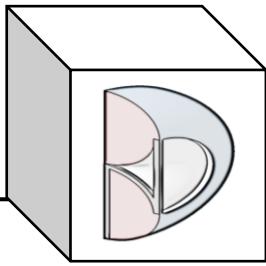


# BND TechSource

BACKLASH

- Circumferential Backlash
- Normal Backlash
- Radial Backlash

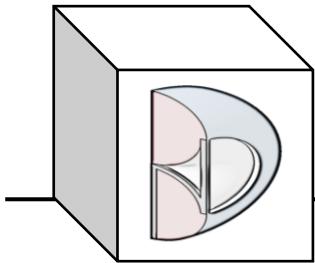




# BND TechSource



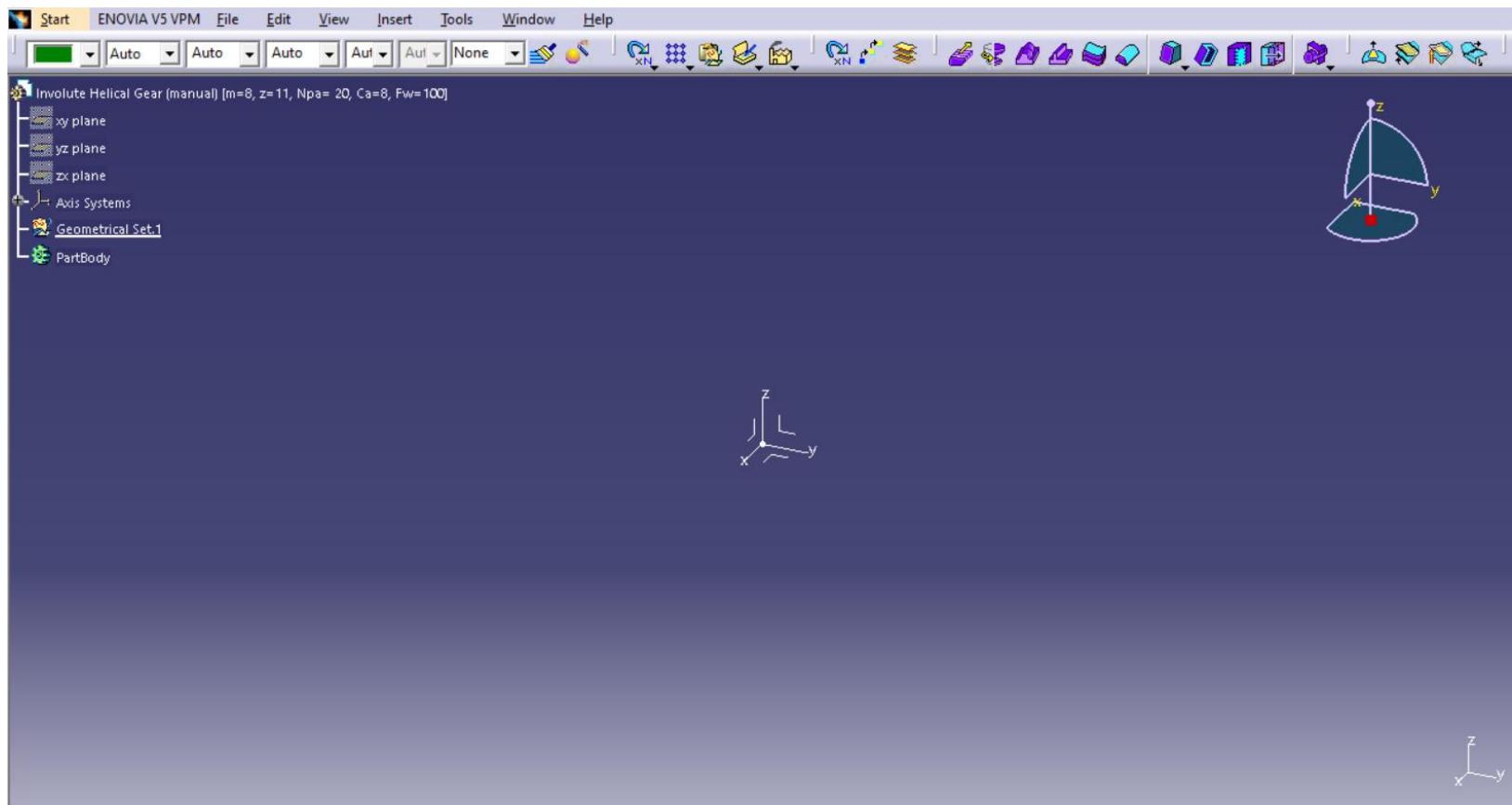
## Create the Parameters

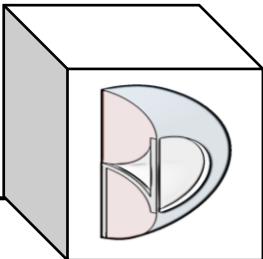


# BND TechSource



- Open a new CATPart and give it the name: Normal Involute Helical Gear [Fw=100, m=8, z=11, Npa=20, Ca=8]





- Create the following Twelve formulae:

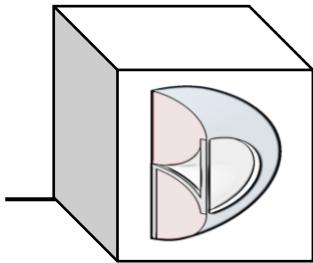
- Known:

- Fw // length parameter [**Face width: Fw = 100mm**]
    - m // length parameter [**Module: m = 8mm**]
    - z // real parameter [**Number of teeth: z = 11**]
    - Npa // angle parameter [**Normal Pressure Angle: Npa = 20 deg**]
    - Ca // angle parameter [**Cylinder helix angle: Ca = 8deg**]

- Resultant:

- Tpa // angle parameter [**Transverse pressure angle: Tpa = atan(tan(Npa)/cos(Ca))**]
    - s // angle parameter [**Symmetry angle: s = 90deg/z**]
    - Pd // length parameter [**Pitch diameter: Pd = (z\*m)/cos(Ca\*1rad)**]
    - Bd // length parameter [**Base diameter: Bd = Pd \* cos(Tpa\*1rad)**]
    - Ad // length parameter [**Addendum diameter: Ad = Pd+(2\*m)**]
    - Dd // length parameter [**Dedendum diameter: Dd = Pd-(2.5\*m)**]
    - tr // length parameter [**tooth radius at dedendum circle: tr = 0.375\*m**]

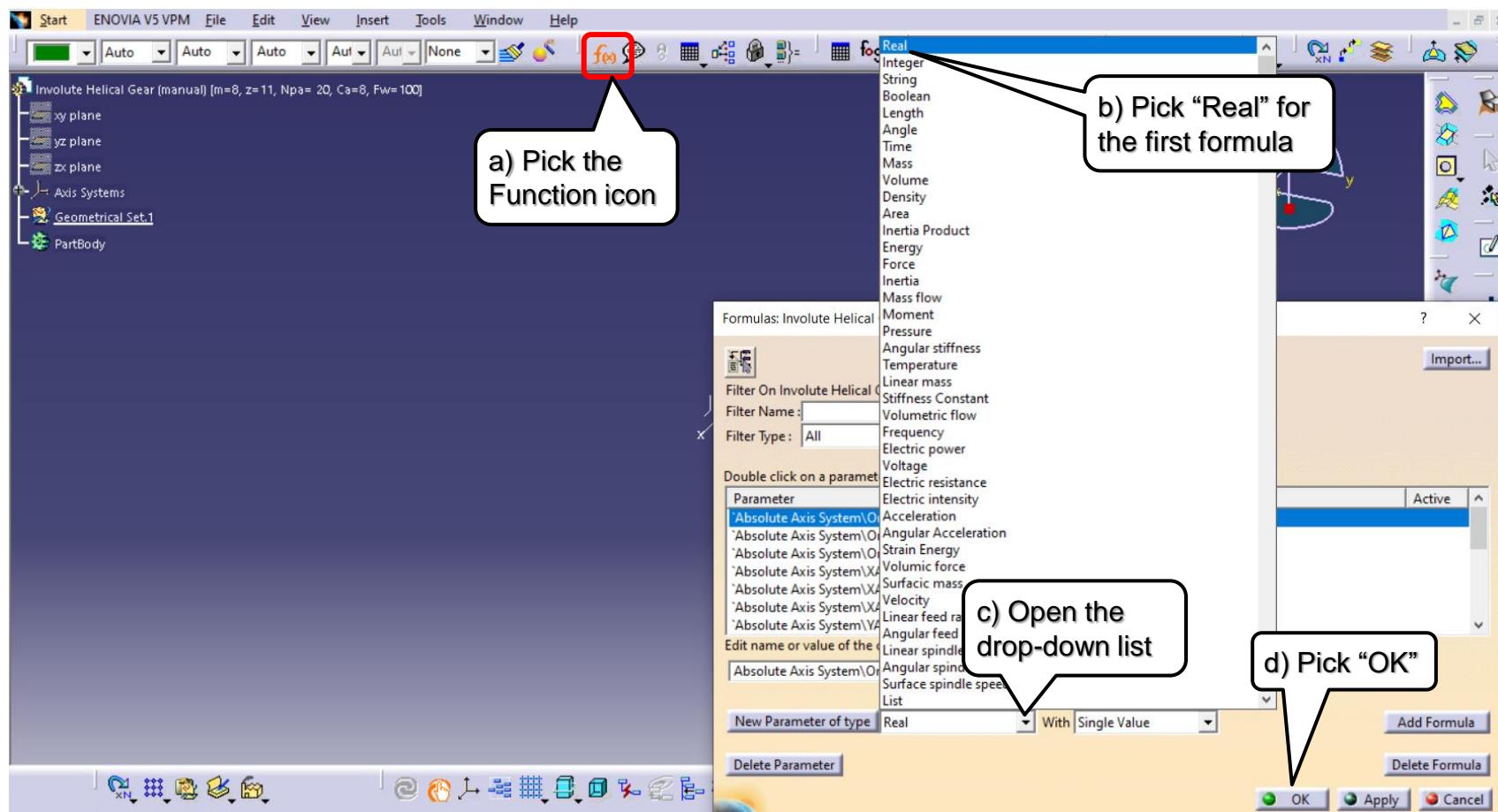
CATIA sees a diametral dimension as a radius. Even though the dimension displays as a diameter.

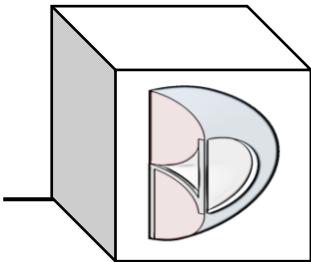


# BND TechSource



- Open the Formulas window





# BND TechSource



## 1) z // real parameter [Number of teeth: z = 11]

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the tree view shows the part structure: PartBody, Geometrical Set.1, Parameters, Axis Systems, zx plane, yz plane, xy plane, and Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]. The main workspace displays a 3D model of a helical gear with a coordinate system (x, y, z). A callout bubble labeled '1' points to the 'Parameters' node in the tree view.

**b) Type "Number of teeth: z" for the name**

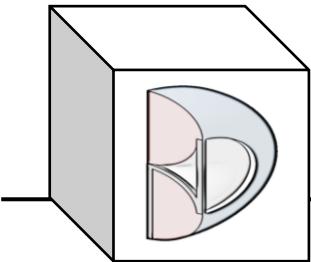
**a) Pick New Parameter**

**c) Set 11 for the number of teeth**

**d) Pick OK**

The 'Formulas' dialog box is open, showing a list of parameters and their values. The 'Number of teeth: z' parameter is selected, set to 11. A callout bubble labeled 'c) Set 11 for the number of teeth' points to the value field. Another callout bubble labeled 'd) Pick OK' points to the 'OK' button at the bottom right of the dialog.

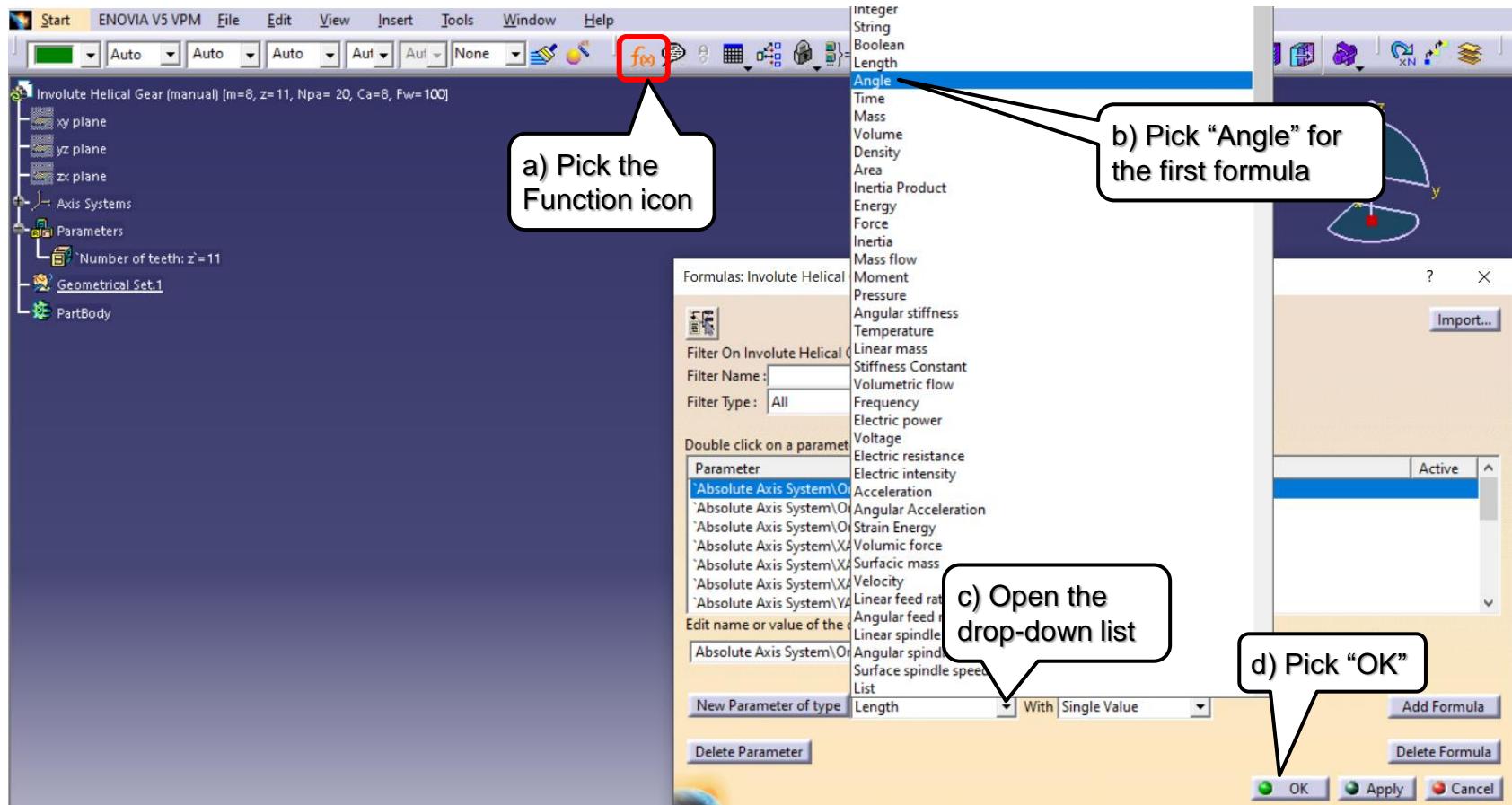
1

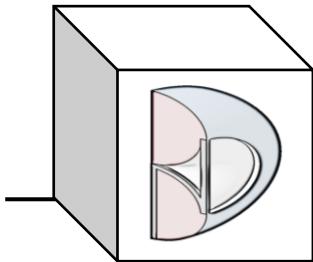


# BND TechSource



- Open the Formulas window





# BND TechSource



## 2) Npa // angle parameter [Normal Pressure Angle: Npa = 20 deg]

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the Feature Tree displays the gear's geometry: xy plane, yz plane, zx plane, Axis Systems, Parameters (Number of teeth: z=11, Normal Pressure Angle: Npa=20deg), Geometrical Set.1, and PartBody. The main workspace shows a 3D model of an involute helical gear with a coordinate system. A callout bubble points to the 'Normal Pressure Angle: Npa' parameter in the Feature Tree with the text 'b) Type "Normal Pressure Angle: Npa" for the name'. In the center, the 'Formulas' dialog box is open, showing a list of formulas for the gear. A callout bubble points to the 'Normal Pressure Angle: Npa' formula with the text 'c) Set 20 for the Normal Pressure Angle'. Another callout bubble points to the 'Value' input field with the value '20deg' with the text 'd) Pick OK'. At the bottom right of the dialog, there are buttons for OK, Apply, and Cancel.

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]

- xy plane
- yz plane
- zx plane
- Axis Systems
- Parameters
  - Number of teeth: z=11
  - Normal Pressure Angle: Npa=20deg
- Geometrical Set.1
- PartBody

Formulas: Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]

Filter On Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]  
Filter Name:   
Filter Type: All

Double click on a parameter to edit it

Parameter	Value	Formula	Active
'Number of teeth: z'			
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...'			
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...'			
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...'			
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...'			
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...'			
'Normal Pressure Angle: Npa'	20deg		

b) Type "Normal Pressure Angle: Npa" for the name

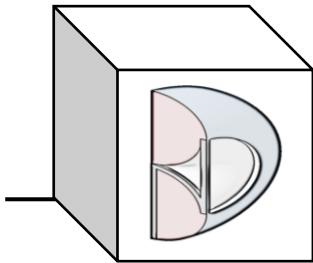
c) Set 20 for the Normal Pressure Angle

a) Pick New Parameter

d) Pick OK

2

Normal Pressure Angle: Npa  
New Parameter of type Angle With Single Value  
Delete Parameter  
OK Apply Cancel



# BND TechSource



## 3) Ca // angle parameter [Cylinder helix angle: Ca = 8deg]

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the FeatureManager tree displays the part structure: 'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]', 'xy plane', 'yz plane', 'zx plane', 'Axis Systems', 'Parameters' (with 'Number of teeth: z=11', 'Normal Pressure Angle: Npa=20deg', and 'Cylinder helix angle: Ca=8deg' selected), 'Geometrical Set.1', and 'PartBody'. A 3D view of the gear is shown on the right.

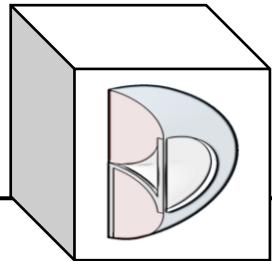
A floating window titled 'Formulas: Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]' is open. It contains a filter dialog with 'Filter Name:' and 'Filter Type: All'. Below it is a table of parameters:

Parameter	Value	Formula	Active
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...		Involut...	
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...		Involut...	
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...		Involut...	
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...		Involut...	
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...		Involut...	
'Normal Pressure Angle: Npa'	20deg		
<b>'Cylinder helix angle: Ca'</b>	<b>8deg</b>		

Callouts provide instructions for the process:

- b) Type "Cylinder helix angle: Ca" for the name
- a) Pick New Parameter
- c) Set 8 for the Cylinder helix angle
- d) Pick OK

A circled '3' is located in the bottom-left corner of the software window.



# BND TechSource



4) Tpa // angle parameter [Transverse pressure angle: Tpa  
 $= \text{atan}(\tan(\text{Npa})/\cos(\text{Ca}))$ ]

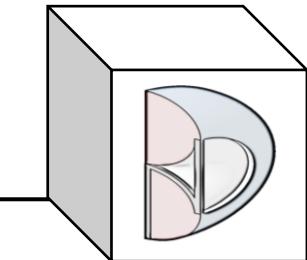
The screenshot shows the ENOVIA V5 VPM software interface with the following steps highlighted:

- Type "Transverse pressure angle: Tpa" for the name.
- Pick New Parameter.
- Pick Add Formula.
- Type atan(tan(`Normal Pressure Angle: Npa`)/cos(`Cylinder helix angle: Ca`)).
- Pick OK.
- Pick OK.

Annotations:

- d) Type atan(tan(`Normal Pressure Angle: Npa`)/cos(`Cylinder helix angle: Ca`))
- e) Pick OK
- c) Pick Add Formula
- f) Pick OK

Bottom left corner: 4



# BND TechSource



5) s // angle parameter [Symmetry angle:  $s = 90\text{deg}/z$ ]

The screenshot shows the ENOVIA V5 VPM interface with a gear model in the background. A formula editor window is open, titled "Formula Editor : 'Symmetry angle: s'".

**d) Type 90deg/Number of teeth: z**: A callout points to the formula input field where "90deg/Number of teeth: z" is typed.

**e) Pick OK**: A callout points to the "OK" button in the formula editor dialog.

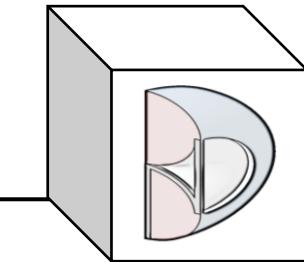
**b) Type "Symmetry angle: s" for the name**: A callout points to the "Edit name or value of the current parameter" field where "Symmetry angle: s" is typed.

**c) Pick Add Formula**: A callout points to the "Add Formula" button in the bottom right of the formula editor dialog.

**a) Pick New Parameter**: A callout points to the "New Parameter of type Angle" button in the bottom left of the formula editor dialog.

**f) Pick Apply**: A callout points to the "Apply" button in the bottom right of the formula editor dialog.

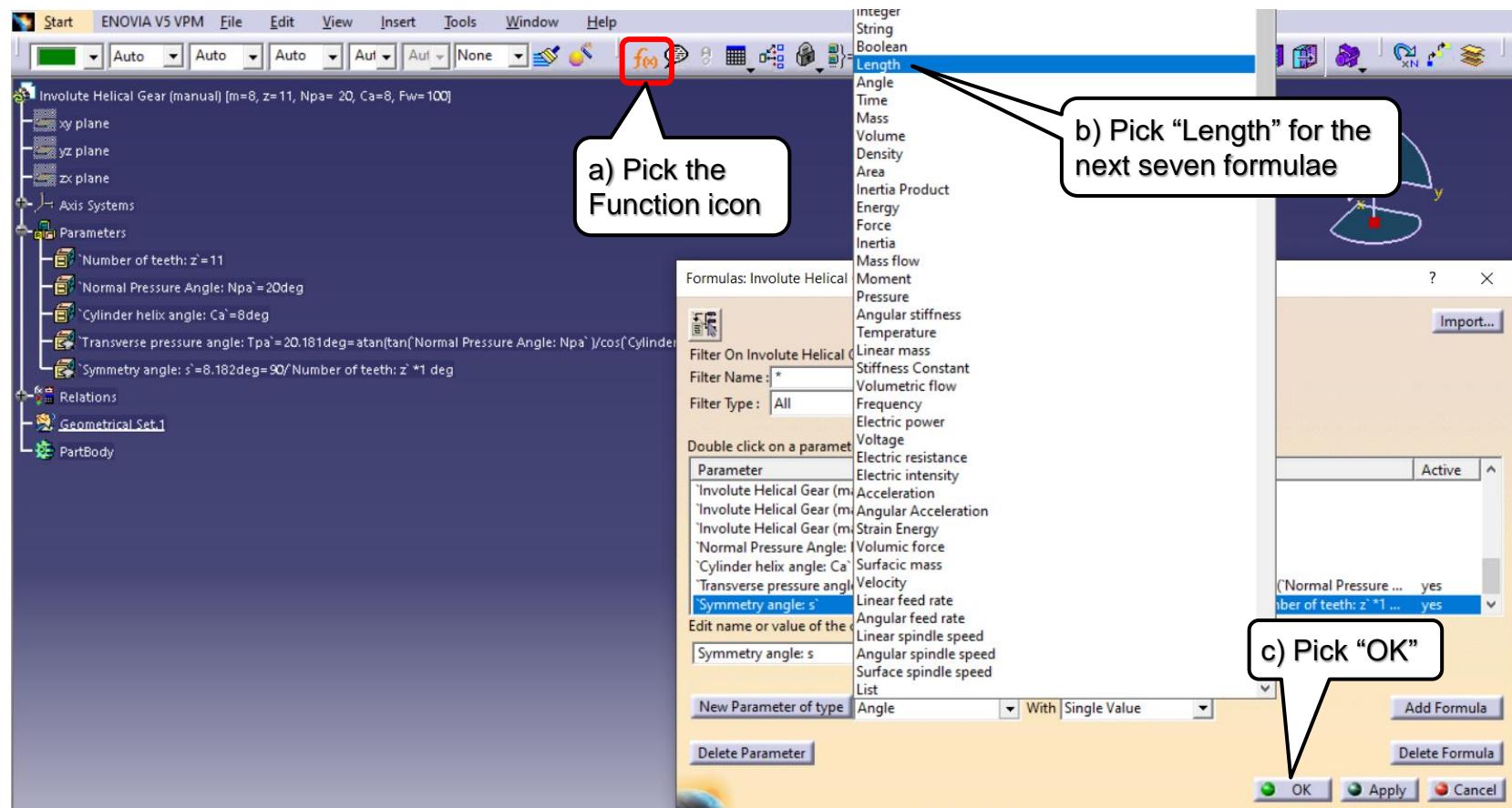
A small circle in the bottom left corner contains the number **5**.

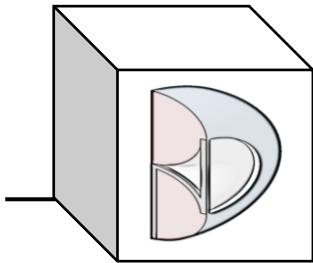


# BND TechSource



- The next seven Parameters will be Length type.





## 6) Fw // length parameter [Face width: Fw = 100mm]

The screenshot shows the ENOVIA V5 VPM interface. On the left, the FeatureManager tree displays the gear's parameters, including 'Number of teeth: z=11', 'Normal Pressure Angle: Npa= 20deg', 'Cylinder helix angle: Ca=8deg', 'Transverse pressure angle: Tpa= 20.181deg', 'Symmetry angle: s= 8.182deg', and 'Face width: Fw= 100mm'. A callout 'b) Type "Face width: Fw" for the name' points to the 'Edit name or value of the current parameter' field where 'Face width: Fw' is typed. A callout 'a) Pick New Parameter' points to the 'New Parameter of type Length With Single Value' button. A callout 'c) Set 100mm for the face width' points to the 'Value' field containing '100mm'. A callout 'd) Pick OK' points to the 'OK' button at the bottom right of the dialog.

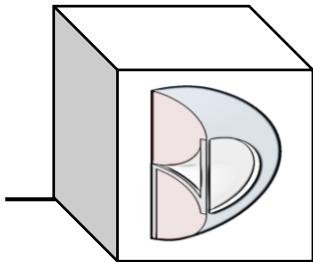
b) Type "Face width: Fw" for the name

c) Set 100mm for the face width

d) Pick OK

a) Pick New Parameter

6



# BND TechSource



## 7) m // length parameter [Module: m = 8mm]

The screenshot shows the ENOVIA V5 VPM interface. On the left, the FeatureManager tree displays parameters like 'Number of teeth: z=11', 'Normal Pressure Angle: Npa= 20deg', and 'Module: m=8mm'. A callout 'b) Type "Module: m" for the name' points to the 'Edit name or value of the current parameter' field where 'Module: m' is typed. In the center, a dialog box titled 'Formulas: Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]' shows a table of parameters. A callout 'a) Pick New Parameter' points to the 'New Parameter of type Length' button. A callout 'c) Set 8mm for the module' points to the 'Value' column for 'Module: m' which is set to '8mm'. A callout 'd) Pick OK' points to the 'OK' button at the bottom right of the dialog. The number '7' is circled in the bottom-left corner.

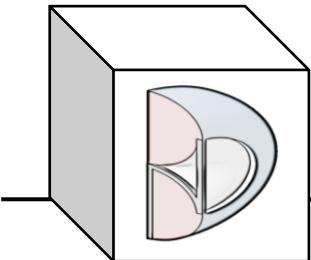
b) Type "Module: m" for the name

c) Set 8mm for the module

d) Pick OK

a) Pick New Parameter

Parameter	Value	Formula	Active
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...			yes
'Normal Pressure Angle: Npa'	20deg		yes
'Cylinder helix angle: Ca'	8deg		
'Transverse pressure angle: Tpa'	20.181deg=atan(tan(Normal Pressure Angle: Npa`)/cos(Cylinder...		
'Symmetry angle: s'	8.182deg=90/Number of teeth: z` *1 deg		
'Face width: Fw'	100mm		
<b>'Module: m'</b>	<b>8mm</b>		



# BND TechSource



8) Pd // length parameter [Pitch diameter:  $Pd = (z*m)/\cos(Ca*1rad)$ ]

The screenshot shows a CAD software interface with a tree view of parameters on the left and a formula editor dialog on the right.

**d) Type (Number of teeth: z \*Module: m)/cos(Cylinder helix angle: Ca\*1rad)**

**b) Type "Pitch diameter: Pd" for the name**

**a) Pick New Parameter**

**c) Pick Add Formula**

**e) Pick OK**

**f) Pick Apply**

**8**

**Formula Editor : 'Pitch diameter: Pd'**

**Pitch diameter: Pd**  
('Number of teeth: z' \* 'Module: m') / cos('Cylinder helix angle: Ca')

**Dictionary**

Parameters	Members of Parameters	Members of Angle
Design Table	All	'Normal Pressure Angle: Npa'
Operators	Renamed parameters	'Cylinder helix angle: Ca'
Pointer on value function	Real	'Transverse pressure angle: Tpa'
Point Constructors	Angle	'Symmetry angle: s'
Law	Length	
Operations Constructors		

**Number of teeth: z** 11

**OK Cancel**

**88.865mm = ('Number o...**

**Edit name or value of the current parameter**

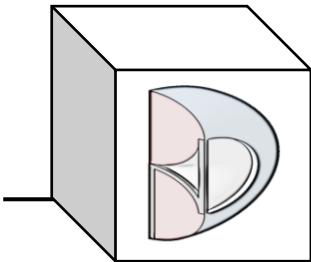
**Pitch diameter: Pd** 88.865mm

**New Parameter of type Length With Single Value**

**Delete Parameter**

**Add Formula Delete Formula**

**OK Apply Cancel**



# BND TechSource



## 9) Bd // length parameter [Base diameter: $Bd = Pd * \cos(Tpa * 1\text{rad})$ ]

The screenshot shows the ENOVIA V5 VPM interface with the Formula Editor open. The formula being created is  $Bd = Pd * \cos(Tpa * 1\text{rad})$ . The formula editor interface includes a toolbar, a list of parameters, and a preview area.

**d) Type Pitch diameter:  $Pd$   
\* $\cos(\text{Transverse pressure angle: } Tpa * 1\text{rad})$**

**b) Type “Base diameter: Bd” for the name**

**a) Pick New Parameter**

**c) Pick Add Formula**

**e) Pick OK**

**f) Pick Apply**

**9**

Formula Editor : 'Base diameter: Bd'

Dictionary

Parameters

Design Table

Operators

Pointer on value function

Point Constructors

Law

Operations Constructors

Members of Parameters

All

Renamed parameters

Real

Angle

Length

Members of All

'Number of teeth: z'

'Normal Pressure Angle: Npa'

'Cylinder helix angle: Ca'

**'Transverse pressure angle: Tpa'**

'Symmetry angle: s'

'Face width: Fw'

'Module: m'

'Pitch diameter: Pd'

Transverse pressure angle:  $Tpa$

20.181deg

OK Cancel

88.865mm

0mm

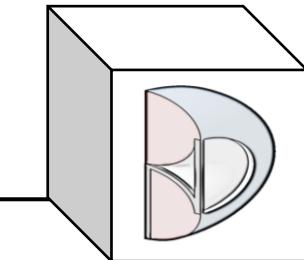
Base diameter: Bd

Edit name or value of the current parameter

New Parameter of type Length With Single Value

Delete Parameter

OK Apply Cancel



# BND TechSource



## 10) Ad // length parameter [Addendum diameter: $Ad = Pd + (2*m)$ ]

Formula Editor : 'Addendum diameter:Ad'

d) Type Pitch diameter:  
 $Pd + (2*Module: m)$

e) Pick OK

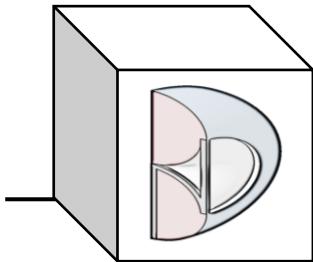
b) Type "Addendum diameter: Ad" for the name

c) Pick Add Formula

a) Pick New Parameter

f) Pick Apply

The screenshot shows the ENOVIA V5 VPM software interface. On the left, there's a tree view of the part structure with various parameters listed. In the center, the 'Formula Editor' dialog is open. The formula input field contains 'Pitch diameter: Pd + (2\*Module: m)'. Below it, the 'Dictionary' pane shows 'Parameters' like 'Number of teeth: z=11', 'Normal Pressure Angle: Npa= 20deg', etc., and 'Operators' like '+', '\*', etc. The 'Members of Parameters' and 'Members of All' panes are also visible. At the bottom of the dialog, there are tabs for 'Edit name or value of the current parameter' (set to 'Addendum diameter: Ad'), 'New Parameter of type' (set to 'Length'), and 'With Single Value' (set to '0mm'). Buttons for 'OK', 'Apply', and 'Cancel' are at the bottom right. A callout 'd)' points to the formula entry field, and another 'e)' points to the 'OK' button. Callouts 'b)' and 'c)' point to the 'Edit name...' field and the 'Add Formula' button respectively. Callouts 'a)' and 'f)' point to the 'New Parameter...' button and the 'Apply' button.



# BND TechSource



11) Dd // length parameter [Dedendum diameter:  $D_d = P_d - (2.5 * m)$ ]

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the PartBody tree view lists various parameters and relations. In the center, the Formula Editor dialog is open with the formula  $Dedendum\ diameter: Dd = Pitch\ diameter: Pd - (2.5 * Module: m)$ . The 'Parameters' tab in the Dictionary is selected. A callout 'd) Type Pitch diameter:  $Pd - (2.5 * Module: m)$ ' points to the formula input field. Another callout 'e) Pick OK' points to the 'OK' button at the bottom right of the dialog. At the bottom, a callout 'c) Pick Add Formula' points to the 'Add Formula' button. Callouts 'f) Pick Apply' and 'a) Pick New Parameter' both point to the 'Apply' button at the bottom right of the dialog. A callout 'b) Type "Dedendum diameter: Dd" for the name' points to the parameter name input field.

d) Type Pitch diameter:  $Pd - (2.5 * Module: m)$

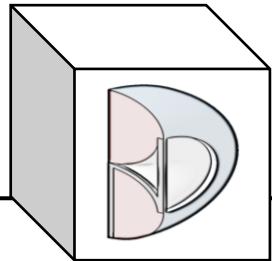
e) Pick OK

c) Pick Add Formula

f) Pick Apply

a) Pick New Parameter

b) Type "Dedendum diameter: Dd" for the name



# BND TechSource



12) tr // length parameter [tooth radius at dedendum circle: tr = 0.375\*m]

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the 'Parameters' tree view is open, showing various gear parameters like Number of teeth, Normal Pressure Angle, and Module. A callout 'd) Type 0.375 \* Module: m' points to the formula entry field in the 'Formula Editor' dialog.

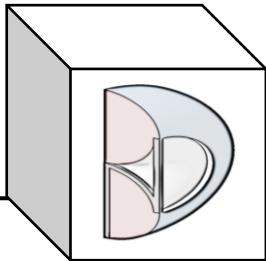
The 'Formula Editor' dialog has the following details:

- Text input field: tooth radius at dedendum circle: tr
- Value input field: 0.375\*Module: m
- Dictionary tab:
  - Parameters: Design Table, Operators, Pointer on value function, Point Constructors, Law, Operations Constructors
  - Members of Parameters: All, Renamed parameters, Boolean, CstAttr\_Mode, Angle, Length, Real, Integer
  - Members of All: Right-hand Geometric Set\Right-hand Ske...
- Buttons: OK, Cancel

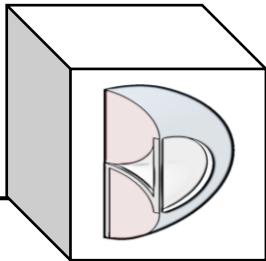
Callouts indicate the steps:

- Pick New Parameter
- Type "tooth radius at dedendum circle: tr" for the name
- Pick Add Formula
- Pick OK
- Type 0.375 \* Module: m

At the bottom of the dialog, there are buttons for OK, Apply, and Cancel.



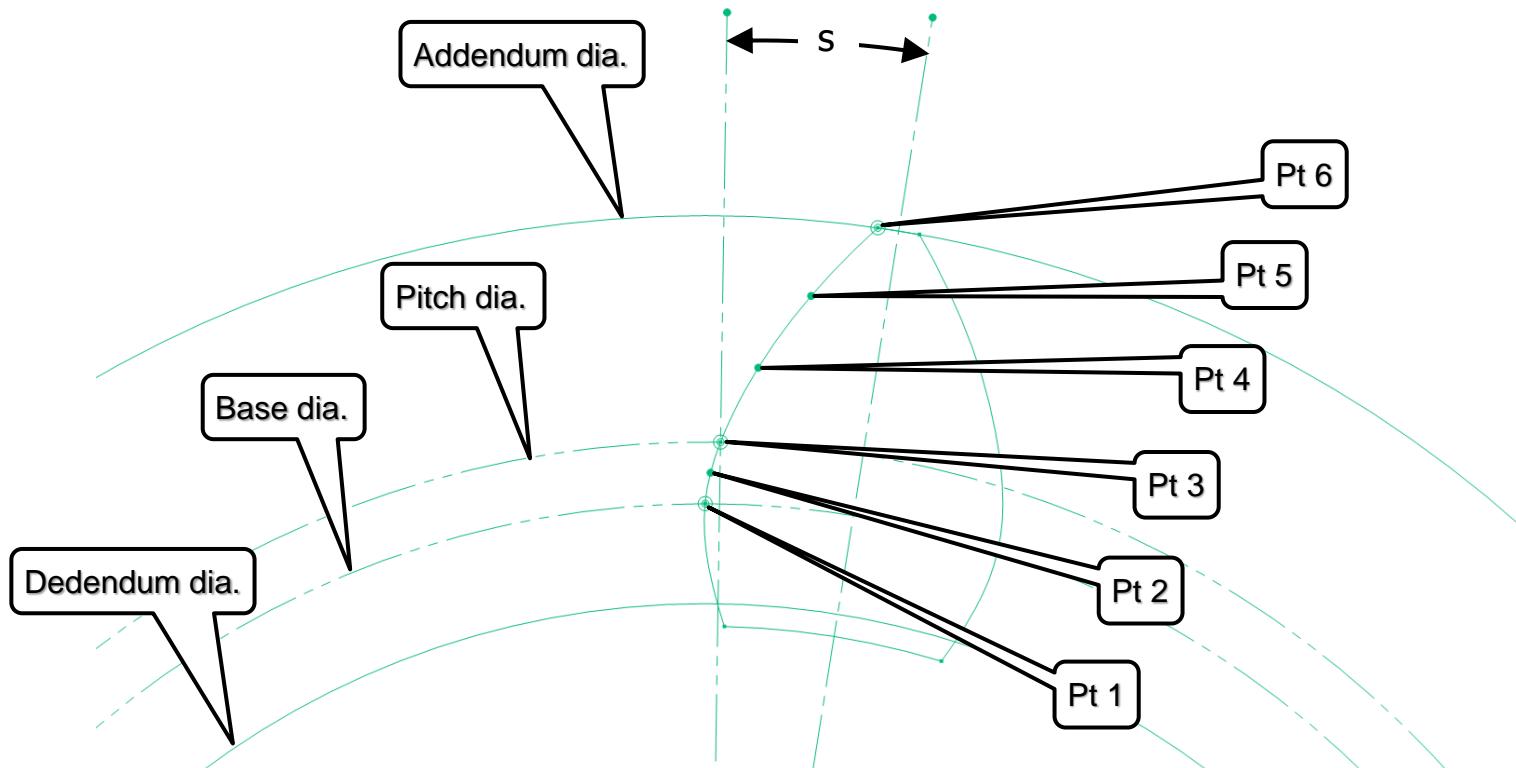
- Create the following six formulae for Involute points:
  - radius (Pt1) // length parameter [ $r (\text{Pt1}) = Bd/2$ ]
  - radius (Pt2) // length parameter [ $r (\text{Pt2}) = ((Pd/2)+(Bd/2))/2$ ]
  - radius (Pt3) // length parameter [ $r (\text{Pt3}) = Pd/2$ ]
  - radius (Pt4) // length parameter [ $r (\text{Pt4}) = (Pd/2)+((Ad/2)-(Pd/2))*.33333$ ]
  - radius (Pt5) // length parameter [ $r (\text{Pt5}) = (Pd/2)+((Ad/2)-(Pd/2))*.66667$ ]
  - radius (Pt6) // length parameter [ $r (\text{Pt6}) = Ad/2$ ]



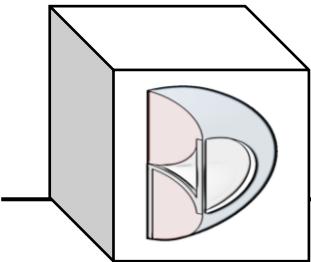
# BND TechSource



## HELICAL GEAR TOOTH INVOLUTE POINTS



Point	r (formula)	r (mm)	a (radians)	inv a (radians)	x <sub>1</sub> (mm)	y <sub>1</sub> (mm)
Pt 1	[Base] Br	43.663	0.0000	0.0000	0.000	43.663
Pt 2	(Pr+Br)/2	45.243	0.2651	0.0064	0.289	45.242
Pt 3	[Pitch] Pr	46.824	0.3695	0.0178	0.833	46.816
Pt 4	Pr+(Ar-Pr)*.33333	49.490	0.4902	0.0434	2.149	49.444
Pt 5	Pr+(Ar-Pr)*.666667	52.157	0.5788	0.0746	3.889	52.012
Pt 6	[Addendum] Ar	54.824	0.6494	0.1099	6.012	54.493



# BND TechSource



1) radius (Pt1) // length parameter [ $r (Pt1) = Bd/2$ ]

The screenshot shows the ENOVIA V5 VPM software interface with a tree view of parameters on the left and a formula editor on the right.

**Left Panel (Parameters Tree):**

- Involute Helical Gear (manual) [m=8]
- xy plane
- yz plane
- zx plane
- Axis Systems
- Parameters
  - Number of teeth: z = 11
  - Normal Pressure Angle: Npa = 20deg
  - Cylinder helix angle: Ca = 8deg
  - Transverse pressure angle: Tpa = 20.181deg = atan(tan(Normal Pressure Angle: Npa) \* sin(Cylinder helix angle: Ca))
  - Symmetry angle: s = 0.182deg = 90deg / Number of teeth: z
  - Face width: Fw = 100mm
  - Module: m = 8mm
  - Pitch diameter: Pd = 88.655mm = (Number of teeth: z \* Module: m) / cos(Cylinder helix angle: Ca)
  - Base diameter: Bd = 83.409mm = Pitch diameter: Pd \* cos(Transverse pressure angle: Tpa)
  - Addendum diameter: Ad = 104.865mm = Pitch diameter: Pd + (2 \* Module: m)
  - Dedendum diameter: Dd = 68.865mm = Pitch diameter: Pd - (2.5 \* Module: m)
  - Tooth radius at dedendum circle: tr = 3.04mm = 0.38 \* Module: m
  - r (Pt1) = 0mm
- Relations
- Geometrical Set.1
- PartBody

**Right Panel (Formula Editor):**

Formula Editor : `r (Pt1)`

d) Type `Base diameter: Bd` / 2

e) Pick OK

f) Pick Apply

Members of Parameters

All

- Renamed parameters
- Real
- Angle
- Length

Members of All

- Number of teeth: z
- Normal Pressure Angle: Npa
- Cylinder helix angle: Ca
- Transverse pressure angle: Tpa
- Symmetry angle: s
- Face width: Fw
- Module: m
- Pitch diameter: Pd

b) Type "r (Pt1)" for the name

c) Pick Add Formula

a) Pick New Parameter

New Parameter of type Length With Single Value

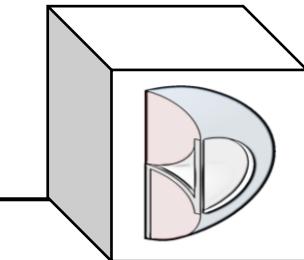
OK Cancel

OK Cancel

OK Cancel

OK Cancel

1



# BND TechSource



2) radius (Pt2) // length parameter [ $r(Pt2) = ((Pd/2)+(Bd/2))/2$ ]

The screenshot shows the ENOVIA V5 software interface with a tree view of parameters on the left and a formula editor window on the right.

**d) Type ((`Pitch diameter:  
Pd`/2)+(`Base diameter:  
Bd`/2))/2**

**b) Type "r (Pt2)" for the name**

**a) Pick New Parameter**

**c) Pick Add Formula**

**e) Pick OK**

**f) Pick Apply**

**Formula Editor : `r (Pt2)`**

**Dictionary**

**Parameters**

- Design Table
- Operators
- Pointer on value function
- Point Constructors
- Law
- Operations Constructors

**Members of Parameters**

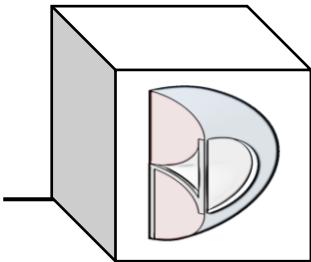
- All
- Renamed parameters
- Length
- Real
- Boolean
- Angle
- String
- Feature

**Members of All**

- 'Absolute Axis System\Origin\X'
- 'Absolute Axis System\Origin\Y'
- 'Absolute Axis System\Origin\Z'
- 'Absolute Axis System\XAxis\X'
- 'Absolute Axis System\XAxis\Y'
- 'Absolute Axis System\XAxis\Z'
- 'Absolute Axis System\YAxis\X'

**OK Cancel**

**OK Apply Cancel**



# BND TechSource



3) radius (Pt2) // length parameter [ $r (Pt3) = Pd/2$ ]

The screenshot shows the ENOVIA V5 VPM software interface with the following steps highlighted:

- Pick New Parameter
- Type "r (Pt3)" for the name
- Pick Add Formula
- Type `Pitch diameter: Pd`/2
- Pick OK
- Pick Apply

Annotations with callouts point to each step:

- d) Type `Pitch diameter: Pd`/2
- e) Pick OK
- f) Pick Apply

The formula editor window shows the parameter definition:

Formula Editor : `r (Pt3)`

`r (Pt3)` =  
`Pitch diameter: Pd`/2

Dictionary

Parameters	Members of Parameters	Members of All
Design Table	Renamed parameters	`Number of teeth: z`
Operators	Real	`Normal Pressure Angle: Npa`
Pointer on value function	Angle	`Cylinder helix angle: Ca`
Point Constructors	Length	`Transverse pressure angle: Tpa`
Law		`Symmetry angle: s`
Operations Constructors		`Face width: Fw`

Pitch diameter: Pd

Members of All

- `Number of teeth: z`
- `Normal Pressure Angle: Npa`
- `Cylinder helix angle: Ca`
- `Transverse pressure angle: Tpa`
- `Symmetry angle: s`
- `Face width: Fw`
- `Module: m`
- Pitch diameter: Pd**

Value: 88.865mm

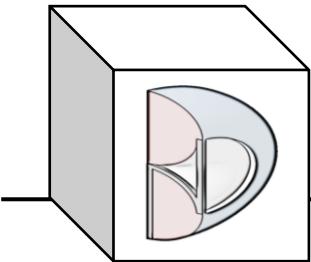
Buttons: OK, Cancel

Bottom panel:

- New Parameter of type Length With Single Value
- Delete Parameter
- Add Formula
- Delete Formula
- OK
- Apply
- Cancel

Bottom left corner: 3

Bottom center: <https://bndtechsource.wixsite.com/home>



# BND TechSource



4) radius (Pt4) // length parameter [ $r (\text{Pt4}) = (\text{Pd}/2) + ((\text{Ad}/2) - (\text{Pd}/2)) * .33333$ ]

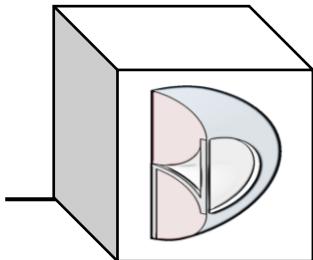
The screenshot shows the ENOVIA V5 VPM interface with the following steps highlighted:

- b) Type "r (Pt4)" for the name**: A callout points to the formula editor where the parameter name is being typed.
- c) Pick Add Formula**: A callout points to the "Add Formula" button in the bottom right corner of the dialog.
- d) Type (' Pitch diameter: Pd`/2) + ((` Addendum diameter: Ad`/2) - (` Pitch diameter: Pd`/2))\*.33333**: A callout points to the formula editor containing the calculated formula.
- e) Pick OK**: A callout points to the "OK" button in the bottom right corner of the dialog.
- f) Pick Apply**: A callout points to the "Apply" button in the bottom right corner of the dialog.

Below the dialog, the parameter list shows:

Length.11	0mm
r (Pt1)	41.705mm
r (Pt2)	86.137mm
r (Pt3)	44.432mm
Length.11	0mm

At the bottom left of the interface, there is a circled number **4**.



# BND TechSource



5) radius (Pt5) // length parameter [ $r(Pt5) = (Pd/2) + ((Ad/2) - (Pd/2)) * .66667$ ]

d) Type (` Pitch diameter: Pd`/2) +  
(` Addendum diameter: Ad`/2) -  
(` Pitch diameter: Pd`/2))\*.66667

b) Type "r (Pt5)" for the name

a) Pick New Parameter

c) Pick Add Formula

e) Pick OK

f) Pick Apply

5

Formula Editor : `r (Pt5)`

Parameters

Design Table

Operators

Pointer on value function

Point Constructors

Law

Operations Constructors

All

Renamed parameters

Length

Real

Boolean

Angle

String

Feature

Absolute Axis System\Origin\X

Absolute Axis System\Origin\Y

Absolute Axis System\Origin\Z

Absolute Axis System\XAxis\X

Absolute Axis System\XAxis\Y

Absolute Axis System\XAxis\Z

Absolute Axis System\YAxis\X

Absolute Axis System\YAxis\Y

Absolute Axis System\YAxis\Z

OK Cancel

Add Formula Delete Parameter

Length.12

86.137mm

44.432mm

91.531mm

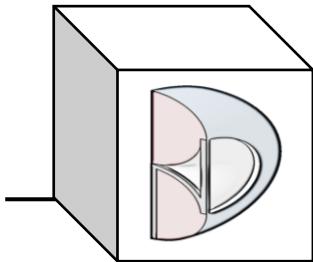
0mm

Length.12=0mm

New Parameter of type Length With Single Value

Edit name or value of the current parameter

OK Apply Cancel



# BND TechSource



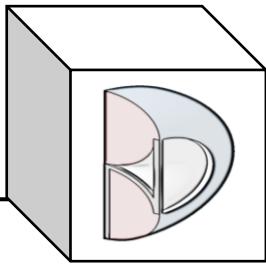
6) radius (Pt6) // length parameter [ $r (Pt6) = Ad/2$ ]

The screenshot shows the ENOVIA V5 VPM interface with the Formula Editor dialog open. The formula being entered is  $r (Pt6)$ , with the expression  $'Addendum diameter: Ad' /2$ .

Annotations provide steps for the process:

- a) Pick New Parameter**: Points to the "New Parameter" button in the bottom right of the dialog.
- b) Type "r (Pt6)" for the name**: Points to the parameter name input field.
- c) Pick Add Formula**: Points to the "Add Formula" button in the bottom right.
- d) Type 'Addendum diameter: Ad' /2**: Points to the formula input field.
- e) Pick OK**: Points to the "OK" button in the bottom right of the dialog.
- f) Pick Apply**: Points to the "Apply" button in the bottom right of the dialog.

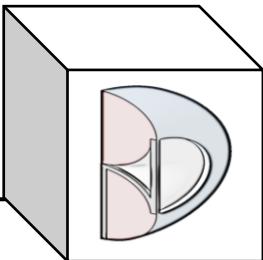
A circled number **6** is located in the bottom left corner of the main window.



# BND TechSource



## Create the Involute Laws



- How the parametric equations for the Involute points are developed:

From Excel  
Spreadsheet

$$\text{inv } \alpha = \tan \alpha - \alpha \quad (\text{rad}) \quad (3.2)$$

With the center of the base circle O at the origin of a coordinate system, the involute curve can be expressed by values of x and y as follows :

$$\begin{aligned}\alpha &= \cos^{-1} \frac{r_b}{r} \\ x &= r \sin(\text{inv } \alpha) \\ y &= r \cos(\text{inv } \alpha)\end{aligned}$$

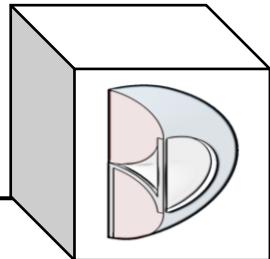
}

(3.3)

Point	r (formula)	r (mm)	$\alpha$ (radians)	inv $\alpha$ (radians)	x (mm)	y (mm)
Pt 1	[Base] Br	41.705	0.0000	0.0000	0.000	41.705
Pt 2	(Pr+Br)/2	43.069	0.2523	0.0055	0.237	43.068
Pt 3	[Pitch] Pr	44.432	0.3522	0.0153	0.681	44.427
Pt 4	Pr+(Ar-Pr)*.33333	47.099	0.4833	0.0415	1.955	47.058
Pt 5	Pr+(Ar-Pr)*.66667	49.766	0.5772	0.0740	3.677	49.630
Pt 6	[Addendum] Ar	52.432	0.6511	0.1109	5.801	52.111

The parametric equations for involute curve points in CATIA:

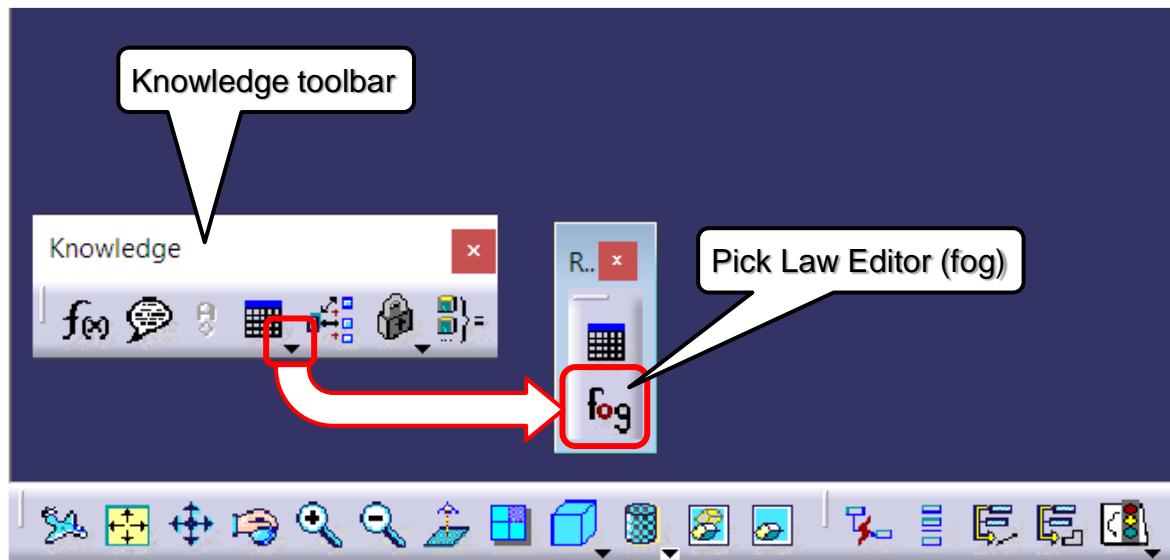
- $x=r*\sin((\tan(\text{acos}(`r(Pt1)`/r)))-(\text{acos}(`r(Pt1)`/r))))$
- $y=r*\cos((\tan(\text{acos}(`r(Pt1)`/r)))-(\text{acos}(`r(Pt1)`/r))))$

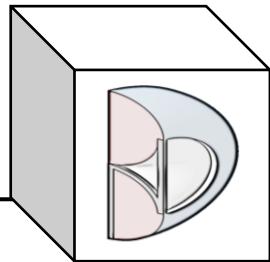


# BND TechSource



- Create the following two Laws for the creation of the Involute points:
  - $x=r*\sin((\tan(\text{acos}(`r (Pt1)`/r))-(\text{acos}(`r (Pt1)`/r))))$
  - $y=r*\cos((\tan(\text{acos}(`r (Pt1)`/r))-(\text{acos}(`r (Pt1)`/r))))$
- In the Knowledge Toolbar, pull out the Law Editor (fog).

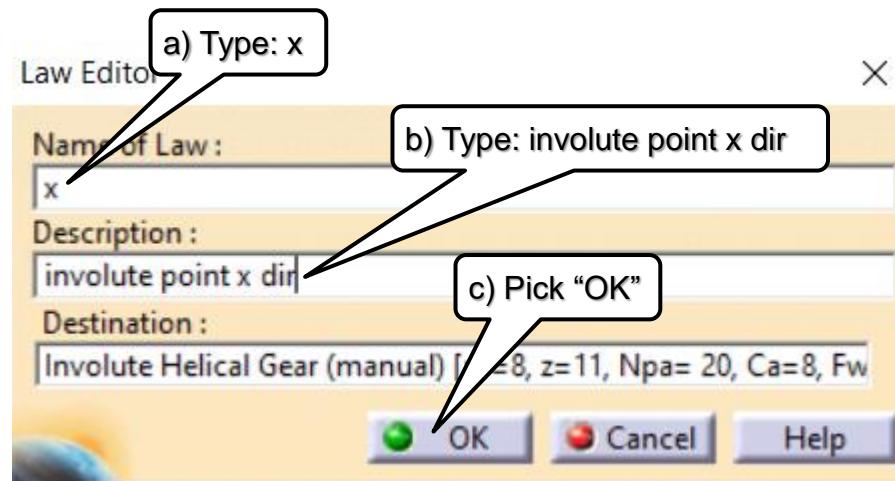


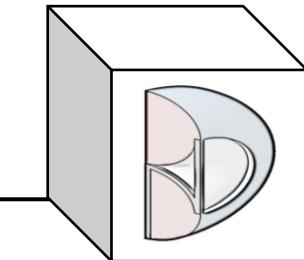


# BND TechSource



- Type the following in the Law Editor (fog):

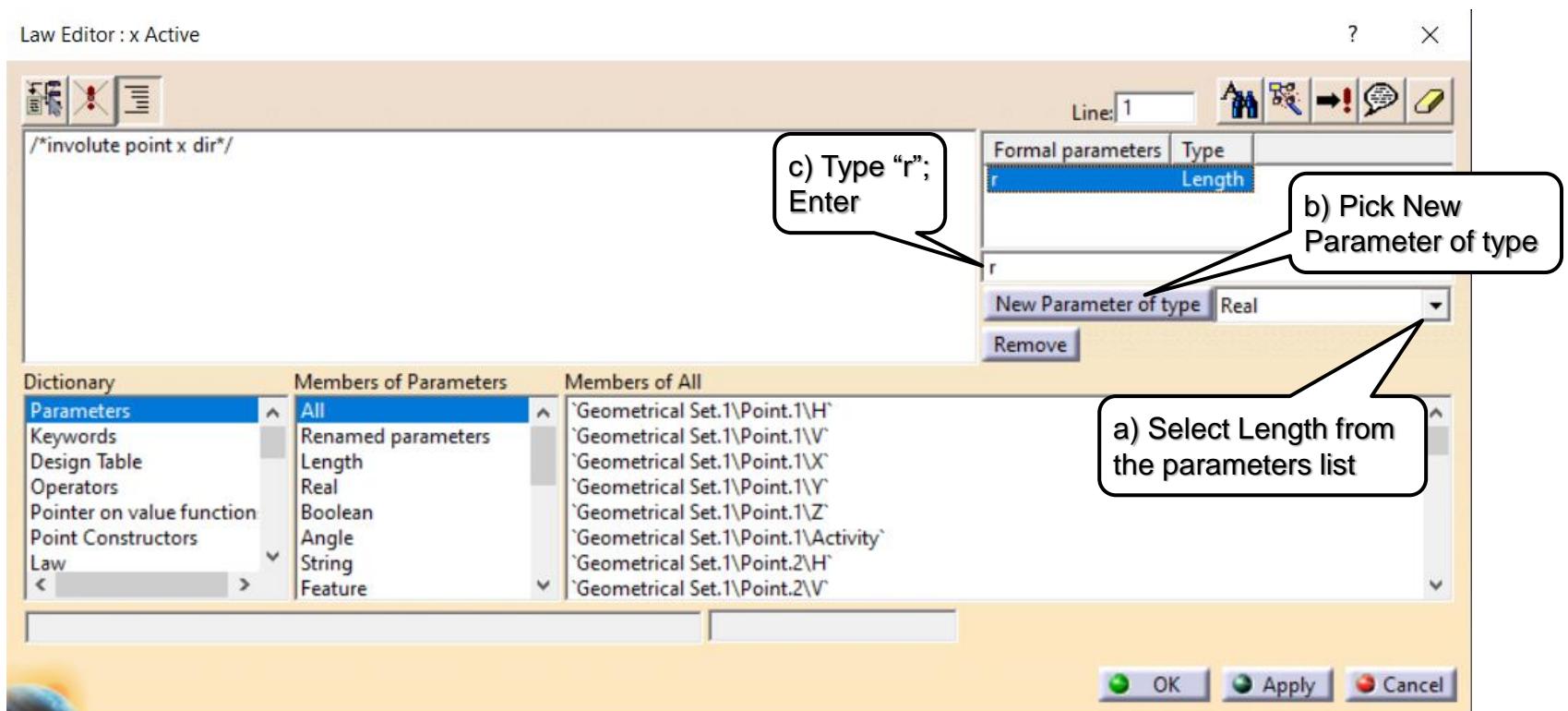


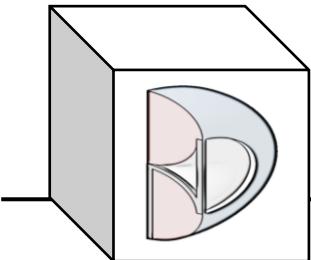


# BND TechSource



- Type the following in the Law Editor (fog):





# BND TechSource



- Type the following in the Law Editor (fog):

The screenshot shows the Law Editor interface with the following steps highlighted:

- Select Length from the parameters list.
- Pick New Parameter of type.
- Type "x"; Enter.
- Type "x=r\*sin((tan(acos(`r(Pt1)`/r))-(acos(`r(Pt1)`/r))))".

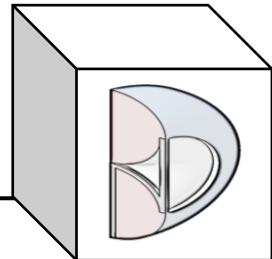
The Law Editor window title is "Law Editor : x Active". The code input field contains: /\*involute point x dir\*/  
x=r\*sin((tan(acos(`r(Pt1)`/r))-(acos(`r(Pt1)`/r))))

The Parameters list on the left includes: Parameters, Keywords, Design Table, Operators, Pointer on value function, Point Constructors, Law.

The Members of Parameters list shows: All, Renamed parameters, Length, Real, Boolean, Angle, String, Feature.

The Members of All list shows: `Geometrical Set.1\Point.1\H`, `Geometrical Set.1\Point.1\V`, `Geometrical Set.1\Point.1\X`, `Geometrical Set.1\Point.1\Y`, `Geometrical Set.1\Point.1\Z`, `Geometrical Set.1\Point.1\Activity`, `Geometrical Set.1\Point.2\H`, `Geometrical Set.1\Point.2\V`.

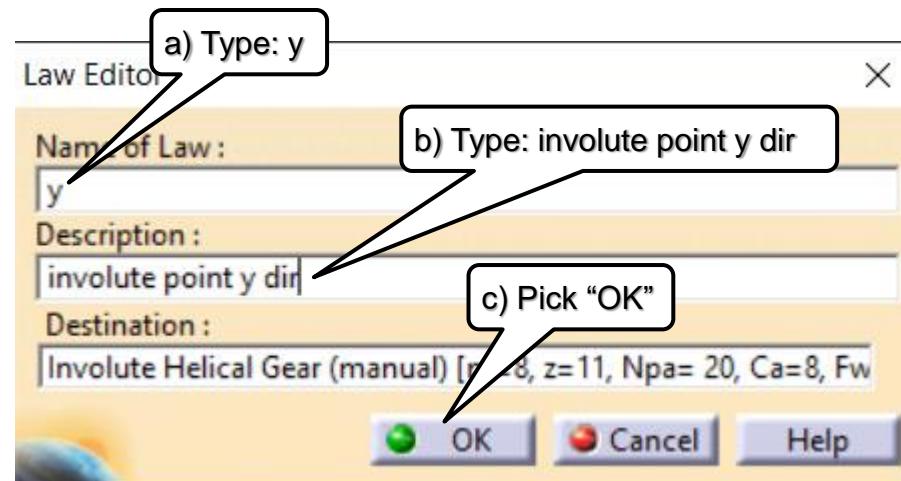
The right panel shows Formal parameters: r (Length), x (Length). A dropdown menu says "New Parameter of type Real". Buttons at the bottom include OK, Apply, and Cancel.

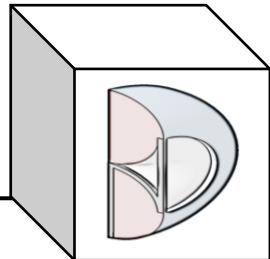


# BND TechSource



- Type the following in the Law Editor (fog):

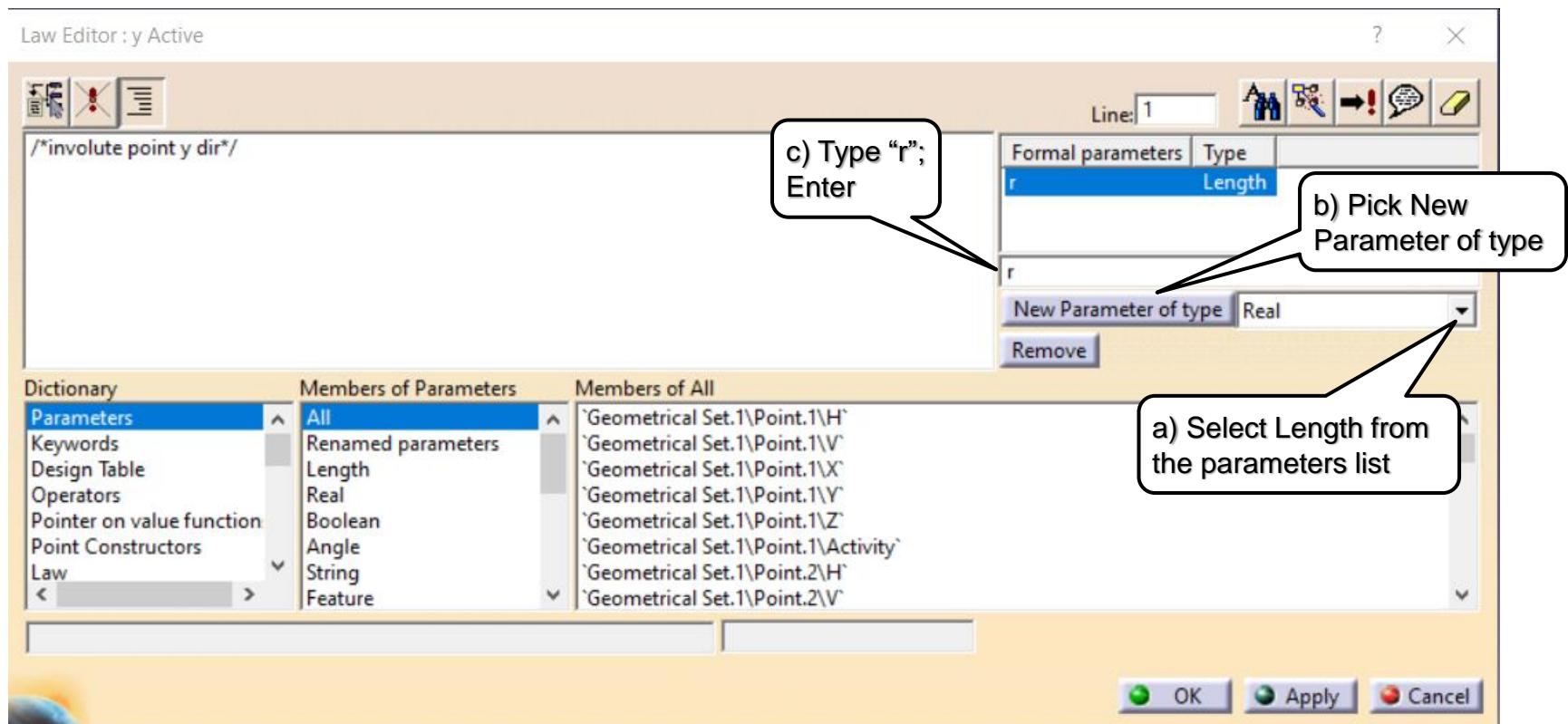


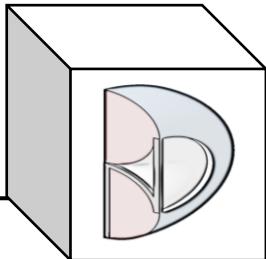


# BND TechSource



- Type the following in the Law Editor (fog):





# BND TechSource



- Type the following in the Law Editor (fog):

Law Editor : y Active

d) Type "y=r\*cos((tan(acos(`r (Pt1)`/r))-(acos(`r (Pt1)`/r))))"

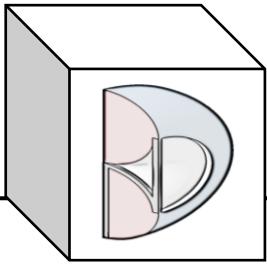
c) Type "y"; Enter

b) Pick New Parameter of type

a) Select Length from the parameters list

The screenshot shows the Law Editor interface with the following components:

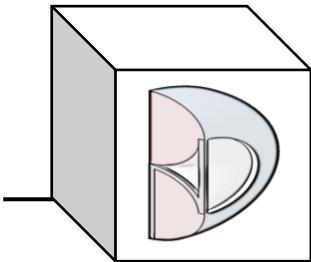
- Code Editor:** Displays the law `/*involute point y dir*/  
y=r*cos(tan(acos(`r (Pt1)`/r))-(acos(`r (Pt1)`/r))))`.
- Parameter Manager:** Shows a list of formal parameters with their types:
  - r: Length
  - y: Length
  - y: Real (highlighted)Buttons include Line: 1, A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z.
- Dictionary:** Shows the Members of Parameters and Members of All sections.
  - Members of Parameters:** Parameters, Keywords, Design Table, Operators, Pointer on value function, Point Constructors, Law.
  - Members of All:** Geometrical Set.1\Point.1\H, Geometrical Set.1\Point.1\V, Geometrical Set.1\Point.1\X, Geometrical Set.1\Point.1\Y, Geometrical Set.1\Point.1\Z, Geometrical Set.1\Point.1\Activity, Geometrical Set.1\Point.2\H, Geometrical Set.1\Point.2\V.
- Buttons at the bottom:** OK, Apply, Cancel.



# BND TechSource



## Create the Construction Geometry (Normal Module Involute Helical Gear)



# BND TechSource



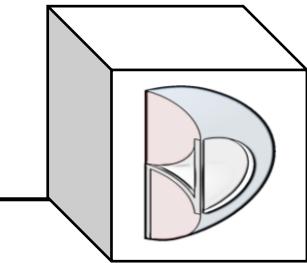
- Create Right-hand Geometrical Set.

The screenshot shows the ENOVIA V5 VPM software interface. The top menu bar includes Start, ENOVIA V5 VPM, File, Edit, View, Insert, Tools, Window, and Help. The toolbar below has various icons for selection, measurement, and modification. The left pane displays a tree view of the model structure:

- Normal Involute Helical Gear (manual input) [Fw=100, m=8, z=11, Npa=20, Ca=8]
  - xy plane
  - yz plane
  - zx plane
- Axis Systems
- Parameters
  - Face width: Fw = 100mm
  - Module: m = 8mm
  - Number of teeth: z = 11
  - Normal Pressure Angle: Npa = 20deg
  - Cylinder helix angle: Ca = 8deg
  - Transverse pressure angle: Tpa = 20.181deg = atan(tan(Normal Pressure Angle: Npa) / cos(Cylinder helix angle: Ca))
  - Symmetry angle: s = 8.182deg = 90deg / Number of teeth: z
  - Pitch diameter: Pd = 88.865mm = (Number of teeth: z \* Module: m) / cos(Cylinder helix angle: Ca \* 1rad)
  - Base diameter: Bd = 83.409mm = Pitch diameter: Pd \* cos(Transverse pressure angle: Tpa \* 1rad)
  - Addendum diameter: Ad = 104.865mm = Pitch diameter: Pd + (2 \* Module: m)
  - Dedendum diameter: Dd = 68.865mm = Pitch diameter: Pd - (2.5 \* Module: m)
  - Tooth radius at dedendum circle: tr = 3.04mm = 0.38 \* Module: m
  - r (Pt1) = 41.705mm = Base diameter: Bd / 2
  - r (Pt2) = 43.069mm = (Pitch diameter: Pd / 2) + (Base diameter: Bd / 2) / 2
  - r (Pt3) = 44.432mm = Pitch diameter: Pd / 2
  - r (Pt4) = 47.099mm = (Pitch diameter: Pd / 2) + ((Addendum diameter: Ad / 2) / 2)
  - r (Pt5) = 49.766mm = (Pitch diameter: Pd / 2) + ((Addendum diameter: Ad / 2) / 2)
  - r (Pt6) = 52.432mm = Addendum diameter: Ad / 2
- Relations
- Right-hand Geometrical Set

A callout bubble points to the "Right-hand Geometrical Set" node with the text: "Rename Geometric Set.1 to Right-hand Geometric Set".

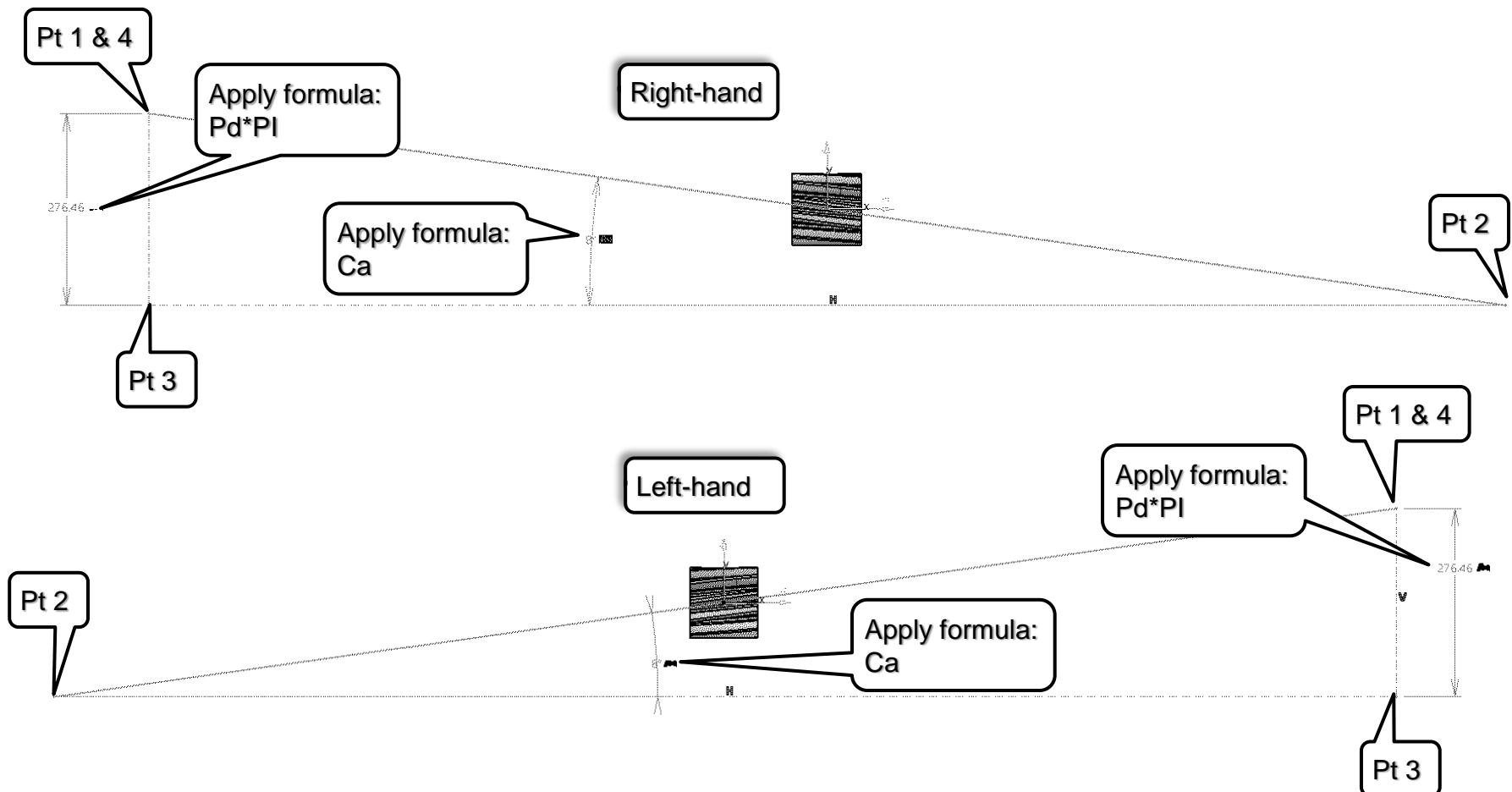
Two 3D coordinate systems are visible on the right side of the interface.

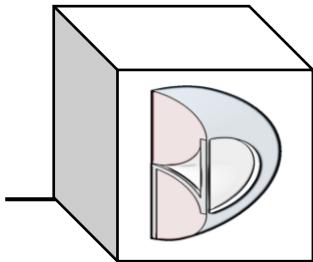


# BND TechSource



- Create the Right & Left-hand Sketch on XY plane.

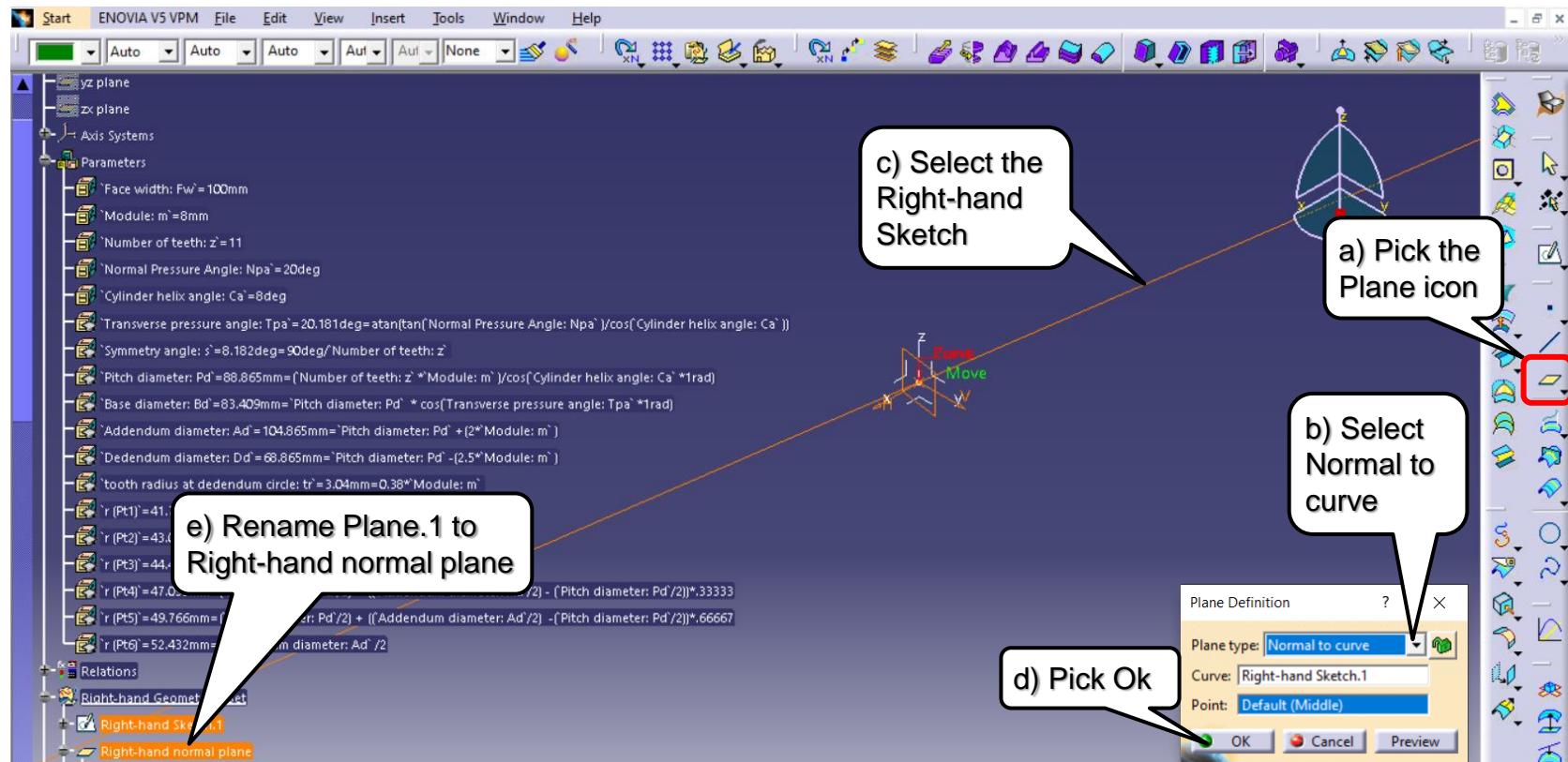


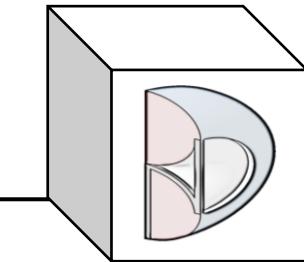


# BND TechSource



- Create Right-hand normal plane through Right-hand Sketch.

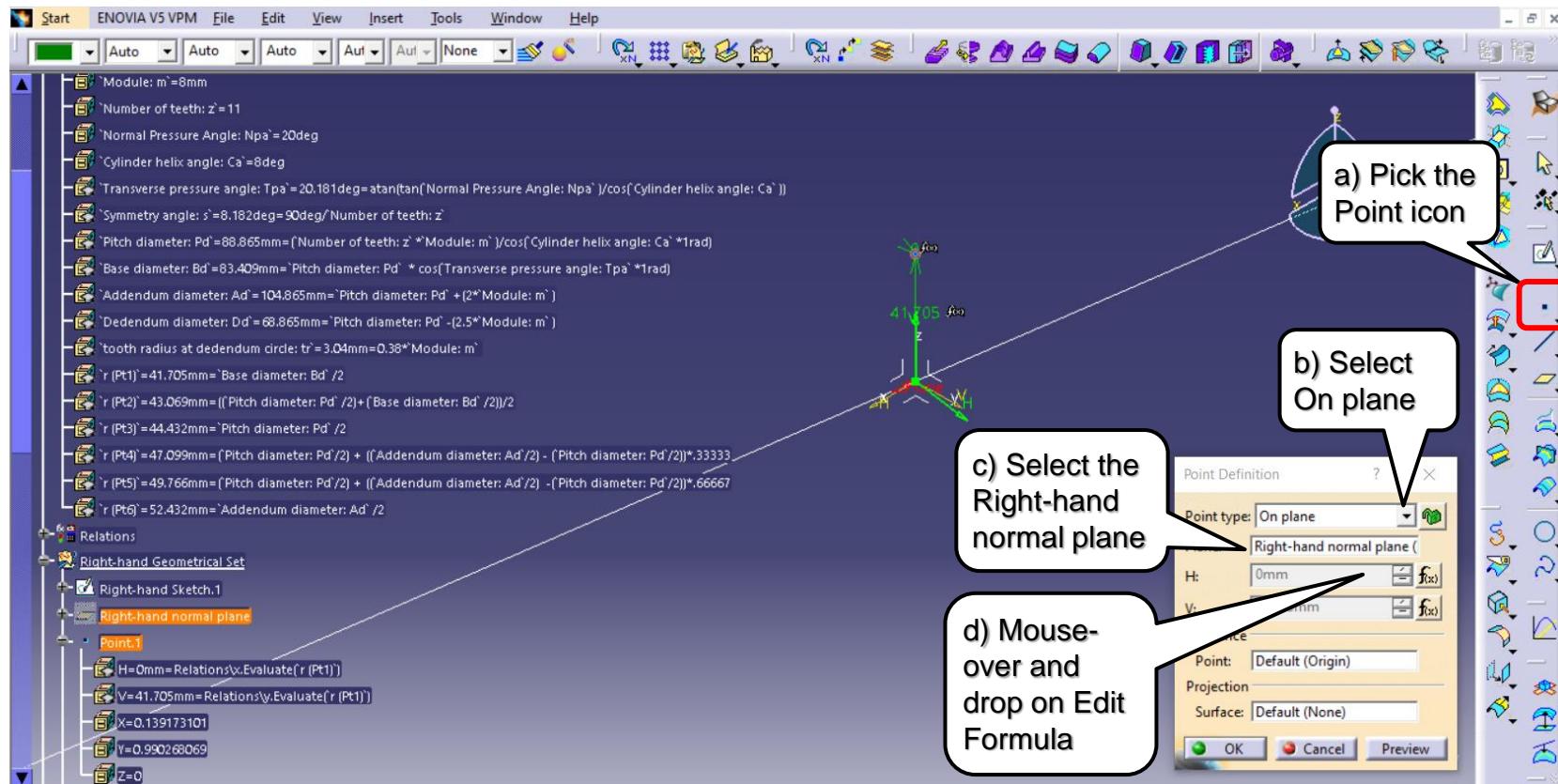


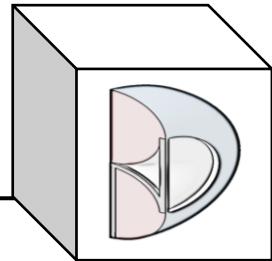


# BND TechSource



- Create points on the Right-hand normal plane for involute spline.

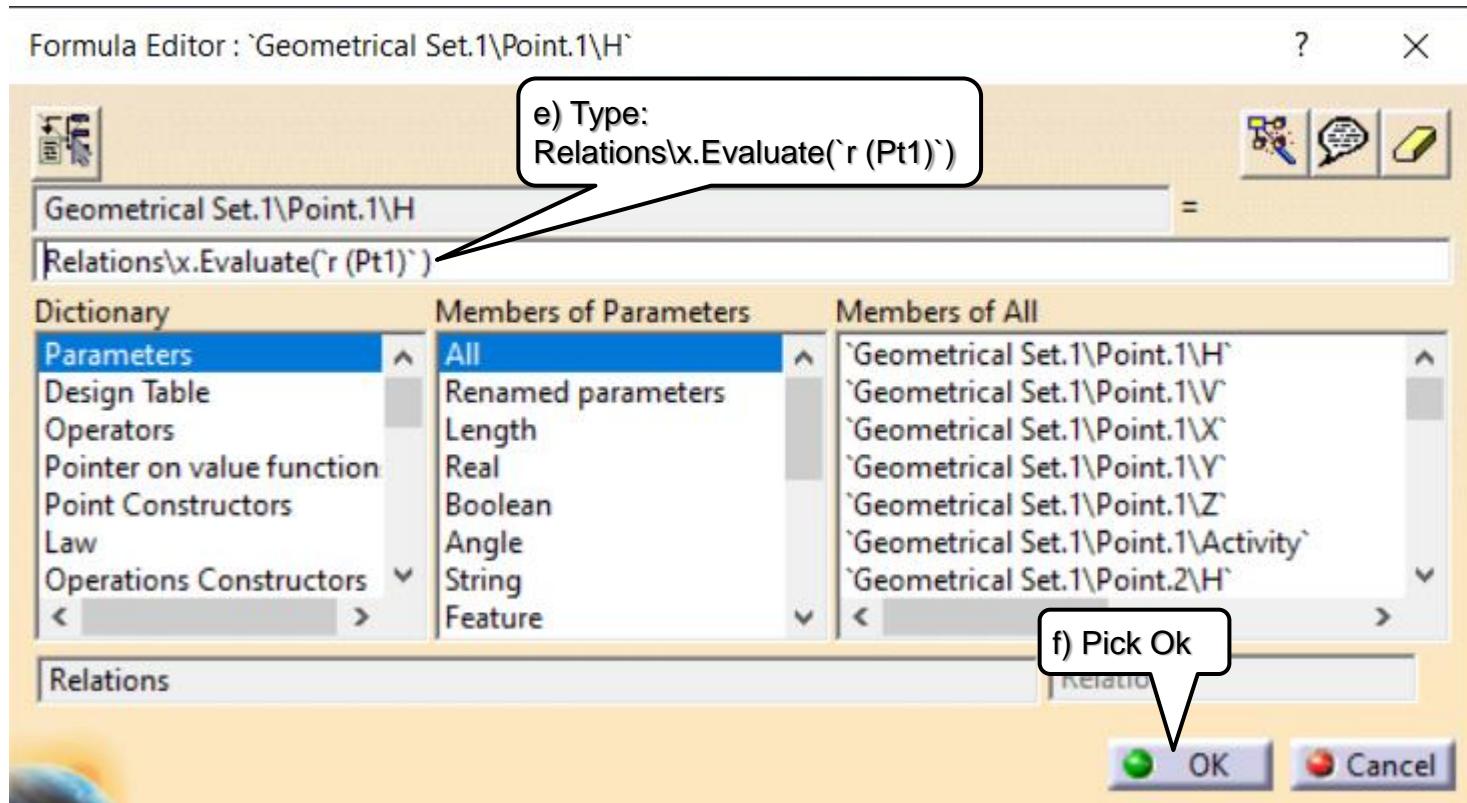


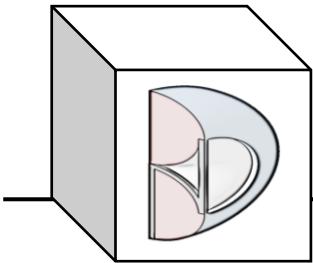


# BND TechSource



- Create points for involute spline.





# BND TechSource



- Create points for involute spline.

The screenshot shows the ENOVIA V5 VPM software interface. On the left, a tree view displays various formulas related to gear geometry. In the center, a 3D model of a gear is shown with a coordinate system (x, y, z) and a point labeled 'Pt1'. A callout bubble with the text "g) Mouse-over and drop on Edit Formula" points to the 'Edit formula...' option in a context menu for a selected formula. The right side of the screen features a toolbar with various icons for modeling operations.

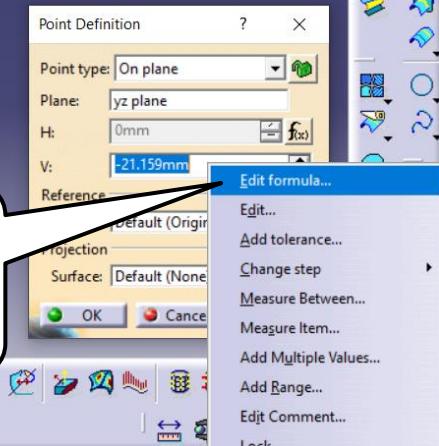
Formulas listed in the tree view:

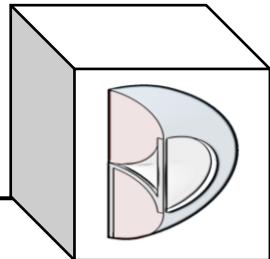
- $r(Pt5)=49.766mm = (\text{Pitch diameter: } Pd/2) + ([\text{Addendum diameter: } Ad/2] - [\text{Pitch diameter: } Pd/2]) * .66667$
- $r(Pt6)=52.432mm = \text{Addendum diameter: } Ad/2$
- $Pa(Pt1)=0=\cos(r(Pt1)/r(Pt1))$
- $Pa(Pt2)=0.252333761=\cos([r(Pt1)]/[r(Pt2)])$
- $Pa(Pt3)=0.352220734=\cos(r(Pt1)/r(Pt3))$
- $Pa(Pt4)=0.483298254=\cos(r(Pt1)/r(Pt4))$
- $Pa(Pt5)=0.577154048=\cos(r(Pt1)/r(Pt5))$
- $Pa(Pt6)=0.651131653=\cos(r(Pt1)/r(Pt6))$

Relations:

- $\text{fix1: Formula.1: Transverse pressure angle: } Tpa = \text{atan}[\tan(\text{Normal Pressure Angle: } Npa)/\cos(\text{Cylinder helix angle: } Ca)]$
- $\text{fix1: Formula.2: Symmetry angle: } s = 90\text{deg}/\text{Number of teeth: } z$
- $\text{fix1: Formula.3: Pitch diameter: } Pd = (\text{Number of teeth: } z * \text{Module: } m) / \cos(\text{Cylinder helix angle: } Ca)$
- $\text{fix1: Formula.4: Base diameter: } Bd = \text{Pitch diameter: } Pd * \cos(\text{Transverse pressure angle: } Tpa)$
- $\text{fix1: Formula.5: Addendum diameter: } Ad = \text{Pitch diameter: } Pd + (2 * \text{Module: } m)$
- $\text{fix1: Formula.6: Dedendum diameter: } Dd = \text{Pitch diameter: } Pd - (2.5 * \text{Module: } m)$
- $\text{fix1: Formula.7: tooth radius at dedendum circle: } tr = 0.38 * \text{Module: } m$
- $\text{fix1: Formula.8: } r(Pt1) = \text{Base diameter: } Bd/2$
- $\text{fix1: Formula.9: } r(Pt2) = (\text{Pitch diameter: } Pd/2) + (\text{Base diameter: } Bd/2)/2$
- $\text{fix1: Formula.10: } r(Pt3) = \text{Pitch diameter: } Pd/2$
- $\text{fix1: Formula.11: } r(Pt4) = (\text{Pitch diameter: } Pd/2) + ([\text{Addendum diameter: } Ad/2] - [\text{Pitch diameter: } Pd/2]) * .33333$
- $\text{fix1: Formula.12: } r(Pt5) = (\text{Pitch diameter: } Pd/2) + ([\text{Addendum diameter: } Ad/2] - [\text{Pitch diameter: } Pd/2]) * .66667$
- $\text{fix1: Formula.13: } r(Pt6) = \text{Addendum diameter: } Ad/2$
- $\text{fix1: Formula.14: } Pa(Pt1)=\cos(r(Pt1)/r(Pt1))$
- $\text{fix1: Formula.15: } Pa(Pt2)=\cos([r(Pt1)]/[r(Pt2)])$
- $\text{fix1: Formula.16: } Pa(Pt3)=\cos(r(Pt1)/r(Pt3))$
- $\text{fix1: Formula.17: } Pa(Pt4)=\cos(r(Pt1)/r(Pt4))$

g) Mouse-over and drop on Edit Formula

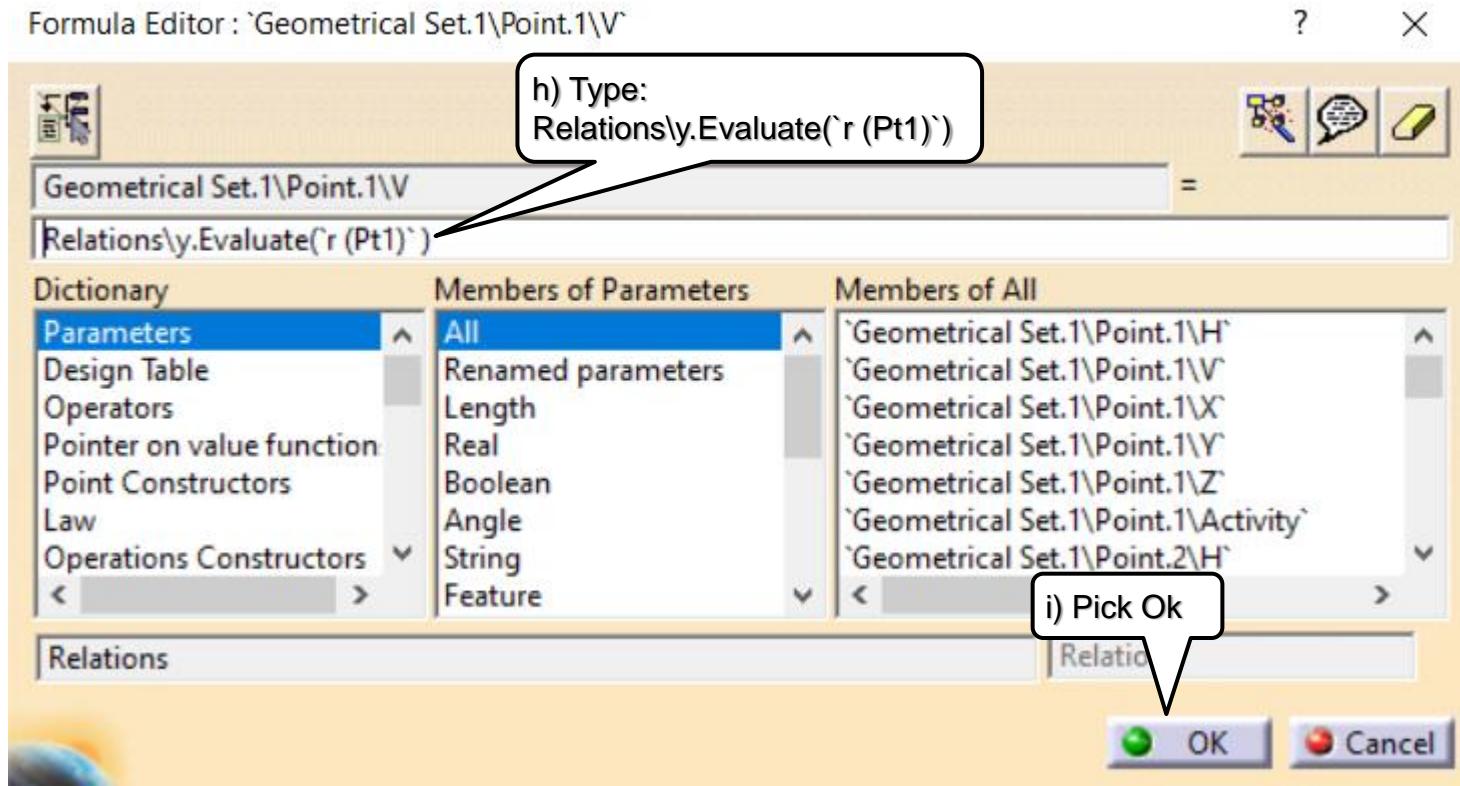


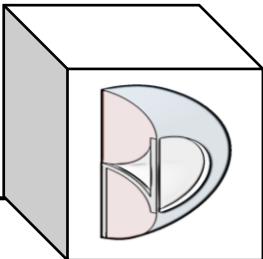


# BND TechSource



- Create points for involute spline.





- Create points for involute spline.
- Repeat steps a) through i) for the next five points evaluating  $r$  ( $Pt_{\_}$ ) for each sequential point.
- Afterwards there should be seven points as follows:

- Point 1:

- H direction = Relations\х.Evaluate ('r (Pt1)')
- V direction = Relations\у.Evaluate ('r (Pt1)')

- Point 2:

- H direction = Relations\х.Evaluate ('r (Pt1)')
- V direction = Relations\у.Evaluate ('r (Pt1)')

- Point 3:

- H direction = Relations\х.Evaluate ('r (Pt1)')
- V direction = Relations\у.Evaluate ('r (Pt1)')

- Point 4:

- H direction = Relations\х.Evaluate ('r (Pt1)')
- V direction = Relations\у.Evaluate ('r (Pt1)')

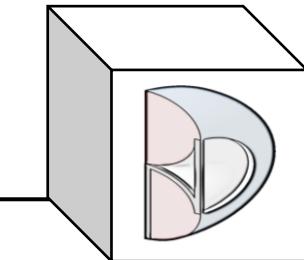
- Point 5:

- H direction = Relations\х.Evaluate ('r (Pt1)')
- V direction = Relations\у.Evaluate ('r (Pt1)')

- Point 6:

- H direction = Relations\х.Evaluate ('r (Pt1)')
- V direction = Relations\у.Evaluate ('r (Pt1)')

```
f(x) Formula.24: `Geometrical Set.1\Point.1\H` = Relations\х.Evaluate(`r (Pt1)` )  
f(x) Formula.25: `Geometrical Set.1\Point.1\V` = Relations\у.Evaluate(`r (Pt1)` )  
f(x) Formula.14: `Geometrical Set.1\Point.2\H` = Relations\х.Evaluate(`r (Pt2)` )  
f(x) Formula.15: `Geometrical Set.1\Point.2\V` = Relations\у.Evaluate(`r (Pt2)` )  
f(x) Formula.16: `Geometrical Set.1\Point.3\H` = Relations\х.Evaluate(`r (Pt3)` )  
f(x) Formula.17: `Geometrical Set.1\Point.3\V` = Relations\у.Evaluate(`r (Pt3)` )  
f(x) Formula.18: `Geometrical Set.1\Point.4\H` = Relations\х.Evaluate(`r (Pt4)` )  
f(x) Formula.19: `Geometrical Set.1\Point.4\V` = Relations\у.Evaluate(`r (Pt4)` )  
f(x) Formula.20: `Geometrical Set.1\Point.5\H` = Relations\х.Evaluate(`r (Pt5)` )  
f(x) Formula.21: `Geometrical Set.1\Point.5\V` = Relations\у.Evaluate(`r (Pt5)` )  
f(x) Formula.22: `Geometrical Set.1\Point.6\H` = Relations\х.Evaluate(`r (Pt6)` )  
f(x) Formula.23: `Geometrical Set.1\Point.6\V` = Relations\у.Evaluate(`r (Pt6)` )
```



# BND TechSource



- Modify parameters for Number of teeth: z to 25 and check the results.

The screenshot shows the ENOVIA V5 VPM software interface. A gear model is displayed on the right, and a parameter dialog box is open in the center. The dialog box is titled "Edit Parameter" and contains a dropdown menu for "Number of teeth: z" with the value set to 25. Buttons for "OK" and "Cancel" are at the bottom. A callout bubble labeled "a) Modify z = 25" points to the parameter value. Another callout bubble labeled "d) Pick Cancel" points to the "Cancel" button.

**a) Modify z = 25**

**d) Pick Cancel**

**b) Notice the division by zero error.**

**c) Notice the cannot evaluate cos error.**

**Knowledge Report**

From	Summary
x	Line 3 : Evaluation error in relation x
x	Line 3 : Evaluation error in relation x
y	Line 3 : Evaluation error in relation y
y	Line 3 : Evaluation error in relation y

**Message:**

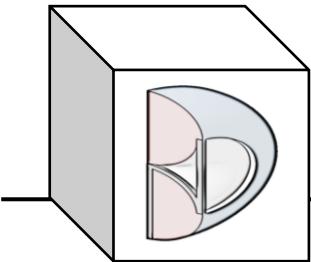
Line 3 : Evaluation error in relation x  
Division by zero: Cannot evaluate

**Knowledge Report**

From	Summary
x	Line 3 : Evaluation error in relation x
x	Line 3 : Evaluation error in relation x
y	Line 3 : Evaluation error in relation y
y	Line 3 : Evaluation error in relation y

**Message:**

Line 3 : Evaluation error in relation x  
Argument is out of bounds: Cannot evaluate acos



# BND TechSource



- Correct the errors and check the results.

The screenshot shows the ENOVIA V5 VPM interface with the Law Editor and Dictionary windows open. A formula in the Law Editor contains a division by zero error. The Dictionary window shows the variable 'r' is defined as a length. Callouts provide step-by-step instructions to fix the formula:

- a) Double-pick the fog "x"
- b) Select "r"
- c) To avoid the division by zero error, change the value to 1. This will be over-written by the Relations\|x.Evaluate.
- d) Pick Ok

Repeat steps a-d for y.

Law Editor : x Active

```
/*involute point x dir/
x=r*sin((tan(arccos(r(Pt1))/r))-(arccos(r(Pt1))/r)))
```

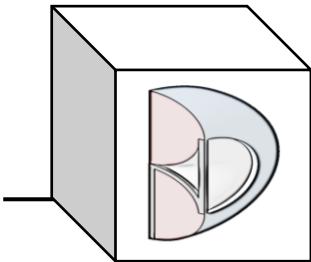
Dictionary

Parameters	Members of Parameters	Members of All
Keywords	All	'Geometrical Set.1\P'
Design Table	Renamed parameters	'Geometrical Set.1\P'
Operators	Length	'Geometrical Set.1\P'
Pointer on value function	Real	'Geometrical Set.1\P'
Point Constructors	Boolean	'Geometrical Set.1\P'
Law	Angle	'Geometrical Set.1\P'
	String	'Geometrical Set.1\Point.2'
	Feature	'Geometrical Set.1\Point.2'

Members of All

Formal parameters Type

r	Length
x	Length

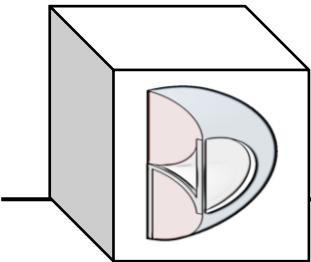


# BND TechSource



- Modify parameters for Number of teeth: z to 25 and check the results.

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the tree view displays various parameters and relations. A dialog box titled "Edit Parameter" is open, showing the "Number of teeth: z" field set to 25. Two callouts point to this dialog: one labeled "a) Modify z = 25" and another labeled "d) Pick Cancel". To the right, a 3D model of a gear is shown in a coordinate system. Below the 3D view is a "Knowledge Report" window. The report lists errors: "Line 3 : Evaluation error in relation y" and "Line 3 : Evaluation error in relation x". A callout labeled "b) Notice the division by zero error has been rectified." points to the report. Another callout labeled "c) Notice the cannot evaluate cos error is still there." points to a specific message in the report: "Line 3 : Evaluation error in relation y Argument is out of bounds: Cannot evaluate acos".



# BND TechSource



- Correct the errors and check the results.

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the Relations tree view lists various formulas. In the center, the Law Editor window displays a law for point 'x' with the formula  $x=r\sin((\tan(\arccos(r(Pt1)/r))-\arccos(r(Pt1)/r)))$ . The 'Dictionary' pane shows parameters 'r' and 'x'. A callout 'a) Double-pick the fog "x"' points to the 'x' parameter in the dictionary. Another callout 'b) Select "r"' points to the 'r' parameter in the dictionary. A callout 'c) To avoid the cannot evaluate acos error, change the value to 1000. This will be over-written by the Relations\!x.Evaluate.' points to the 'r' value in the 'Formal parameters' table, which is highlighted with a red box containing '1000mm'. A callout 'd) Pick Ok' points to the 'OK' button at the bottom right of the Law Editor. A callout 'Repeat steps a-d for y.' points to the 3D model of a gear with a callout 'y'.

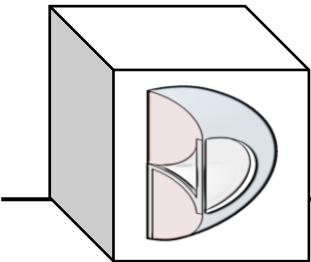
a) Double-pick the fog "x"

b) Select "r"

c) To avoid the cannot evaluate acos error, change the value to 1000. This will be over-written by the Relations\!x.Evaluate.

d) Pick Ok

Repeat steps a-d for y.



# BND TechSource



- Modify parameters for Number of teeth: z to 25 and check the results.

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the parameter tree view displays various gear parameters. A callout bubble labeled "a) Modify z = 25" points to the "Number of teeth: z=25" parameter, which is highlighted with a yellow selection box. Another callout bubble labeled "b) Pick Update" points to the "Update" button on the toolbar at the bottom center, which is also highlighted with a red selection box. The main workspace shows a 3D model of a gear with a coordinate system (x, y, z). A callout bubble on the right states: "Notice all errors have been rectified." The toolbar at the top contains numerous icons for different operations, and the bottom toolbar includes standard CAD tool icons like selection, move, copy, and properties.

a) Modify z = 25

b) Pick Update

Notice all errors  
have been rectified.

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

Number of teeth: z=25

Normal Pressure Angle: Npa'=20deg

Cylinder helix angle: Ca'=8deg

Transverse pressure angle: Tpa'=20.181deg=atan(tan("Normal Pressure Angle: Npa' )/cos("Cylinder helix angle: Ca' ))

Symmetry angle: s=3.6deg=90deg/Number of teeth: z'

Face width: Fw =100mm

Module: m =8mm

Pitch diameter: Pd' = 201.966mm=(Number of teeth: z' \* Module: m')/cos(Cylinder helix angle: Ca' \*1rad)

Base diameter: Bd' = 189.567mm='Pitch diameter: Pd'\*cos(Transverse pressure angle: Tpa'\*1rad)

Addendum diameter: Ad' = 217.966mm='Pitch diameter: Pd'+(2\*Module: m')

Dedendum diameter: Dd' = 181.966mm='Pitch diameter: Pd'- (2.5\*Module: m')

Tooth radius at dedendum circle: tr' = 3.04mm=0.38\*Module: m'

r (Pt1)' = 94.783mm='Base diameter: Bd' /2

r (Pt2)' = 97.883mm='(Pitch diameter: Pd'/2)+(Base diameter: Bd'/2)/2

r (Pt3)' = 100.983mm='Pitch diameter: Pd' /2

r (Pt4)' = 103.649mm='(Pitch diameter: Pd'/2)+((Addendum diameter: Ad'/2)-(Pitch diameter: Pd'/2))\*33333

r (Pt5)' = 106.316mm='(Pitch diameter: Pd'/2)+((Addendum diameter: Ad'/2)-(Pitch diameter: Pd'/2))\*666667

r (Pt6)' = 108.983mm='Addendum diameter: Ad' /2

Relations

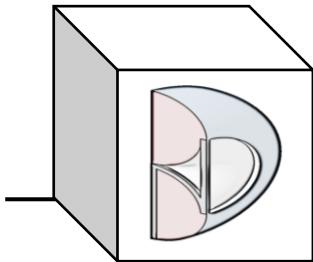
fix: Formula.1: Transverse pressure angle: Tpa'=20.181deg=atan(tan("Normal Pressure Angle: Npa' )/cos("Cylinder helix angle: Ca' ))

fix: Formula.2: Symmetry angle: s=90deg/Number of teeth: z'

fix: Formula.3: Pitch diameter: Pd' =(Number of teeth: z' \* Module: m')/cos(Cylinder helix angle: Ca' \*1rad)

fix: Formula.4: Base diameter: Bd' ='Pitch diameter: Pd'\*cos(Transverse pressure angle: Tpa'\*1rad)

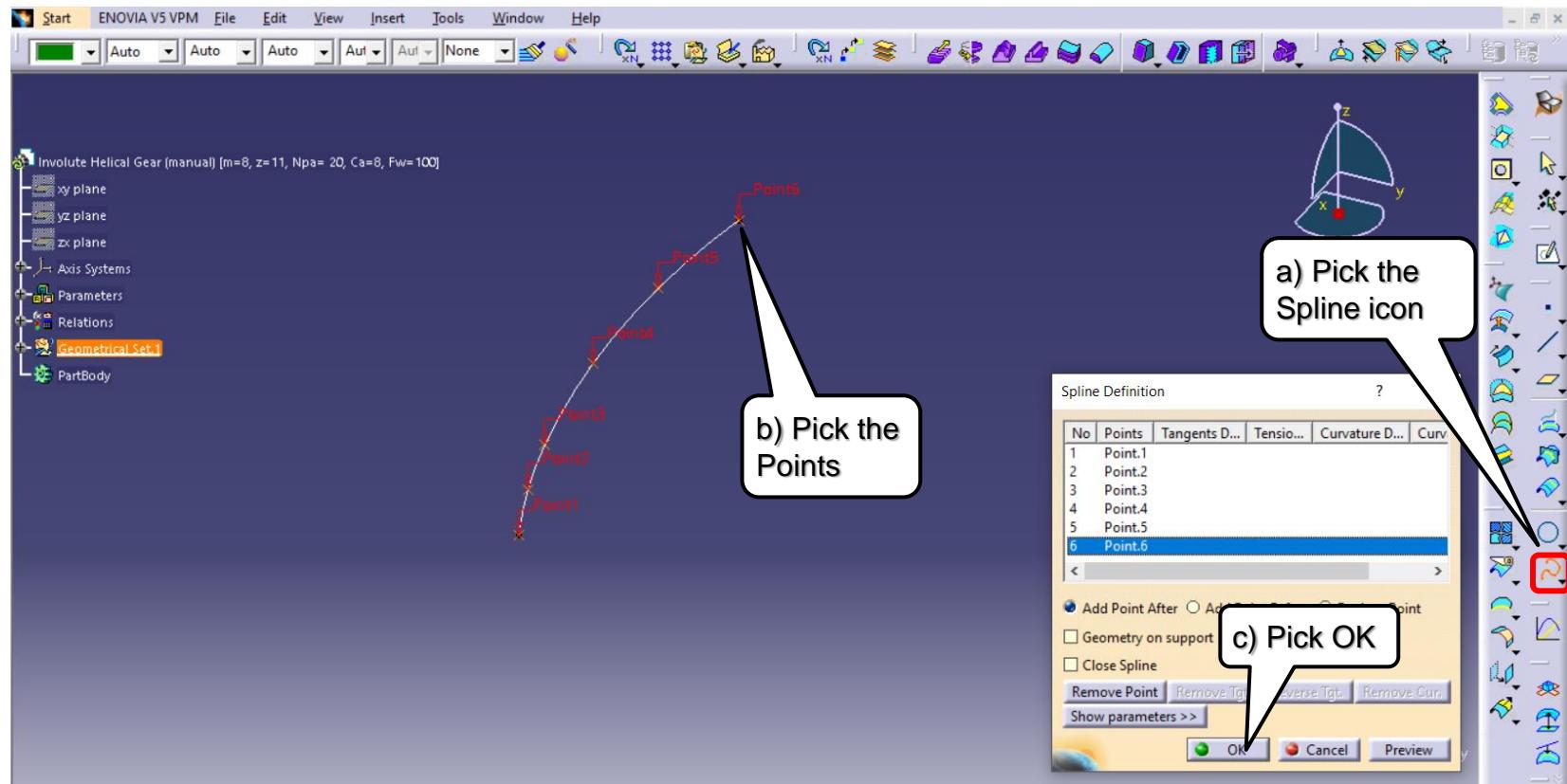
Geometrical Set.1

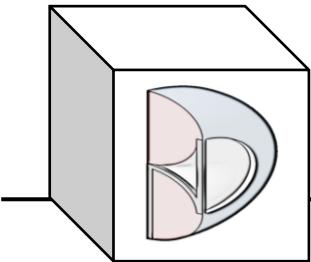


# BND TechSource



- Create the involute spline through the points.

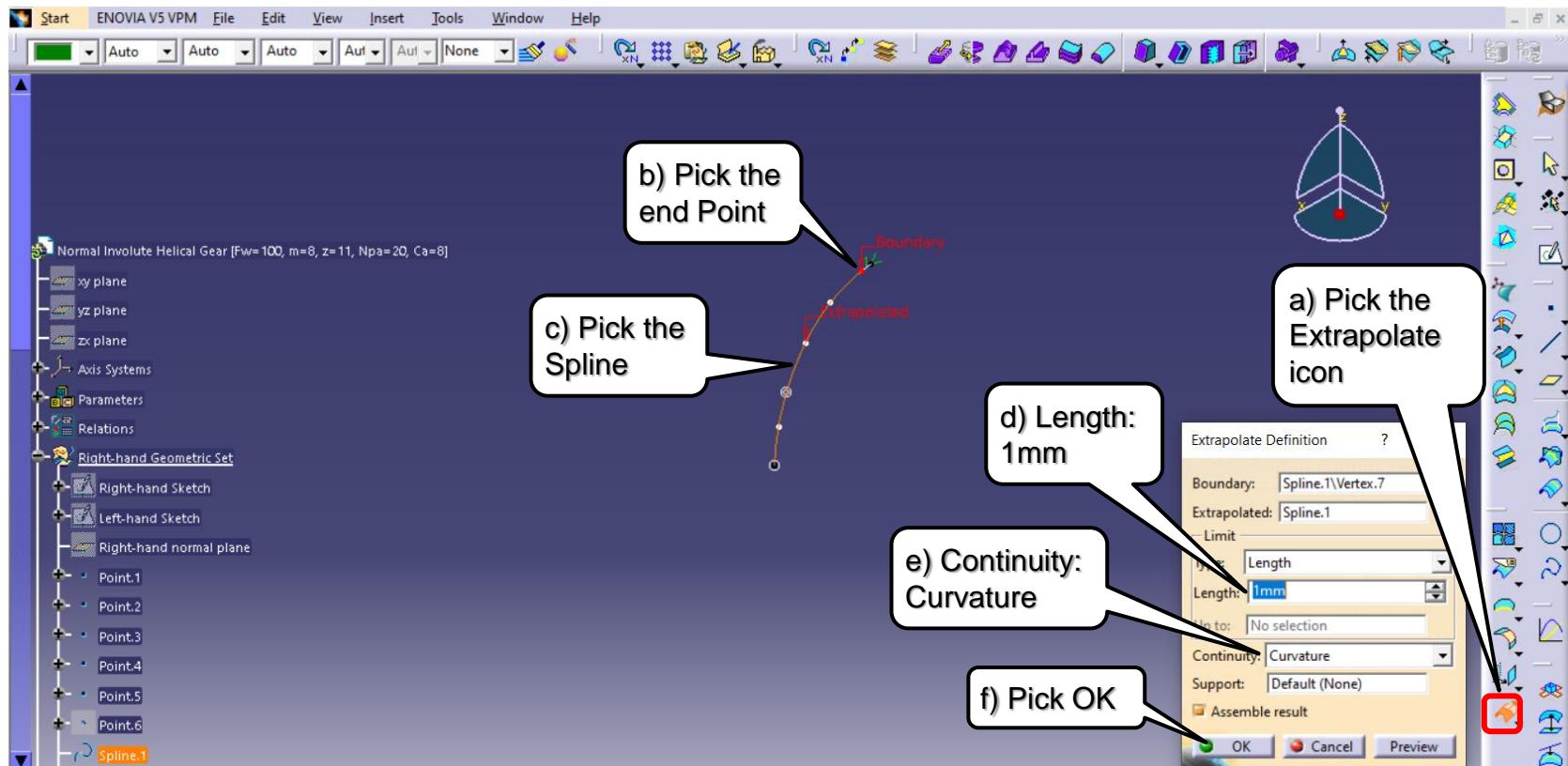


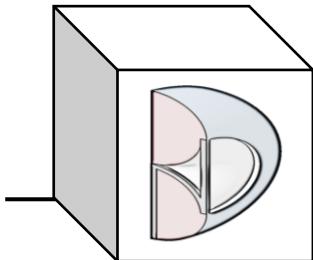


# BND TechSource



- Extrapolate the involute spline (1mm).

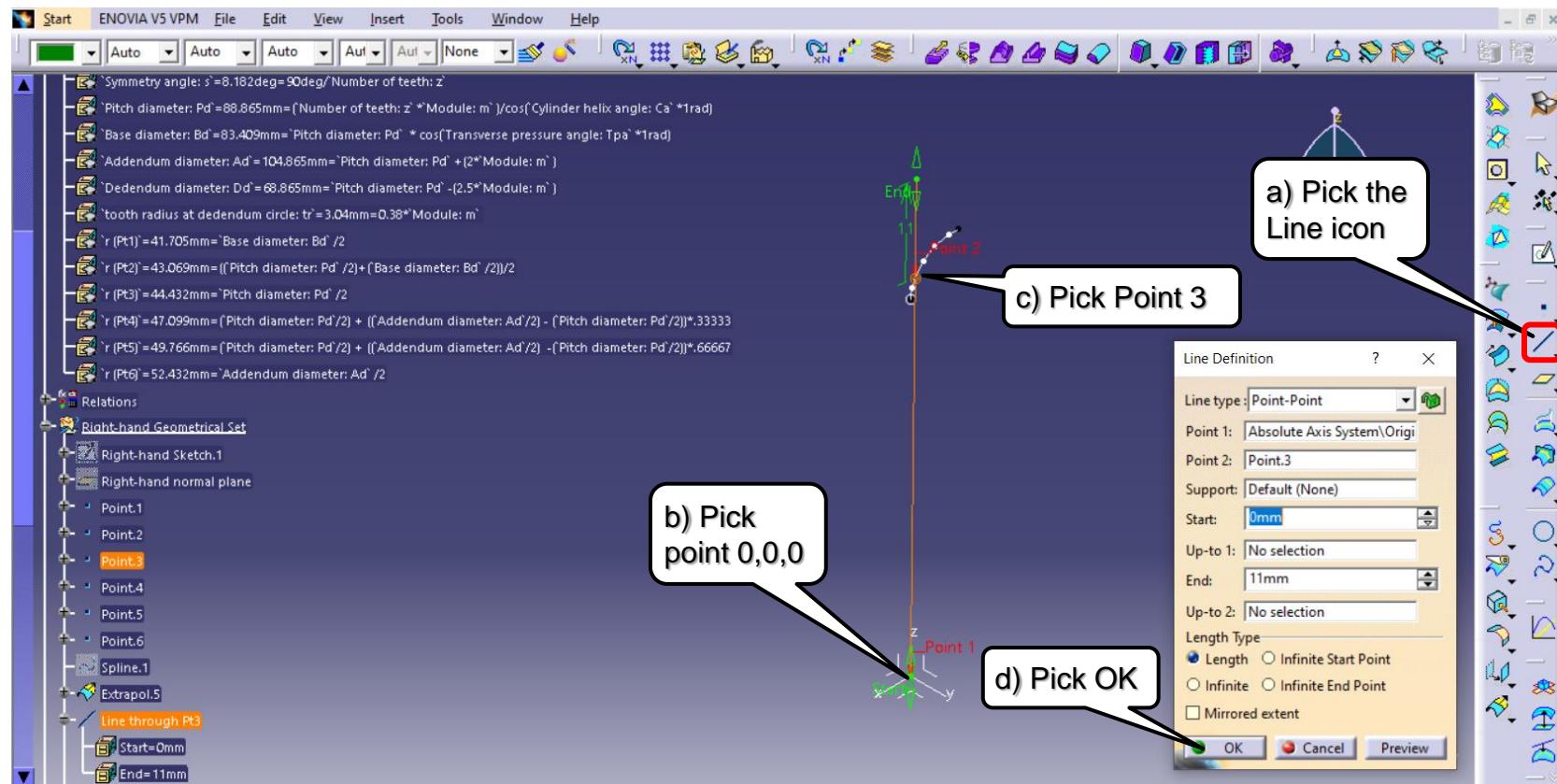


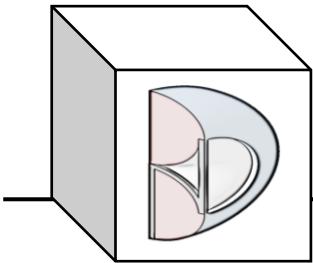


# BND TechSource



- Create a line from 0,0,0 through Point 3.

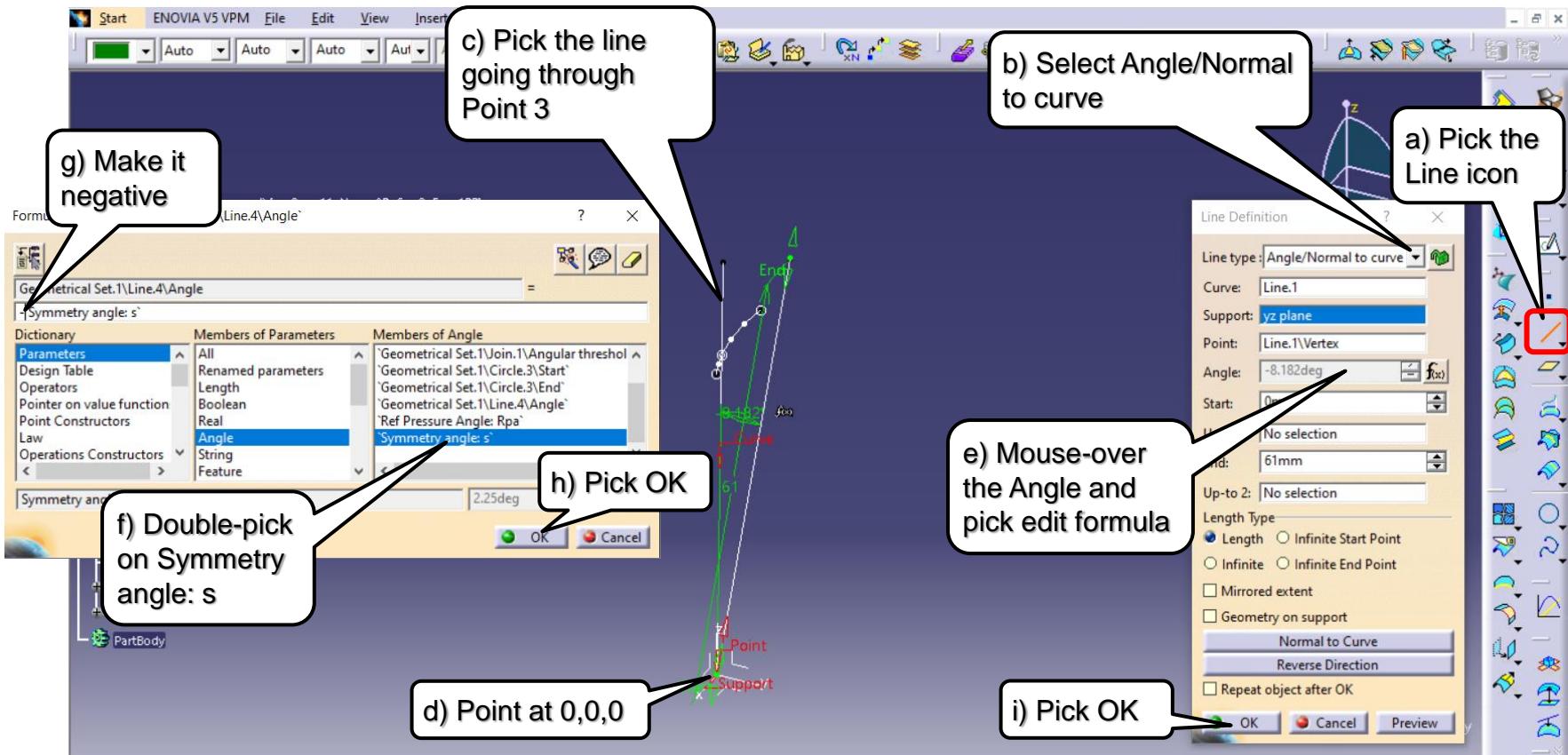


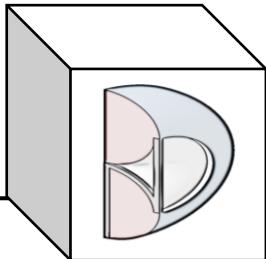


# BND TechSource



- Create an angle/normal to curve line (Symmetry Line) from 0,0,0 relative to the line going through Point 3.

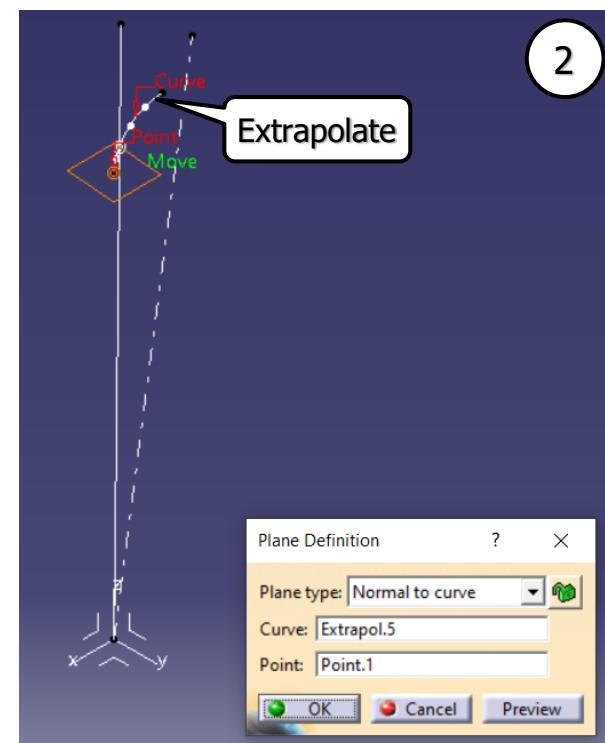
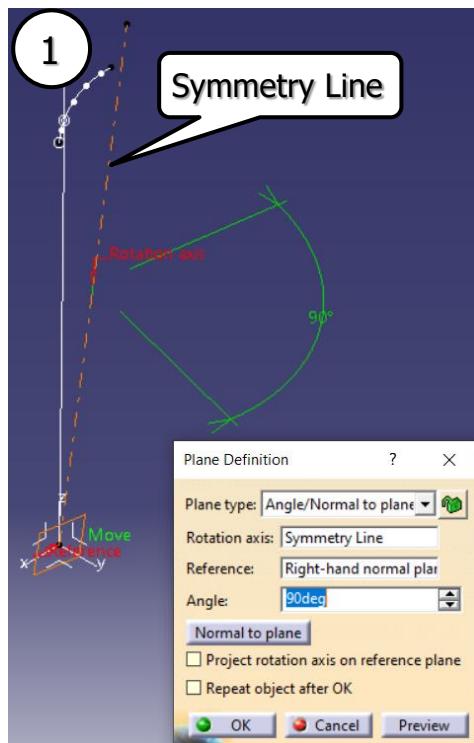


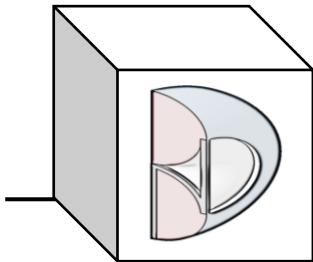


# BND TechSource



- Create two symmetry planes normal to the Right-hand normal plane.
  1. Through Symmetry Line.
  2. Normal to the Extrapolate and through Point 1.

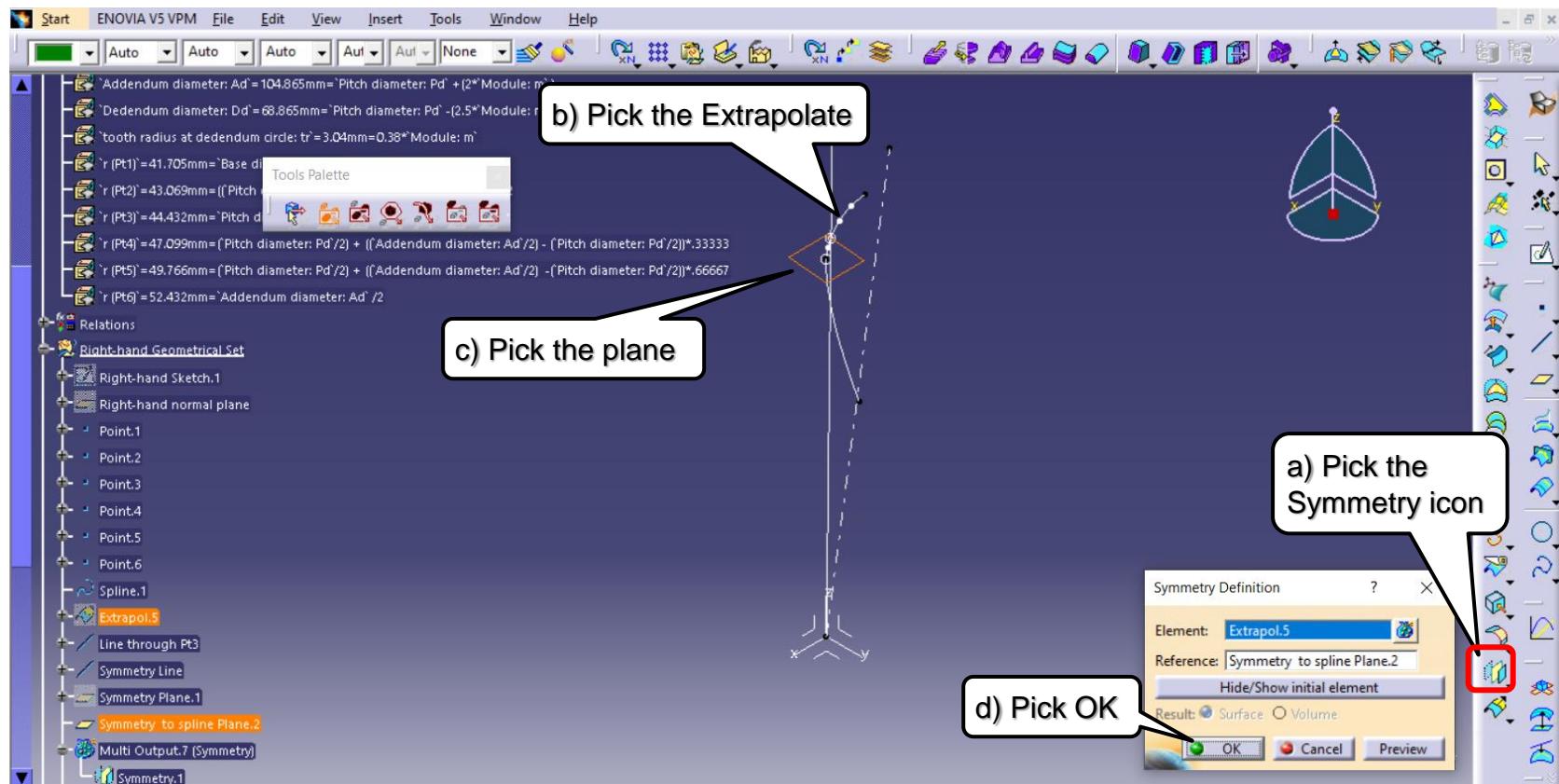


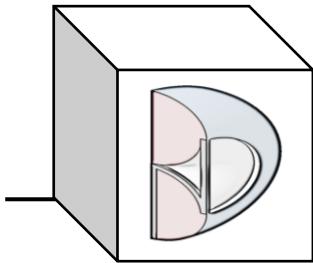


# BND TechSource



- Symmetry the Extrapolate about Plane 2.





# BND TechSource



- Join the Symmetry and Extrapolate together.

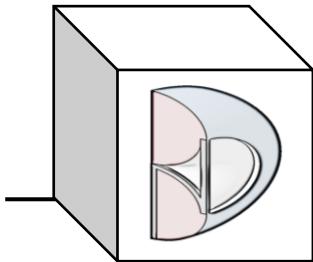
The screenshot displays the ENOVIA V5 VPM software interface. The FeatureManager tree on the left lists several geometric elements:

- Relations
- Right-hand Geometrical Set
  - Right-hand Sketch.1
  - Right-hand normal plane
- Point.1, Point.2, Point.3, Point.4, Point.5, Point.6
- Spline.1
- Extrapol.5
- Line through P2
- Symmetry Line
- Symmetry Plane.1
- Symmetry to spline Plane.2
- Symmetry.1
- Join.1
- Curve smooth.1
- Symmetry.2
- Addendum Circle
- Dedendum Circle

The 3D view on the right shows a 3D model of a gear profile with a green curve representing the profile. A 'Join Definition' dialog box is open, showing the following settings:

- Elements To Join: Symmetry.1, Extrapol.5
- Parameters tab selected
- Check tangency, Check connexity, Check manifold checkboxes checked
- Merging distance: 0.001mm
- Angular Threshold: 0.5deg
- OK, Cancel, Preview buttons at the bottom

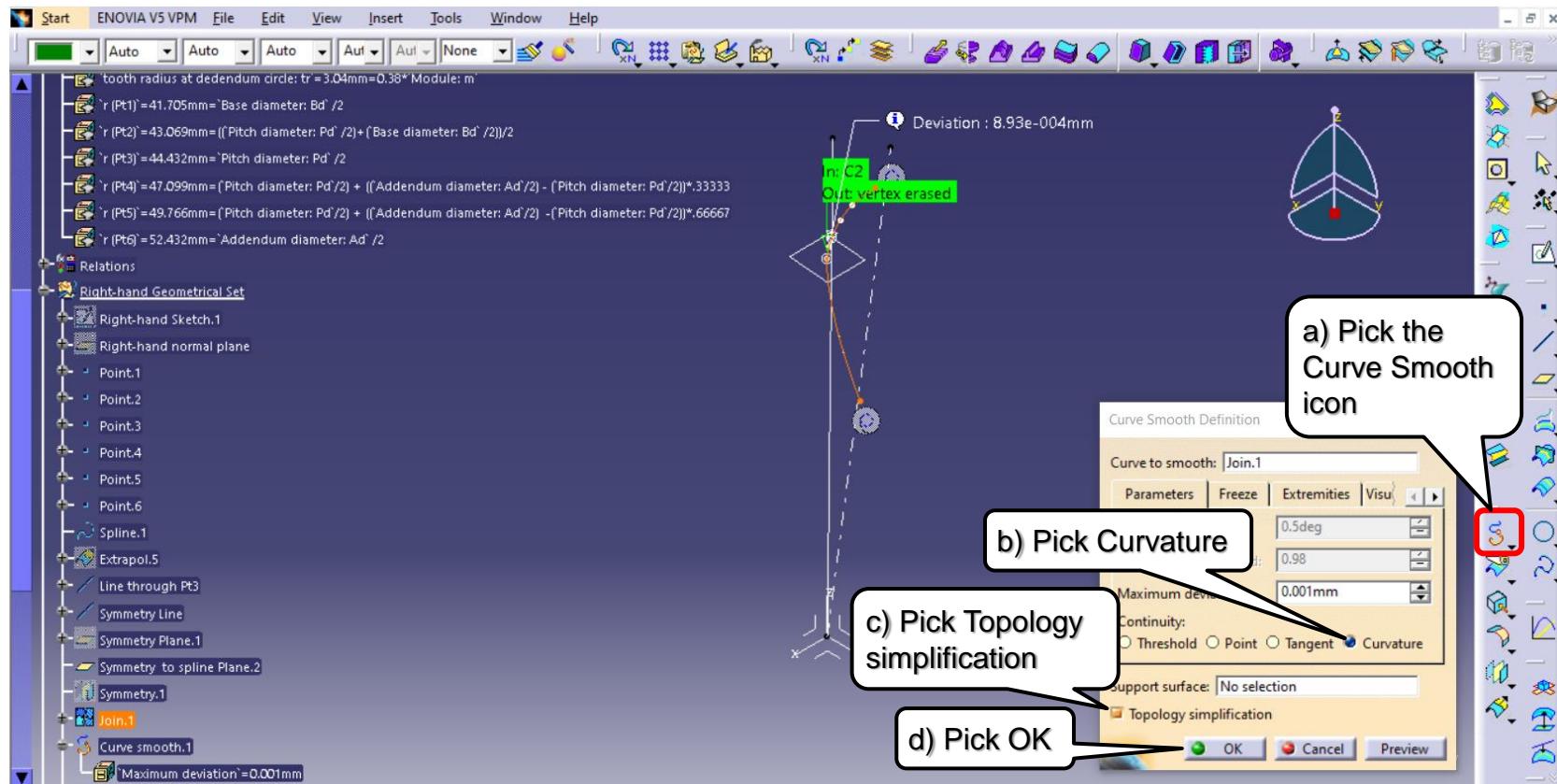
A red box highlights the 'Join Mode' button in the toolbar on the right side of the interface.

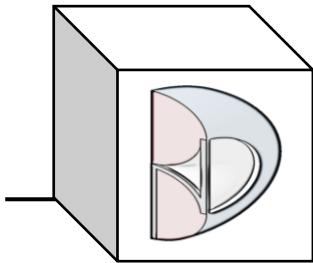


# BND TechSource



- Create a Smooth Curve (with Curvature).

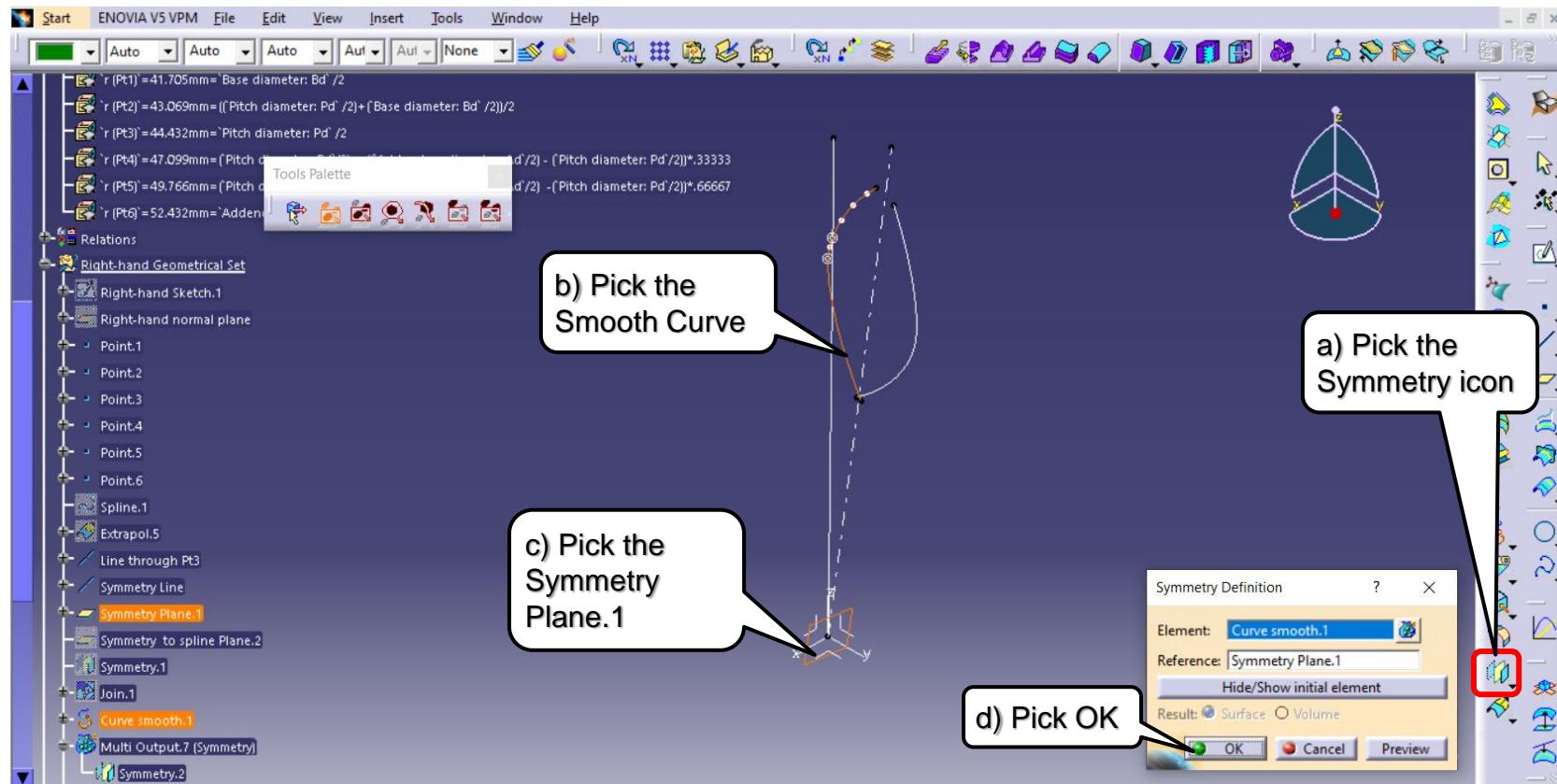


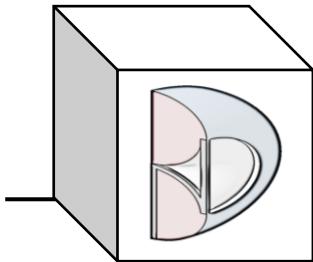


# BND TechSource



- Symmetry the Smooth Curve about Symmetry Plane 1.

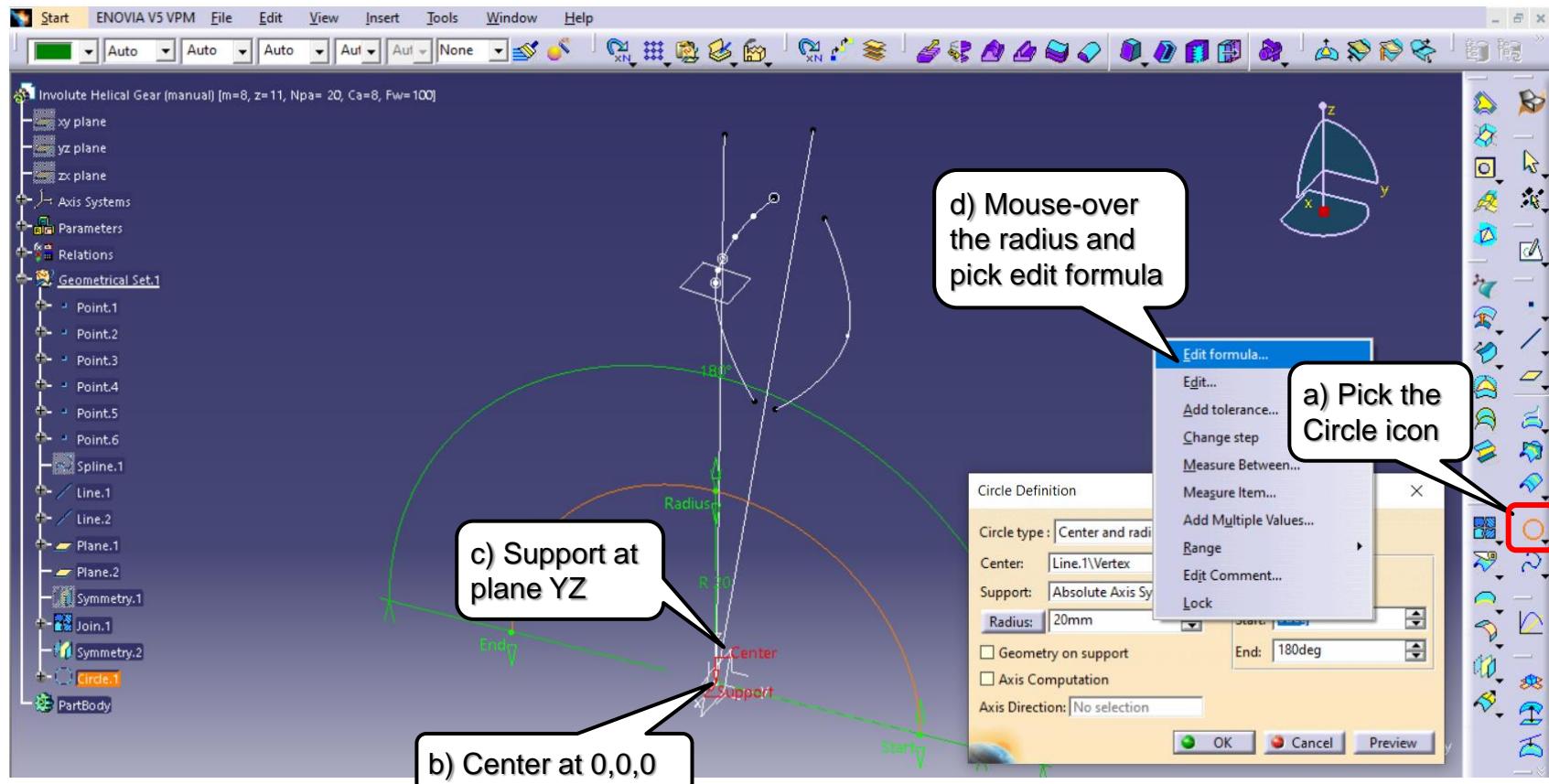


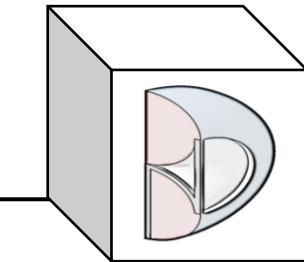


# BND TechSource



- Create the Addendum Circle with center at 0,0,0 on plane YZ.

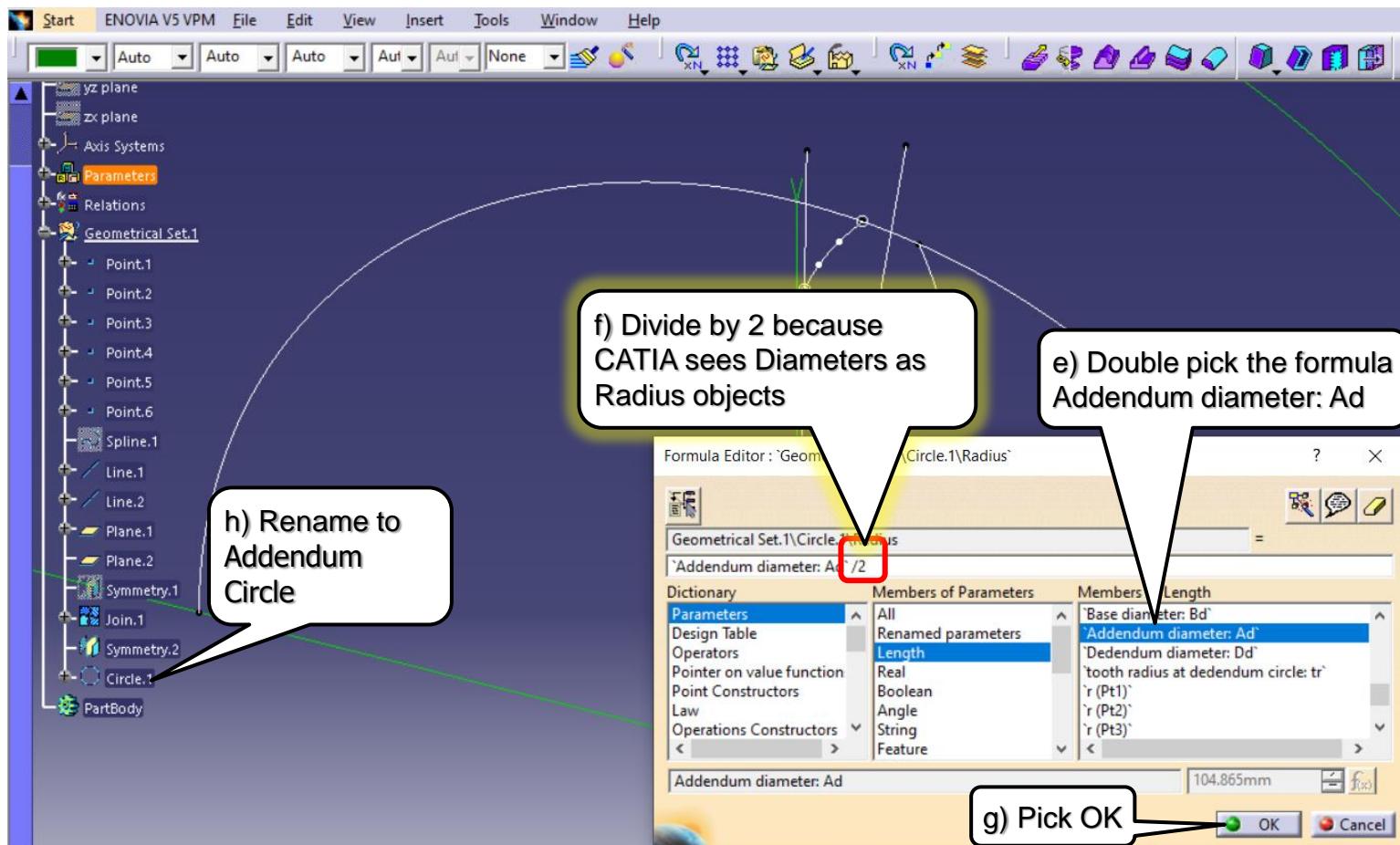


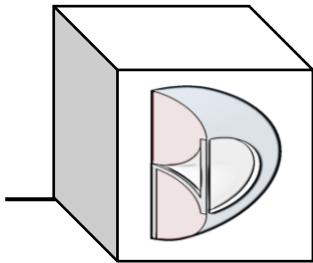


# BND TechSource



- Apply the formula (Addendum diameter: Ad) to the addendum circle.

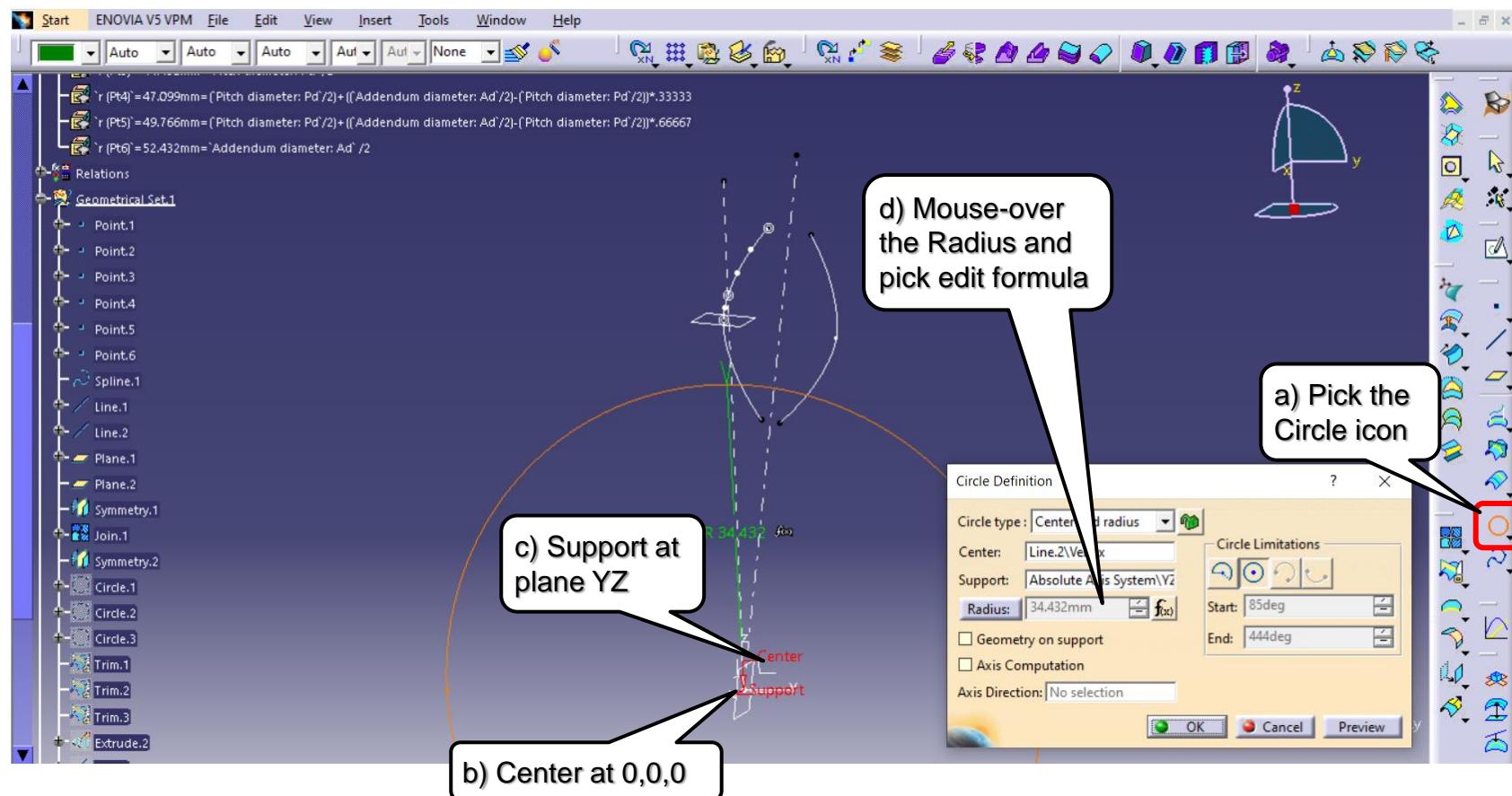


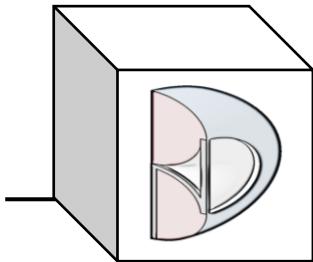


# BND TechSource



- Create the Dedendum Circle with center at 0,0,0 on plane YZ.

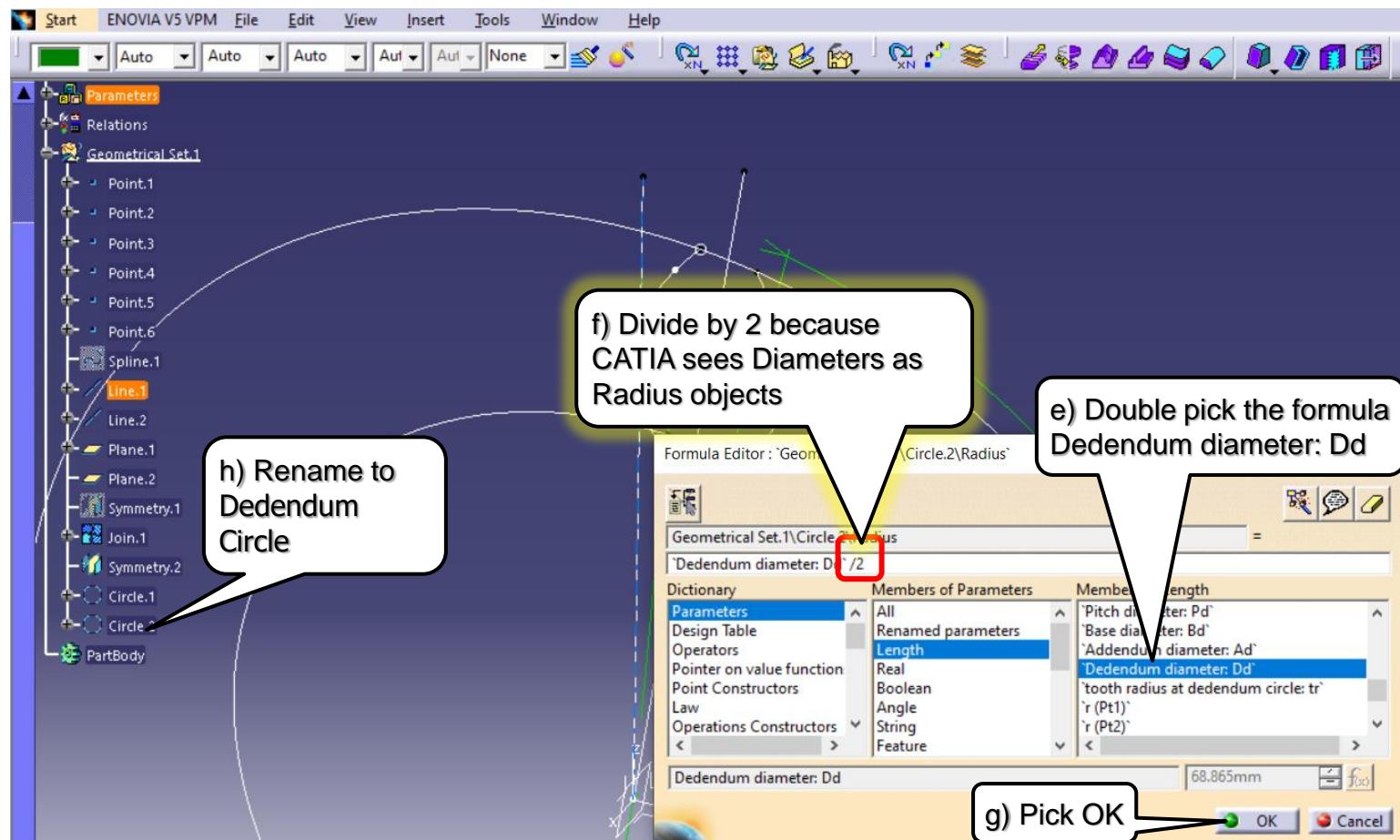


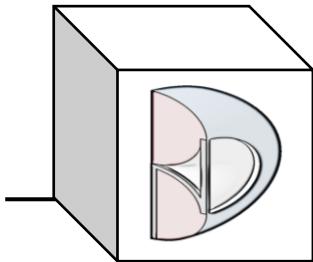


# BND TechSource



- Apply the formula (Dedendum diameter: Dd) to the dedendum circle.

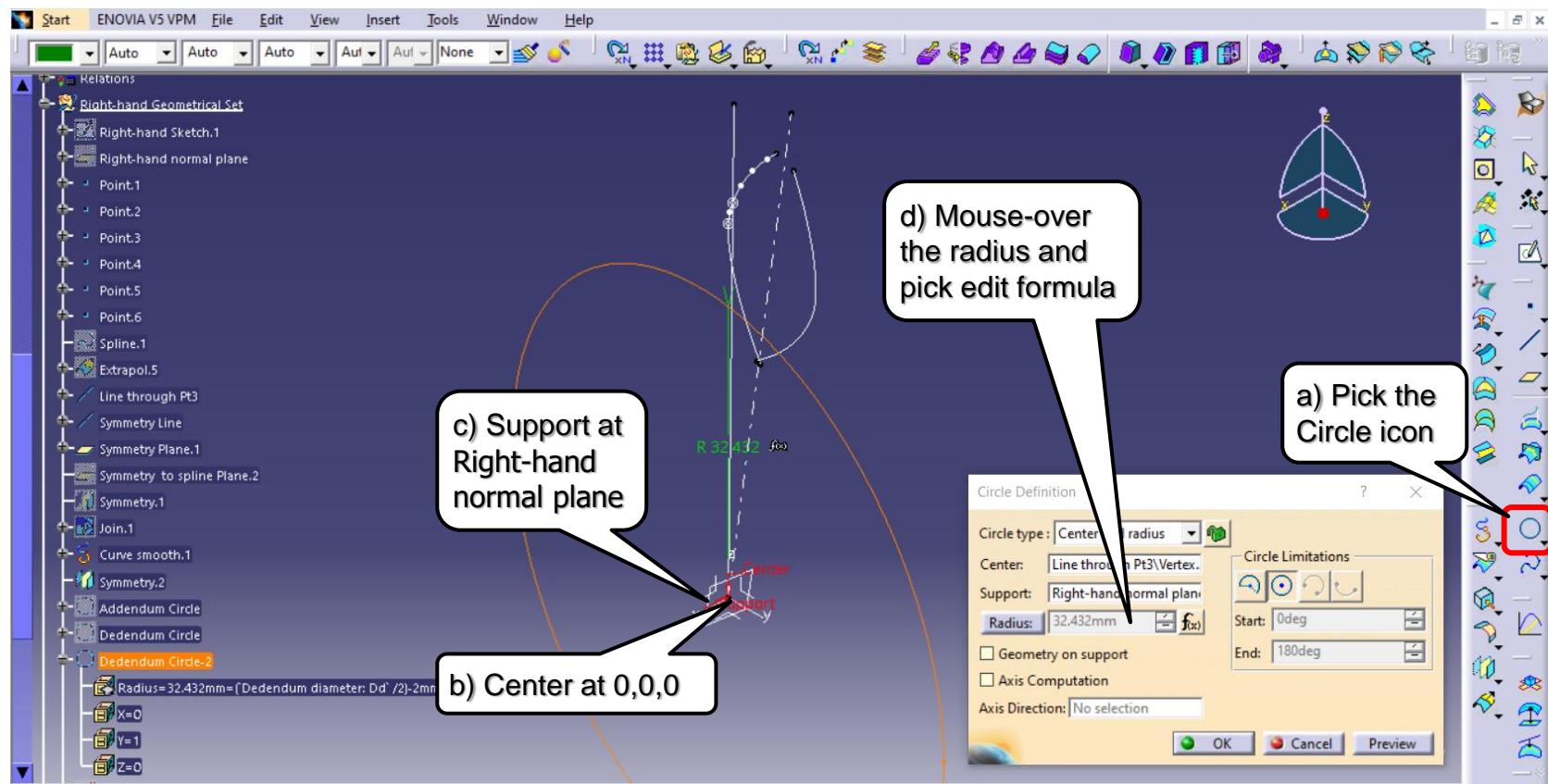


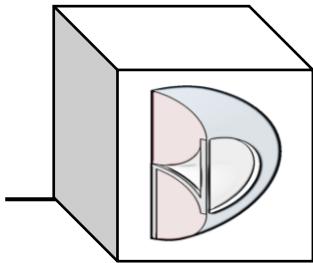


# BND TechSource



- Create the Dedendum Circle - 2 with center at 0,0,0 on the Right-hand normal plane.





# BND TechSource



- Apply the formula [(Dedendum diameter:  $Dd/2 - 2\text{mm}$ )] to the dedendum circle.

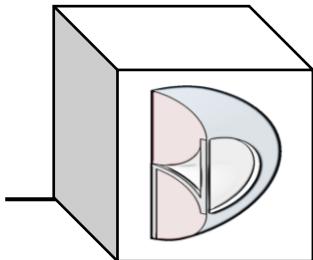
The screenshot shows the CATIA V5 interface with a 3D model of a gear. A callout box labeled "h) Rename to Dedendum Circle -2" points to the feature tree where the feature is renamed. Another callout box labeled "f) Divide by 2 because CATIA sees Diameters as Radius objects" points to the Formula Editor dialog, which displays the formula  $(\text{Dedendum diameter: } Dd)/2 - 2\text{mm}$ . A third callout box labeled "e) Double pick the formula Dedendum diameter: Dd" points to the formula entry field. A fourth callout box labeled "g) Pick OK" points to the "OK" button at the bottom right of the dialog. The formula editor also shows a dictionary with "Length" selected and a list of members including "Dedendum diameter: Dd".

h) Rename to  
Dedendum  
Circle -2

f) Divide by 2 because  
CATIA sees Diameters as  
Radius objects

e) Double pick the formula  
Dedendum diameter: Dd

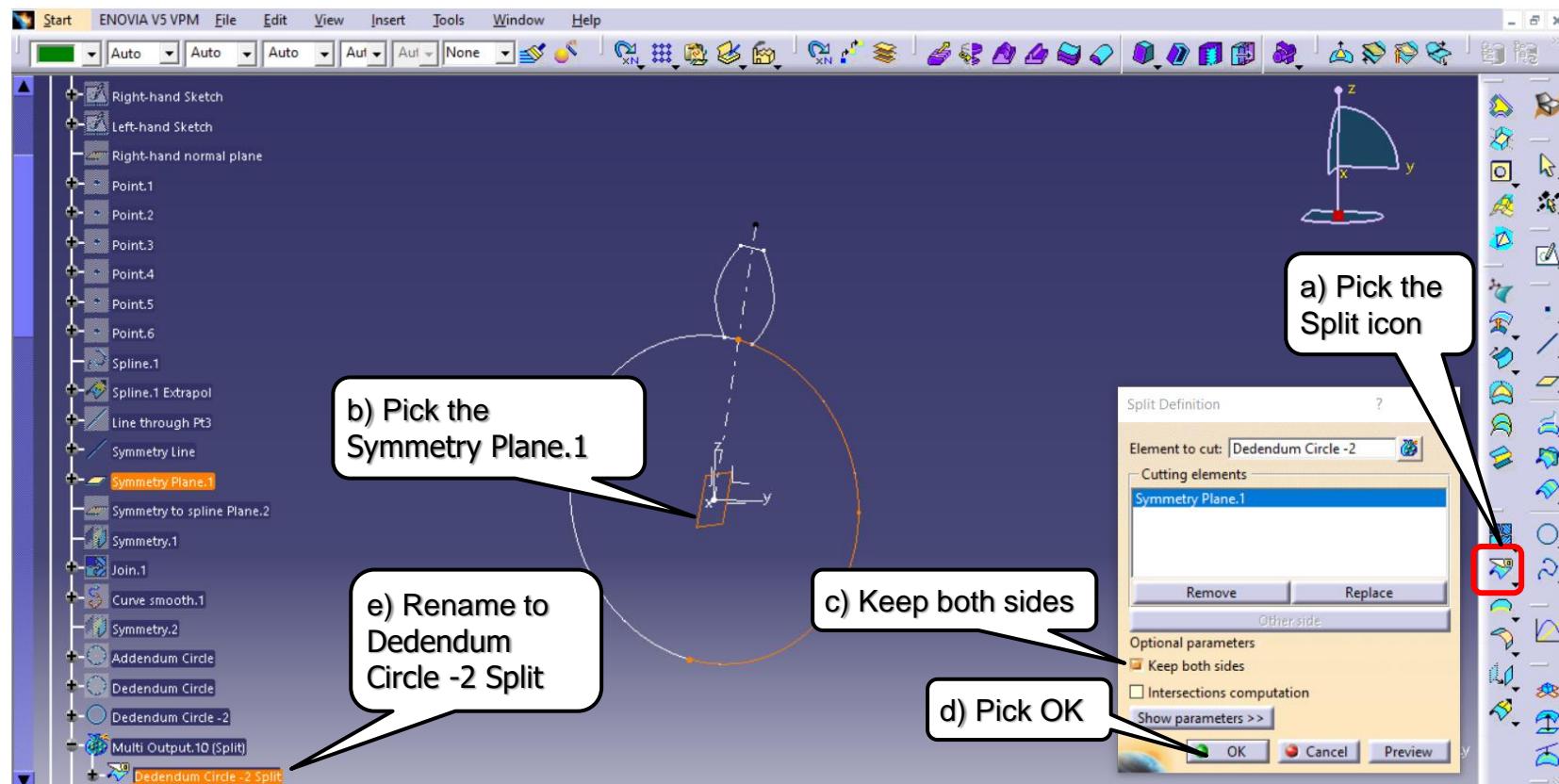
g) Pick OK

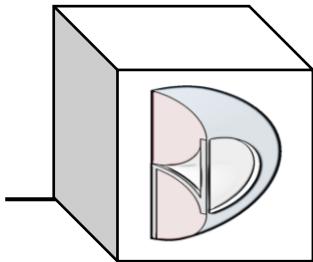


# BND TechSource



- Split the Dedendum Circle - 2 with Symmetry Plane.1.

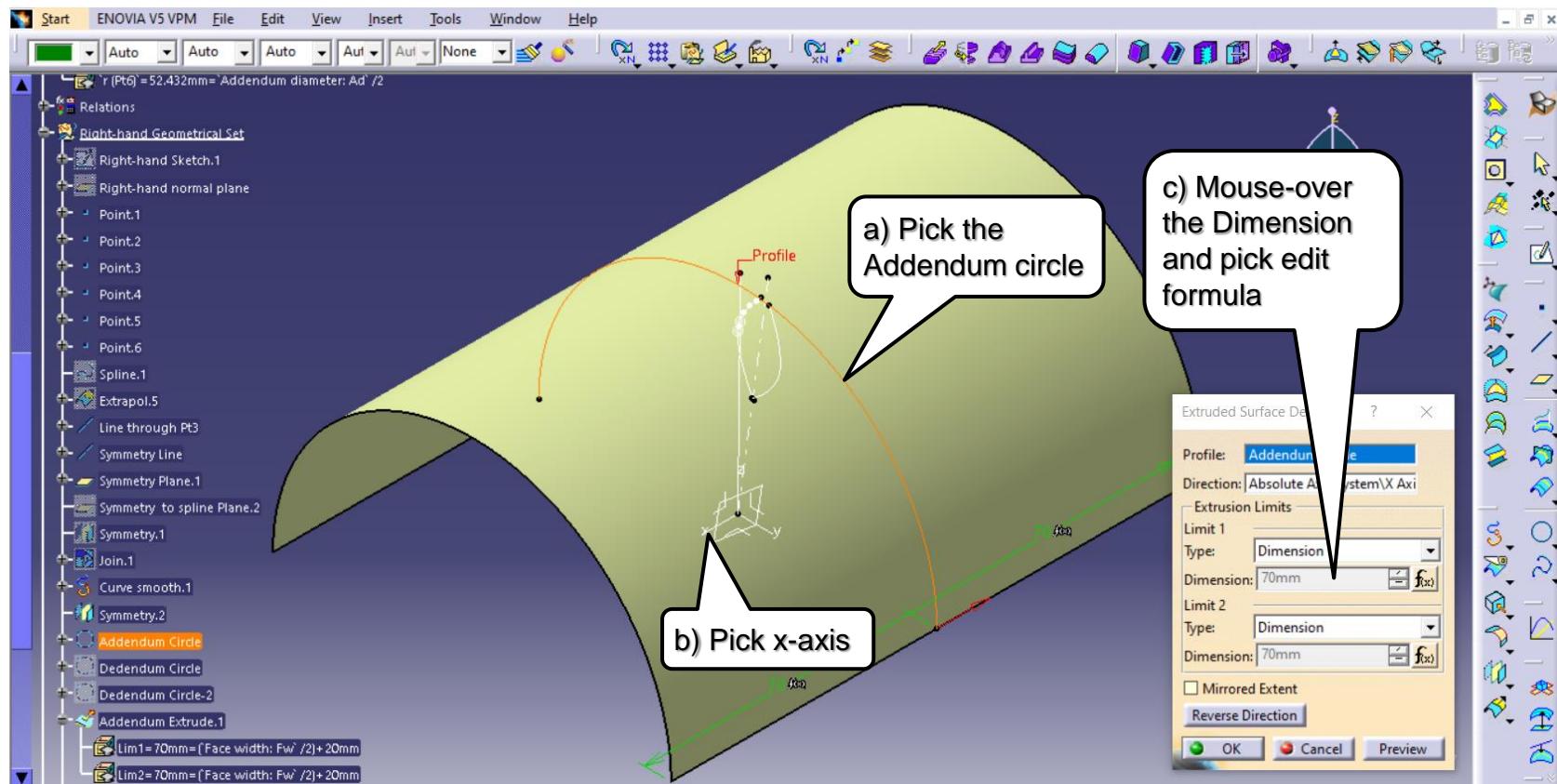


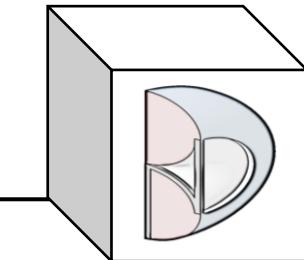


# BND TechSource



- Create the Addendum Extrude surface.





# BND TechSource



- Apply the formula [ $(`Face width: Fw` /2)+20mm$ ] to limits 1 & 2.

The screenshot shows the ENOVIA V5 VPM interface with a 3D model of a gear. The feature tree on the left lists various geometric sets and operations, including 'Addendum Extrude.1'. A callout box labeled 'd) Type: [ $(`Face width: Fw` /2)+20mm$ ' points to the formula input field in the 'Addendum Extrude' dialog. Another callout labeled 'e) Pick OK' points to the 'OK' button. A third callout labeled 'f) Rename to Addendum Extrude' points to the feature name in the feature tree. A note in the top right says 'Repeat steps a-e for limit 2.'

d) Type: [ $(`Face width: Fw` /2)+20mm$

f) Rename to Addendum Extrude

Repeat steps a-e for limit 2.

e) Pick OK

Right-hand Geometrical Set\Addendum Extrude.1\Lim1

Formula:  $(`Face width: Fw` /2)+20mm$

Dictionary

- Parameters
- Design Table
- Operators
- Pointer on value function
- Point Constructors
- Law
- Operations Constructors

Members of Parameters

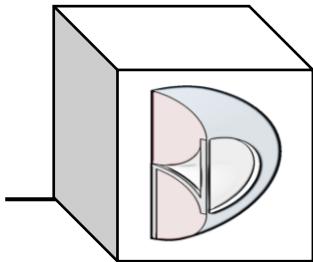
- All
- Renamed parameters
- Boolean
- CstAttr\_Mode
- Angle
- Length
- Real
- Plane

Members of Length

- 'Left-hand Gear\CircPattern.4\CircleSpacir
- 'Absolute Axis System\Origin\X'
- 'Absolute Axis System\Origin\Y'
- 'Absolute Axis System\Origin\Z'
- Face width: Fw**
- 'Module: m'
- 'Pitch diameter: Pd'

Face width: Fw 100mm

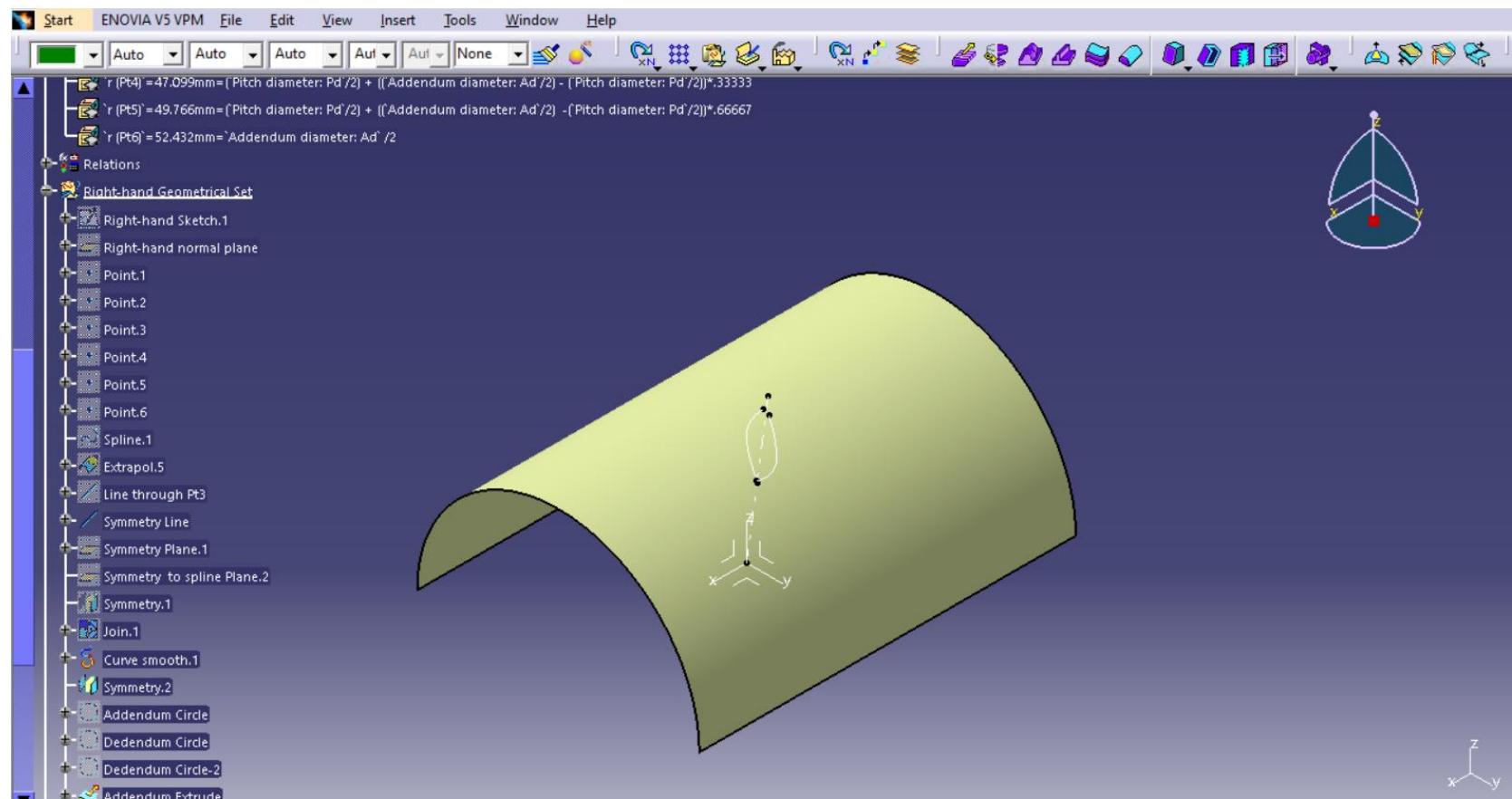
OK Cancel

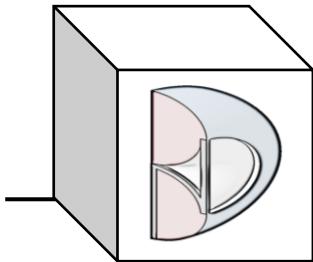


# BND TechSource



- Clean up (hide) the construction geometry.

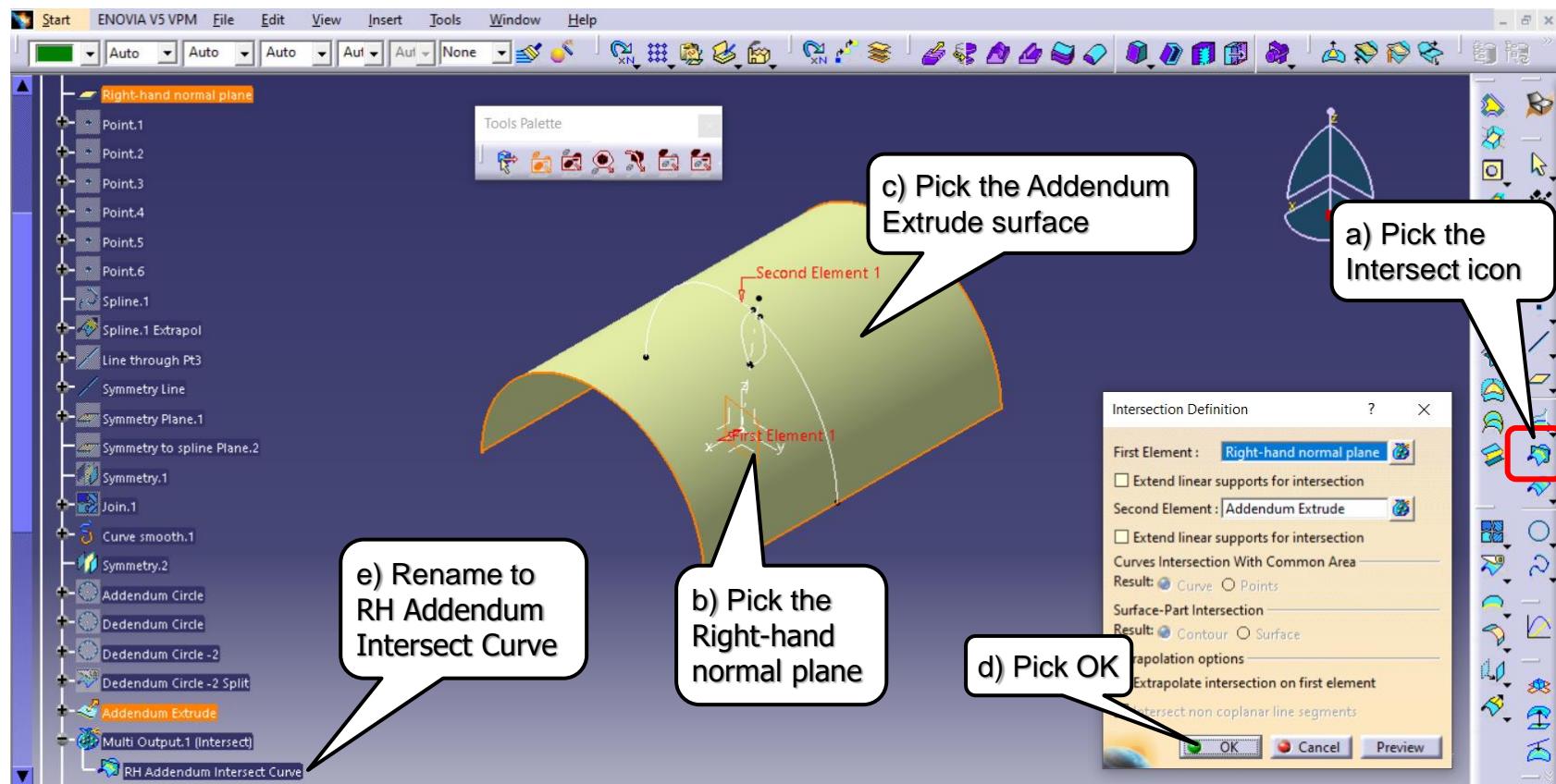


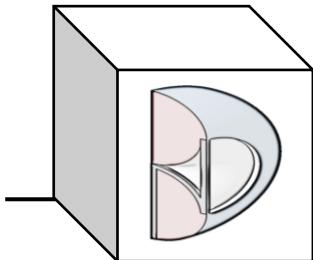


# BND TechSource



- Create the RH Addendum Intersect Curve.

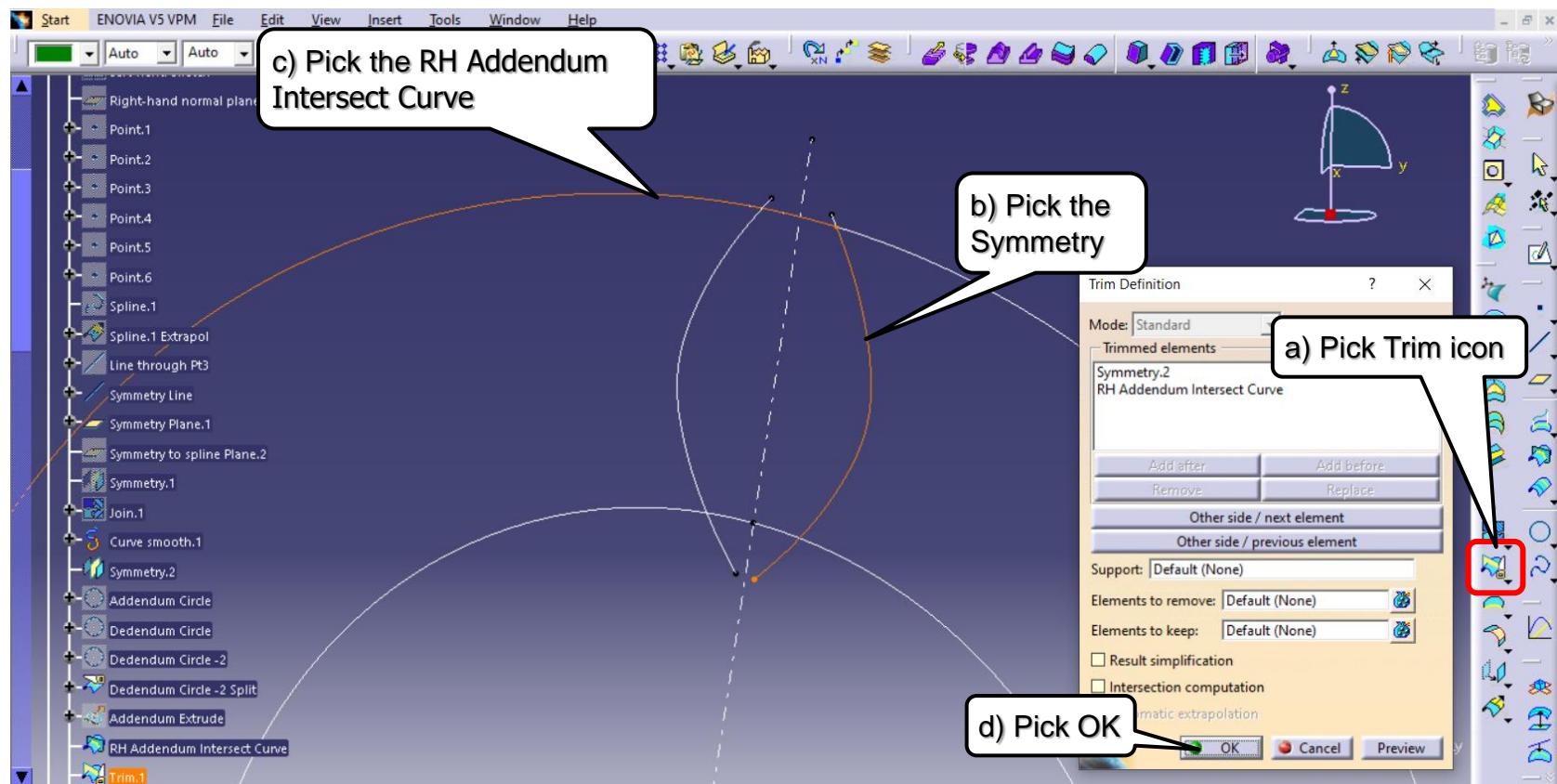


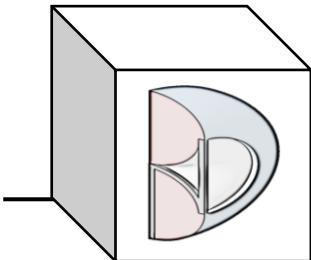


# BND TechSource



- Trim the tooth profile (Trim.1).

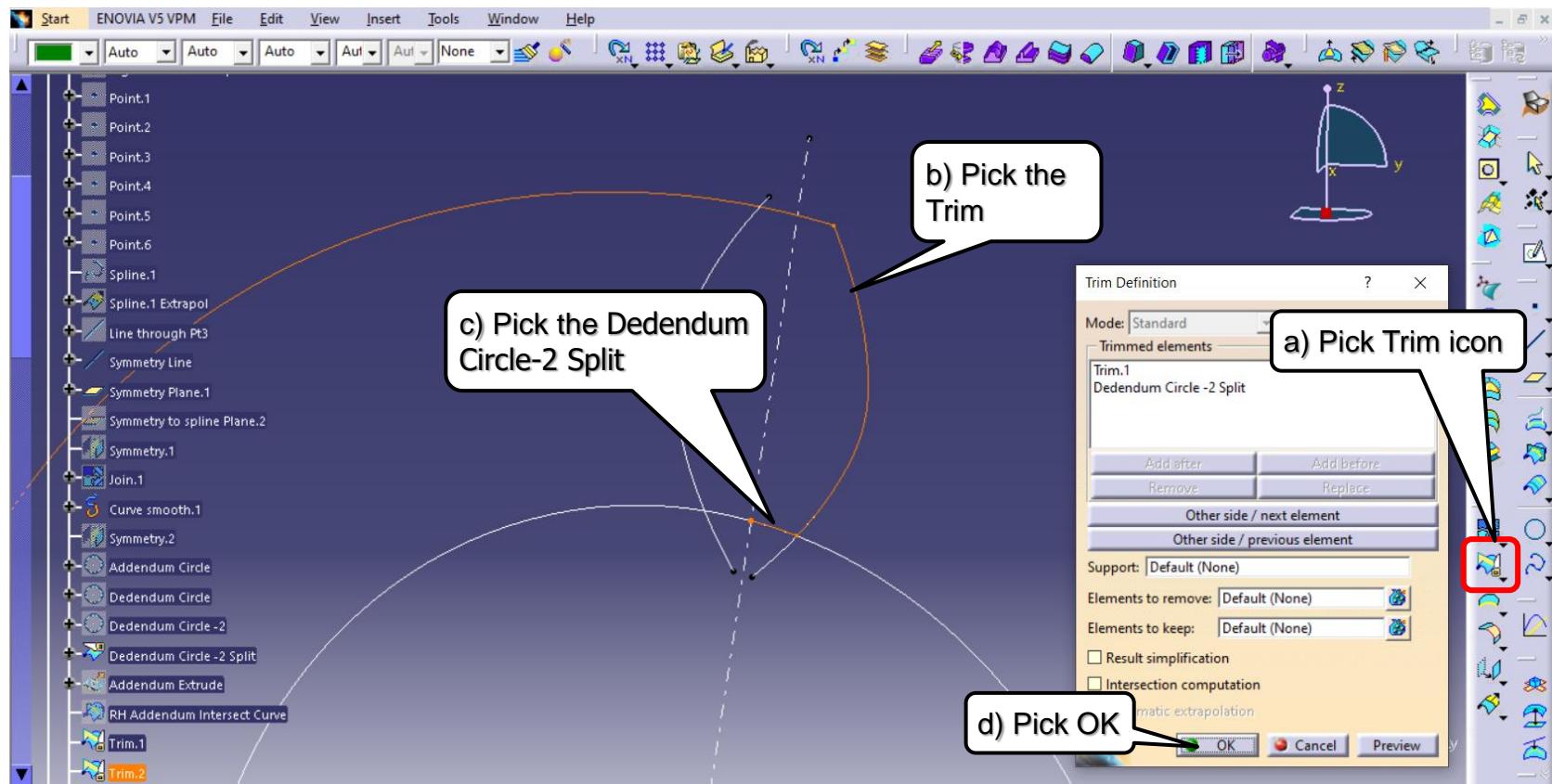


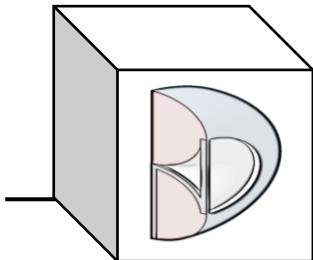


# BND TechSource



- Trim the tooth profile (Trim.2).

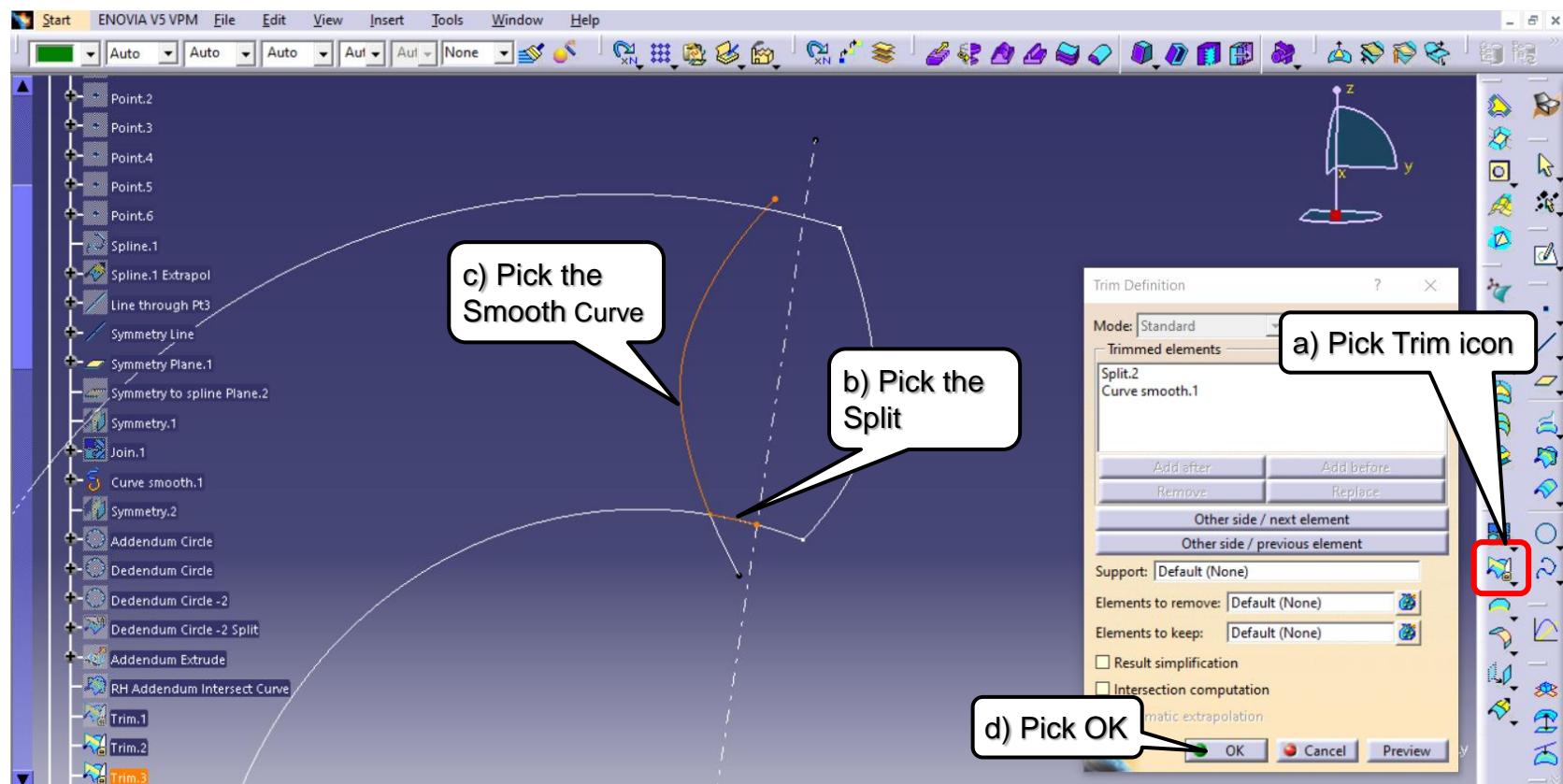


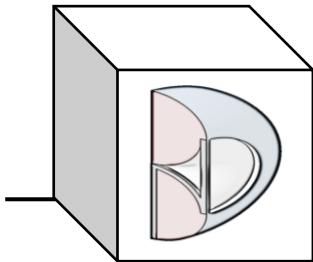


# BND TechSource



- Trim the tooth profile (Trim.3).

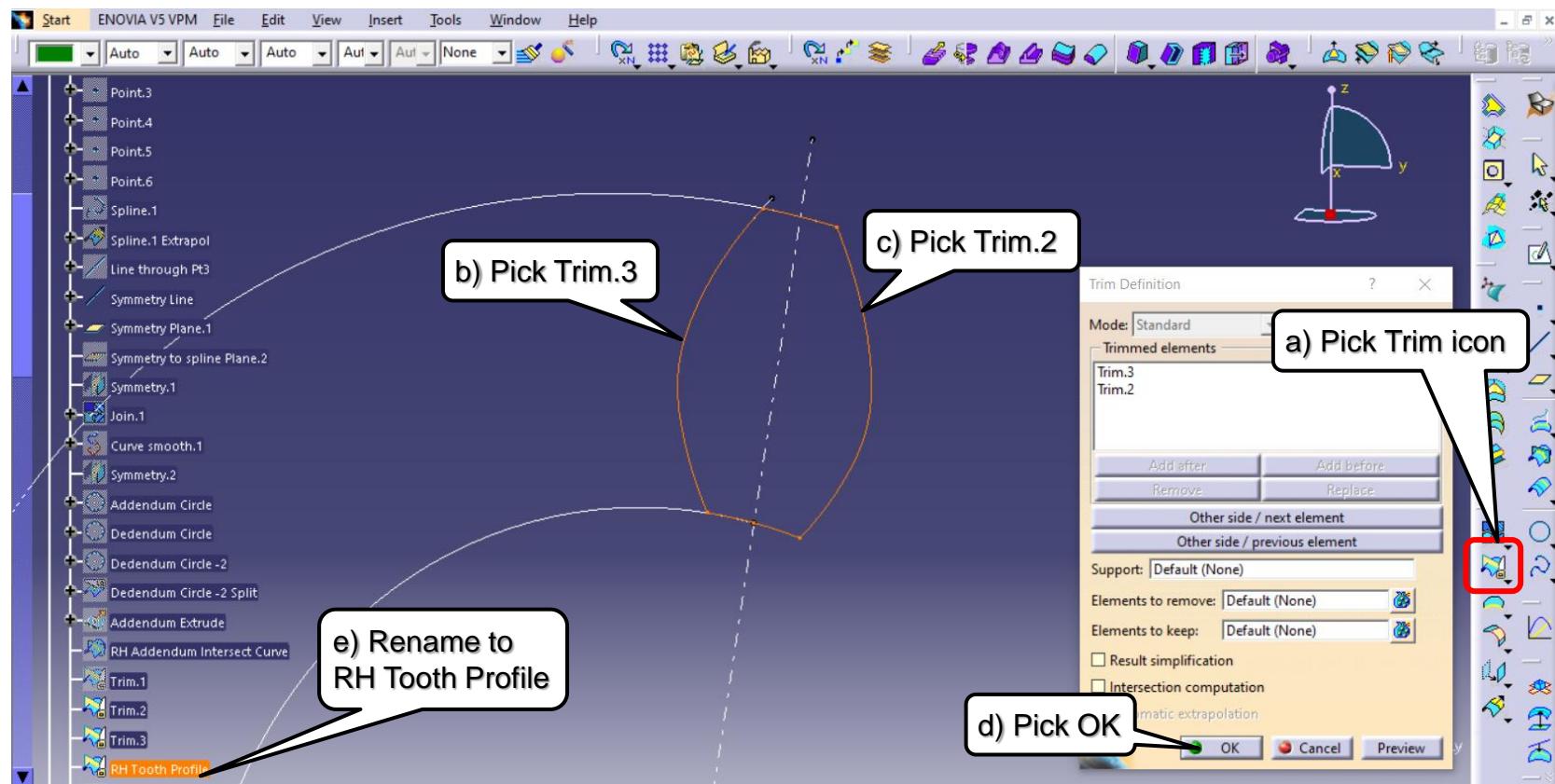


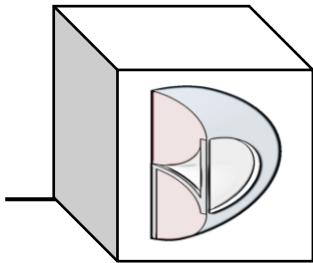


# BND TechSource



- Trim the tooth profile (RH Tooth Profile).

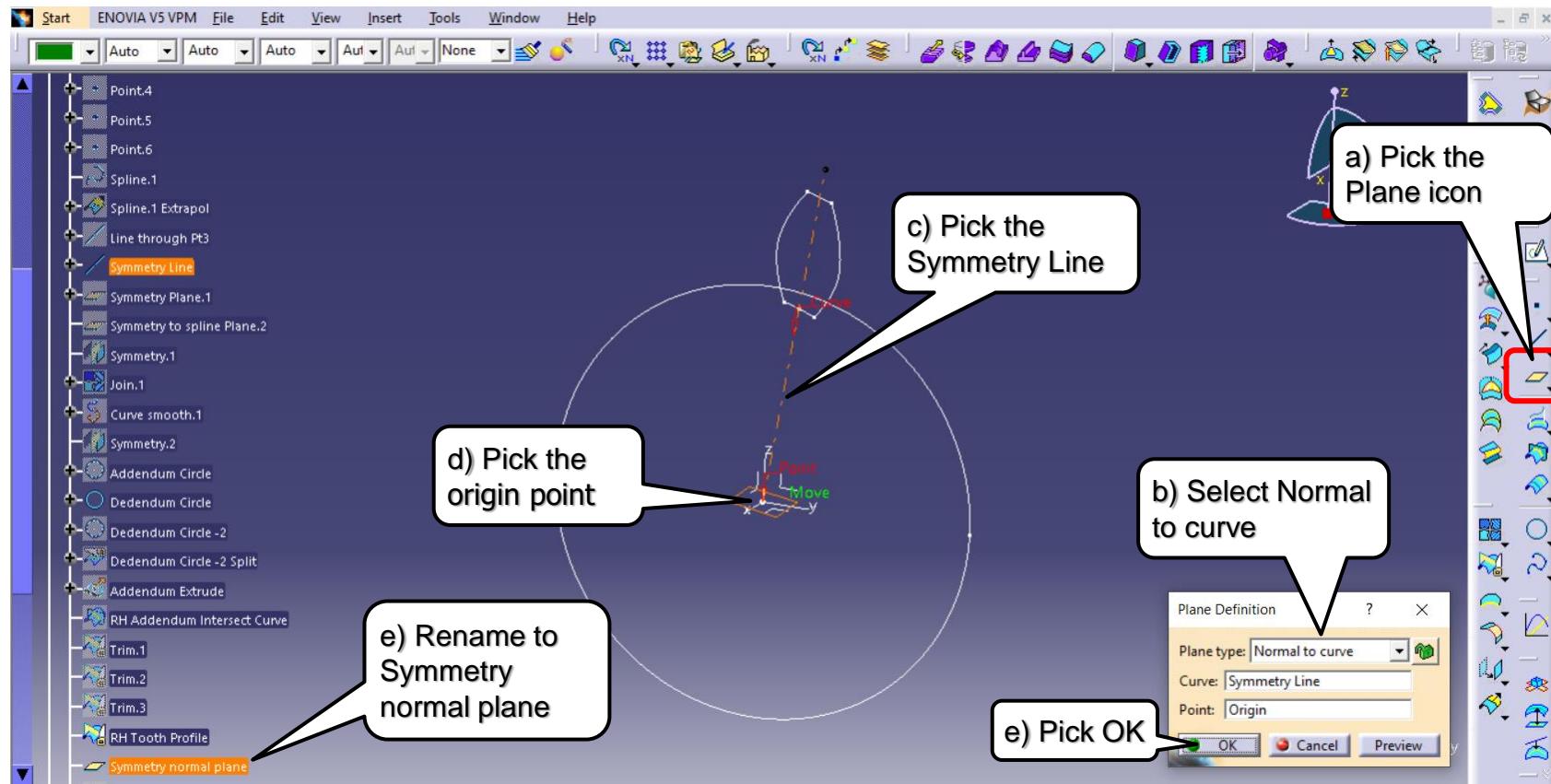


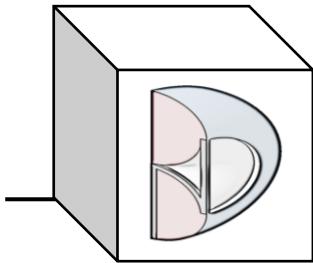


# BND TechSource



- Create the Symmetry normal plane.

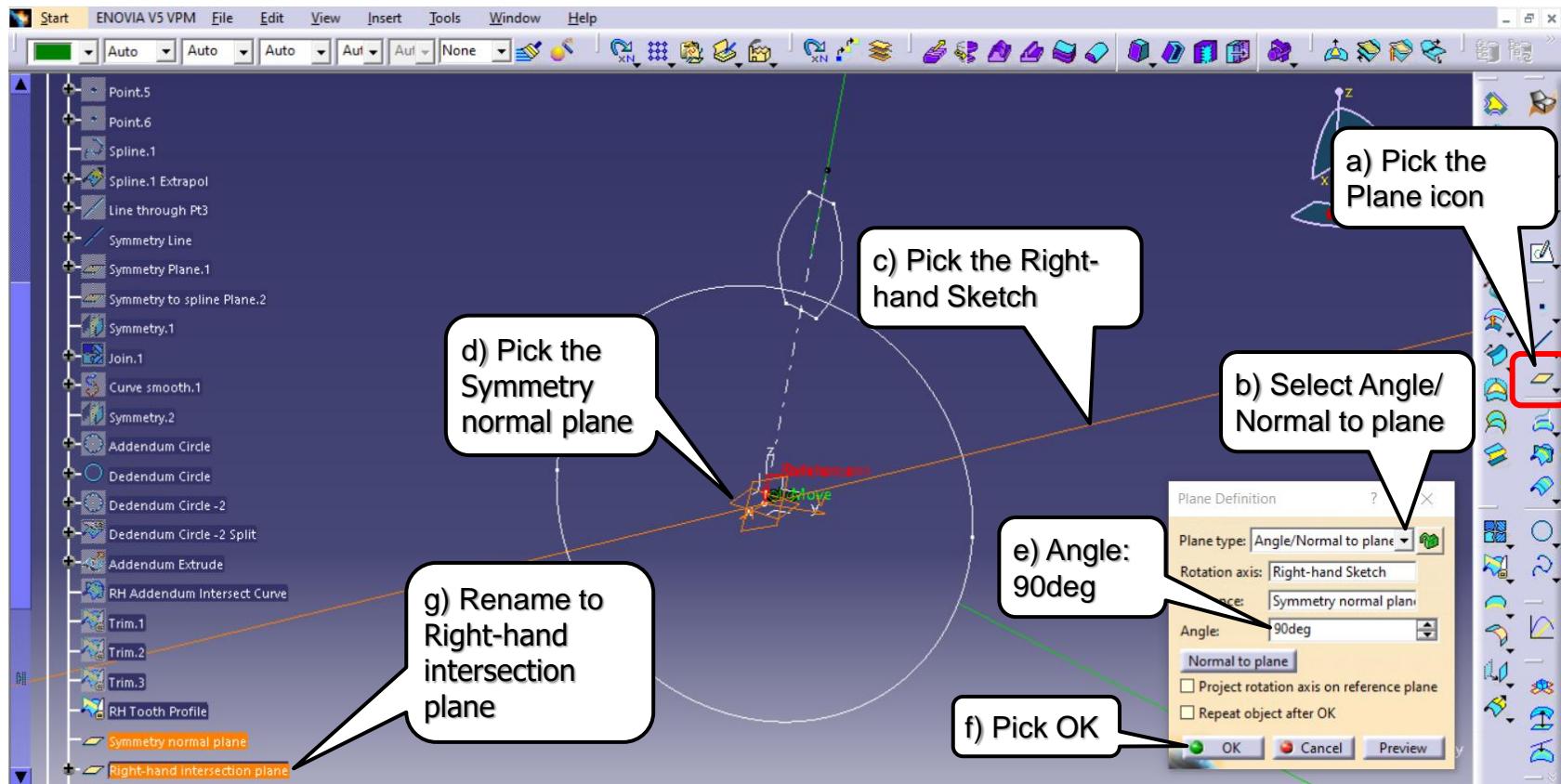


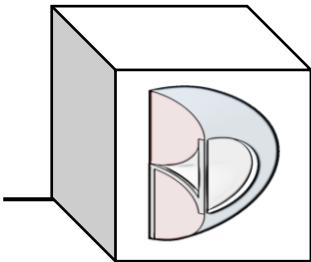


# BND TechSource



- Create the Right-hand intersection plane.

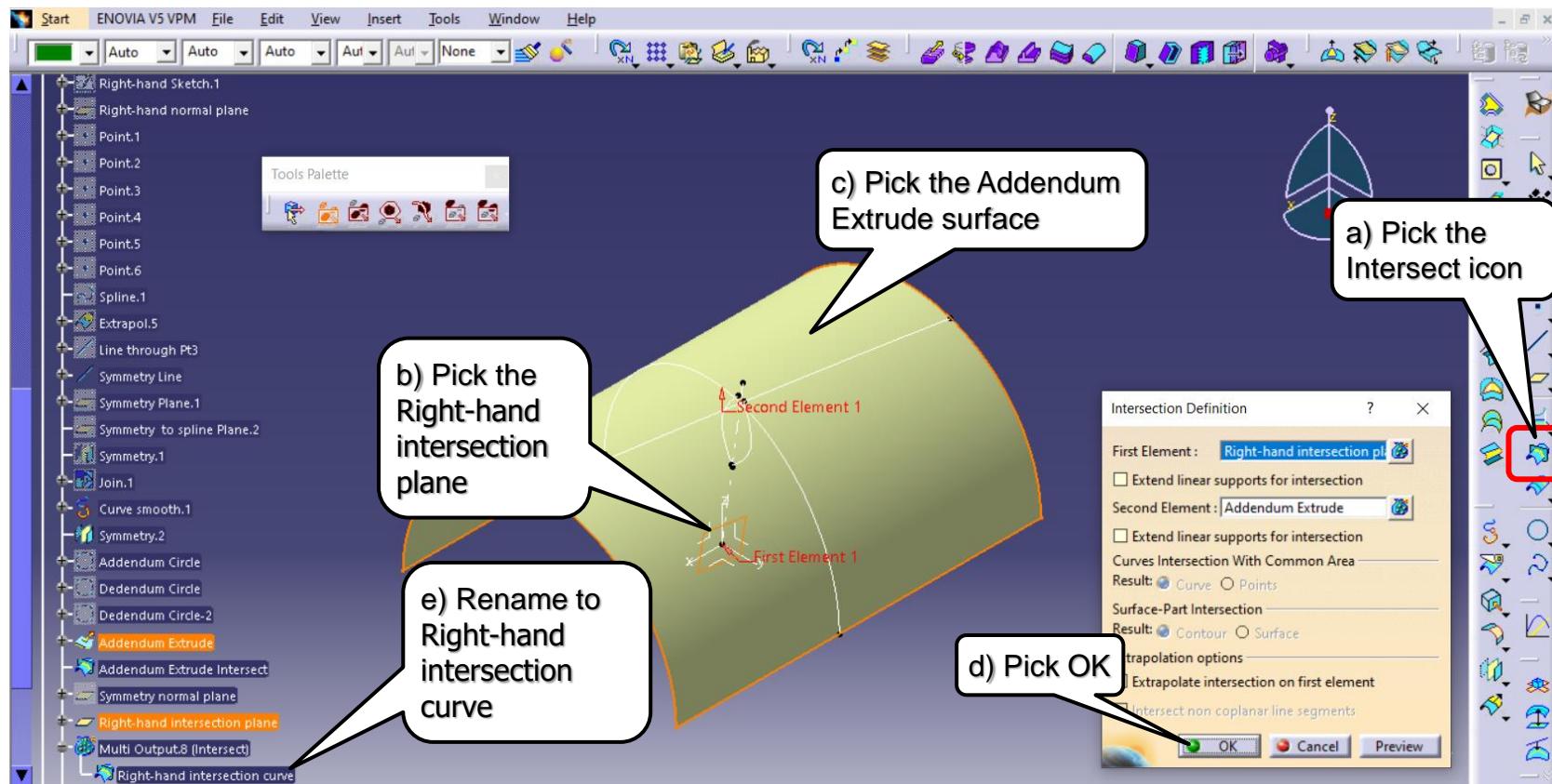


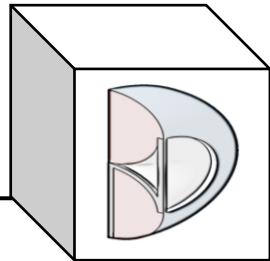


# BND TechSource



- Create the Right-hand intersection curve.

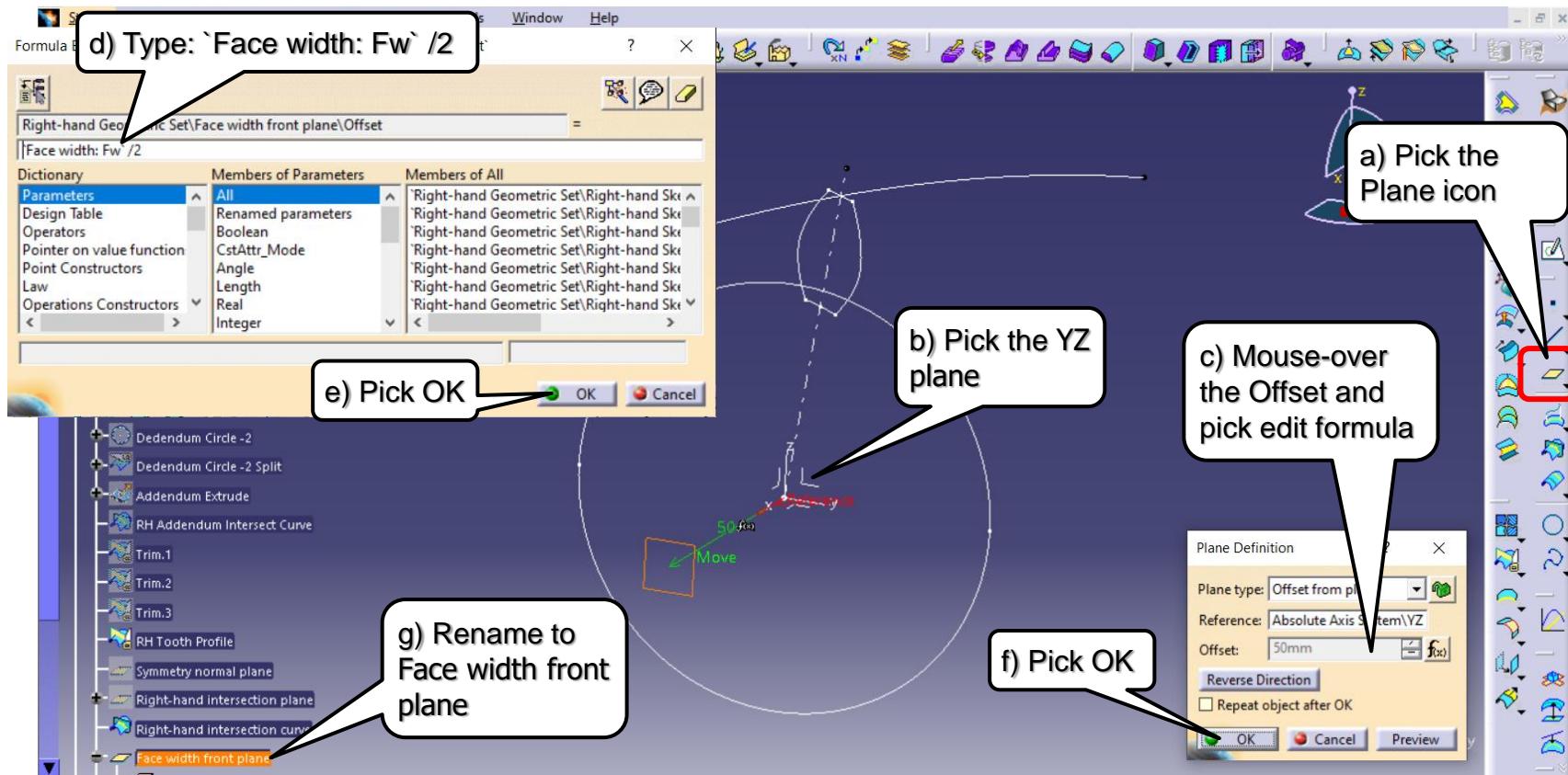


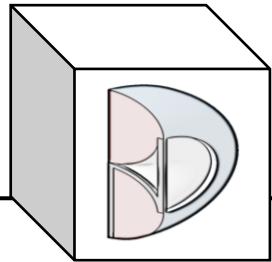


# BND TechSource



- Create the Face width front plane.

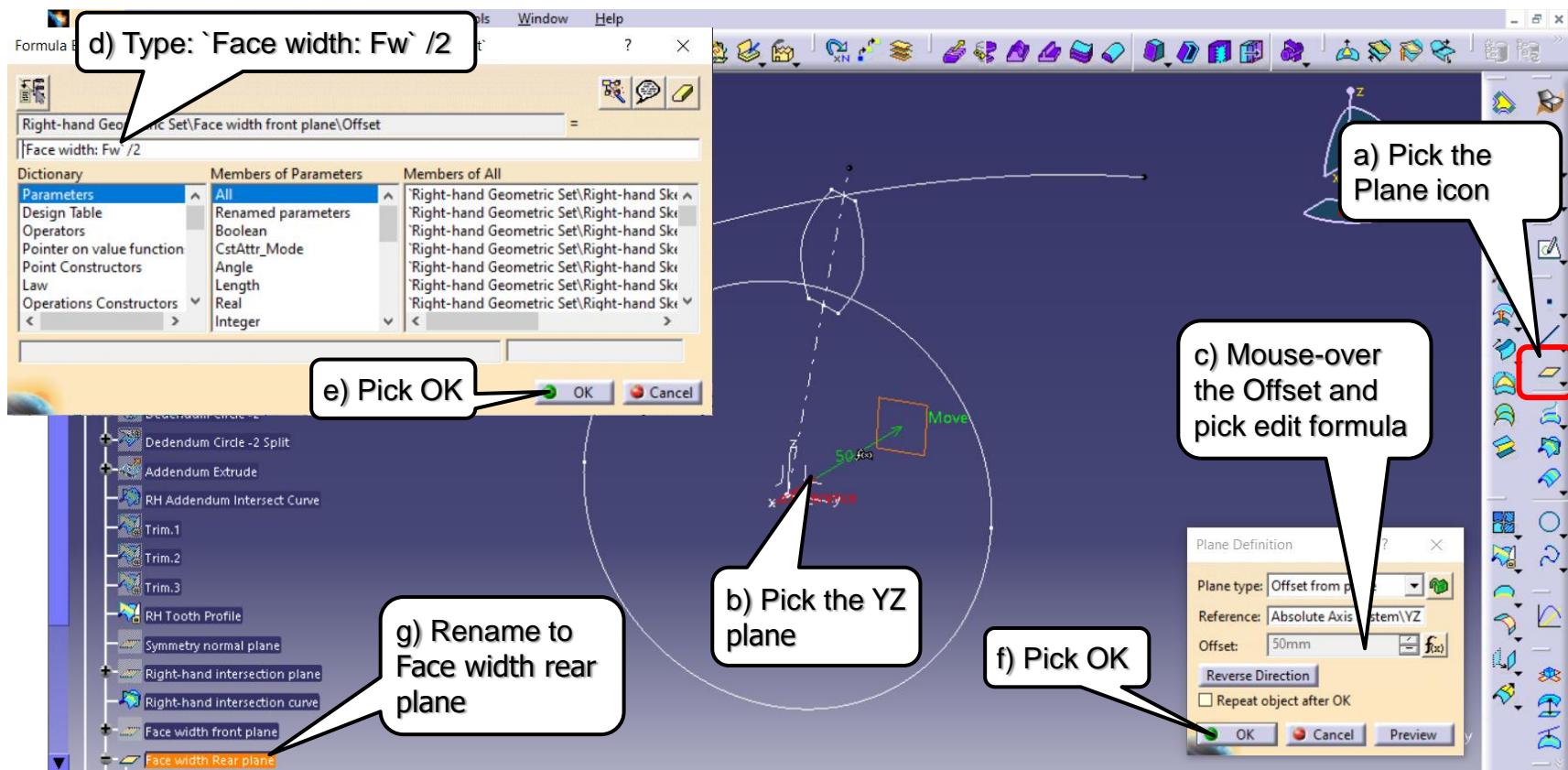


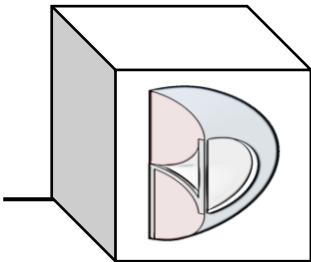


# BND TechSource



- Create the Face width rear plane.

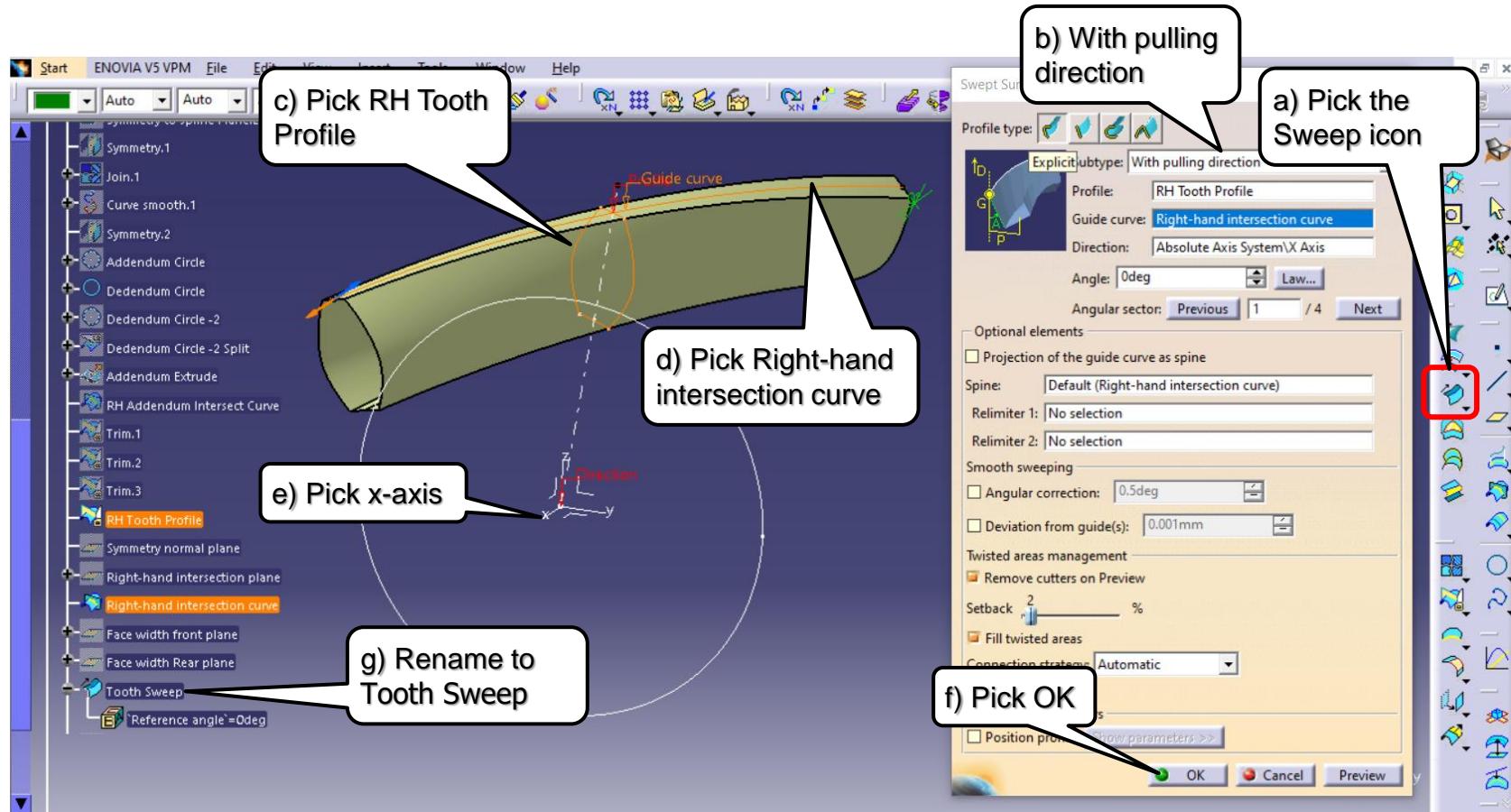


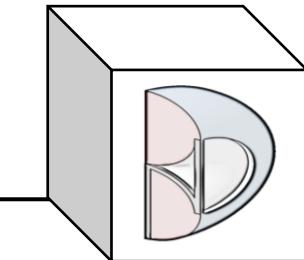


# BND TechSource



- Create the Tooth Sweep.

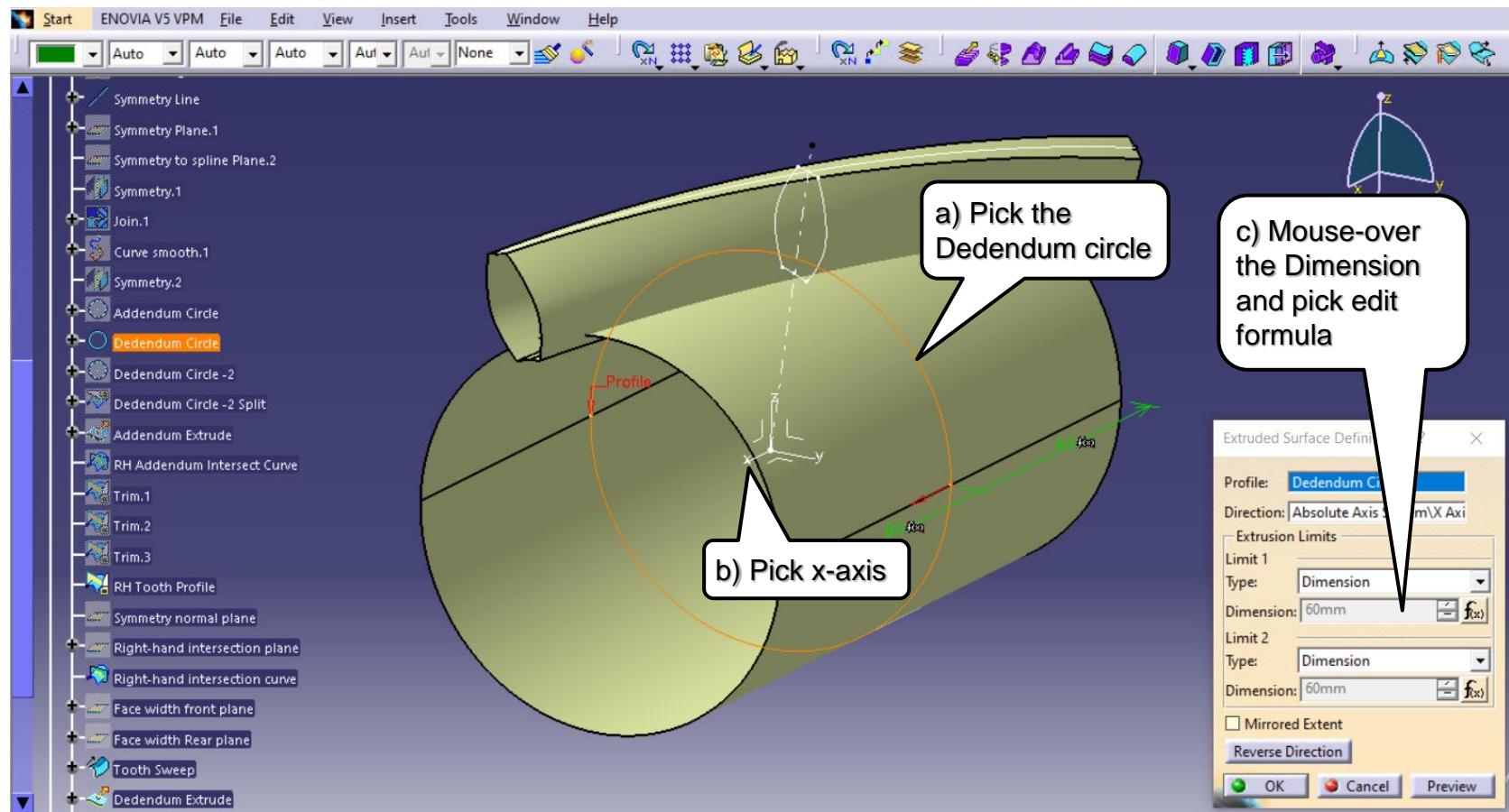


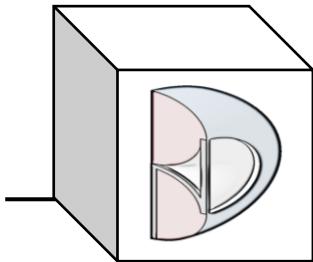


# BND TechSource



- Create the Dedendum Extrude surface.

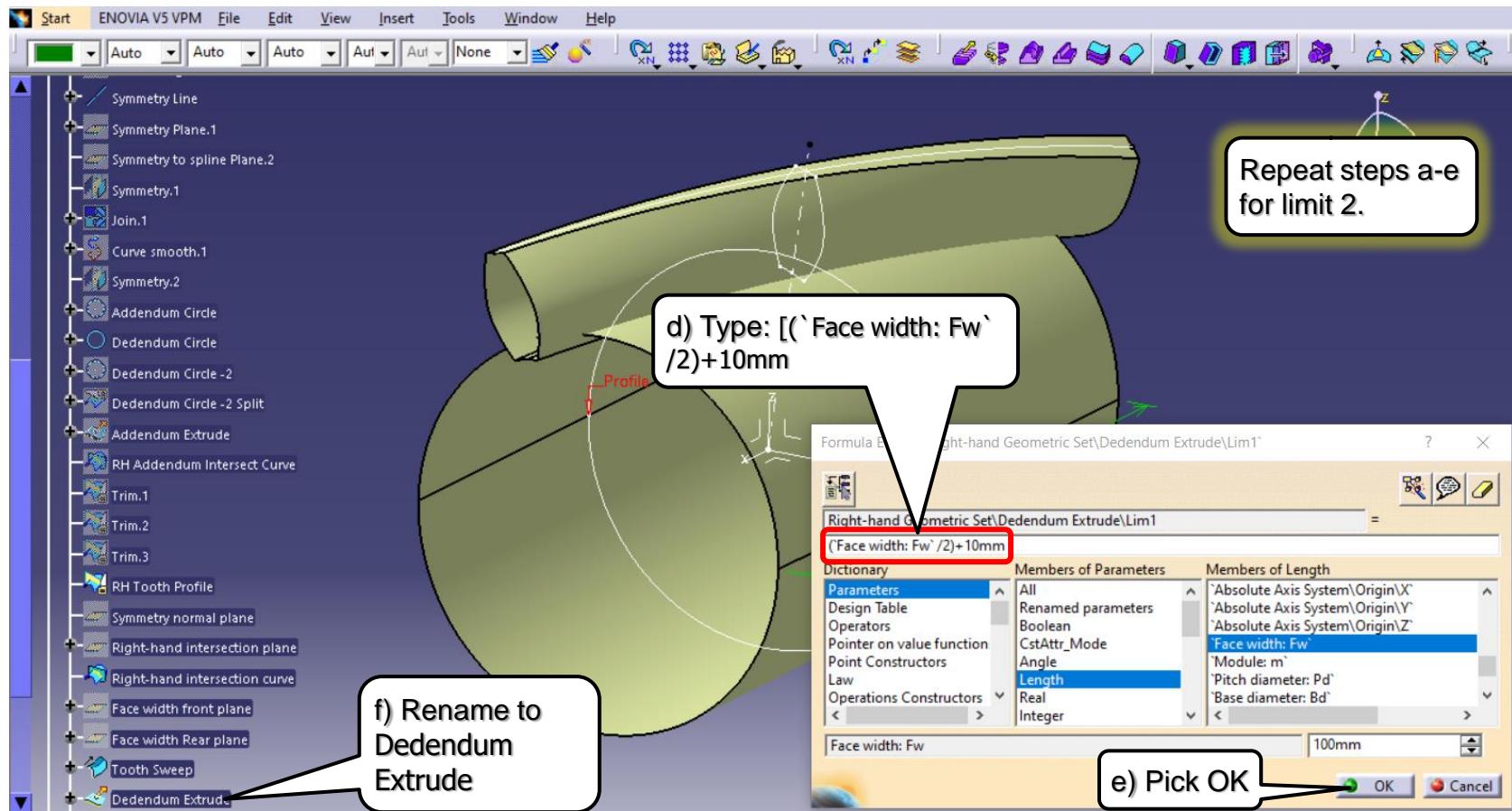


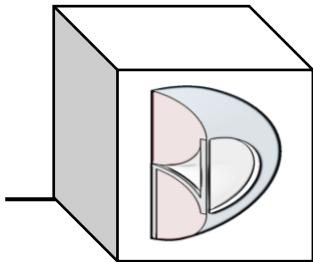


# BND TechSource



- Apply the formula [ $(`Face width: Fw` /2)+10mm$ ] to limits 1 & 2.

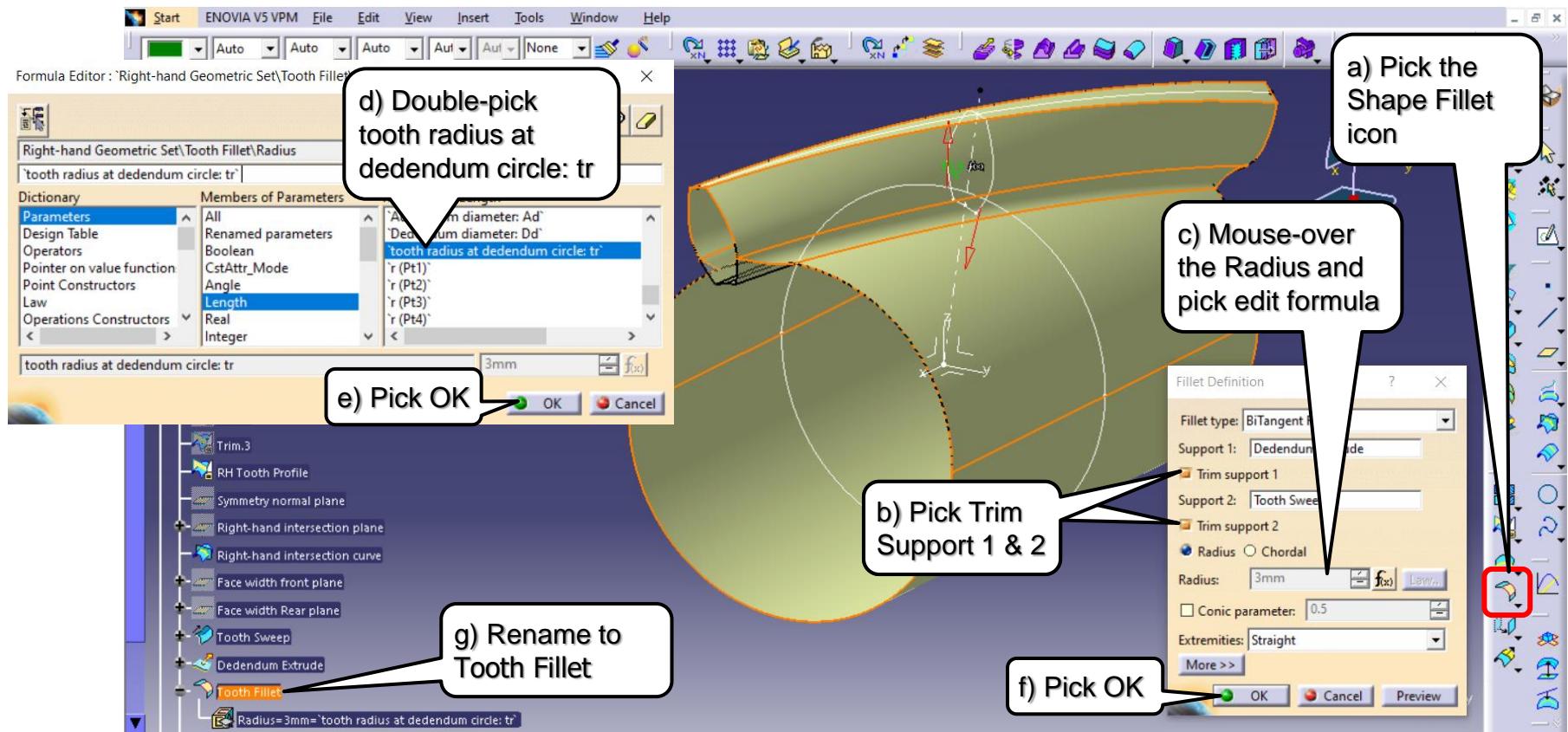


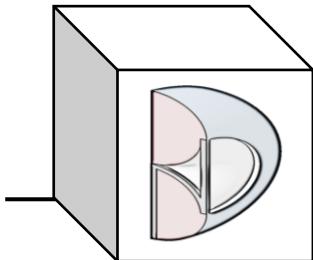


# BND TechSource



- Create the Tooth Fillet.

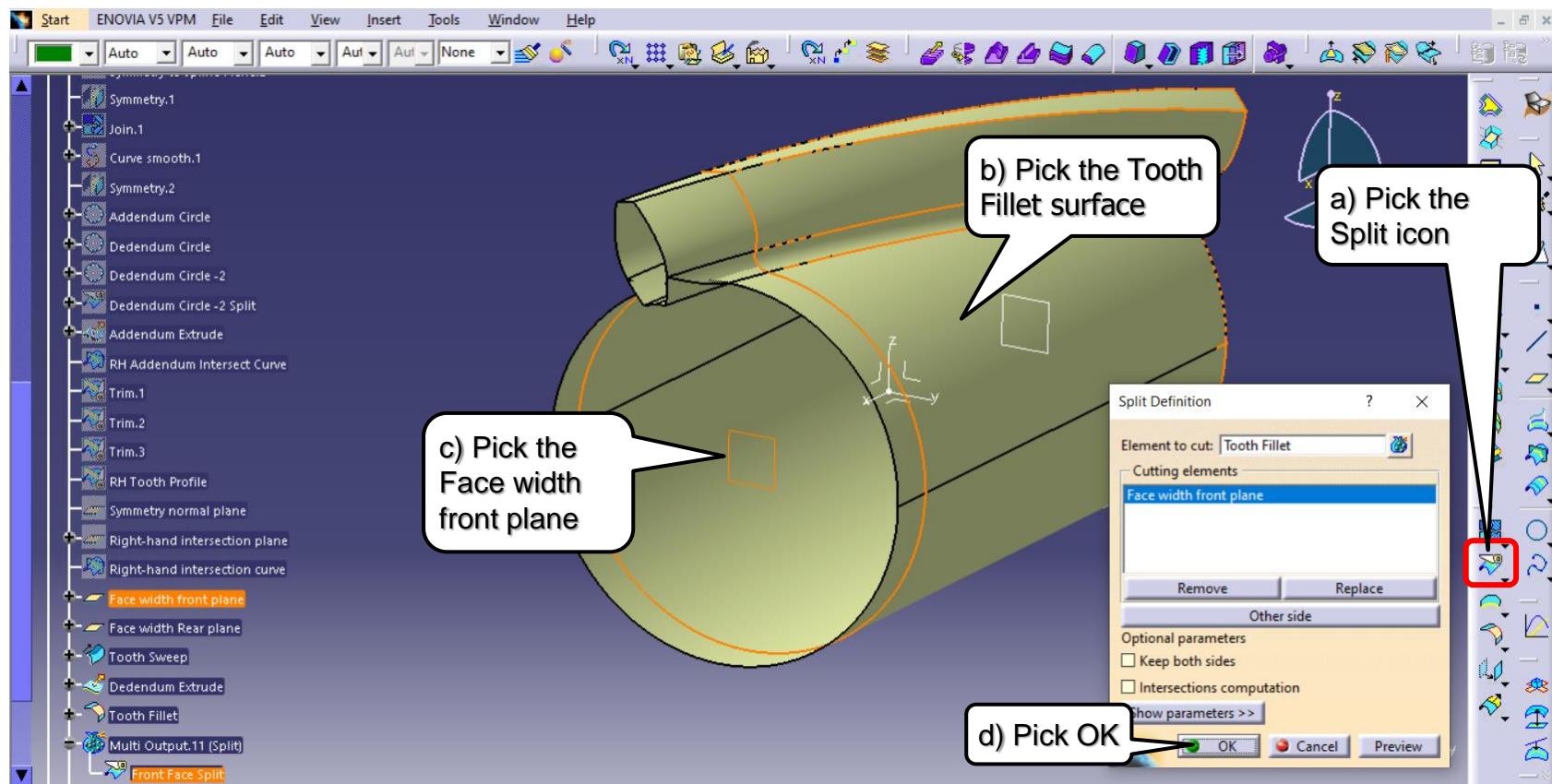


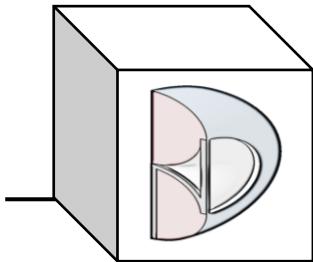


# BND TechSource



- Create the Front Face Split.

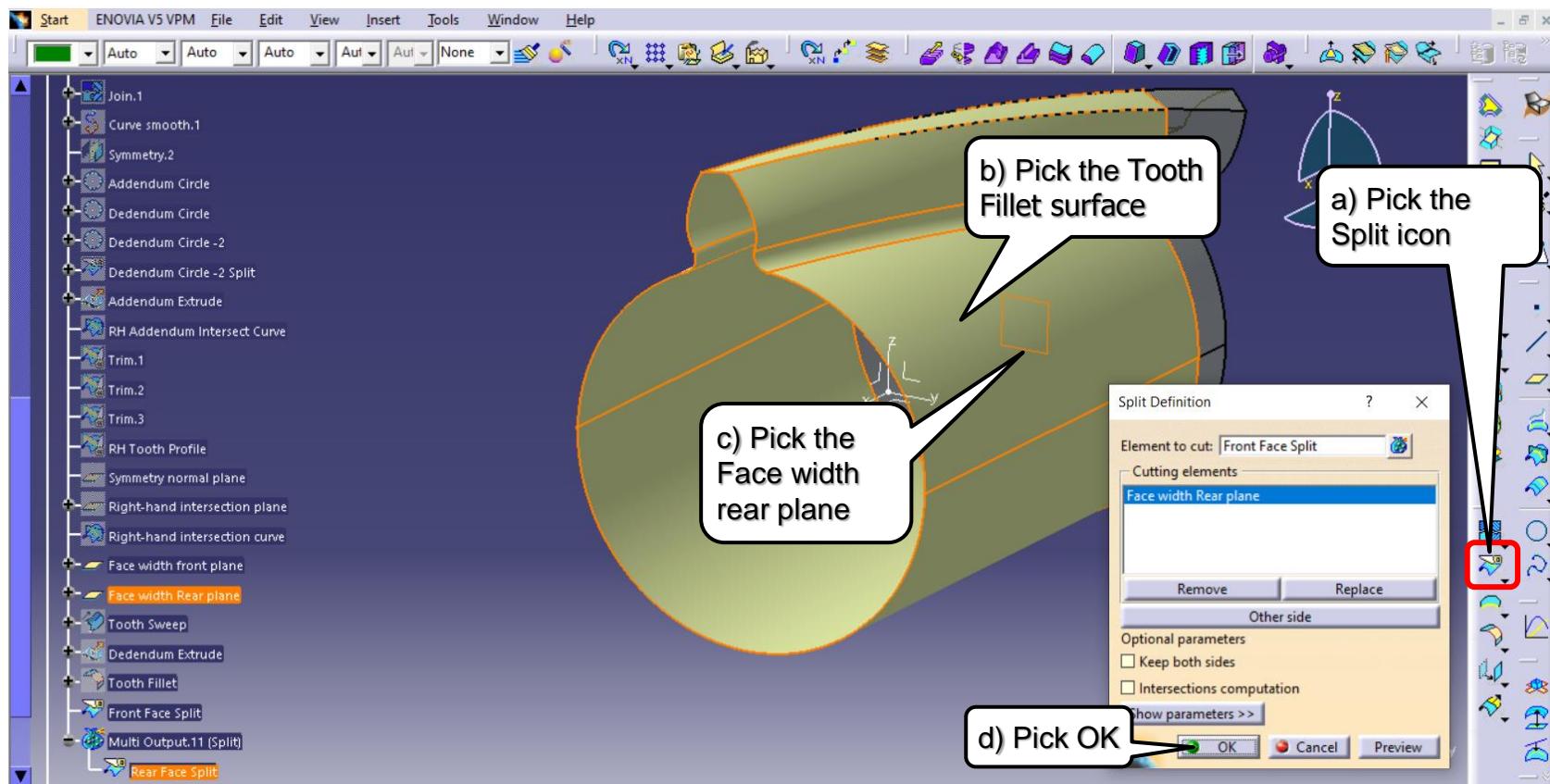


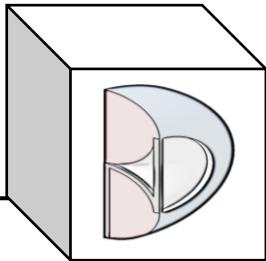


# BND TechSource



- Create the Rear Face Split.

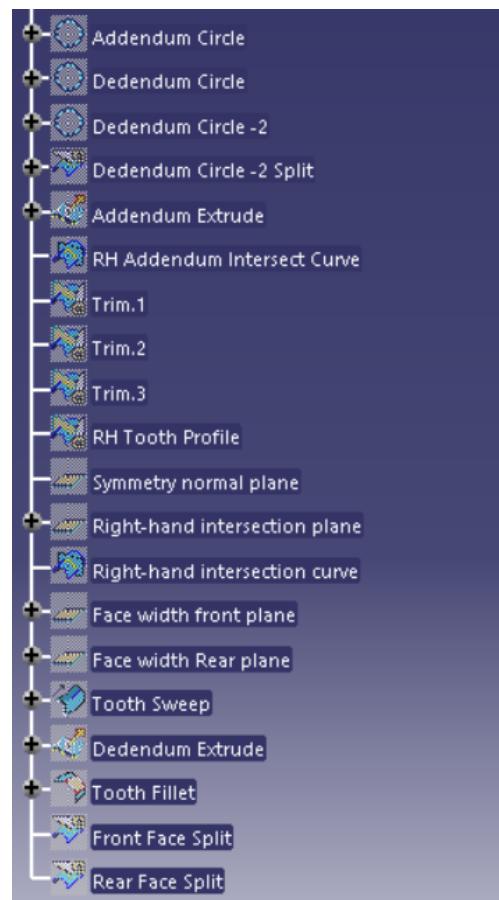
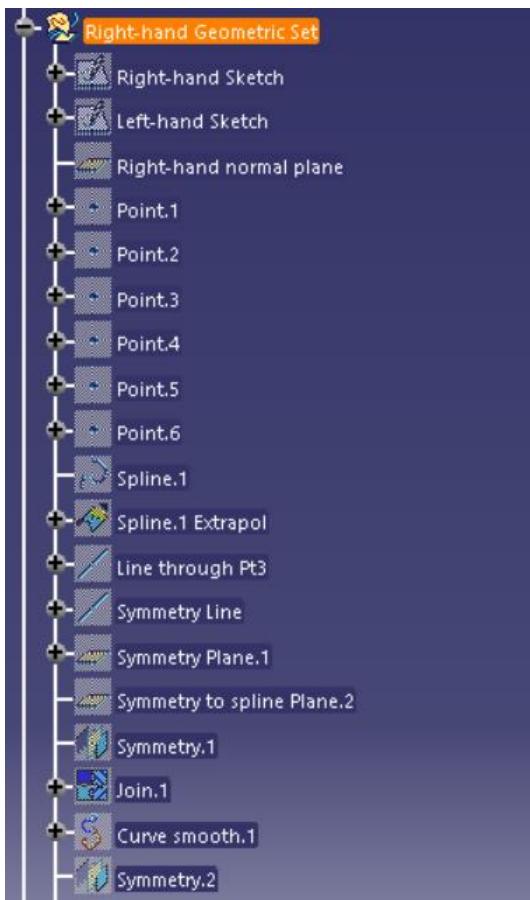


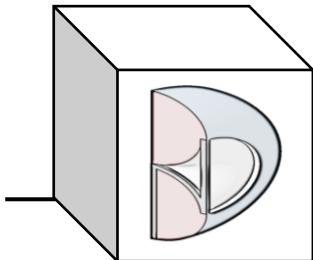


# BND TechSource



- Rename the Right-hand construction geometry as shown.

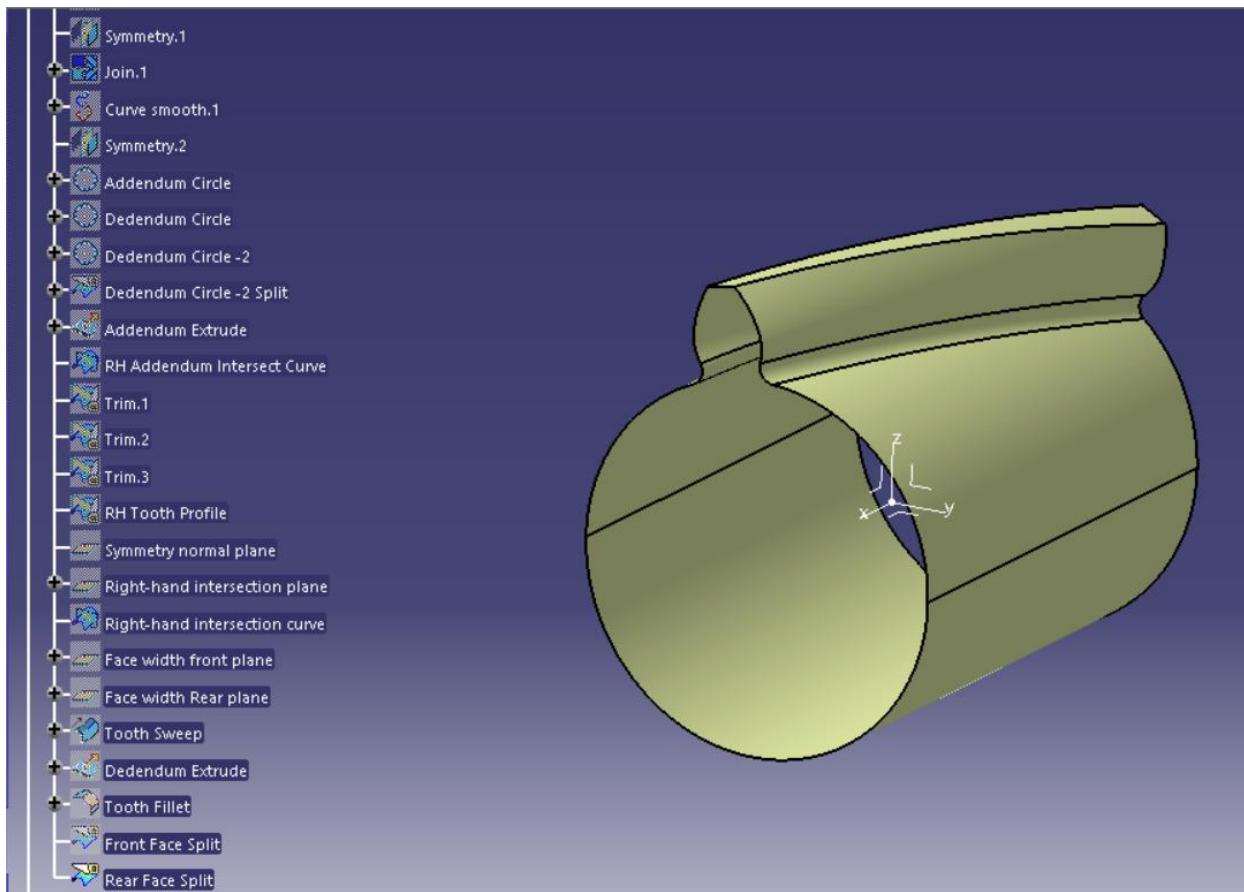


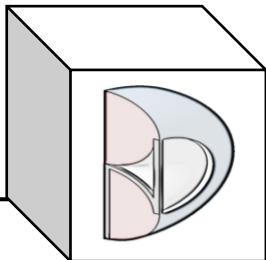


# BND TechSource



- Clean up (hide) the construction geometry.

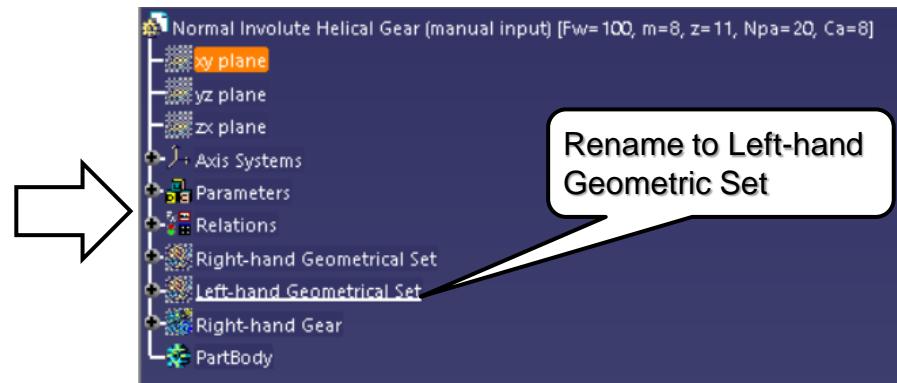
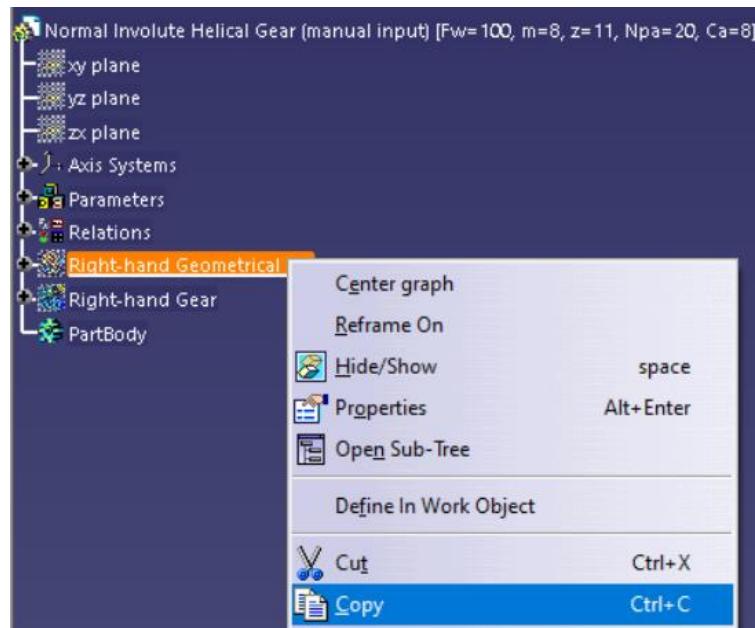


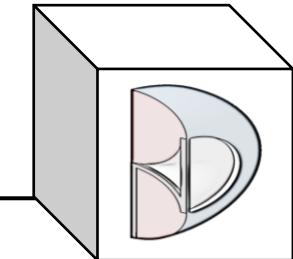


# BND TechSource



- Copy the Right-hand Geometric Set, paste it into the Part and rename it Left-hand Geometric Set.

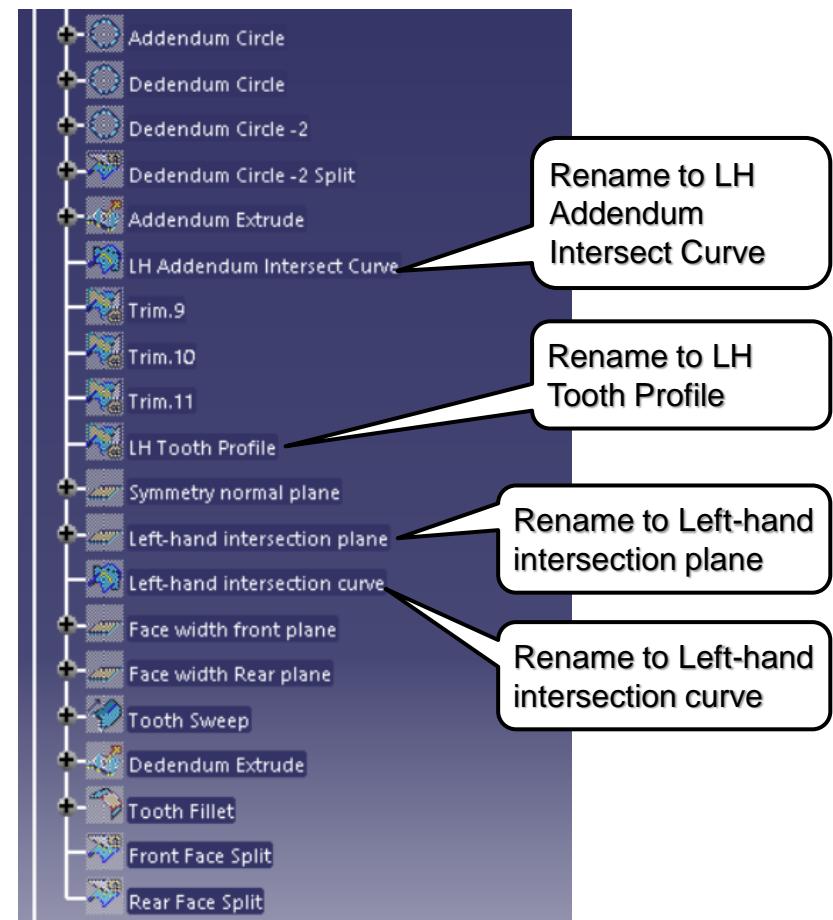
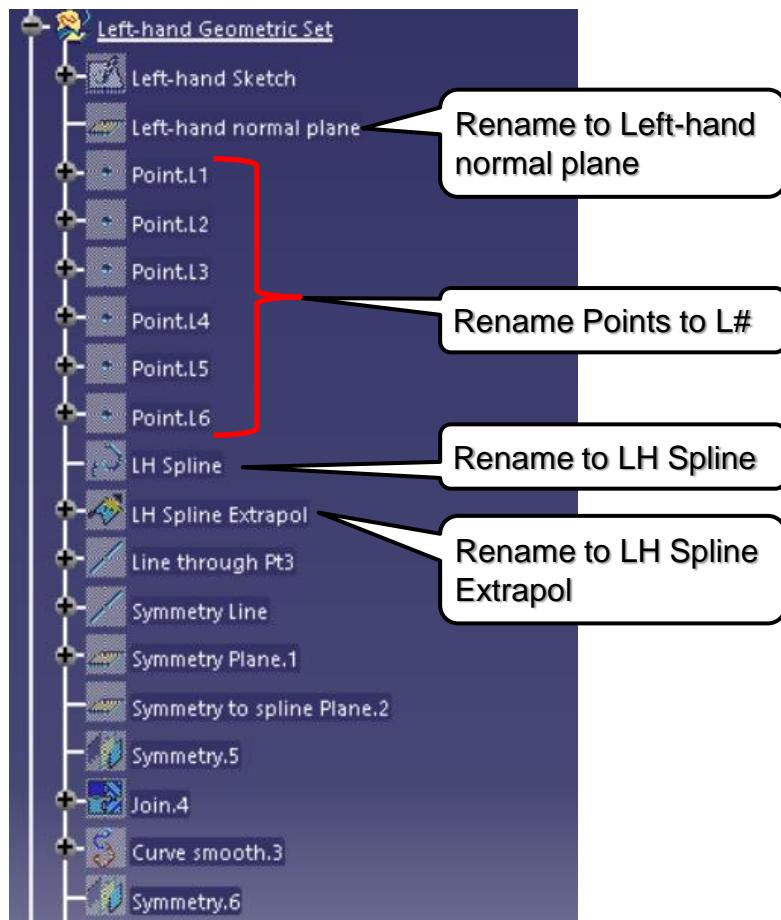


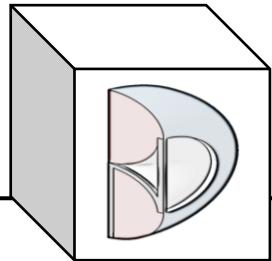


# BND TechSource

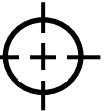


- Rename Left-hand specific geometry.

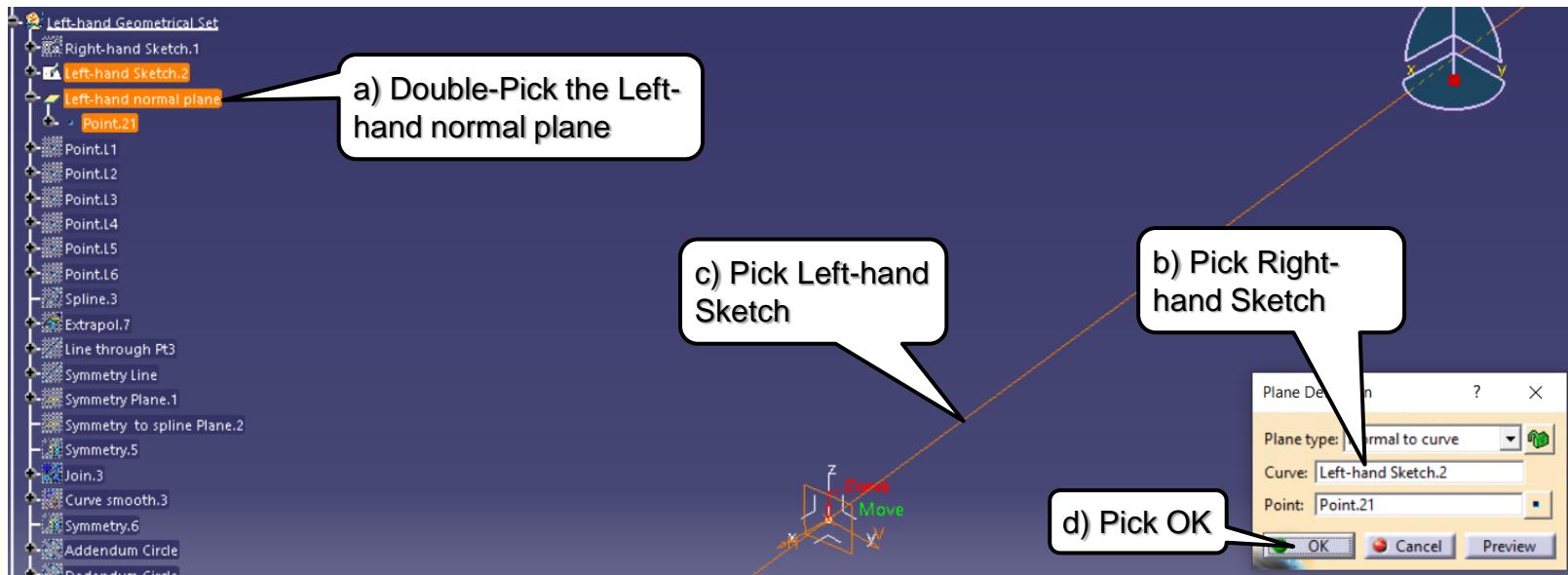


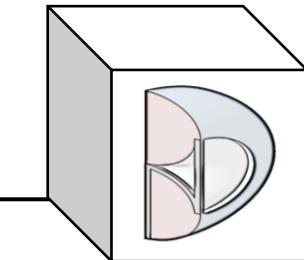


# BND TechSource



- Edit Left-hand specific geometry.

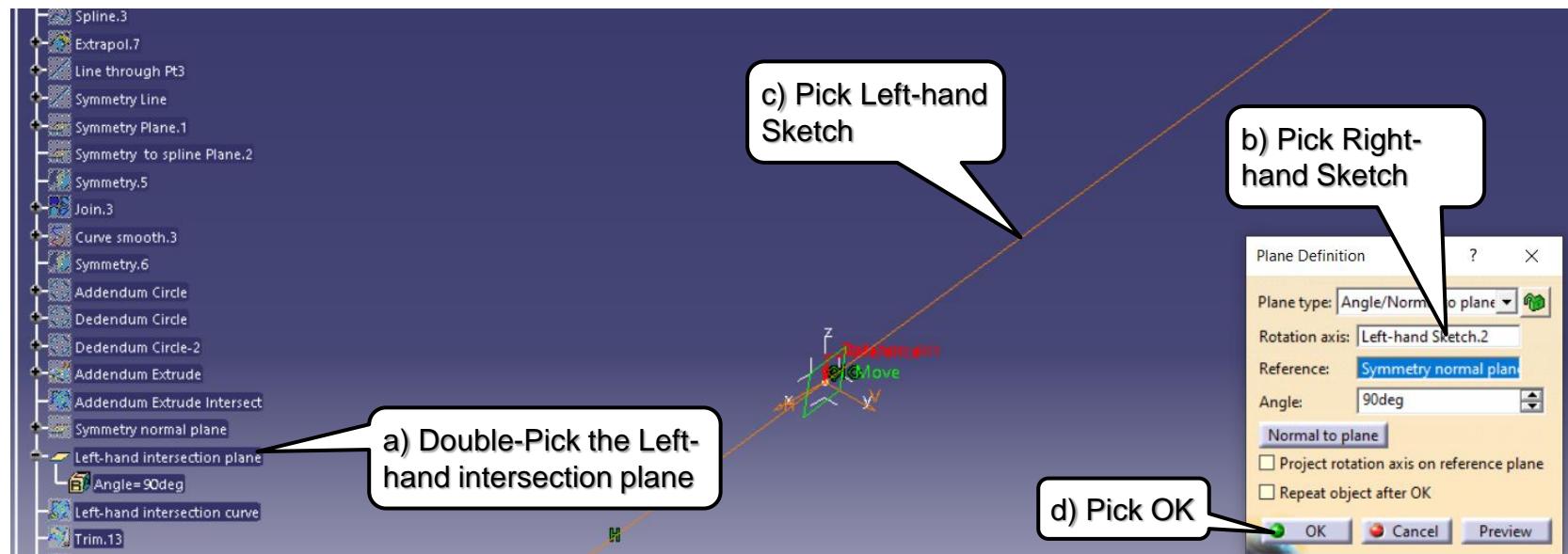


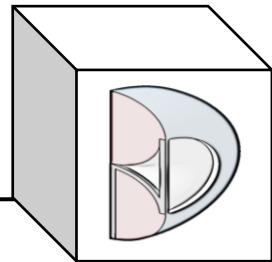


# BND TechSource



- Edit Left-hand specific geometry.





# BND TechSource



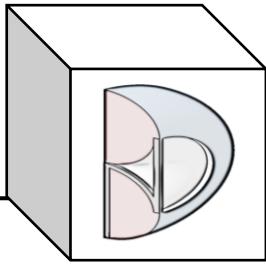
- Edit Left-hand specific geometry.

a) Delete the Right-hand Sketch from the Left-hand Geometric set



b) Delete the Left-hand Sketch from the Right-hand Geometric set

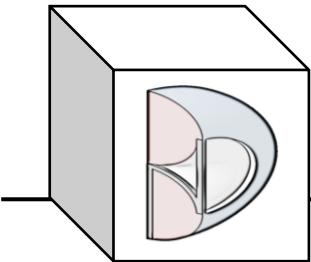




# BND TechSource



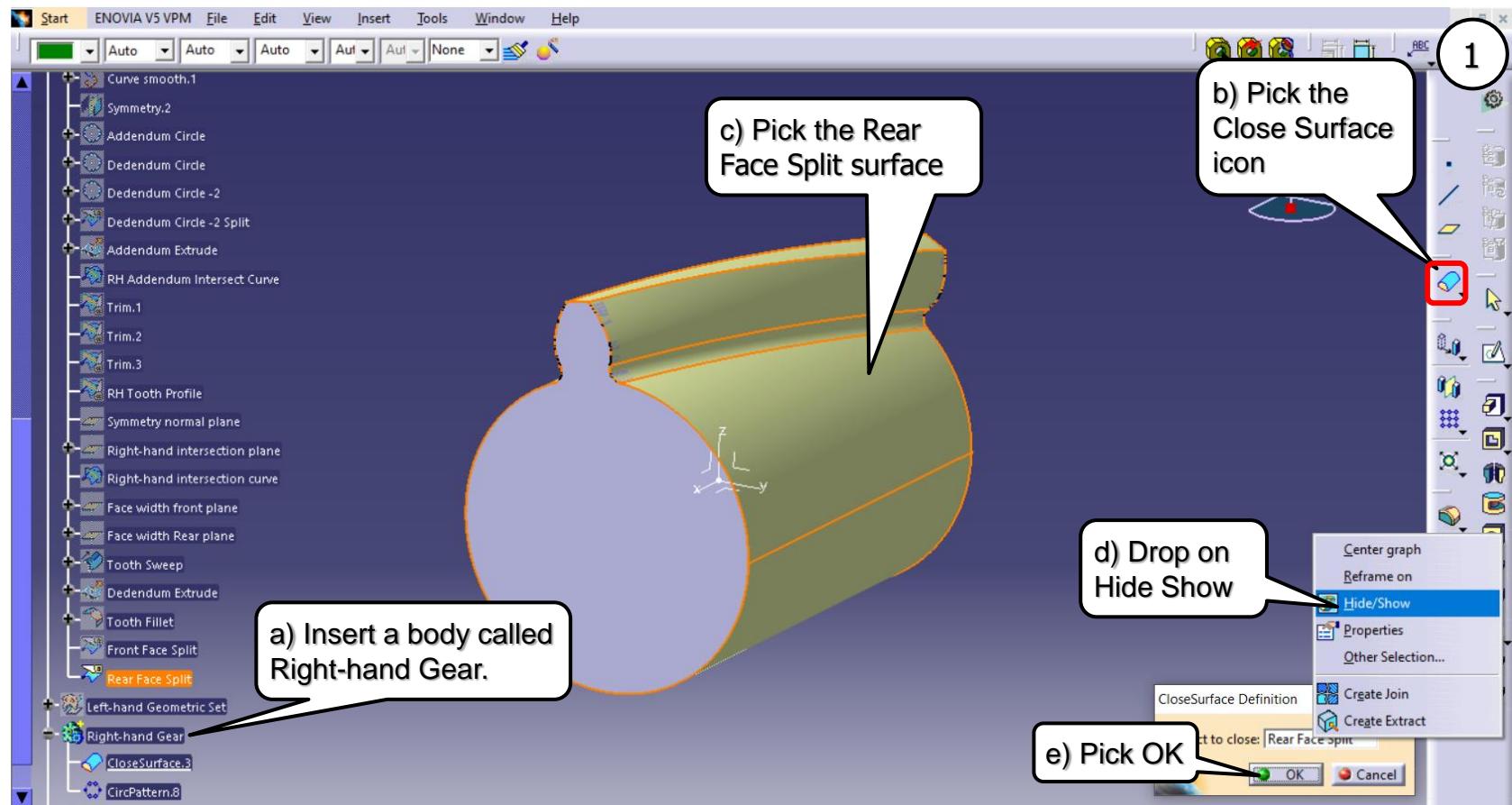
## Create the Solid Geometry (Normal Module Involute Helical Gear)

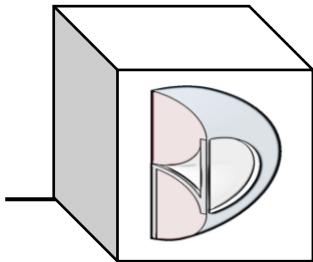


# BND TechSource



- Create a solid Close Surface using the Rear Face Split.

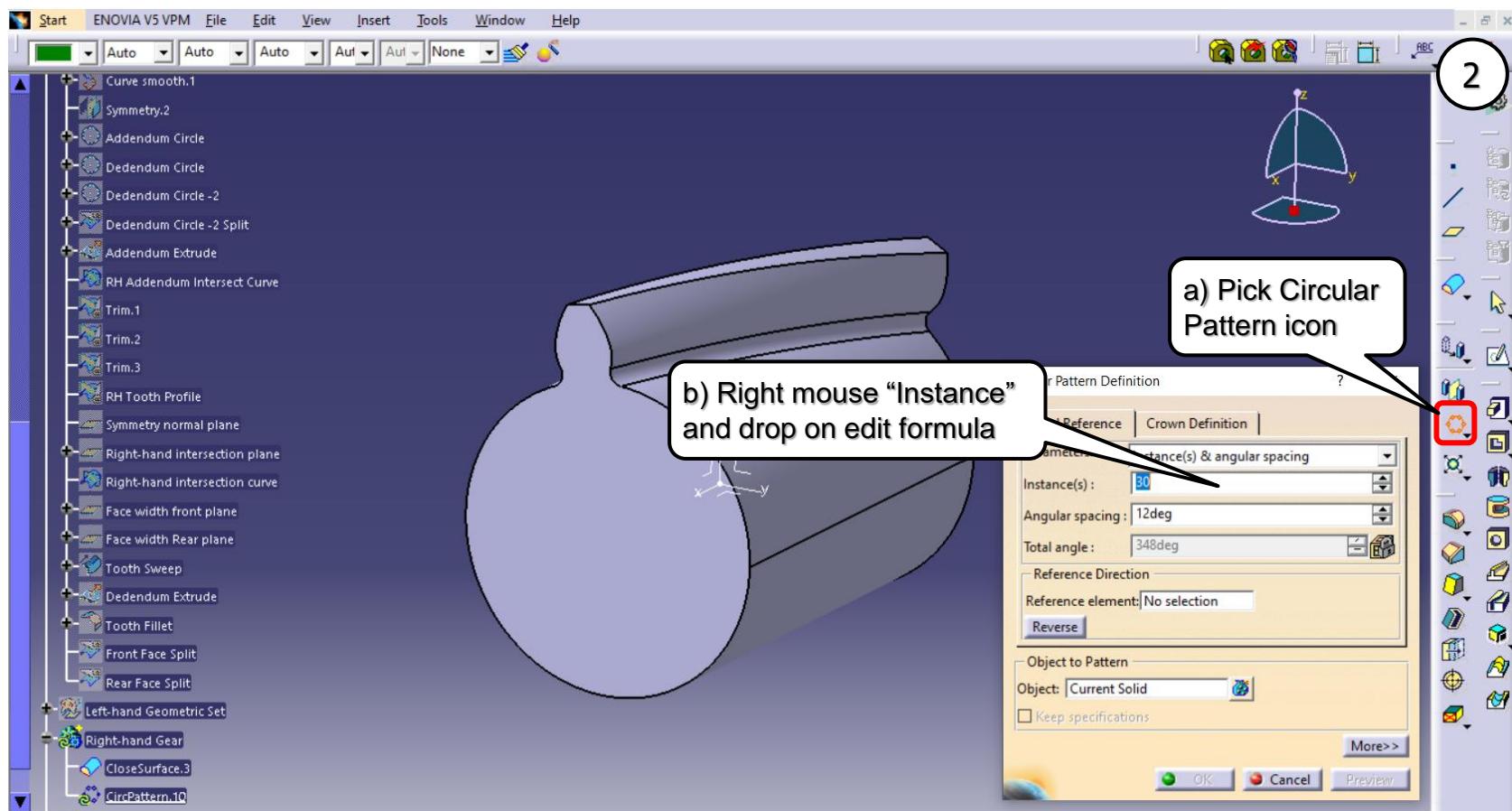


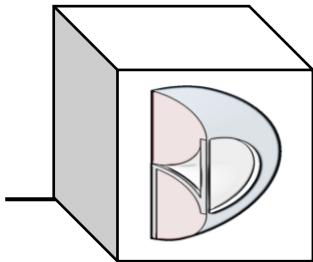


# BND TechSource



- Create the pattern for the number of teeth.

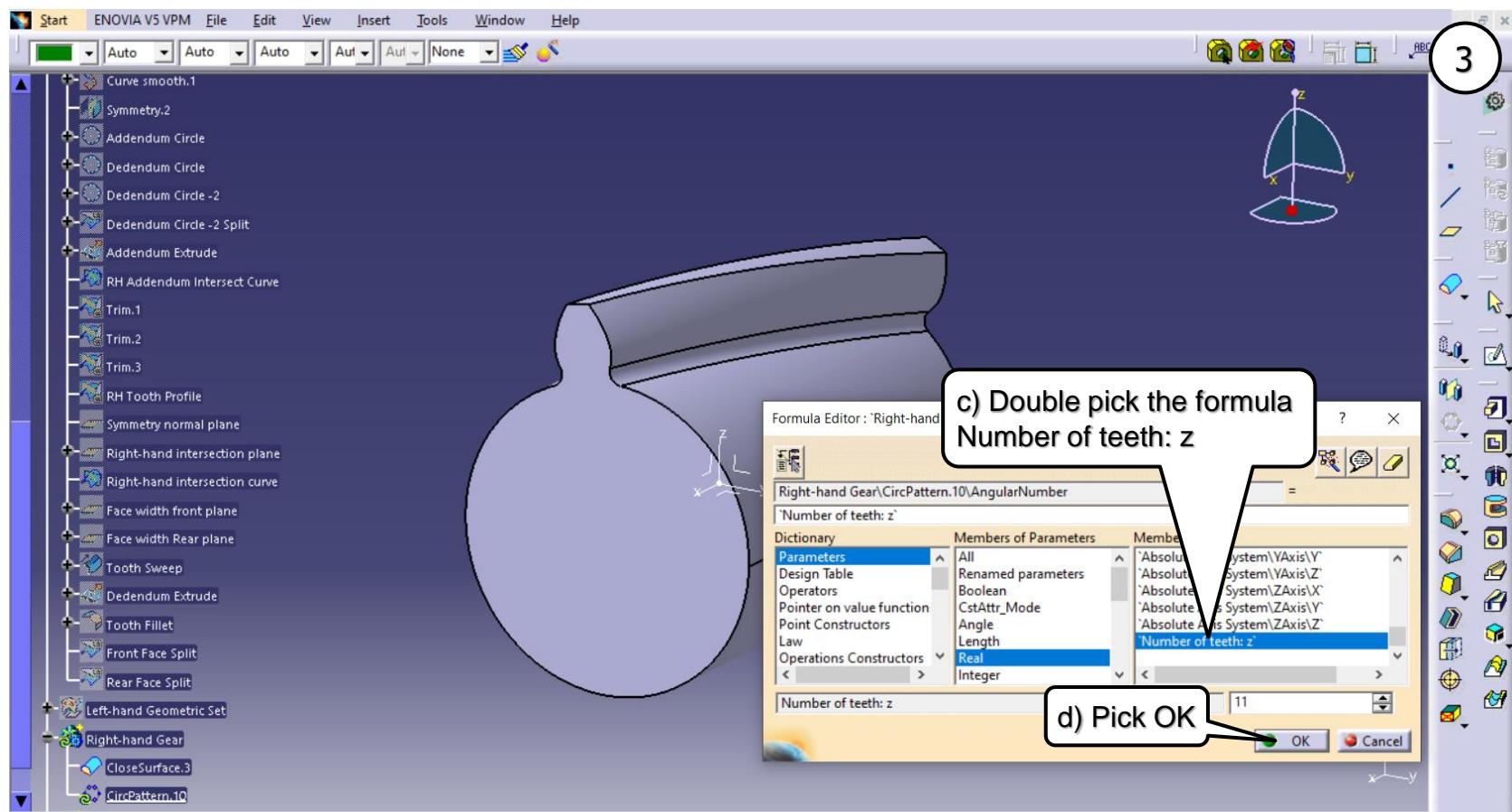


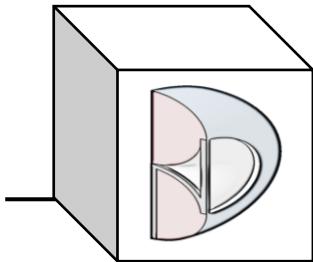


# BND TechSource



- Create the pattern for the number of teeth.

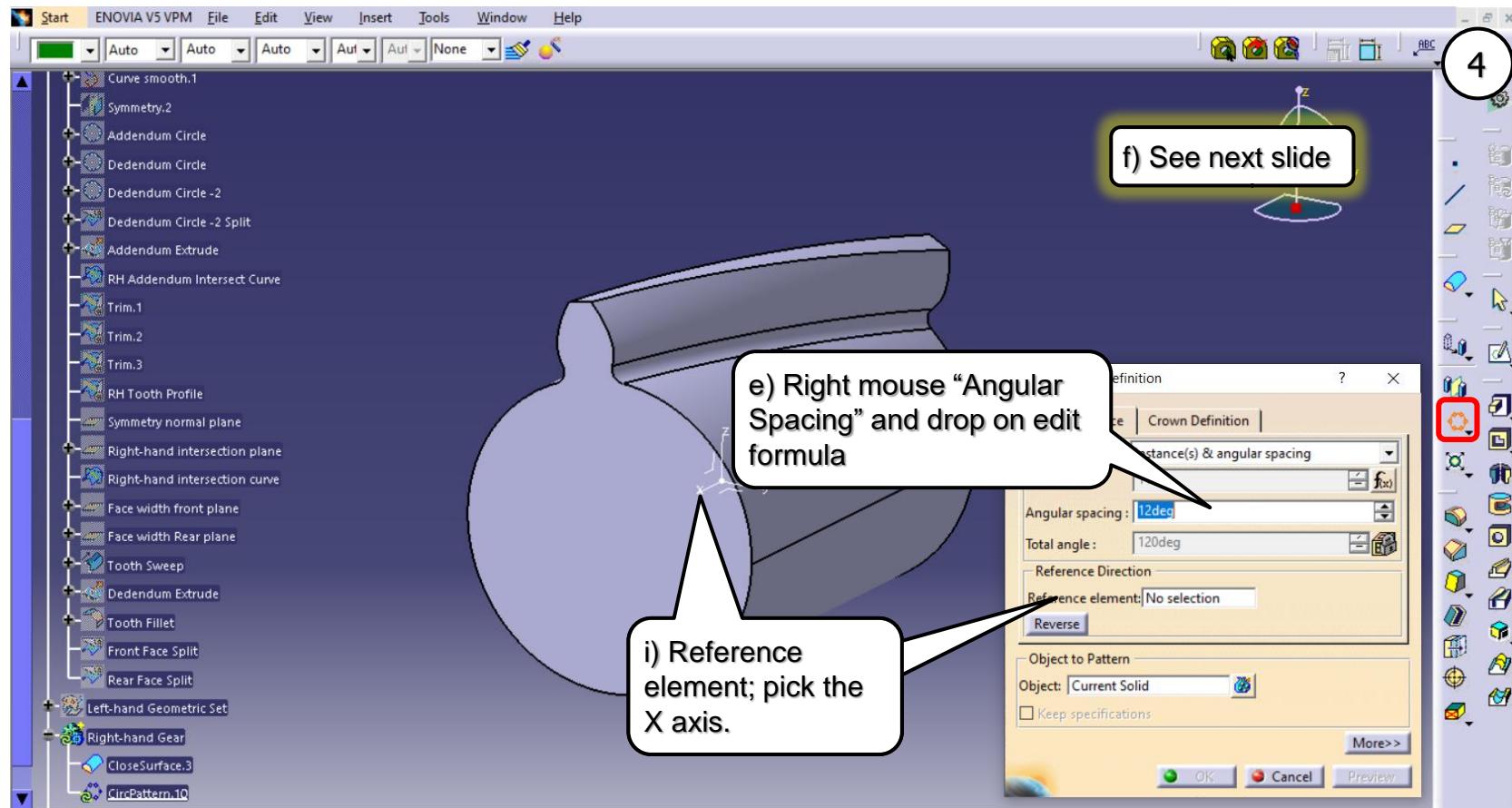


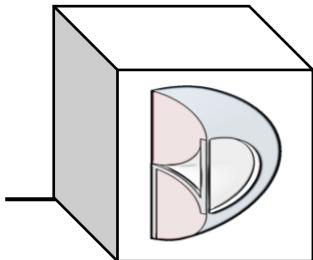


# BND TechSource



- Create the pattern for the number of teeth.

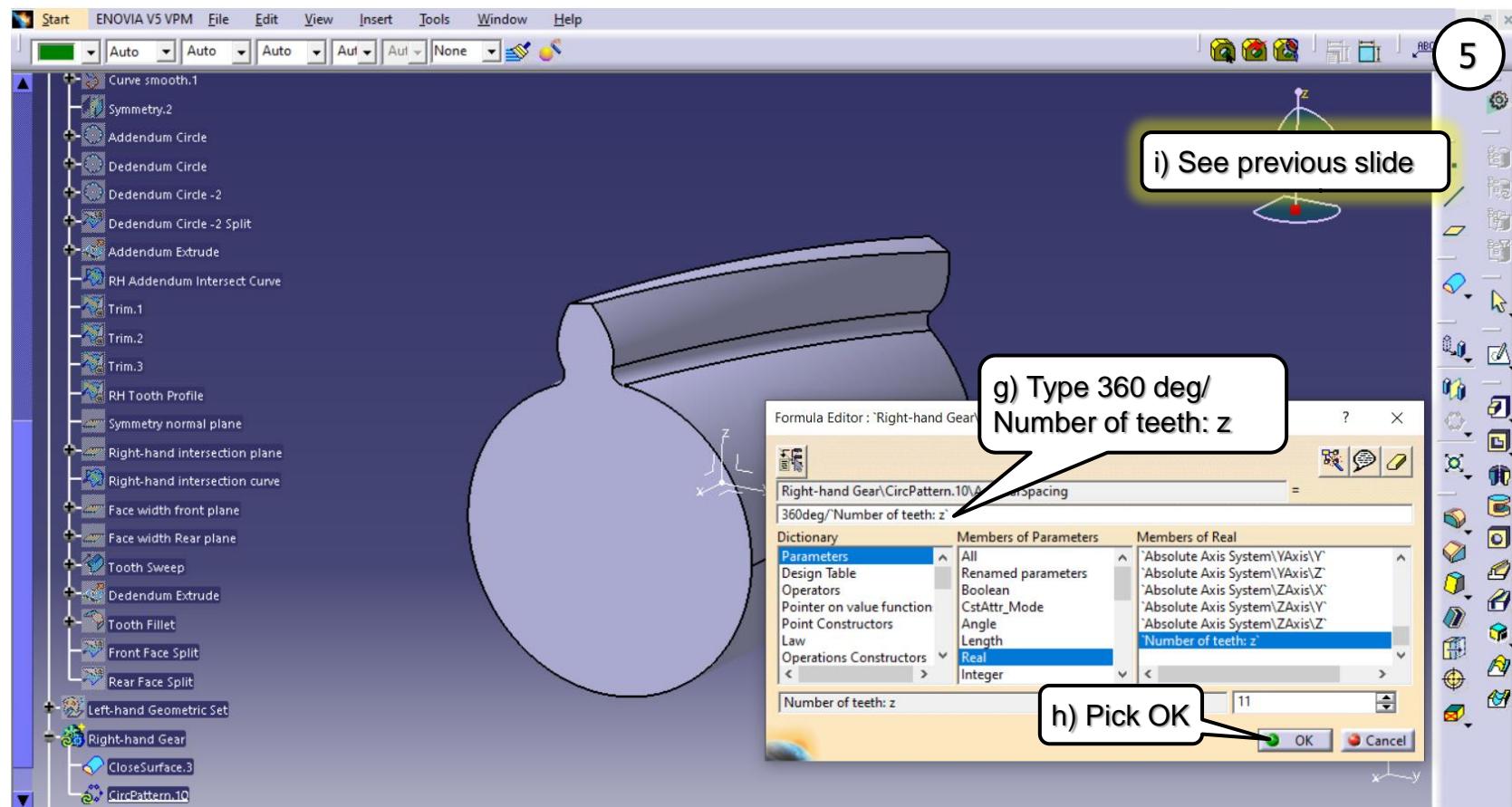


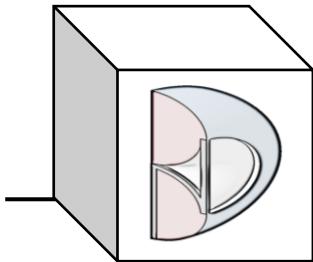


# BND TechSource



- Create the pattern for the number of teeth.

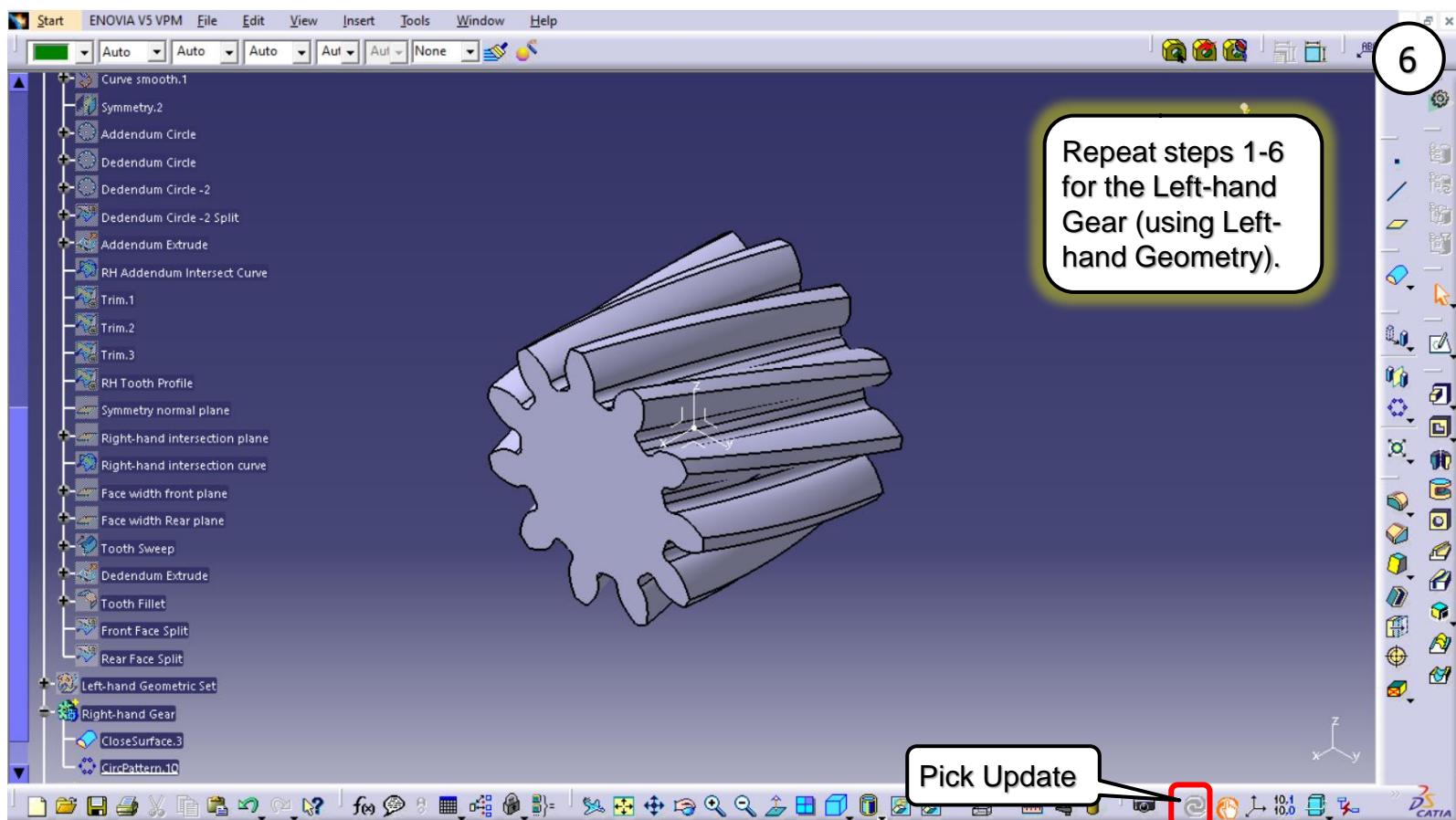


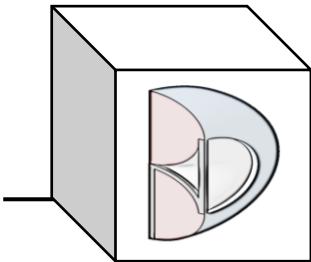


# BND TechSource



- And there you have it! A Normal Involute Helical Gear which is modifiable through parameters.





# BND TechSource



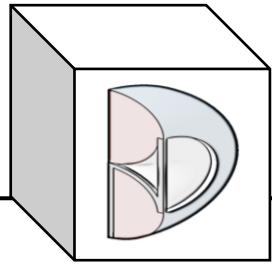
- Modify parameters for Number of teeth: z to 30 and check the results.

a) Modify  $z = 30$

Parameters [...] (6)

- Face width:  $F_w = 100\text{mm}$
- Module:  $m = 8\text{mm}$
- Number of teeth:  $z = 30$**
- Normal Pressure Angle:  $Npa = 20\text{deg}$
- Cylinder helix angle:  $Ca = 8\text{deg}$
- Transverse pressure angle:  $Tpa = 20.181\text{deg} = \text{atan}(\tan(\text{Normal Pressure Angle: } Npa) / \cos(\text{Cylinder helix angle: } Ca))$
- Symmetry angle:  $\beta = 3\text{deg} = 90\text{deg} / \text{Number of teeth: } z$
- Pitch diameter:  $Pd = 242.359\text{mm} = (\text{Number of teeth: } z * \text{Module: } m) / \cos(\text{Cylinder helix angle: } Ca * \text{1rad})$
- Base diameter:  $Bd = 227.48\text{mm} = \text{Pitch diameter: } Pd * \cos(\text{Transverse pressure angle: } Tpa * \text{1rad})$
- Addendum diameter:  $A_d = 258.359\text{mm} = \text{Pitch diameter: } Pd + (2 * \text{Module: } m)$
- Dedendum diameter:  $D_d = 222.359\text{mm} = \text{Pitch diameter: } Pd - (2.5 * \text{Module: } m)$
- Tooth radius at dedendum circle:  $r_t = 3\text{mm} = 0.375 * \text{Module: } m$

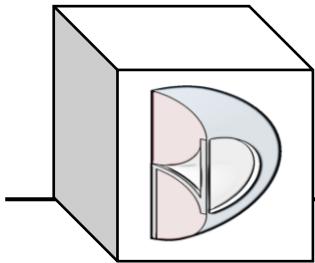
c) Pick Update



# BND TechSource



## Undercutting

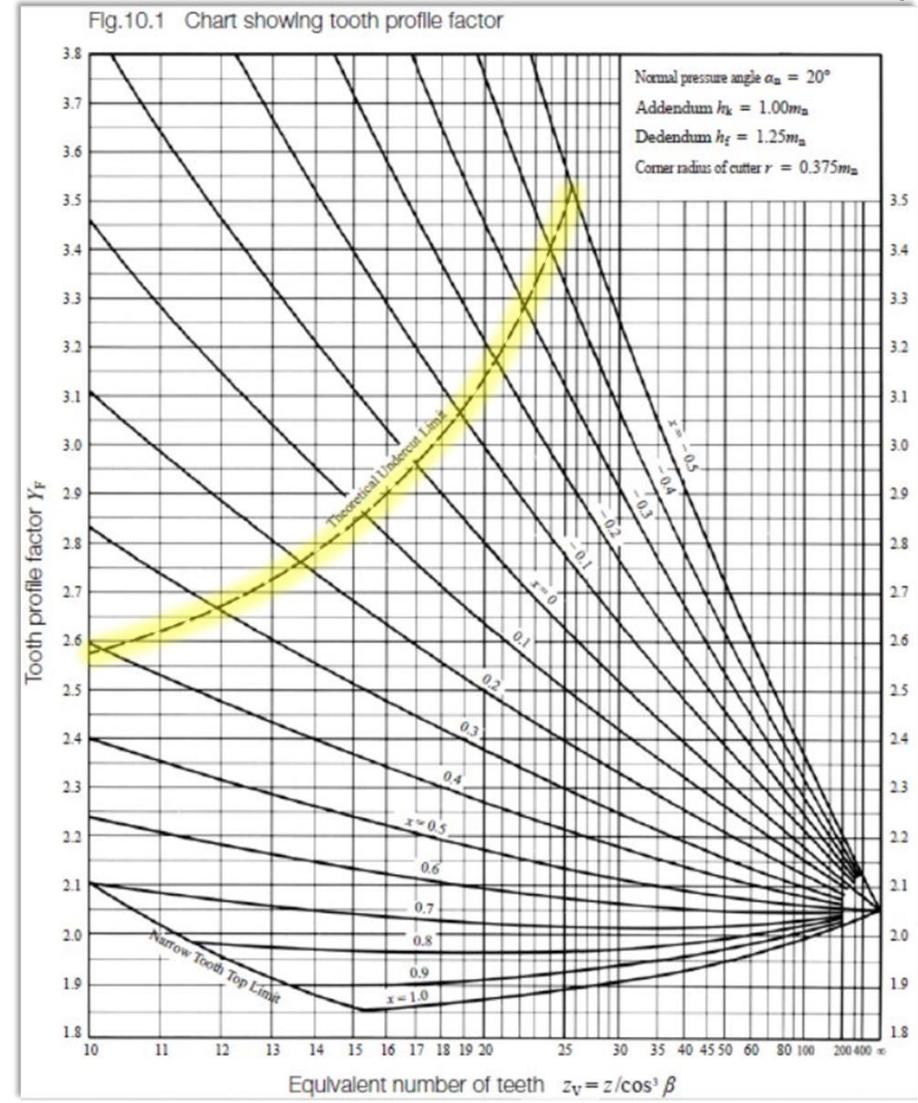
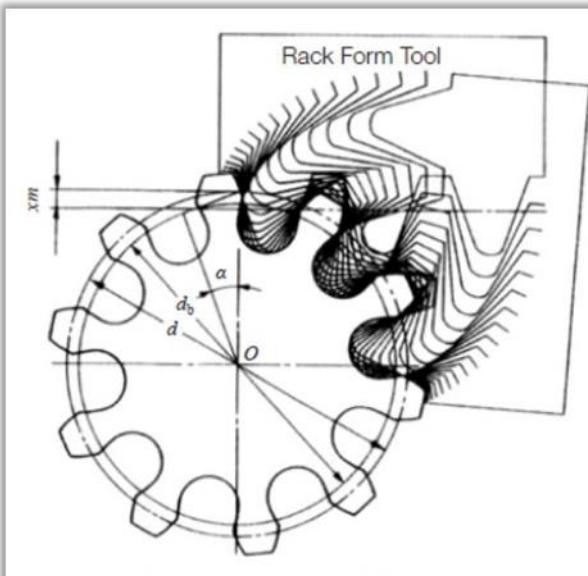


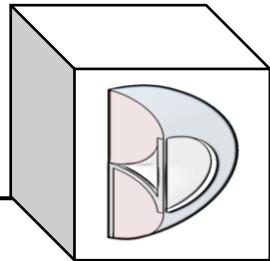
# BND TechSource



## UNDERCUTTING

Undercutting occurs geometrically when the standard formulae allow for the dedendum circle to fall too far below the base circle. This can be rectified by adjusting both the addendum and dedendum circles.



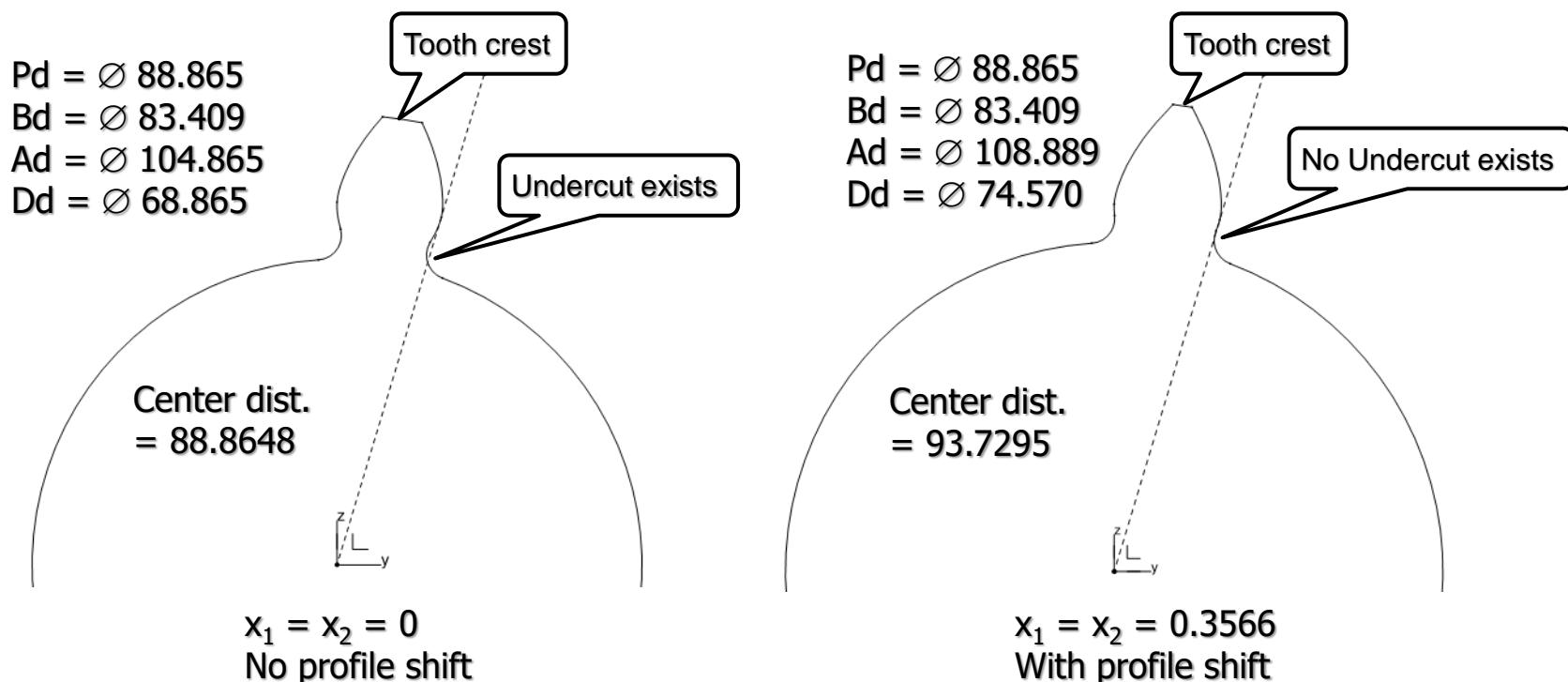


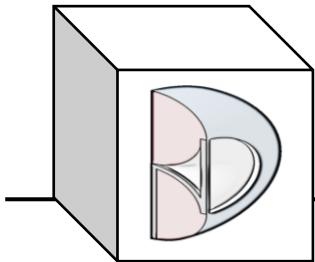
# BND TechSource

## PROFILE SHIFT



- Profile shift ( $x$ ) is not merely used to prevent undercut, it can also be used to adjust the center distance between two gears.
- If a positive correction is applied (addendum and dedendum circles increased) to prevent undercut in a gear, the tooth crest is sharpened.



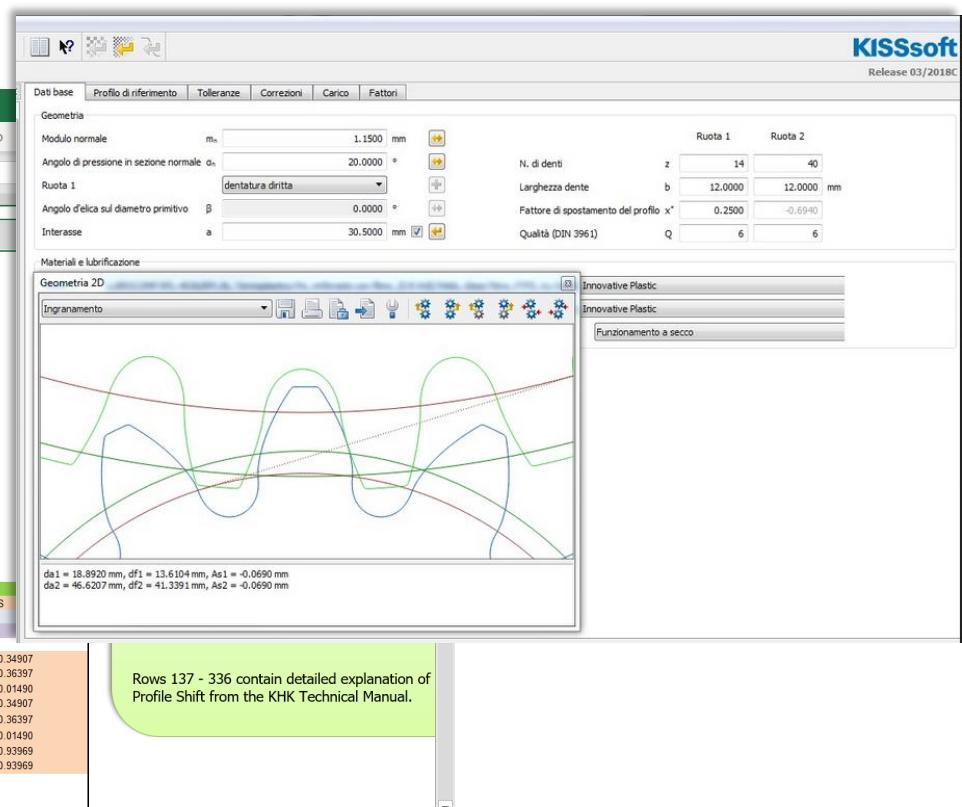
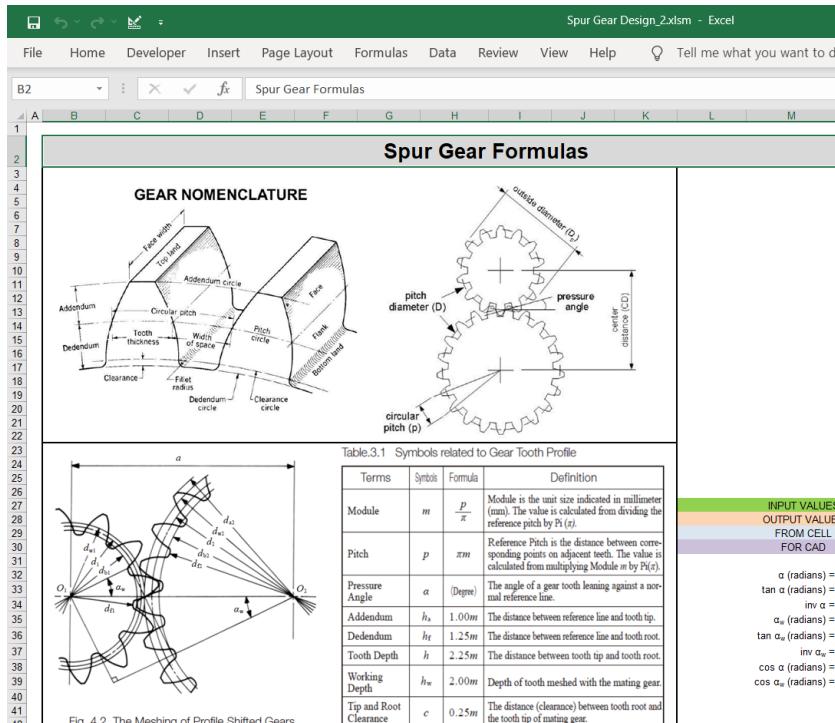


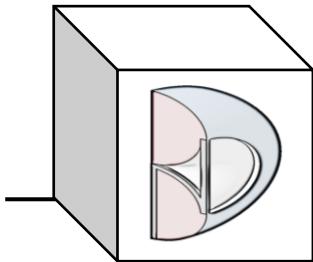
# BND TechSource

## PROFILE SHIFT



- By using a gear calculator (i.e. MS Excel) or a gear simulation software (i.e. KISSsoft) users can get the required values to optimize their design beyond the basic standard formulae we have used thus far.





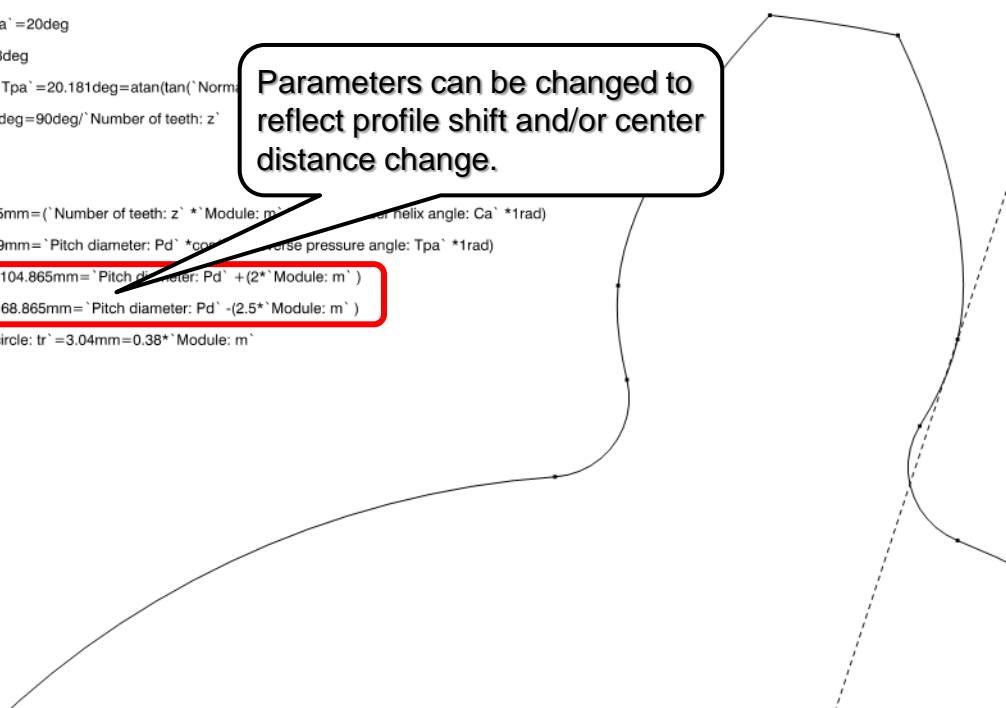
# BND TechSource



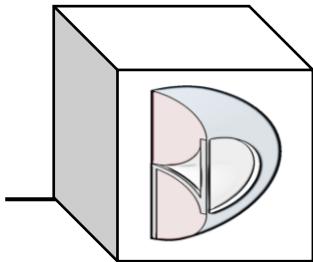
- Parameters for Ad & Dd from standard formulae (no profile shift).

Parameters [...] (6)	
'Number of teeth:	$z = 11$
'Normal Pressure Angle:	$Npa = 20\text{deg}$
'Cylinder helix angle:	$Ca = 8\text{deg}$
'Transverse pressure angle:	$Tpa = 20.181\text{deg} = \text{atan}(\tan('Normal Pressure Angle') * \cos('Cylinder helix angle'))$
'Symmetry angle:	$s = 8.182\text{deg} = 90\text{deg} / \text{Number of teeth: } z$
'Face width:	$Fw = 100\text{mm}$
'Module:	$m = 8\text{mm}$
'Pitch diameter:	$Pd = 88.865\text{mm} = ('Number of teeth: } z * \text{Module: } m)$
'Base diameter:	$Bd = 83.409\text{mm} = \text{Pitch diameter: } Pd * \cos('Transverse pressure angle: Tpa) * 1\text{rad}$
'Addendum diameter:	$Ad = 104.865\text{mm} = \text{Pitch diameter: } Pd + (2 * \text{Module: } m)$
'Dedendum diameter:	$Dd = 68.865\text{mm} = \text{Pitch diameter: } Pd - (2.5 * \text{Module: } m)$
'tooth radius at dedendum circle:	$tr = 3.04\text{mm} = 0.38 * \text{Module: } m$
Relations	
Geometrical Set.1	
Body.2	
PartBody	

Parameters can be changed to reflect profile shift and/or center distance change.



	Gear 1	Gear 2
$Fw =$	100	
$m_n =$	8	
$\alpha_n =$	20	degrees
$\alpha_n =$	0.3491	radians
$\beta =$	8	
$z =$	11	11
$x_n =$	0.00000	0.00000
(.)	20.18076	
$d_w =$	88.865	88.865
$h_a =$	8.000	8.000
$h =$	18.000	
$d_a =$	104.865	104.865
$d_f =$	68.865	68.865
$Fw =$	100.000	100.000
$m =$	8	8
$z =$	11	11
$Npa =$	20	20
$Ca =$	8	8
$Tpa =$	20.181	20.181
$s =$	8.182	8.182
$Pd =$	88.865	88.865
$Bd =$	83.409	83.409
$Ad =$	104.865	104.865
$Dd =$	68.865	68.865
$tr =$	3.040	3.040
$a =$	88.8648	(88.865)



# BND TechSource



- Parameters for Ad & Dd from updated formulae (with profile shift).

Parameters can be changed to reflect profile shift and/or center distance change.

**Parameters [..] (6)**

- 'Number of teeth: z' = 11
- 'Normal Pressure Angle: Npa' = 20deg
- 'Cylinder helix angle: Ca' = 8deg
- 'Transverse pressure angle: Tpa' = 20.181deg = atan(tan('Normal Pressure Angle: Npa') / tan('Cylinder helix angle: Ca'))
- 'Symmetry angle: s' = 8.182deg = 90deg / 'Number of teeth: z'
- 'Face width: Fw' = 100mm
- 'Module: m' = 8mm
- 'Pitch diameter: Pd' = 88.865mm = ('Number of teeth: z' \* 'Module: m')
- 'Base diameter: Bd' = 83.409mm = 'Pitch diameter: Pd' \* cos('Cylinder helix angle: Ca' \* 1rad)
- 'Addendum diameter: Ad' = 108.889mm
- 'Dedendum diameter: Dd' = 74.57mm
- 'tooth radius at dedendum circle: tr' = 3.04mm = 0.38 \* 'Module: m'

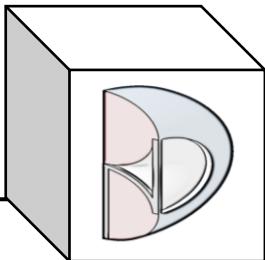
**Relations**

**Geometrical Set.1**

**Body.2**

**PartBody**

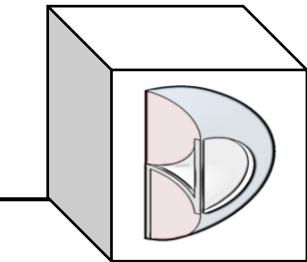
	Gear 1	Gear 2
Fw =	100	
m <sub>n</sub> =	8	
$\alpha_n$ =	20	degrees
$\alpha_n$ =	0.3491	radians
$\beta$ =	8	
z =	11	11
x <sub>n</sub> =	0.35660 (.3566)	0.35660
$\alpha_t$ =	20.18076	
d <sub>w</sub> =	93.730	93.730
h <sub>a</sub> =	10.012	10.012
h =	17.159	
d <sub>a</sub> =	108.889	108.889
d <sub>f</sub> =	74.570	74.570
Fw =	100.000	100.000
m =	8	8
z =	11	11
Npa =	20	20
Ca =	8	8
Tpa =	20.181	20.181
s =	8.182	8.182
Pd =	88.865	88.865
Bd =	83.409	83.409
Ad =	108.889	108.889
Dd =	74.570	74.570
tr =	3.040	3.040
a =	93.7295 (88.865)	



# BND TechSource



- We now have a “template” part for our Normal Involute Helical Gear.
- This part may be modified by simply changing the parameters of any/all of the following five formulae:
  1. Fw - Face width // length parameter [Fw = input]
  2. z - number of teeth // real parameter [z = input]
  3. Npa - Normal Pressure Angle // angle parameter [Npa = input]
  4. m - module // length parameter [m = input]
  5. Ca - Cylinder helix angle // angle parameter [Ca = input]
- Please comment or contact us if you would be interested in seeing how to create the Helical gears with a CATIA Macro.



- Conclusion:

This is an example of designing a Normal Involute Helical Gear in CATIA V5 (manual input).

We hope this will help those who need this type of simulation.

As always, we are open to any discussions this may bring.

Please **subscribe** to our YouTube channel!

