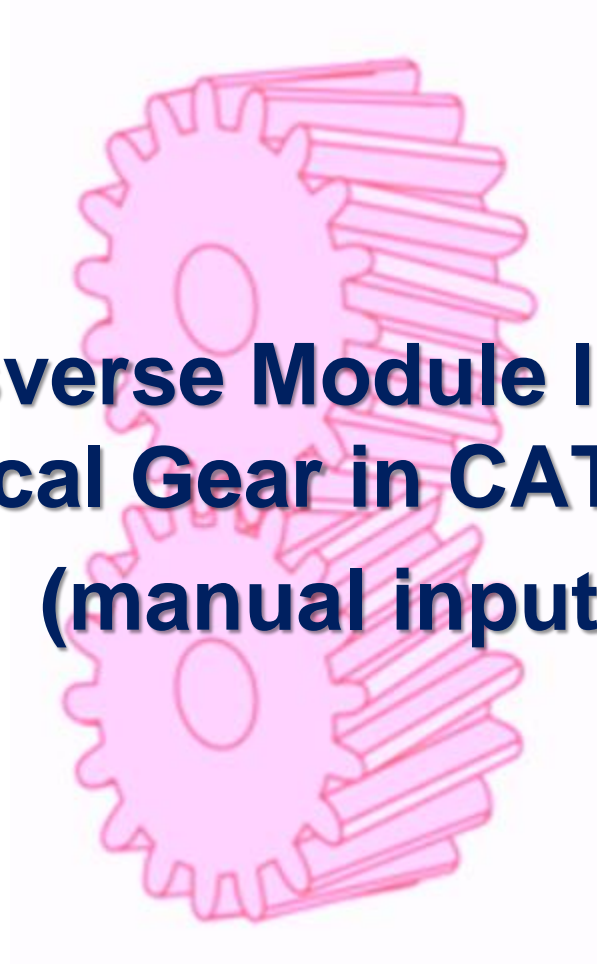
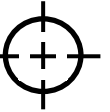
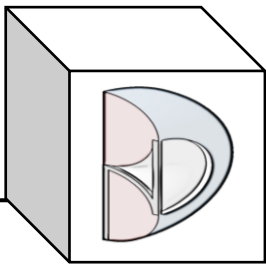


Transverse Module Involute Helical Gear in CATIA V5 (manual input)

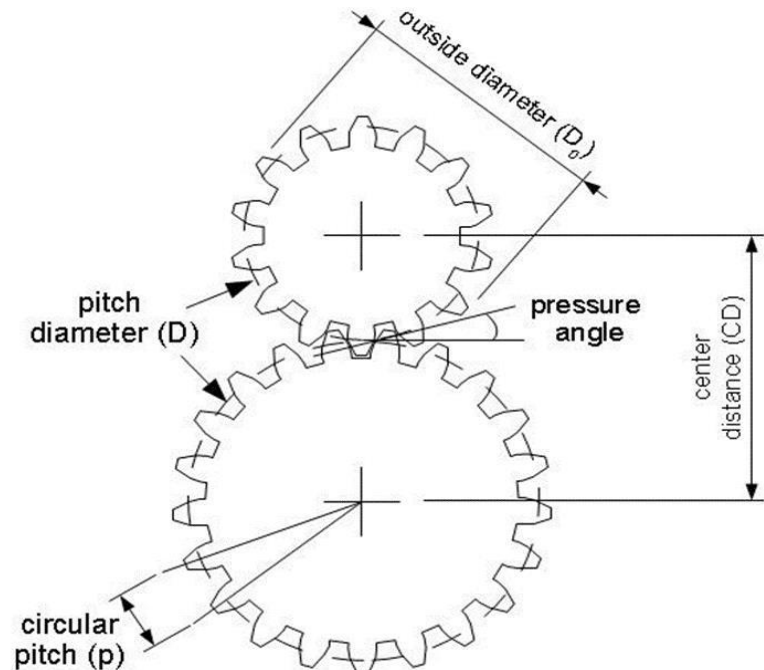
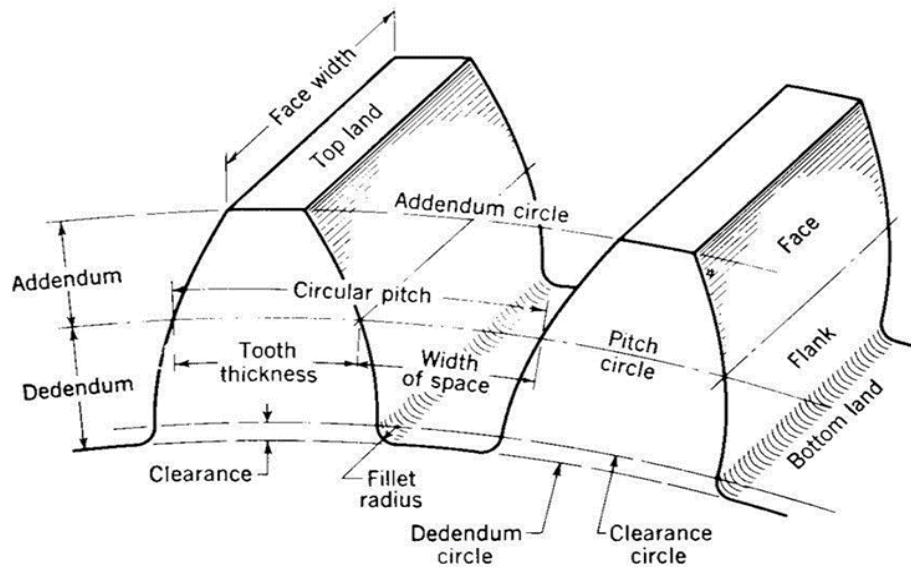


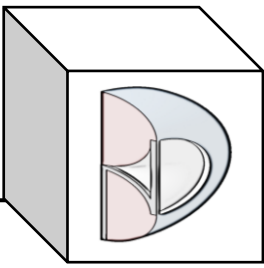


TRANSVERSE MODULE INVOLUTE HELICAL GEAR

- 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



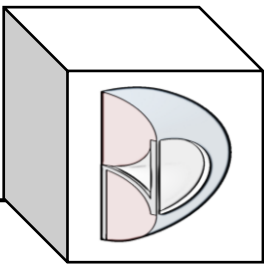


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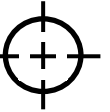


TRANSVERSE MODULE INVOLUTE HELICAL GEAR

- 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.



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TRANSVERSE 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.

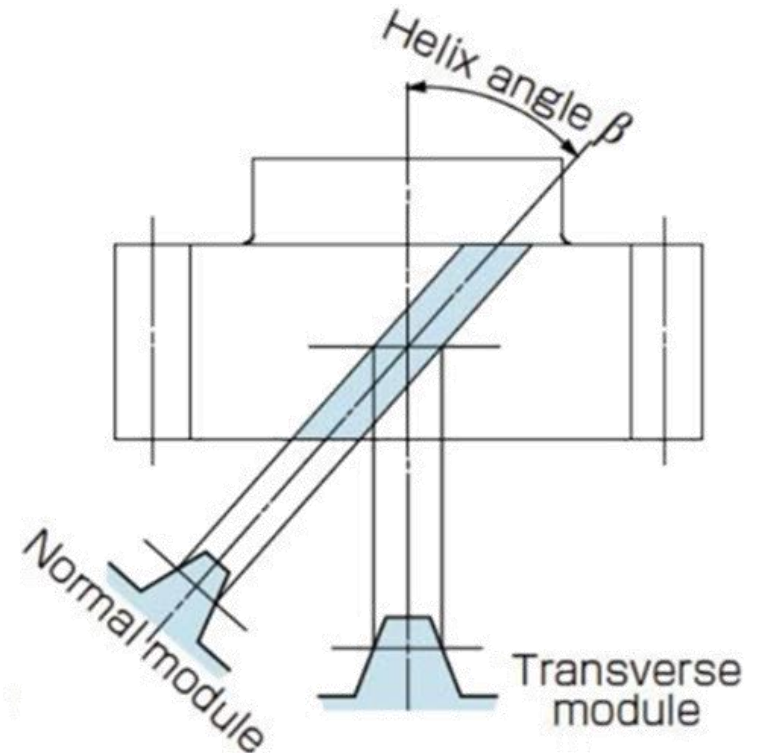
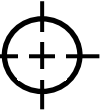
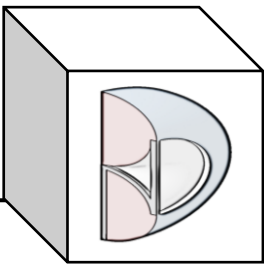
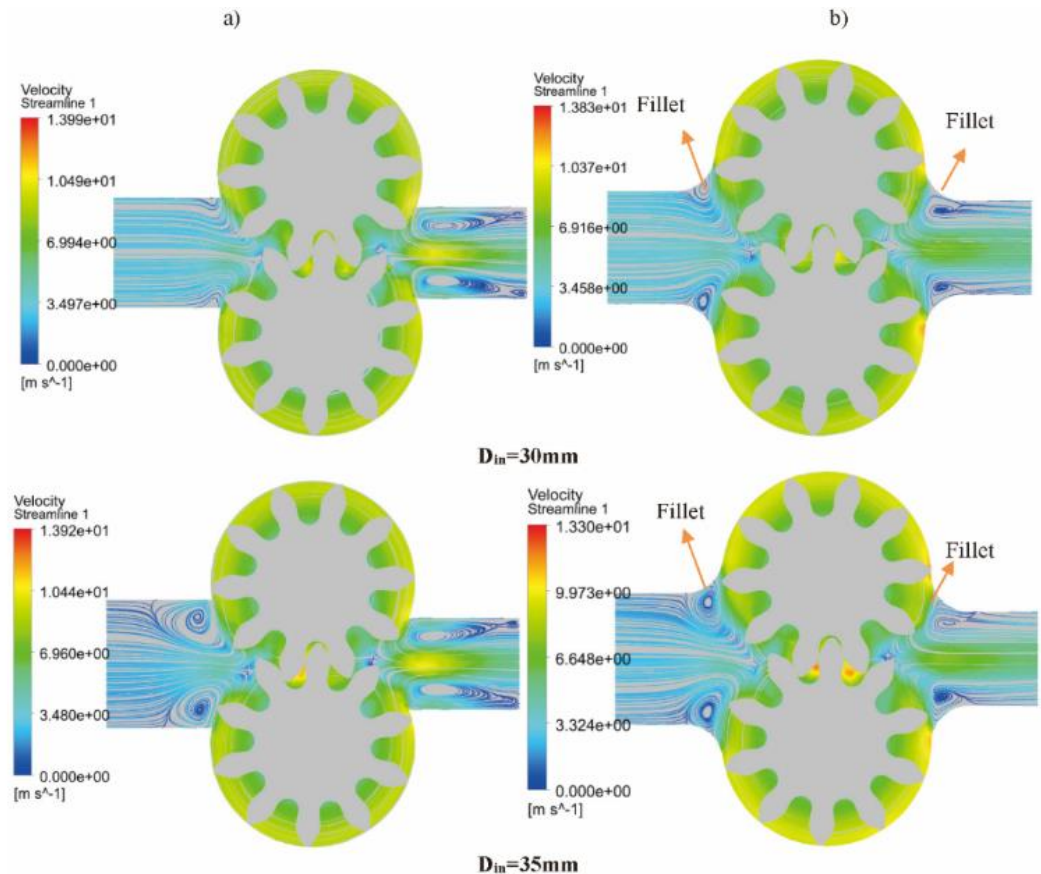


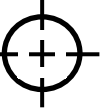
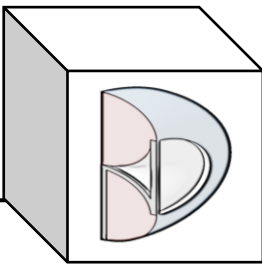
Fig. 2.9 Right-handed Helical Gear



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

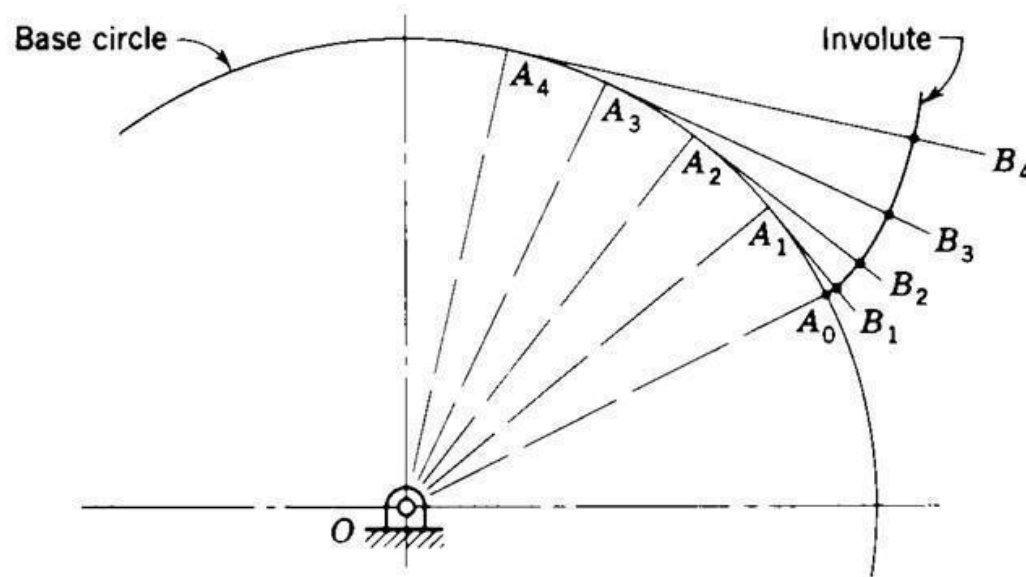
A: CFD (Computational Fluid Dynamics). Take for example an external, positive displacement oil pump with helical gears. For CFD to accurately simulate the flow of the pump, the gears must be modeled as they will be manufactured.

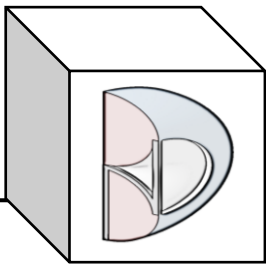




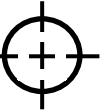
MODELLING AN INVOLUTE

- 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.



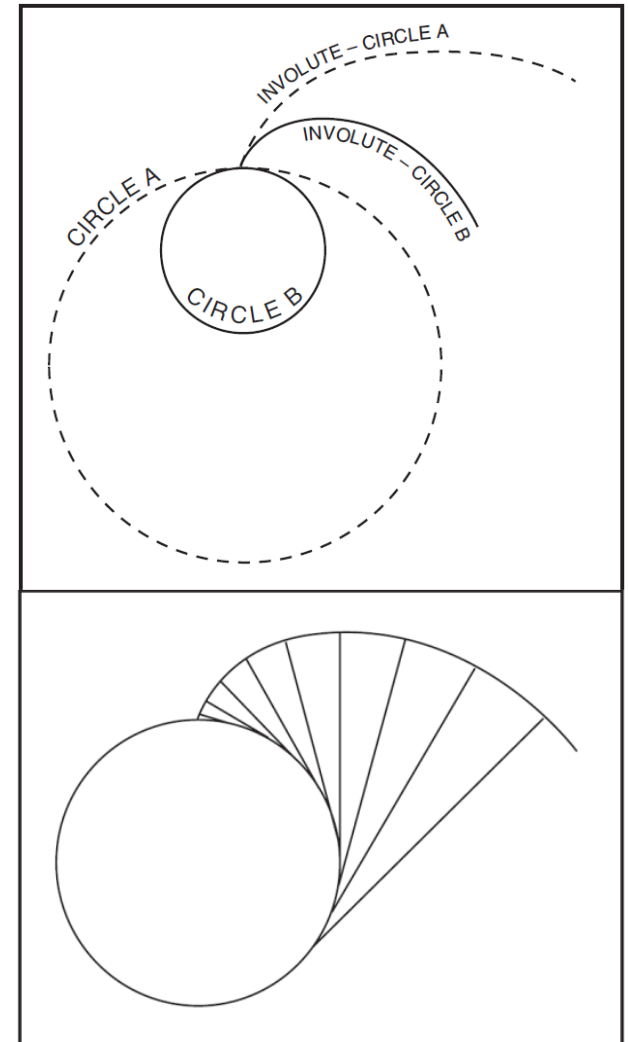


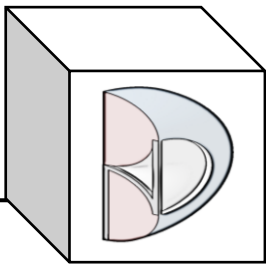
BND TechSource



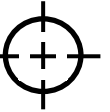
HELICAL GEARS INVOLUTE FORM

- 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.





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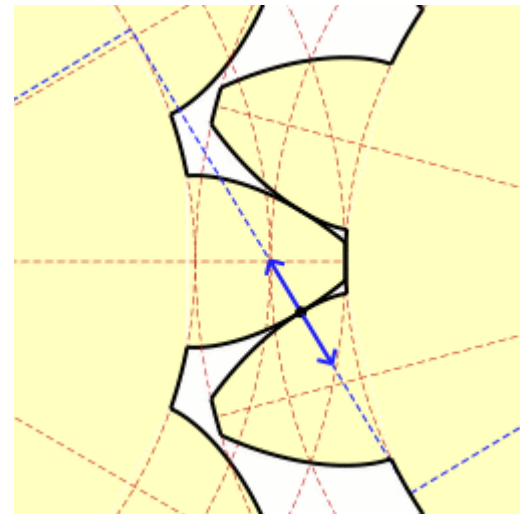


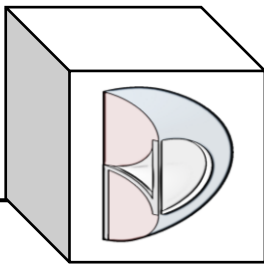
HELICAL GEARS INVOLUTE FORM

- 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.





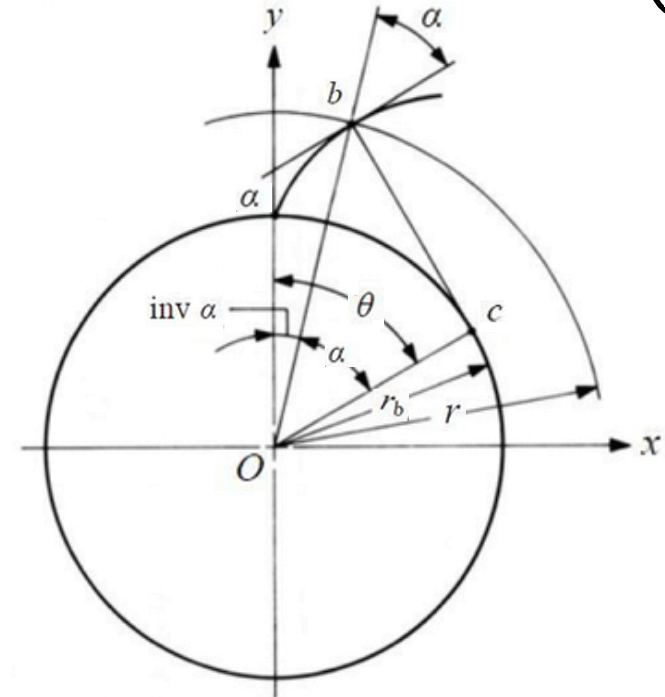
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HELICAL GEARS INVOLUTE FORM



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.

$\text{inv } \alpha$ stands for Involute Angle (Involute α). The units for $\text{inv } \alpha$ is radians. θ is called involute rolling angle.



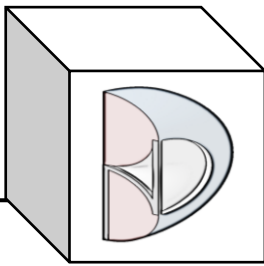
$$\text{inv } \alpha = \tan \alpha - \alpha \quad (\text{radians})$$

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:

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

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

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



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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]

Tpa –Transverse pressure angle // angle parameter [Tpa = 20 deg]

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

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

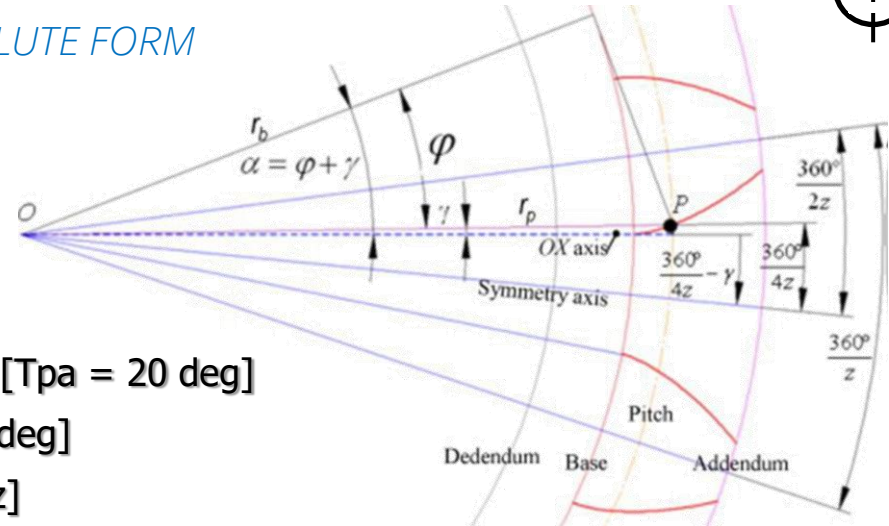
Pd -Pitch diameter // length parameter [Pd = z * m]

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 = 0.38*m]



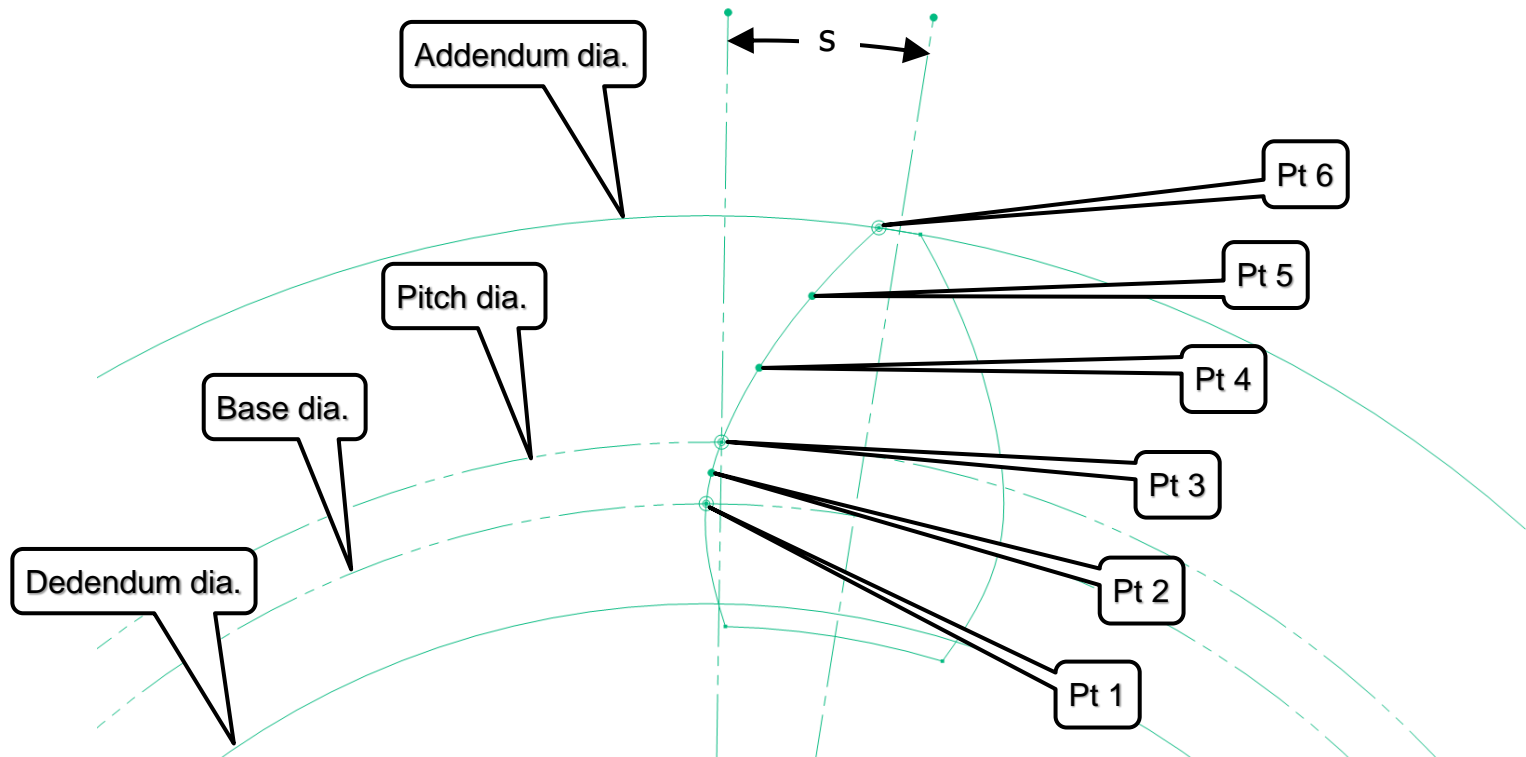
The parametric equations for involute curve points in CATIA:

$$x = r * \sin((\tan(\arccos(r(Pt1)/r)) - (\arccos(r(Pt1)/r))))$$

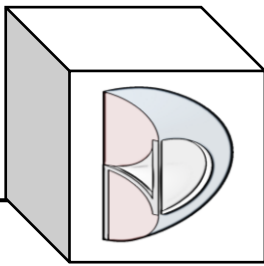
$$y = r * \cos((\tan(\arccos(r(Pt1)/r)) - (\arccos(r(Pt1)/r))))$$

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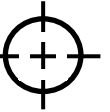
HELICAL GEAR TOOTH INVOLUTE POINTS



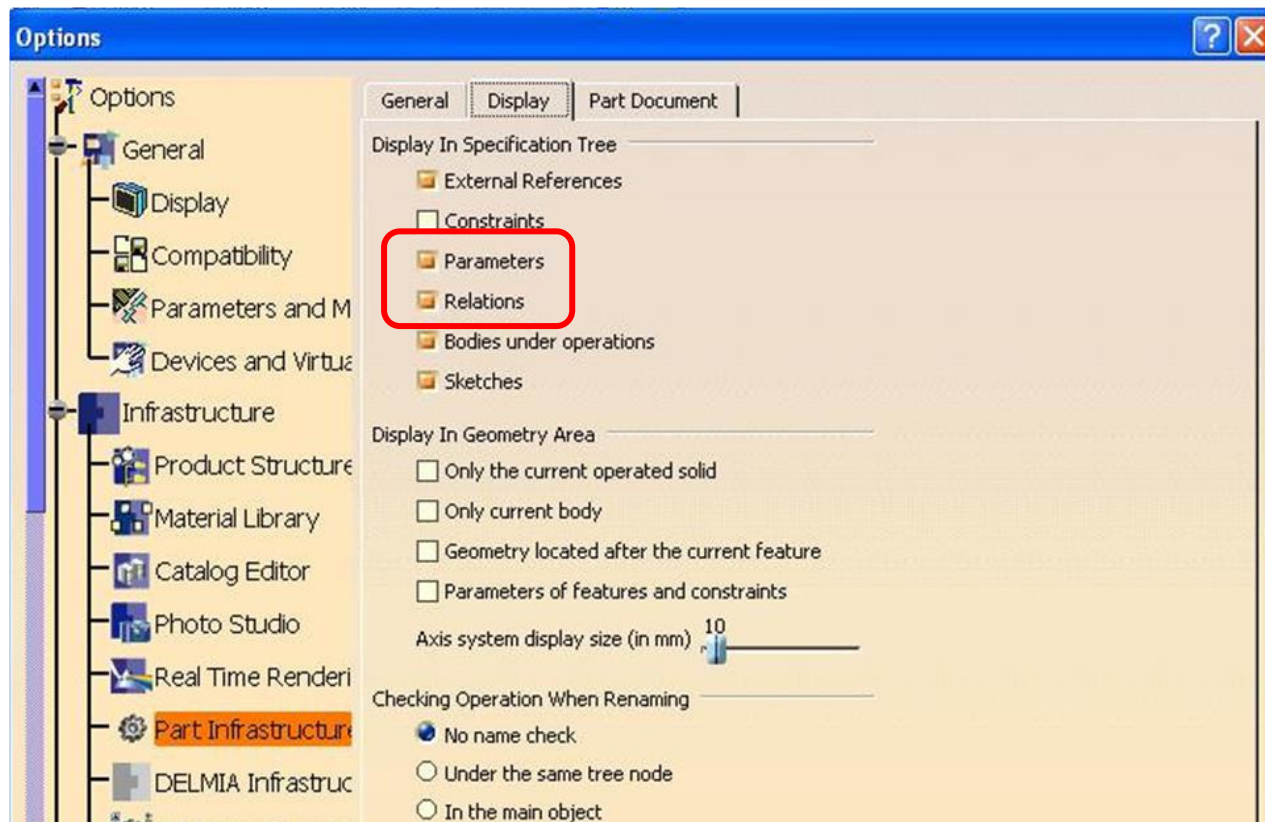
Point	r (formula)	r (mm)	α (radians)	inv α (radians)	x (mm)	y (mm)
Pt 1	[Base] Br	41.346	0.0000	0.0000	0.000	41.346
Pt 2	(Pr+Br)/2	42.673	0.2500	0.0053	0.228	42.673
Pt 3	[Pitch] Pr	44.000	0.3491	0.0149	0.656	43.995
Pt 4	Pr+(Ar-Pr)*.33333	46.667	0.4822	0.0412	1.922	46.627
Pt 5	Pr+(Ar-Pr)*.66667	49.333	0.5770	0.0739	3.642	49.199
Pt 6	[Addendum] Ar	52.000	0.6516	0.1111	5.766	51.679

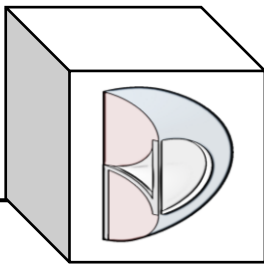


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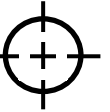


- When you start CATIA, go to TOOLS->OPTIONS->Infrastructure->
- Part Infrastructure and in Display select “Parameters” and “Relations”.

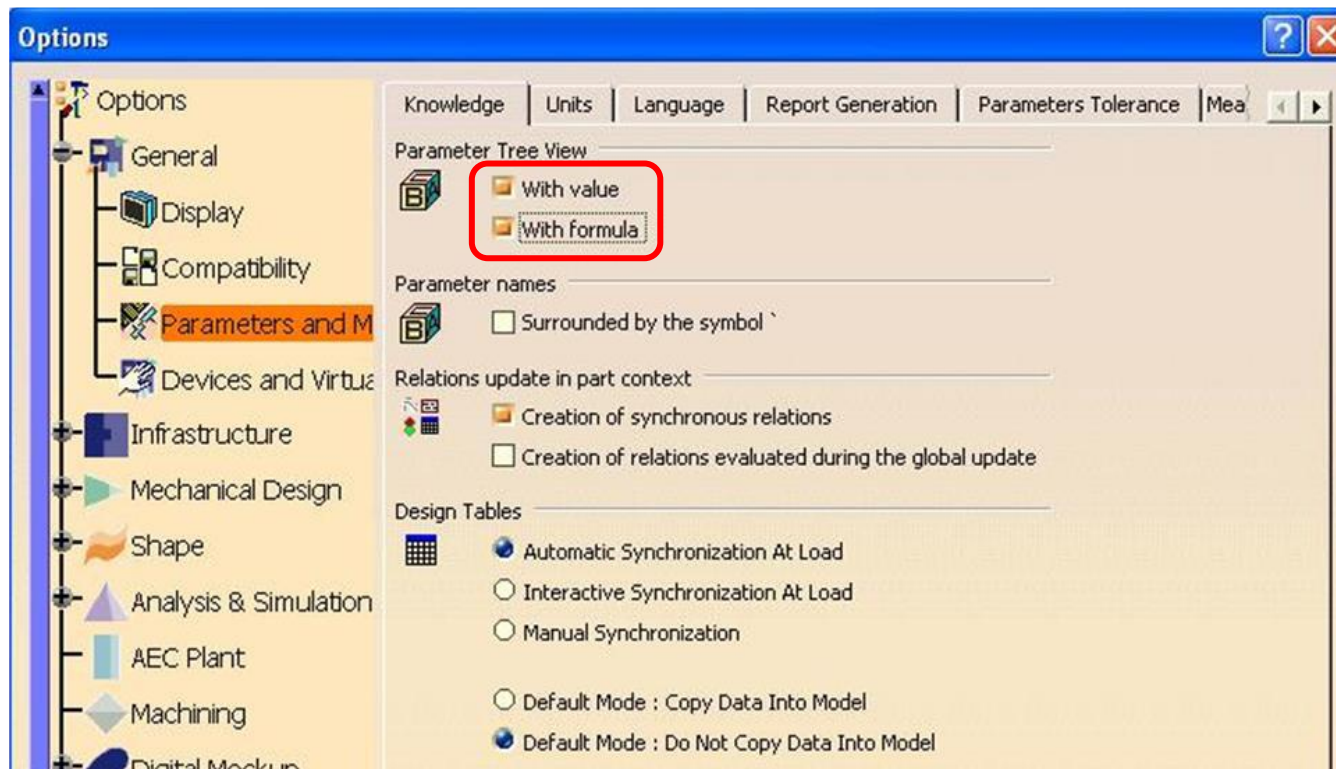


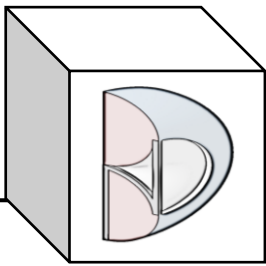


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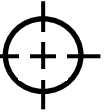


- Then in Options->General in Parameters and Measures select “With Value” and “With Formula” in Parameters Tree View.



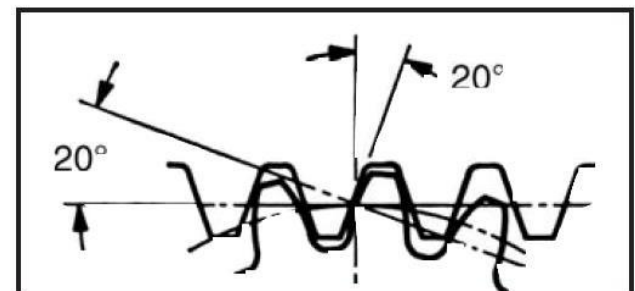
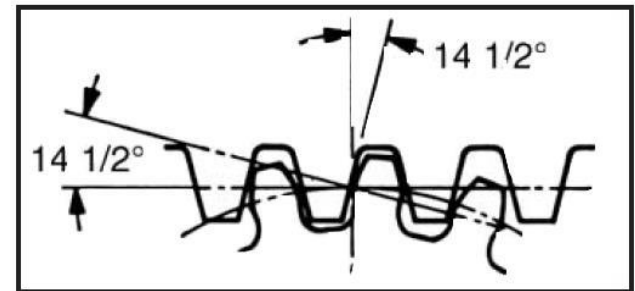


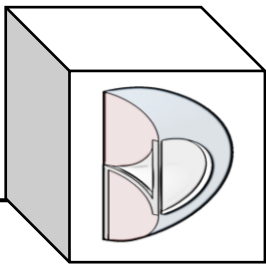
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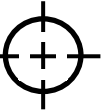
PRESSURE ANGLE

- 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° . While 20° 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.



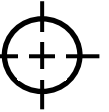
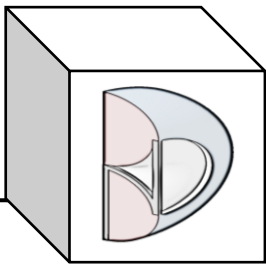


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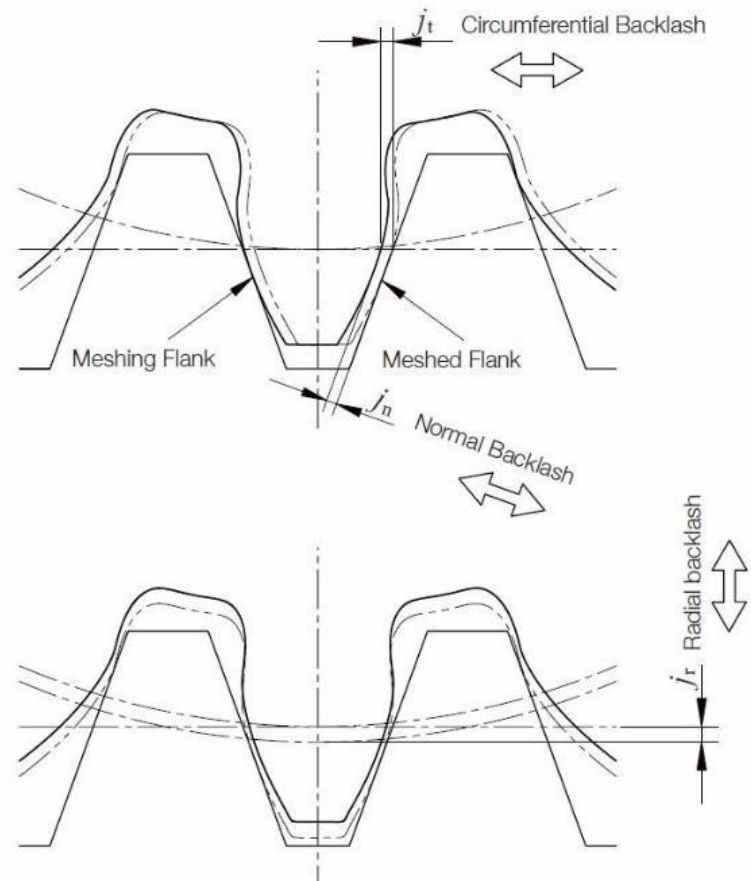
BACKLASH

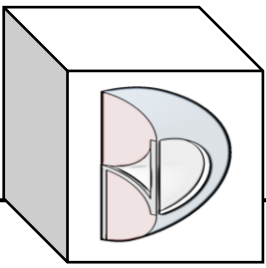
- Backlash, a clearance between mating gear teeth, is built into speed reducers to let the gears mesh without binding and to provide space for a film of lubricating oil between the teeth. This prevents overheating and tooth damage.
- For smooth rotation of meshed gears, backlash is necessary. Backlash 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_θ) – 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.



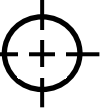
BACKLASH

- Circumferential Backlash
- Normal Backlash
- Radial Backlash

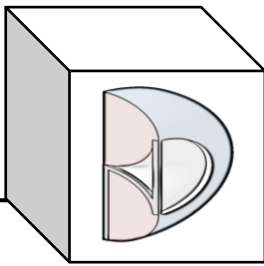




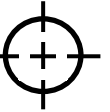
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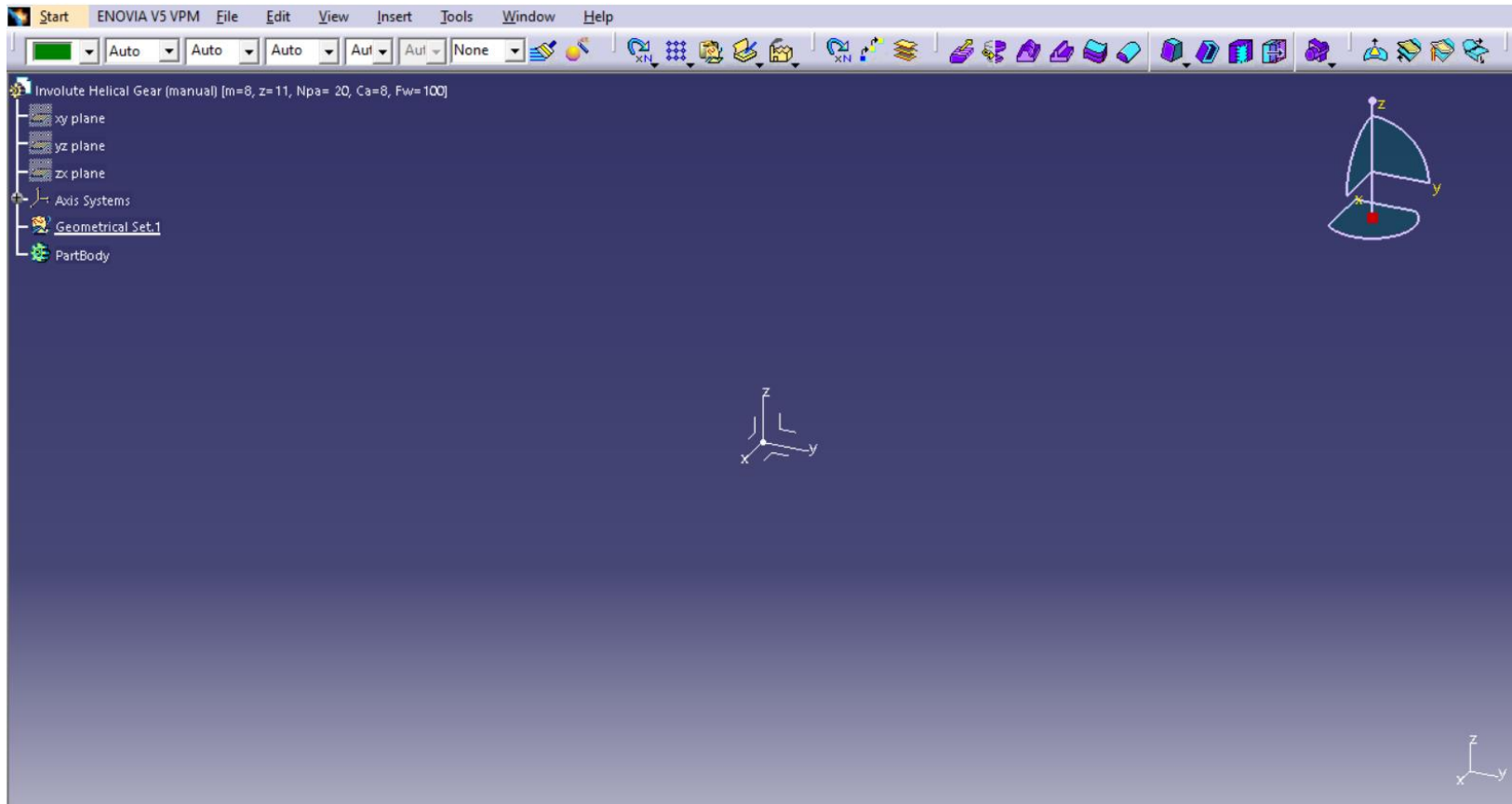
Create the Parameters

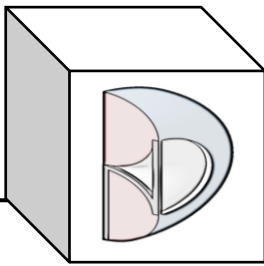


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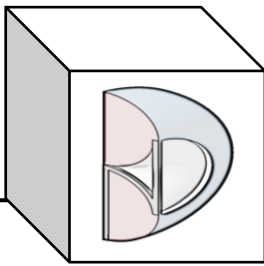
- Open a new CATPart and give it the name: Transverse Involute Helical Gear [Fw=100, m=8, z=11, Tpa=20, Ca=8]



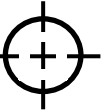


- Create the following Eleven formulae:
 - Known:
 - Fw // length parameter [**Face width: Fw** = 100mm]
 - m // length parameter [**Module: m** = 8mm]
 - z // real parameter [**Number of teeth: z** = 11]
 - Tpa // angle parameter [**Transverse pressure angle: Tpa** = 20 deg]
 - Ca // angle parameter [**Cylinder helix angle: Ca** = 8deg]
 - Resultant:
 - s // angle parameter [**Symmetry angle: s** = 90deg/z]
 - Pd // length parameter [**Pitch diameter: Pd** = $z \cdot m$]
 - Bd // length parameter [**Base diameter: Bd** = $Pd \cdot \cos(Tpa \cdot 1\text{rad})$]
 - Ad // length parameter [**Addendum diameter: Ad** = $Pd + (2 \cdot m)$]
 - Dd // length parameter [**Dedendum diameter: Dd** = $Pd - (2.5 \cdot m)$]
 - tr // length parameter [**tooth radius at dedendum circle: tr** = $0.38 \cdot m$]

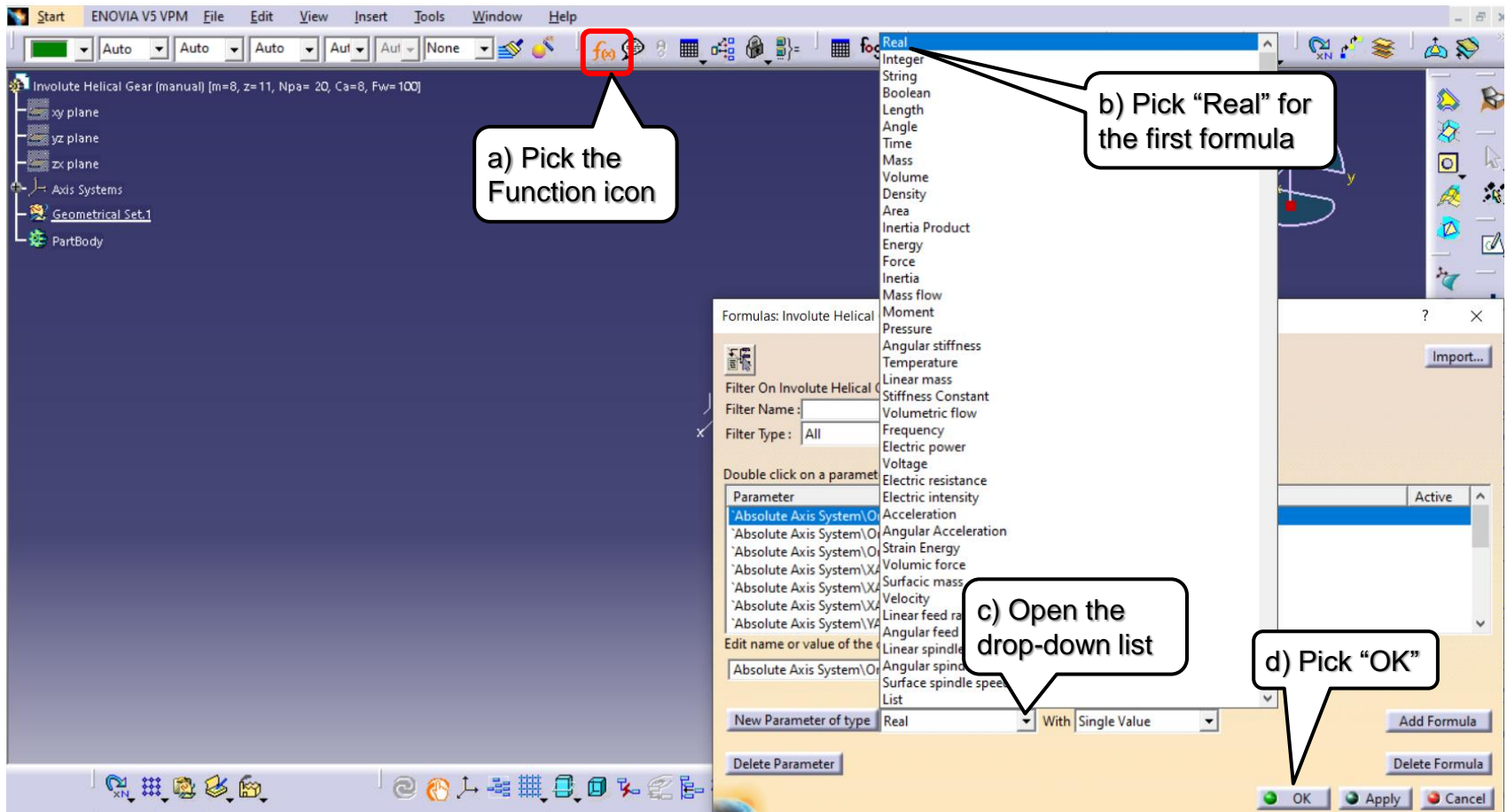
CATIA sees a diametral dimension as a radius. Even though the dimension displays as a diameter.

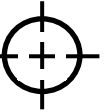
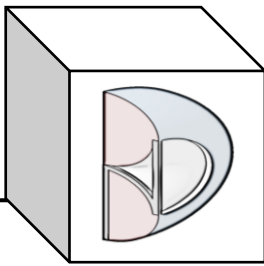


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- Open the Formulas window





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

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

Auto Auto Auto Aut Aut None

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

xy plane
yz plane
zx plane
Axis Systems
Parameters
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
'Absolute Axis System'\Activity	true		
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...	Involute		
'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...			
'Number of teeth: z'	11		

Edit name or value of the current parameter
Number of teeth: z 11

New Parameter of type Real With Single Value

Delete Parameter

a) Pick New Parameter

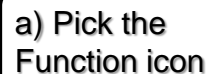
b) Type "Number of teeth: z" for the name

c) Set 11 for the number of teeth

d) Pick OK

OK Apply Cancel

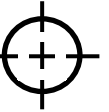
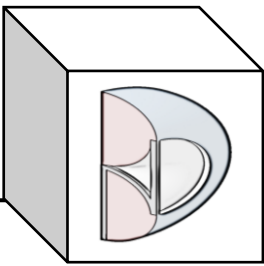
1



b) Pick "Angle" for the first formula

c) Open the drop-down list

d) Pick "OK"



2) Tpa // angle parameter [Transverse pressure angle: Tpa = 20 deg]

Formulas: Parameters

Filter On Parameters
Filter Name:
Filter Type: All

Import...

Parameter list

Parameter Name	Value	Formula	Active
100mm	100mm		
8mm	8mm		
30	30		
Transverse Pressure Angle: Tpa	20deg		

Edit name or value of the current parameter

Transverse Pressure Angle: Tpa 20deg

New Parameter of type Angle With Single Value

Delete Parameter

Add Formula

Delete Formula

OK Apply Cancel

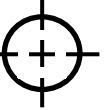
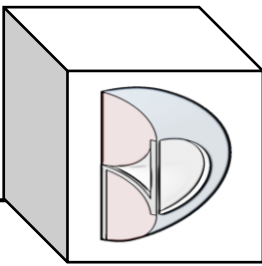
a) Pick New Parameter

b) Type "Transverse pressure angle: Tpa" for the name

c) Set 20 for the Normal Pressure Angle

d) Pick OK

2



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

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

Auto Auto Auto Auto Aut Aut None

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
 - Cylinder helix angle: Ca=8deg
- Geometrical Solids
- 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
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...	Involu		
'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		
'Cylinder helix angle: Ca'	8deg		

Edit name or value of the current parameter

Cylinder helix angle: Ca 8deg

New Parameter of type Angle With Single Value

Delete Parameter

OK Apply Cancel

Add Formula Delete Formula

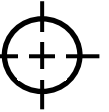
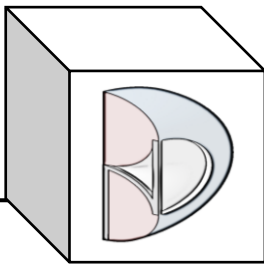
a) Pick New Parameter

b) Type "Cylinder helix angle: Ca" for the name

c) Set 8 for the Cylinder helix angle

d) Pick OK

3



4) s // angle parameter [**Symmetry angle: s** = 90deg/z]

d) Type 90deg/Number of teeth: z

b) Type "Symmetry angle: s" for the name

a) Pick New Parameter

c) Pick Add Formula

e) Pick OK

f) Pick Apply

4

Formula Editor: 'Symmetry angle: s'

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

Dictionary	Members of Parameters	Members of Real
Parameters	All	'Absolute Axis System\XAxis\Z'
Design Table	Renamed parameters	'Absolute Axis System\YAxis\X'
Operators	Length	'Absolute Axis System\YAxis\Y'
Pointer on value function	Real	'Absolute Axis System\YAxis\Z'
Point Constructors	Boolean	'Absolute Axis System\ZAxis\X'
Law	Angle	'Absolute Axis System\ZAxis\Y'
Operations Constructors	String	'Absolute Axis System\ZAxis\Z'
	Feature	Number of teeth: z

Number of teeth: z = 11

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

'Normal Pressure Angle: Npa' 20deg

'Cylinder helix angle: Ca' 8deg

'Transverse pressure angle: Tpa' 20.181deg

Angle.4 0deg

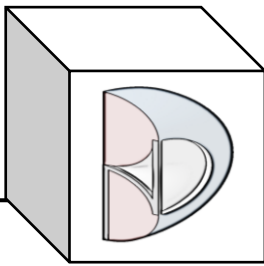
Edit name or value of the current parameter

Symmetry angle: s 0deg

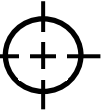
New Parameter of type Angle With Single Value

Delete Parameter

OK Apply Cancel

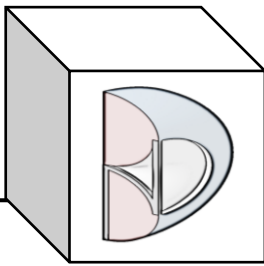


BND TechSource



- The next seven Parameters will be Length type.

The screenshot shows the ENOVIA V5 VPM software interface. The 'Formulas: Involute Helical' dialog box is open, displaying a list of parameters and their values. The 'Function' icon is highlighted with a red box, and a callout points to it with the text 'a) Pick the Function icon'. The 'Unit' dropdown is set to 'Length', and a callout points to it with the text 'b) Pick "Length" for the next seven formulae'. The 'OK' button is highlighted with a red box, and a callout points to it with the text 'c) Pick "OK"'. The dialog box also includes fields for 'Filter Name', 'Filter Type', and 'Double click on a parameter'.



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

ENOVIA V5 VPM

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
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=90/Number of teeth: z' *1 deg
Face width: Fw=100mm
Relations
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
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]			
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]			
'Normal Pressure Angle: Npa'	20deg		
'Cylinder helix angle: Ca'	8deg		
'Transverse pressure angle: Tpa'	20.181deg		yes
'Symmetry angle: s'	8.182deg		yes
'Face width: Fw'	100mm		

Edit name or value of the current parameter
Face width: Fw 100mm

New Parameter of type Length With Single Value

Delete Parameter

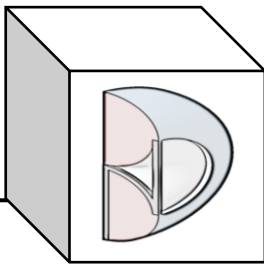
OK Apply Cancel

a) Pick New Parameter

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

c) Set 100mm for the face width

d) Pick OK



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

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

Auto Auto Auto Aut Aut None

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
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=90/Number of teeth: z *1 deg
Face width: Fw=100mm
Module: m=8mm
Relations
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
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw=100]			
'Normal Pressure Angle: Npa'	20deg		yes
'Cylinder helix angle: Ca'	8deg		yes
'Transverse pressure angle: Tpa'	20.181deg		
'Symmetry angle: s'	8.182deg		
'Face width: Fw'	100mm		
'Module: m'	8mm		

Edit name or value of the current parameter
Module: m 8mm

New Parameter of type Length With Single Value

Delete Parameter

OK Apply Cancel

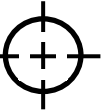
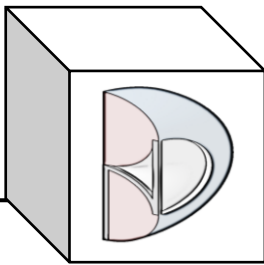
a) Pick New Parameter

b) Type "Module: m" for the name

c) Set 8mm for the module

d) Pick OK

6



7) Pd // length parameter [**Pitch diameter: Pd** = $(z \cdot m) / \cos(Ca \cdot 1 \text{ rad})$]

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

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

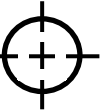
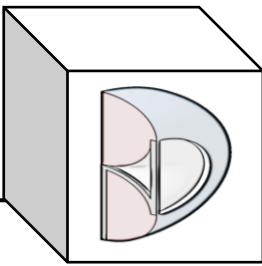
c) Pick Add Formula

e) Pick OK

f) Pick Apply

a) Pick New Parameter

7



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

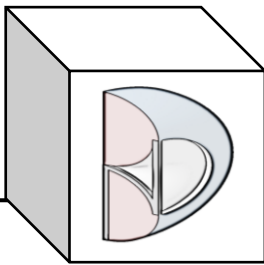
The screenshot shows the ENOVIA V5 VPM interface with the Formula Editor open for the parameter 'Base diameter: Bd'. The editor displays the formula: $\text{Base diameter: Bd} = \text{Pitch diameter: Pd} \cdot \cos(\text{Transverse pressure angle: Tpa} \cdot 1 \text{ rad})$. The 'Transverse pressure angle: Tpa' is set to 20.181deg. The 'Pitch diameter: Pd' is 88.865mm. The 'Base diameter: Bd' is currently 0mm.

Annotations on the screenshot:

- a) Pick New Parameter**: Points to the 'New Parameter of type' dropdown menu.
- b) Type "Base diameter: Bd" for the name**: Points to the text input field for the parameter name.
- c) Pick Add Formula**: Points to the 'Add Formula' button.
- d) Type Pitch diameter: Pd * cos(Transverse pressure angle: Tpa * 1rad)**: Points to the formula input field.
- e) Pick OK**: Points to the 'OK' button.
- f) Pick Apply**: Points to the 'Apply' button.

The left sidebar shows the 'Parameters' list with the following values:

- 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
- Face width: Fw = 100mm
- Module: m = 8mm
- Pitch diameter: Pd = 88.865mm = (Number of teeth: z * Module: m) / cos(Cylinder helix angle: Ca)
- Base diameter: Bd = 0mm



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

d) Type Pitch diameter: $Pd + (2 * \text{Module: } m)$

e) Pick OK

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

c) Pick Add Formula

f) Pick Apply

a) Pick New Parameter

9

Formula Editor: 'Addendum diameter:Ad'

Addendum diameter:Ad =

Pitch diameter: Pd' + (2 * Module: m')

Dictionary	Members of Parameters	Members of All
Parameters	All	'Absolute Axis System\Origin\X'
Design Table	Renamed parameters	'Absolute Axis System\Origin\Y'
Operators	Length	'Absolute Axis System\Origin\Z'
Pointer on value function	Real	'Absolute Axis System\XAxis\X'
Point Constructors	Boolean	'Absolute Axis System\XAxis\Y'
Law	Angle	'Absolute Axis System\XAxis\Z'
Operations Constructors	String	'Absolute Axis System\YAxis\X'
	Feature	

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

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')/cos('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')/cos('Cylinder helix angle: Ca')

'Base diameter: Bd'=83.409mm='Pitch diameter: Pd' * cos('Transverse pressure angle: Tpa')

'Addendum diameter: Ad=0mm

Relations

Geometrical Set.1

PartBody

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...]

'Pitch diameter: Pd' 88.865mm =

'Base diameter: Bd' 83.409mm =

'Addendum diameter: Ad' 0mm =

Edit name or value of the current parameter

Addendum diameter: Ad 0mm

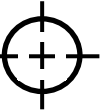
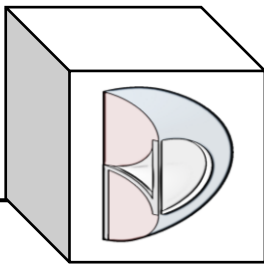
New Parameter of type Length With Single Value

Delete Parameter

Add Formula

Delete Formula

OK Apply Cancel



10) Dd // length parameter [**Dedendum diameter: $Dd = Pd - (2.5 * m)$**]

The screenshot shows the ENOVIA V5 VPM software interface. On the left, the 'Parameters' tree lists various gear parameters. The 'Formula Editor' window is open, showing the formula for 'Dedendum diameter: Dd' as $Pd - (2.5 * \text{Module: } m)$. The 'Dictionary' tab is selected, showing a list of parameters and their values. The 'Members of Parameters' list includes 'All', 'Renamed parameters', 'Length', 'Real', 'Boolean', 'Angle', 'String', and 'Feature'. The 'Members of All' list shows the absolute axis system coordinates. The 'Edit name or value of the current parameter' field is set to 'Dedendum diameter: Dd' with a value of '0mm'. The 'New Parameter of type' dropdown is set to 'Length' with 'Single Value' selected. The 'Add Formula' button is highlighted, and the 'Apply' button is also visible.

d) Type Pitch diameter: $Pd - (2.5 * \text{Module: } m)$

e) Pick OK

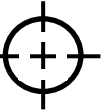
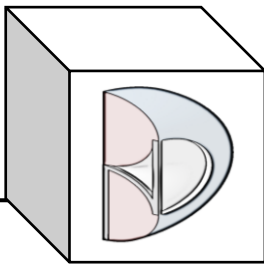
c) Pick Add Formula

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

f) Pick Apply

a) Pick New Parameter

10



11) tr // length parameter [tooth radius at dedendum circle: $tr = 0.38 * m$]

d) Type $0.38 * \text{Module: } m$

b) Type "tooth radius at dedendum circle: tr" for the name

a) Pick New Parameter

c) Pick Add Formula

e) Pick OK

f) Pick Apply

Formula Editor: 'tooth radius at dedendum circle: tr'

tooth radius at dedendum circle: tr = $0.38 * \text{Module: } m$

Dictionary	Members of Parameters	Members of Length
Parameters	All	'Module: m'
Design Table	Renamed parameters	'Pitch circle radius: Rp'
Operators	Boolean	'Base circle radius: Rb'
Pointer on value function	Length	'Addendum circle radius: Ra'
Point Constructors	CstAttr_Mode	'Dedendum circle radius: Rd'
Law	Angle	'tooth radius at dedendum circle: tr'
Operations Constructors	Integer	
	Real	

Module: m 3mm

OK Cancel

Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...

Parameter	Value	Formula
Pitch diameter: Pd'	88.865mm	= ('Number of teeth: z' * Mod...
Base diameter: Bd'	83.409mm	= 'Pitch diameter: Pd' * cos(T...
Addendum diameter: Ad'	104.865mm	=
Dedendum diameter: Dd'	68.865mm	=
tooth radius at dedendum circle: tr'	0mm	

Edit name or value of the current parameter

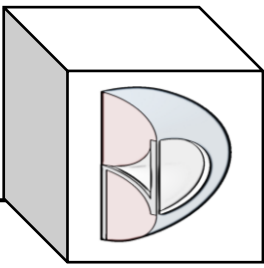
tooth radius at dedendum circle: tr 0mm

New Parameter of type Length With Single Value

Delete Parameter

OK Apply Cancel

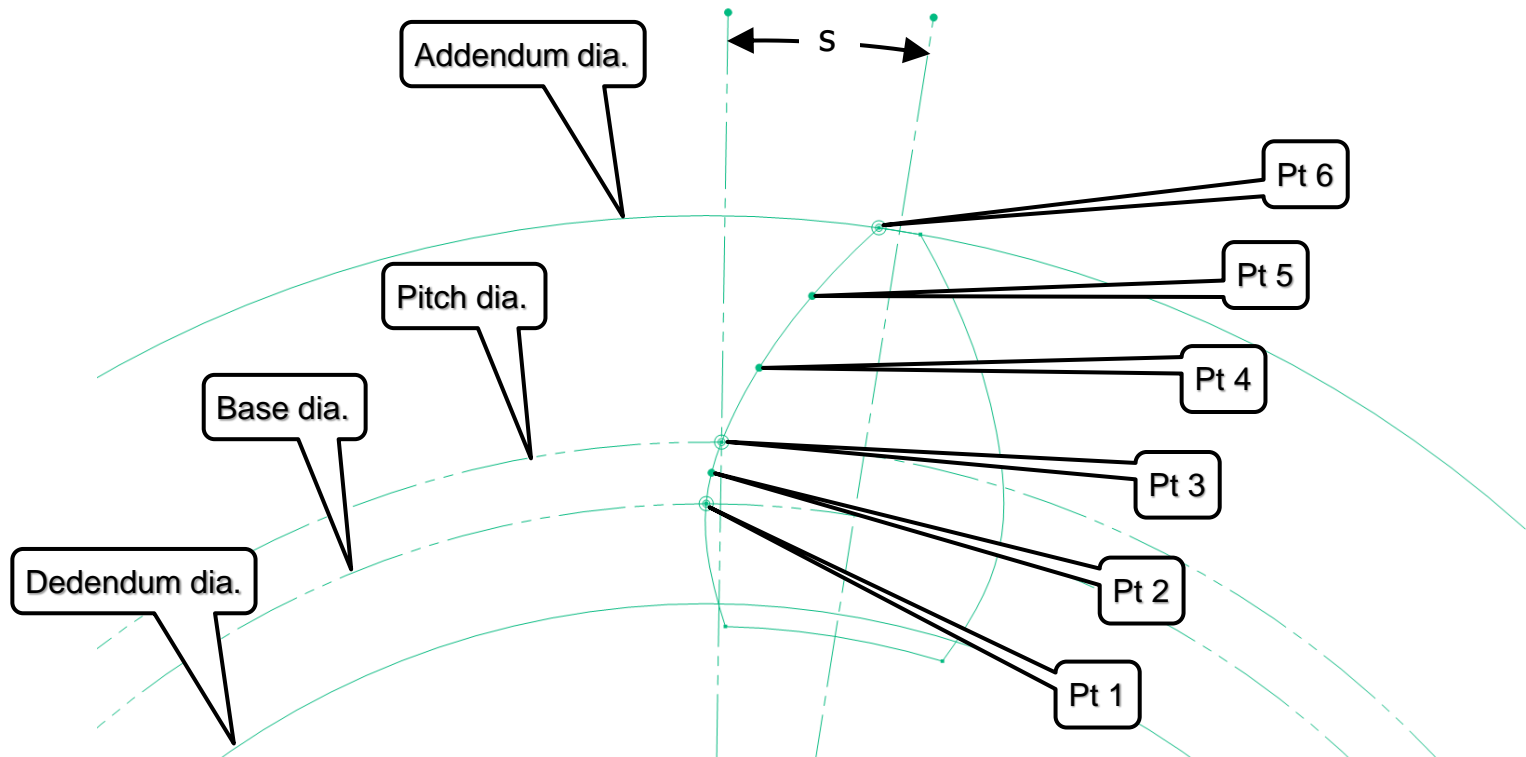
11



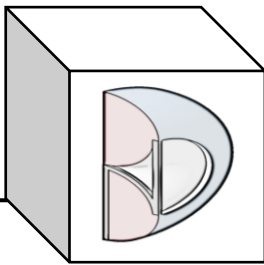
- Create the following six formulae for Involute points:
 - radius (Pt1) // length parameter [$r(\mathbf{Pt1}) = Bd/2$]
 - radius (Pt2) // length parameter [$r(\mathbf{Pt2}) = ((Pd/2) + (Bd/2))/2$]
 - radius (Pt3) // length parameter [$r(\mathbf{Pt3}) = Pd/2$]
 - radius (Pt4) // length parameter [$r(\mathbf{Pt4})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

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HELICAL GEAR TOOTH INVOLUTE POINTS



Point	r (formula)	r (mm)	α (radians)	inv α (radians)	x (mm)	y (mm)
Pt 1	[Base] Br	41.346	0.0000	0.0000	0.000	41.346
Pt 2	(Pr+Br)/2	42.673	0.2500	0.0053	0.228	42.673
Pt 3	[Pitch] Pr	44.000	0.3491	0.0149	0.656	43.995
Pt 4	Pr+(Ar-Pr)*.33333	46.667	0.4822	0.0412	1.922	46.627
Pt 5	Pr+(Ar-Pr)*.66667	49.333	0.5770	0.0739	3.642	49.199
Pt 6	[Addendum] Ar	52.000	0.6516	0.1111	5.766	51.679



BND TechSource



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

d) Type `Base diameter: Bd` / 2

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

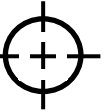
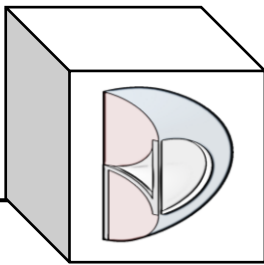
a) Pick New Parameter

e) Pick OK

c) Pick Add Formula

f) Pick Apply

1



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

d) Type $((\text{Pitch diameter: } Pd/2) + (\text{Base diameter: } Bd/2))/2$

e) Pick OK

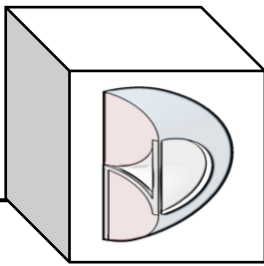
b) Type "r (Pt2)" for the name

c) Pick Add Formula

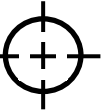
f) Pick Apply

a) Pick New Parameter

2



BND TechSource



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

d) Type `Pitch diameter: Pd` / 2

e) Pick OK

c) Pick Add Formula

f) Pick Apply

a) Pick New Parameter

b) Type "r (Pt3)" for the name

3

Formula Editor : `r (Pt3)`

r (Pt3) =

Pitch diameter: Pd` / 2

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

Pitch diameter: Pd 88.865mm

OK Cancel

Parameter	Value
'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...	
'r (Pt1)'	41.705mm
'r (Pt2)'	86.137mm
Length.10	0mm

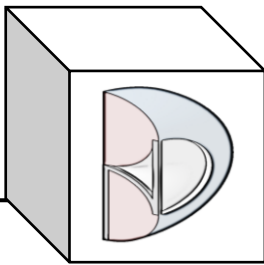
Edit name or value of the current parameter

r (Pt3) 0mm

New Parameter of type Length With Single Value

Delete Param

OK Apply Cancel



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

d) Type ('Pitch diameter: Pd`/2) + ((`Addendum diameter: Ad`/2) - (`Pitch diameter: Pd`/2))* .33333

b) Type "r (Pt4)" for the name

a) Pick New Parameter

e) Pick OK

c) Pick Add Formula

f) Pick Apply

4

Formula Editor : `r (Pt4)`

$r(\text{Pt4}) = (\text{Pitch diameter: Pd} / 2) + ((\text{Addendum diameter: Ad} / 2) - (\text{Pitch diameter: Pd} / 2)) \cdot .33333$

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

Pitch diameter: Pd 88.865mm

OK Cancel

Parameter	Value
'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, F...	
'r (Pt1)`	41.705mm
'r (Pt2)`	86.137mm
'r (Pt3)`	44.432mm
Length.11	0mm

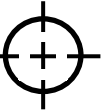
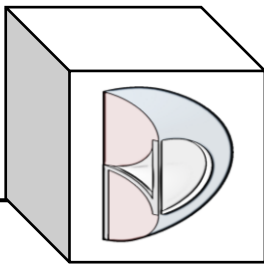
Edit name or value of the current parameter

r (Pt4) 0mm

New Parameter of type Length With Single Value

Delete Param

OK Apply Cancel



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

e) Pick OK

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

c) Pick Add Formula

f) Pick Apply

a) Pick New Parameter

5

Formula Editor: `r (Pt5)`

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`

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: Np
- 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`)/cos(Cylinder
- Base diameter: Bd`=83.409mm=`Pitch diameter: Pd` *cos(Transverse pressure ang
- 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: Pd` /2
- r (Pt2)=86.137mm=`Pitch diameter: Pd` /2
- r (Pt3)=44.432mm=`Pitch diameter: Pd` /2
- r (Pt4)=91.531mm=`Pitch diameter: Pd` /2
- Length.12=0mm

Formula Editor: `r (Pt5)`

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

OK Cancel

Length.12=0mm

Edit name or value of the current parameter

r (Pt5) 0mm

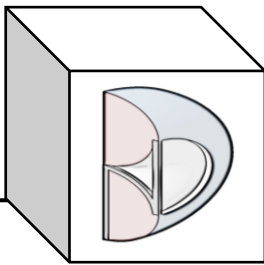
New Parameter of type Length With Single Value

Delete Parameter

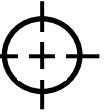
Add Formula

Delete Formula

OK Apply Cancel



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6) radius (Pt6) // length parameter [$r(\text{Pt6}) = \text{Ad}/2$]

The screenshot shows the ENOVIA V5 VPM software interface. The main window displays a list of parameters for an 'Involute Helical Gear (manual)'. The parameters include: 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, Face width: Fw = 100mm, Module: m = 8mm, Pitch diameter: Pd = 88.865mm, Base diameter: Bd = 83.409mm, Addendum diameter: Ad = 104.865mm, Dedendum diameter: Dd = 68.865mm, tooth radius at dedendum circle: tr = 3.04mm, and various radii for points Pt1 through Pt6. The Formula Editor is open, showing the formula for 'r (Pt6)' as 'Addendum diameter: Ad' / 2. The Parameters list on the left shows 'Addendum diameter: Ad' with a value of 104.865mm. The Formula Editor has three panes: Dictionary, Members of Parameters, and Members of All. The Dictionary pane shows 'Parameters' selected. The Members of Parameters pane shows 'All' selected. The Members of All pane shows a list of parameters including 'Number of teeth: z', 'Normal Pressure Angle: Npa', 'Cylinder helix angle: Ca', 'Transverse pressure angle: Tpa', 'Symmetry angle: s', 'Face width: Fw', 'Module: m', and 'Pitch diameter: Pd'. The Formula Editor has a text input field for the formula, a 'New Parameter of type' dropdown set to 'Length', and a 'With' dropdown set to 'Single Value'. The Formula Editor has buttons for 'OK', 'Cancel', 'Add Formula', 'Delete Formula', and 'Apply'.

d) Type 'Addendum diameter: Ad' / 2

e) Pick OK

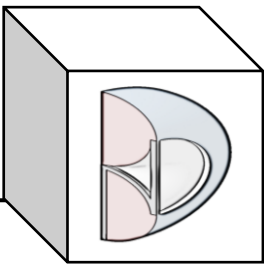
b) Type "r (Pt6)" for the name

c) Pick Add Formula

f) Pick Apply

a) Pick New Parameter

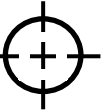
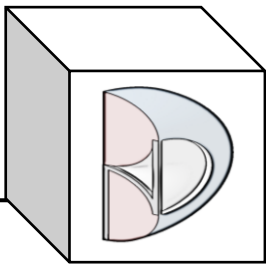
6



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Create the Involute Laws



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

From Excel Spreadsheet

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

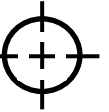
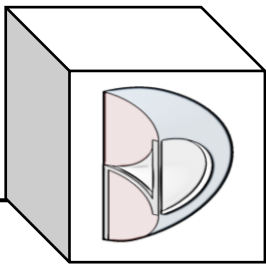
With the center of the base circle O at the origin of a coordinate system, the involute curve can be expressed by values of x and y as follows :

$$\left. \begin{aligned} \alpha &= \cos^{-1} \frac{r_b}{r} \\ x &= r \sin(\text{inv } \alpha) \\ y &= r \cos(\text{inv } \alpha) \end{aligned} \right\} \quad (3.3)$$

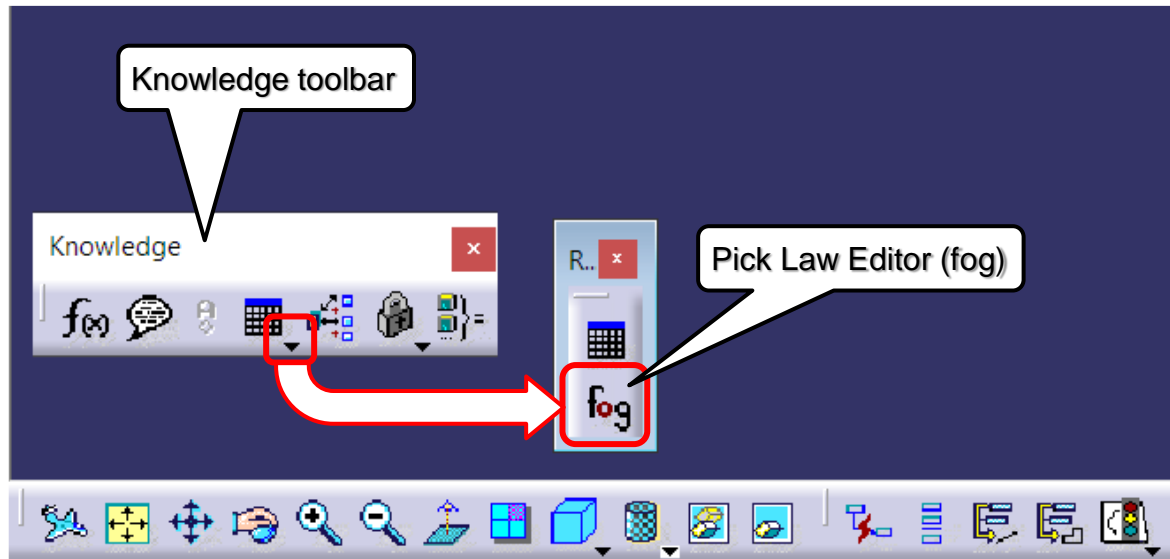
Point	r (formula)	r (mm)	α (radians)	inv α (radians)	x (mm)	y (mm)
Pt 1	[Base] Br	41.705	0.0000	0.0000	0.000	41.705
Pt 2	(Pr+Br)/2	43.069	0.2523	0.0055	0.237	43.068
Pt 3	[Pitch] Pr	44.432	0.3522	0.0153	0.681	44.427
Pt 4	Pr+(Ar-Pr)*.33333	47.099	0.4833	0.0415	1.955	47.058
Pt 5	Pr+(Ar-Pr)*.66667	49.766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

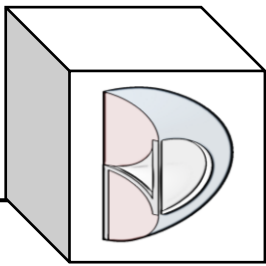
The parametric equations for involute curve points in CATIA:

- $x = r * \sin((\tan(\cos^{-1}(r_b / r)) - (\cos^{-1}(r_b / r))))$
- $y = r * \cos((\tan(\cos^{-1}(r_b / r)) - (\cos^{-1}(r_b / r))))$

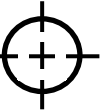


- Create the following two Laws for the creation of the Involute points:
 - $x=r*\sin((\tan(\arccos(r(Pt1)/r))-(\arccos(r(Pt1)/r))))$
 - $y=r*\cos((\tan(\arccos(r(Pt1)/r))-(\arccos(r(Pt1)/r))))$
- In the Knowledge Toolbar, pull out the Law Editor (fog).





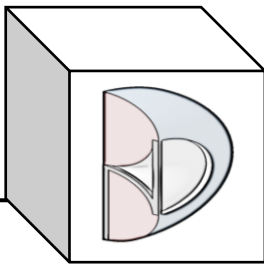
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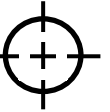
- Type the following in the Law Editor (fog):

The screenshot shows a 'Law Editor' dialog box with the following fields and callouts:

- Name of Law :** The text 'x' is entered. A callout bubble labeled 'a) Type: x' points to this text.
- Description :** The text 'involute point x dir' is entered. A callout bubble labeled 'b) Type: involute point x dir' points to this text.
- Destination :** The text 'Involute Helical Gear (manual) [m=8, z=11, Npa= 20, Ca=8, Fw' is entered.
- At the bottom, there are three buttons: 'OK' (with a green circle icon), 'Cancel' (with a red circle icon), and 'Help'. A callout bubble labeled 'c) Pick "OK"' points to the 'OK' button.



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

Law Editor : x Active

Line: 1

/*involute point x dir*/

c) Type "r";
Enter

b) Pick New
Parameter of type

a) Select Length from
the parameters list

Formal parameters | Type

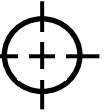
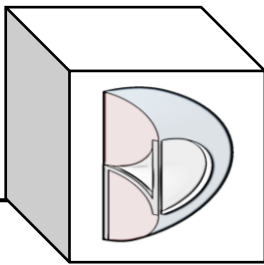
Formal parameters	Type
r	Length

New Parameter of type Real

Remove

Dictionary	Members of Parameters	Members of All
Parameters	All	'Geometrical Set.1\Point.1\H'
Keywords	Renamed parameters	'Geometrical Set.1\Point.1\V'
Design Table	Length	'Geometrical Set.1\Point.1\X'
Operators	Real	'Geometrical Set.1\Point.1\Y'
Pointer on value function	Boolean	'Geometrical Set.1\Point.1\Z'
Point Constructors	Angle	'Geometrical Set.1\Point.1\Activity'
Law	String	'Geometrical Set.1\Point.2\H'
	Feature	'Geometrical Set.1\Point.2\V'

OK Apply Cancel



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

Law Editor : x Active

d) Type "x=r*sin((tan(acos(`r (Pt1)`/r)))-(acos(`r (Pt1)`/r))))"

c) Type "x"; Enter

b) Pick New Parameter of type

a) Select Length from the parameters list

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

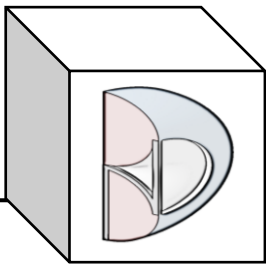
Formal parameters	Type
r	Length
x	Length

New Parameter of type Real

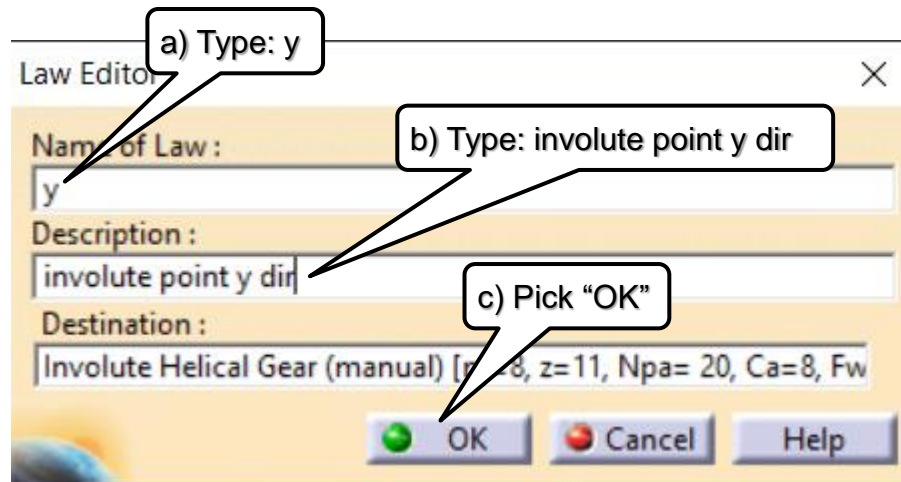
Remove

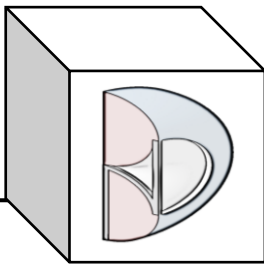
Dictionary	Members of Parameters	Members of All
Parameters	All	`Geometrical Set.1\Point.1\H`
Keywords	Renamed parameters	`Geometrical Set.1\Point.1\V`
Design Table	Length	`Geometrical Set.1\Point.1\X`
Operators	Real	`Geometrical Set.1\Point.1\Y`
Pointer on value function	Boolean	`Geometrical Set.1\Point.1\Z`
Point Constructors	Angle	`Geometrical Set.1\Point.1\Activity`
Law	String	`Geometrical Set.1\Point.2\H`
	Feature	`Geometrical Set.1\Point.2\V`

OK Apply Cancel

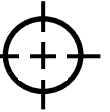


- Type the following in the Law Editor (fog):





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

Law Editor : y Active

Line: 1

Formal parameters Type

r Length

r

New Parameter of type Real

Remove

Dictionary

Parameters

Keywords

Design Table

Operators

Pointer on value function

Point Constructors

Law

Members of Parameters

All

Renamed parameters

Length

Real

Boolean

Angle

String

Feature

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`

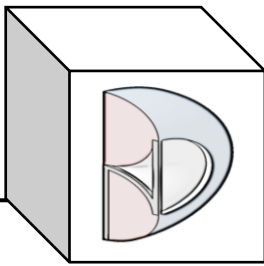
`Geometrical Set.1\Point.2\V`

a) Select Length from the parameters list

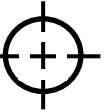
b) Pick New Parameter of type

c) Type "r"; Enter

OK Apply Cancel



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

Law Editor : y Active

d) Type " $y=r\cos((\tan(\arccos(r(Pt1)/r)))-(\arccos(r(Pt1)/r)))$ "

c) Type "y"; Enter

b) Pick New Parameter of type

a) Select Length from the parameters list

Formal parameters | Type

Formal parameters	Type
r	Length
y	Length

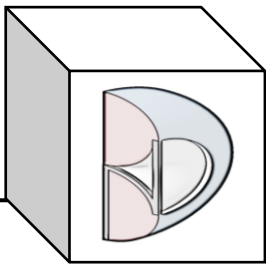
New Parameter of type Real

Remove

Dictionary

Dictionary	Members of Parameters	Members of All
Parameters	All	`Geometrical Set.1\Point.1\H`
Keywords	Renamed parameters	`Geometrical Set.1\Point.1\V`
Design Table	Length	`Geometrical Set.1\Point.1\X`
Operators	Real	`Geometrical Set.1\Point.1\Y`
Pointer on value function	Boolean	`Geometrical Set.1\Point.1\Z`
Point Constructors	Angle	`Geometrical Set.1\Point.1\Activity`
Law	String	`Geometrical Set.1\Point.2\H`
	Feature	`Geometrical Set.1\Point.2\V`

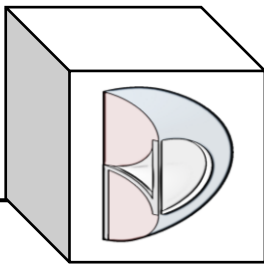
OK Apply Cancel



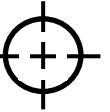
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Create the Geometry (Transverse Module Involute Helical Gear)



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- Create points on plane YZ for involute spline.

The screenshot shows the ENOVIA V5 VPM software interface. The Relations panel on the left lists 19 formulas for calculating gear parameters. The main workspace displays a 3D coordinate system with X, Y, and Z axes. A red box highlights the 'Point' icon in the toolbar. A callout 'a) Pick the Point icon' points to this icon. Another callout 'b) Select on Plane' points to the 'On plane' option in the Point Definition dialog box. A third callout 'c) Select the YZ Plane' points to the 'yz plane' in the same dialog box. A fourth callout 'd) Mouse-over and drop on Edit Formula' points to the 'Edit formula...' option in the context menu that appears when hovering over the 'Edit formula...' button in the dialog box.

Relations

- Formula.1: Transverse pressure angle: $Tpa = \arctan(\tan(\text{Normal Pressure Angle: } Npa) / \cos(\text{Cylinder helix angle: } Ca))$
- Formula.2: Symmetry angle: $s = 90\text{deg} / \text{Number of teeth: } z$
- Formula.3: Pitch diameter: $Pd = (\text{Number of teeth: } z * \text{Module: } m) / \cos(\text{Cylinder helix angle: } Ca)$
- Formula.4: Base diameter: $Bd = \text{Pitch diameter: } Pd * \cos(\text{Transverse pressure angle: } Tpa)$
- Formula.5: Addendum diameter: $Ad = \text{Pitch diameter: } Pd + (2 * \text{Module: } m)$
- Formula.6: Dedendum diameter: $Dd = \text{Pitch diameter: } Pd - (2.5 * \text{Module: } m)$
- Formula.7: tooth radius at dedendum circle: $tr = 0.38 * \text{Module: } m$
- Formula.8: $r(Pt1) = \text{Base diameter: } Bd / 2$
- Formula.9: $r(Pt2) = ((\text{Pitch diameter: } Pd / 2) + (\text{Base diameter: } Bd / 2)) / 2$
- Formula.10: $r(Pt3) = \text{Pitch diameter: } Pd / 2$
- Formula.11: $r(Pt4) = (\text{Pitch diameter: } Pd / 2) + ((\text{Addendum diameter: } Ad / 2) - (\text{Pitch diameter: } Pd / 2)) * .33333$
- Formula.12: $r(Pt5) = (\text{Pitch diameter: } Pd / 2) + ((\text{Addendum diameter: } Ad / 2) - (\text{Pitch diameter: } Pd / 2)) * .66667$
- Formula.13: $r(Pt6) = \text{Addendum diameter: } Ad / 2$
- Formula.14: $Pa(Pt1) = \arccos(r(Pt1) / r(Pt1))$
- Formula.15: $Pa(Pt2) = \arccos(r(Pt1) / r(Pt2))$
- Formula.16: $Pa(Pt3) = \arccos(r(Pt1) / r(Pt3))$
- Formula.17: $Pa(Pt4) = \arccos(r(Pt1) / r(Pt4))$
- Formula.18: $Pa(Pt5) = \arccos(r(Pt1) / r(Pt5))$
- Formula.19: $Pa(Pt6) = \arccos(r(Pt1) / r(Pt6))$

Geometrical Set.1

- Point.1
- PartBody

Point Definition

Type: On plane

Plane: yz plane

H: 181.258mm

V: 12.5mm

Point: Default (Origin)

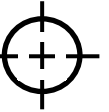
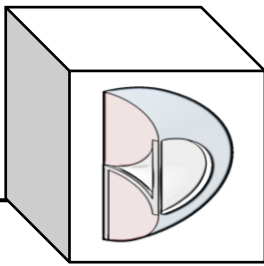
Projection: Default (None)

Surface: Default (None)

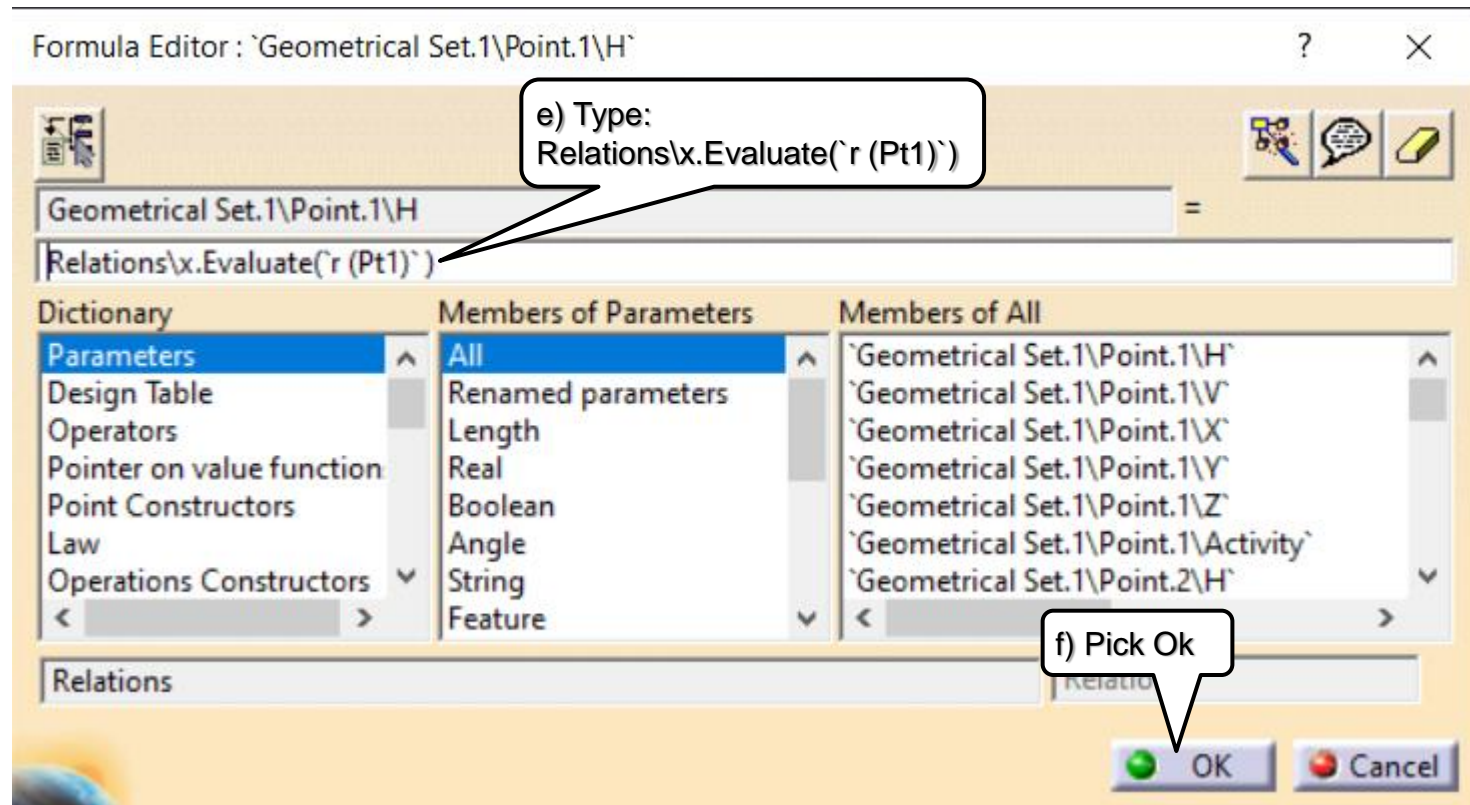
OK Cancel

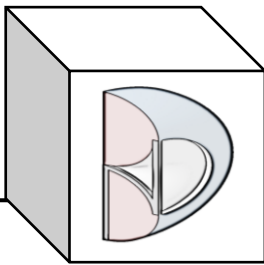
Edit formula...

- Edit...
- Add tolerance...
- Change step
- Measure Between...
- Measure Item...
- Add Multiple Values...
- Add Range...
- Edit Comment...
- Lock

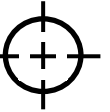


- Create points for involute spline.





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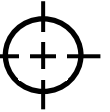
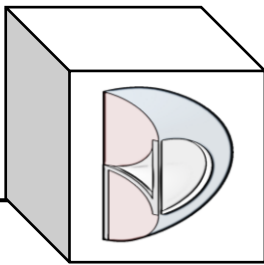


- Create points for involute spline.

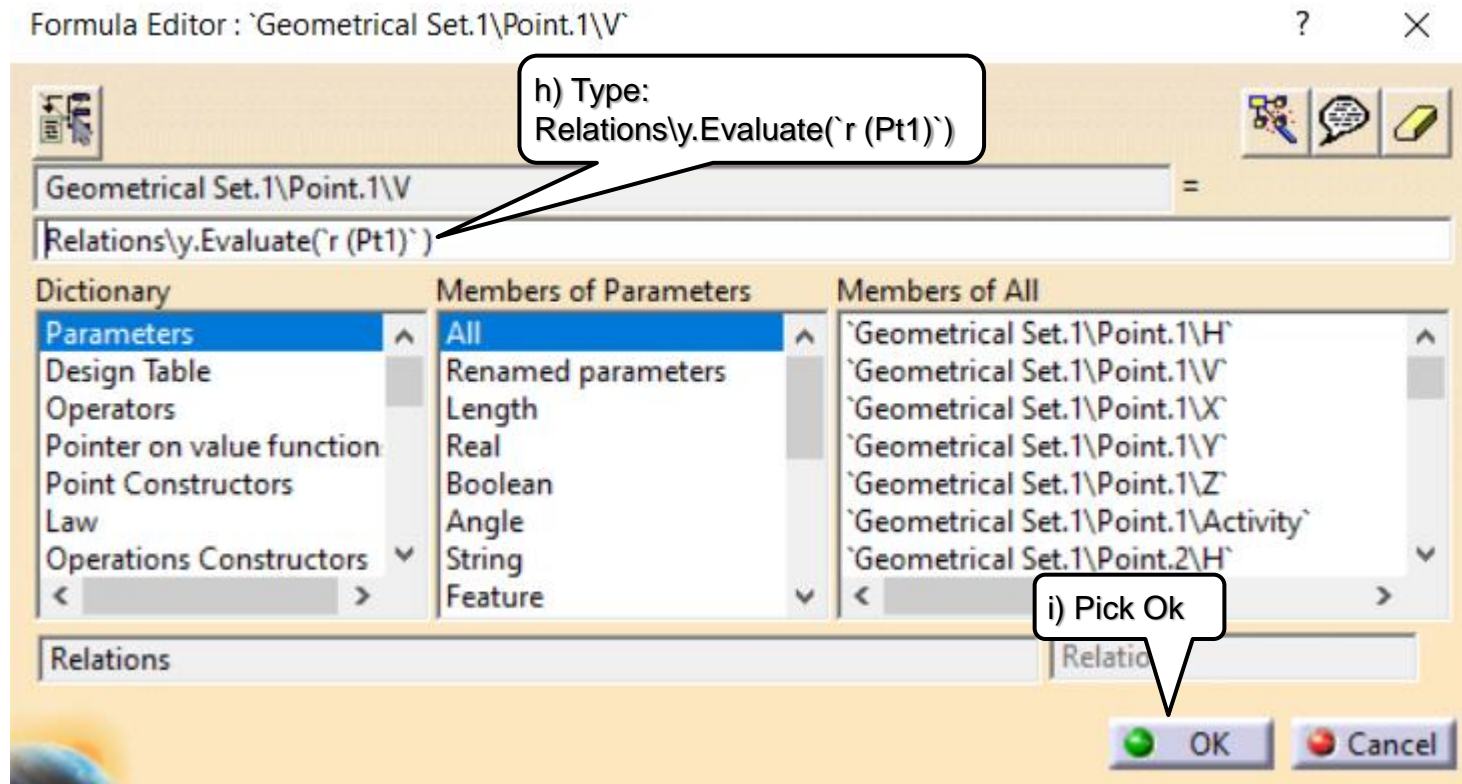
The screenshot displays the ENOVIA V5 VPM software interface. The main window shows a list of formulas for creating points for an involute spline. The formulas are as follows:

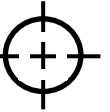
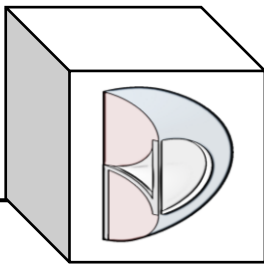
- Formula 1: $r(Pt5) = 49.766mm = (Pitch\ diameter: Pd/2) + ((Addendum\ diameter: Ad/2) - (Pitch\ diameter: Pd/2)) * .66667$
- Formula 2: $r(Pt6) = 52.432mm = Addendum\ diameter: Ad / 2$
- Formula 3: $Pa(Pt1) = 0 = \cos(r(Pt1) / r(Pt1))$
- Formula 4: $Pa(Pt2) = 0.252333761 = \cos((r(Pt1) / (r(Pt2)))$
- Formula 5: $Pa(Pt3) = 0.352220734 = \cos(r(Pt1) / r(Pt3))$
- Formula 6: $Pa(Pt4) = 0.483298254 = \cos(r(Pt1) / r(Pt4))$
- Formula 7: $Pa(Pt5) = 0.577154048 = \cos(r(Pt1) / r(Pt5))$
- Formula 8: $Pa(Pt6) = 0.651131653 = \cos(r(Pt1) / r(Pt6))$
- Formula 9: $Transverse\ pressure\ angle: Tpa = \arctan(\tan(Normal\ Pressure\ Angle: Npa) / \cos(Cylinder\ helix\ angle: Ca))$
- Formula 10: $Symmetry\ angle: s = 90deg / Number\ of\ teeth: z$
- Formula 11: $Pitch\ diameter: Pd = (Number\ of\ teeth: z * Module: m) / \cos(Cylinder\ helix\ angle: Ca)$
- Formula 12: $Base\ diameter: Bd = Pitch\ diameter: Pd * \cos(Transverse\ pressure\ angle: Tpa)$
- Formula 13: $Addendum\ diameter: Ad = Pitch\ diameter: Pd + (2 * Module: m)$
- Formula 14: $Dedendum\ diameter: Dd = Pitch\ diameter: Pd - (2.5 * Module: m)$
- Formula 15: $tooth\ radius\ at\ dedendum\ circle: tr = 0.38 * Module: m$
- Formula 16: $r(Pt1) = Base\ diameter: Bd / 2$
- Formula 17: $r(Pt2) = ((Pitch\ diameter: Pd/2) + (Base\ diameter: Bd/2)) / 2$
- Formula 18: $r(Pt3) = Pitch\ diameter: Pd / 2$
- Formula 19: $r(Pt4) = (Pitch\ diameter: Pd/2) + ((Addendum\ diameter: Ad/2) - (Pitch\ diameter: Pd/2)) * .33333$
- Formula 20: $r(Pt5) = (Pitch\ diameter: Pd/2) + ((Addendum\ diameter: Ad/2) - (Pitch\ diameter: Pd/2)) * .66667$
- Formula 21: $r(Pt6) = Addendum\ diameter: Ad / 2$
- Formula 22: $Pa(Pt1) = \cos(r(Pt1) / r(Pt1))$
- Formula 23: $Pa(Pt2) = \cos((r(Pt1) / (r(Pt2)))$
- Formula 24: $Pa(Pt3) = \cos(r(Pt1) / r(Pt3))$
- Formula 25: $Pa(Pt4) = \cos(r(Pt1) / r(Pt4))$

A callout box labeled "g) Mouse-over and drop on Edit Formula" points to the "Edit formula..." option in the context menu of a formula.



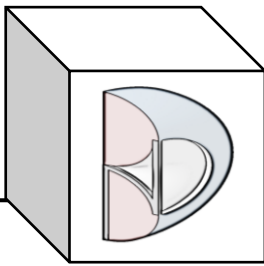
- Create points for involute spline.



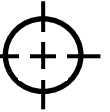


- Create points for involute spline.
- Repeat steps a) through i) for the next five points evaluating r (Pt₁) for each sequential point.
- Afterwards there should be seven points as follows:
 - Point 1:
 - H direction = Relations\X.Evaluate ('r (Pt1)')
 - V direction = Relations\Y.Evaluate ('r (Pt1)')
 - Point 2:
 - H direction = Relations\X.Evaluate ('r (Pt1)')
 - V direction = Relations\Y.Evaluate ('r (Pt1)')
 - Point 3:
 - H direction = Relations\X.Evaluate ('r (Pt1)')
 - V direction = Relations\Y.Evaluate ('r (Pt1)')
 - Point 4:
 - H direction = Relations\X.Evaluate ('r (Pt1)')
 - V direction = Relations\Y.Evaluate ('r (Pt1)')
 - Point 5:
 - H direction = Relations\X.Evaluate ('r (Pt1)')
 - V direction = Relations\Y.Evaluate ('r (Pt1)')
 - Point 6:
 - H direction = Relations\X.Evaluate ('r (Pt1)')
 - V direction = Relations\Y.Evaluate ('r (Pt1)')

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



BND TechSource



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

a) Modify z = 25

b) Notice the division by zero error.

c) Notice the cannot evaluate cos error.

d) Pick Cancel

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

- Correct the errors and check the results.

Repeat steps a-d for y.

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

Formal parameters

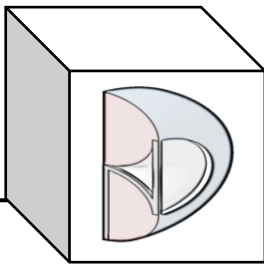
Formal parameters	Type
r	Length
x	Length

Dictionary

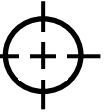
Dictionary	Members of Parameters	Members of All
Parameters	All	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))
Keywords	Renamed parameters	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))
Design Table	Length	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))
Operators	Real	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))
Pointer on value function	Boolean	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))
Point Constructors	Angle	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))
Law	String	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))
	Feature	'Geometrical Set.1\Point.1\H' = Relations\X.Evaluate(r (Pt1))

0mm

OK Apply Cancel



BND TechSource



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

The screenshot shows the ENOVIA V5 VPM software interface. The left sidebar contains a tree view with 'Parameters' and 'Relations'. The main area displays a list of parameters and formulas. A dialog box titled 'Edit Parameter' is open, showing the 'Number of teeth: z' parameter set to 25. A callout 'a) Modify z = 25' points to the input field. Another callout 'd) Pick Cancel' points to the 'Cancel' button. A third callout 'b) Notice the division by zero error has been rectified.' points to the 'Pitch diameter: Pd' formula. A fourth callout 'c) Notice the cannot evaluate cos error is still there.' points to the 'Knowledge Report' window, which shows a table with error messages.

ENOVIA V5 VPM

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

0% 0

yz plane
zx plane
Axis Systems
Parameters

Number of teeth: z = 25
Normal Pressure Angle: Npa
Cylinder helix angle: Ca
Transverse pressure angle: Tpa
Symmetry angle: s = 8.0
Face width: Fw = 100mm
Module: m = 8mm
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 = 0.36 * 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)
r (Pt5) = 49.766mm = (Pitch diameter: Pd / 2) + (Addendum diameter: Ad / 2) + (Pitch diameter: Pd / 2) * cos(Transverse pressure angle: Tpa * 1rad)
r (Pt6) = 52.432mm = Addendum diameter: Ad / 2

Relations

Formula.1: Transverse pressure angle: Tpa = atan(tan(Normal Pressure Angle: Npa) / cos(Cylinder helix angle: Ca))
Formula.2: Symmetry angle: s = 90deg / Number of teeth: z
Formula.3: Pitch diameter: Pd = (Number of teeth: z * Module: m) / cos(Cylinder helix angle: Ca * 1rad)
Formula.4: Base diameter: Bd = Pitch diameter: Pd * cos(Transverse pressure angle: Tpa * 1rad)

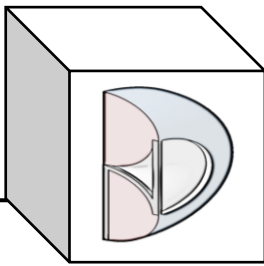
Knowledge Report

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

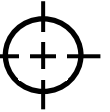
Message:

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

Close



BND TechSource



- Correct the errors and check the results.

Repeat steps a-d for 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

Formal parameters

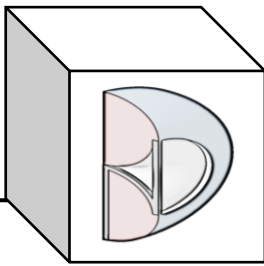
Formal parameters	Type
r	Length
x	Length

Dictionary

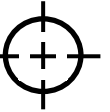
Dictionary	Members of Parameters	Members of All
Parameters	All	'Geometrical Set.1\Point.1\H' = Relations.x.Evaluate(r (Pt1))
Keywords	Renamed parameters	'Geometrical Set.1\Point.1\V' = Relations.y.Evaluate(r (Pt1))
Design Table	Length	'Geometrical Set.1\Point.1\Z' = Relations.z.Evaluate(r (Pt1))
Operators	Real	'Geometrical Set.1\Point.2\H' = Relations.x.Evaluate(r (Pt2))
Pointer on value function	Boolean	'Geometrical Set.1\Point.2\Z' = Relations.z.Evaluate(r (Pt2))
Point Constructors	Angle	'Geometrical Set.1\Point.3\H' = Relations.x.Evaluate(r (Pt3))
Law	String	'Geometrical Set.1\Point.3\Z' = Relations.z.Evaluate(r (Pt3))
	Feature	'Geometrical Set.1\Point.4\H' = Relations.x.Evaluate(r (Pt4))
		'Geometrical Set.1\Point.4\Z' = Relations.z.Evaluate(r (Pt4))

1000mm

OK Apply Cancel



BND TechSource



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

a) Modify z = 25

Notice all errors have been rectified.

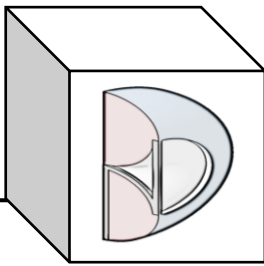
b) Pick Update

Parameters

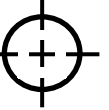
- Number of teeth: $z = 25$
- Normal Pressure Angle: $Np\alpha = 20\text{deg}$
- Cylinder helix angle: $Ca = 8\text{deg}$
- Transverse pressure angle: $Tpa = 20.181\text{deg} = \text{atan}(\tan(\text{Normal Pressure Angle: } Np\alpha) / \cos(\text{Cylinder helix angle: } Ca))$
- Symmetry angle: $s = 3.6\text{deg} = 90\text{deg} / \text{Number of teeth: } z$
- Face width: $Fw = 100\text{mm}$
- Module: $m = 8\text{mm}$
- Pitch diameter: $Pd = 201.966\text{mm} = (\text{Number of teeth: } z * \text{Module: } m) / \cos(\text{Cylinder helix angle: } Ca * 1\text{rad})$
- Base diameter: $Bd = 189.567\text{mm} = \text{Pitch diameter: } Pd * \cos(\text{Transverse pressure angle: } Tpa * 1\text{rad})$
- Addendum diameter: $Ad = 217.966\text{mm} = \text{Pitch diameter: } Pd + (2 * \text{Module: } m)$
- Dedendum diameter: $Dd = 181.966\text{mm} = \text{Pitch diameter: } Pd - (2.5 * \text{Module: } m)$
- tooth radius at dedendum circle: $tr = 3.04\text{mm} = 0.38 * \text{Module: } m$
- $r(Pt1) = 94.783\text{mm} = \text{Base diameter: } Bd / 2$
- $r(Pt2) = 97.883\text{mm} = ((\text{Pitch diameter: } Pd / 2) + (\text{Base diameter: } Bd / 2)) / 2$
- $r(Pt3) = 100.983\text{mm} = \text{Pitch diameter: } Pd / 2$
- $r(Pt4) = 103.649\text{mm} = (\text{Pitch diameter: } Pd / 2) + ((\text{Addendum diameter: } Ad / 2) - (\text{Pitch diameter: } Pd / 2)) * .33333$
- $r(Pt5) = 106.316\text{mm} = (\text{Pitch diameter: } Pd / 2) + ((\text{Addendum diameter: } Ad / 2) - (\text{Pitch diameter: } Pd / 2)) * .66667$
- $r(Pt6) = 108.983\text{mm} = \text{Addendum diameter: } Ad / 2$

Relations

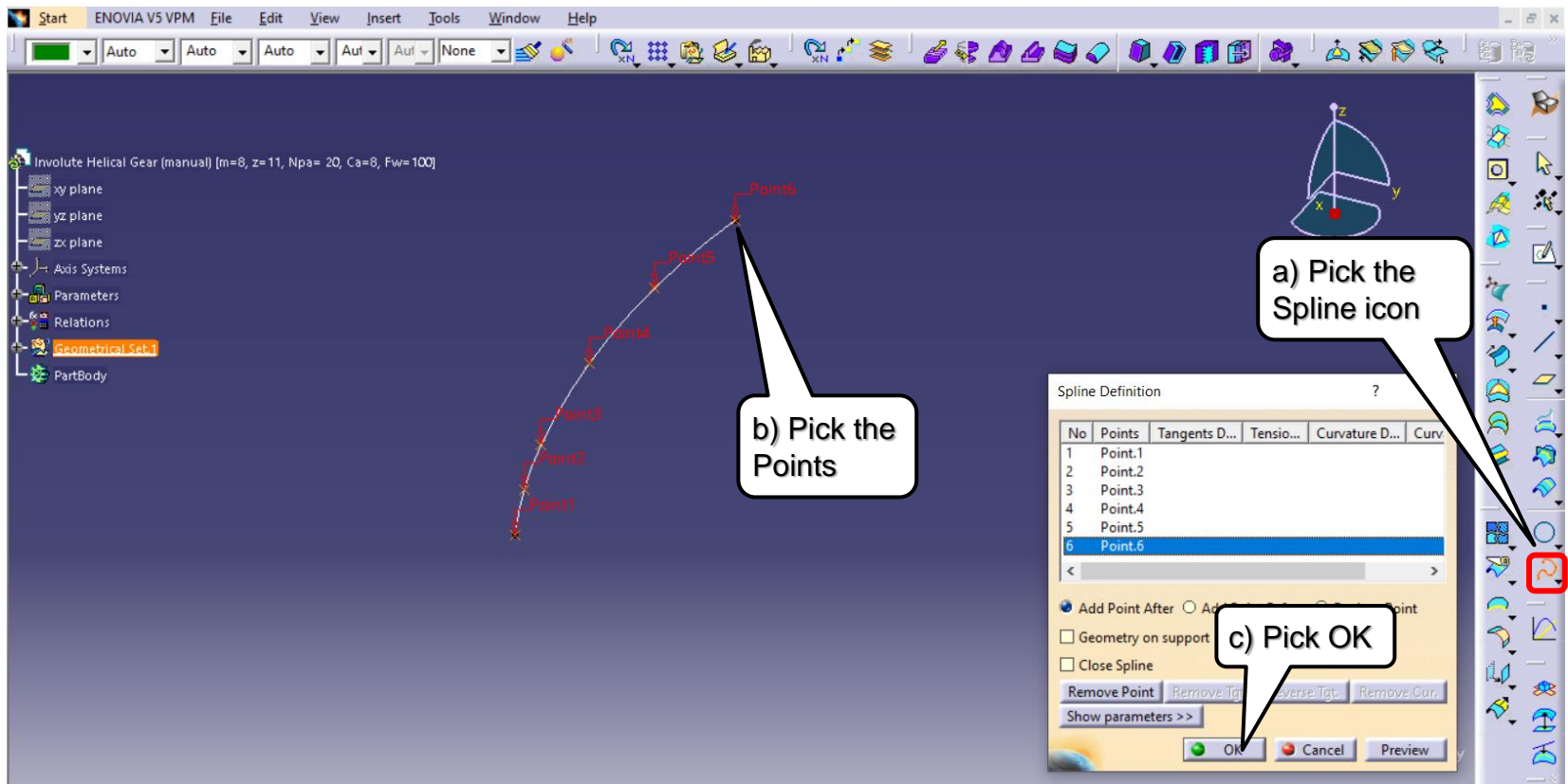
- Formula.1: Transverse pressure angle: $Tpa = \text{atan}(\tan(\text{Normal Pressure Angle: } Np\alpha) / \cos(\text{Cylinder helix angle: } Ca))$
- Formula.2: Symmetry angle: $s = 90\text{deg} / \text{Number of teeth: } z$
- Formula.3: Pitch diameter: $Pd = (\text{Number of teeth: } z * \text{Module: } m) / \cos(\text{Cylinder helix angle: } Ca * 1\text{rad})$
- Formula.4: Base diameter: $Bd = \text{Pitch diameter: } Pd * \cos(\text{Transverse pressure angle: } Tpa * 1\text{rad})$

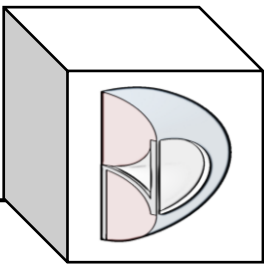


BND TechSource

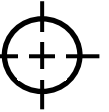


- Create the involute spline through the points.

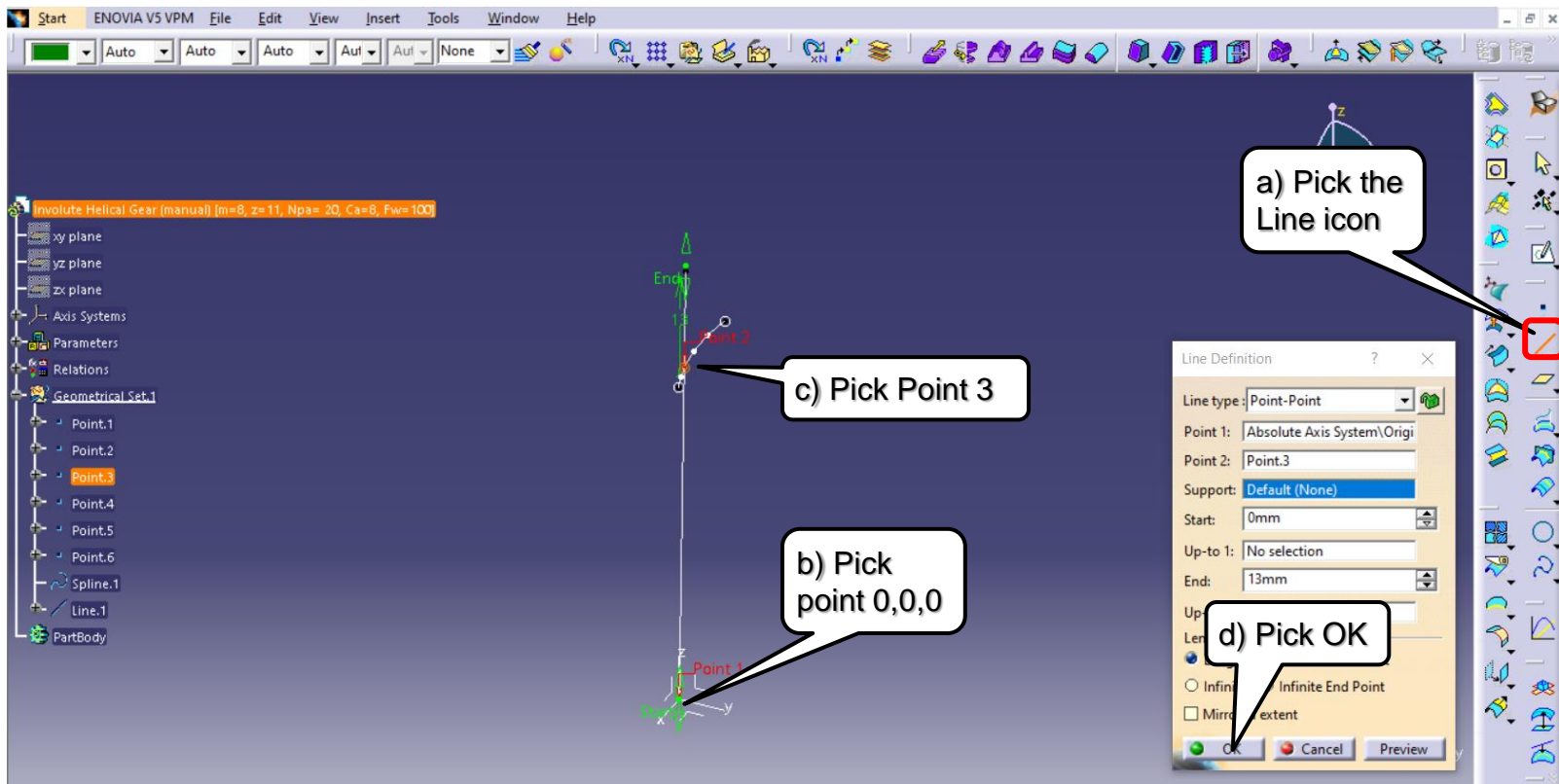


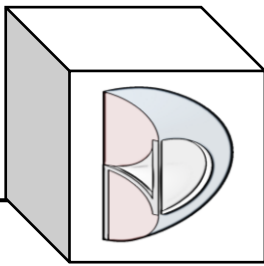


BND TechSource

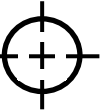


- Create a line from 0,0,0 through Point 3.





BND TechSource



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

a) Pick the Line icon

b) Select Angle/Normal to curve

c) Pick the line going through Point 3

d) Point at 0,0,0

e) Mouse-over the Angle and pick edit formula

f) Double-pick on Symmetry angle: s

g) Make it negative

h) Pick OK

i) Pick OK

Line Definition

Line type: Angle/Normal to curve

Curve: Line.1

Support: yz plane

Point: Line.1\Vertex

Angle: -8.182deg

Start: 0

End: No selection

Mid: 61mm

Up-to 2: No selection

Length Type

☒ Length ☐ Infinite Start Point

☐ Infinite ☐ Infinite End Point

☐ Mirrored extent

☐ Geometry on support

Normal to Curve

Reverse Direction

☐ Repeat object after OK

OK Cancel Preview

Symmetry angle: s

Members of Parameters

All

Renamed parameters

Length

Boolean

Real

Angle

String

Feature

Members of Angle

'Geometrical Set.1\Join.1\Angular threshold

'Geometrical Set.1\Circle.3\Start

'Geometrical Set.1\Circle.3\End

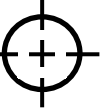
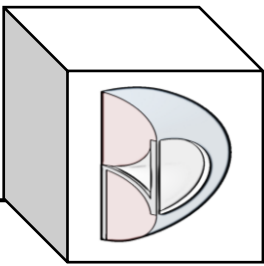
'Geometrical Set.1\Line.4\Angle

'Ref Pressure Angle: Rpa

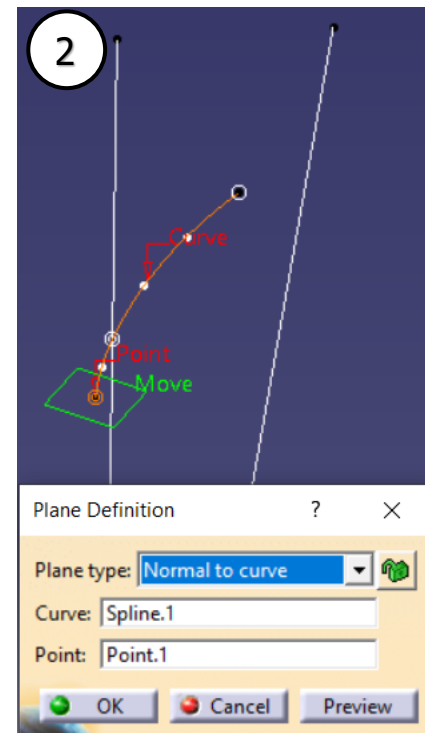
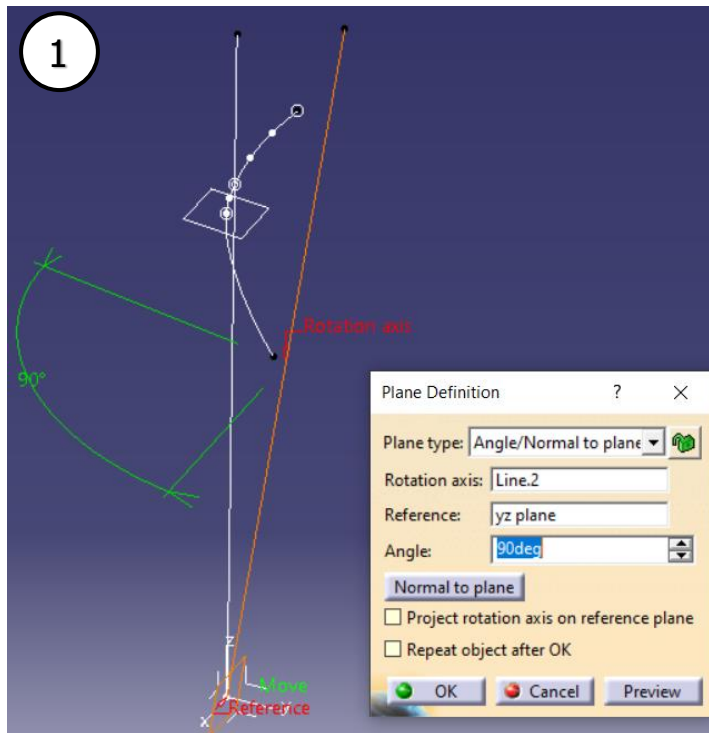
'Symmetry angle: s'

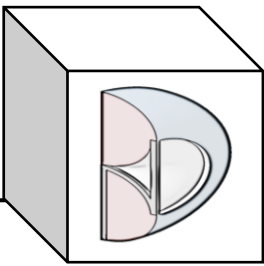
2.25deg

OK Cancel

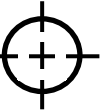


- Create two symmetry planes normal to plane YZ.
 1. Through Line 2.
 2. Normal to the spline and through Point 1.

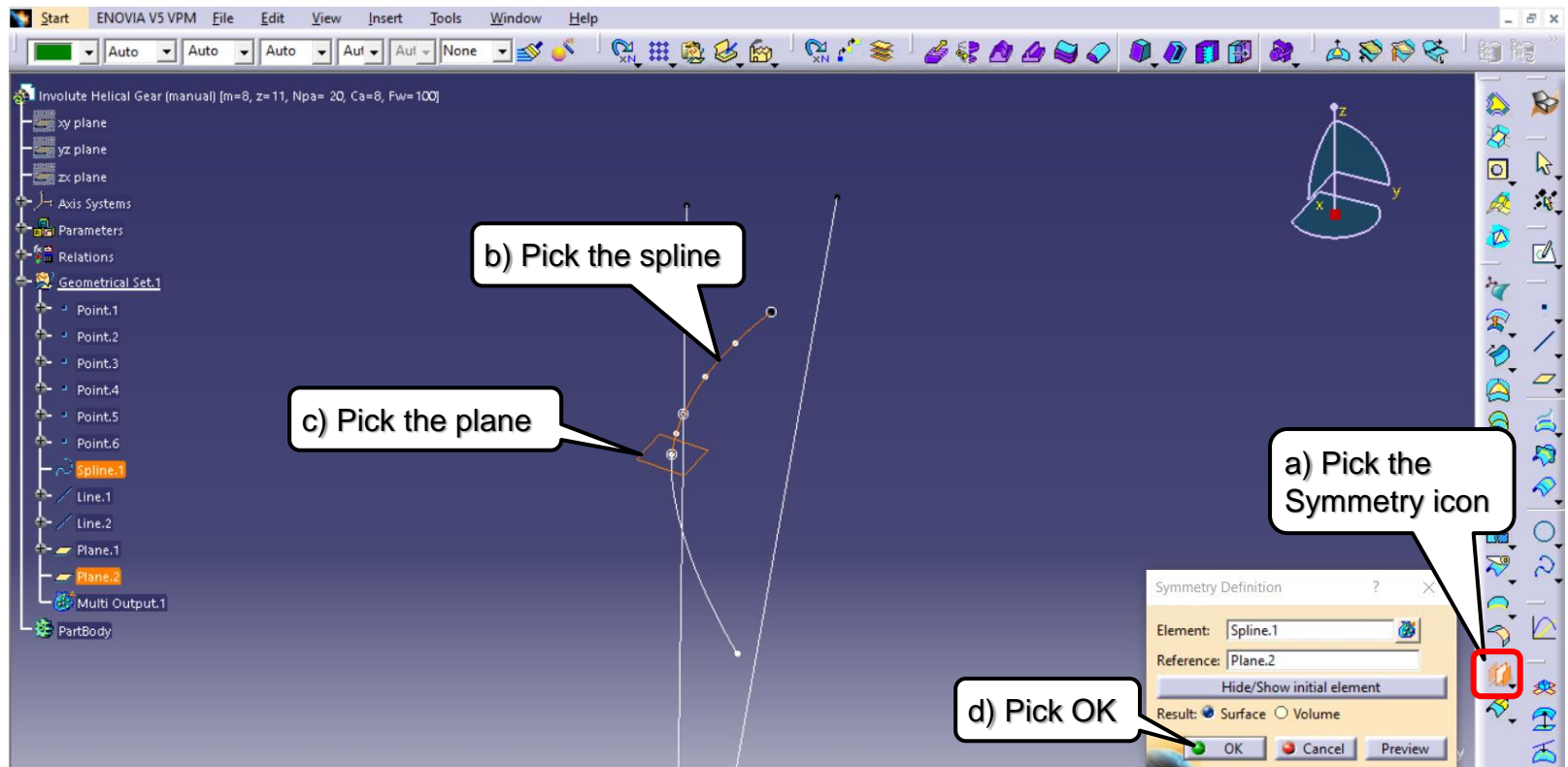


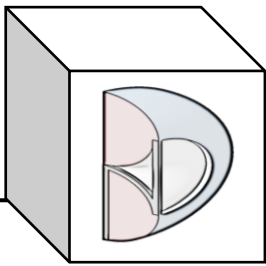


BND TechSource

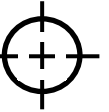


- Symmetry the spline about Plane 2.

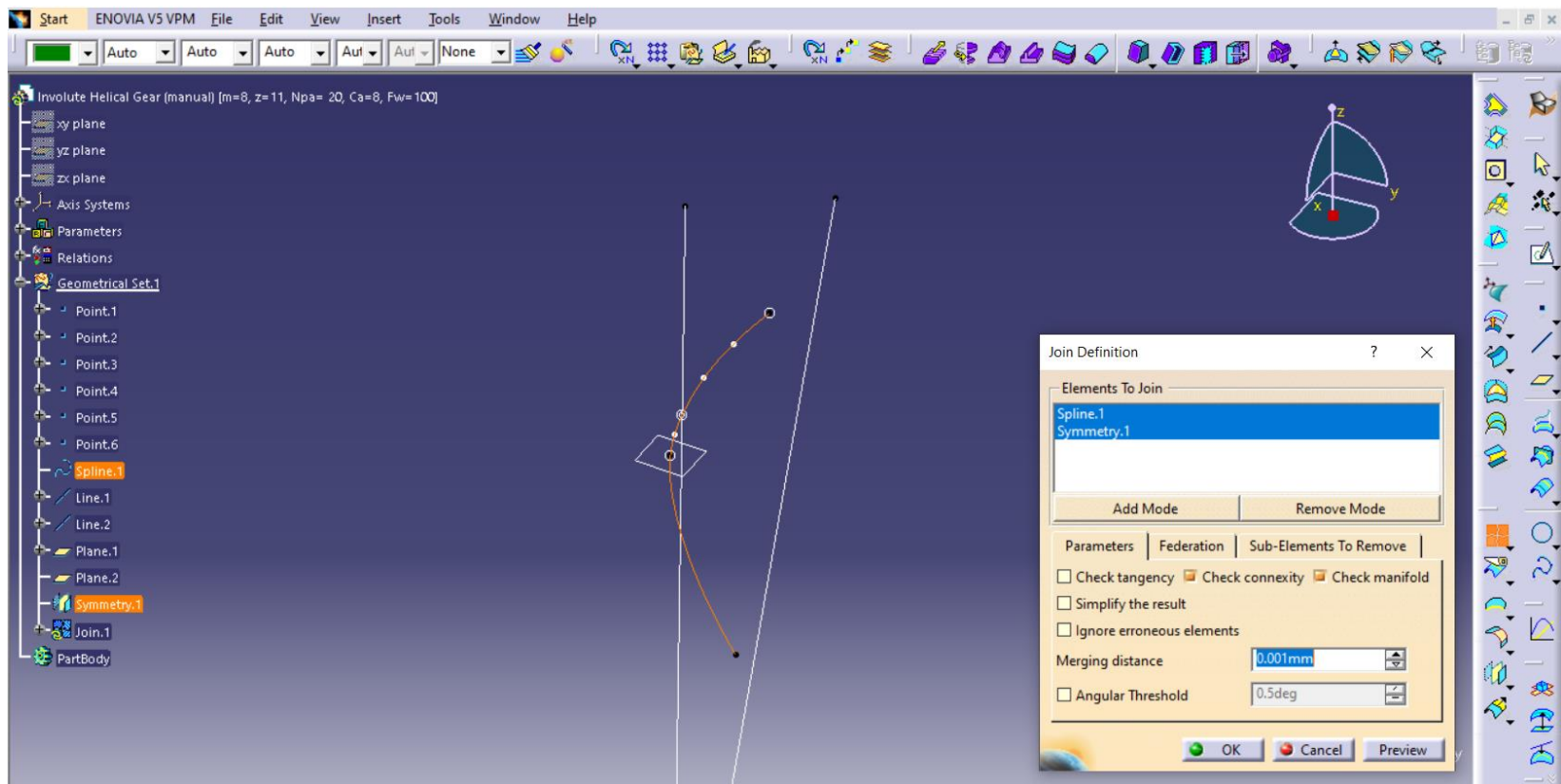


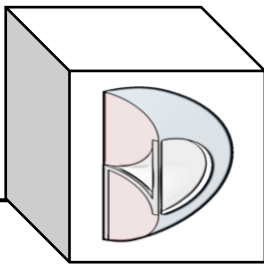


BND TechSource

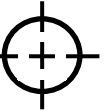


- Join the two splines together.

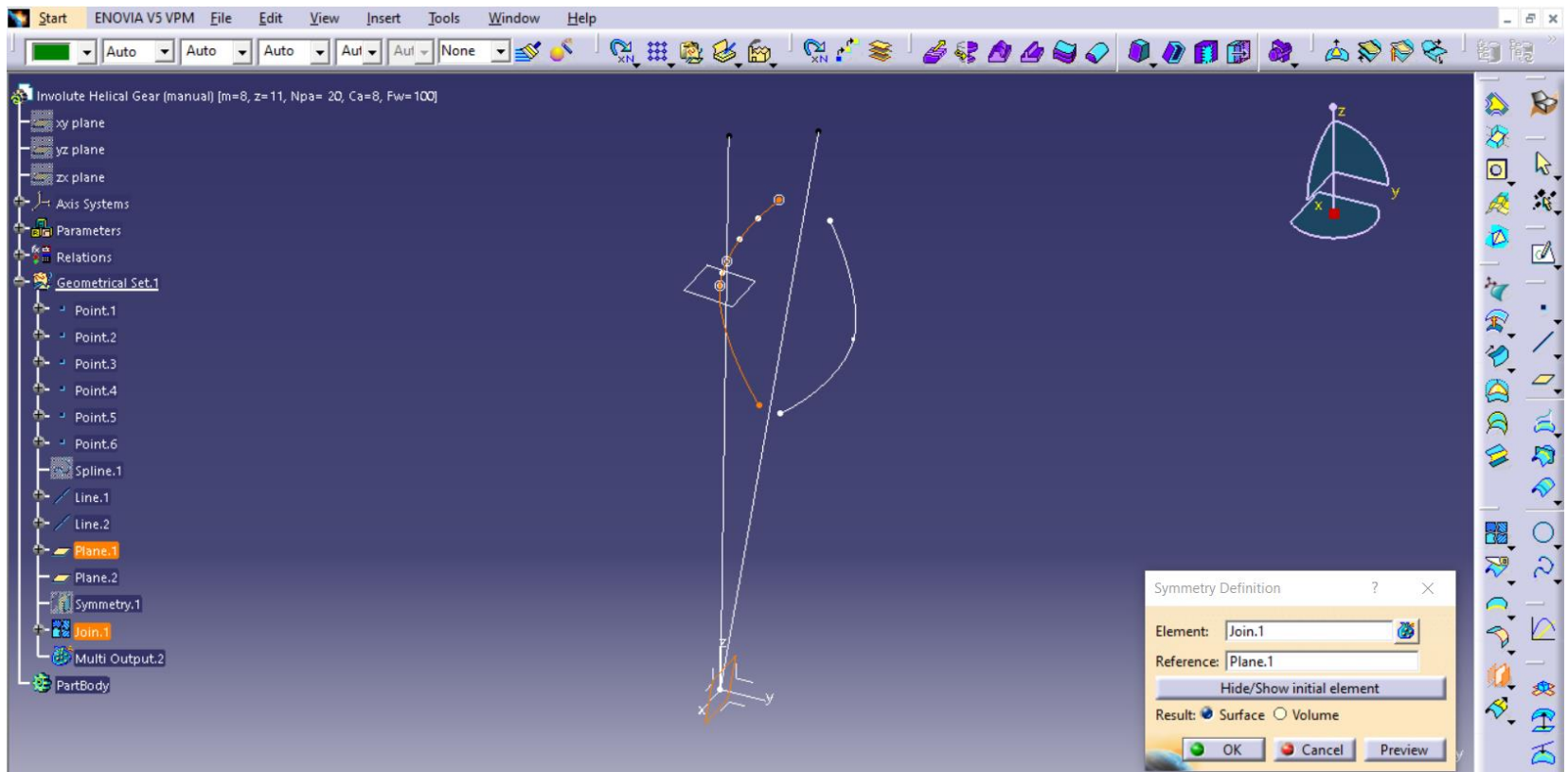


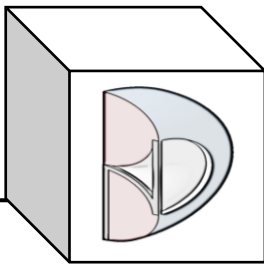


BND TechSource

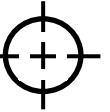


- Symmetry the Join about Plane 1.

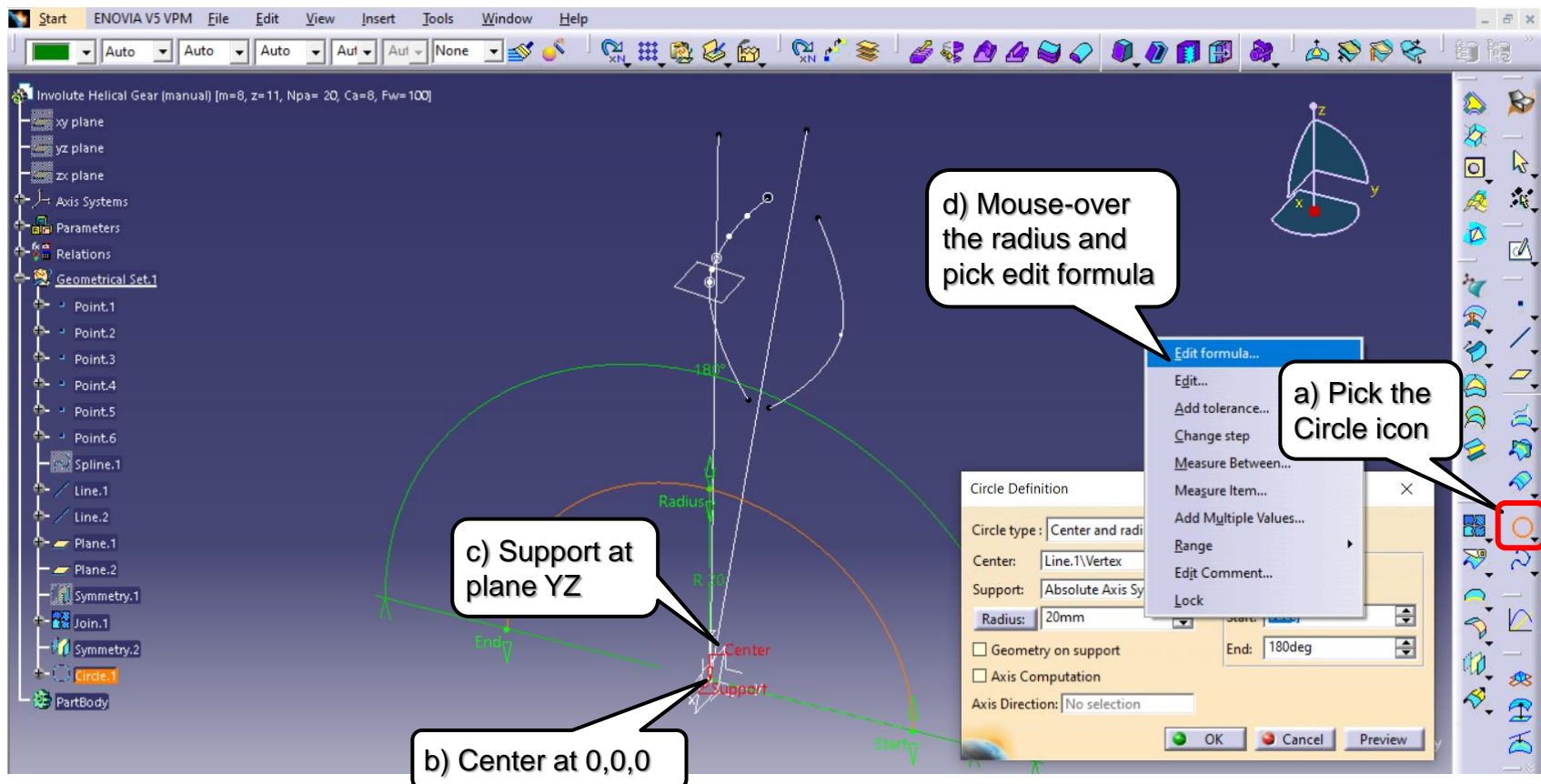


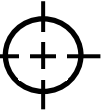
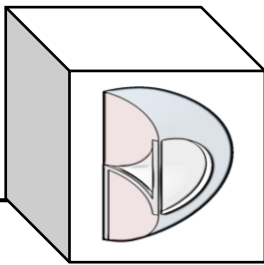


BND TechSource



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





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

The screenshot shows the CATIA V5 VPM software interface. The main workspace displays a gear design with a large arc representing the addendum circle. The left-hand tree structure lists various geometric elements: yz plane, zc plane, Axis Systems, Parameters, Relations, Geometrical Set.1, Point.1 through Point.6, Spline.1, Line.1 and Line.2, Plane.1 and Plane.2, Symmetry.1 and Symmetry.2, Join.1, Circle.1, and PartBody. A callout box labeled 'b)' points to the formula editor, stating: 'b) Divide by 2 because CATIA sees Diameters as Radius objects'. Another callout box labeled 'a)' points to the formula editor, stating: 'a) Double pick the formula Addendum diameter: Ad'. The Formula Editor dialog box is open, showing the formula: $\text{Addendum diameter: Ad} = \text{Circle.1} \backslash \text{Radius} \times 2$. The 'Members of Parameters' list includes: All, Renamed parameters, Length, Real, Boolean, Angle, String, and Feature. The 'Members Length' list includes: 'Base diameter: Bd', 'Addendum diameter: Ad', 'Dedendum diameter: Dd', 'tooth radius at dedendum circle: tr', 'r (Pt1)', 'r (Pt2)', and 'r (Pt3)'. The formula editor shows the value 104.865mm. A callout box labeled 'c)' points to the OK button, stating: 'c) Pick OK'.

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

a) Double pick the formula Addendum diameter: Ad

Formula Editor: 'Geometrical Set.1 \ Circle.1 \ Radius'

Geometrical Set.1 \ Circle.1 \ Radius =

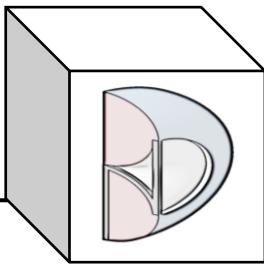
'Addendum diameter: Ad' \times 2

Dictionary

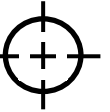
Parameters	Members of Parameters	Members Length
Design Table	All	'Base diameter: Bd'
Operators	Renamed parameters	'Addendum diameter: Ad'
Pointer on value function	Length	'Dedendum diameter: Dd'
Point Constructors	Real	'tooth radius at dedendum circle: tr'
Law	Boolean	'r (Pt1)'
Operations Constructors	Angle	'r (Pt2)'
	String	'r (Pt3)'
	Feature	

Addendum diameter: Ad 104.865mm

c) Pick OK



BND TechSource



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

Start ENOVIA V5 VPM File Edit View Insert Tools Window Help

Relations

Geometrical Set.1

- Point.1
- Point.2
- Point.3
- Point.4
- Point.5
- Point.6
- Spline.1
- Line.1
- Line.2
- Plane.1
- Plane.2
- Symmetry.1
- Join.1
- Symmetry.2
- Circle.1
- Circle.2
- Circle.3
- Trim.1
- Trim.2
- Trim.3
- Extrude.2

$r(Pt4) = 47.099mm = (Pitch\ diameter: Pd/2) + ((Addendum\ diameter: Ad/2) - (Pitch\ diameter: Pd/2)) * .33333$

$r(Pt5) = 49.766mm = (Pitch\ diameter: Pd/2) + ((Addendum\ diameter: Ad/2) - (Pitch\ diameter: Pd/2)) * .66667$

$r(Pt6) = 52.432mm = Addendum\ diameter: Ad/2$

d) Mouse-over the radius and pick edit formula

a) Pick the Circle icon

c) Support at plane YZ

b) Center at 0,0,0

Circle Definition

Circle type: Center and radius

Center: Line.2Vertex

Support: Absolute Axis System\YZ

Radius: 34.432mm

Circle Limitations

Start: 85deg

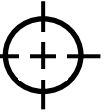
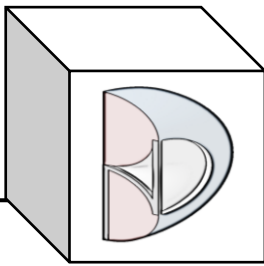
End: 444deg

☐ Geometry on support

☐ Axis Computation

Axis Direction: No selection

OK Cancel Preview



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

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

a) Double pick the formula Dedendum diameter: Dd

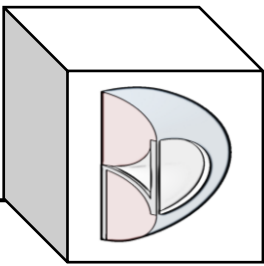
c) Pick OK

Formula Editor: '<Geometrical Set.1> \Circle.2 Radius'

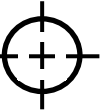
<Dedendum diameter: Dd> / 2

Dictionary	Members of Parameters	Members of Length
Parameters	All	'Pitch diameter: Pd'
Design Table	Renamed parameters	'Base diameter: Bd'
Operators	Length	'Addendum diameter: Ad'
Pointer on value function	Real	'Dedendum diameter: Dd'
Point Constructors	Boolean	'Tooth radius at dedendum circle: tr'
Law	Angle	'r (Pt1)'
Operations Constructors	String	'r (Pt2)'
	Feature	

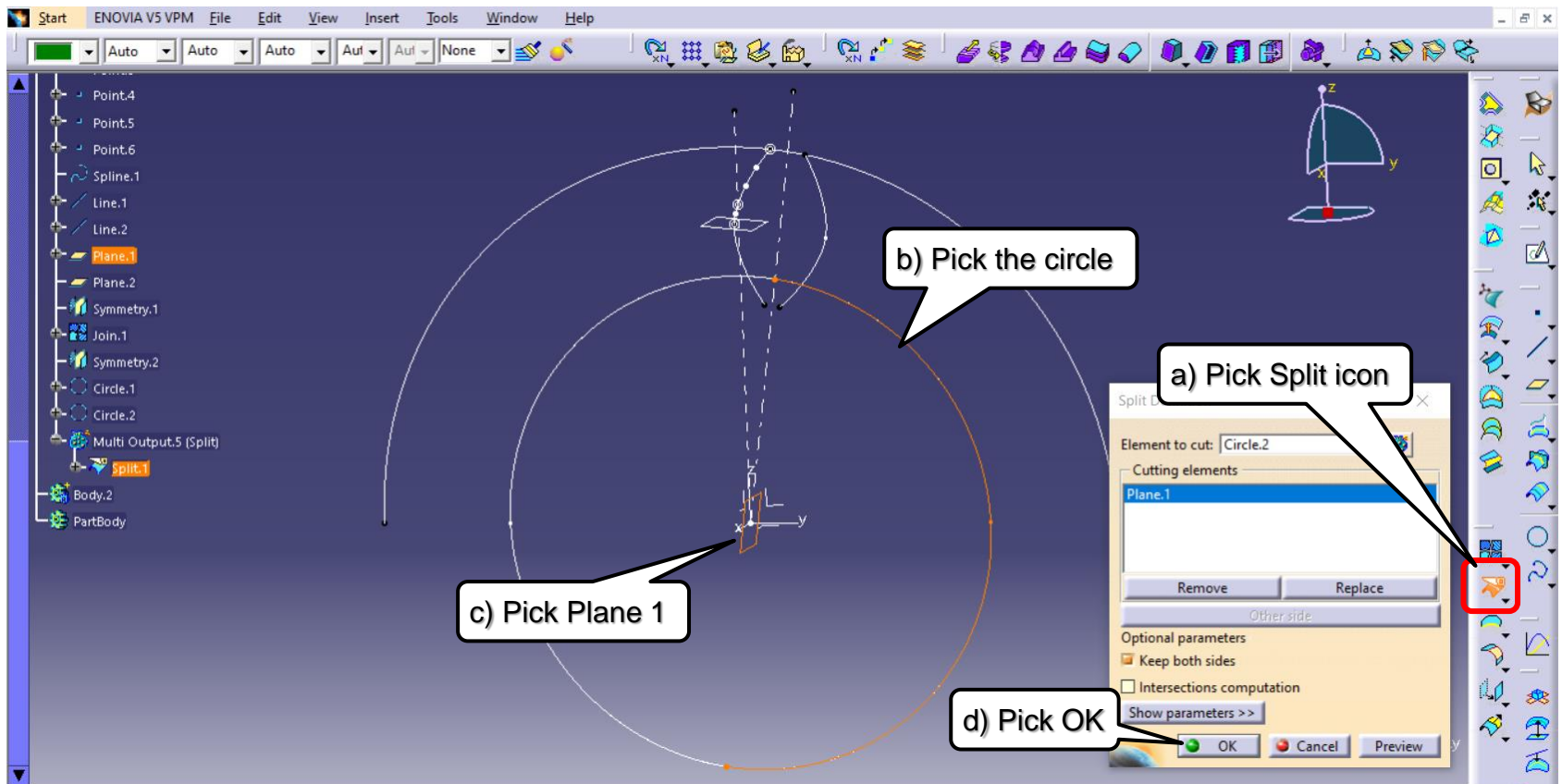
Dedendum diameter: Dd 68.865mm

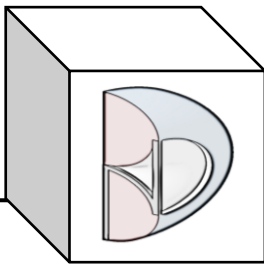


BND TechSource



- Split the dedendum circle with Plane 1.





BND TechSource

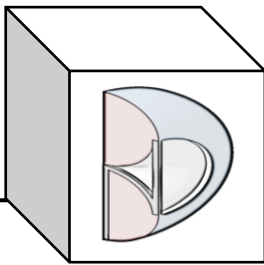


- Trim the tooth profile.

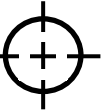
The screenshot shows the ENOVIA V5 VPM software interface. The main 3D model displays a gear-like tooth profile. Several callouts with arrows point to specific elements in the model and the software interface:

- a) Pick the Corner icon**: Points to the 'Corner' icon in the bottom-right toolbar.
- b) Pick right side of the dedendum circle**: Points to the right side of the dedendum circle in the 3D model.
- c) Pick the Symmetry of the Join**: Points to the symmetry line in the 3D model.
- d) Mouse-over the Radius and pick edit formula**: Points to the 'Edit formula' button in the 'Corner Definition' dialog.
- e) Double pick the formula 'tooth radius at dedendum circle: tr'**: Points to the formula 'tooth radius at dedendum circle: tr' in the 'Formula Editor'.
- f) Pick OK**: Points to the 'OK' button in the 'Corner Definition' dialog.
- g) Pick OK**: Points to the 'OK' button in the 'Formula Editor'.

The 'Formula Editor' shows the formula 'tooth radius at dedendum circle: tr' and a list of parameters including 'Pitch dia: Pd', 'Base dia: Bd', 'Addendum parameter: Ad', 'Dedendum parameter: Dd', 'tooth radius at dedendum circle: tr', 'r (Pt1)', and 'r (Pt2)'. The 'Corner Definition' dialog shows 'Corner Type: Corner On Support', 'Element 1: Split.1', 'Element 2: Symmetry.2', and 'Radius: 3.04mm'.



BND TechSource



- Trim the tooth profile.

c) Pick the Join

b) Pick left side of the dedendum circle

a) Pick the Corner icon

e) Double pick the formula 'tooth radius at dedendum circle: tr'

d) Mouse-over the Radius and pick edit formula

g) Pick OK

f) Pick OK

Formula Editor: 'Geometrical Set.1\Corner.3\Radius'

Dictionary	Members of Parameters	Members	With
Parameters	All	'Pitch dia: Pd'	
Design Table	Renamed parameters	'Base dia: Bd'	
Operators	Length	'Addendum parameter: Ad'	
Pointer on value function	Real	'Dedendum parameter: Dd'	
Point Constructors	Boolean	'tooth radius at dedendum circle: tr'	
Law	Angle	'r (Pt1)'	
Operations Constructors	String	'r (Pt2)'	
	Feature		

tooth radius at dedendum circle: tr

3.04mm

Corner Definition

Corner Type: Corner On Support

☐ Corner On Vertex

Element 1: Split.2

☒ Trim element 1

Element 2: Join.1

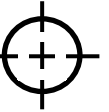
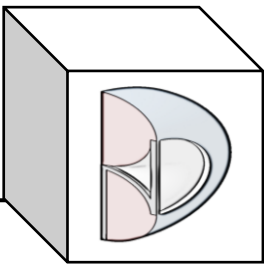
☐ Trim element 2

Support: Default (Plane)

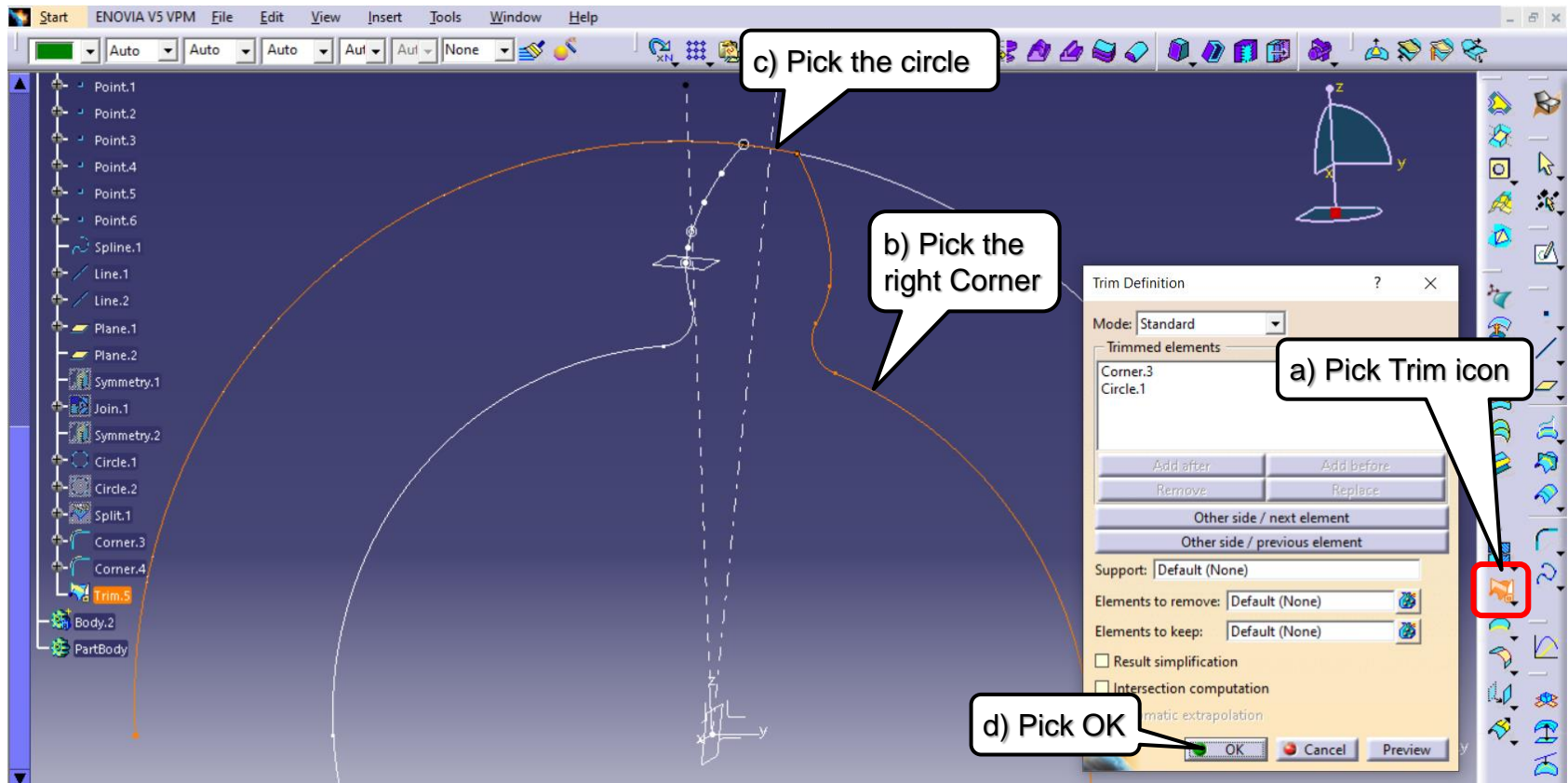
Radius: 3.04mm

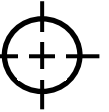
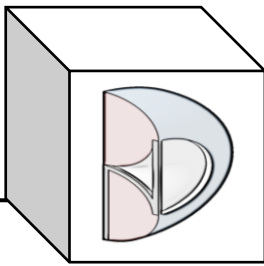
Next Solution

OK Cancel Preview

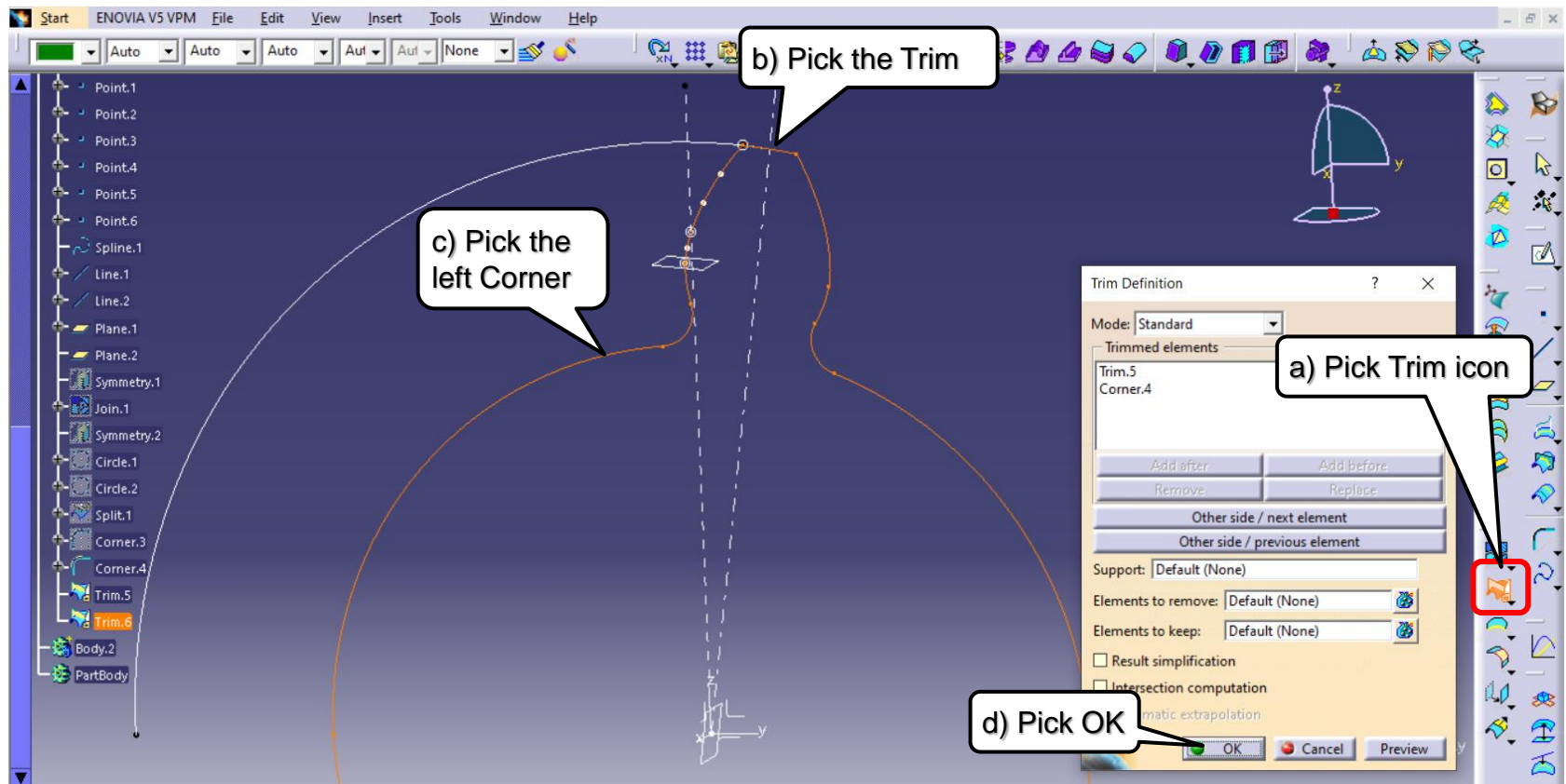


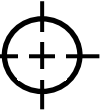
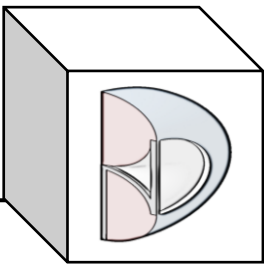
- Trim the tooth profile.



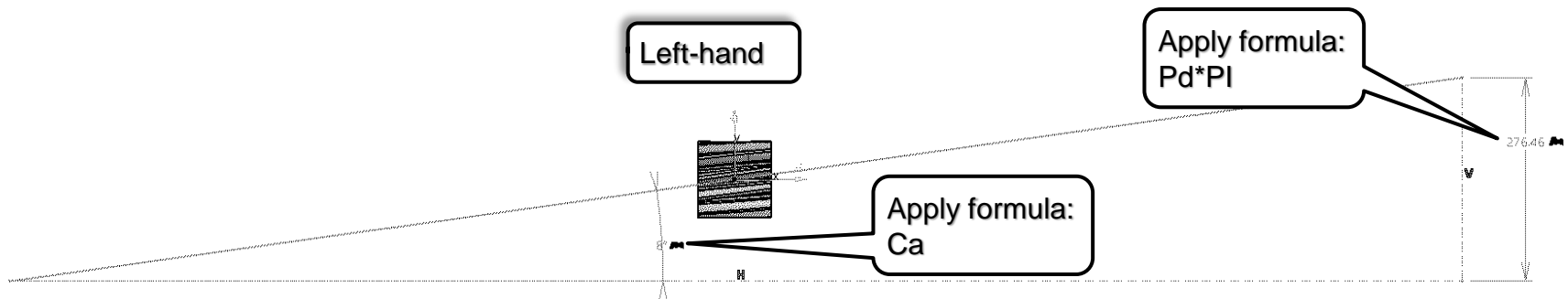
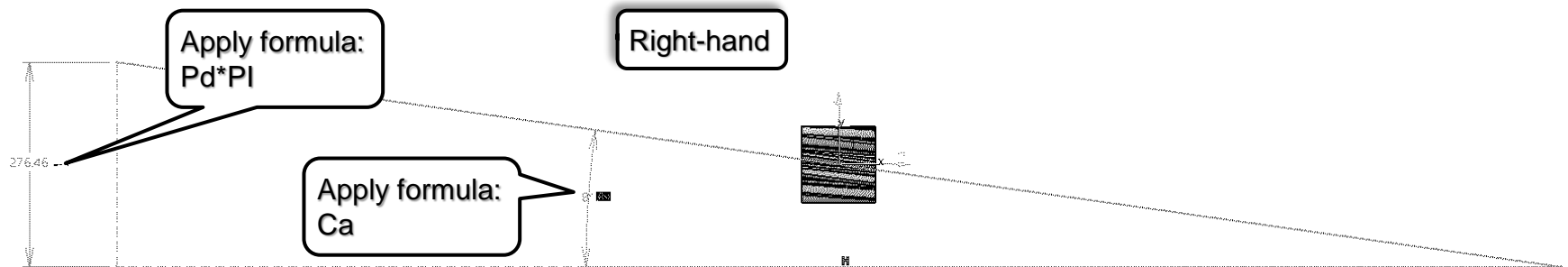


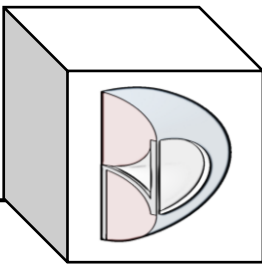
- Trim the tooth profile.



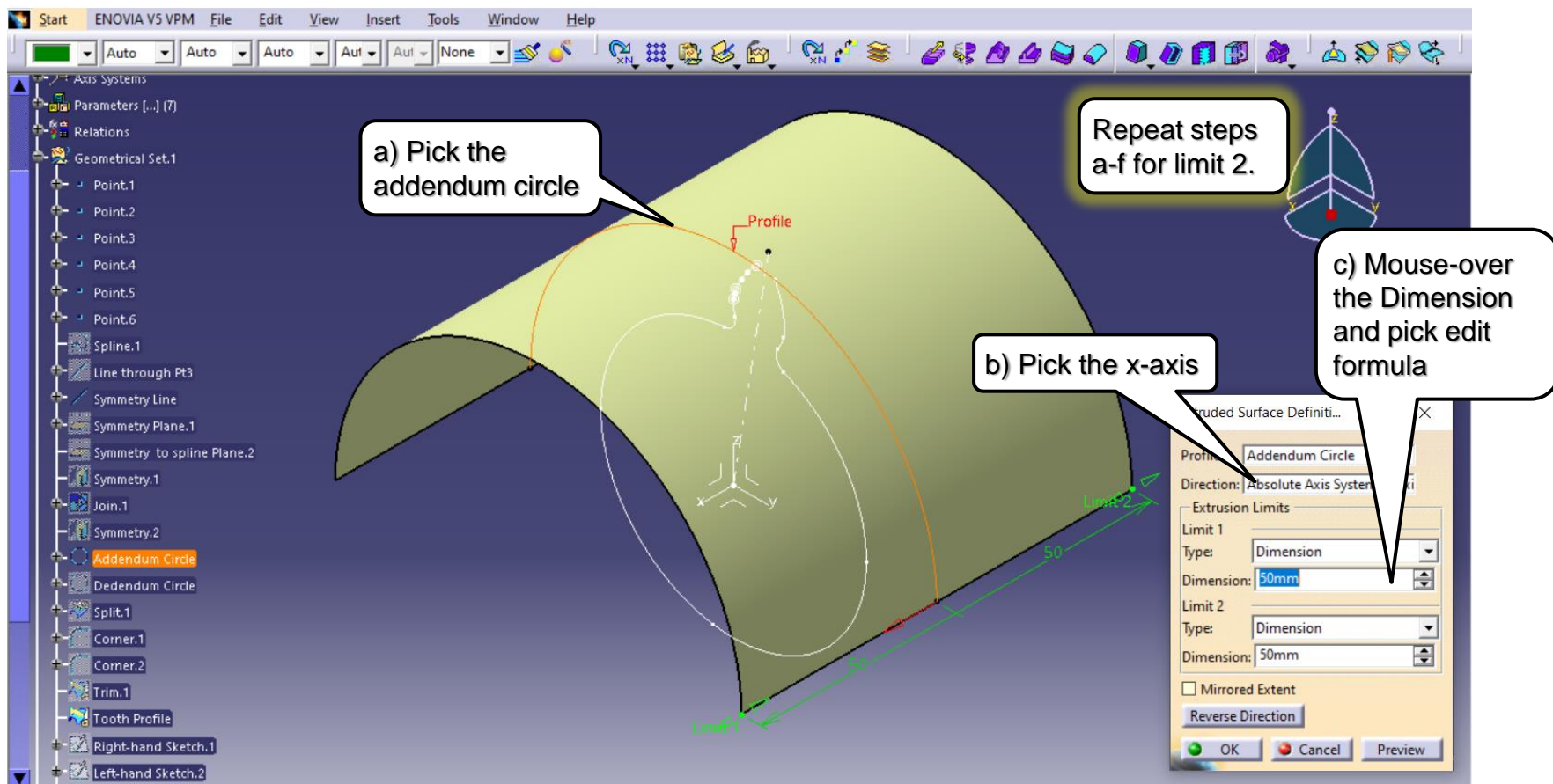


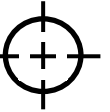
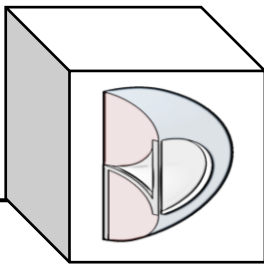
- Create both Right & Left-hand Sketches on XY plane.





- Extrude a surface using the Addendum circle.





- Apply the formula (Face width: $Fw / 2$) for the limits 1 & 2.

Repeat steps a-f for limit 2.

d) Double pick the formula Face width: Fw

e) Apply the formula 'Face width: Fw'/2

f) Pick OK

Formula Editor: 'Geometrical Set.1\Extrude.2\Lim1'

Geometrical Set.1\Extrude.2\Lim1

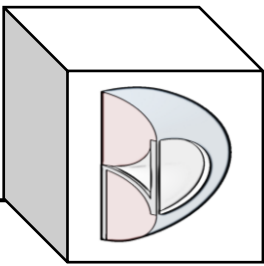
'Face width: Fw' / 2

Dictionary	Members of Parameters	Members of Length
Parameters	All	'Absolute Axis System\Origin\Z'
Design Table	Renamed parameters	'Face width: Fw'
Operators	Length	'Module: m'
Pointer on value function	Real	'Pitch diameter: Pd'
Point Constructors	Boolean	'Base diameter: Bd'
Law	Angle	'Addendum diameter: Ad'
Operations Constructors	CstAttr_Mode	'Dedendum diameter: Dd'
	Plane	

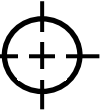
Face width: Fw

100mm

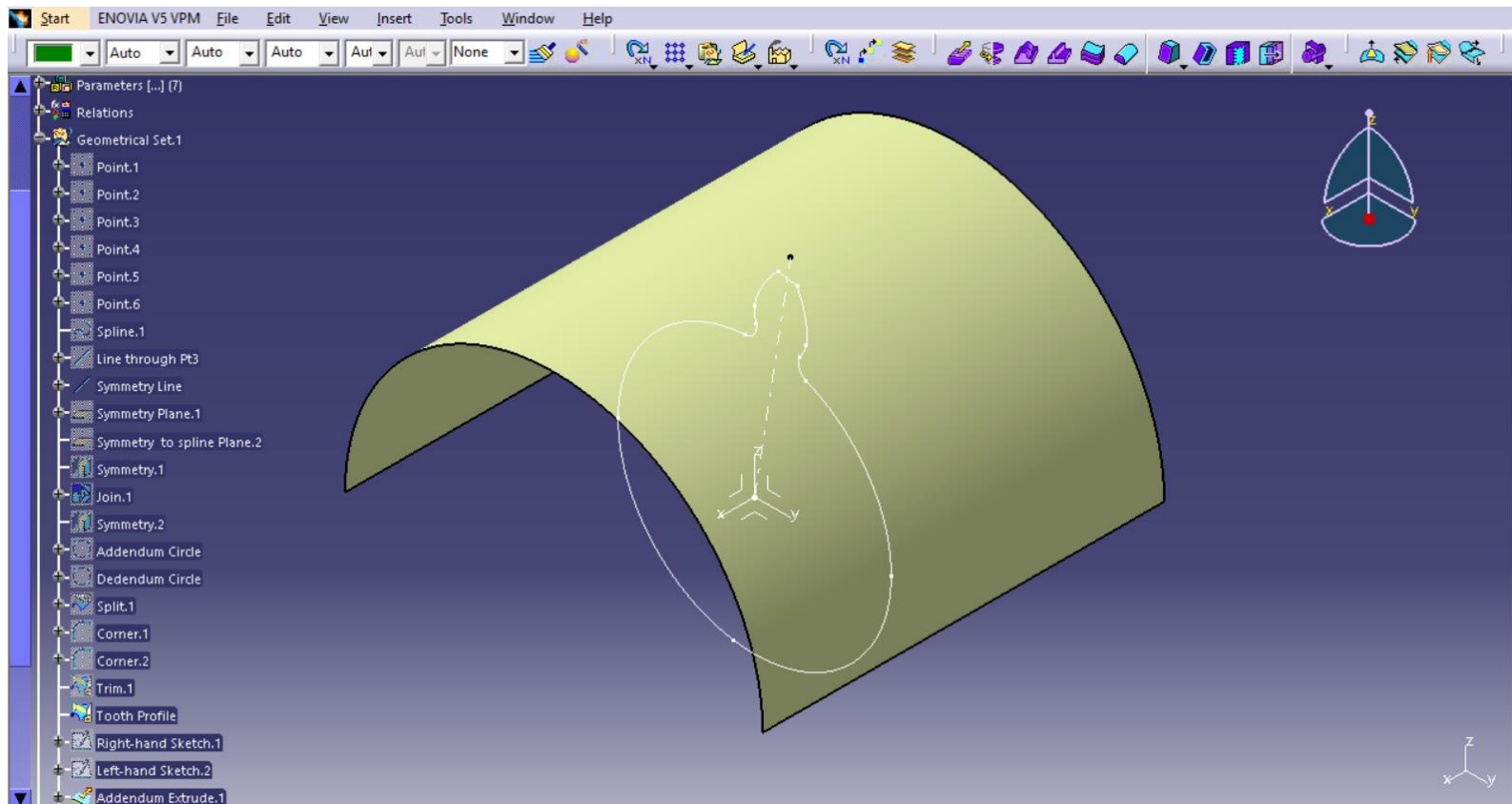
OK Cancel

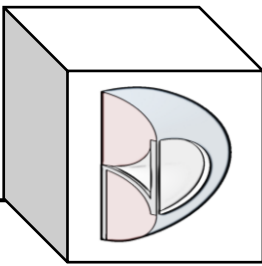


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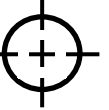


- Clean up (hide) the construction geometry.

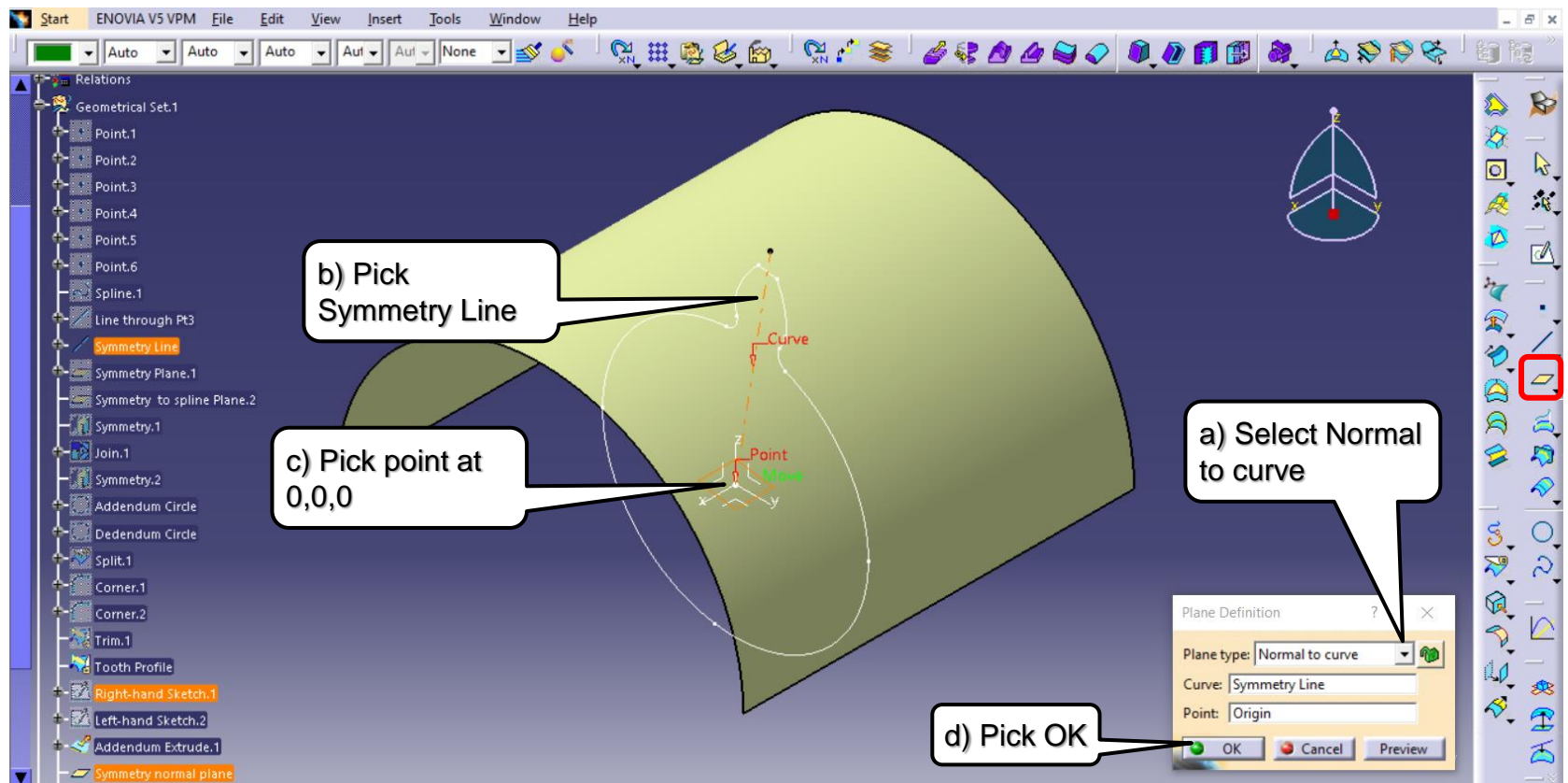


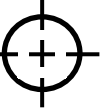
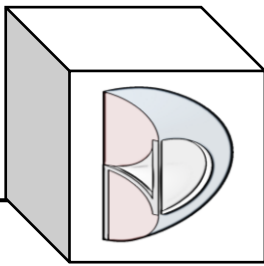


BND TechSource

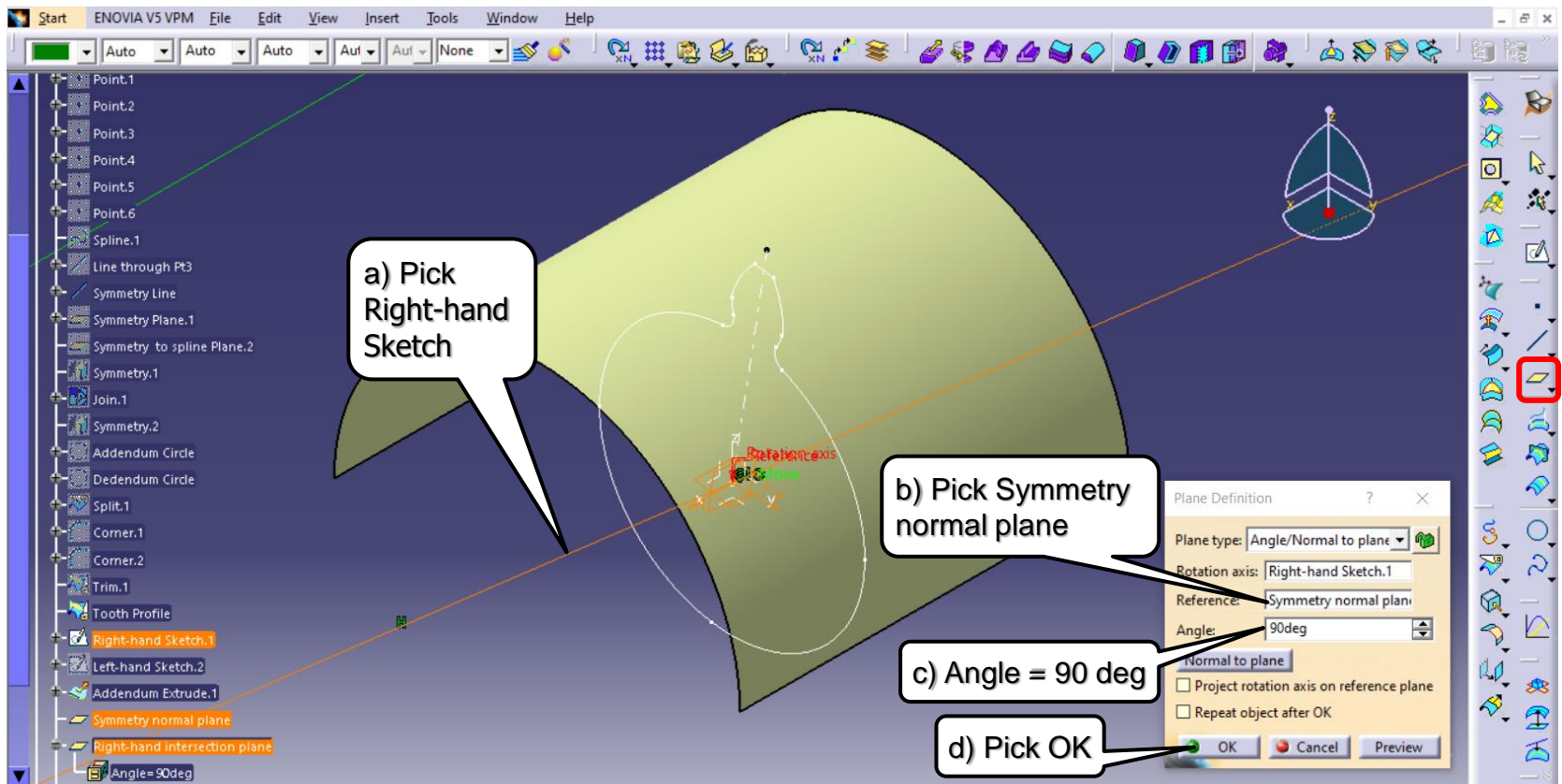


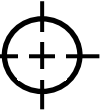
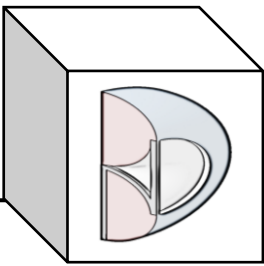
- Create Symmetry normal plane.



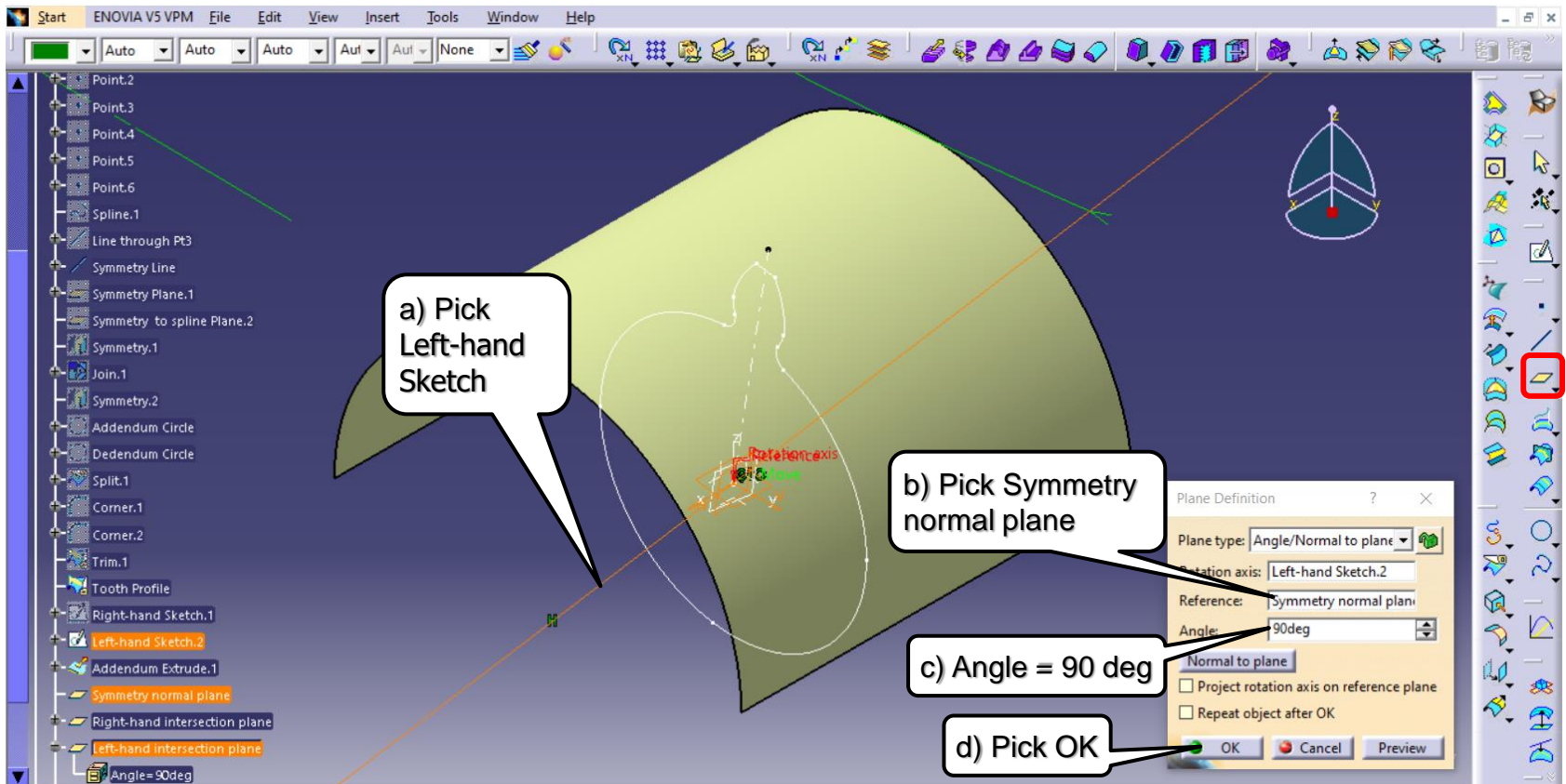


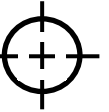
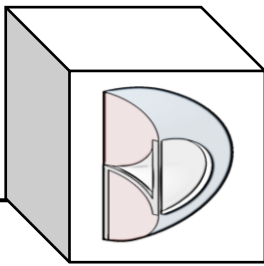
- Create the Right-hand intersection plane through Right-hand Sketch normal to the Symmetry normal plane.



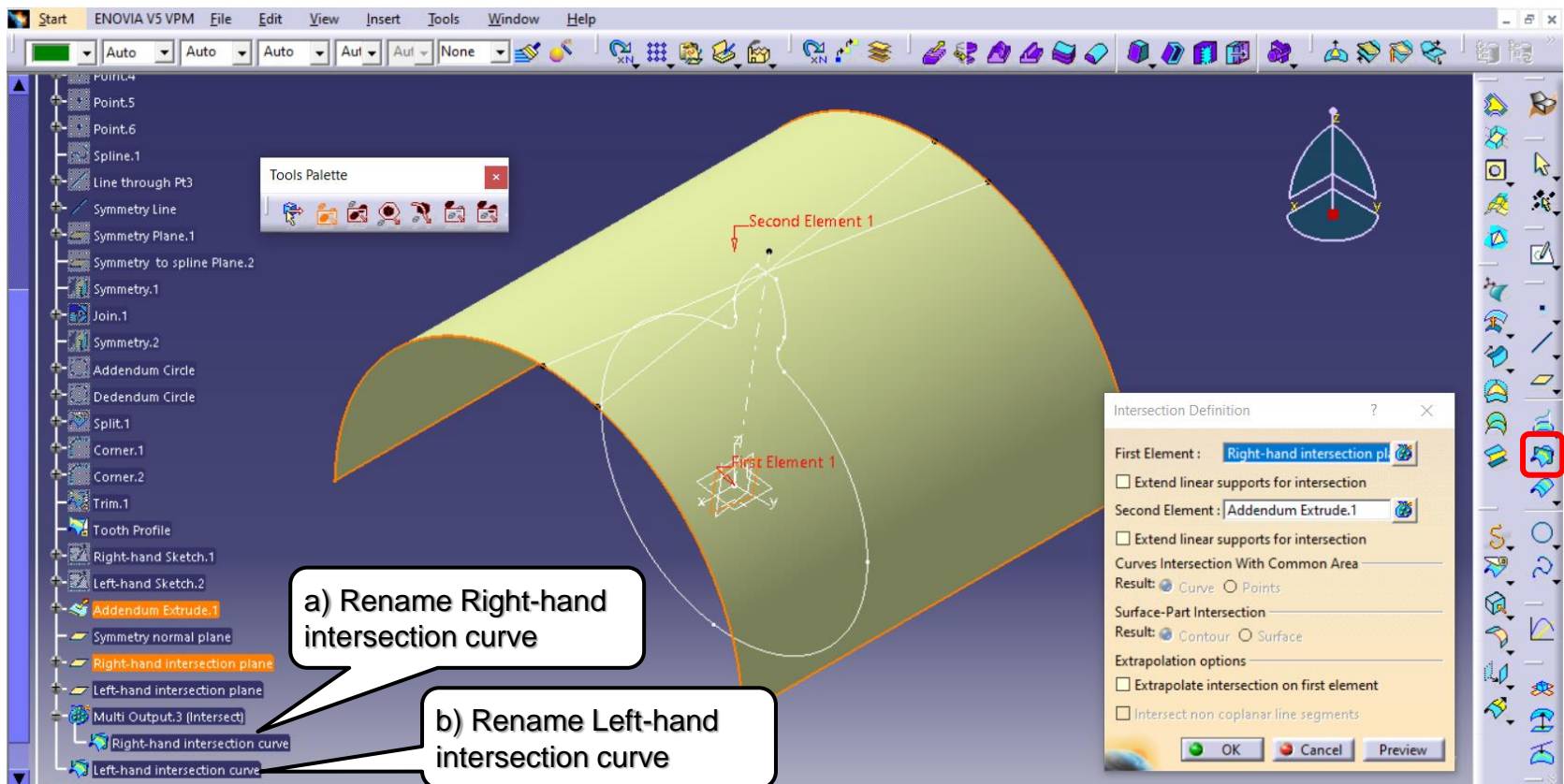


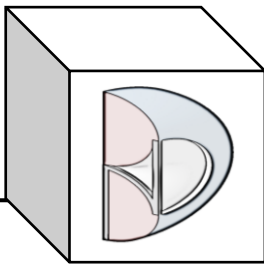
- Create the Left-hand intersection plane through Left-hand Sketch normal to the Symmetry normal plane.



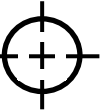


- Create the Right-hand and Left-hand intersection curves between the intersection planes and the extruded surface.

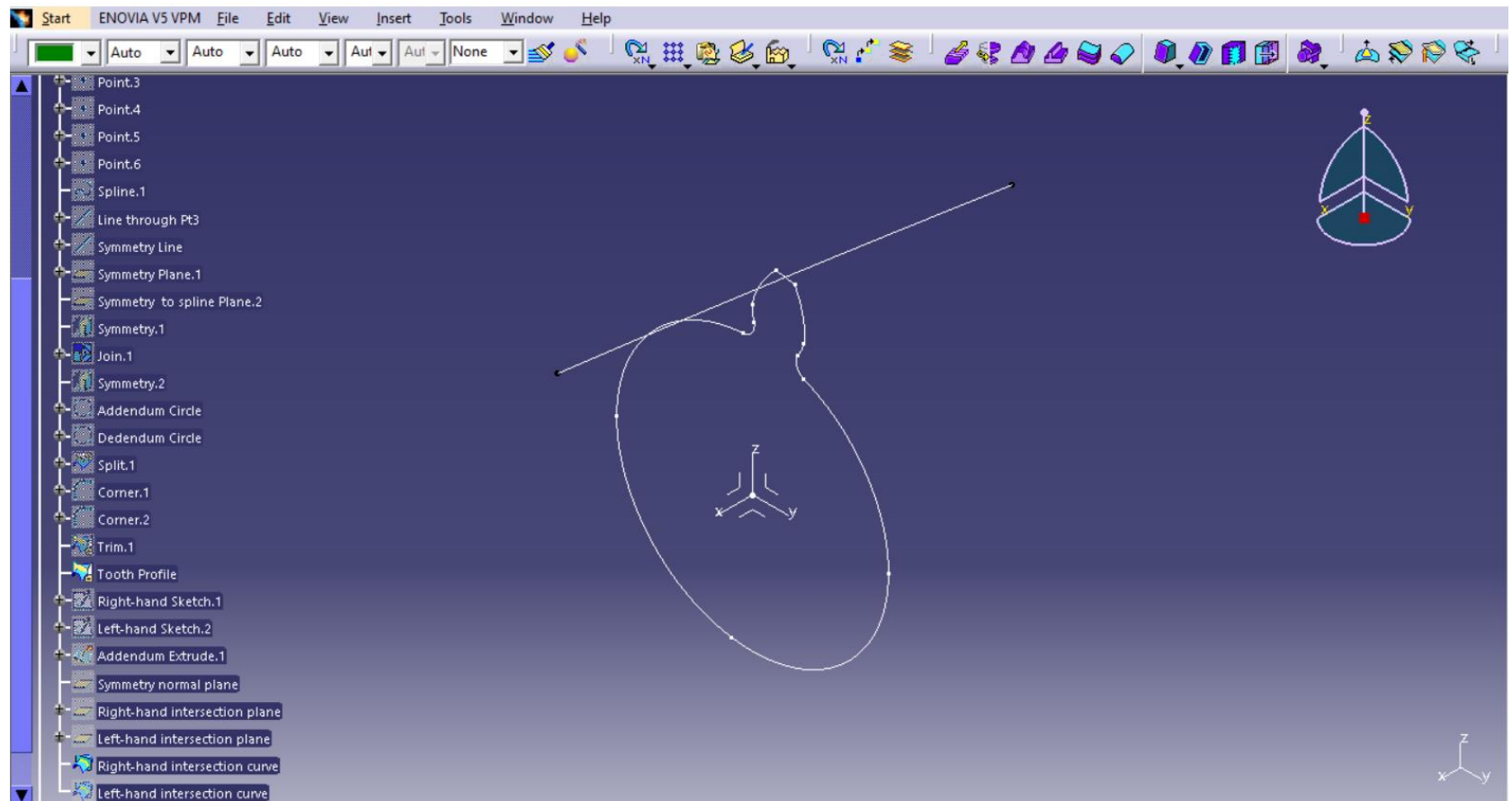


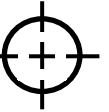
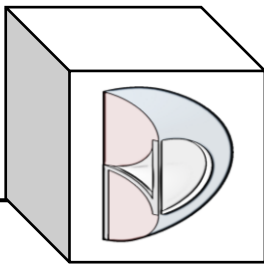


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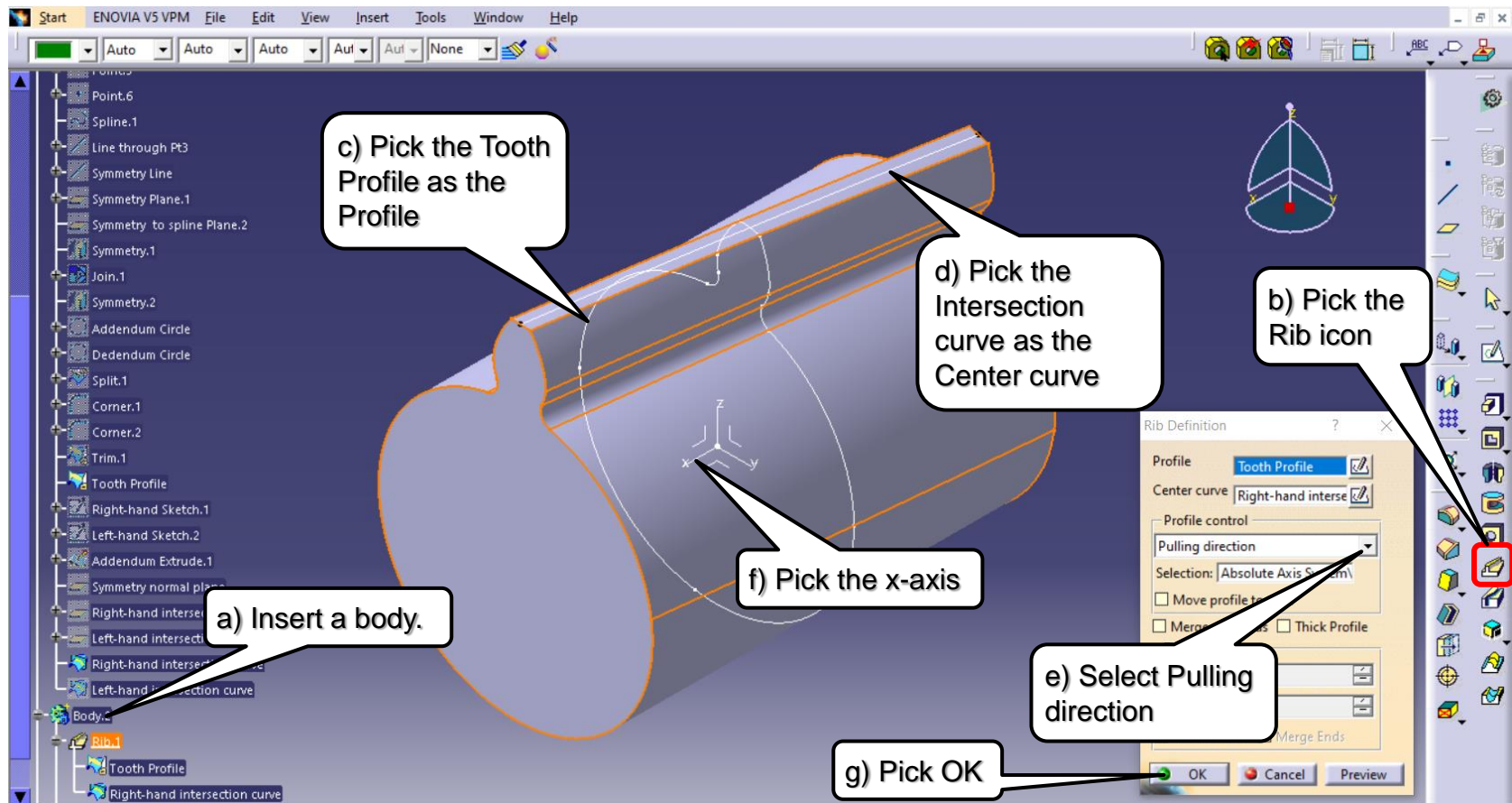


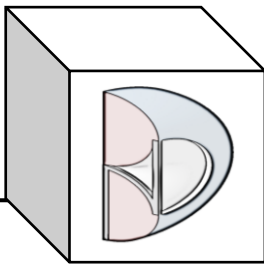
- Clean up (hide) the construction geometry.



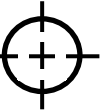


- Create a solid rib using the Tooth Profile Trim as the Profile.

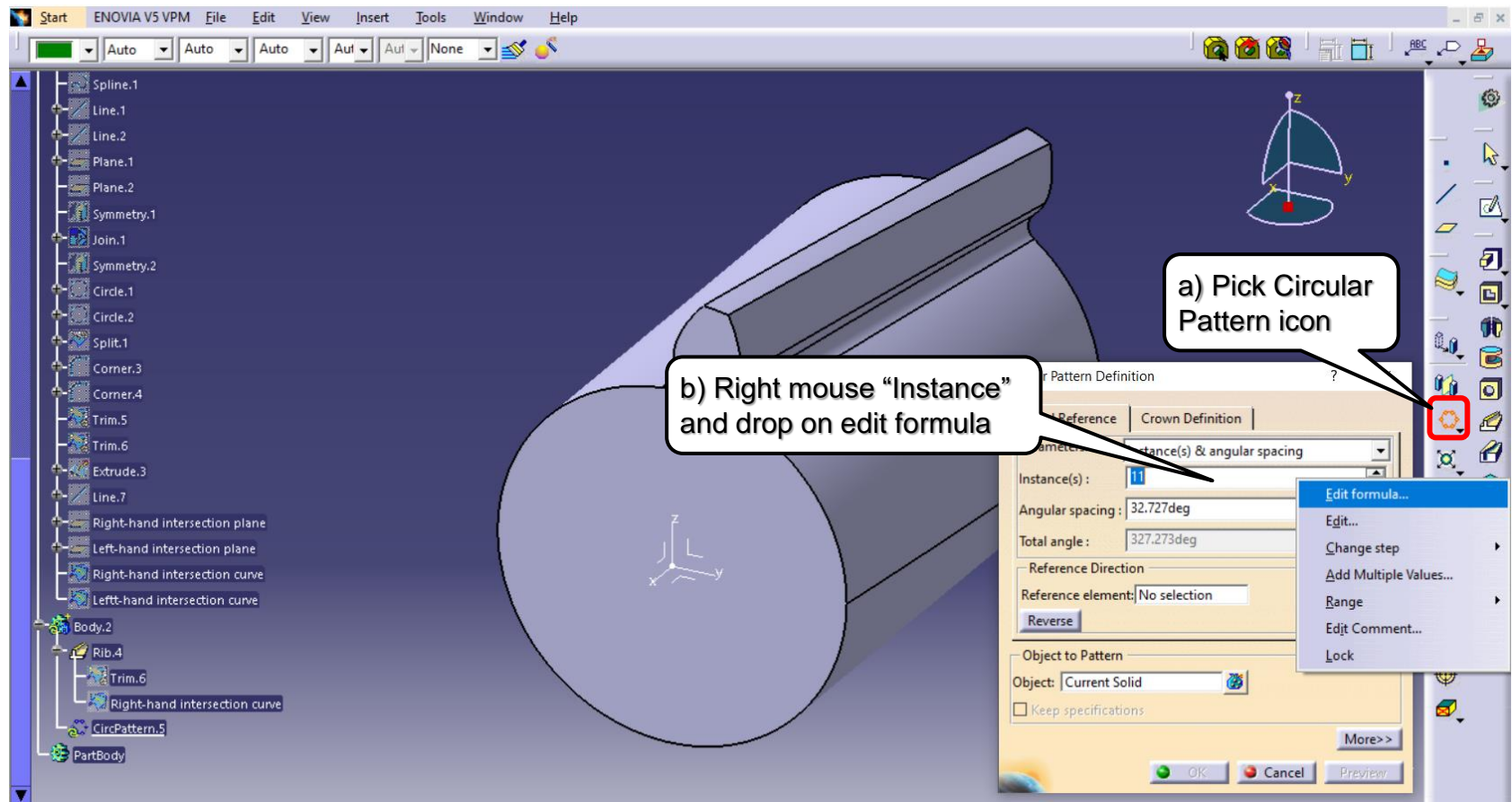


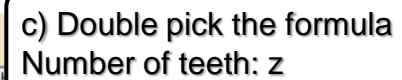


BND TechSource

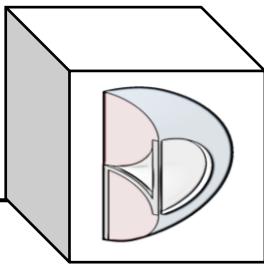


- Create the pattern for the number of teeth.

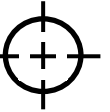




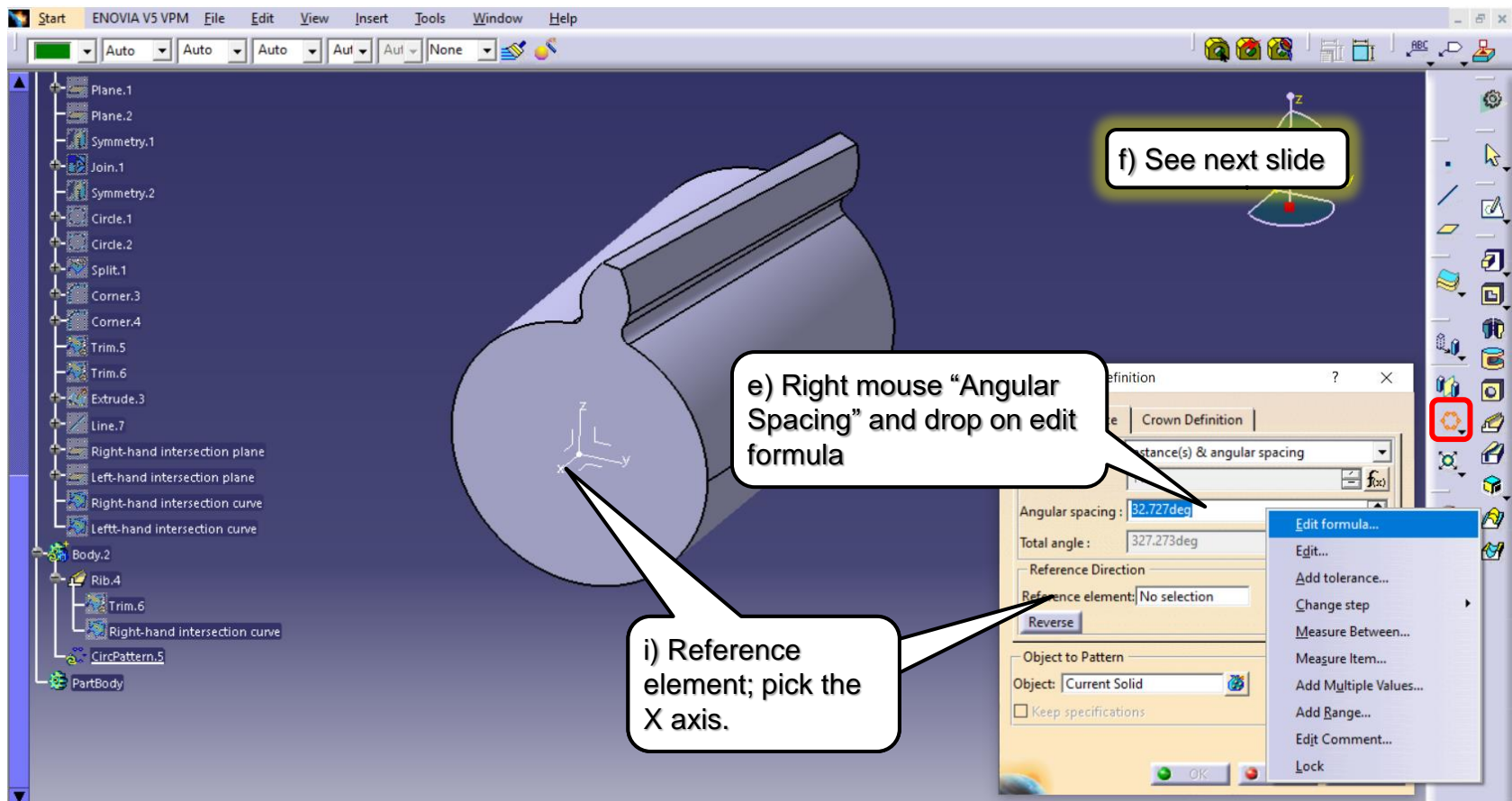
d) Pick OK

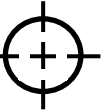
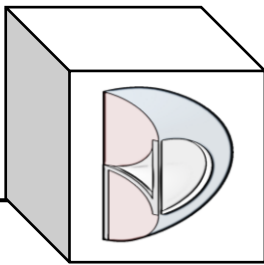


BND TechSource



- Create the pattern for the number of teeth.





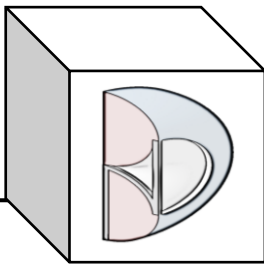
- Create the pattern for the number of teeth.

The screenshot shows the ENOVIA V5 VPM software interface. The main window displays a 3D model of a gear-like part with a circular cutout. The left sidebar shows a tree view of the model's features, including Plane.1, Plane.2, Symmetry.1, Join.1, Symmetry.2, Circle.1, Circle.2, Split.1, Corner.3, Corner.4, Trim.5, Trim.6, Extrude.3, Line.7, Right-hand intersection plane, Left-hand intersection plane, Right-hand intersection curve, Left-hand intersection curve, Body.2, Rib.4, Trim.6, Right-hand intersection curve, and CircPattern.5. The top menu bar includes Start, ENOVIA V5 VPM, File, Edit, View, Insert, Tools, Window, and Help. The top toolbar includes Auto, Auto, Auto, Auf, Auf, None, and a color selection tool. The right sidebar shows a 3D coordinate system with X, Y, and Z axes. A callout box labeled 'i) See previous slide' points to the 3D model. A callout box labeled 'g) Type 360 deg/ Number of teeth: z' points to the Formula Editor dialog box. The Formula Editor dialog box shows the formula '360deg/Number of teeth: z' and a list of parameters. The 'Number of teeth: z' parameter is selected. A callout box labeled 'h) Pick OK' points to the OK button in the Formula Editor dialog box.

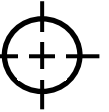
i) See previous slide

g) Type 360 deg/
Number of teeth: z

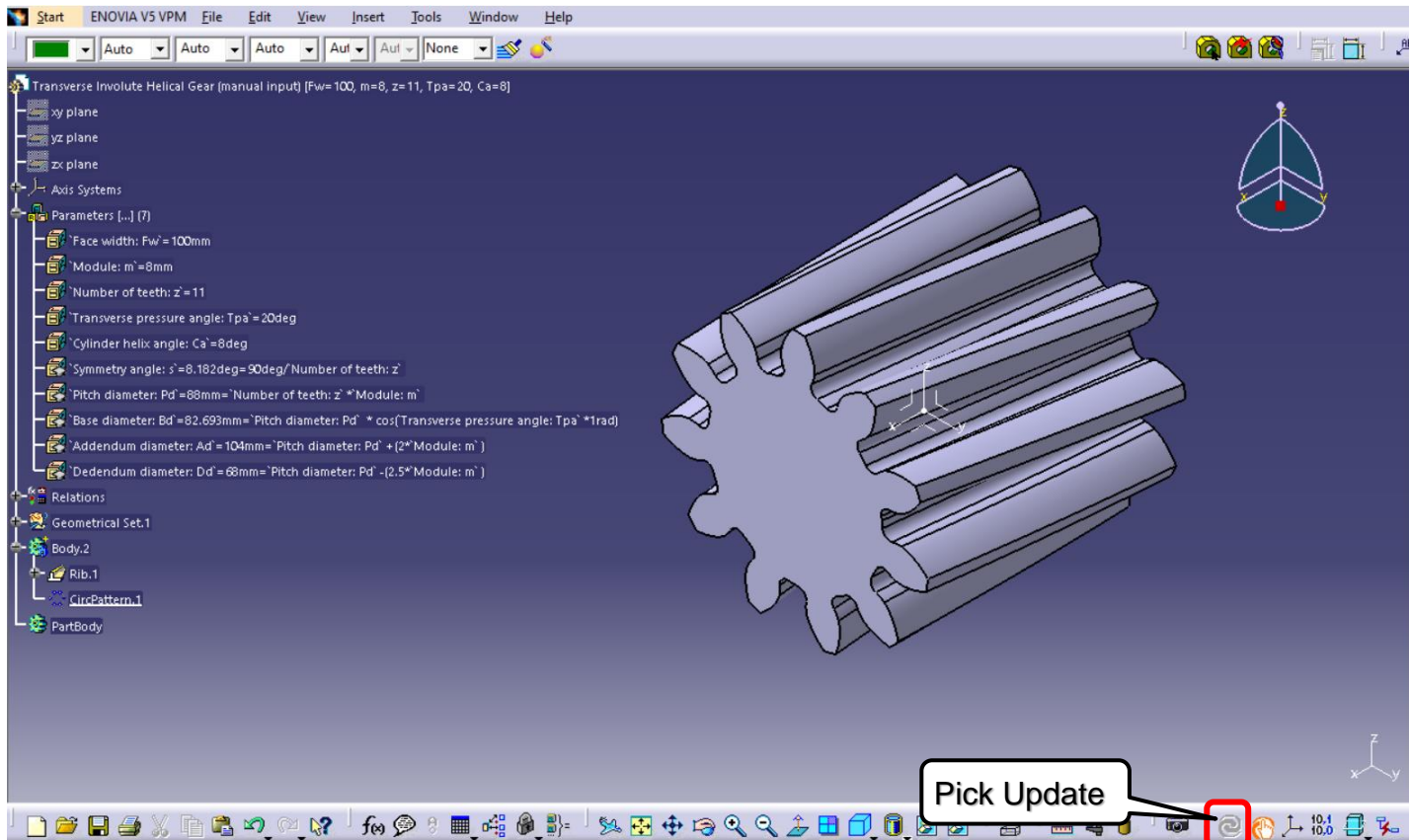
h) Pick OK

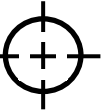
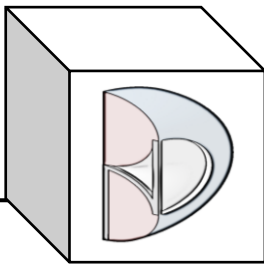


BND TechSource

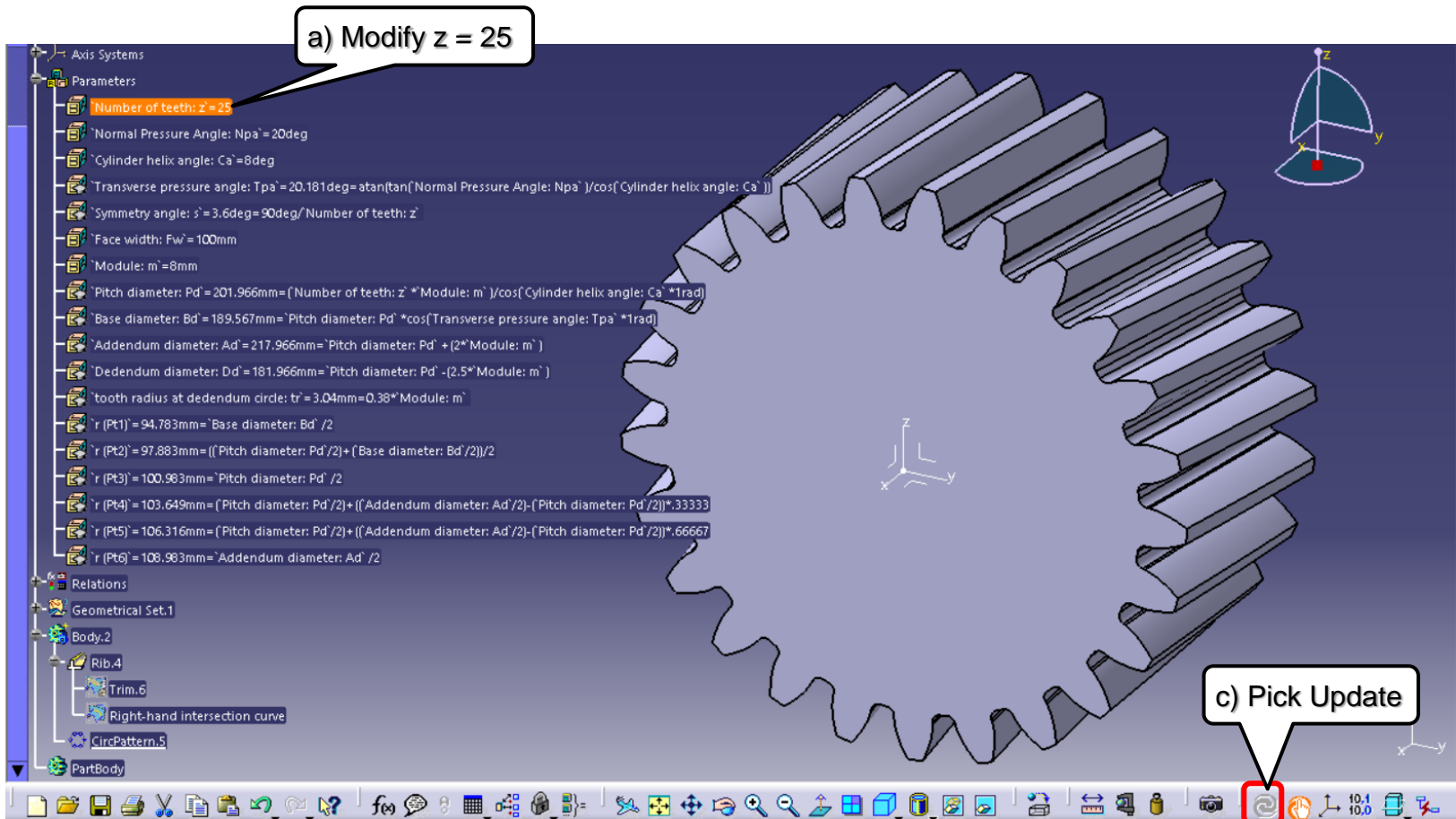


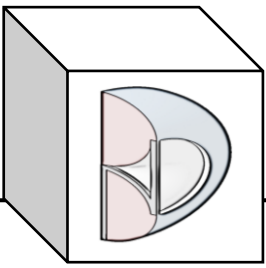
- And there you have it! An Involute Helical Gear which is modifiable through parameters.





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

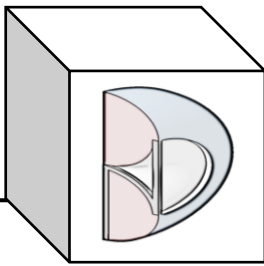




BND TechSource



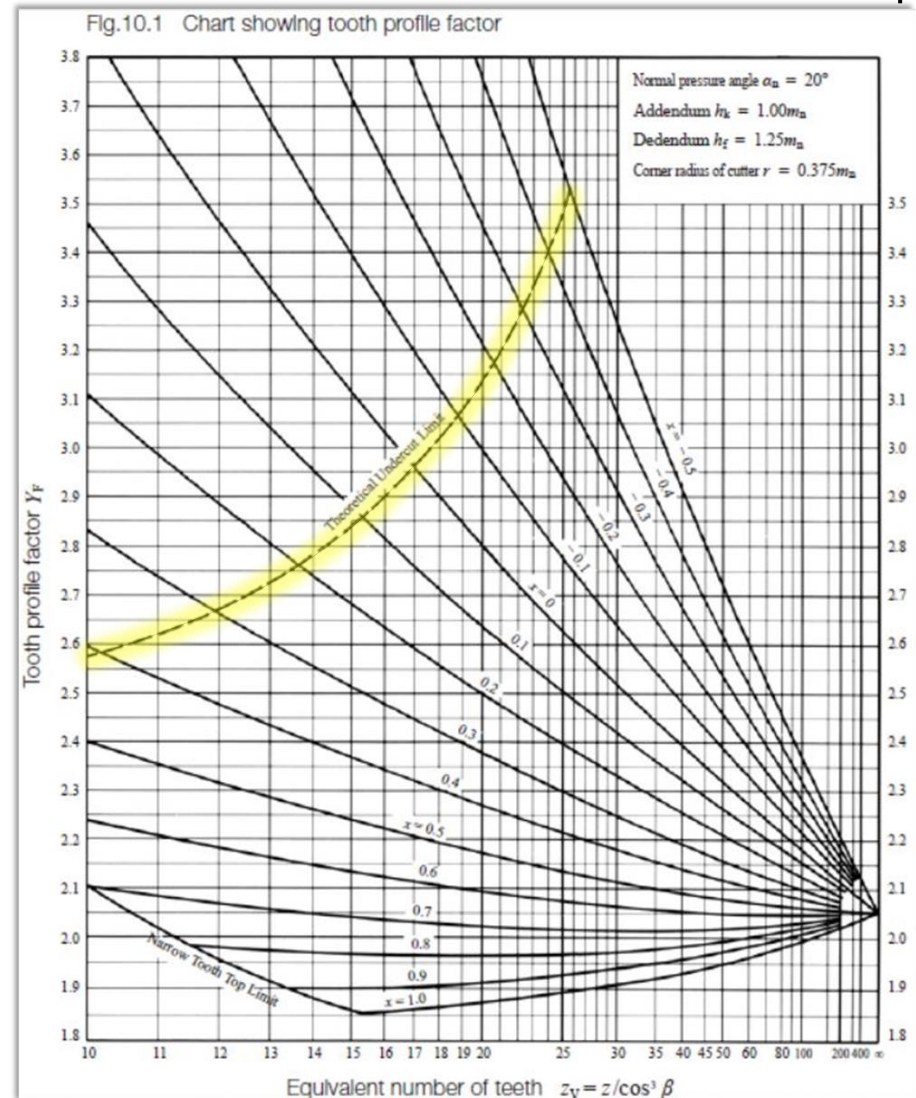
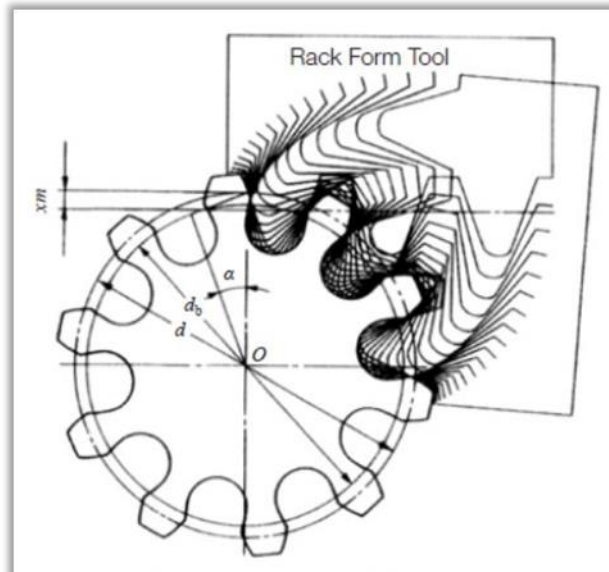
Undercutting

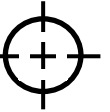
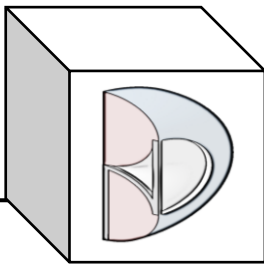


BND TechSource

UNDERCUTTING

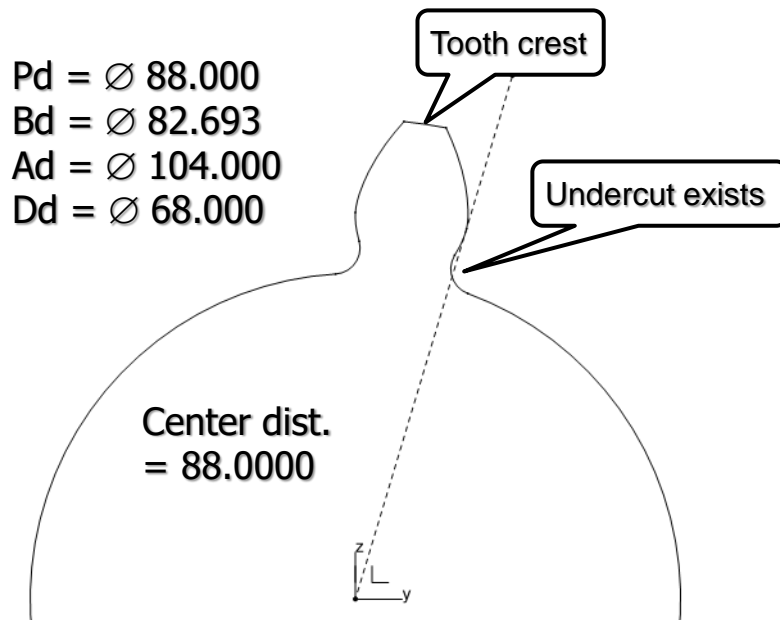
Undercutting occurs geometrically when the standard formulae allow for the dedendum circle to fall too far below the base circle. This can be rectified by adjusting both the addendum and dedendum circles.



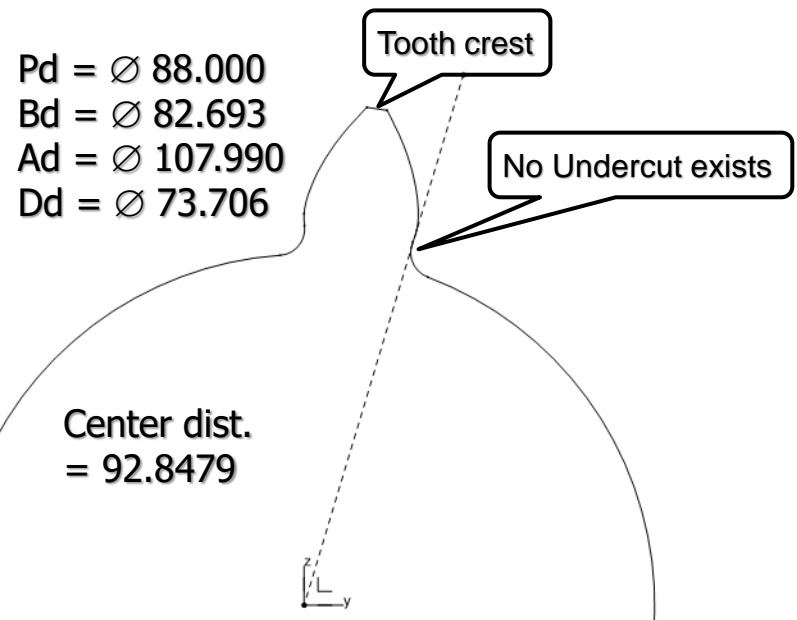


PROFILE SHIFT

- 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.



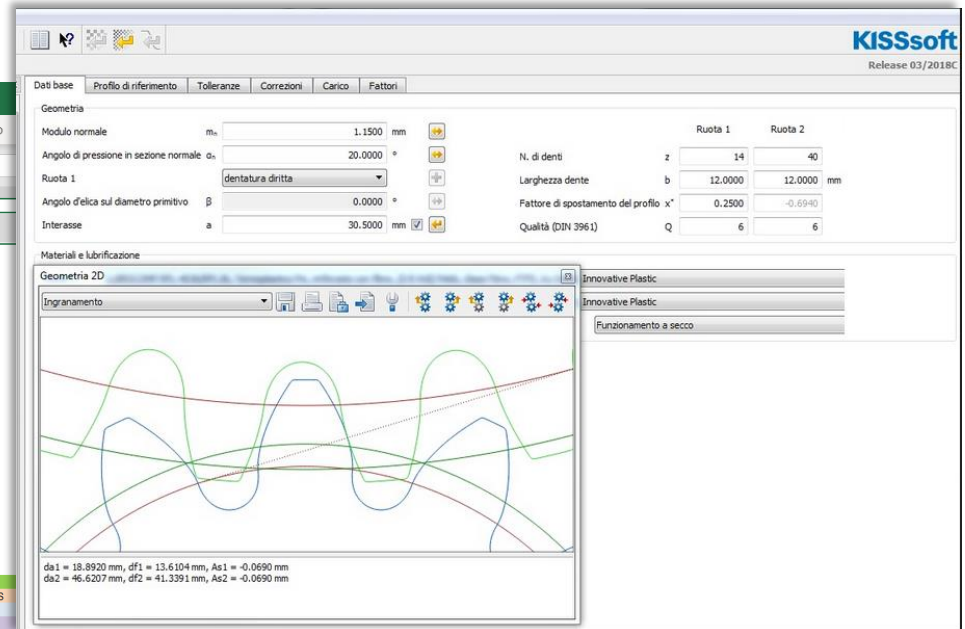
$x_1 = x_2 = 0$
No profile shift



$x_1 = x_2 = 0.3566$
With profile shift

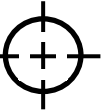
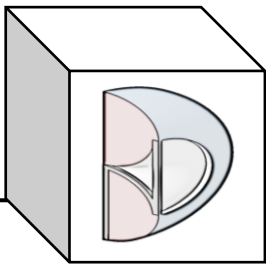


- By using a gear calculator (i.e. MS Excel) or a gear simulation software (i.e. KISSsoft) users can get the required values to optimize their design beyond the basic standard formulae we have used thus far.

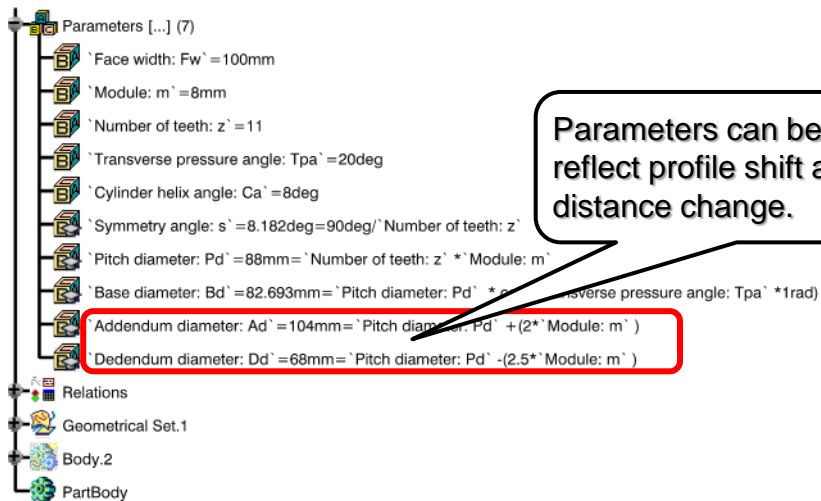


Rows 137 - 336 contain detailed explanation of Profile Shift from the KHK Technical Manual.

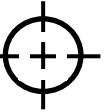
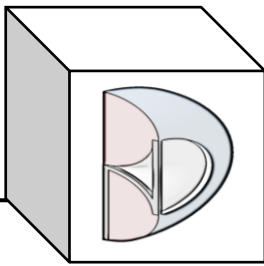
α (radians)	=	0.34907
$\tan \alpha$ (radians)	=	0.36397
$\text{inv } \alpha$	=	0.01490
α_w (radians)	=	0.34907
$\tan \alpha_w$ (radians)	=	0.36397
$\text{inv } \alpha_w$	=	0.01490
$\cos \alpha$ (radians)	=	0.93969
$\cos \alpha_w$ (radians)	=	0.93969



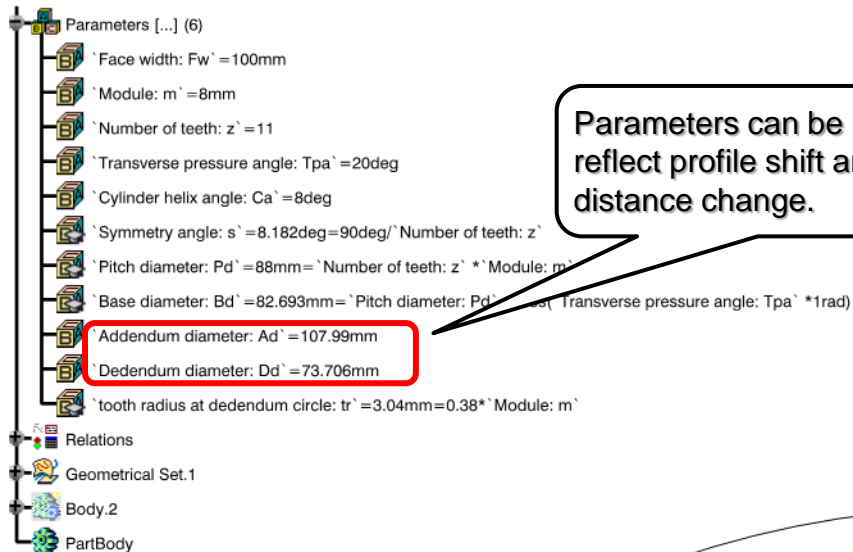
- Parameters for Ad & Dd from standard formulae (no profile shift).



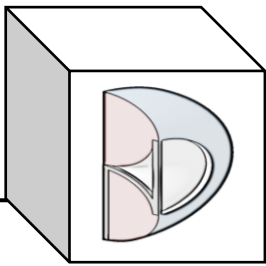
Transverse System		
	Gear 1	Gear 2
Fw =	100	100
m_t =	8	8
α_t (degrees) =	20	20
α_t (radians) =	0.3491	0.3491
β =	8	8
z =	11	11
x_t =	0.00000	0.00000
Fw =	100.000	100.000
m =	8	8
z =	11	11
Tpa =	20	20
Ca =	8	8
s =	8.182	8.182
Pd =	88.000	88.000
Bd =	82.693	82.693
Ad =	104.000	104.000
Dd =	68.000	68.000
tr =	3.040	3.040
a =	88.0000	(88.)
y =	0.00000	
α_{wt} =	20.0000	
Σx_n =	0.000000	0.0000
x_n =	0.0000	0.3566



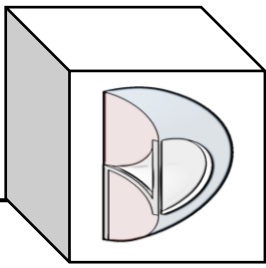
- Parameters for Ad & Dd from updated formulae (with profile shift).



Transverse System		
	Gear 1	Gear 2
$Fw =$	100	100
$m_t =$	8	8
$\alpha_t (\text{degrees}) =$	20	20
$\alpha_t (\text{radians}) =$	0.3491	0.3491
$\beta =$	8	8
$z =$	11	11
$x_t =$	0.35660	0.35660
	(.3566)	
$Fw =$	100.000	100.000
$m =$	8	8
$z =$	11	11
$Tpa =$	20	20
$Ca =$	8	8
$s =$	8.182	8.182
$Pd =$	88.000	88.000
$Bd =$	82.693	82.693
$Ad =$	107.990	107.990
$Dd =$	73.706	73.706
$tr =$	3.040	3.040
$a =$	92.8479	(88.)
$y =$	0.60599	
$\alpha_{wt} =$	27.0477	
$\Sigma x_n =$	0.713210	0.3566
		0.3566
$x_n =$	0.3566	0.3566



- We now have a “template” part for our Transverse Module 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]
- Next we will look at using CATIA V5 to create the Normal Module Involute Helical Gear.



- Conclusion:

This is an example of designing Transverse Module 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!

