

# PSTricks

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## **pst-euclide**

A PSTricks package for drawing geometric pictures; v.1.60a

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The `pst-eucl` package allow the drawing of Euclidean geometric figures using  $\text{\LaTeX}$  macros for specifying mathematical constraints. It is thus possible to build point using common transformations or intersections. The use of coordinates is limited to points which controlled the figure.

I would like to thanks the following persons for the help they gave me for development of this package:

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- Alain Delplanque for its modification propositions on automatic placing of points name and the ability of giving a list of points in `\pstGeonode`.

Thanks to: Manuel Luque; Thomas Söll.

## Contents

<b>I. The package</b>	<b>5</b>
<b>1. Special specifications</b>	<b>5</b>
1.1. PSTricks Options . . . . .	5
1.2. Conventions . . . . .	5
<b>2. Basic Objects</b>	<b>5</b>
2.1. Points . . . . .	5
2.2. Segment mark . . . . .	7
2.3. Triangles . . . . .	7
2.4. Angles . . . . .	8
2.5. Lines, half-lines and segments . . . . .	9
2.6. Circles . . . . .	10
2.7. Circle arcs . . . . .	11
2.8. Curved abscissa . . . . .	11
2.9. Generic curve . . . . .	12
<b>3. Geometric Transformations</b>	<b>12</b>
3.1. Central symmetry . . . . .	13
3.2. Orthogonal (or axial) symmetry . . . . .	13
3.3. Rotation . . . . .	13
3.4. Translation . . . . .	14
3.5. Homothetie . . . . .	14
3.6. Orthogonal projection . . . . .	15
<b>4. Special object</b>	<b>15</b>
4.1. Midpoint . . . . .	15
4.2. Triangle center of gravity . . . . .	15
4.3. Centre of the circumcircle of a triangle . . . . .	16
4.4. Perpendicular bisector of a segment . . . . .	16
4.5. Bisectors of angles . . . . .	17
<b>5. Intersections</b>	<b>17</b>
5.1. Line-Line . . . . .	18
5.2. Circle-Line . . . . .	18
5.3. Circle-Circle . . . . .	19
5.4. Function-function . . . . .	20
5.5. Function-line . . . . .	21
5.6. Function-Circle . . . . .	21
<b>6. Helper Macros</b>	<b>22</b>

<b>II. Examples gallery</b>	<b>24</b>
<b>A. Basic geometry</b>	<b>24</b>
A.1. Drawing of the bissector . . . . .	24
A.2. Transformation de polygones et courbes . . . . .	25
A.3. Triangle lines . . . . .	26
A.4. Euler circle . . . . .	27
A.5. Orthocenter and hyperbola . . . . .	28
A.6. 17 sides regular polygon . . . . .	29
A.7. Circles & tangents . . . . .	31
A.8. Fermat's point . . . . .	33
A.9. Escribed and inscribed circles of a triangle . . . . .	34
<b>B. Some locus points</b>	<b>36</b>
B.1. Parabola . . . . .	36
B.2. Hyperbola . . . . .	37
B.3. Cycloid . . . . .	37
B.4. Hypocycloids (Astroid and Deltoid) . . . . .	39
<b>C. Lines and circles envelope</b>	<b>41</b>
C.1. Conics . . . . .	41
C.2. Cardioid . . . . .	42
<b>D. Homotethy and fractals</b>	<b>43</b>
<b>E. hyperbolic geometry: a triangle and its altitudes</b>	<b>44</b>
<b>F. List of all optional arguments for pst-eucl</b>	<b>45</b>
<b>References</b>	<b>46</b>

## Part I.

### The package

#### 1. Special specifications

##### 1.1. PSTricks Options

The package activates the `\SpecialCoor` mode. This mode extend the coordinates specification. Furthermore the plotting type is set to `dimen=middle`, which indicates that the position of the drawing is done according to the middle of the line. Please look at the user manual for more information about these setting.

At last, the working axes are supposed to be (ortho)normed.

##### 1.2. Conventions

For this manual, I used the geometric French conventions for naming the points:

- $O$  is a centre (circle, axes, symmetry, homothety, rotation);
- $I$  defined the unity of the abscissa axe, or a midpoint;
- $J$  defined the unity of the ordinate axe;
- $A, B, C, D$  are points ;
- $M'$  is the image of  $M$  by a transformation ;

At last, although these are nodes in PSTricks, I treat them intentionally as points.

#### 2. Basic Objects

##### 2.1. Points

`\pstGeonode [Options] (x1,y1){A1}(x2,y2){A1}\dots(x,y){An}`

This command defines one or more geometrical points associated with a node in the default cartesian coordinate system. Each point has a node name  $A_i$  which defines the default label put on the picture. This label is managed by default in mathematical mode, the boolean parameter `PtNameMath` (default true) can modify this behavior and let manage the label in normal mode. It is placed at a distance of `PointNameSep` (default 1em) of the center of the node with a angle of `PosAngle` (default 0). It is possible to specify another label using the parameter `PointName=default`, and an empty label can be specified by selecting the value none, in that case the point will have no name on the picture.

The point symbol is given by the parameter `PointSymbol=*`. The symbol is the same as used by the macro `\psdot`. This parameter can be set to none, which means that the point will not be drawn on the picture.

Here are the possible values for this parameter:

- |                             |                              |                              |
|-----------------------------|------------------------------|------------------------------|
| • <code>*</code> : ●        | • <code>otimes</code> : ~    | • <code>diamond*</code> : ◆  |
| • <code>o</code> : ○        | • <code>triangle</code> : △  | • <code>pentagon</code> : ⬠  |
| • <code>+</code> : +        | • <code>triangle*</code> : ▲ | • <code>pentagon*</code> : ⬡ |
| • <code>x</code> : ·        | • <code>square</code> : □    | • <code> </code> :           |
| • <code>asterisk</code> : ★ | • <code>square*</code> : ■   |                              |
| • <code>oplus</code> : −    | • <code>diamond</code> : ◇   |                              |

Furthermore, these symbols can be controlled with some others PSTricks, several of these are :

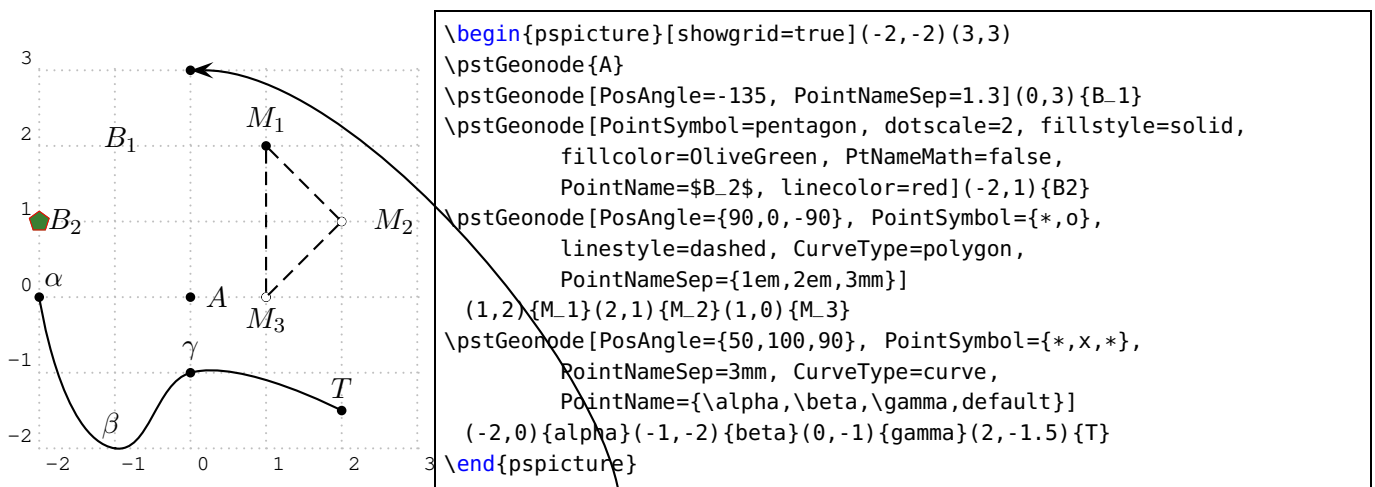
- their scale with `dotscale`, the value of whom is either two numbers defining the horizontal and vertical scale factor, or one single value being the same for both,
- their angle with parameter `dotangle`.

Please consult the PSTricks documentation for further details. The parameters `PosAngle`, `PointSymbol`, `PointName` and `PointNameSep` can be set to :

- either a single value, the same for all points ;
- or a list of values delimited by accolads `{ ... }` and separated with comma *without any blanks*, allowing to differentiate the value for each point.

In the later case, the list can have less values than point which means that the last value is used for all the remaining points. At least, the parameter setting `CurveType=none` can be used to draw a line between the points:

- opened polyline ;
- closed polygon ;
- open and curved curve.



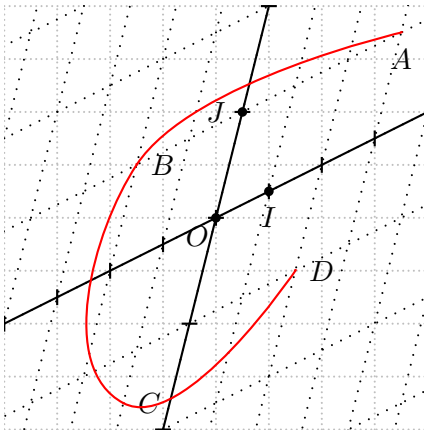
Obviously, the nodes appearing in the picture can be used as normal PSTricks nodes. Thus, it is possible to reference a point from here.

`\pstOIJGeonode` creates a list of points in the landmark ( $O; I; J$ ). Possible parameters are `PointName`, `PointNameSep`, `PosAngle`, `PointSymbol`, and `PtNameMath`.

```

\pstOIJGeonode [Options] (x1,y1){A1}{O}{I}{J} (x2,y2){A2}... (x,y){An}

```



```
\psset{unit=.7}
\begin{pspicture*}[showgrid=true](-4,-4)(4,4)
\pstGeonode[PosAngle={-135,-90,180}]{0}{(1,0.5)}{I}{(0.5,2)}{J}
\pstLineAB[nodesep=10]{0}{I}
\pstLineAB[nodesep=10]{0}{J}
\multips(-5,-2.5)(1,0.5){11}{\psline(0,-.15)(0,.15)}
\multips(-2,-8)(0.5,2){9}{\psline(-.15,0)(.15,0)}
\psset{linestyle=dotted}%
\multips(-5,-2.5)(1,0.5){11}{\psline(-10,-40)(10,40)}
\multips(-2,-8)(0.5,2){9}{\psline(-10,-5)(10,5)}
\psset{PointSymbol=x,linestyle=solid}
\pstOIJGeonode[PosAngle={-90,0},CurveType=curve,
linecolor=red](3,1){A}{0}{I}{J}{(-2,1){B}{-1,-1.5){C}{2,-1){D}
\end{pspicture*}
```

## 2.2. Segment mark

A segment can be drawn using the `\ncline` command. However, for marking a segment there is the following command:

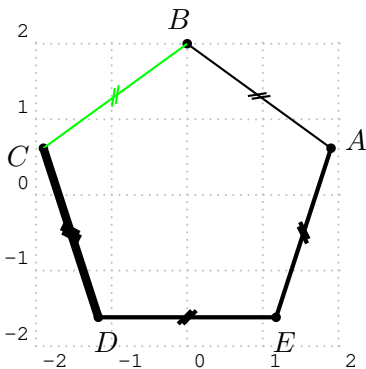
```
\pstSegmentMark [Options] {A}{B}
```

The symbol drawn on the segment is given by the parameter `SegmentSymbol`. Its value can be any valid command which can be used in math mode. Its default value is `MarkHashh`, which produced two slashes on the segment. The segment is drawn.

Several commands are predefined for marking the segment:

- |                           |                           |                            |
|---------------------------|---------------------------|----------------------------|
| • <code>pstslash</code>   | • <code>MarkHashh</code>  | • <code>MarkArrow</code>   |
| • <code>pstslashh</code>  | • <code>MarkHashhh</code> | • <code>MarkArroww</code>  |
| • <code>pstslashhh</code> | • <code>MarkCross</code>  | • <code>MarkArrowww</code> |
| • <code>MarkHash</code>   | • <code>MarkCross</code>  |                            |

The three commands of the family `MarkHash` draw a line whose inclination is controlled by the parameter `MarkAngle` (default is 45). Their width and colour depends of the width and color of the line when the drawing is done, as shown is the next example.



```
\begin{pspicture}[showgrid=true](-2,-2)(2,2)
\rput{18}{%
\pstGeonode[PosAngle={0,90,180,-90}]{2,0}{A}{(2;72){B}
(2;144){C}{(2;216){D}{(2;288){E}}
\pstSegmentMark{A}{B}
\pstSegmentMark[linecolor=green]{B}{C}
\psset{linewidth=2\pslinewidth}
\pstSegmentMark[linecolor=green]{C}{D}
\pstSegmentMark{D}{E}
\pstSegmentMark{E}{A}
\end{pspicture}
```

The length and the separation of multiple hashes can be set by `MarkHashLength` and `MarkHashSep`.

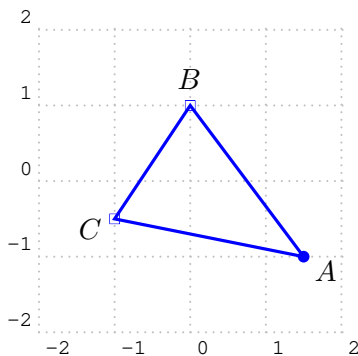
## 2.3. Triangles

The more classical figure, it has its own macro for a quick definition:

```
\pstTriangle [Options] (x1,y1){A}(x2,y2){B}(x3,y3){C}
```

Valid optional arguments are `PointName`, `PointNameSep`, `PosAngle`, `PointSymbol`, `PointNameA`, `PosAngleA`, `PointSymbolA`, `PointNameB`, `PosAngleB`, `PointSymbolB`, `PointNameC`, `PosAngleC`, and `PointSymbolC`. In order to accurately put the name of the points, there are three parameters `PosAngleA`, `PosAngleB` and `PosAngleC`, which are associated respectively to the nodes  $\langle A \rangle$ ,  $\langle B \rangle$  and  $\langle C \rangle$ . Obviously they have the same meaning as the parameter `PosAngle`. If one or more of such parameters is omitted, the value of `PosAngle` is taken. If no angle is specified, points name are placed on the bissector line.

In the same way there are parameters for controlling the symbol used for each points: `PointSymbolA`, `PointSymbolB` and `PointSymbolC`. They are equivalent to the parameter `PointSymbol`. The management of the default value followed the same rule.



```
\begin{pspicture}[showgrid](-2,-2)(2,2)
\pstTriangle[PointSymbol=square,PointSymbolC=o,
linecolor=blue,linewidth=1.5\pslinewidth]
(1.5,-1){A}(0,1){B}(-1,-.5){C}
\end{pspicture}
```

## 2.4. Angles

Each angle is defined with three points. The vertex is the second point. Their order is important because it is assumed that the angle is specified in the direct order. The first command is the marking of a right angle:

```
\pstRightAngle [Options] {A}{B}{C}
```

Valid optional arguments are `RightAngleType`, `RightAngleSize`, and `RightAngleSize`

The symbol used is controlled by the parameter `RightAngleType` default. Its possible values are :

- \* : standard symbol ;
- german : german symbol (given by U. Dirr) ;
- suisse romand : swiss romand symbol (given P. Schneulin).

The only parameter controlling this command, excepting the ones which controlled the line, is `RightAngleSize` which defines the size of the symbol (by default 0.28 unit).

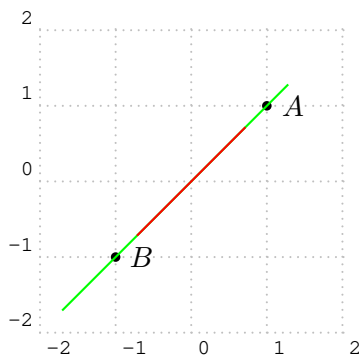
For other angles, there is the command:

```
\pstMarkAngle [Options] {A}{B}{C}
```

Valid optional arguments are `MarkAngleRadius`, `LabelAngleOffset`, and `Mark`. The label can be any valid  $\text{T}_{\text{E}}\text{X}$  box, it is put at `LabelSep` (by default 1 unit) of the node in the direction of the bisector of the angle modified by `LabelAngleOffset` (by default 0) and positioned using `LabelRefPt` (by default c). Furthermore the arc used for marking has a radius of `MarkAngleRadius` (by default .4 unit). At least, it is possible to place an arrow using the parameter `arrows`. Finally, it is possible to mark the angle by specifying a  $\text{T}_{\text{E}}\text{X}$  command as argument of parameter `Mark`.







```
\begin{pspicture}[showgrid](-2,-2)(2,2)
\pstGeonode(1,1){A}(-1,-1){B}
\pstLineAB[nodesepA=-.4,nodesepB=-1,
           linecolor=green]{A}{B}
\pstLineAB[nodesep=.4,linecolor=red]{A}{B}
\end{pspicture}
```

## 2.6. Circles

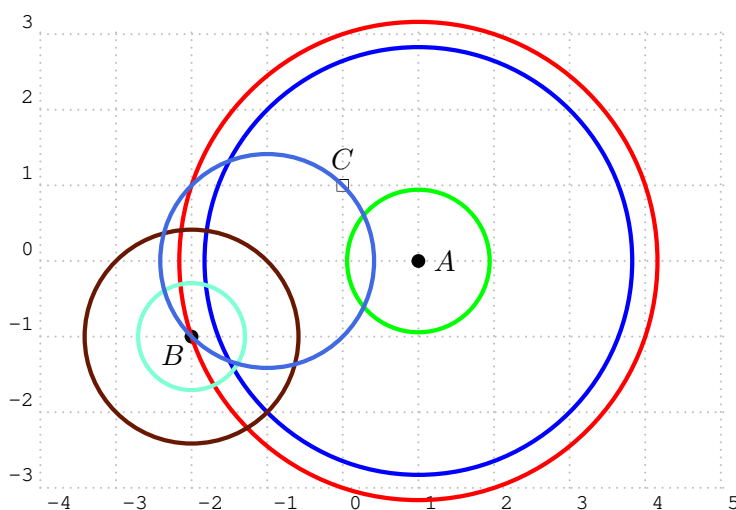
A circle can be defined either with its center and a point of its circumference, or with two diametrically opposed points. There are two commands :

```
\pstCircleOA [Options] {O}{A}
\pstCircleAB [Options] {O}{A}
\pstDistAB [Options] {A}{B}
\pstDistVal [Options] {x}
```

For the first macro, it is possible to omit the second point and then to specify a radius or a diameter using the parameters `Radius` and `Diameter`. The values of these parameters must be specified with one of the two following macros :

The first specifies a distance between two points. The parameter `DistCoef` can be used to specify a coefficient to reduce or enlarge this distance. To be taken into account this last parameter must be specified before the distance. The second macro can be used to specify an explicit numeric value. We will see later how to draw the circle crossing three points. With this package, it becomes possible to draw:

- the circle of center  $A$  crossing  $B$ ;
- the circle of center  $A$  whose radius is  $AC$ ;
- the circle of center  $A$  whose radius is  $BC$ ;
- the circle of center  $B$  whose radius is  $AC$ ;
- the circle of center  $B$  of diameter  $AC$ ;
- the circle whose diameter is  $BC$ .



```

\begin{pspicture}[showgrid](-4,-4)(5,3)
\psset{linewidth=2\pslinewidth}
\pstGeonode[PosAngle={0,-135,90},PointSymbol={*,*,square}](1,0){A}(-2,-1){B}(0,1){C}
\pstCircleOA[linecolor=red]{A}{B}
\pstCircleOA[linecolor=green,DistCoef=2\psdiv,Radius=\pstDistAB{A}{C}]{A}{}
\pstCircleOA[linecolor=blue,Radius=\pstDistAB{B}{C}]{A}{}
\pstCircleOA[linecolor=Sepia,Radius=\pstDistAB{A}{C}]{B}{}
\pstCircleOA[linecolor=Aquamarine,Diameter=\pstDistAB{A}{C}]{B}{}
\pstCircleAB[linecolor=RoyalBlue]{B}{C}
\end{pspicture}

```

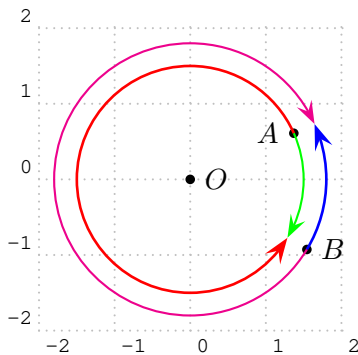
## 2.7. Circle arcs

```

\pstArcOAB [Options] {O}{A}{B}
\pstArcnOAB [Options] {O}{A}{B}

```

These two macros draw circle arcs,  $O$  is the center, the radius defined by  $OA$ , the beginning angle given by  $A$  and the final angle by  $B$ . Finally, the first macro draws the arc in the direct way, whereas the second in the indirect way. It is not necessary that the two points are at the same distance of  $O$ .



```

\begin{pspicture}[showgrid](-2,-2)(2,2)
\pstGeonode[PosAngle={180,0}](1.5;24){A}(1.8;-31){B}
\pstGeonode{O}
\psset{arrows=->,arrowscale=2}
\pstArcOAB[linecolor=red,linewidth=1pt]{O}{A}{B}
\pstArcOAB[linecolor=blue,linewidth=1pt]{O}{B}{A}
\pstArcnOAB[linecolor=green]{O}{A}{B}
\pstArcnOAB[linecolor=magenta]{O}{B}{A}
\end{pspicture}

```

## 2.8. Curved abscissa

A point can be positioned on a circle using its curved abscissa.

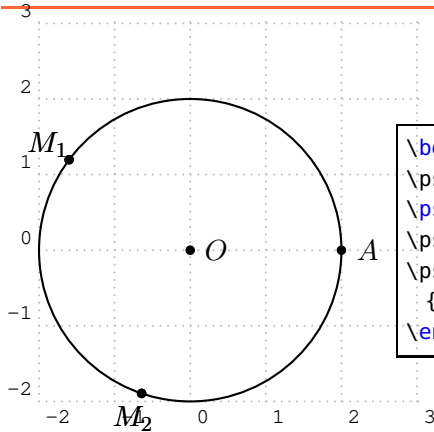
```

\pstCurvAbsNode [Options] {O}{A}{B}{Abs}

```

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, `PtNameMath`, and `CurvAbsNeg`. The point  $\langle B \rangle$  is positioned on the circle of center  $\langle O \rangle$  crossing  $\langle A \rangle$ , with the curved abscissa  $\langle Abs \rangle$ . The origin is  $\langle A \rangle$  and the direction is anti-clockwise by default. The parameter `CurvAbsNeg` (by default false) can change this behavior.

If the parameter `PosAngle` is not specified, the point label is put automatically in order to be aligned with the circle center and the point.



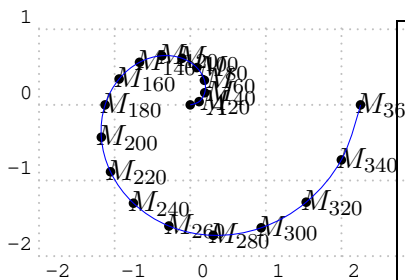
```
\begin{pspicture}[showgrid](-2.5,-2.5)(2.5,2.5)
\pstGeonode{O}(2,0){A}
\pstCircleOA{O}{A}
\pstCurvAbsNode{O}{A}{M_1}{\pstDistVal{5}}
\pstCurvAbsNode[CurvAbsNeg=true]{%
{O}{A}{M_2}}{\pstDistAB{A}{M_1}}
\end{pspicture}
```

## 2.9. Generic curve

It is possible to generate a set of points using a loop, and to give them a generic name defined by a radical and a number. The following command can draw a interpolated curve crossing all such kind of points.

```
\pstGenericCurve [Options] {Radical}{n1}{n2}
```

Possible optional arguments are GenCurvFirst, GenCurvInc, and GenCurvLast. The curve is drawn on the points whose name is defined using the radical  $\langle \text{Radical} \rangle$  followed by a number from  $\langle n_1 \rangle$  to  $\langle n_2 \rangle$ . In order to manage side effect, the parameters GenCurvFirst et GenCurvLast can be used to specified special first or last point. The parameter GenCurvInc can be used to modify the increment from a point to the next one (by default 1).



```
\begin{pspicture}[showgrid](-2.5,-2.5)(2.5,1)
\psset{unit=.00625}
\pstGeonode{A}
\multido{\n=20+20}{18}{%
\pstGeonode[PointName=M_{\n}]{\n;\n}{M_{\n}}
\pstGenericCurve[GenCurvFirst=A,GenCurvInc=20,
linecolor=blue,linewidth=.5\pslinewidth]{M_{\n}}{20}{360}
}
\end{pspicture}
```

## 3. Geometric Transformations

The geometric transformations are the ideal tools to construct geometric figures. All the classical transformations are available with the following macros which share the same syntactic scheme and two parameters.

The common syntax put at the end two point lists whose second is optional or with a cardinal at least equal. These two lists contain the antecedent points and their respective images. In the case no image is given for some points the a default name is build appending a ' to the antecedent name.

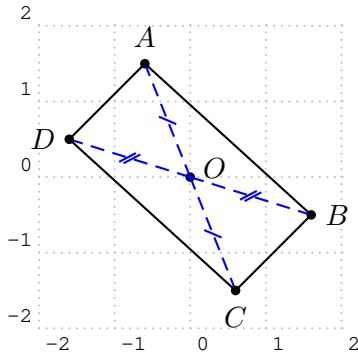
The first shared parameter is CodeFig which draws the specific constructions lines. Its default value is false, and a true value activates this optional drawing. The drawing is done using the line style CodeFigStyle (by default dashed), with the color CodeFigColor (by default cyan).

Their second shared parameter is CurveType which controls the drawing of a line crossing all images, and thus allow a quick description of a transformed figure.

### 3.1. Central symmetry

`\pstSym0 [Options] {O}{M1, M2, ..., Mn} [M'1, M'2, ..., M'p]`

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, `PtNameMath`, `CodeFig`, `CodeFigColor`, and `CodeFigStyle`. Draw the symmetric point in relation to point  $O$ . The classical parameter of point creation are usable here, and also for all the following functions.

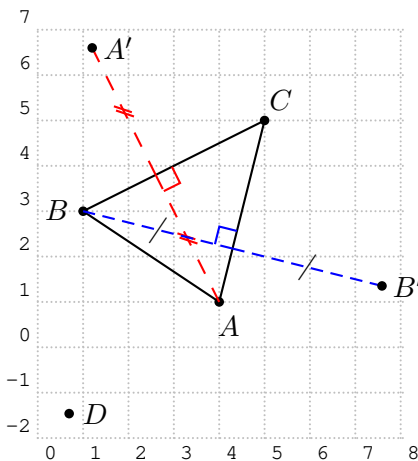


```
\begin{pspicture}[showgrid](-2,-2)(2,2)
\psset{CodeFig=true}
\pstGeonode[PosAngle={20,90,0}]{O}{(-.6,1.5){A}{(1.6,-.5){B}
\pstSym0[CodeFigColor=blue,
PosAngle={-90,180}]{O}{A,B}{C,D}
\pstLineAB{A}{B}\pstLineAB{C}{D}
\pstLineAB{A}{D}\pstLineAB{C}{B}
\end{pspicture}
```

### 3.2. Orthogonal (or axial) symmetry

`\pstOrtSym [Options] {A}{B}{M1, M2, ..., Mn} [M'1, M'2, ..., M'p]`

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, `PtNameMath`, `CodeFig`, `CodeFigColor`, and `CodeFigStyle`. Draws the symmetric point in relation to line  $(AB)$ .



```
\psset{unit=0.6}
\begin{pspicture}[showgrid](0,-2)(8,7)
\pstTriangle(1,3){B}(5,5){C}(4,1){A}
\pstOrtSym{A}{B}{C}{D}
\psset{CodeFig=true}
\pstOrtSym[dash=2mm 2mm,CodeFigColor=red]%
{C}{B}{A}
\pstOrtSym[SegmentSymbol=pstslash,
linestyle=dotted,dotsep=3mm,CodeFigColor=blue]%
{C}{A}{B}
\end{pspicture}
```

### 3.3. Rotation

`\pstRotation [Options] {O}{M1, M2, ..., Mn} [M'1, M'2, ..., M'p]`  
`\pstAngleAOB{A}{O}{B}`

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, `PtNameMath`, and `RotAngle` for `\pstRotation` and `AngleCoef`, `RotAngle` for `\pstAngleABC`. Draw the image of  $M_i$  by the rotation of center  $O$  and angle given by the parameter `RotAngle`. This later can be an angle specified by three points. In such a case, the following function must be used:

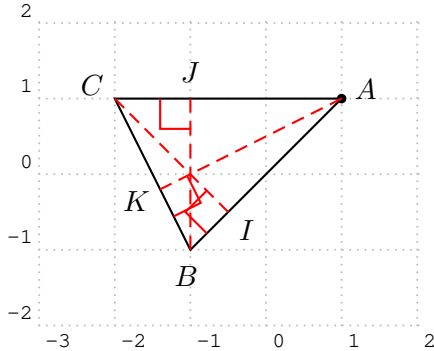
Never forget to use the rotation for drawing a square or an equilateral triangle. The parameter `CodeFig` puts a bow with an arrow between the point and its image, and if `TransformLabel` (by default none) contain some text, it is put on the corresponding angle in mathematical mode.



### 3.6. Orthogonal projection

`\pstProjection` [Options] {A}{B}{ $M_1, M_2, \dots, M_n$ } [ $M'_1, M'_2, \dots, M'_p$ ]

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, `PtNameMath`, `CodeFig`, `CodeFigColor`, and `CodeFigStyle`. Projects orthogonally the point  $M_i$  on the line  $(AB)$ . Useful for the altitude of a triangle. The name is aligned with the point and the projected point as shown in the example.



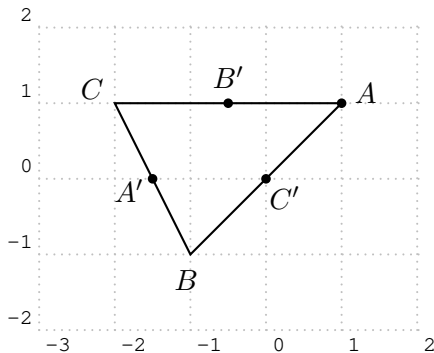
```
\begin{pspicture}[showgrid](-3,-2)(2,2)
\psset{PointSymbol=none,CodeFig,CodeFigColor=red}
\pstTriangle(1,1){A}(-2,1){C}(-1,-1){B}
\pstProjection{A}{B}{C}[I]
\pstProjection{A}{C}{B}[J]
\pstProjection{C}{B}{A}[K]
\end{pspicture}
```

## 4. Special object

### 4.1. Midpoint

`\pstMiddleAB` [Options] {A}{B}{I}

PointSymbol, PosAngle, PointName, PointNameSep, PtNameMath, SegmentSymbol, CodeFig, CodeFigColor, and CodeFigStyle. Draw the midpoint  $I$  of segment  $[AB]$ . By default, the point name is automatically put below the segment.

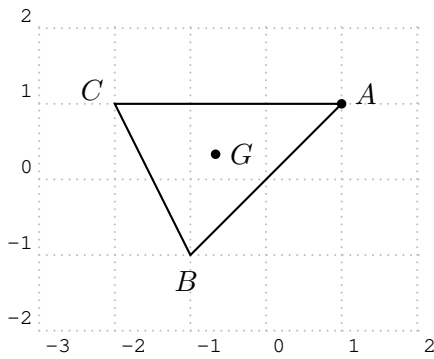


```
\begin{pspicture}[showgrid](-3,-2)(2,2)
\pstTriangle[PointSymbol=none]%
(1,1){A}(-1,-1){B}(-2,1){C}
\pstMiddleAB{A}{B}{C'}
\pstMiddleAB{C}{A}{B'}
\pstMiddleAB{B}{C}{A'}
\end{pspicture}
```

### 4.2. Triangle center of gravity

`\pstCGravABC` [Options] {A}{B}{C}{G}

Possible optional arguments are `PointName`, `PointNameSep`, `PosAngle`, `PointSymbol`, and `PtNameMath`. Draw the  $ABC$  triangle centre of gravity  $G$ .

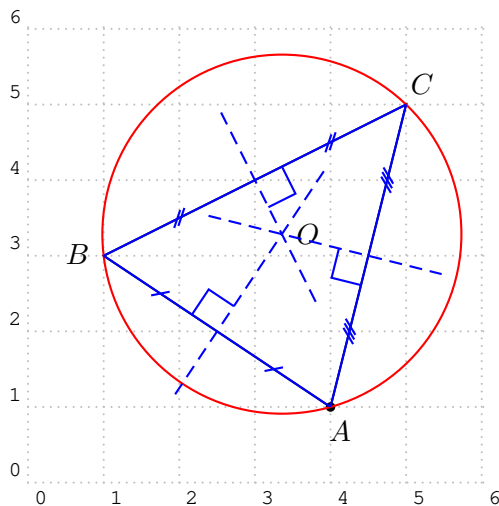


```
\begin{pspicture}[showgrid](-3,-2)(2,2)
\pstTriangle[PointSymbol=none]%
(1,1){A}(-1,-1){B}(-2,1){C}
\pstCGravABC{A}{B}{C}{G}
\end{pspicture}
```

### 4.3. Centre of the circumcircle of a triangle

`\pstCircleABC` [Options] {A}{B}{C}{O}

Possible optional arguments are `PointName`, `PointNameSep`, `PosAngle`, `PointSymbol`, `PtNameMath`, `DrawCirABC`, `CodeFig`, `CodeFigColor`, `CodeFigStyle`, `SegmentSymbolA`, `SegmentSymbolB`, and `SegmentSymbolC`. Draws the circle crossing three points (the circum circle) and put its center  $O$ . The effective drawing is controlled by the boolean parameter `DrawCirABC` (by default true). Moreover the intermediate constructs (mediator lines) can be drawn by setting the boolean parameter `CodeFig`. In that case the middle points are marked on the segments using three different marks given by the parameters `SegmentSymbolA`, `SegmentSymbolB` et `SegmentSymbolC`.



```
\begin{pspicture}[showgrid](6,6)
\pstTriangle[PointSymbol=none]%
(4,1){A}(1,3){B}(5,5){C}
\pstCircleABC[CodeFig,CodeFigColor=blue,
linecolor=red,PointSymbol=none]{A}{B}{C}{O}
\end{pspicture}
```

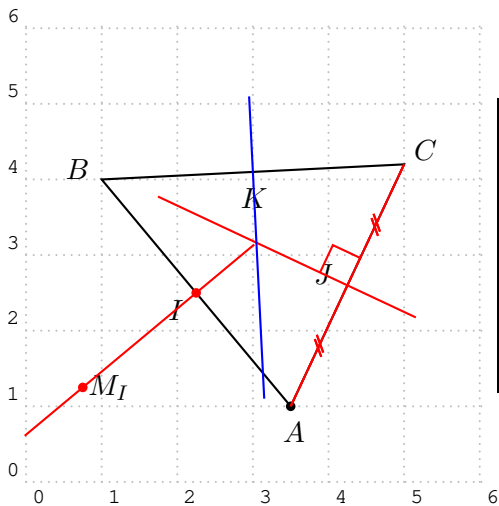
### 4.4. Perpendicular bisector of a segment

`\pstMediatorAB` [Options] {A}{B}{I}{M}

Possible optional arguments are `PointName`, `PointNameSep`, `PosAngle`, `PointSymbol`, `PtNameMath`, `CodeFig`, `CodeFigColor`, `CodeFigStyle`, and `SegmentSymbol`. The perpendicular bisector of a segment is a line perpendicular to this segment in its midpoint. The segment is  $[AB]$ , the midpoint  $I$ , and  $M$  is a point belonging to the perpendicular bisector line. It is build by a rotation of  $B$  of 90 degrees around  $I$ . This mean that the order of  $A$  and  $B$  is important, it controls the position of  $M$ . The command creates the two points  $M$  end  $I$ . The construction is controlled by the following parameters:

- `CodeFig`, `CodeFigColor` and `SegmentSymbol` for marking the right angle ;
- `PointSymbol` et `PointName` for controlling the drawing of the two points, each of them can be specified separately with the parameters `...A` and `...B` ;
- parameters controlling the line drawing.



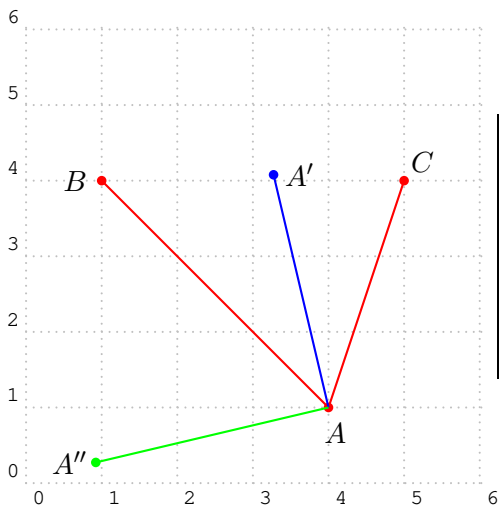


```
\begin{pspicture}[showgrid](6,6)
\pstTriangle[PointSymbol=none](3.5,1){A}(1,4){B}(5,4.2){C}
\psset{linecolor=red,CodeFigColor=red,nodesep=-1}
\pstMediatorAB[PointSymbolA=none]{A}{B}{I}{M_I}
\psset{PointSymbol=none,PointNameB=none}
\pstMediatorAB[CodeFig=true]{A}{C}{J}{M_J}
\pstMediatorAB[PosAngleA=45,linecolor=blue]
{C}{B}{K}{M_K}
\end{pspicture}
```

#### 4.5. Bisectors of angles

```
\pstBisectBAC [Options] {B}{A}{C}{N}
\pstOutBisectBAC [Options] {B}{A}{C}{N}
```

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, and `PtNameMath`. There are two bisectors for a given geometric angle: the inside one and the outside one; this is why there is two commands. The angle is specified by three points specified in the trigonometric direction (anti-clockwise). The result of the commands is the specific line and a point belonging to this line. This point is built by a rotation of point  $B$ .



```
\begin{pspicture}[showgrid](6,6)
\psset{CurveType=polyline,linecolor=red}
\pstGeonode[PosAngle={180,-75,45}]%
(1,4){B}(4,1){A}(5,4){C}
\pstBisectBAC[linecolor=blue]{C}{A}{B}{A'}
\pstOutBisectBAC[linecolor=green,PosAngle=180]%
{C}{A}{B}{A''}
\end{pspicture}
```

#### 5. Intersections

Points can be defined by intersections. Six intersection types are managed:

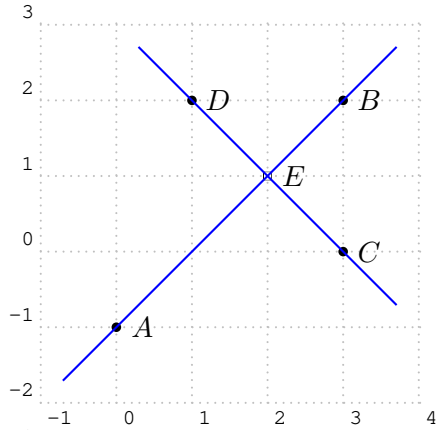
- line-line;
- line-circle;
- circle-circle;
- function-function;
- function-line;
- function-circle.

An intersection can not exist: case of parallel lines. In such a case, the point(s) are positioned at the origin. In fact, the user has to manage the existence of these points.

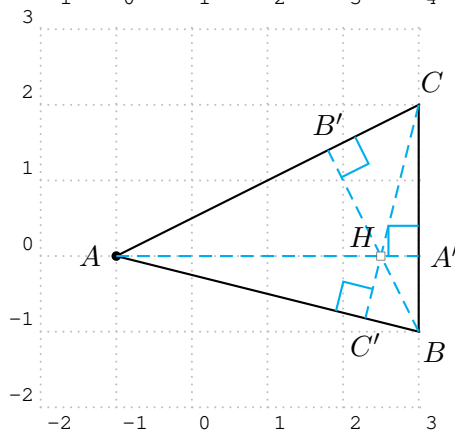
### 5.1. Line-Line

`\pstInterLL [Options] {A}{B}{C}{D}{M}`

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, and `PtNameMath`. Draw the intersection point between lines  $(AB)$  and  $(CD)$ .



```
\begin{pspicture}[showgrid](-1,-2)(4,3)
\pstGeonode(0,-1){A}(3,2){B}(3,0){C}(1,2){D}
\pstInterLL[PointSymbol=square]{A}{B}{C}{D}{E}
\psset{linecolor=blue,nodesep=-1}
\pstLineAB{A}{B}\pstLineAB{C}{D}
\end{pspicture}
```



```
\begin{pspicture}[showgrid](-2,-2)(3,3)
\psset{CodeFig,PointSymbol=none}
\pstTriangle[PosAngleA=180](-1,0){A}(3,-1){B}(3,2){C}
\pstProjection[PosAngle=-90]{B}{A}{C}
\pstProjection{B}{C}{A}
\pstProjection[PosAngle=90]{A}{C}{B}
\pstInterLL[PosAngle=135,PointSymbol=square]{A}{A'}{B}{B'}{
H}
\end{pspicture}
```

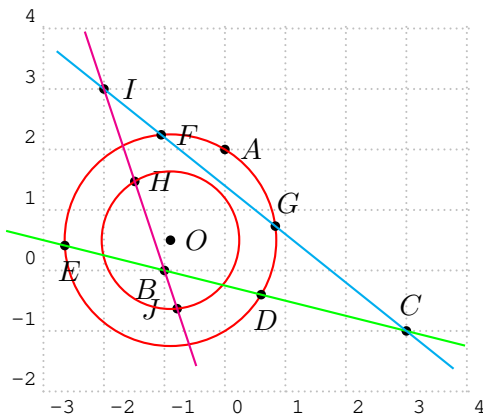
### 5.2. Circle-Line

`\pstInterLC [Options] {A}{B}{O}{C}{M_1}{M_2}`

Possible optional arguments are `PointSymbol`, `PosAngle`, `PointName`, `PointNameSep`, `PtNameMath`, `PointSymbolA`, `PosAngleA`, `PointNameA`, `PointSymbolB`, `PosAngleB`, `PointNameB`, `Radius`, and `Diameter`. Draw the one or two intersection point(s) between the line  $(AB)$  and the circle of centre  $O$  and with radius  $OC$ .

The circle is specified with its center and either a point of its circumference or with a radius specified with parameter `radius` or its diameter specified with parameter `Diameter`. These two parameters can be modified by coefficient `DistCoef`.

The position of the two points is such that the vectors  $\vec{AB}$  and  $\vec{M_1M_2}$  are in the same direction. Thus, if the points defining the line are switched, then the resulting points will be also switched. If the intersection is void, then the points are positioned at the center of the circle.

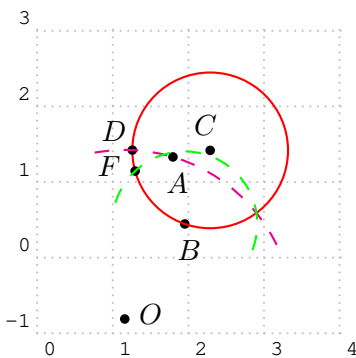


```
\psset{unit=0.8}
\begin{pspicture}[showgrid](-3,-2)(4,4)
\pstGeonode[PosAngle={-135,80,0}]{(-1,0){B}(3,-1){C}(-.9,.5){O}
(0,2){A}
\pstGeonode(-2,3){I}
\pstCircleOA[linecolor=red]{O}{A}
\pstInterLC[PosAngle=-80]{C}{B}{O}{A}{D}{E}
\pstInterLC[PosAngleB=60, Radius=\pstDistAB{O}{D}]{I}{C}{O}{F}{G}
\pstInterLC[PosAngleB=180, DistCoef=1.3, Diameter=\pstDistAB{O}{D}]{I}{B}{O}{H}{J}
\pstCircleOA[linecolor=red, DistCoef=1.3, Diameter=\pstDistAB{O}{D}]{O}{J}
\psset{nodesep=-1}
\pstLineAB[linecolor=green]{E}{C}
\pstLineAB[linecolor=cyan]{I}{C}
\pstLineAB[linecolor=magenta]{J}{I}
\end{pspicture}
```

### 5.3. Circle-Circle

`\pstInterCC [Options] {O1}{B}{O2}{C}{M1}{M2}`

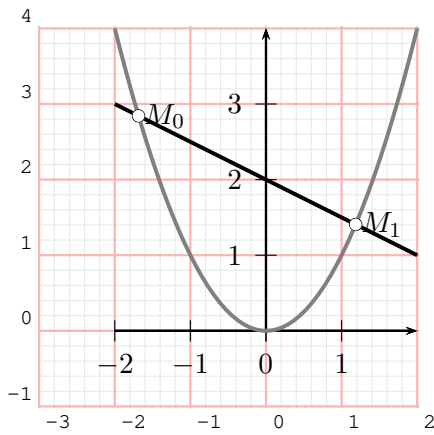
This function is similar to the last one. The boolean parameters CodeFigA et CodeFigB allow the drawing of the arcs at the intersection. In order to get a coherence CodeFig allow the drawing of both arcs. The boolean parameters CodeFigArc and CodeFigBarc specified the direction of these optional arcs: trigonometric (by default) or clockwise. Here is a first example.



```
\begin{pspicture}[showgrid](0,-1)(4,3)
\psset{dash=2mm 2mm}
\rput{10}{%
\pstGeonode[PosAngle={0,-90,-90,90}]
(1,-1){O}(2,1){A}(2,0.1){B}(2.5,1){C}
\pstCircleOA[linecolor=red]{C}{B}
\pstInterCC[PosAngleA=135, CodeFigA=true, CodeFigArc=false,
CodeFigColor=magenta]{O}{A}{C}{B}{D}{E}
\pstInterCC[PosAngleA=170, CodeFigA=true,
CodeFigArc=false,
CodeFigColor=green]{B}{E}{C}{B}{F}{G}
}
\end{pspicture}
```

And a more complete one, which includes the special circle specification using radius and diameter. For such specifications it exists the parameters RadiusA, RadiusB, DiameterA and DiameterB.



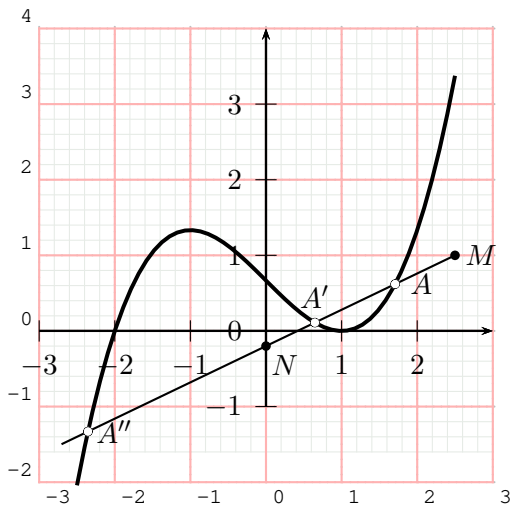


```
\begin{pspicture}[showgrid](-3,-1)(2,4)
\psaxes{->}(0,0)(-2,0)(2,4)
\psset{linewidth=1.5pt,algebraic}
\psplot[linecolor=gray]{-2}{2}{x^2}
\psplot{-2}{2}{2-x/2}
\psset{PointSymbol=o}
\pstInterFF{2-x/2}{x^2}{1}{M_1}
\pstInterFF{2-x/2}{x^2}{-2}{M_0}
\end{pspicture}
```

### 5.5. Function-line

`\pstInterFL [Options] {f}{A}{B}{x_0}{M}`

Puts a point at the intersection between the function  $f$  and the line  $(AB)$ .

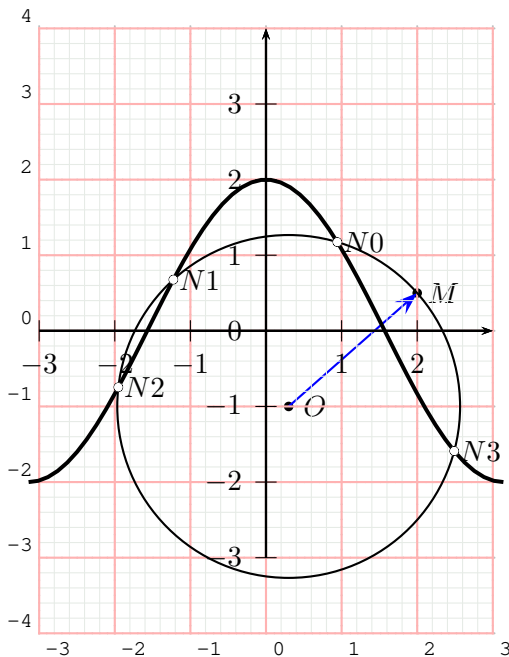


```
\begin{pspicture}[showgrid](-3,-1.5)(3,4)
\def\F{x^3/3 - x + 2/3 }
\psaxes{->}(0,0)(-3,-1)(3,4)
\psplot[linewidth=1.5pt,algebraic]{-2.5}{2.5}{\F}
\psset{PointSymbol=*}
\pstGeonode[PosAngle=-45,0](0,-.2){N}(2.5,1){M}
\pstLineAB[nodesepA=-3cm]{N}{M}
\psset{PointSymbol=o,algebraic}
\pstInterFL{\F}{N}{M}{2}{A}
\pstInterFL[PosAngle=90]{\F}{N}{M}{0}{A'}
\pstInterFL{\F}{N}{M}{-2}{A''}
\end{pspicture}
```

### 5.6. Function-Circle

`\pstInterFC [Options] {f}{O}{A}{x_0}{M}`

Puts a point at the intersection between the function  $f$  and the circle of centre  $O$  and radius  $OA$ .

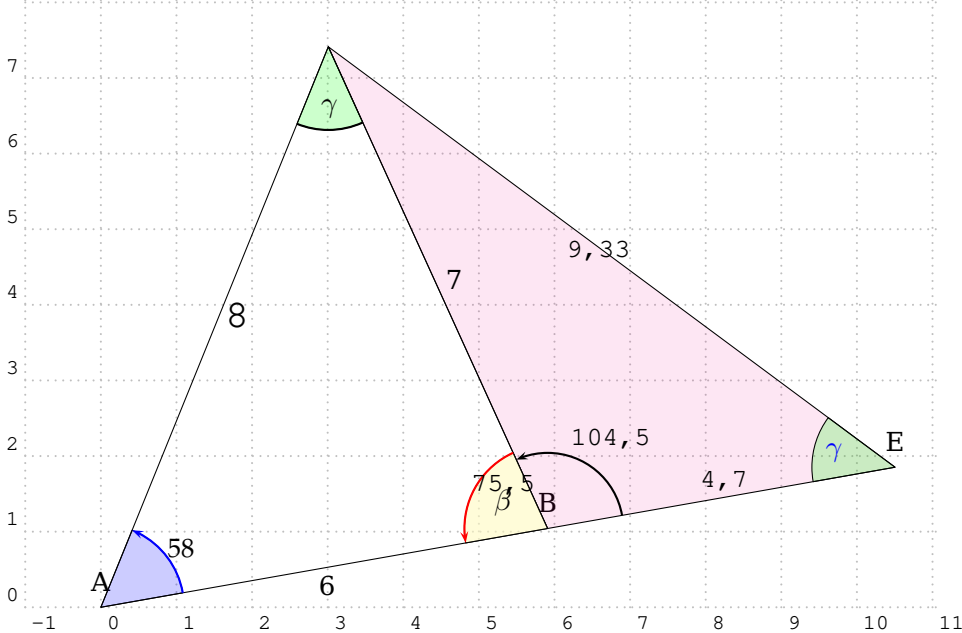


```
\begin{pspicture}[showgrid](-3,-4)(3,4)
\def\F{2*cos(x)}
\psset{algebraic}
\pstGeonode(0.3,-1){O}(2,.5){M}
\ncline[linecolor=blue,arrowscale=2]{->}{O}{M}
\psaxes{->}(0,0)(-3,-3)(3,4)
\psplot[linewidth=1.5pt]{-3.14}{3.14}{\F}
\pstCircleOA[PointSymbol=*]{O}{M}
\psset{PointSymbol=o}
\pstInterFC{\F}{O}{M}{1}{N0}
\pstInterFC{\F}{O}{M}{-1}{N1}
\pstInterFC{\F}{O}{M}{-2}{N2}
\pstInterFC{\F}{O}{M}{2}{N3}
\end{pspicture}
```

## 6. Helper Macros

```
\psGetDistanceAB [Options] (x1,y1)(x2,y2){<name>}
\psGetAngleABC [Options] (x1,y1)(x2,y2)(x3,y3){<symbol>}
```

Calculates and prints the values. This is only possible on PostScript level!



```
\begin{pspicture}(-1,0)(11,8)
\psgrid[gridlabels=0pt,subgriddiv=2,gridwidth=0.4pt,subgridwidth=0.2pt,gridcolor=black!60,
subgridcolor=black!40]
\def\sideC{6} \def\sideA{7} \def\sideB{8}
\psset{PointSymbol=none,linejoin=1,linewidth=0.4pt,PtNameMath=false,labelsep=0.07,MarkAngleRadius
=1.1,decimals=1,comma}
\pstGeonode[PosAngle={90,90}](0,0){A}(\sideC;10){B}
% \pstGeonode[PosAngle={225,-75}](0,0){A}(\sideC;10){B}
\psset{PointName=}
```

```

\pstInterCC[RadiusA=\pstDistVal{\sideB},RadiusB=\pstDistVal{\sideA},PosAngle=-90,PointNameA=C]{A}{B}{C}{C-}
\pstInterCC[RadiusA=\pstDistAB{A}{B},RadiusB=\pstDistAB{B}{C}]{C}{D}{A}{D-}{D}
\pstInterLC[Radius=\pstDistAB{A}{C}]{C}{D}{C}{A'-}{A'}
\pstInterCC[RadiusA=\pstDistAB{A}{B},RadiusB=\pstDistAB{B}{C}]{A'}{C}{B'}{B'-}
\pstInterLL[PosAngle=90,PointName=default]{B'}{C}{A}{B}{E}
\pspolygon(A)(B)(C)
\pspolygon[fillstyle=solid,fillcolor=magenta,opacity=0.1](C)(E)(B)
%
\psGetAngleABC[ArcColor=blue,AngleValue=true,LabelSep=0.7,arrows=->,decimals=0,PSfont=Palatino-Roman]
(B)(A)(C){}
\psGetAngleABC[AngleValue=true,ArcColor=red,arrows=->,WedgeOpacity=0.6,WedgeColor=yellow!30,LabelSep=0.5]
(C)(B)(A){$\beta$}
\psGetAngleABC[LabelSep=0.7,WedgeColor=green,xShift=-6,yShift=-10](A)(C)(B){$\gamma$}
\psGetAngleABC[LabelSep=0.7,AngleArc=false,WedgeColor=green,arrows=->,xShift=-15,yShift=0](C)(E)(B)
{\color{blue}$\gamma$}
\psGetAngleABC[AngleValue=true,MarkAngleRadius=1.0,LabelSep=0.5,ShowWedge=false,xShift=-5,yShift=7,
arrows=->](E)(B)(C){}
%
\pcline[linestyle=none](A)(B)\nbput{\sideC}
\pcline[linestyle=none](C)(B)\naput{\sideA}
\psGetDistanceAB[xShift=-8,yShift=4](B)(E){MW}
\psGetDistanceAB[fontscale=15,xShift=4,decimals=0](A)(C){MAC}
\psGetDistanceAB[xShift=-17,decimals=2](E)(C){MEC}
\end{pspicture}

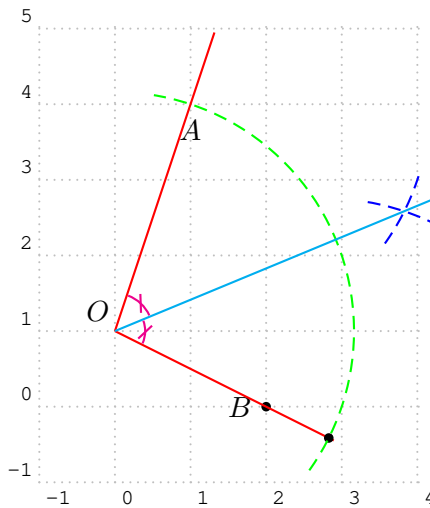
```

## Part II.

### Examples gallery

#### A. Basic geometry

##### A.1. Drawing of the bissector

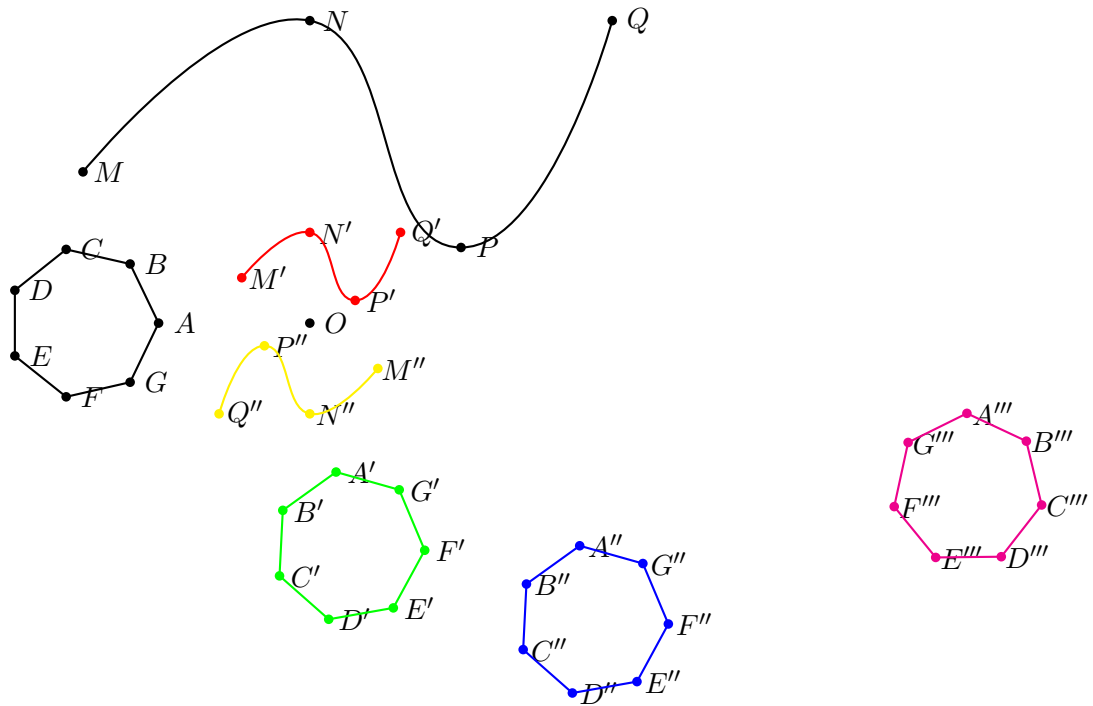


```
\begin{pspicture}[showgrid](-1,-1)(4.4,5)
\psset{PointSymbol=none,PointName=none}
\pstGeonode[PosAngle={180,130,-90},PointSymbol={*,none},
PointName=default](2,0){B}(0,1){O}(1,4){A}
\pstLineAB[nodesepB=-1,linecolor=red]{O}{A}
\pstLineAB[nodesepB=-1,linecolor=red]{O}{B}
\pstInterLC[PosAngleB=-45]{O}{B}{O}{A}{G}{C}
\psset{arcsepA=-1,arcsepB=-1}
\pstArcOAB[linecolor=green,linestyle=dashed]{O}{C}{A}
\pstInterCC[PosAngleA=100]{A}{O}{C}{O'}{O0}
\pstArcOAB[linecolor=blue,linestyle=dashed]{A}{O'}{O'}
\pstArcOAB[linecolor=blue,linestyle=dashed]{C}{O'}{O'}
\pstLineAB[nodesepB=-1,linecolor=cyan]{O}{O'}
\psset{arcsep=1pt,linecolor=magenta,Mark=MarkHash}
\pstMarkAngle{C}{O}{O'}{}
\pstMarkAngle[MarkAngleRadius=.5]{O'}{O}{A}{}
\end{pspicture}
```



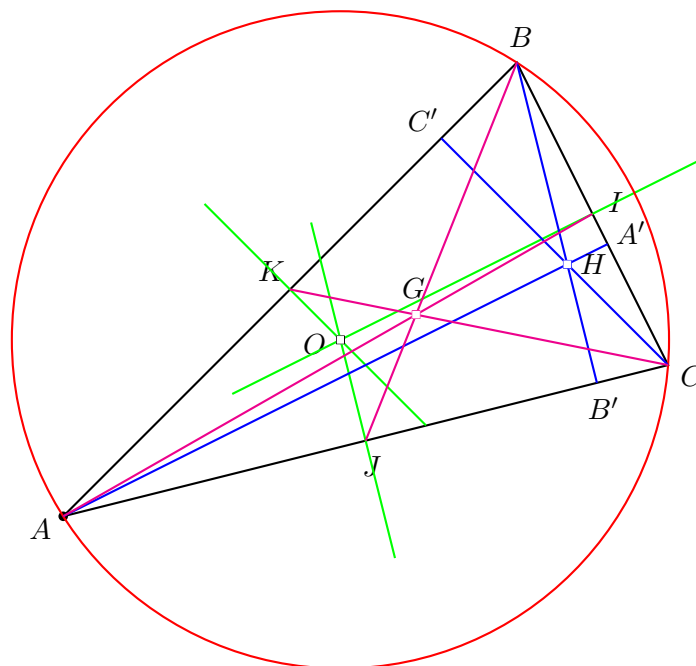
## A.2. Transformation de polygones et courbes

Here is an example of the use of CurveType with transformation.



```
\begin{pspicture}(-5,-5)(10,5)
\pstGeonode{O}
\rput(-3,0){\pstGeonode[CurveType=polygon](1,0){A}(1;51.43){B}(1;102.86){C}
(1;154.29){D}(1;205.71){E}(1;257.14){F}(1;308.57){G}}
\rput(-4,-1){\pstGeonode[CurveType=curve](1,3){M}(4,5){N}(6,2){P}(8,5){Q}}
\pstRotation[linecolor=green, RotAngle=100, CurveType=polygon]{O}{A, B, C, D, E, F, G}
\pstHomO[linecolor=red, HomCoef=.3, CurveType=curve]{O}{M,N,P,Q}
\pstTranslation[linecolor=blue, CurveType=polygon]{C}{O}{A', B', C', D', E', F', G'}
\pstSymO[linecolor=yellow, CurveType=curve]{O}{M',N',P',Q'}
\pstOrtSym[linecolor=magenta, CurveType=polygon]{Q}{F'''}
{A', B', C', D', E', F', G'}{A''', B''', C''', D''', E''', F''', G'''}
\end{pspicture}
```

## A.3. Triangle lines

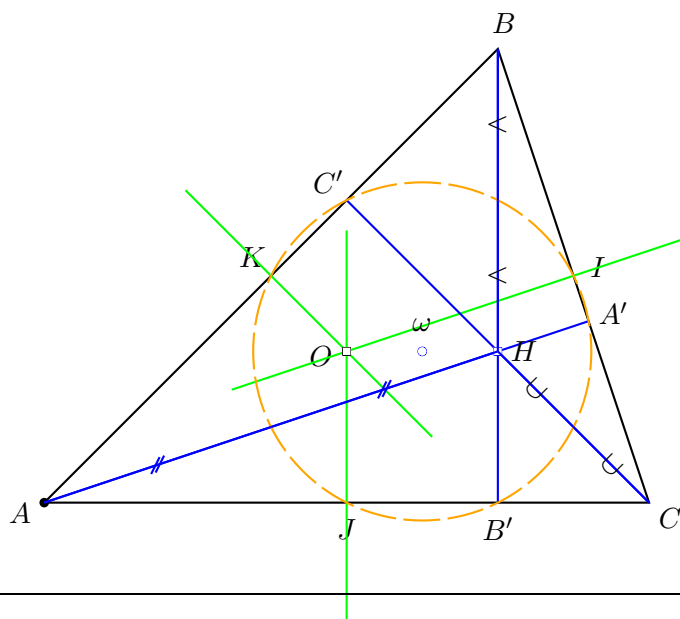


```

\psset{unit=2}
\begin{pspicture}(-3,-2)(3,3)
\psset{PointSymbol=none}
\pstTriangle[PointSymbol=none](-2,-1){A}(1,2){B}(2,0){C}
{ \psset{linestyle=none, PointNameB=none}
  \pstMediatorAB{A}{B}{K}{KP}
  \pstMediatorAB[PosAngleA=-40]{C}{A}{J}{JP}
  \pstMediatorAB[PosAngleA=75]{B}{C}{I}{IP}
}% fin
\pstInterLL[PointSymbol=square, PosAngle=-170]{I}{IP}{J}{JP}{O}
{% encapsulation de modif parametres
  \psset{nodesep=-.8, linecolor=green}
  \pstLineAB{O}{I}\pstLineAB{O}{J}\pstLineAB{O}{K}
}% fin
\pstCircleOA[linecolor=red]{O}{A}
% pour que le symbol de O soit sur et non sous les droites
\psdot[dotstyle=square](O)
% les hauteurs et l'orthocentre
\pstProjection{B}{A}{C}
\pstProjection{B}{C}{A}
\pstProjection{A}{C}{B}
\psset{linecolor=blue}\ncline{A}{A'}\ncline{C}{C'}\ncline{B}{B'}
\pstInterLL[PointSymbol=square]{A}{A'}{B}{B'}{H}
% les medianes et le centre de gravite
\psset{linecolor=magenta}\ncline{A}{I}\ncline{C}{K}\ncline{B}{J}
\pstCGravABC[PointSymbol=square, PosAngle=95]{A}{B}{C}{G}
\end{pspicture}

```

## A.4. Euler circle



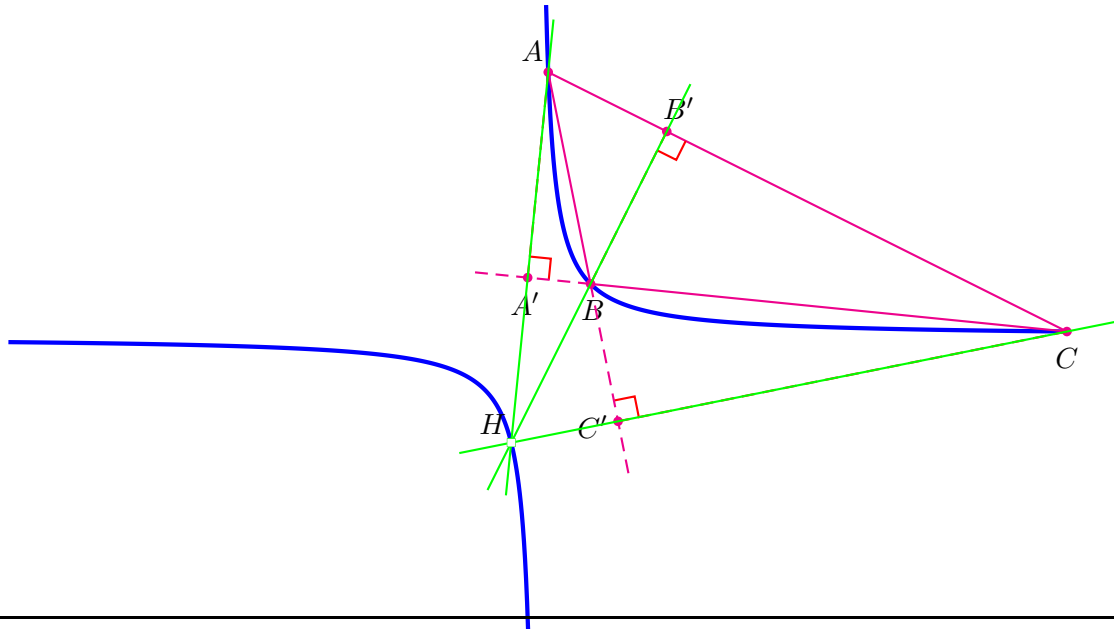
```

\psset{unit=2}
\begin{pspicture}(-3,-1.5)(3,2.5)
\psset{PointSymbol=none}
\pstTriangle(-2,-1){A}(1,2){B}(2,-1){C}
% encapsulation de modif parametres
\psset{linestyle=none, PointSymbolB=none, PointNameB=none}
\pstMediatorAB{A}{B}{K}{KP}
\pstMediatorAB{C}{A}{J}{JP}
\pstMediatorAB{B}{C}{I}{IP}
}% fin
\pstInterLL[PointSymbol=square, PosAngle=-170]{I}{IP}{J}{JP}{O}
% encapsulation de modif parametres
\psset{nodesep=-.8, linecolor=green}
\pstLineAB{O}{I}\pstLineAB{O}{J}\pstLineAB{O}{K}
}% fin
\psdot[dotstyle=square](O)
\pstProjection{B}{A}{C}
\pstProjection{B}{C}{A}
\pstProjection{A}{C}{B}
\psset{linecolor=blue}\ncline{A}{A'}\ncline{C}{C'}\ncline{B}{B'}
\pstInterLL[PointSymbol=square]{A}{A'}{B}{B'}{H}
% le cercle d'Euler (centre au milieu de [OH])
\pstMiddleAB[PointSymbol=o, PointName=\omega]{O}{H}{\omega}
\pstCircleOA[linecolor=orange, linestyle=dashed, dash=5mm 1mm]{\omega}{B'}
\psset{PointName=none}
% il passe par le milieu des segments joignant l'orthocentre et les sommets
\pstMiddleAB{H}{A}{AH}\pstMiddleAB{H}{B}{BH}\pstMiddleAB{H}{C}{CH}
\pstSegmentMark{H}{AH}\pstSegmentMark{AH}{A}
\psset{SegmentSymbol=wedge}\pstSegmentMark{H}{BH}\pstSegmentMark{BH}{B}
\psset{SegmentSymbol=cup}\pstSegmentMark{H}{CH}\pstSegmentMark{CH}{C}
\end{pspicture}

```

### A.5. Orthocenter and hyperbola

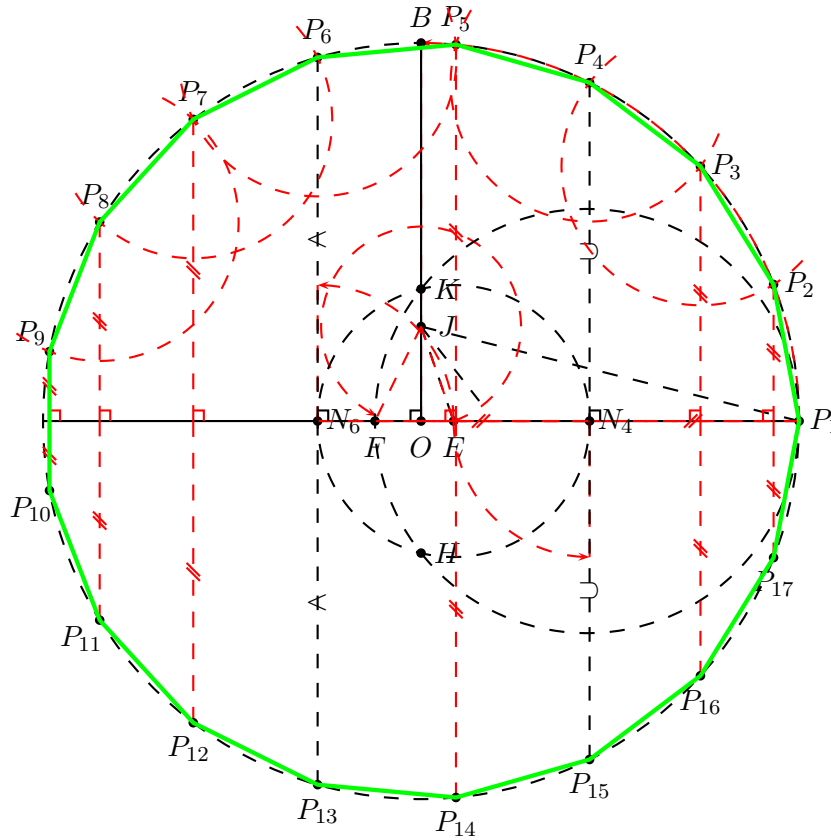
The orthocenter of a triangle whose points are on the branches of the hyperbola  $\mathcal{H} : y = a/x$  belong to this hyperbola.



```
\psset{unit=0.7}
\begin{pspicture}(-11,-5)(11,7)
\psset{linecolor=blue, linewidth=2\pslinewidth}
\psplot[yMaxValue=6,plotpoints=500]{-10}{-.1}{1 x div}
\psplot[yMaxValue=6,plotpoints=500]{.1}{10}{1 x div}
\psset{%PointSymbol=none,
linewidth=.5\pslinewidth}
\pstTriangle[linecolor=magenta, PosAngleB=-85, PosAngleC=-90](.2,5){A}(1,1){B}(10,.1){C}
\psset{linecolor=magenta,CodeFig=true, CodeFigColor=red}
\pstProjection{B}{A}{C}
\ncline[nodesepA=-1,linestyle=dashed,linecolor=magenta]{C'}{B}
\pstProjection{B}{C}{A}
\ncline[nodesepA=-1,linestyle=dashed,linecolor=magenta]{A'}{B}
\pstProjection{A}{C}{B}
\pstInterLL[PosAngle=135,PointSymbol=square]{A}{A'}{B}{B'}{H}
\psset{linecolor=green, nodesep=-1}
\pstLineAB{A}{H}\pstLineAB{B'}{H}\pstLineAB{C}{H}
\psdot[dotstyle=square](H)
\end{pspicture}
```

### A.6. 17 sides regular polygon

Striking picture created by K. F. Gauss. he also proved that it is possible to build the regular polygons which have  $2^{2^p} + 1$  sides, the following one has 257 sides!



```
\begin{pspicture}(-5.5,-5.5)(5.5,6)
\psset{CodeFig, RightAngleSize=.14, CodeFigColor=red,
CodeFigB=true, linestyle=dashed, dash=2mm 2mm}
\pstGeonode[PosAngle={-90,0}]{0}{5;0}{P_1}
\pstCircleOA{0}{P_1}
\pstSymO[PointSymbol=none, PointName=none, CodeFig=false]{0}{P_1}[PP_1]
\ncircle[linestyle=solid]{PP_1}{P_1}
\pstRotation[RotAngle=90, PosAngle=90]{0}{P_1}[B]
\pstRightAngle[linestyle=solid]{B}{0}{PP_1}\ncircle[linestyle=solid]{0}{B}
\pstHomO[HomCoef=.25]{0}{B}[J] \ncircle{J}{P_1}
\pstBisectBAC[PointSymbol=none, PointName=none]{0}{J}{P_1}{PE1}
\pstBisectBAC[PointSymbol=none, PointName=none]{0}{J}{PE1}{PE2}
\pstInterLL[PosAngle=-90]{0}{P_1}{J}{PE2}{E}
\pstRotation[PosAngle=-90, RotAngle=-45, PointSymbol=none, PointName=none]{J}{E}[PF1]
\pstInterLL[PosAngle=-90]{0}{P_1}{J}{PF1}{F}
\pstMiddleAB[PointSymbol=none, PointName=none]{F}{P_1}{MFP1} \pstCircleOA{MFP1}{P_1}
\pstInterLC[PointSymbolA=none, PointNameA=none]{0}{B}{MFP1}{P_1}{H}{K}
\pstCircleOA{E}{K} \pstInterLC{0}{P_1}{E}{K}{N_6}{N_4}
\pstRotation[RotAngle=90, PointSymbol=none, PointName=none]{N_6}{E}[PP_6]
\pstInterLC[PosAngleA=90, PosAngleB=-90, PointNameB=P_{13}]{PP_6}{N_6}{0}{P_1}{P_6}{P_{13}}
\pstSegmentMark[SegmentSymbol=wedge]{N_6}{P_6}
\pstSegmentMark[SegmentSymbol=wedge]{P_{13}}{N_6}
\pstRotation[RotAngle=90, PointSymbol=none, PointName=none]{N_4}{E}[PP_4]
\pstInterLC[PosAngleA=90, PosAngleB=-90, PointNameB=P_{15}]{N_4}{PP_4}{0}{P_1}{P_4}{P_{15}}
\pstSegmentMark[SegmentSymbol=cup]{N_4}{P_4}
```

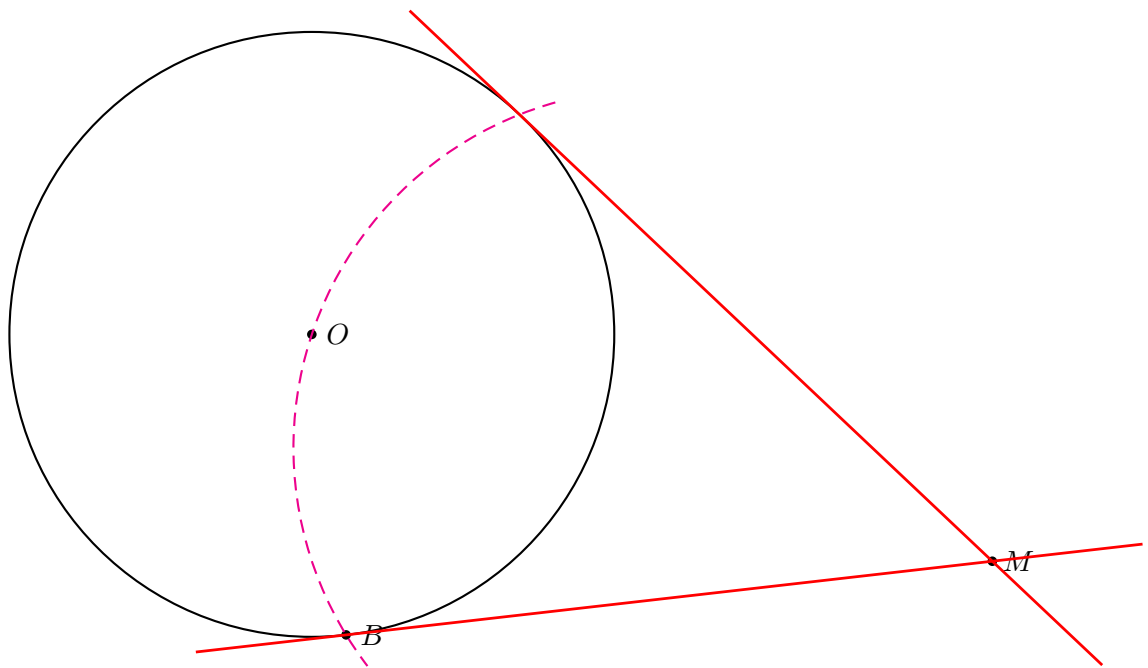
```

\pstSegmentMark[SegmentSymbol=cup]{P_15}{N_4}
\pstRightAngle[linestyle=solid]{P_1}{N_6}{P_6}
\pstRightAngle[linestyle=solid]{P_1}{N_4}{P_4}
\pstBissectBAC[PosAngle=90, linestyle=none]{P_4}{O}{P_6}{P_5}
\pstInterCC[PosAngleB=90, PointSymbolA=none, PointNameA=none]{O}{P_1}{P_4}{P_5}{H}{P_3}
\pstInterCC[PosAngleB=90, PointSymbolA=none, PointNameA=none]{O}{P_1}{P_3}{P_4}{H}{P_2}
\pstInterCC[PosAngleA=90, PointSymbolB=none, PointNameB=none]{O}{P_1}{P_6}{P_5}{P_7}{H}
\pstInterCC[PosAngleA=100, PointSymbolB=none, PointNameB=none]{O}{P_1}{P_7}{P_6}{P_8}{H}
\pstInterCC[PosAngleA=135, PointSymbolB=none, PointNameB=none]{O}{P_1}{P_8}{P_7}{P_9}{H}
\pstOrtSym[PosAngle={-90,-90,-90,-100,-135}, PointName={P_{17},P_{16},P_{14},P_{12},P_{11},P_{10}}]
{O}{P_1}{P_2,P_3,P_5,P_7,P_8,P_9}[P_{17},P_{16},P_{14},P_{12},P_{11},P_{10}]
\pspolygon[linecolor=green, linestyle=solid, linewidth=2\pslinewidth]
(P_1)(P_2)(P_3)(P_4)(P_5)(P_6)(P_7)(P_8)(P_9)(P_{10})(P_{11})(P_{12})(P_{13})(P_{14})(P_{15})(P_{16})(P_{17})
\end{pspicture}

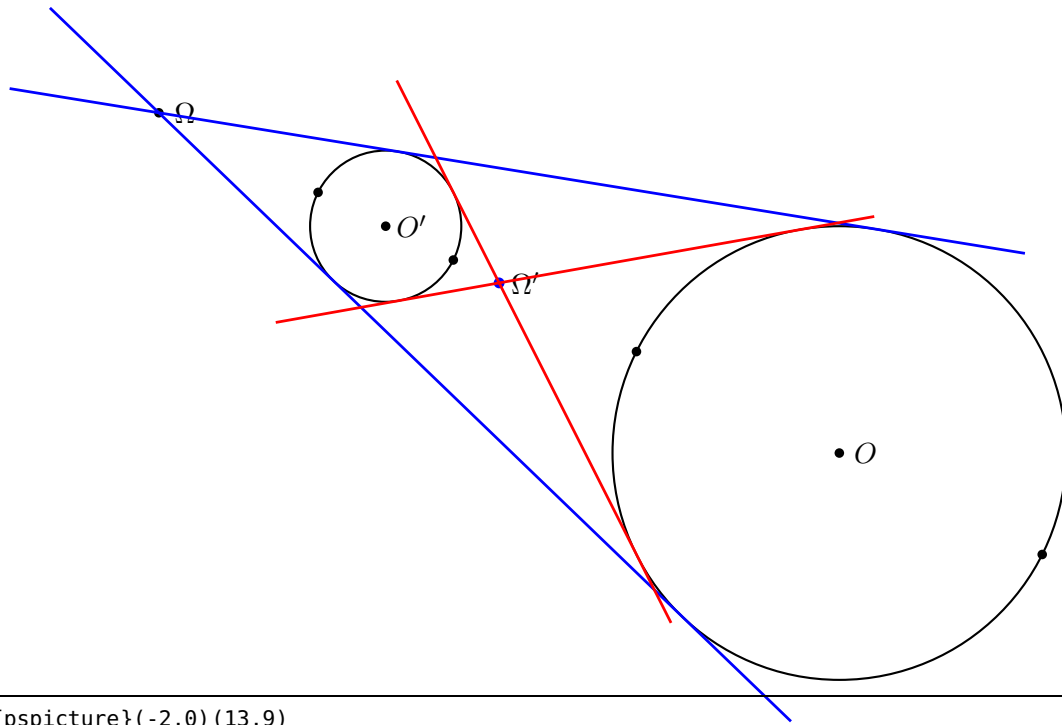
```

### A.7. Circles & tangents

The drawing of the circle tangents which crosses a given point.



```
\begin{pspicture}(15,10)
\pstGeonode(5, 5){O}(14,2){M}
\pstCircleOA[Radius=\pstDistVal{4}]{O}{}
\pstMiddleAB[PointSymbol=none, PointName=none]{O}{M}{O'}
\pstInterCC[RadiusA=\pstDistVal{4}, DiameterB=\pstDistAB{O}{M},
CodeFigB=true, CodeFigColor=magenta, PosAngleB=45]{O}{O'}{}{A}{B}
\psset{linecolor=red, linewidth=1.3\pslinewidth, nodesep=-2}
\pstLineAB{M}{A}\pstLineAB{M}{B}
\end{pspicture}
```



```

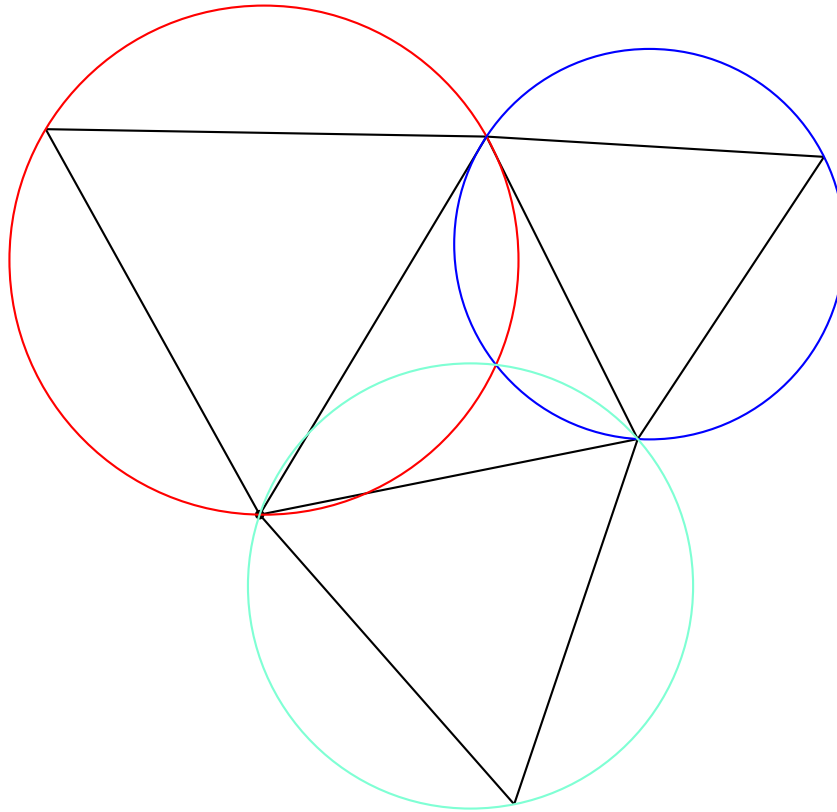
\begin{pspicture}(-2,0)(13,9)
\pstGeonode(9,3){O}(3,6){O'}\psset{PointSymbol=none, PointName=none}
\pstCircleOA[Radius=\pstDistVal{3}]{O}{O'}\pstCircleOA[Radius=\pstDistVal{1}]{O'}{}
\pstInterLC[Radius=\pstDistVal{3}]{O}{O'}{O}{M}{toto}
\pstInterLC[Radius=\pstDistVal{1}]{O}{O'}{O'}{M'}{toto}
\pstRotation[RotAngle=30]{O}{M}{N}
\pstRotation[RotAngle=30]{O'}{M'}{N'}
\pstInterLL[PointSymbol=*, PointName=\Omega]{O}{O'}{N}{N'}{\Omega}
\pstMiddleAB{O}{\Omega}{I} \pstInterCC{I}{O}{O}{M}{A}{B}
\psset{nodesepA=-1, nodesepB=-3, linecolor=blue, linewidth=1.3\pslinewidth}
\pstLineAB[nodesep=-2]{A}{\Omega}\pstLineAB[nodesep=-2]{B}{\Omega}
\pstRotation[RotAngle=-150]{O'}{M'}{N''}
\pstInterLL[PointSymbol=*, PointName=\Omega']{O}{O'}{N}{N''}{\Omega'}
\pstMiddleAB{O}{\Omega'}{J}
\pstInterCC{J}{O}{O}{M}{A'}{B'}
\psset{nodesepA=-1, nodesepB=-3, linecolor=red}
\pstLineAB{A'}{\Omega'}\pstLineAB{B'}{\Omega'}
\end{pspicture}

```



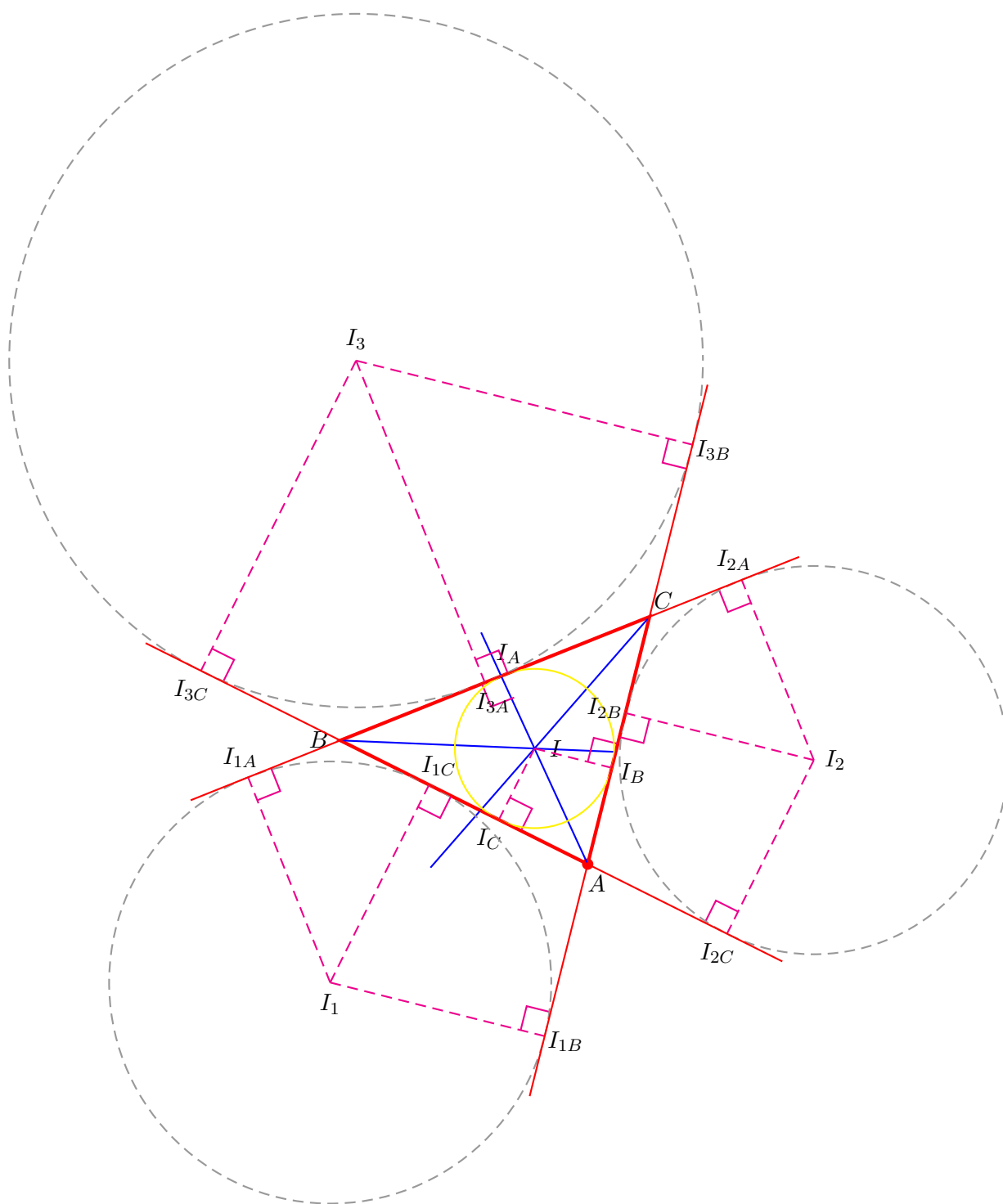
### A.8. Fermat's point

Drawing of Manuel Luque.



```
\begin{pspicture}(-7,-6)(5,5)
\psset{PointSymbol=none, PointName=none}
\pstTriangle[PosAngleA=-160,PosAngleB=90,PosAngleC=-25](-3,-2){B}(0,3){A}(2,-1){C}%
\psset{RotAngle=-60}
\pstRotation[PosAngle=-90]{B}{C}{A'}
\pstRotation{C}{A}{B'}
\pstRotation[PosAngle=160]{A}{B}{C'}
\pstLineAB{A}{B'}
\pstLineAB{C}{B'}
\pstLineAB{B}{A'}
\pstLineAB{C}{A'}
\pstLineAB{B}{C'}
\pstLineAB{A}{C'}
\pstCircleABC[linecolor=red]{A}{B}{C'}{0_1}
\pstCircleABC[linecolor=blue]{A}{C}{B'}{0_2}
\pstCircleABC[linecolor=Aquamarine]{A'}{C}{B}{0_3}
\pstInterCC[PointSymbolA=none]{0_1}{A}{0_2}{A}{E}{F}
\end{pspicture}
```

## A.9. Escribed and inscribed circles of a triangle



```

\begin{pspicture}(-6,-5)(11,15)
\psset{PointSymbol=none}
\pstTriangle[linewidth=2\pslinewidth,linecolor=red](4,1){A}(0,3){B}(5,5){C}
\psset{linecolor=blue}
\pstBisectBAC[PointSymbol=none,PointName=none]{C}{A}{B}{AB}
\pstBisectBAC[PointSymbol=none,PointName=none]{A}{B}{C}{BB}

```

```

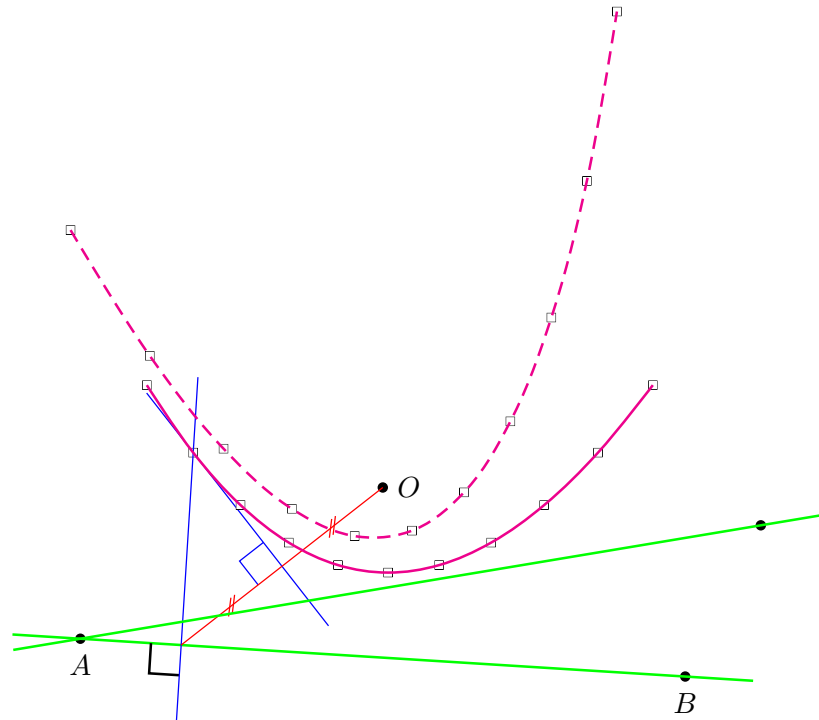
\pstBissectBAC[PointSymbol=none,PointName=none]{B}{C}{A}{CB}
\pstInterLL{A}{AB}{B}{BB}{I}
\psset{linecolor=magenta, linestyle=dashed}
\pstProjection{A}{B}{I}{I_C}
\pstLineAB{I}{I_C}\pstRightAngle[linestyle=solid]{A}{I_C}{I}
\pstProjection{A}{C}{I}{I_B}
\pstLineAB{I}{I_B}\pstRightAngle[linestyle=solid]{C}{I_B}{I}
\pstProjection[PosAngle=80]{C}{B}{I}{I_A}
\pstLineAB{I}{I_A}\pstRightAngle[linestyle=solid]{B}{I_A}{I}
\pstCircleOA[linecolor=yellow, linestyle=solid]{I}{I_A}
\psset{linecolor=magenta, linestyle=none}
\pstOutBissectBAC[PointSymbol=none,PointName=none]{C}{A}{B}{AOB}
\pstOutBissectBAC[PointSymbol=none,PointName=none]{A}{B}{C}{BOB}
\pstOutBissectBAC[PointSymbol=none,PointName=none]{B}{C}{A}{COB}
\pstInterLL[PosAngle=-90]{A}{AOB}{B}{BOB}{I_1}
\pstInterLL{A}{AOB}{C}{COB}{I_2}
\pstInterLL[PosAngle=90]{C}{COB}{B}{BOB}{I_3}
\psset{linecolor=magenta, linestyle=dashed}
\pstProjection[PointName=I_1C]{A}{B}{I_1}{I1C}
\pstLineAB{I_1}{I1C}\pstRightAngle[linestyle=solid]{I_1}{I1C}{A}
\pstProjection[PointName=I_1B]{A}{C}{I_1}{I1B}
\pstLineAB{I_1}{I1B}\pstRightAngle[linestyle=solid]{A}{I1B}{I_1}
\pstProjection[PointName=I_1A]{C}{B}{I_1}{I1A}
\pstLineAB{I_1}{I1A}\pstRightAngle[linestyle=solid]{I_1}{I1A}{C}
\pstProjection[PointName=I_2B]{A}{C}{I_2}{I2B}
\pstLineAB{I_2}{I2B}\pstRightAngle[linestyle=solid]{A}{I2B}{I_2}
\pstProjection[PointName=I_2C]{A}{B}{I_2}{I2C}
\pstLineAB{I_2}{I2C}\pstRightAngle[linestyle=solid]{I_2}{I2C}{A}
\pstProjection[PointName=I_2A]{B}{C}{I_2}{I2A}
\pstLineAB{I_2}{I2A}\pstRightAngle[linestyle=solid]{C}{I2A}{I_2}
\pstProjection[PointName=I_3A]{C}{B}{I_3}{I3A}
\pstLineAB{I_3}{I3A}\pstRightAngle[linestyle=solid]{C}{I3A}{I_3}
\pstProjection[PointName=I_3C]{A}{B}{I_3}{I3C}
\pstLineAB{I_3}{I3C}\pstRightAngle[linestyle=solid]{A}{I3C}{I_3}
\pstProjection[PointName=I_3B]{C}{A}{I_3}{I3B}
\pstLineAB{I_3}{I3B}\pstRightAngle[linestyle=solid]{I_3}{I3B}{A}
\psset{linecolor=yellow, linestyle=solid}
\pstCircleOA{I_1}{I1C} \pstCircleOA{I_2}{I2B} \pstCircleOA{I_3}{I3A}
\psset{linecolor=red, linestyle=solid, nodesepA=-1, nodesepB=-1}
\pstLineAB{I1B}{I3B}\pstLineAB{I1A}{I2A}\pstLineAB{I2C}{I3C}
\end{pspicture}

```

## B. Some locus points

### B.1. Parabola

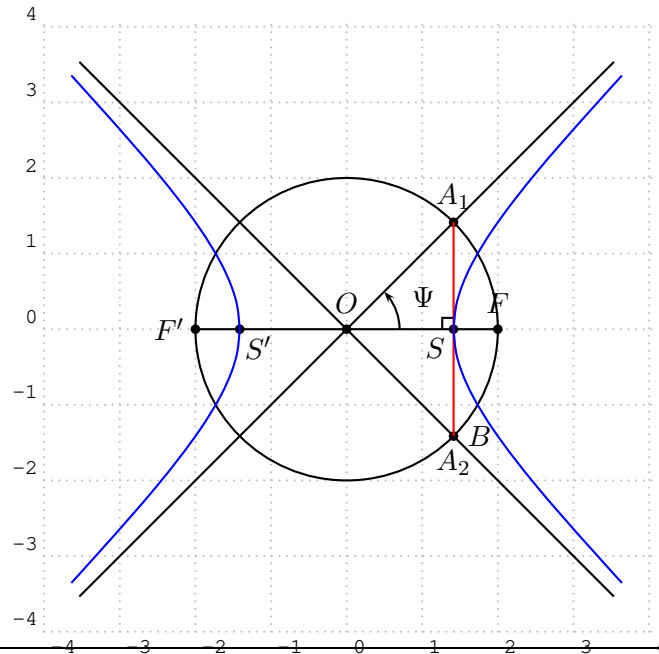
The parabola is the set of points which are at the same distance between a point and a line.



```
\def\NbPt{11}
\begin{pspicture}(-0.5,0)(11,10)
\psset{linewidth=1.2\pslinewidth}\renewcommand{\NbPt}{11}
\pstGeonode[PosAngle={0,-90}](5,4){O}(1,2){A}(9,1.5){B}
\newcommand\Parabole[1][100]{%
\pstLineAB[nodesep=-.9, linecolor=green]{A}{B}
\psset{RotAngle=90, PointSymbol=none, PointName=none}
\multido{\n=1+1}{\NbPt}{%
\pstHomO[HomCoef=\n\space \NbPt\space 1 add div]{A}{B}[M\n]
\pstMediatorAB[linestyle=none]{M\n}{O}{M\n_I}{M\n_IP}
\pstRotation{M\n}{A}[M\n_P]
\pstInterLL[PointSymbol=square, PointName=none]{M\n_I}{M\n_IP}{M\n}{M\n_P}{P\n}
\ifnum\n=#1 \bgroup
\pstRightAngle{A}{M\n}{M\n_P}
\psset{linewidth=.5\pslinewidth, nodesep=-1, linecolor=blue}
\pstLineAB{M\n_I}{P\n}\pstLineAB{M\n}{P\n}
\pstRightAngle{P\n}{M\n_I}{M\n}
\psset{linecolor=red}\pstSegmentMark{M\n}{M\n_I}\pstSegmentMark{M\n_I}{O}
\egroup \fi}}
\Parabole[2]\pstGenericCurve[linecolor=magenta]{P_}{1}{\NbPt}
\pstGeonode[PointSymbol=*, PosAngle=-90](10,3.5){B}
\Parabole\pstGenericCurve[linecolor=magenta, linestyle=dashed]{P_}{1}{\NbPt}
\end{pspicture}
```

## B.2. Hyperbola

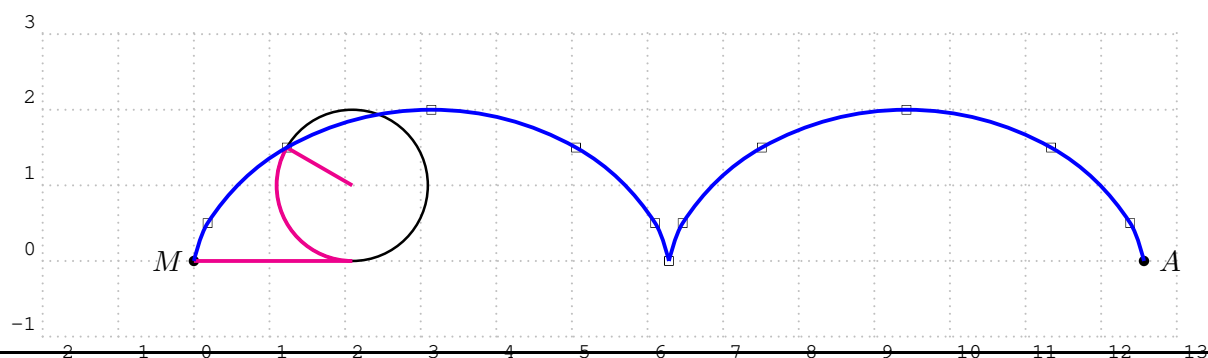
The hyperbola is the set of points whose difference between their distance of two points (the focus) is constant.



```
\begin{pspicture}[showgrid](-4,-4)(4,4)
\newcommand\Sommet{1.4142135623730951 } \newcounter{i} \setcounter{i}{1}
\newcommand\PosFoyer{2 } \newcommand\HypAngle{0}
\newcounter{CoefDiv}\setcounter{CoefDiv}{20}
\newcounter{Inc}\setcounter{Inc}{2} \newcounter{n}\setcounter{n}{2}
\newcommand\Ri{ \PosFoyer \Sommet sub \arabic{i}\space\arabic{CoefDiv}\space div add }
\newcommand\Rii{\Ri \Sommet 2 mul add }
\pstGeonode[PosAngle=90]{0}{\PosFoyer;\HypAngle}{F}
\pstSym0[PosAngle=180]{0}{F}\pstLineAB{F}{F'} \pstCircleOA{0}{F}
\pstGeonode[PosAngle=-135]{\Sommet;\HypAngle}{S}
\pstGeonode[PosAngle=-45]{-\Sommet;\HypAngle}{S'}
\pstRotation[RotAngle=90, PointSymbol=none]{S}{0}[B]
\pstInterLC[PosAngleA=90, PosAngleB=-90]{S}{B}{0}{F}{A_1}{A_2}
\pstLineAB[nodesepA=-3,nodesepB=-5]{A_1}{0}\pstLineAB[nodesepA=-3,nodesepB=-5]{A_2}{0}
\pstMarkAngle[LabelSep=.8,MarkAngleRadius=.7,arrows=->,LabelSep=1.1]{F}{0}{A_1}{\Psi}
\ncolor{linecolor=red}{A_1}{A_2} \pstRightAngle[RightAngleSize=.15]{A_1}{S}{0}
\psset{PointName=none}
\whiledo{\value{n}<8}{%
\psset{RadiusA=\pstDistVal{\Ri},RadiusB=\pstDistVal{\Rii},PointSymbol=none}
\pstInterCC{F}{F'}{M\arabic{n}}{P\arabic{n}}
\pstInterCC{F'}{F}{M'\arabic{n}}{P'\arabic{n}}
\stepcounter{n}\addtocounter{i}{\value{Inc}}
\addtocounter{Inc}{\value{Inc}}}% fin de whiledo
\psset{linecolor=blue}
\pstGenericCurve[GenCurvFirst=S]{M}{2}{7}
\pstGenericCurve[GenCurvFirst=S]{P}{2}{7}
\pstGenericCurve[GenCurvFirst=S']{M'}{2}{7}
\pstGenericCurve[GenCurvFirst=S']{P'}{2}{7}
\end{pspicture}
```

## B.3. Cycloid

The wheel rolls from  $M$  to  $A$ . The circle points are on a cycloid.



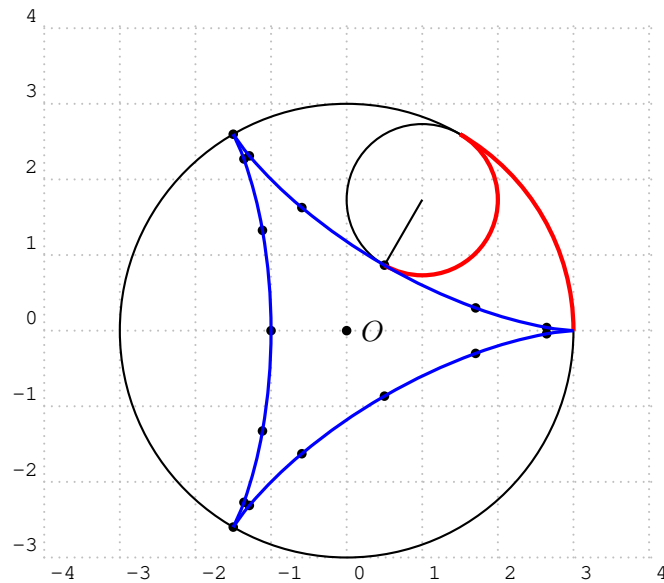
```

\begin{pspicture}[showgrid](-2,-1)(13,3)
\providecommand\NbPt{11}
\psset{linewidth=1.2\pslinewidth}
\pstGeonode[PointSymbol={*,none}, PointName={default,none}, PosAngle=180]{M}{0,1}{0}
\pstGeonode(12.5663706144,0){A}
\pstTranslation[PointSymbol=none, PointName=none]{M}{A}{0}[B]
\multido{\nA=1+1}{\NbPt}{%
  \pstHomO[HomCoef=\nA\space\NbPt\space 1 add div,PointSymbol=none,PointName=none]{0}{B}[O\nA]
  \pstProjection[PointSymbol=none, PointName=none]{M}{A}{O\nA}[P\nA]
  \pstCurvAbsNode[PointSymbol=square, PointName=none,CurvAbsNeg=true]%
    {O\nA}{P\nA}{M\nA}{\pstDistAB{0}{O\nA}}
  \ifnum\nA=2 \bgroup
    \pstCircleOA{O\nA}{M\nA}
    \psset{linecolor=magenta, linewidth=1.5\pslinewidth}
    \pstArcnOAB{O\nA}{P\nA}{M\nA}
    \ncline{O\nA}{M\nA}\ncline{P\nA}{M}
  \egroup \fi
}% fin du multido
\psset{linecolor=blue, linewidth=1.5\pslinewidth}
\pstGenericCurve[GenCurvFirst=M]{M}{1}{6} \pstGenericCurve[GenCurvLast=A]{M}{6}{\NbPt}
\end{pspicture}

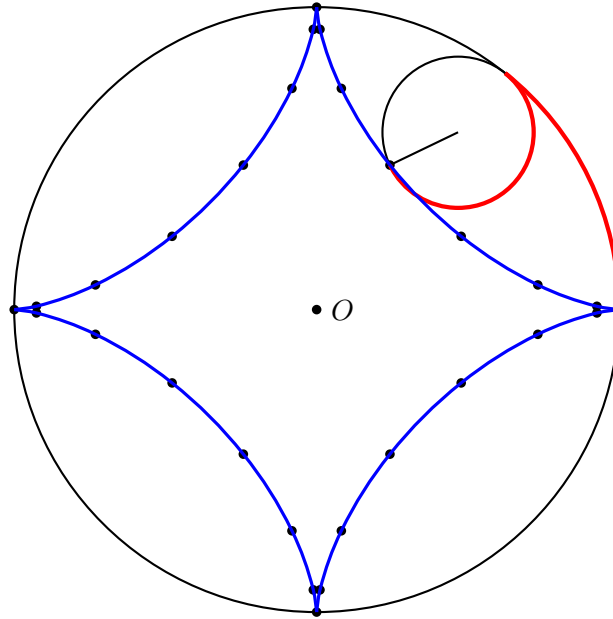
```

### B.4. Hypocycloids (Astroid and Deltoid)

A wheel rolls inside a circle, and depending of the radius ratio, it is an astroid, a deltoid and in the general case hypo-cycloids.



```
\newcommand\HypoCyclo[4][100]{%
\def\R{#2}\def\petitR{#3}\def\NbPt{#4}
\def\Anglen{\n\space 360 \NbPt\space 1 add div mul}
\psset{PointSymbol=none,PointName=none}
\pstGeonode[PointSymbol=*,none],PointName={default,none}, PosAngle=0]{O}{\R;0}{P}
\pstCircleOA{O}{P}
\pstHomO[HomCoef=\petitR\space\R\space div]{P}{O}{M}
\multido{\n=1+1}{\NbPt}{%
\pstRotation[RotAngle=\Anglen]{O}{M}{M\n}
\rput(M\n){\pstGeonode(\petitR;0){Q}}
\pstRotation[RotAngle=\Anglen]{M\n}{Q}{N}
\pstRotation[RotAngle=\n\space -360 \NbPt\space 1 add div
mul \R\space\petitR\space div mul,PointSymbol=*,PointName=none]{M\n}{N}{N\n}
\ifnum\n=#1
\pstCircleOA{M\n}{N\n}\ncircle{M\n}{N\n}%
{\psset{linecolor=red, linewidth=2\pslinewidth}
\pstArcOAB{M\n}{N\n}{N}\pstArcOAB{O}{P}{N}}
\fi}%fin multido-newcommand
\begin{pspicture}[showgrid](-3.5,-3.4)(3.5,4)
\HypoCyclo[3]{3}{1}{17}
\psset{linecolor=blue,linewidth=1.5\pslinewidth}
\pstGenericCurve[GenCurvFirst=P]{N}{1}{6}
\pstGenericCurve{N}{6}{12}
\pstGenericCurve[GenCurvLast=P]{N}{12}{17}
\end{pspicture}
```



```

\newcommand\HypoCyclo[4][100]{%
\def\R{#2}\def\petitR{#3}\def\NbPt{#4}
\def\Anglen{\n\space 360 \NbPt\space 1 add div mul}
\psset{PointSymbol=none,PointName=none}
\pstGeonode[PointSymbol=*,none],PointName={default,none}, PosAngle=0]{0}{\R;0}{P}
\pstCircleOA{0}{P}
\pstHomO[HomCoef=\petitR\space\R\space div]{P}{0}{M}
\multido{\n=1+1}{\NbPt}{%
\pstRotation[RotAngle=\Anglen]{0}{M}[M\n]
\rput(M\n){\pstGeonode(\petitR;0){Q}}
\pstRotation[RotAngle=\Anglen]{M\n}{Q}[N]
\pstRotation[RotAngle=\n\space -360 \NbPt\space 1 add div
mul \R\space\petitR\space div mul, PointSymbol=*, PointName=none]{M\n}{N}[N\n]
\ifnum\n=#1
\pstCircleOA{M\n}{N\n}\ncline{M\n}{N\n}%
{\psset{linecolor=red, linewidth=2\pslinewidth}
\pstArcOAB{M\n}{N\n}{N}\pstArcOAB{0}{P}{N}}
\fi}%\fin multido-newcommand
\begin{pspicture}(-4.5,-4)(4.5,4.5)
\HypoCyclo[4]{4}{1}{27}
\psset{linecolor=blue, linewidth=1.5\pslinewidth}
\pstGenericCurve[GenCurvFirst=P]{N}{1}{7}
\pstGenericCurve{N}{7}{14}\pstGenericCurve{N}{14}{21}
\pstGenericCurve[GenCurvLast=P]{N}{21}{27}
\end{pspicture}

```



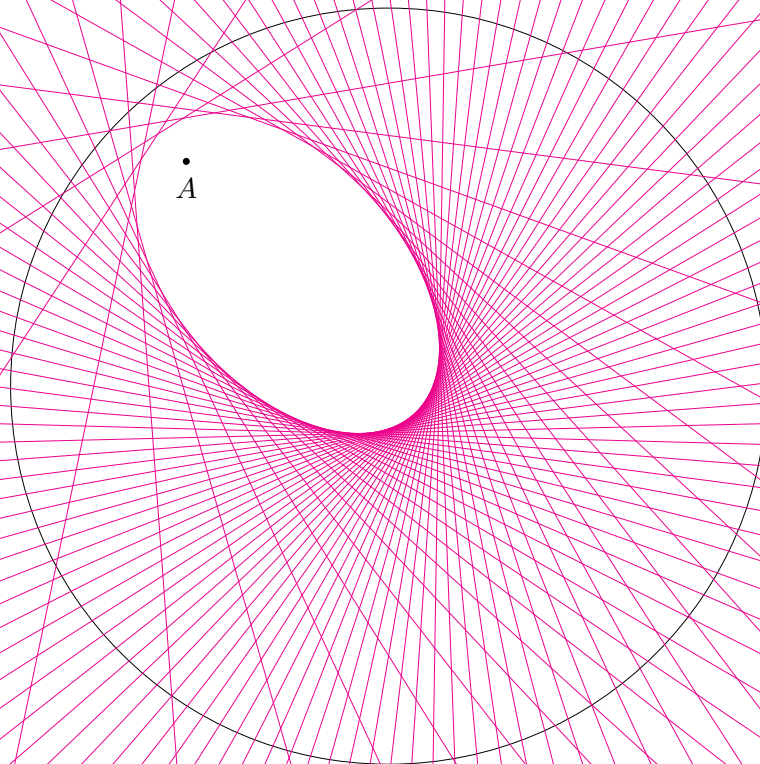
## C. Lines and circles envelope

### C.1. Conics

Let's consider a circle and a point  $A$  not on the circle. The set of all the mediator lines of segments defined by  $A$  and the circle points, create two conics depending of the position of  $A$ :

- inside the circle: an hyperbola;
- outside the circle: an ellipse.

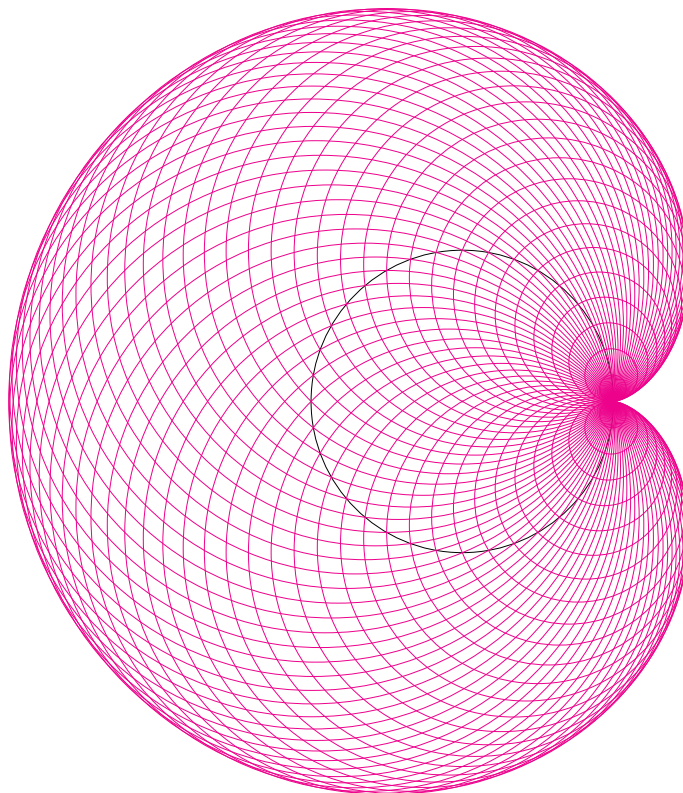
(figure of O. Reboux).



```
\begin{pspicture}(-6,-6)(6,6)
\psset{linewidth=0.4\pslinewidth,PointSymbol=none, PointName=none}
\pstGeonode[PosAngle=-90, PointSymbol={none,*,none}, PointName={none,default,none}]
{0}(4;132){A}(5,0){O'}
\pstCircleOA{0}{O'}
\multido{\n=5+5}{72}{%
\pstGeonode(5;\n){M\n}
\pstMediatorAB[nodesep=-15,linecolor=magenta]
{A}{M\n}{I}{J}}% fin multido
\end{pspicture}
```

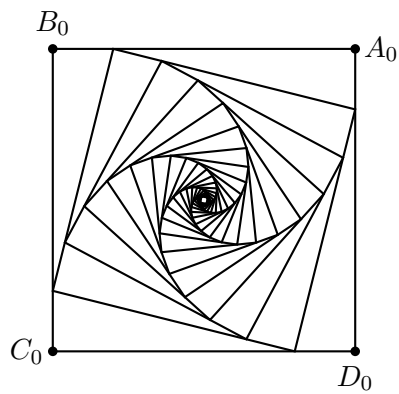
## C.2. Cardioid

The cardioid is defined by the circles centered on a circle and crossing a given point.



```
\begin{pspicture}(-6,-6)(3,5)
\psset{linewidth=0.4\pslinewidth,PointSymbol=x,nodesep=0,linecolor=magenta}
\pstGeonode[PointName=none]{0}{2,0}{0'}
\pstCircleOA[linecolor=black]{0}{0'}
\multido{\n=5+5}{72}{%
\pstGeonode[PointSymbol=none, PointName=none](2;\n){M_\n}
\pstCircleOA{M_\n}{0'}}
\end{pspicture}
```

## D. Homotethy and fractals

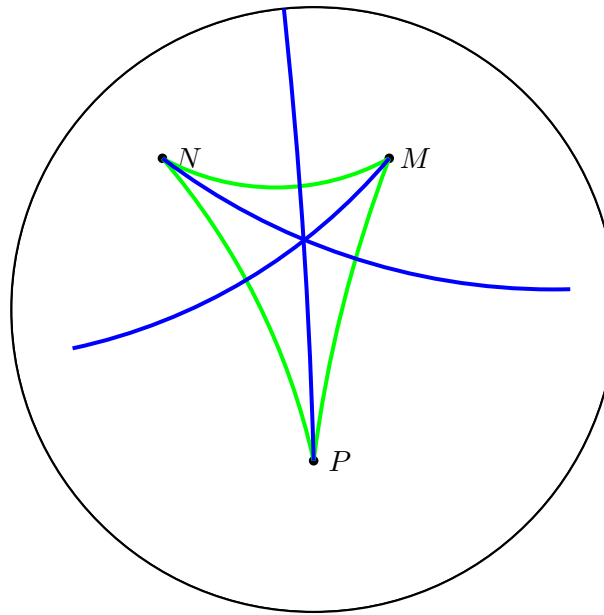


```

\begin{pspicture}(-2.8,-3)(2.8,3)
\pstGeonode[PosAngle={0,90}](2,2){A_0}(-2,2){B_0}%
\psset{RotAngle=90}
\pstRotation[PosAngle=270]{A_0}{B_0}[D_0]
\pstRotation[PosAngle=180]{D_0}{A_0}[C_0]
\pspolygon(A_0)(B_0)(C_0)(D_0)%
\psset{PointSymbol=none, PointName=none, HomCoef=.2}
\multido{\n=1+1,\i=0+1}{20}{%
\pstHom0[PosAngle=0]{B_\i}{A_\i}[A_\n]
\pstHom0[PosAngle=90]{C_\i}{B_\i}[B_\n]
\pstHom0[PosAngle=180]{D_\i}{C_\i}[C_\n]
\pstHom0[PosAngle=270]{A_\i}{D_\i}[D_\n]
\pspolygon(A_\n)(B_\n)(C_\n)(D_\n)}% fin multido
\end{pspicture}

```

## E. hyperbolic geometry: a triangle and its altitudes



```

\begin{pspicture}(-5,-5)(5,5)
\psclip{\pscircle(0,0){4}}
\pstGeonode(1,2){M}\pstGeonode(-2,2){N}\pstGeonode(0,-2){P}
\psset{DrawCirABC=false, PointSymbol=none, PointName=none}%
\pstGeonode(0,0){O}\pstGeonode(4,0){A}\pstCircleOA{O}{A}
\pstHomO[HomCoef=\pstDistAB{O}{A} 2 mul \pstDistAB{O}{M} sub
\pstDistAB{O}{M} div]{O}{M}{M'}%
\pstHomO[HomCoef=\pstDistAB{O}{A} 2 mul \pstDistAB{O}{P} sub
\pstDistAB{O}{P} div]{O}{P}{P'}%
\pstHomO[HomCoef=\pstDistAB{O}{A} 2 mul \pstDistAB{O}{N} sub
\pstDistAB{O}{N} div]{O}{N}{N'}%
\psset{linecolor=green, linewidth=1.5pt}%
\pstCircleABC{M}{N}{M'}{OmegaMN}\pstArcOAB{OmegaMN}{N}{M}
\pstCircleABC{M}{P}{M'}{OmegaMP}\pstArcOAB{OmegaMP}{M}{P}
\pstCircleABC{N}{P}{P'}{OmegaNP}\pstArcOAB{OmegaNP}{P}{N}
\psset{linecolor=blue}
\pstHomO[HomCoef=\pstDistAB{OmegaNP}{N} 2 mul \pstDistAB{OmegaNP}{M} sub %% M
\pstDistAB{OmegaNP}{M} div]{OmegaNP}{M}{MH'}
\pstCircleABC{M}{M'}{MH'}{OmegaMH}\pstArcOAB{OmegaMH}{MH'}{M} %% N
\pstHomO[HomCoef=\pstDistAB{OmegaMP}{M} 2 mul \pstDistAB{OmegaMP}{N} sub
\pstDistAB{OmegaMP}{N} div]{OmegaMP}{N}{NH'}
\pstCircleABC{N}{N'}{NH'}{OmegaNH}\pstArcOAB{OmegaNH}{N}{NH'} %% P
\pstHomO[HomCoef=\pstDistAB{OmegaMN}{M} 2 mul \pstDistAB{OmegaMN}{P} sub
\pstDistAB{OmegaMN}{P} div]{OmegaMN}{P}{PH'}
\pstCircleABC{P}{P'}{PH'}{OmegaPH}\pstArcOAB{OmegaPH}{P}{PH'}
\endpsclip
\end{pspicture}

```

**F. List of all optional arguments for pst-eucl**

Key	Type	Default
PointSymbol	ordinary	*
PointSymbolA	ordinary	*
PointSymbolB	ordinary	*
PointSymbolC	ordinary	*
PointName	ordinary	default
PointNameA	ordinary	undef
PointNameB	ordinary	undef
PointNameC	ordinary	undef
PtNameMath	ordinary	false
PointNameSize	ordinary	\normalsize
PointNameMathSize	ordinary	\textnormal
SegmentSymbol	ordinary	MarkHashh
SegmentSymbolA	ordinary	MarkHashh
SegmentSymbolB	ordinary	MarkHashh
SegmentSymbolC	ordinary	MarkHashh
Mark	ordinary	undef
mark	ordinary	undef
MarkAngle	ordinary	undef
MarkHashLength	ordinary	1.25mm
MarkHashSep	ordinary	0.625mm
PointNameSep	ordinary	[none]
PosAngle	ordinary	[none]
PosAngleA	ordinary	undef
PosAngleB	ordinary	undef
PosAngleC	ordinary	undef
RightAngleSize	ordinary	4
RightAngleType	ordinary	default
MarkAngleRadius	ordinary	0.4
LabelAngleOffset	ordinary	0
LabelSep	ordinary	1
LabelRefPt	ordinary	c
CurveType	ordinary	none
HomCoef	ordinary	0.5
RotAngle	ordinary	60
TransformLabel	ordinary	none
Central@Sym	ordinary	false
DrawCirABC	ordinary	true
CodeFig	boolean	true
CodeFigA	ordinary	undef
CodeFigB	ordinary	undef
CodeFigColor	ordinary	cyan
CodeFigStyle	ordinary	dashed
CodeFigArc	ordinary	true
CodeFigBarc	ordinary	true

*Continued on next page*

*Continued from previous page*

Key	Type	Default
Radius	ordinary	none
RadiusA	ordinary	undef
RadiusB	ordinary	undef
Diameter	ordinary	none
DiameterA	ordinary	undef
DiameterB	ordinary	undef
DistCoef	ordinary	none
AngleCoef	ordinary	none
CurvAbsNeg	ordinary	false
GenCurvFirst	ordinary	none
GenCurvLast	ordinary	none
GenCurvInc	ordinary	1
AngleValue	boolean	false
AngleArc	boolean	true
ShowWedge	boolean	true
ArcColor	ordinary	[none]
ArcLinestyle	ordinary	[none]
ArcLinewidth	ordinary	[none]
WedgeColor	ordinary	[none]
WedgeFillstyle	ordinary	[none]
WedgeOpacity	ordinary	[none]

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## Index

### Symbols

$*$ , 5, 8  
 $+$ , 5  
...A, 16  
...B, 16

### A

AngleCoef, 13  
arrows, 8  
asterisk, 5

### C

CodeFig, 12–16, 19  
CodeFigA, 19  
CodeFigArc, 19  
CodeFigB, 19  
CodeFigBarc, 19  
CodeFigColor, 12, 13, 15, 16  
CodeFigStyle, 12, 13, 15, 16  
CurvAbsNeg, 11  
CurveType, 12, 25  
CurveType=none, 6

### D

default, 5  
Diameter, 10, 18  
DiameterA, 19  
DiameterB, 19  
diamond, 5  
diamond\*, 5  
dimen, 5  
DistCoef, 10, 14, 18  
dotangle, 6  
dotscale, 6  
DrawCirABC, 16

### F

false, 12

### G

GenCurvFirst, 12  
GenCurvInc, 12  
GenCurvLast, 12  
german, 8

### H

HomCoef, 14

### K

Keyvalue

- $*$ , 8
- german, 8
- MarkArrow, 7
- MarkArroww, 7
- MarkArrowww, 7
- MarkCros, 7
- MarkCross, 7
- MarkHash, 7
- MarkHashh, 7
- MarkHashhh, 7
- none, 5
- pstslash, 7
- pstslashh, 7
- pstslashhh, 7
- suisse romand, 8

Keyword

- $*$ , 5
- $+$ , 5
- ...A, 16
- ...B, 16
- AngleCoef, 13
- arrows, 8
- asterisk, 5
- CodeFig, 12–16, 19
- CodeFigA, 19
- CodeFigArc, 19
- CodeFigB, 19
- CodeFigBarc, 19
- CodeFigColor, 12, 13, 15, 16
- CodeFigStyle, 12, 13, 15, 16
- CurvAbsNeg, 11
- CurveType, 12, 25
- CurveType=none, 6
- Diameter, 10, 18
- DiameterA, 19
- DiameterB, 19
- diamond, 5
- diamond\*, 5
- dimen, 5
- DistCoef, 10, 14, 18
- dotangle, 6
- dotscale, 6
- DrawCirABC, 16

- false, 12
- GenCurvFirst, 12
- GenCurvInc, 12
- GenCurvLast, 12
- HomCoef, 14
- label, 8
- LabelAngleOffset, 8
- LabelRefPt, 8
- LabelSep, 8
- Mark, 8
- MarkAngle, 7
- MarkAngleRadius, 8
- MarkHashLength, 7
- MarkHashSep, 7
- nodesep, 9
- nodesepA, 9
- nodesepB, 9
- o, 5
- opus, 5
- otimes, 5
- pentagon, 5
- pentagon\*, 5
- PointName, 5, 6, 8, 11, 13–18
- PointNameA, 8, 18
- PointNameB, 8, 18
- PointNameC, 8
- PointNameSep, 5, 6, 8, 11, 13–18
- PointSymbol, 5, 6, 8, 11, 13–18
- PointSymbolA, 8, 18
- PointSymbolB, 8, 18
- PointSymbolC, 8
- PosAngle, 5, 6, 8, 11, 13–18
- PosAngleA, 8, 18
- PosAngleB, 8, 18
- PosAngleC, 8
- PtNameMath, 5, 6, 11, 13–18
- Radius, 10, 18
- radius, 18
- RadiusA, 19
- RadiusB, 19
- RightAngleSize, 8
- RightAngleType, 8
- RotAngle, 13
- SegmentSymbol, 7, 15, 16
- SegmentSymbolA, 16
- SegmentSymbolB, 16
- SegmentSymbolC, 16
- square, 5

- square\*, 5
- TransformLabel, 13, 14
- triangle, 5
- triangle\*, 5
- true, 12
- x, 5

## L

- label, 8
- LabelAngleOffset, 8
- LabelRefPt, 8
- LabelSep, 8

## M

### Macro

- \ncline, 7
- \psdot, 5
- \psGetAngleABC, 22
- \psGetDistanceAB, 22
- \psplot, 20
- \pstAngleABC, 13
- \pstAngleAOB, 13
- \pstArcnOAB, 11
- \pstArcOAB, 11
- \pstBissectBAC, 17
- \pstCGravABC, 15
- \pstCircleAB, 10
- \pstCircleABC, 16
- \pstCircleOA, 10
- \pstCurvAbsNode, 11
- \pstDistAB, 10
- \pstDistVal, 10
- \pstGenericCurve, 12
- \pstGeonode, 2, 5
- \pstHomO, 14
- \pstInterCC, 19
- \pstInterFC, 21
- \pstInterFF, 20
- \pstInterFL, 21
- \pstInterLC, 18
- \pstInterLL, 18
- \pstLineAB, 9
- \pstMarkAngle, 8
- \pstMediatorAB, 16
- \pstMiddleAB, 15
- \pstOIJGeonode, 6
- \pstOrtSym, 13
- \pstOutBissectBAC, 17
- \pstProjection, 15



- \pstRightAngle, 8
- \pstRotation, 13
- \pstSegmentMark, 7
- \pstSym0, 13
- \pstTranslation, 14
- \pstTriangle, 8
- \SpecialCoor, 5
- Mark, 8
- MarkAngle, 7
- MarkAngleRadius, 8
- MarkArrow, 7
- MarkArroww, 7
- MarkArrowww, 7
- MarkCros, 7
- MarkCross, 7
- MarkHash, 7
- MarkHashh, 7
- MarkHashhh, 7
- MarkHashLength, 7
- MarkHashSep, 7
- middle, 5
- N**
- \ncline, 7
- nodesep, 9
- nodesepA, 9
- nodesepB, 9
- none, 5
- O**
- o, 5
- oplus, 5
- otimes, 5
- P**
- Package
- pst-eucl, 2
- pentagon, 5
- pentagon\*, 5
- PointName, 5, 6, 8, 11, 13–18
- PointNameA, 8, 18
- PointNameB, 8, 18
- PointNameC, 8
- PointNameSep, 5, 6, 8, 11, 13–18
- PointSymbol, 5, 6, 8, 11, 13–18
- PointSymbolA, 8, 18
- PointSymbolB, 8, 18
- PointSymbolC, 8
- PosAngle, 5, 6, 8, 11, 13–18
- PosAngleA, 8, 18
- PosAngleB, 8, 18
- PosAngleC, 8
- \psdot, 5
- \psGetAngleABC, 22
- \psGetDistanceAB, 22
- \psplot, 20
- pst-eucl, 2
- \pstAngleABC, 13
- \pstAngleA0B, 13
- \pstArcnOAB, 11
- \pstArcOAB, 11
- \pstBissectBAC, 17
- \pstCGravABC, 15
- \pstCircleAB, 10
- \pstCircleABC, 16
- \pstCircleOA, 10
- \pstCurvAbsNode, 11
- \pstDistAB, 10
- \pstDistVal, 10
- \pstGenericCurve, 12
- \pstGeonode, 2, 5
- \pstHom0, 14
- \pstInterCC, 19
- \pstInterFC, 21
- \pstInterFF, 20
- \pstInterFL, 21
- \pstInterLC, 18
- \pstInterLL, 18
- \pstLineAB, 9
- \pstMarkAngle, 8
- \pstMediatorAB, 16
- \pstMiddleAB, 15
- \pstOIJGeonode, 6
- \pstOrtSym, 13
- \pstOutBissectBAC, 17
- \pstProjection, 15
- \pstRightAngle, 8
- \pstRotation, 13
- \pstSegmentMark, 7
- pstslash, 7
- pstslashh, 7
- pstslashhh, 7
- \pstSym0, 13
- \pstTranslation, 14
- \pstTriangle, 8
- PtNameMath, 5, 6, 11, 13–18

**R**

Radius, 10, 18

radius, 18

RadiusA, 19

RadiusB, 19

RightAngleSize, 8

RightAngleType, 8

RotAngle, 13

**S**

SegmentSymbol, 7, 15, 16

SegmentSymbolA, 16

SegmentSymbolB, 16

SegmentSymbolC, 16

\SpecialCoor, 5

square, 5

square\*, 5

suisseromand, 8

**T**

TransformLabel, 13, 14

triangle, 5

triangle\*, 5

true, 12

**V**

Value

– \*, 5

– default, 5

– middle, 5

**X**

x, 5