

pst-spirograph

v.0.52

A PSTricks package for drawing spirograph curves

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April 12, 2026

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Thanks for feedback and contributions to:
Uwe Ziegenhagen;

1 Introduction

`pst-spirograph` is a package to simulate the operation of a spirograph. A spirograph is a geometric drawing toy that produces mathematical roulette curves that are technically known as hypotrochoids and epitrochoids. The mathematician Bruno Abakanowicz invented the spirograph between 1881 and 1900.¹ It was used to calculate an area delimited by curves. A hypotrochoid is generated by a fixed point on a circle rolling inside a fixed circle.² It consists of a small toothed wheel rotating inside or outside a ring gear. The weighing tile wheel has nine drilled holes numbered from 0–8, through these small holes the tip of a pen or pencil can be put. This causes the small wheel to rotate one or more laps around the crown and draws a hypocycloid.

The wheel can also turn off a first fixed gear, it is thus possible to draw epicycloids. The command is written as

```
\psSpirograph [Options] (x,y)
\psSpirographB [Options] (x,y)
```

and can optionally be followed by the coordinates of the point where you wish to place the Spirograph: `\psSpirograph [Options] (x,y)` which by default is centered at the origin. The optional parameters, including default values are indicated as following:

1. `Z1=20`: number of teeth of the wheel 1, the crown;
2. `Z2=10`: number of teeth of the wheel 2;
3. `m=0.5`: relative size of the gear;
4. `ap=20`: pressure angle in degrees, it must be reduced if the number of teeth crown is large (if the path of the teeth will be incorrect), e.g. take `Z1=120`;
5. `holenumber=0`: active hole number;
6. `polarangle=0`: polar angle in degrees to position the center of the inner/outer gear; of the small wheel. It is a useful parameter for an animation, then it is the starting angle..
7. `thetamax=360`: the end value for the rotation of the second inside/outside gear;

There are two Boolean values for the organisation of the two circles:

- `circles`: to draw circles of contact (default is false).
- `inner`: the gear rotates inside of the crown (true — default) or outside (false).

In the drawing, the color selection wheel and the line of the curve is made with the following setting:

1. `color1={rgb}{0.625 0.75 1}`;
2. `color2={rgb}{0.75 1 0.75}`;
3. `curvecolor=red`;
4. `curvewidth=1pt`: linewidth of the hypocycloid;
5. `circlescolor=red`.

The origin of the spirograph can be set by the coordinates (x, y) . If they are missing, $(0, 0)$ is assumed. By default, the wheels are not filled with color. The color inside the wheels must be set by the option `fillStyle=solid`.

The choice of color and line thickness contour of the wheels is made with usual PSTricks options: `linecolor` and `linewidth`. The transparency of the small wheel is adjusted with the `opacity` option of PSTricks.

The last parameter is the angle `thetamax=360`, which represents the rotation in degrees the center of the small wheel around the ring, so it is a parameter to adjust, depending on the planned route of the hypocycloid.

2 Parameter

2.1 Relative size

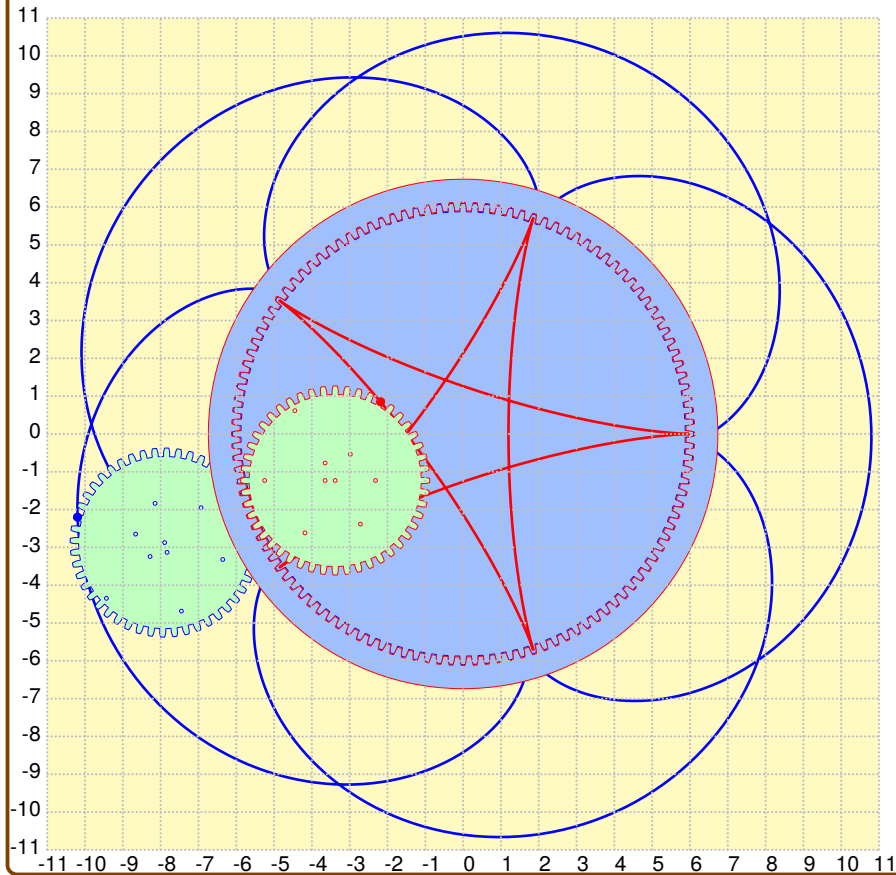
The relative size of the two gears can be set by the optional argument `m`, which can take every possible value.

¹ <http://en.wikipedia.org/wiki/Spirograph>

² <http://mathworld.wolfram.com/Spirograph.html>

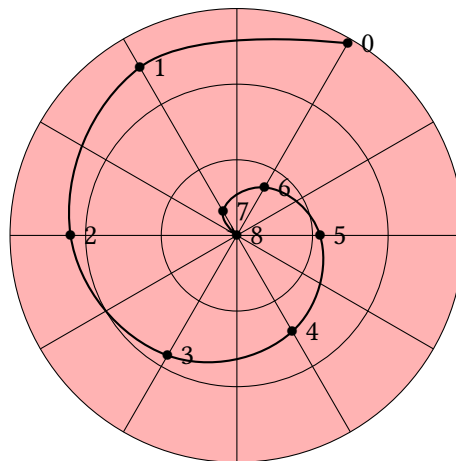
```
inner=false,m=0.1,polarangle=200,holenumber=0
```

```
\psset{unit=0.5}
\begin{pspicture}[showgrid=top,opacity=0.5](-11,-11)(11,11)
\psframe*[linecolor=yellow!30](-11,-11)(11,11)
\psset{thetamax=720,Z1=120,Z2=48,ap=10,linewidth=0.025,fillstyle=solid}
\psSpirograph[inner=false,m=0.1,polarangle=200,holenumber=0,linecolor=blue,curvecolor=blue]
\psSpirograph[m=0.1,polarangle=200,holenumber=0,linecolor=red]
\end{pspicture}
```



2.2 Pencil position

The holes (holenumber) for the pencil are ordered from outside into the center of the gear with different polar coordinates (radius and angle). They are numbered from 0 to 8 and the position cannot be changed. Every given number greater than 8 will be reset internally to 8.

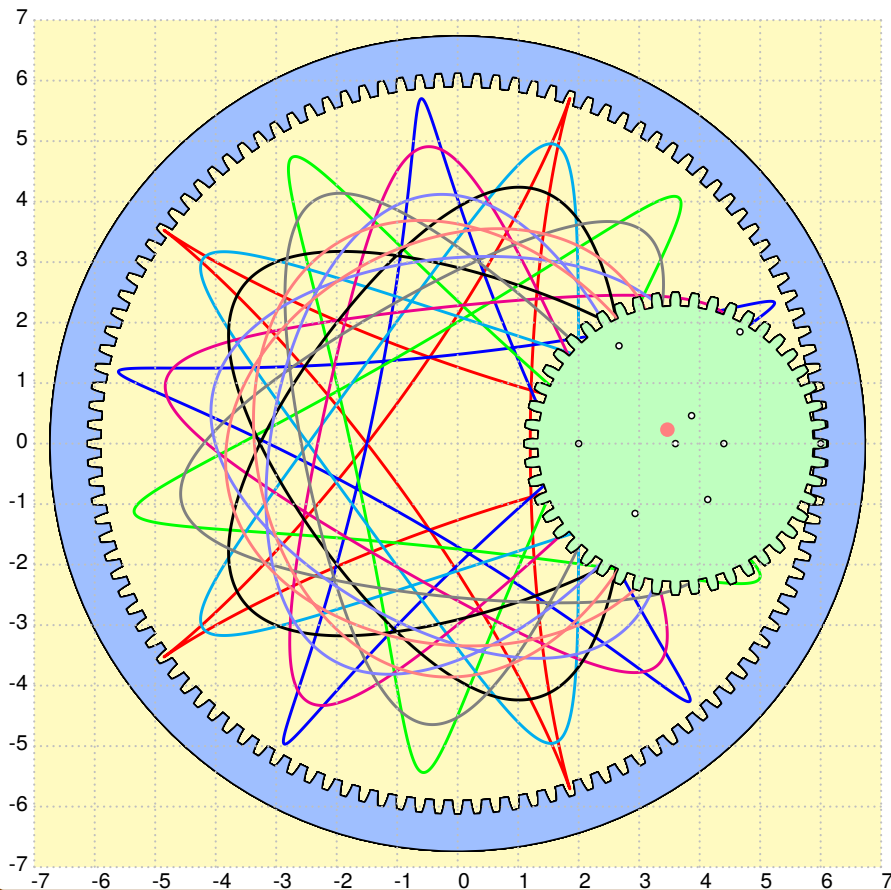


holenumber

```

\psset{unit=0.8cm}
\begin{pspicture}[showgrid=top,opacity=0.5](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psset{thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,curvewidth=1.1pt}
\psSpirograph[holenumber=0]
\psSpirograph[holenumber=1,curvecolor=blue] \psSpirograph[holenumber=2,curvecolor=green]
\psSpirograph[holenumber=3,curvecolor=cyan] \psSpirograph[holenumber=4,curvecolor=magenta]
\psSpirograph[holenumber=6,curvecolor=black] \psSpirograph[holenumber=5,curvecolor=black!50]
\psSpirograph[holenumber=7,curvecolor=blue!50]\psSpirograph[holenumber=8,curvecolor=red!50]
\end{pspicture}

```

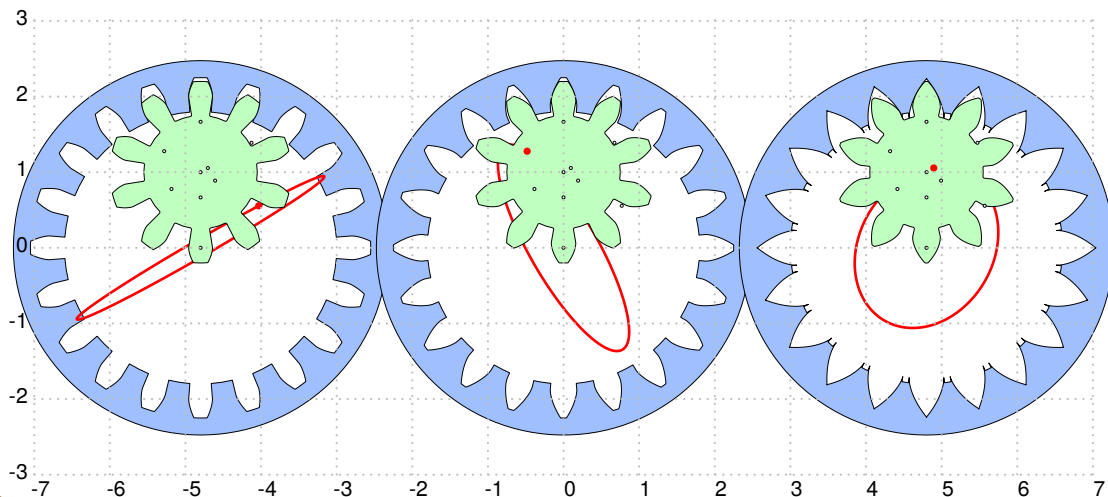


2.3 Pressure Angle

This value defines the look of a “teeth”. Values greater than 30 make no real sense.

ap, holenummer

```
\psset{unit=1cm}
\begin{pspicture}[showgrid=top,opacity=0.5](-7,-3)(7,3)
\psset{unit=0.4,linewidth=0.025,fillstyle=solid,polarangle=90}
\psSpirograph[ap=0](-12,0)
\psSpirograph[ap=20, holenummer=4](0,0)
\psSpirograph[ap=30, holenummer=8](12,0)
\end{pspicture}
```



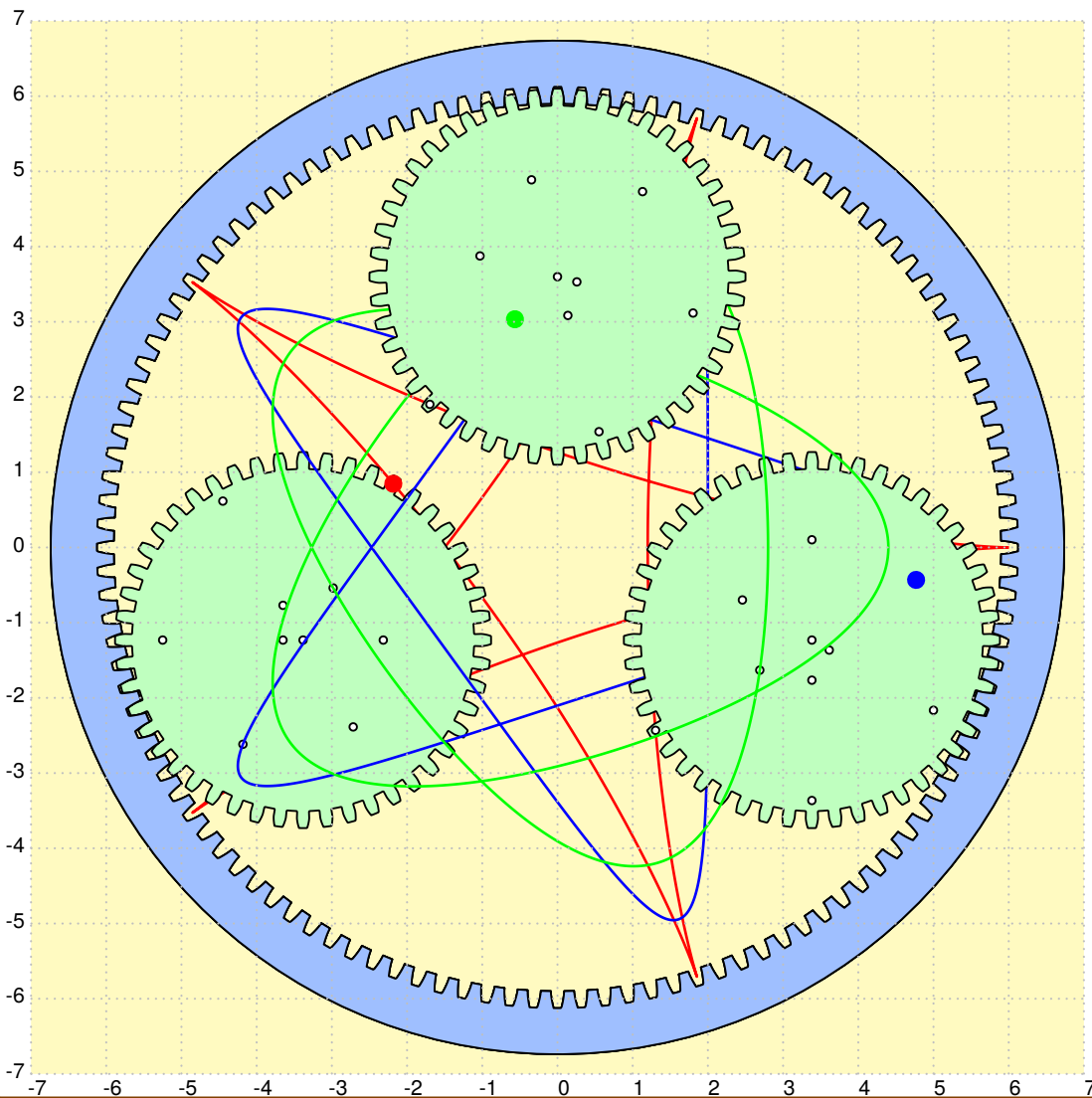
3 Examples

thetamax=720,Z1=120,Z2=48,m=0.1,ap=10

```

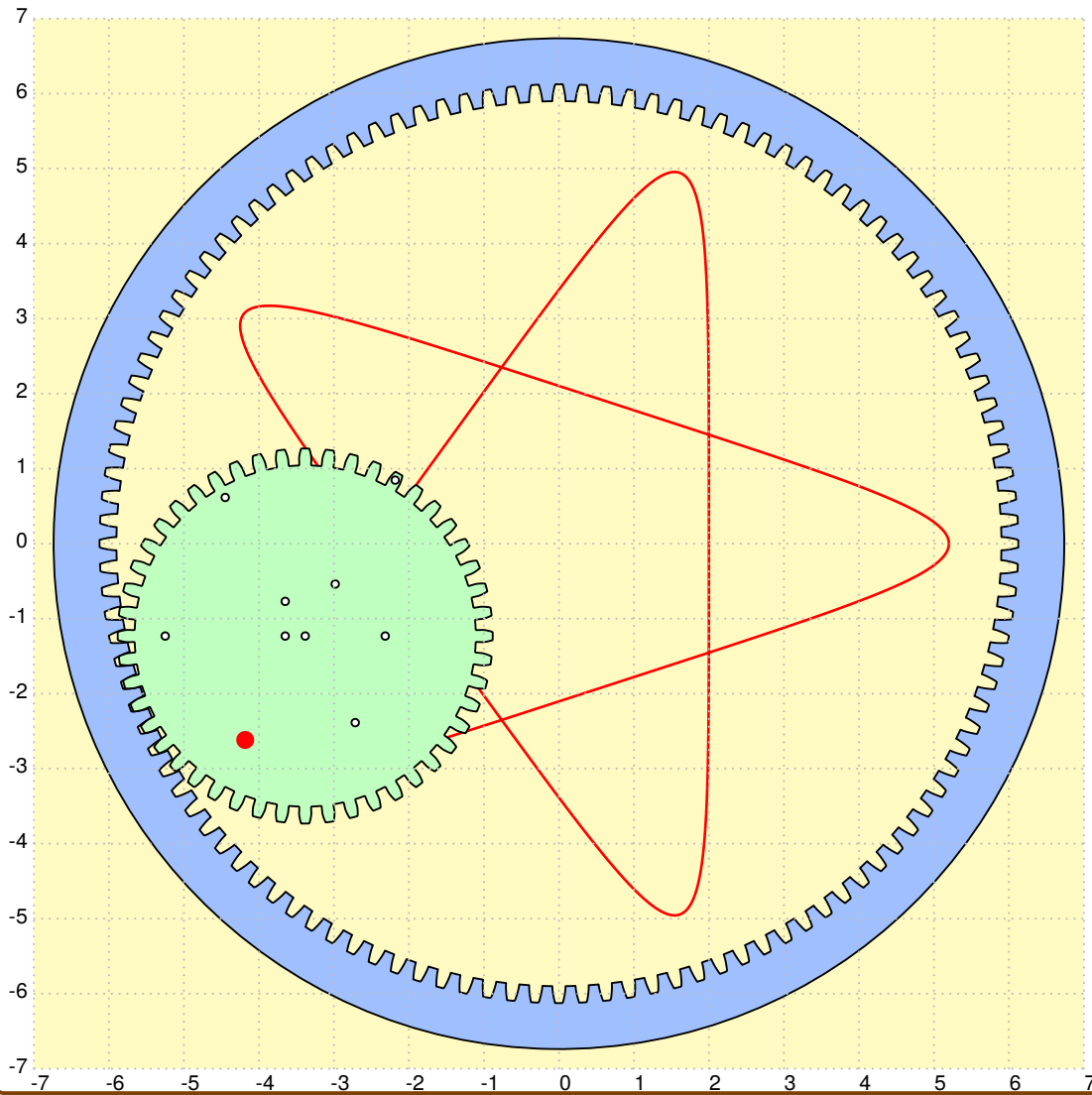
\psset{unit=1cm}
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,
fillstyle=solid,polarangle=200,holenumber=0,opacity=0.3]
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,
fillstyle=solid,polarangle=340,holenumber=3,opacity=0.3,curvecolor=blue]
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,
fillstyle=solid,polarangle=90,holenumber=6,opacity=0.3,curvecolor=green]
\end{pspicture}

```



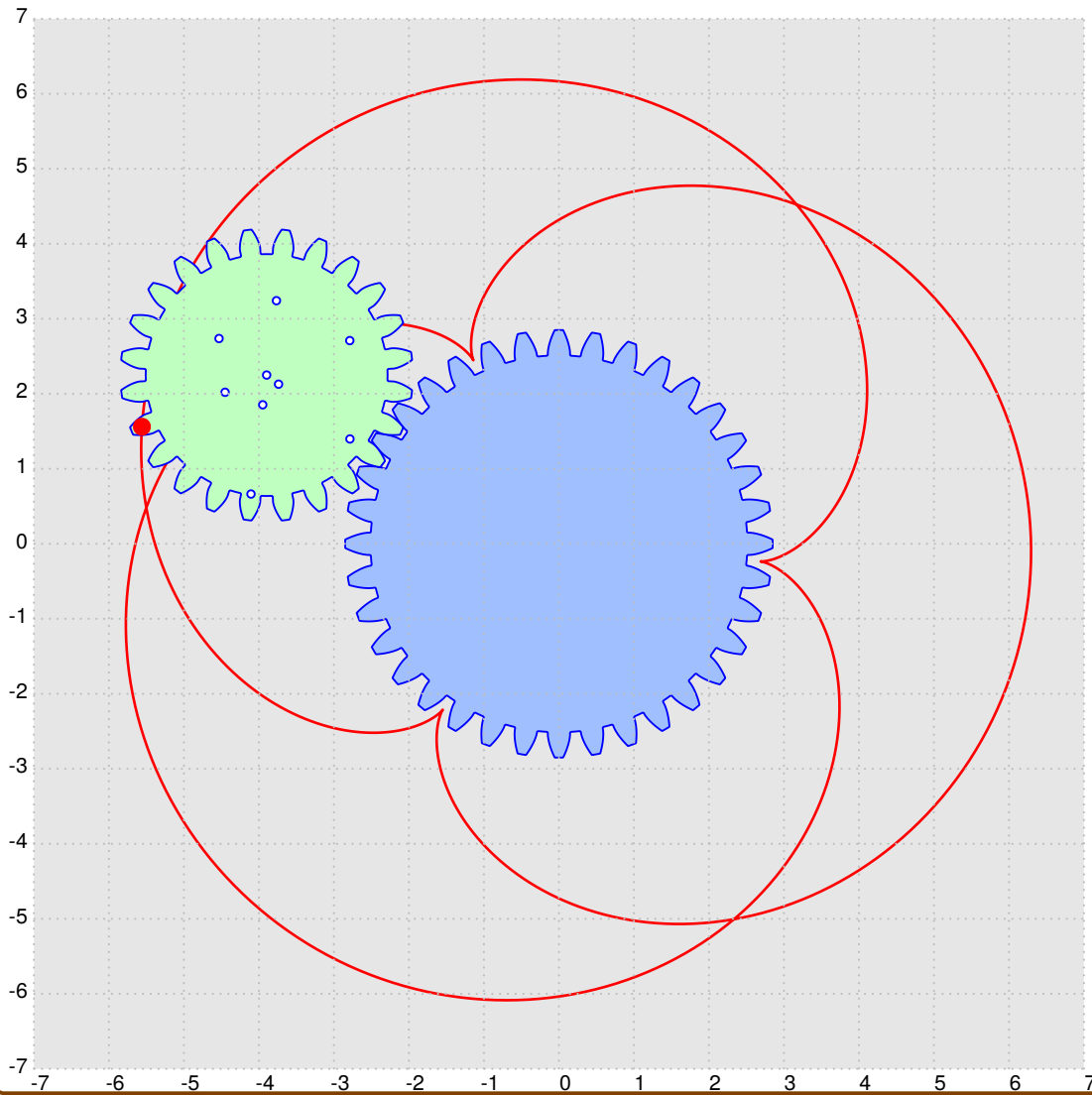
```
thetamax=720,Z1=120,Z2=48,m=0.1,ap=10
```

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)  
\psframe*[linecolor=yellow!30](-7,-7)(7,7)  
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,  
fillstyle=solid,polarangle=200,holenumber=3,opacity=0.75]  
\end{pspicture}
```



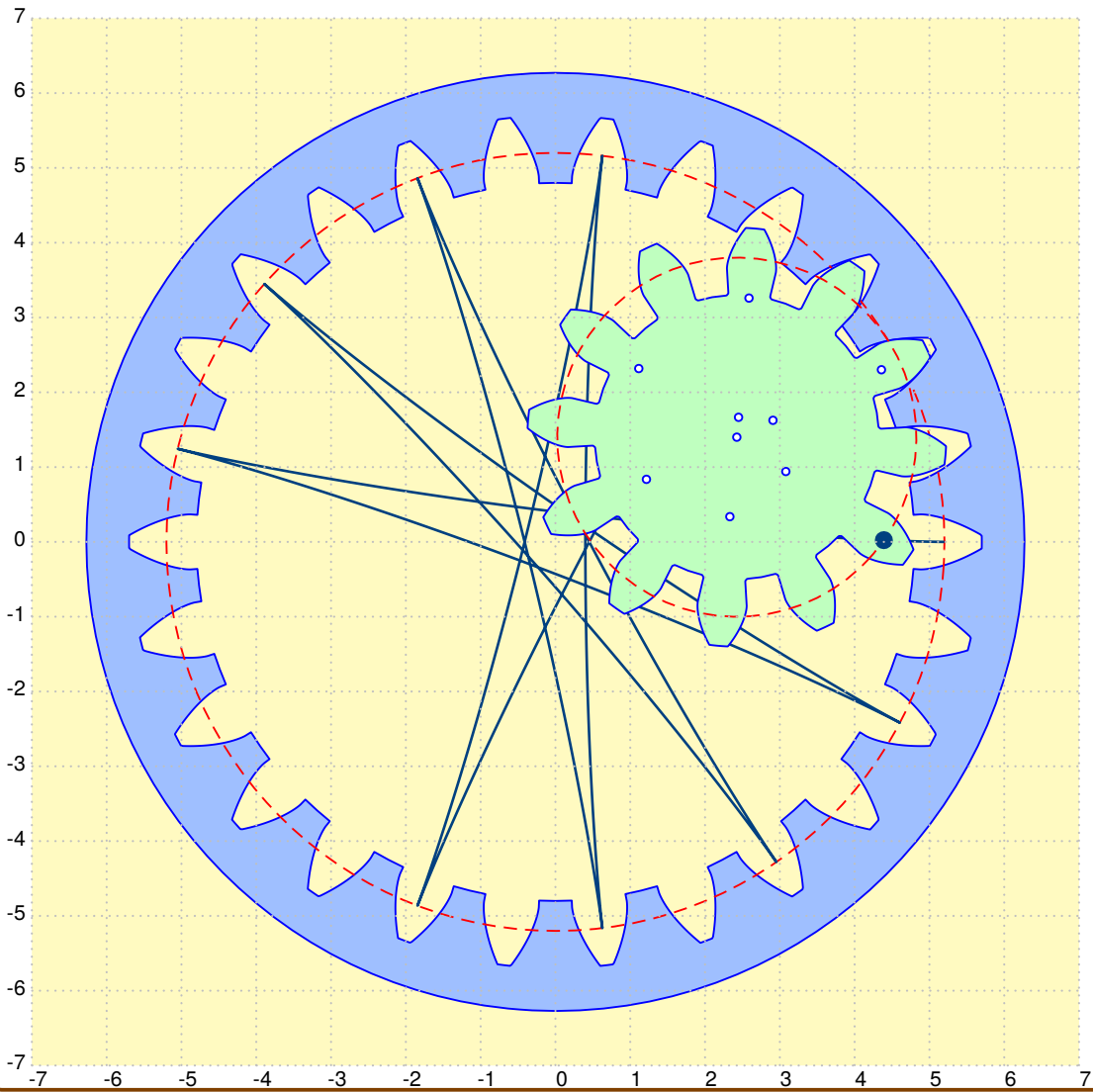
```
thetamax=720,Z1=36,Z2=24,m=0.15
```

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=gray!20](-7,-7)(7,7)
\psSpirograph[thetamax=720,Z1=36,Z2=24,m=0.15,linewidth=0.025,ap=20,inner=false,
fillstyle=solid,polarangle=150,linecolor=blue,holeumber=0,opacity=0.8]
\end{pspicture}
```



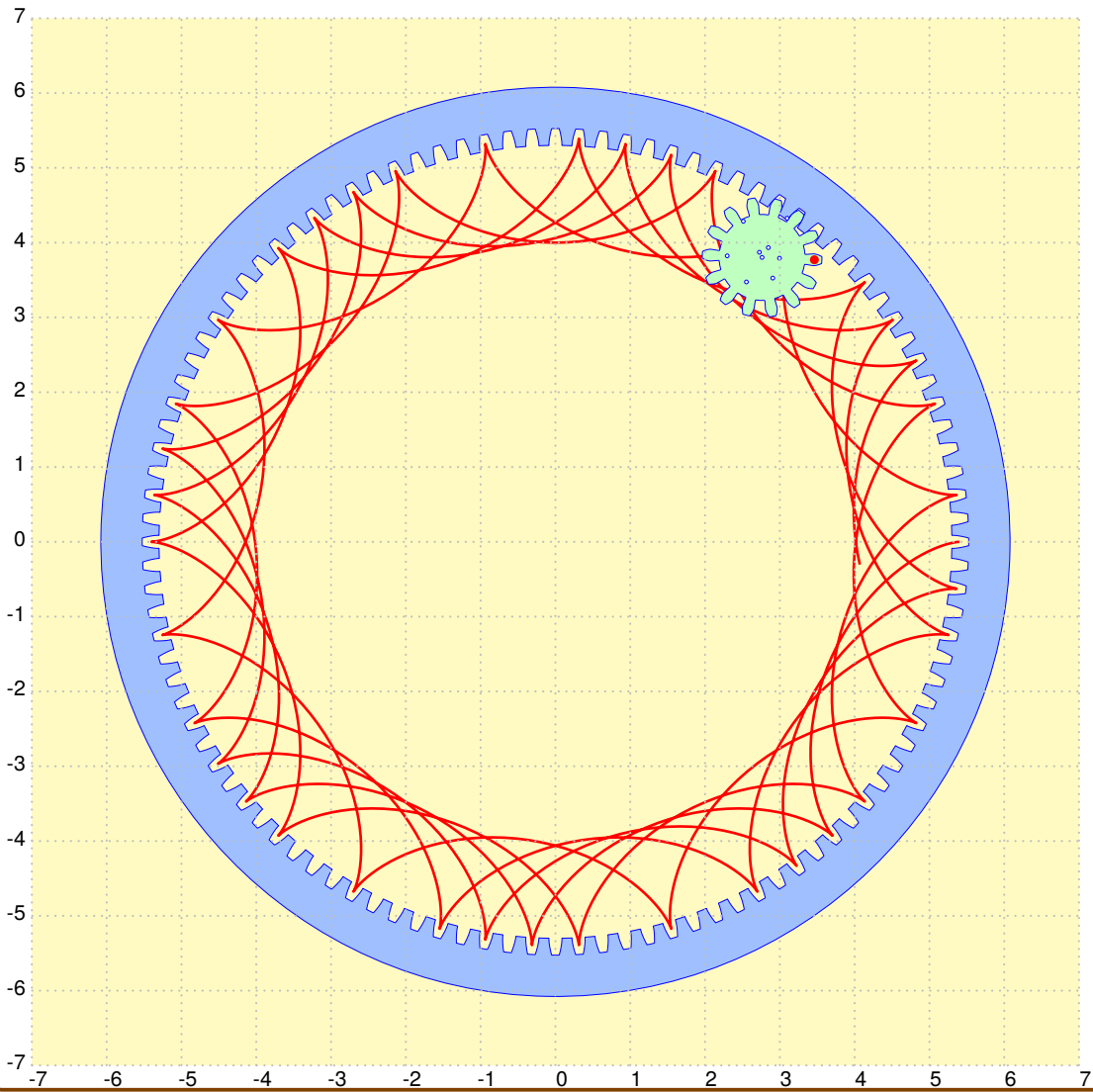

```
thetamax=1440,Z1=27,Z2=12,m=0.4
```

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)  
\psframe*[linecolor=yellow!30](-7,-7)(7,7)  
\psSpirograph[thetamax=1440,Z1=27,Z2=12,m=0.4,linewidth=0.025,  
  curvecolor={rgb}{0 0.25 0.5}},circles,fillstyle=solid,polarangle=30,  
  linecolor=blue,holenumber=0,opacity=0.75]  
\end{pspicture}
```



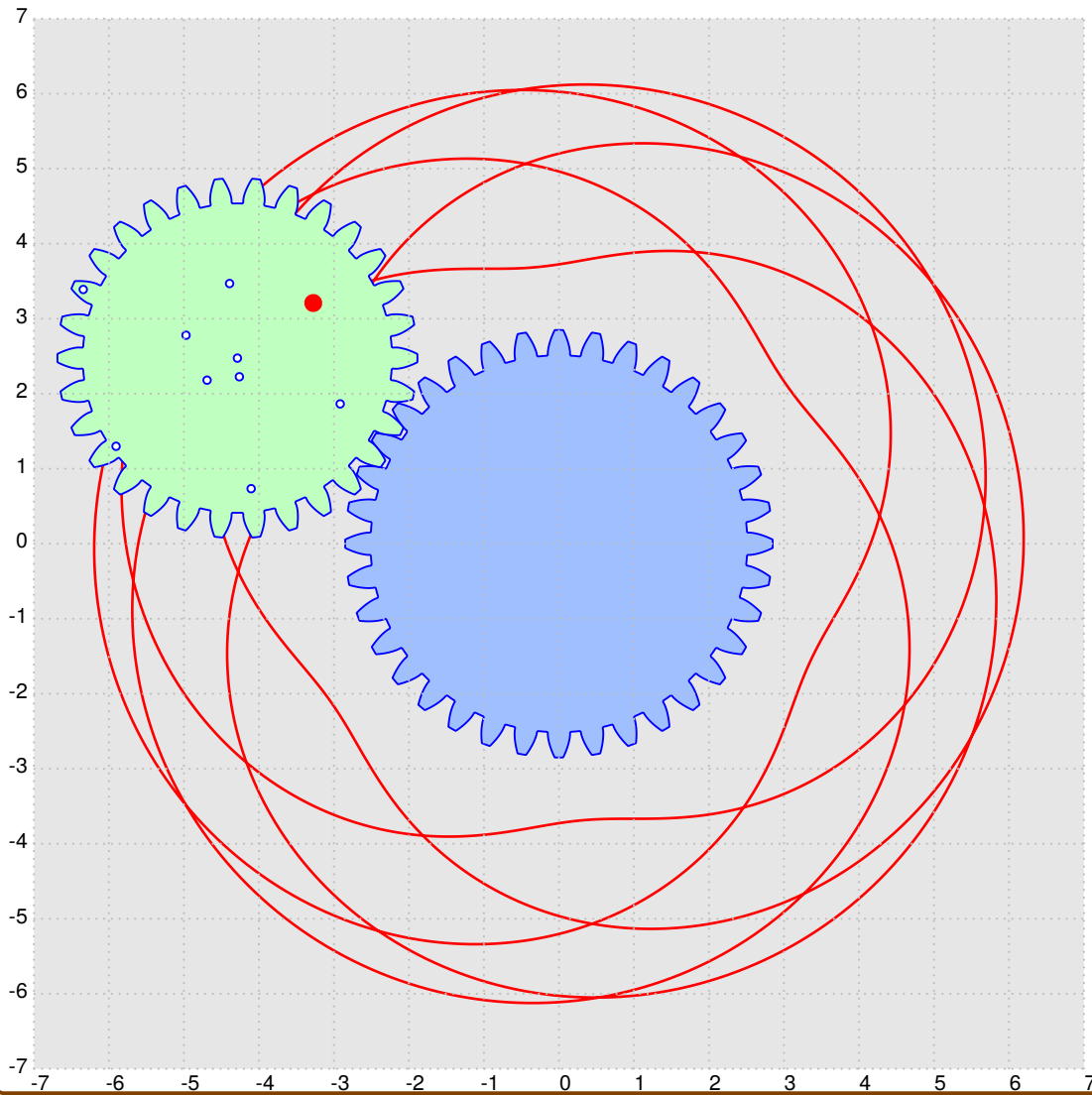
```
thetamax=-1800,Z1=108,Z2=15,m=0.2,ap=10,polarangle=54
```

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psset{unit=0.5}
\psSpirograph[thetamax=-1800,Z1=108,Z2=15,m=0.2,linewidth=0.025,ap=10,
fillstyle=solid,polarangle=54,linecolor=blue,holenumber=0,opacity=0.75]
\end{pspicture}
```



```
thetamax=1800,Z1=36,Z2=30,m=0.15,ap=20,inner=false,polarangle=150,holenumber=4
```

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)  
\psframe*[linecolor=gray!20](-7,-7)(7,7)  
\psSpirograph[thetamax=1800,Z1=36,Z2=30,m=0.15,linewidth=0.025,ap=20,inner=false,  
fillstyle=solid,polarangle=150,linecolor=blue,holenumber=4,opacity=0.8]  
\end{pspicture}
```



4 Animations

With package `animate` one can easily create animations. You get a better result with `\multiframe{360}{iA=0+4}{...}` but that increases the file size of the PDF. To save disk space the following examples use a bigger angle step than useful for a single animation.

First animation

```
1 %\psset{unit=0.75cm}
2 \begin{animateinline}[
3   width=0.9\linewidth,
4   begin={\begin{pspicture}(-4,-4)(4,4)},
5   end={\end{pspicture}},
6   palindrome,controls,
7   % autoplay
8 ]{5}
9 \multiframe{80}{iA=0+10}{%
10  \psSpirograph[thetamax=\iA,Z1=59,Z2=24,m=0.1,ap=10,curvewidth=1.1pt,
11   linewidth=0.025,fillstyle=solid,polarangle=\iA,holenumber=5,opacity=0.5](0,0)}
12 \end{animateinline}
```

Animation example

```
1 \psset{unit=0.6cm}
2 \begin{animateinline}[
3   width=0.9\linewidth,
4   begin={\begin{pspicture}(-14,-14)(14,14)},
5   end={\end{pspicture}},palindrome,controls]{5}
6 \multiframe{181}{i=0+10}{%
7   \psgrid[style=gridstyleA,unit=1.4](-10,-10)(10,10)%
8   \ifnum\i=181 \psset{gearwheels=false}\fi
9   \psSpirograph[Z1=50,Z2=20,m=0.2,linewidth=0.025,fillstyle=solid,opacity=0.75,polarangle=\i,circles,TypeA=false,
10    thetamax=\i,curvecolor=red,curvewidth=2pt,HolePos=1.5]}
11 \end{animateinline}
```

5 Connect the two gears with a rubberband

This is an adaptation with PStricks of an idea of Alejandro Teutli which he realized with Mathematica: <https://demonstrations.wolfram.com/ParametricMovementOfARubberBand/> which is a variation of a spirograph. A rubber band is fixed by its ends on two gears. A pencil tied in the middle of the elastic rubberband draws the curve obtained when the gears are rotating. The optional argument `RubberBand` must be used, if you want such a spirograph. It is only available in 3D.

Example with a rubber band

```
1 \begin{animateinline}[
2   begin={\begin{pspicture}(-6,-3)(9,5.5)\psframe*[linecolor=yellow!40](-6,-3)(9,5.5)},
3   end={\end{pspicture}}},
4   palindrome,controls,
5   % autoplay
6 ]{5}
7   \multiframe{181}{iA=0+4}{%           2 -5 3
8     \psSpirograph[RubberBand,Z1=20,Z2=40,m=0.2,viewpoint=2 -5 3,arrowinset=0,arrowsize=0.2,
9       wheelrotation=iA, opacity=0.5,
10      linewidth=0.025,color1=yellow,color2=blue!50]}
11 \end{animateinline}
```


6 List of all optional arguments for pst-spirograph

Key	Type	Default
Z1	ordinary	20
Z2	ordinary	10
m	ordinary	0.5
ap	ordinary	20
polarangle	ordinary	0
holenumber	ordinary	1
thetamax	ordinary	360
Rarct	ordinary	[none]
wheelrotation	ordinary	[none]
int	boolean	true
notdrawWheel	boolean	true
color1	ordinary	[rgb]{0.625 0.75 1}
color2	ordinary	[rgb]{0.75 1 0.75}
circlescolor	ordinary	red
curvecolor	ordinary	red
curvewidth	ordinary	1pt
inner	boolean	true
circles	boolean	true
HolePos	ordinary	[none]
gearwheels	boolean	true
TypeA	boolean	true
RubberBand	boolean	true
theta1	ordinary	[none]
theta2	ordinary	[none]

References

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