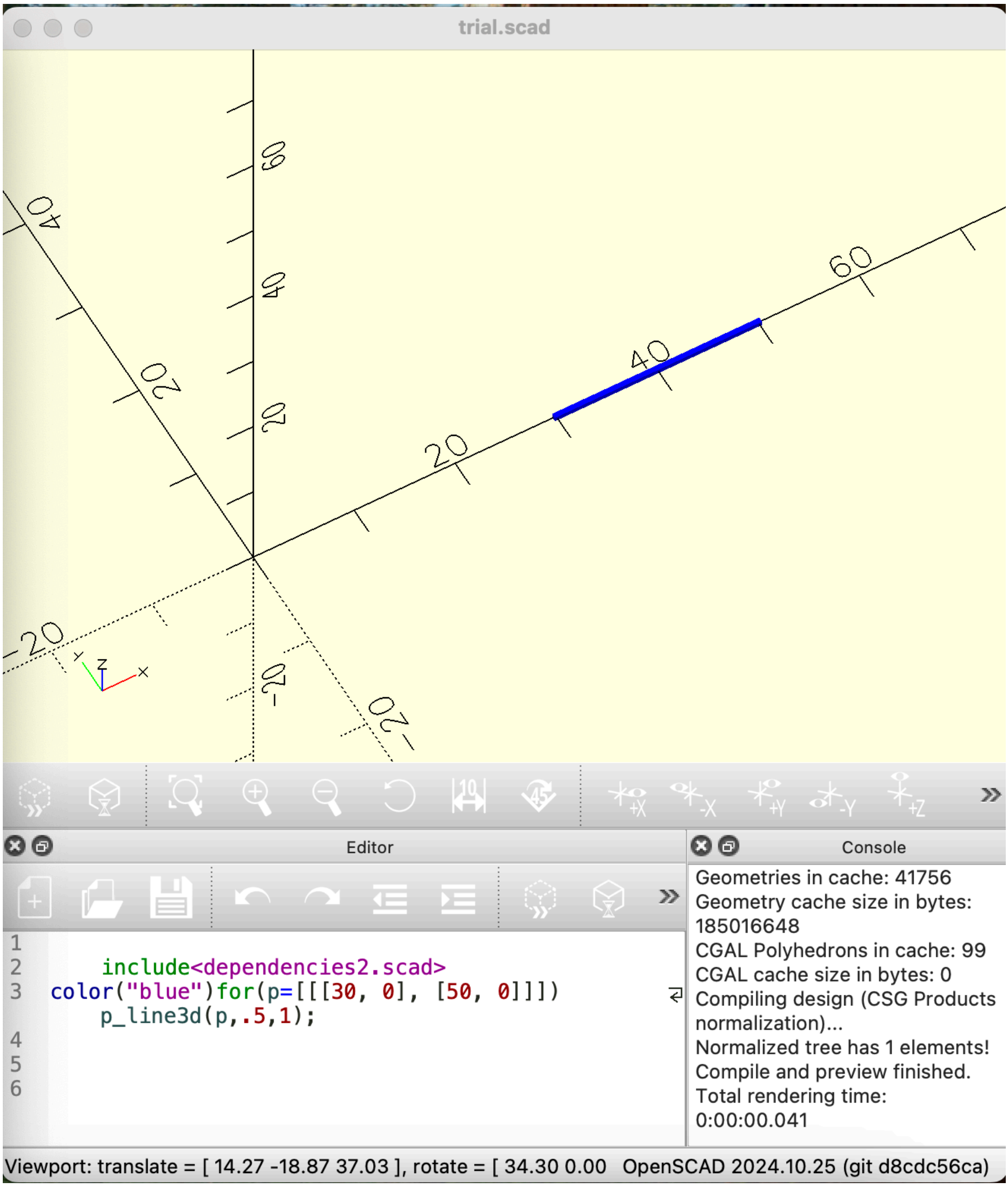
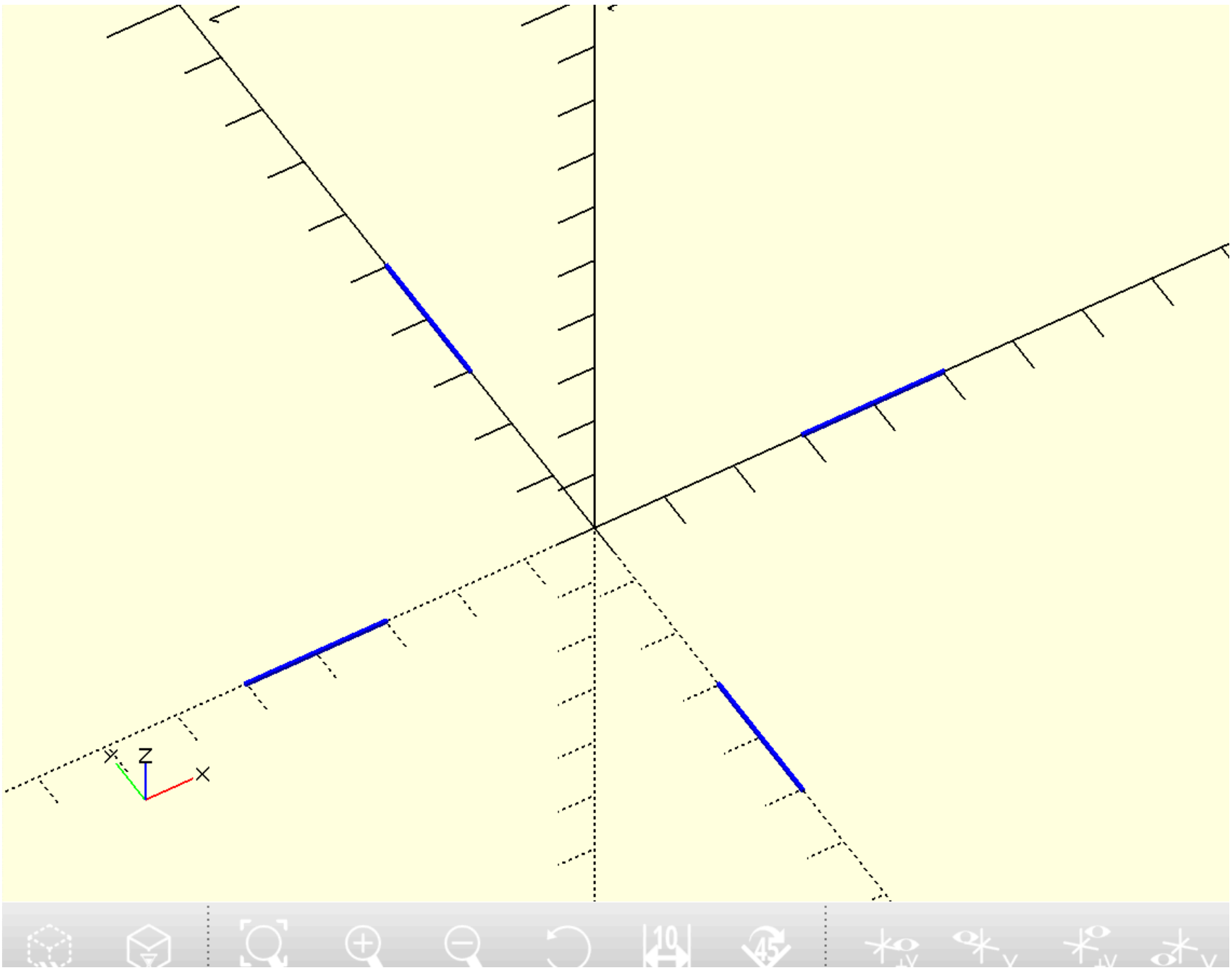
In [99]:
```
from openscad2 import *
```

In [100…
```
# hirth coupling explanation
n=4 # number of teeths
ta=60 # teeth angle
ca=10 #  cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height

# Draw a line with length outer radius - inner radius
l1=[[i_r,0],[o_r,0]]

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l1]})p_line3d(p,.5,1);


    ''')
```



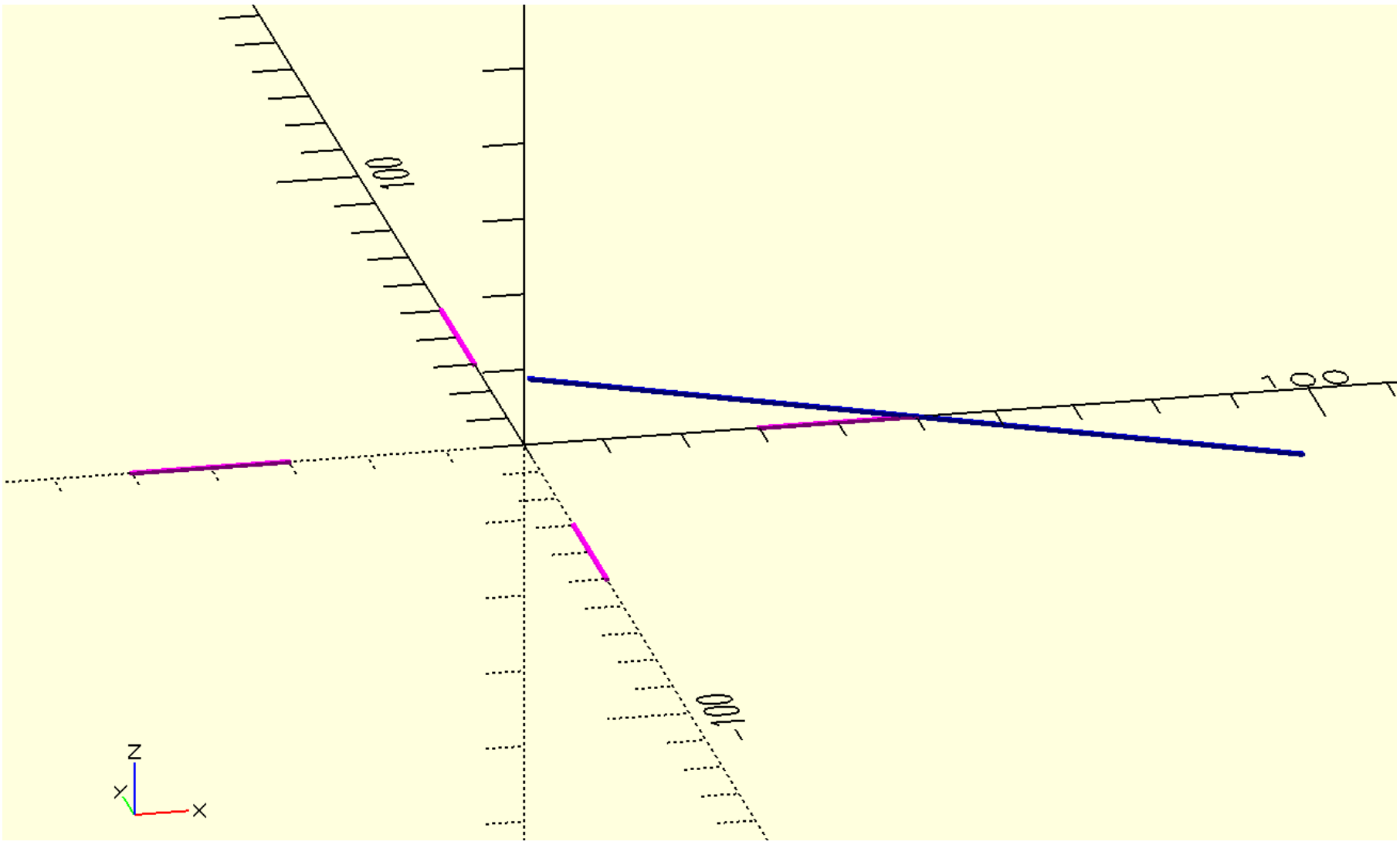
In [102…
```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # cone angle
i_r=30 # inner radius
```

```
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]

# Rotate the line number of teeths times around 360 deg
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]


with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={l2})p_line3d(p,.5,1);

    ''')
```



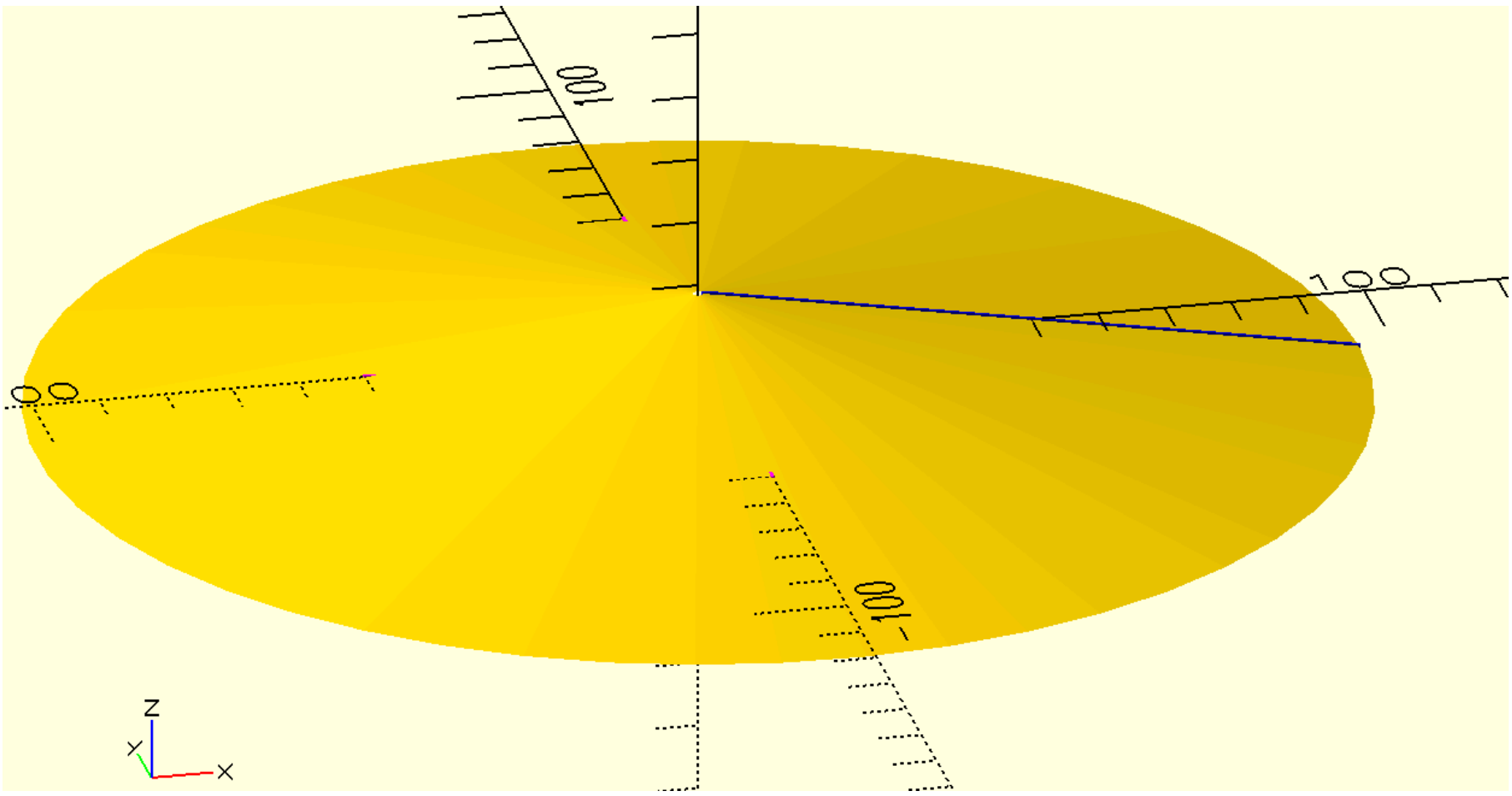
In [103…

```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]
# Rotate l1 by amount cone angle, axis of rotation is 'Y' and
# point of rotation is end of the line i.e. [50,0] in this case
l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)

# Then increase the length of the line 'l3' both sides outer and inner by an
# amount such that all the l2 lines could be projected on them
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l3]})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);

    ''')
```



In [104…

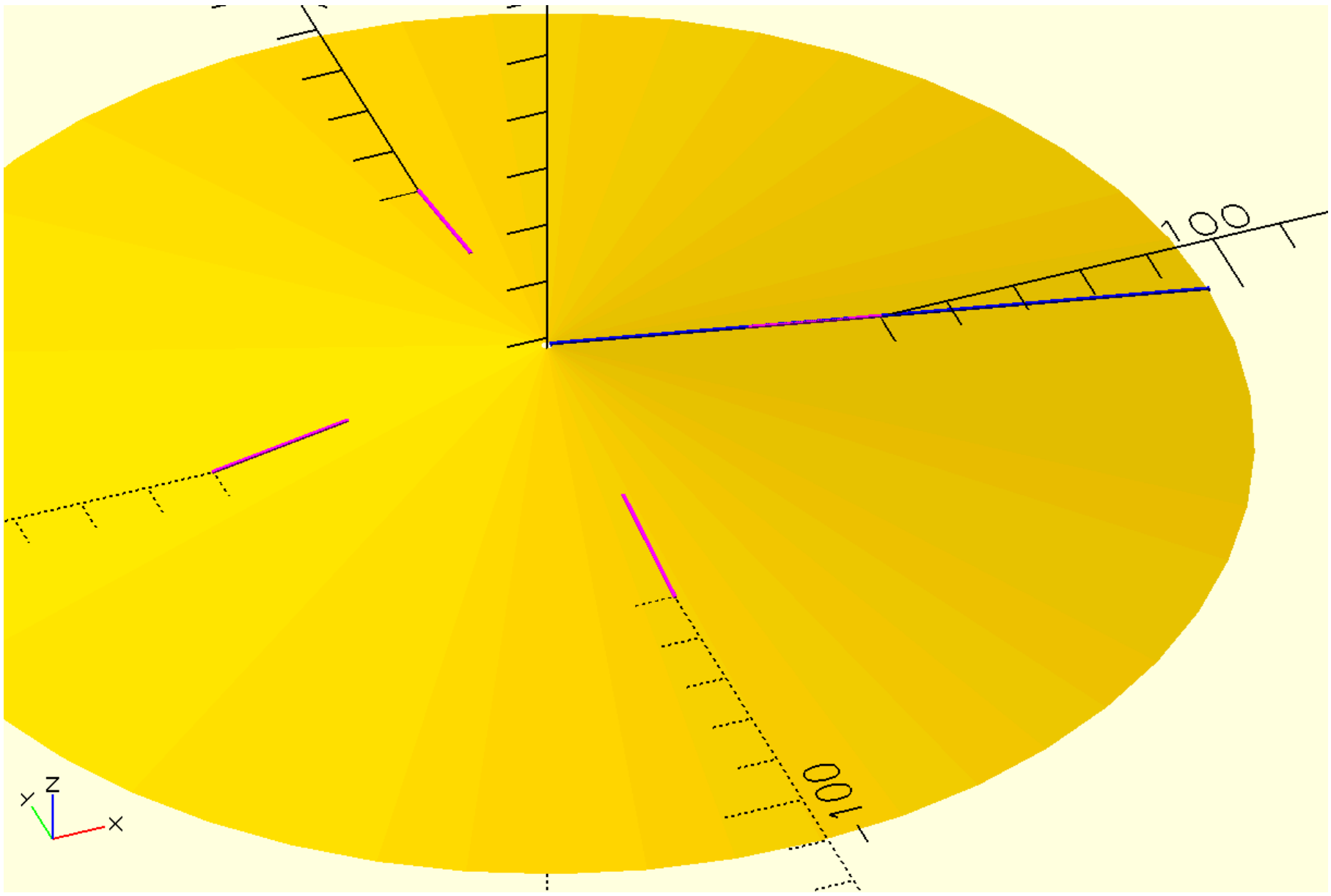
```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)

# Rotate the line l3 to create a surface
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l3]})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
{swp_surf(cone1)}

    ''')
```



In [ ]:

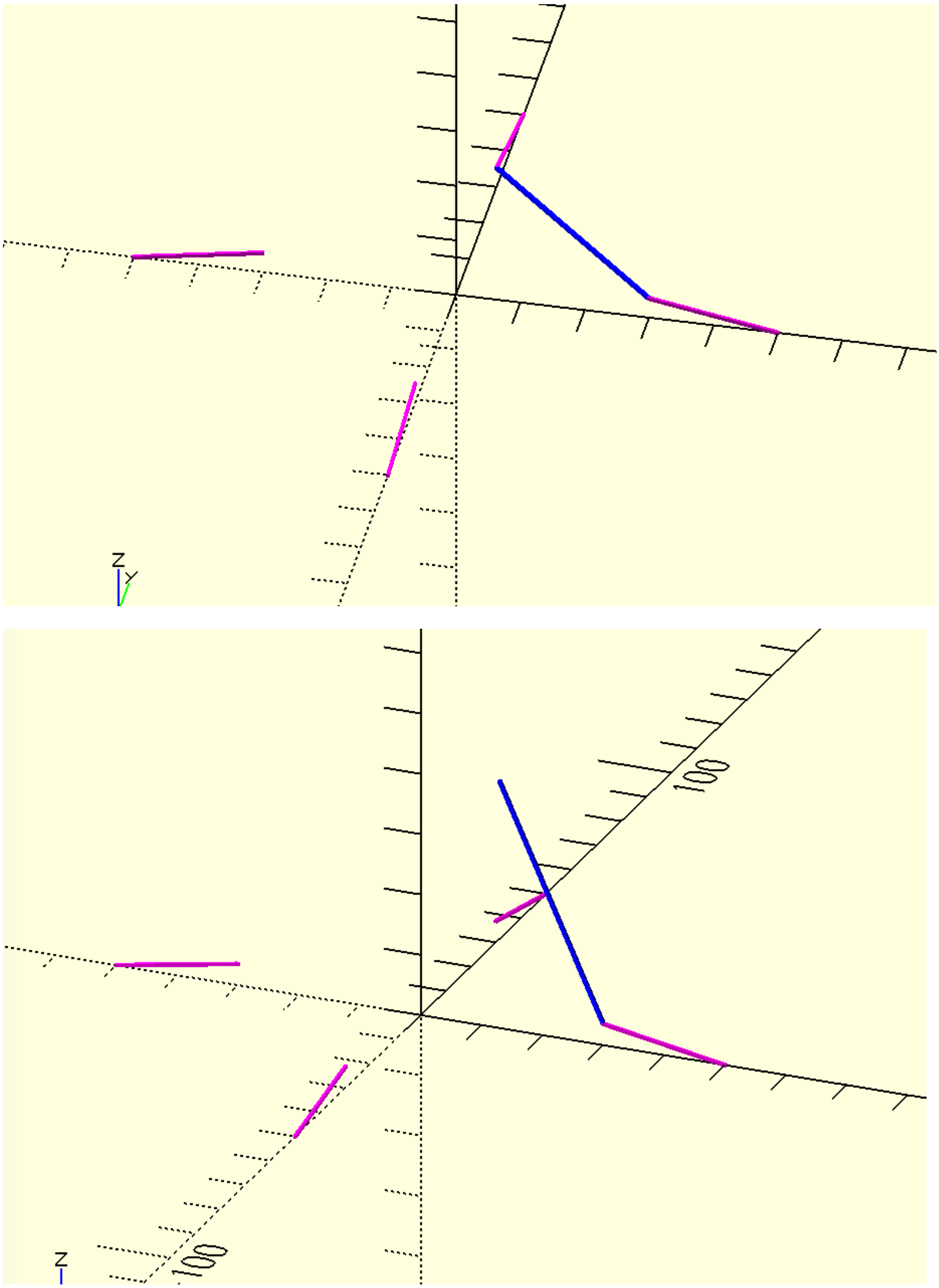
```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
```

```
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]

# project the lines 'l2' on to this cone1
l2=psos(cone1,l2,[0,0,1])

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l3]})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
{swp_surf(cone1)}

    ''')
```



In [109…

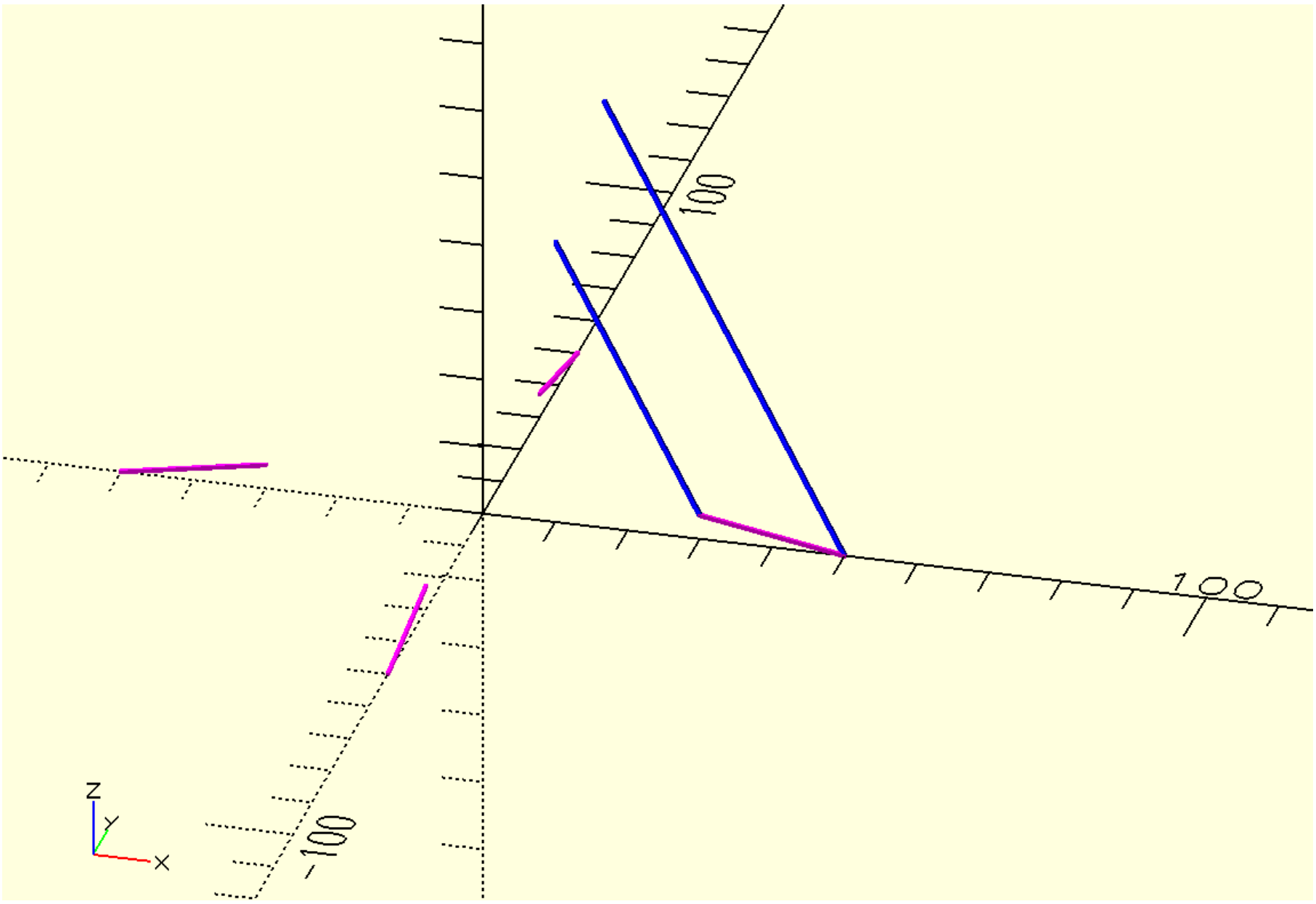
```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
# draw a line joining the 2 inner pitch points
l1=[l2[0][0],l2[1][0]]
# rotate the line l1 by amount teeth angle, consider l2[0] i.e. first
# line in 'l2' group as axis of rotation and point of rotation is l2[0][0]
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
# set the length of line 'l1' as 'd1' to get the end point of line 'l1'
# at the center of 2 pitch points
d1=l_len(l1)/2/cos(d2r(ta))
l1=line2length(l1,d1)

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l1]})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
//{swp_surf(cone1)}

    ''')
```



In [110…

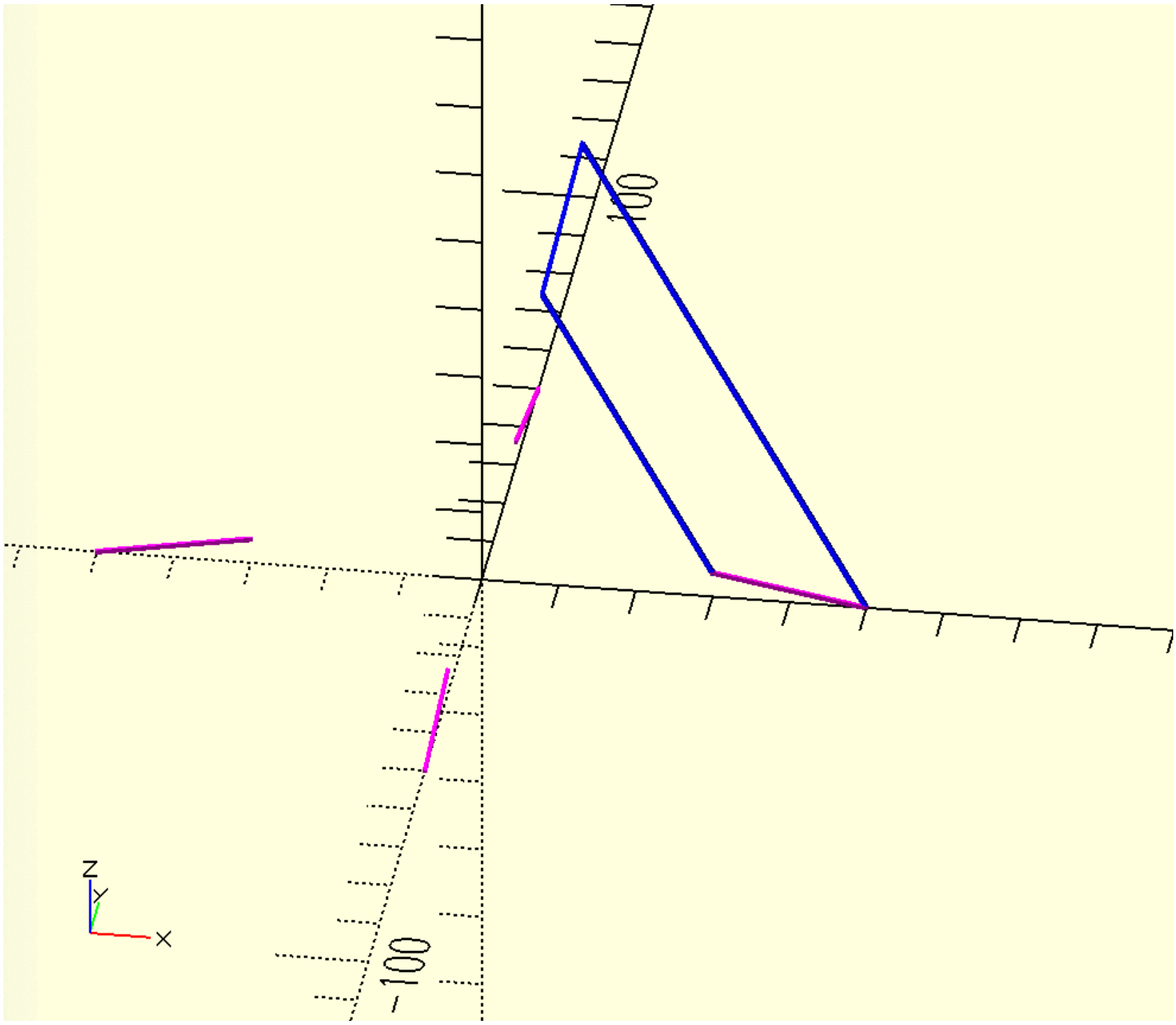
```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
l1=[l2[0][0],l2[1][0]]
d1=l_len(l1)/2/cos(d2r(ta))
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
l1=line2length(l1,d1)

# Repeat the same for outer pitch points
l3=[l2[0][1],l2[1][1]]
d2=l_len(l3)/2/cos(d2r(ta))
l3=axis_rot_1(l3,line_as_axis(l2[0]),l2[0][1],ta)
l3=line2length(l3,d2)

with open('trial.scad','w+') as f:
```

```
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l1,l3]})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
//{swp_surf(cone1)}

    ''')
```



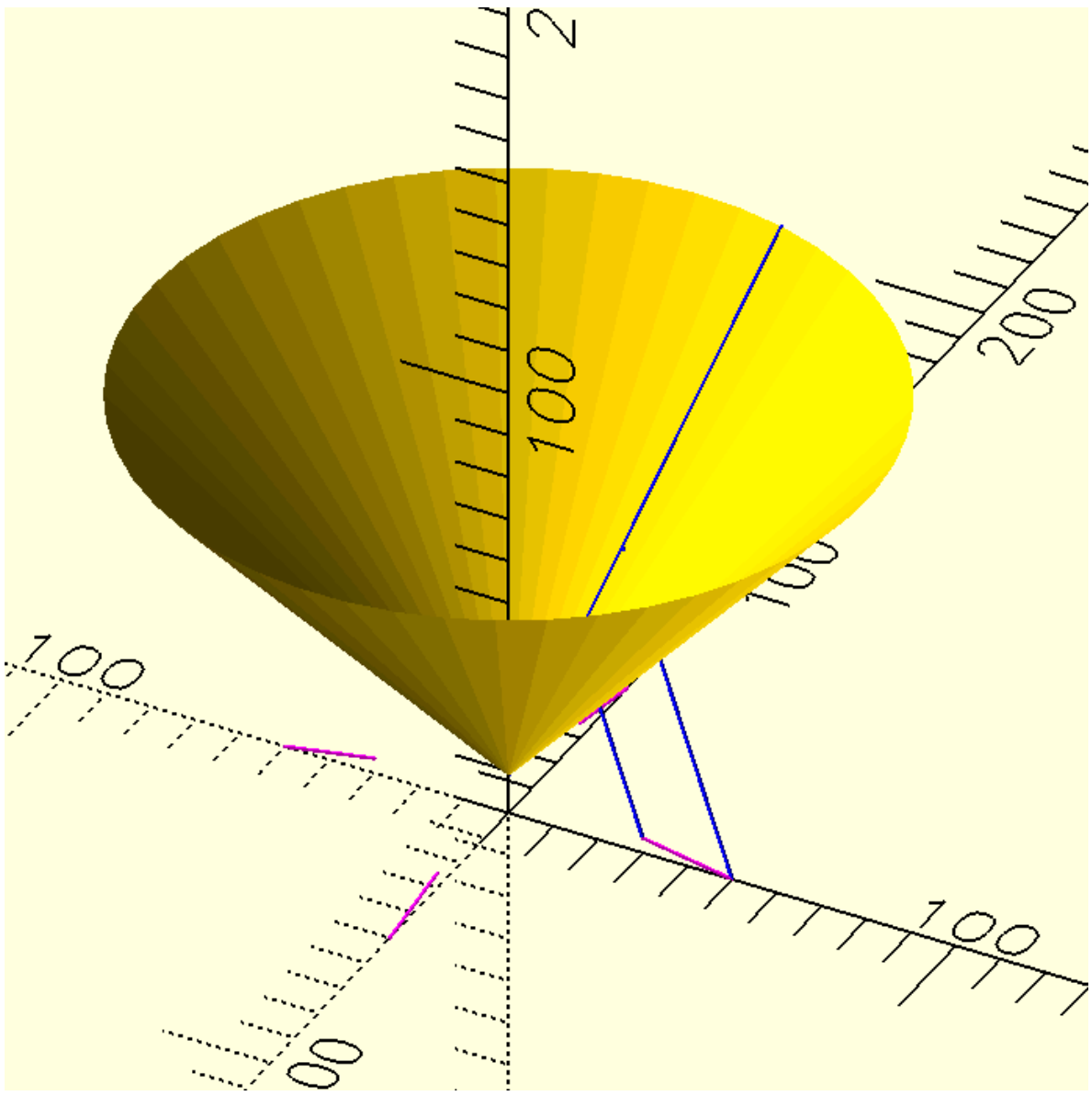
In [111…

```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
l1=[l2[0][0],l2[1][0]]
d1=l_len(l1)/2/cos(d2r(ta))
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
l1=line2length(l1,d1)
l3=[l2[0][1],l2[1][1]]
d2=l_len(l3)/2/cos(d2r(ta))
l3=axis_rot_1(l3,line_as_axis(l2[0]),l2[0][1],ta)
l3=line2length(l3,d2)

# Now join the end points of these 2 lines 'l1' and 'l3'
l4=[l1[1],l3[1]]

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l1,l3,l4]})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
//{swp_surf(cone1)}

    ''')
```



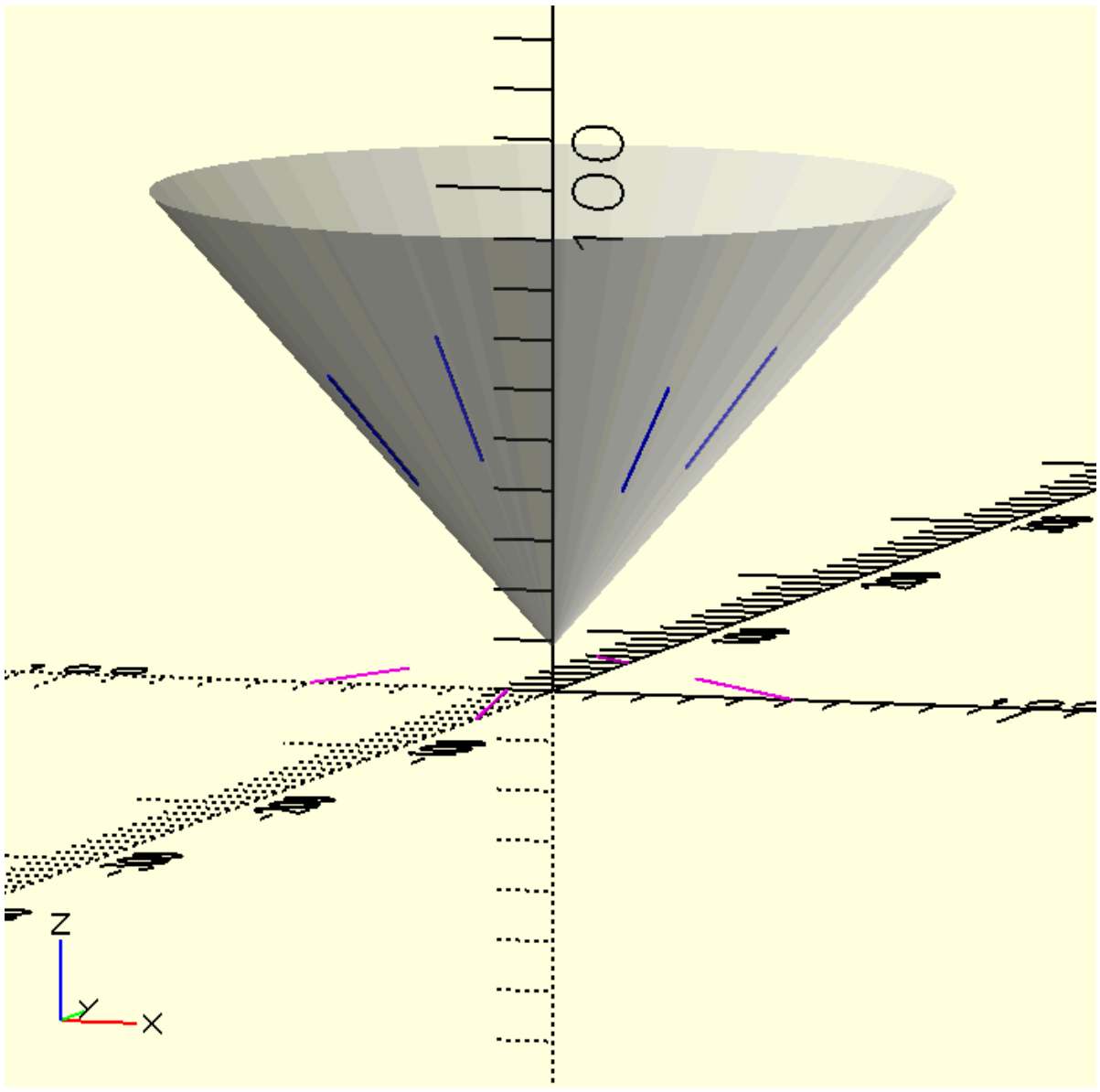
In [112…

```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
l1=[l2[0][0],l2[1][0]]
d1=l_len(l1)/2/cos(d2r(ta))
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
l1=line2length(l1,d1)
l3=[l2[0][1],l2[1][1]]
d2=l_len(l3)/2/cos(d2r(ta))
l3=axis_rot_1(l3,line_as_axis(l2[0]),l2[0][1],ta)
l3=line2length(l3,d2)
l4=[l1[1],l3[1]]
# increase the length of the line 'l4' such that the lines 'l2' can be
# projected on this resultant surface

l4=line2length(flip(line2length(l4,(o_r-i_r)+d2)),(o_r-i_r)+d2+i_r)
cone2=[ q_rot([f'z{i}'],l4) for i in linspace(0,360,50)]

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
color("blue")for(p={[l1,l3,l4]})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
//{swp_surf(cone1)}
{swp_surf(cone2)}
    ''')
```



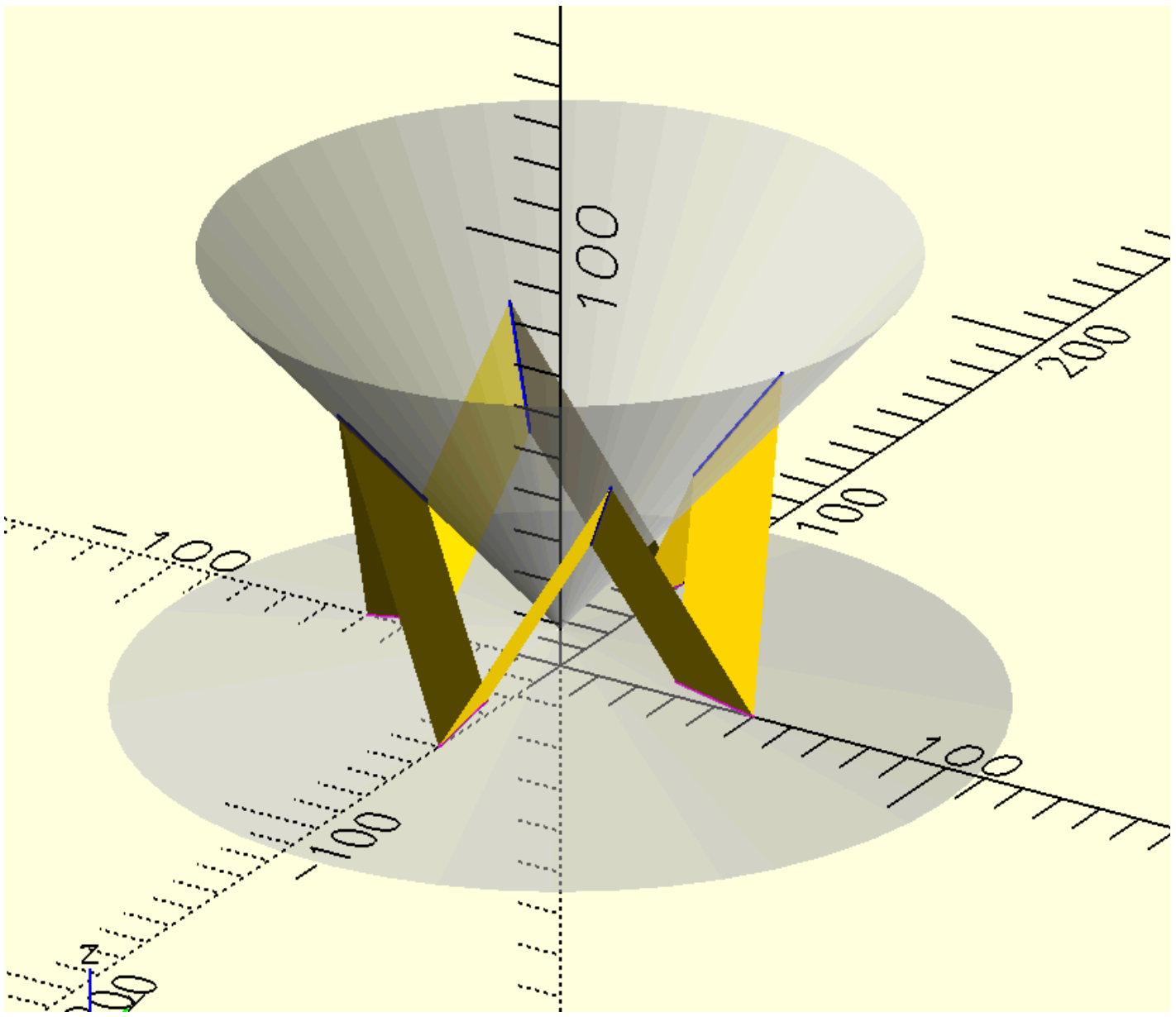
In [114…

```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
l1=[l2[0][0],l2[1][0]]
d1=l_len(l1)/2/cos(d2r(ta))
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
l1=line2length(l1,d1)
l3=[l2[0][1],l2[1][1]]
d2=l_len(l3)/2/cos(d2r(ta))
l3=axis_rot_1(l3,line_as_axis(l2[0]),l2[0][1],ta)
l3=line2length(l3,d2)
l4=[l1[1],l3[1]]

l4=line2length(flip(line2length(l4,(o_r-i_r)+d2)),(o_r-i_r)+d2+i_r)
cone2=[ q_rot([f'z{i}'],l4) for i in linspace(0,360,50)]

# Now project lines 'l2' on this cone2
l3=psos(cone2,l2,[0,0,1])

# Rotate these projected lines by angle half the pitch angle
l3=q_rot([f'z{360/n/2}'],l3)

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>

color("blue")for(p={l3})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
//{swp_surf(cone1)}
%{swp_surf(cone2)}

    ''')
```



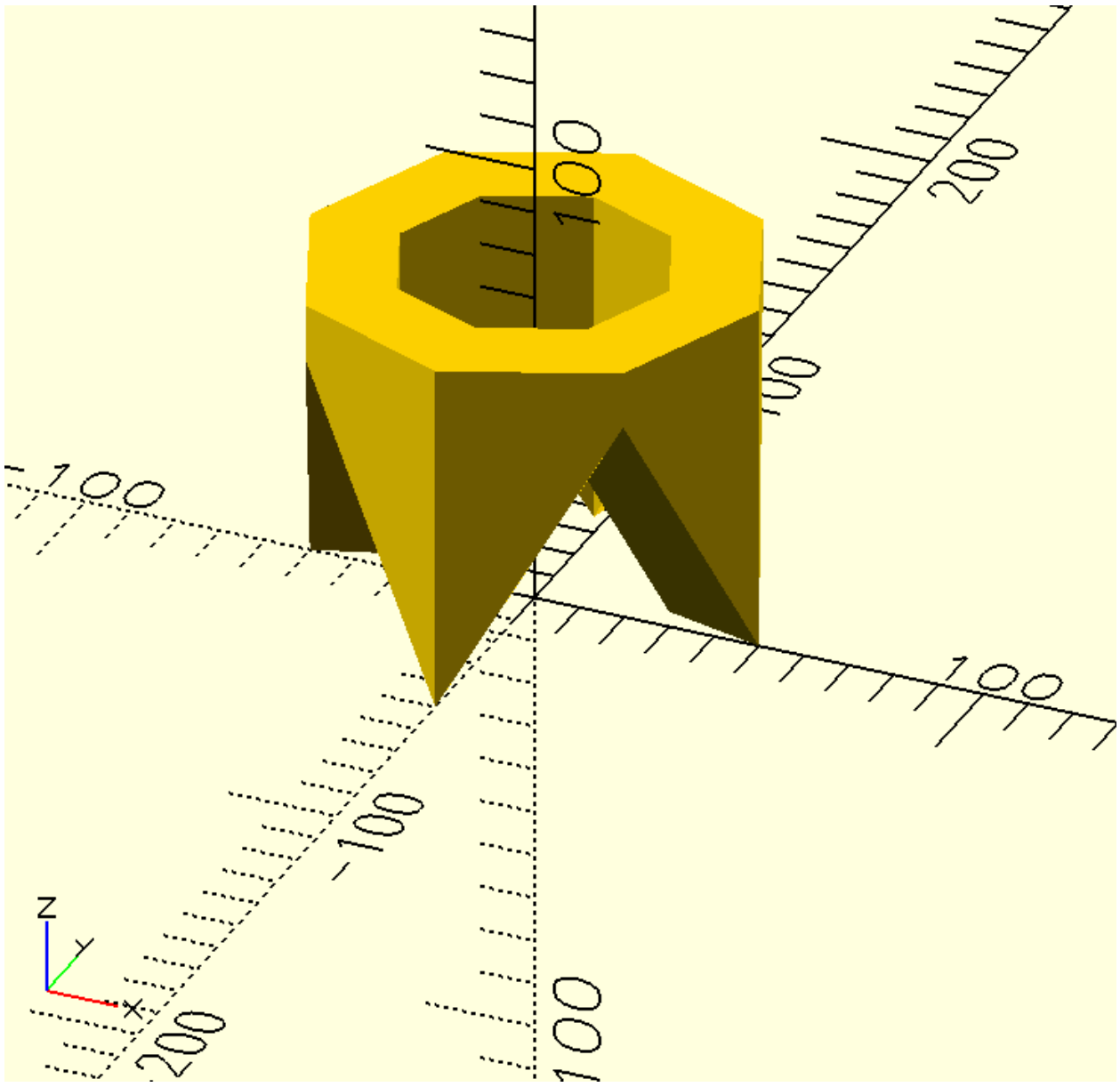
In [116…

```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
l1=[l2[0][0],l2[1][0]]
d1=l_len(l1)/2/cos(d2r(ta))
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
l1=line2length(l1,d1)
l3=[l2[0][1],l2[1][1]]
d2=l_len(l3)/2/cos(d2r(ta))
l3=axis_rot_1(l3,line_as_axis(l2[0]),l2[0][1],ta)
l3=line2length(l3,d2)
l4=[l1[1],l3[1]]
l4=line2length(flip(line2length(l4,(o_r-i_r)+d2)),(o_r-i_r)+d2+i_r)
cone2=[ q_rot([f'z{i}'],l4) for i in linspace(0,360,50)]
l3=psos(cone2,l2,[0,0,1])
l3=q_rot([f'z{360/n/2}'],l3)
# make a surface by arranging lines 'l2' and 'l3'
s1=l_(a_([l2,l3]).transpose(1,0,2,3).reshape(n*2,2,3))
s1=s1+[s1[0]]

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
 color("blue")for(p={l3})p_line3d(p,.5,1);
color("magenta")for(p={l2})p_line3d(p,.5,1);
%{swp_surf(cone1)}
%{swp_surf(cone2)}

{swp_surf(s1)}

    ''')
```



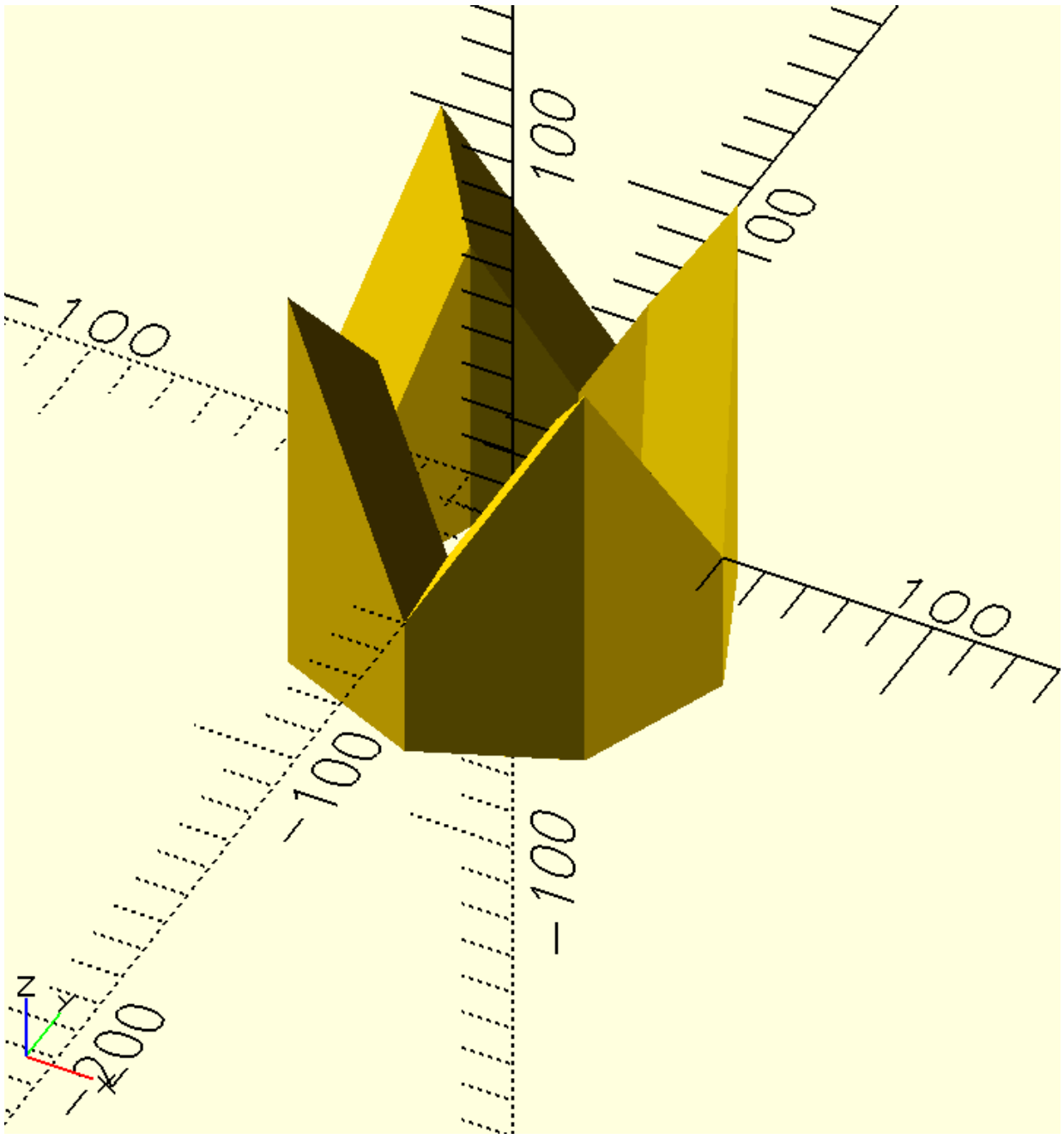
In [117…

```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
l1=[l2[0][0],l2[1][0]]
d1=l_len(l1)/2/cos(d2r(ta))
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
l1=line2length(l1,d1)
l3=[l2[0][1],l2[1][1]]
d2=l_len(l3)/2/cos(d2r(ta))
l3=axis_rot_1(l3,line_as_axis(l2[0]),l2[0][1],ta)
l3=line2length(l3,d2)
l4=[l1[1],l3[1]]
l4=line2length(flip(line2length(l4,(o_r-i_r)+d2)),(o_r-i_r)+d2+i_r)
cone2=[ q_rot([f'z{i}'],l4) for i in linspace(0,360,50)]
l3=psos(cone2,l2,[0,0,1])
l3=q_rot([f'z{360/n/2}'],l3)
s1=l_(a_([l2,l3]).transpose(1,0,2,3).reshape(n*2,2,3))
s1=s1+[s1[0]]

# solids can be made by projecting this surface up and down
s1=l_(a_(s1).transpose(1,0,2))
sol1=flip(surf_base(s1,s1[0][1][2]+d2/2))

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
{swp_c(sol1)}

    ''')
```



In [120…

```
# hirth coupling
n=4 # number of teeths
ta=60 # teeth angle
ca=10 # for straight 360/42.232 # cone angle
i_r=30 # inner radius
o_r=50 # outer radius
ch=.75 # chamfer height
l1=[[i_r,0],[o_r,0]]
l2=[ q_rot([f'z{i}'],l1)  for i in linspace(0,360,n+1)[:-1]]

l3=axis_rot_1(l1,ax1=[0,1,0],loc1=[o_r,0],theta=ca)
l3= line2length(flip(line2length(l3,(o_r-i_r)+o_r)),(o_r-i_r)+o_r+i_r)
cone1=[ q_rot([f'z{i}'],l3) for i in linspace(0,360,50)]
l2=psos(cone1,l2,[0,0,1])
l1=[l2[0][0],l2[1][0]]
d1=l_len(l1)/2/cos(d2r(ta))
l1=axis_rot_1(l1,line_as_axis(l2[0]),l2[0][0],ta)
l1=line2length(l1,d1)
l3=[l2[0][1],l2[1][1]]
d2=l_len(l3)/2/cos(d2r(ta))
l3=axis_rot_1(l3,line_as_axis(l2[0]),l2[0][1],ta)
l3=line2length(l3,d2)
l4=[l1[1],l3[1]]
# a,b=l4
l4=line2length(flip(line2length(l4,(o_r-i_r)+d2)),(o_r-i_r)+d2+i_r)
cone2=[ q_rot([f'z{i}'],l4) for i in linspace(0,360,50)]
l3=psos(cone2,l2,[0,0,1])
l3=q_rot([f'z{360/n/2}'],l3)
s1=l_(a_([l2,l3]).transpose(1,0,2,3).reshape(n*2,2,3))
s1=s1+[s1[0]]
s1=l_(a_(s1).transpose(1,0,2))
sol1=flip(surf_base(s1,s1[0][1][2]+d2/2))

sol2=surf_base(flip(s1),s1[1][0][2]-d2/2)

with open('trial.scad','w+') as f:
    f.write(f'''
    include<dependencies2.scad>
{swp(sol2)}
    ''')
```



In [ ]:
```
# Chamfers can be made by offsetting the surface cone1 up by the
# amount of chamfer and similarly offset cone2 down
```