MATH1110H-S62-A2-Solutions

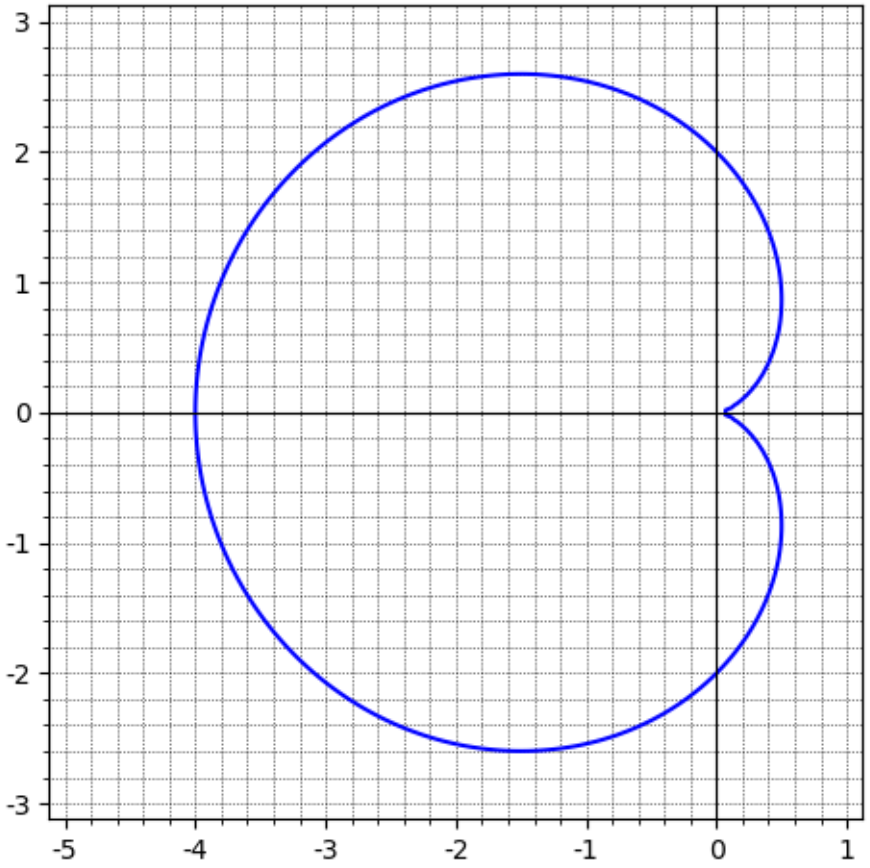
June 29, 2026

[1]:
```
# MATH 1110H,  Summer 2026 (S62)
# Solutions to Assignment #2
```

[2]:
```
# 1
# A cardioid with parameter a = 0 consists of the points (x,y) satisfying
# the equation (x^2 + y^2)^2 = 0,  and hence x^2 + y^2 = 0.  Since x^2
# and y^2 both have to be >= 0,  the only way this can happen is if x = 0
# and y = 0,  so the cardioid with parameter 0 consists of the single point
# (0,0).
```

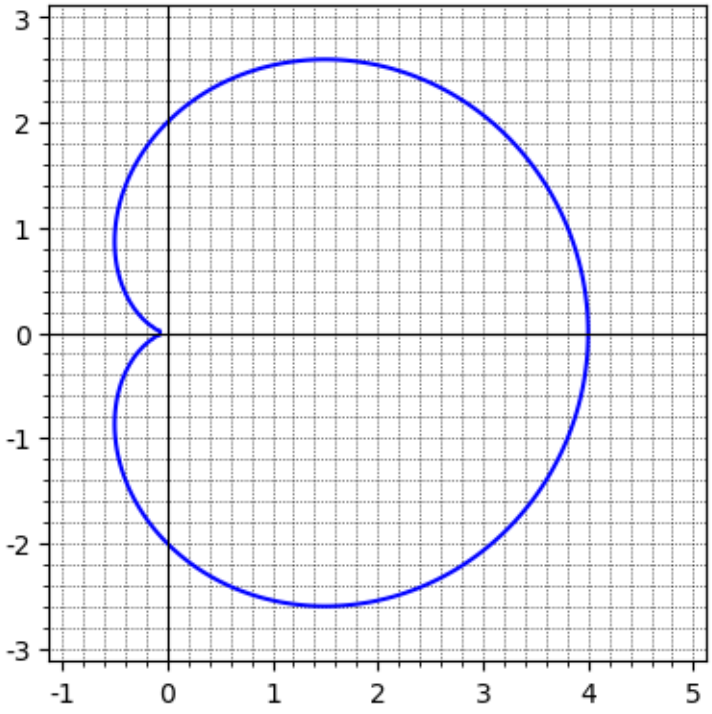
[3]:
```
# 2
var('y')
a = 1
implicit_plot( (x^2 + y^2)^2 + 4*a*x*(x^2 + y^2) - 4*a^2*y^2 == 0, (x,-5,1),␣
↪(y,-3,3), axes=True, gridlines='minor' )
```

[3]:



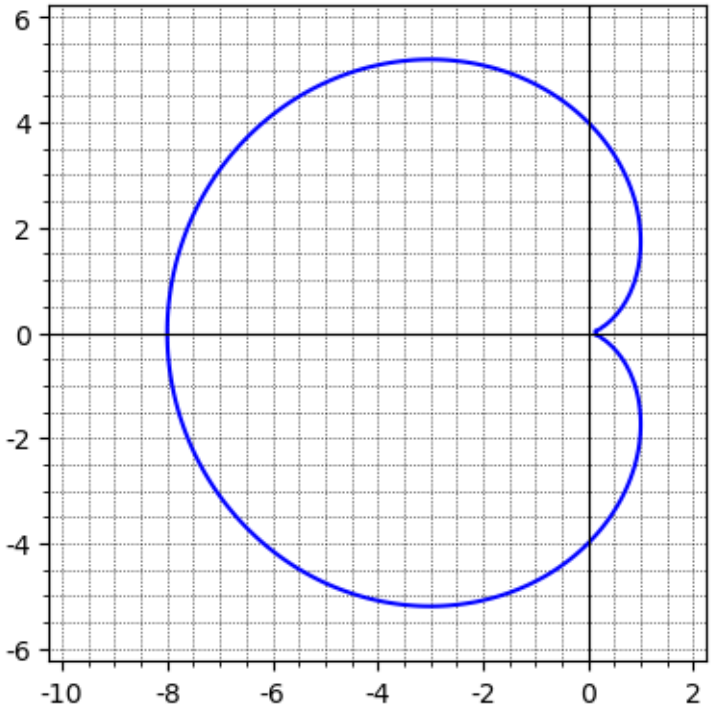
[4]:
```
a = -1
implicit_plot( (x^2 + y^2)^2 + 4*a*x*(x^2 + y^2) - 4*a^2*y^2 == 0, (x,-1,5),␣
↪(y,-3,3), axes=True, gridlines='minor' )
```

[4]:



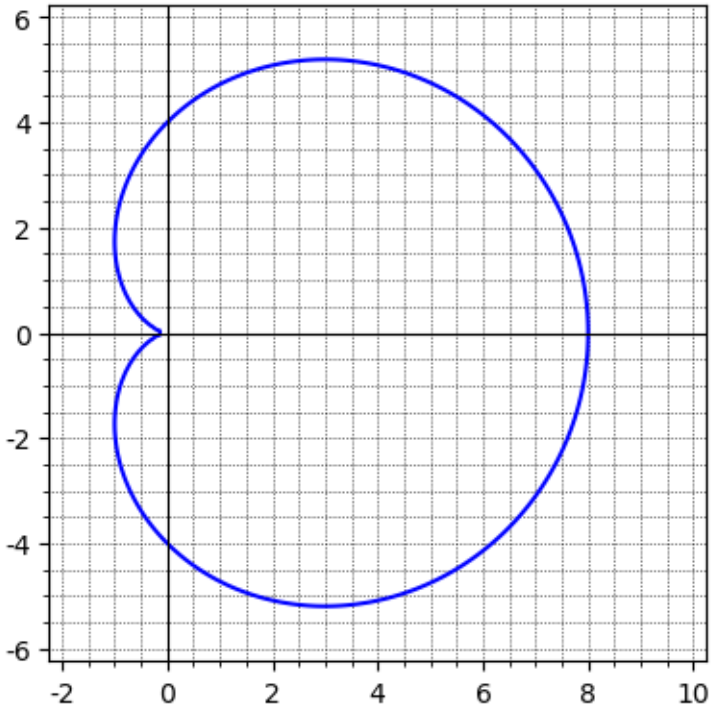
[5]:
```
a = 2
implicit_plot( (x^2 + y^2)^2 + 4*a*x*(x^2 + y^2) - 4*a^2*y^2 == 0, (x,-10,2),␣
↪(y,-6,6), axes=True, gridlines='minor' )
```

[5]:



[6]:
```
a = -2
implicit_plot( (x^2 + y^2)^2 + 4*a*x*(x^2 + y^2) - 4*a^2*y^2 == 0, (x,-2,10),␣
↪(y,-6,6), axes=True, gridlines='minor' )
```

[6]:

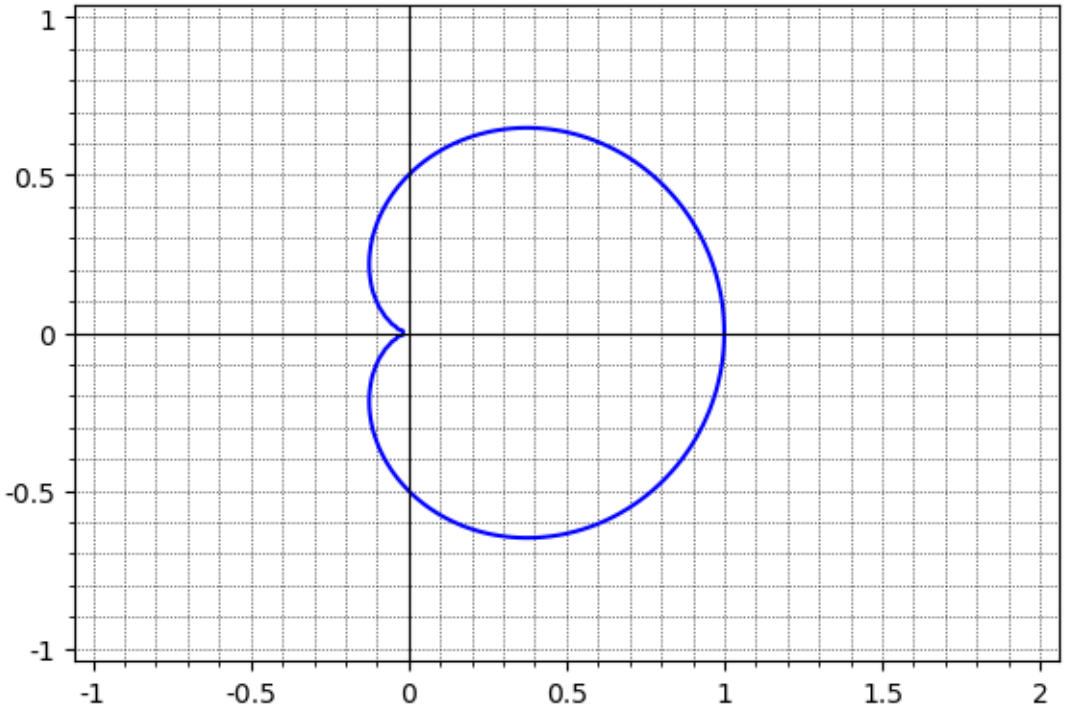


[7]:
```
# Changing the sign of the parameter a flips cardioid about the y-axis,
# and otherwise appears to scale the cardioid by a factor of |a|.
```

[8]:
```
# 3
# A limacon with parameters b = c = 0 consists of the points (x,y) that
# satisfy the equation (x^2 + y^2)^2 = 0.  Just as in question 1,  the
# only way this can happen is if x = 0 and y = 0,  so the limacon here
# also consists of the single point (0,0).
```

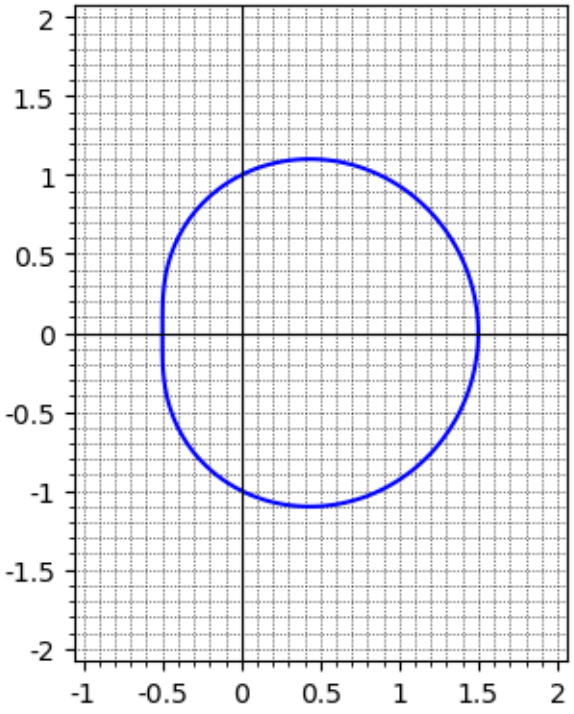
[9]:
```
# 4
b = 1/2
c = 1/2
implicit_plot( (x^2 + y^2 - b*x)^2 == c^2*(x^2 + y^2), (x,-1,2), (y,-1,1),␣
 ↪axes=True, gridlines='minor' )
```

[9]:



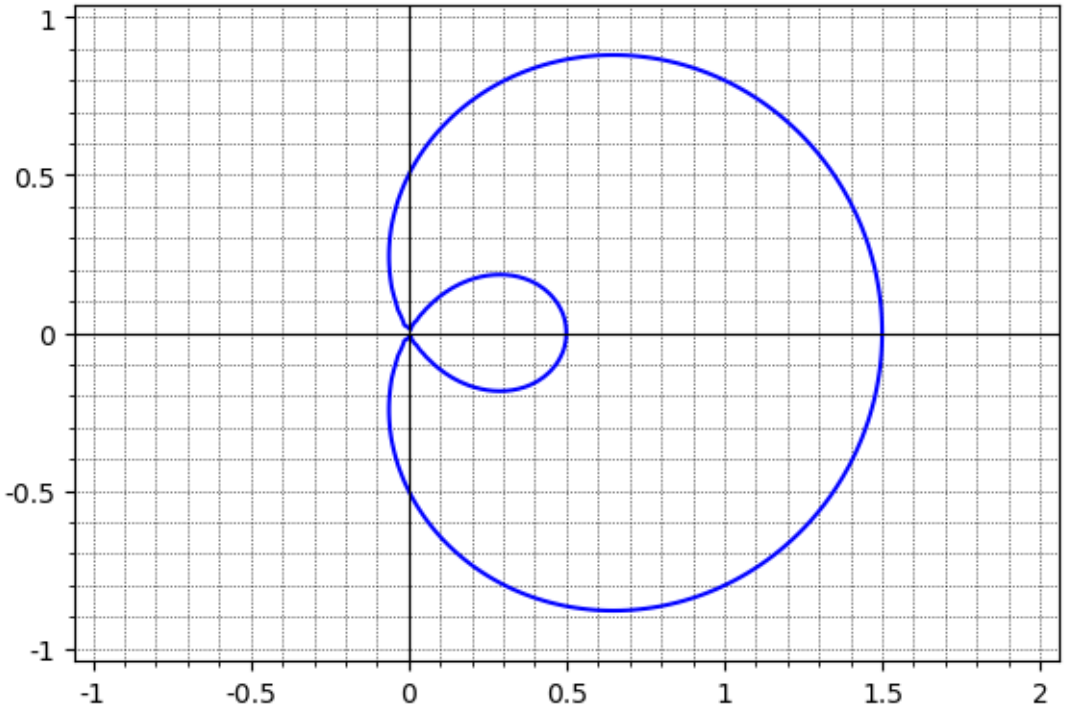
[10]:
```
b = 1/2
c = 1
implicit_plot( (x^2 + y^2 - b*x)^2 == c^2*(x^2 + y^2), (x,-1,2), (y,-2,2),␣
↪axes=True, gridlines='minor' )
```

[10]:



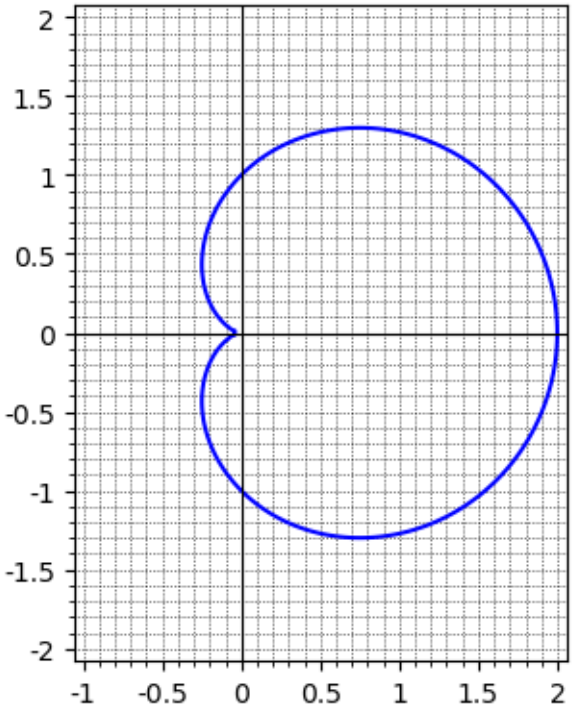
[11]:
```
b = 1
c = 1/2
implicit_plot( (x^2 + y^2 - b*x)^2 == c^2*(x^2 + y^2), (x,-1,2), (y,-1,1),␣
↪axes=True, gridlines='minor' )
```

[11]:



[12]:
```
b = 1
c = 1
implicit_plot( (x^2 + y^2 - b*x)^2 == c^2*(x^2 + y^2), (x,-1,2), (y,-2,2),␣
↪axes=True, gridlines='minor' )
```

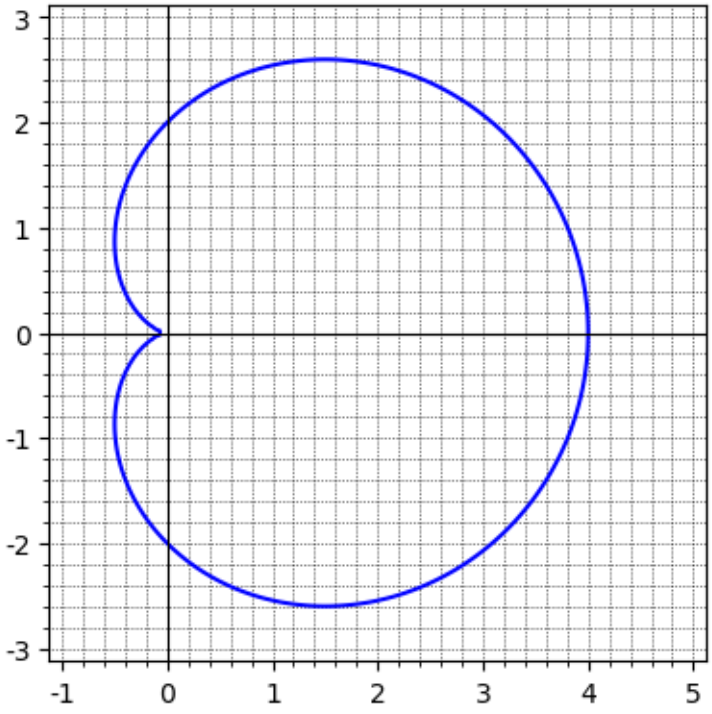
[12]:



[13]:
```
# If b = c you get a cardioid,  scaled according to the magnitude of b = c.
# Making b > c gives the curve a loop inside the rest of the curve,  while
# making b < c flattens out the cusp and moves that part of the curve away
# from the origin.
```

[14]:
```
# 5
b = 2
c = 2
implicit_plot( (x^2 + y^2 - b*x)^2 == c^2*(x^2 + y^2), (x,-1,5), (y,-3,3),␣
 ↪axes=True, gridlines='minor' )
```

[14]:



[15]:
```
# This is the cardioid with parameter a = -1,  as previously plotted in
# question 2.
```