Problem 1

Language: Python3

A 2-link manipulator has a revolute joint 1 with the angle and followed by a prismatic joint with the value q. The end effector position is given by

x=a*cθ-q*sθ

y=a*sθ+q*cθ

Find the Jacobian matrix of the robot, and determine its singularities.

In [2]:
```
import sympy as sp
```

In [13]:
```
# define symbolic variables
q,t = sp.symbols('q t')

# define forward kinematic equations
x = a*sp.cos(t) - q*sp.sin(t)
y = a*sp.sin(t) + q*sp.cos(t)

# define intermediate diff varialbes
_x11 = sp.diff(x, t)
_x12 = sp.diff(x, q)
_y21 = sp.diff(y, t)
_y22 = sp.diff(y, q)

# define jacobian matrix
p1_j = sp.simplify(
    sp.Matrix([
        [_x11, _x12],
        [_y21, _y22]
    ])
)
print("jacobian matrix:")
display(p1_j)

# determine singularities
# find determinate of jacobian
p1_j_det = sp.det(p1_j)
print("determinate of jacobian:")
display(p1_j_det)

# solve for singularities
p1_singularities = sp.solve(sp.simplify(p1_j_det), [t, q])
print("singularities:")
display(sp.simplify(p1_singularities))
```

```
jacobian matrix:
```

$$\begin{bmatrix} -a\sin(t) - q\cos(t) & -\sin(t) \\ a\cos(t) - q\sin(t) & \cos(t) \end{bmatrix}$$

```
determinate of jacobian:
```

$$(-a\sin(t) - q\cos(t))\cos(t) + (a\cos(t) - q\sin(t))\sin(t)$$

```
singularities:
[(t, 0)]
```