3.39. We can use Bloch-equations.

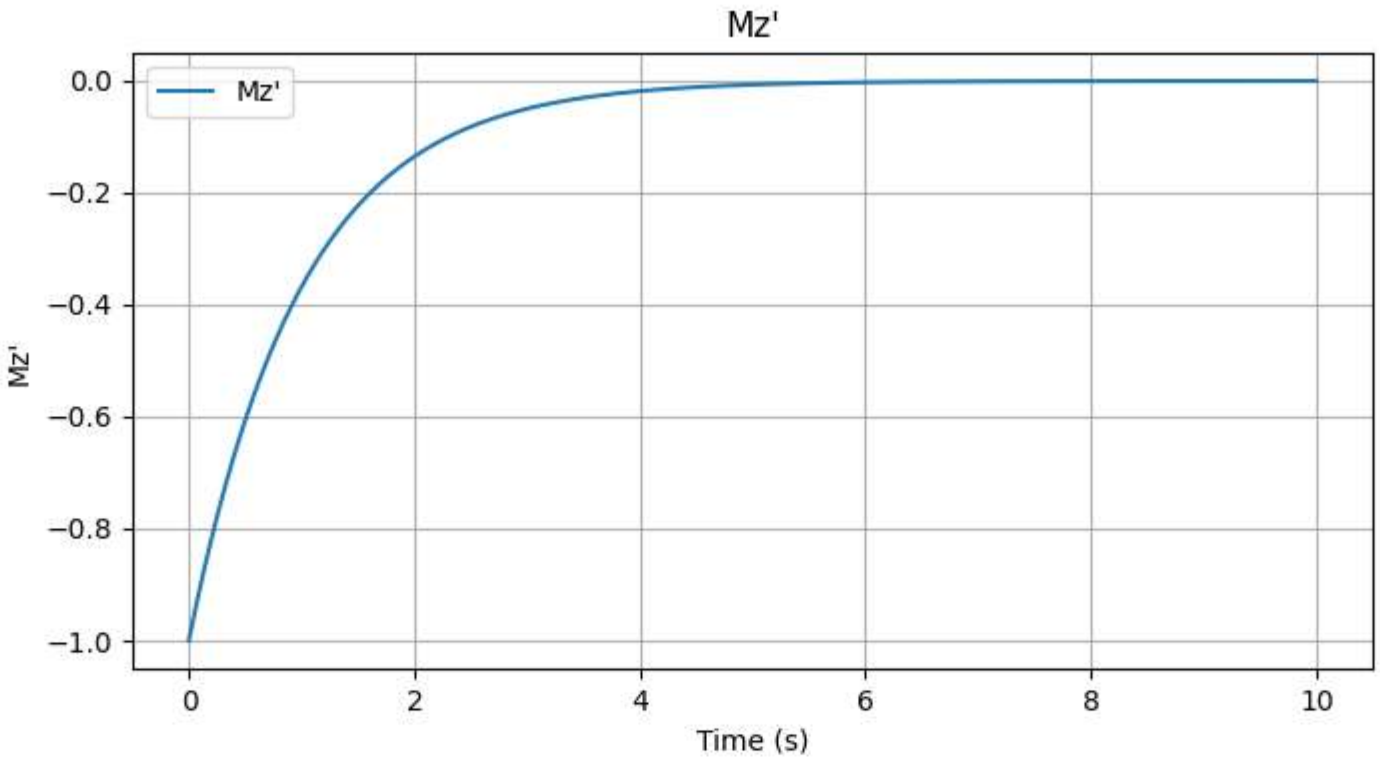
(a) after 180°_x pulse
$$\begin{cases} M_x' = -M_0 \\ M_y' = 0 \\ M_z' = 0 \end{cases}$$

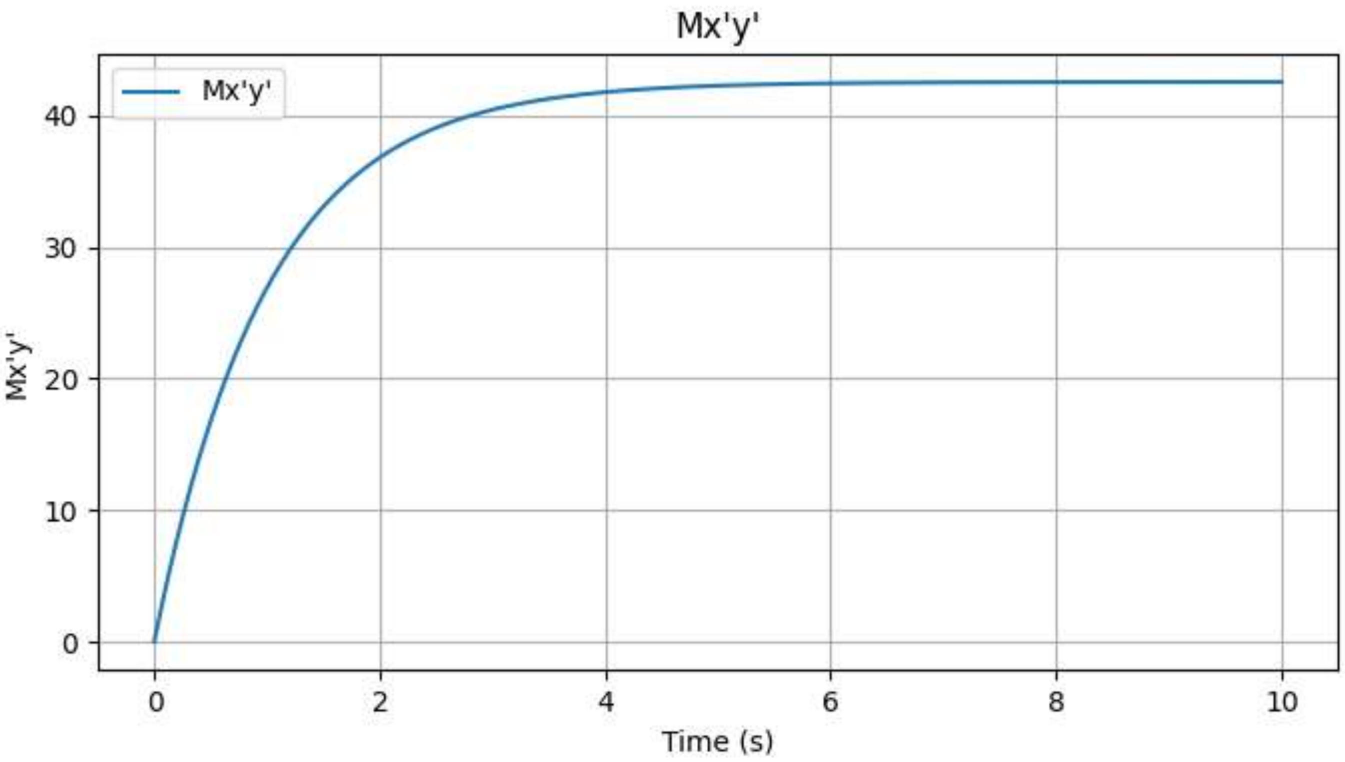
Bloch equations:
$$\begin{cases} \dfrac{dM_x}{dt} = \lambda \cdot M_z(t) \cdot B_{1x} \\ \dfrac{dM_y}{dt} = \lambda \cdot M_z(t) \cdot B_{1y} \\ \dfrac{dM_z}{dt} = \lambda \cdot (M_x(t) \cdot B_{1x} - M_y(t) \\ \qquad - (M_z(t-a) - M_0)/T_1 \end{cases}$$

(b) after 90°_x $M_{xy}' = \sqrt{M_x^2 + M_y^2}$

$= |M_0|$.

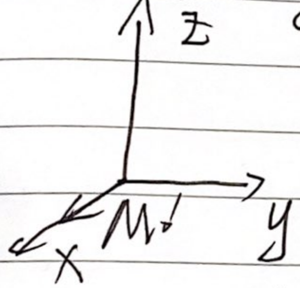
```
import numpy as np
import matplotlib.pyplot as plt

#Initial parameters
gamma = 42.58;
B1x = 1;
B1y = 1;
M0 = 1;
T1 = 1;
dt = 0.001;
t = np.arange(0, 10, dt);

Mx = np.zeros(len(t))
My = np.zeros(len(t))
Mz = np.zeros(len(t))

#After 180xpusle
Mx[0] = 0
My[0] = 0
Mz[0] = -M0

for i in range(1, len(t)):
        dMx = gamma * (Mz[i-1] * B1x)
        dMy = 0
        dMz = -Mz[i-1] / T1

    Mx[i] = Mx[i-1] + dMx * dt
    My[i] = My[i-1] + dMy * dt
    Mz[i] = Mz[i-1] + dMz * dt

plt.figure(figsize=(8, 4))
plt.plot(t, Mz, label="Mz'")
plt.title("Mz'")
plt.xlabel("Time (s)")
plt.ylabel("Mz'")
plt.legend()
plt.grid()
plt.show()

#$Mx'y'=\sqrt{Mx^2+My^2}$
Mxy = np.sqrt(Mx[0]**2 + My[0]**2)
```


Mz'
Mz'
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
Mz'
0
2
4
6
8
10
Time (s)


Mx'y'
Mx'y'
40
30
20
10
0
Mx'y'
0
2
4
6
8
10
Time (s)

4.11 (a) after a $90^{\circ}_{x'}$-pulse.

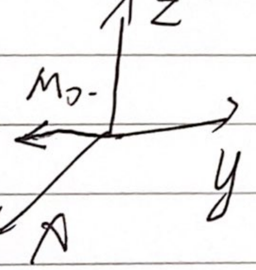
The 90°_{x} pulse flips the magnetization from the z-axis to the x-axis. Immediaty after this pulse, the magnetization vector lies in the x-axis.



while $\begin{cases} M_{x'} = M_0 \\ M_{y'} = 0 \\ M_z = 0 \end{cases}$

after a 90°_{y}-pulse.

The 90°_{y} pulse flips the magnetization from the z-axis to the minus y-axis like



$\begin{cases} M_x = 0 \\ M_y = -M_0 \\ M_z = 0. \end{cases}$

(b). $S_1(t)$ and $S_2(t)$ are the FID signals generated after the two different pulses.

On the same ~~init~~ initial state. The magnitude of them is the same while they have a phase difference of 90°. It's $S_1(t) = S_2(t) \cdot e^{-\frac{\pi}{2}j}$ or $S_1(t) = S_2(t - \frac{\pi}{2\omega})$.