Exercício 1 - Física Moderna (ANP)

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Neste exercício devemos representar os estados |0>, |1>, (|0> + |1>)/sqrt(2), (|0> - |1>)/sqrt(2), (|0> + i|*1>)/sqrt(2) e (|0> - i*|1>)/sqrt(2) na Esfera de Bloch. Esses estados representam os pontos de interseção da Esfera de Bloch com os eixos coordenados.

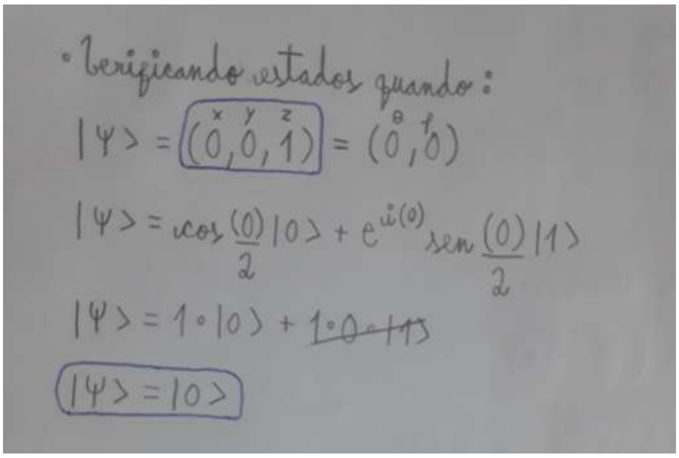
Dados iniciais auxiliares:

$$|\psi\rangle = \cos\frac{\theta}{2}|0\rangle + e^{i\varphi}\sin\frac{\theta}{2}|1\rangle.$$

Importando as bibliotecas necessárias para a plotagem gráfica da Esfera de Bloch usando o Qiskit:

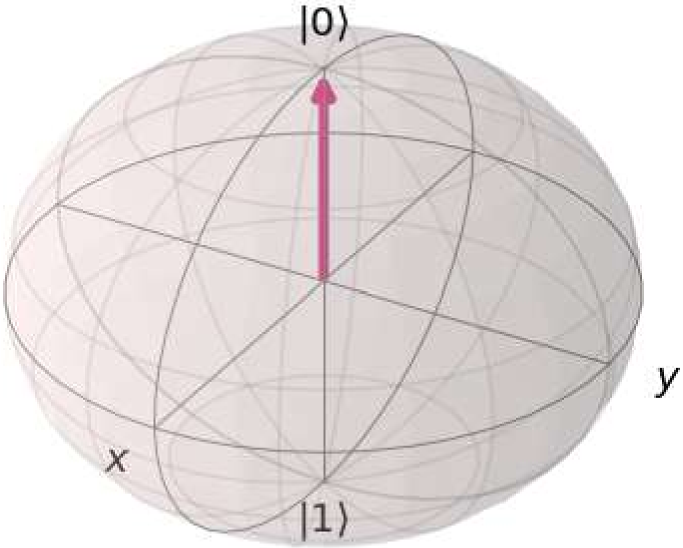
In [3]:
```
%matplotlib inline
from qiskit import *
import matplotlib
from qiskit.visualization import plot_bloch_vector
```

- Estado |0> :

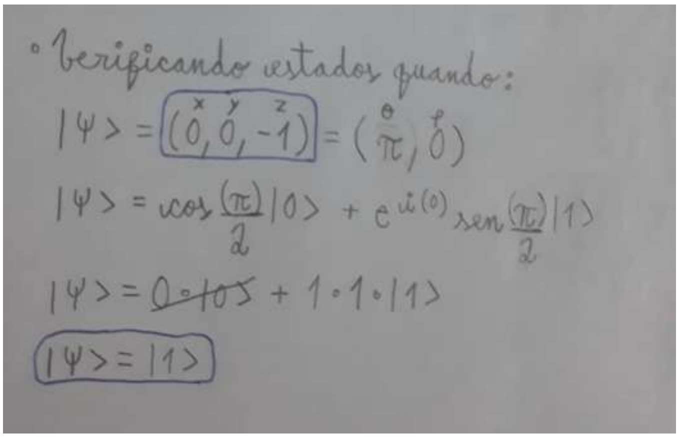


In [4]:
```
plot_bloch_vector((0,0,1))
```

Out[4]:



- Estado |1> :



• verificando estados quando:

$$|\psi\rangle = \boxed{(\overset{x}{0}, \overset{y}{0}, \overset{z}{-1})} = (\overset{\theta}{\pi}, \overset{\varphi}{0})$$

$$|\psi\rangle = \cos\frac{(\pi)}{2}|0\rangle + e^{i(0)} \operatorname{sen}\frac{(\pi)}{2}|1\rangle$$

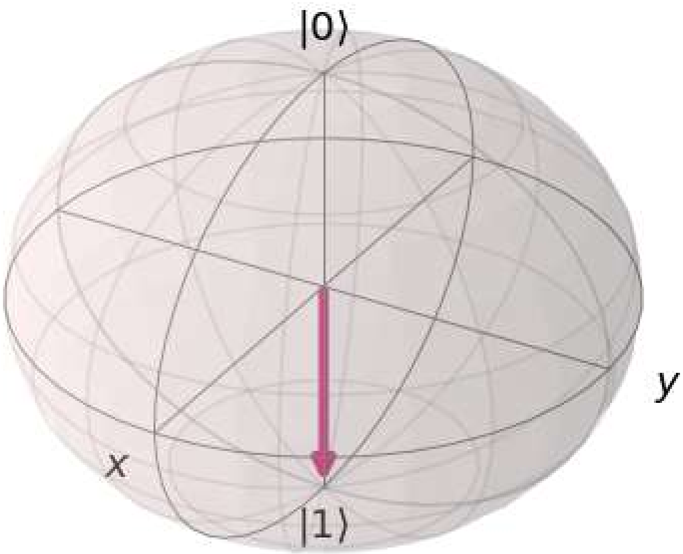
$$|\psi\rangle = \cancel{0 \cdot |0\rangle} + 1 \cdot 1 \cdot |1\rangle$$

$$\boxed{|\psi\rangle = |1\rangle}$$

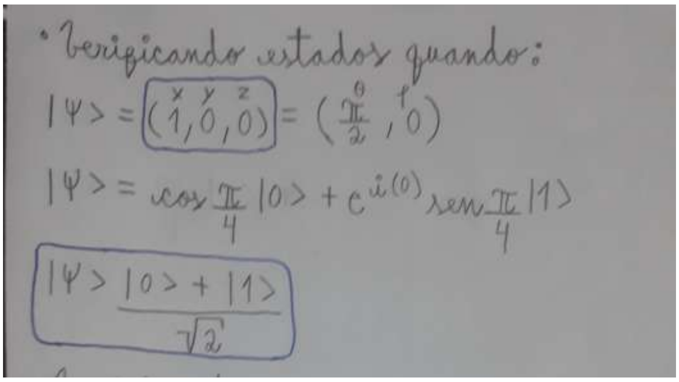
In [6]:

```
plot_bloch_vector((0,0,-1))
```

Out[6]:



- Estado (|0> + |1>)/sqrt(2) :



• Verificando estados quando:

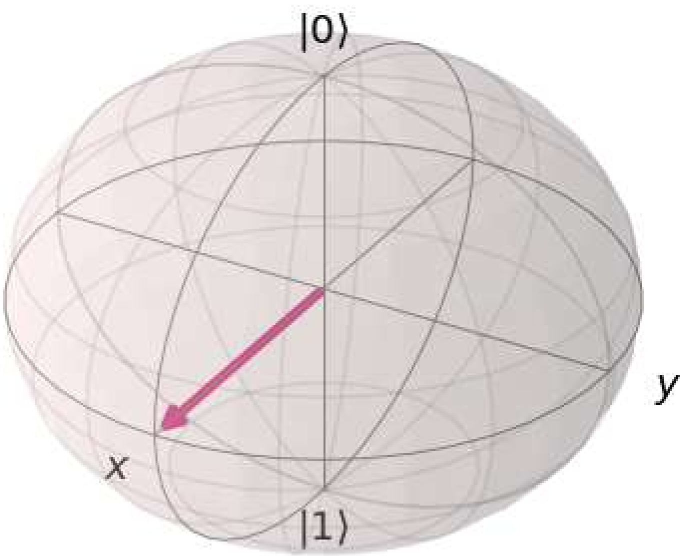
$|\psi\rangle = \boxed{(\overset{x}{1},\overset{y}{0},\overset{z}{0})} = (\overset{\theta}{\tfrac{\pi}{2}}, \overset{\varphi}{0})$

$|\psi\rangle = \cos\frac{\pi}{4}|0\rangle + e^{i(0)}\,\mathrm{sen}\frac{\pi}{4}|1\rangle$

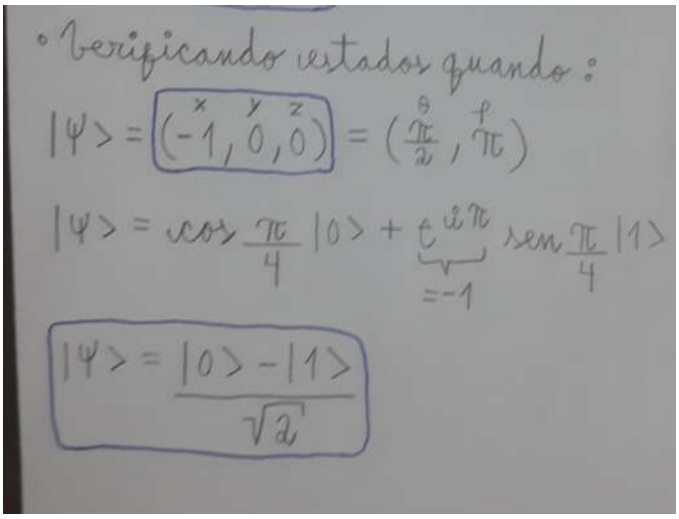
$\boxed{|\psi\rangle\ \frac{|0\rangle + |1\rangle}{\sqrt{2}}}$

In [8]:
```
plot_bloch_vector((1,0,0))
```

Out[8]:



- Estado (|0> - |1>)/sqrt(2) :



• Verificando estados quando:

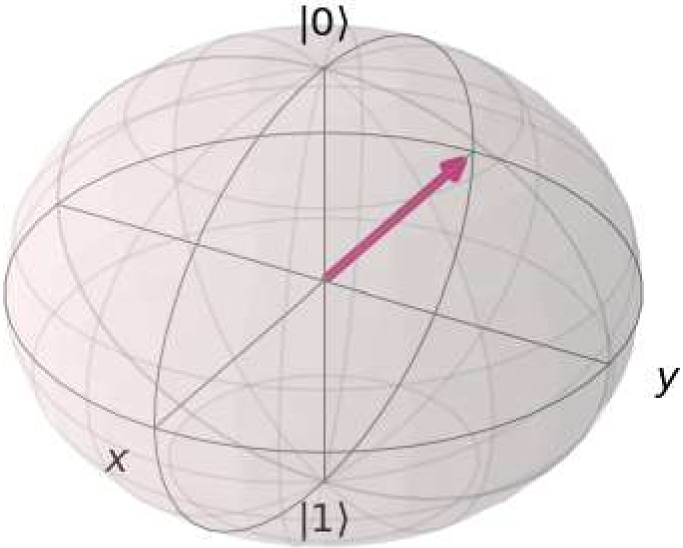
$|\psi\rangle = \boxed{(\overset{x}{-1},\overset{y}{0},\overset{z}{0})} = (\overset{\theta}{\tfrac{\pi}{2}}, \overset{\varphi}{\pi})$

$|\psi\rangle = \cos\frac{\pi}{4}|0\rangle + \underbrace{e^{i\pi}}_{=-1}\,\mathrm{sen}\frac{\pi}{4}|1\rangle$

$\boxed{|\psi\rangle = \frac{|0\rangle - |1\rangle}{\sqrt{2}}}$

In [9]:
```
plot_bloch_vector((-1,0,0))
```

Out[9]:



- Estado (|0> + i * |1>)/sqrt(2) :

∘ verificando estados quando:

$$|\psi\rangle = \boxed{\begin{array}{ccc} x & y & z \\ (0, & 1, & 0) \end{array}} = \begin{array}{cc} \theta & \varphi \\ \left(\frac{\pi}{2}, \right. & \left. \frac{\pi}{2}\right) \end{array}$$

$$|\psi\rangle = \cos\frac{\pi}{4}|0\rangle + e^{i\left(\frac{\pi}{2}\right)} \operatorname{sen}\frac{\pi}{4}|1\rangle$$

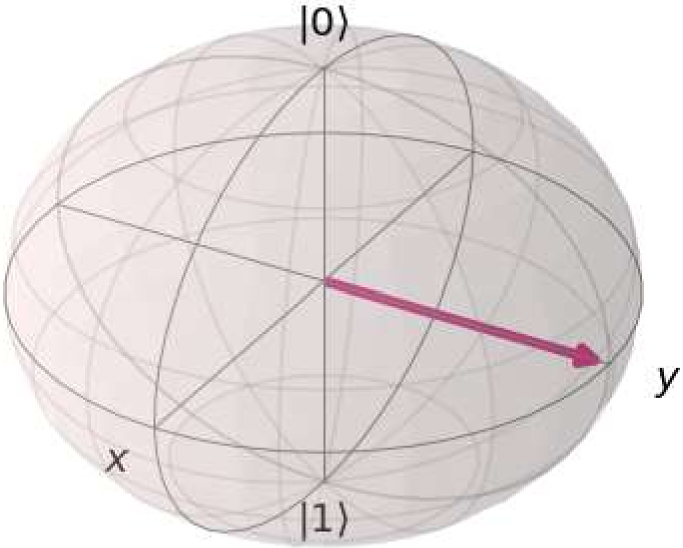
$$|\psi\rangle = \frac{|0\rangle}{\sqrt{2}} + \underbrace{\left(e^{i\pi}\right)}_{=-1}{}^{\frac{1}{2}} \frac{|1\rangle}{\sqrt{2}}$$

$$|\psi\rangle = \frac{|0\rangle}{\sqrt{2}} + \underbrace{\sqrt{-1}}_{=i} \frac{|1\rangle}{\sqrt{2}}$$

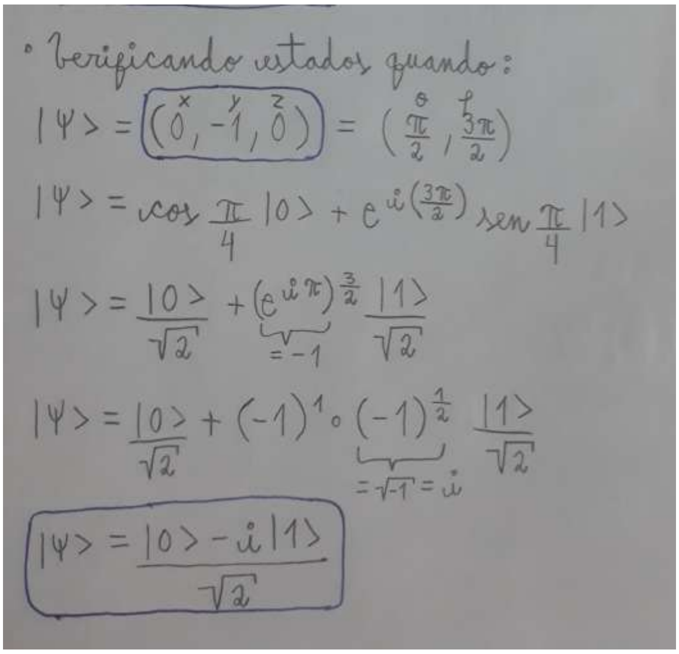
$$\boxed{|\psi\rangle = \frac{|0\rangle + i|1\rangle}{\sqrt{2}}}$$

In [10]:
```
plot_bloch_vector((0,1,0))
```

Out[10]:



- Estado (|0> - i*|1>)/sqrt(2) :



• verificando estados quando:

$$|\psi\rangle = \boxed{(\overset{x}{0}, \overset{y}{-1}, \overset{z}{0})} = \left(\overset{\theta}{\frac{\pi}{2}}, \overset{\varphi}{\frac{3\pi}{2}}\right)$$

$$|\psi\rangle = \cos\frac{\pi}{4}|0\rangle + e^{i\left(\frac{3\pi}{2}\right)} \operatorname{sen}\frac{\pi}{4}|1\rangle$$

$$|\psi\rangle = \frac{|0\rangle}{\sqrt{2}} + \underbrace{(e^{i\pi})}_{=-1}{}^{\frac{3}{2}} \frac{|1\rangle}{\sqrt{2}}$$

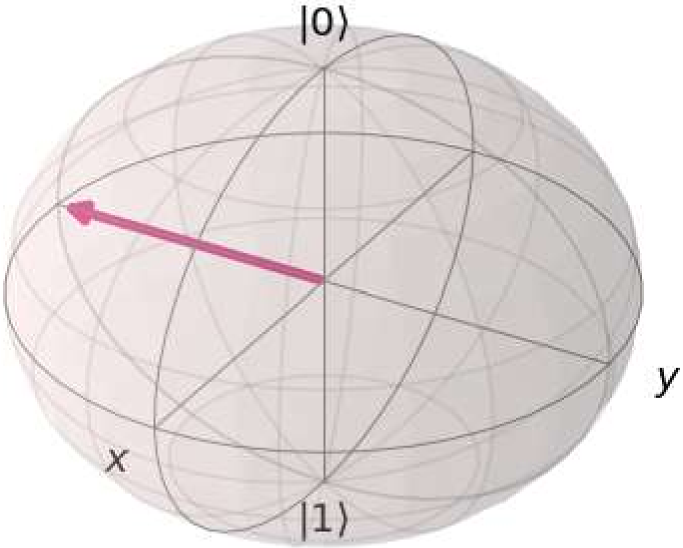
$$|\psi\rangle = \frac{|0\rangle}{\sqrt{2}} + (-1)^1 \circ \underbrace{(-1)^{\frac{1}{2}}}_{=\sqrt{-1}=i} \frac{|1\rangle}{\sqrt{2}}$$

$$\boxed{|\psi\rangle = \frac{|0\rangle - i|1\rangle}{\sqrt{2}}}$$

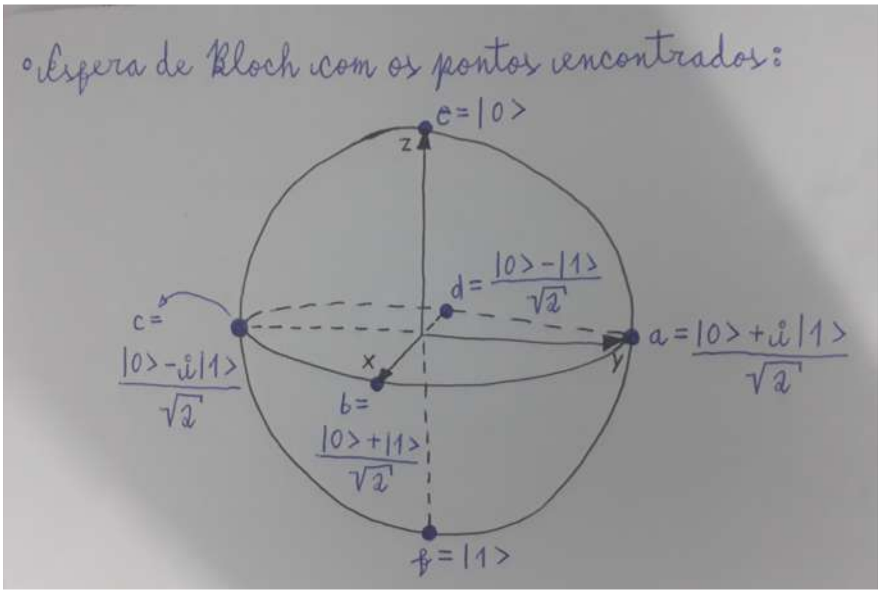
In [11]:

```
plot_bloch_vector((0,-1,0))
```

Out[11]:



- Esfera com todos os estados representados:



In [ ]: