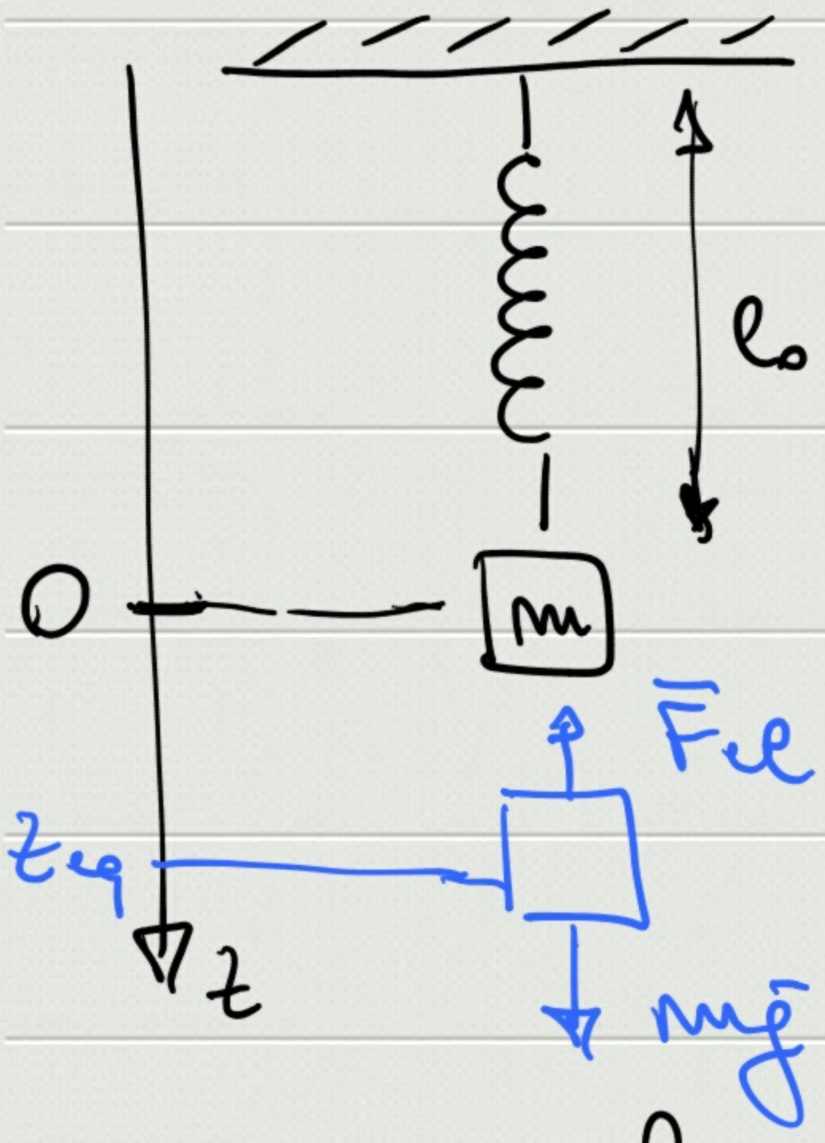


$k = 100\ N/m$

$m = 1\ kg$

$v_0 = 0$

$z_0 = l_0$

$\hookrightarrow 0$

1. Punto eq. forze 2. pulsazione 3. z_{max}

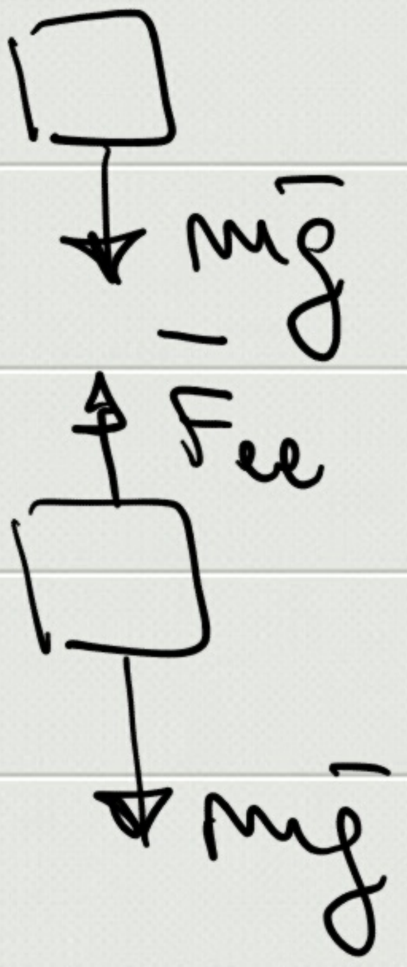
$z_{eq} = 0$

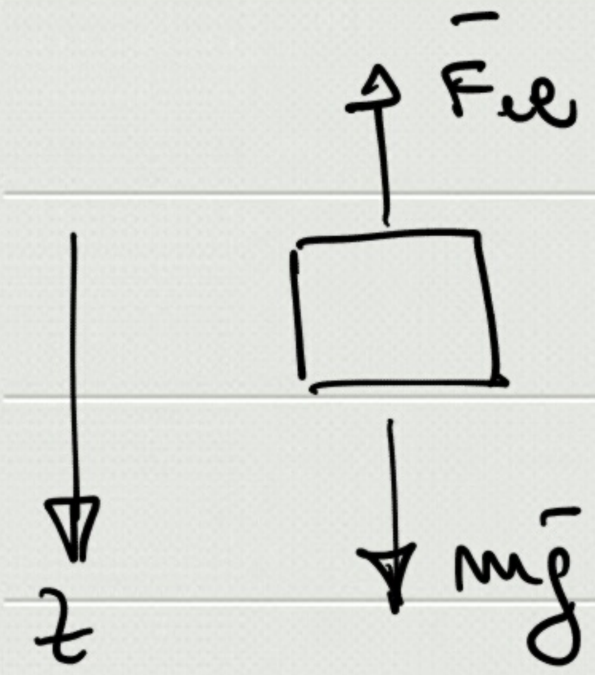
$$mg\, z_{eq} + \frac{1}{2} k z_{eq}^2 = 0$$

$$mg + k z_{eq} = 0$$

$$mg - k z_{eq} = 0 \quad *$$

$$\Rightarrow z_{eq} = \frac{mg}{k} > 0$$





$$mg - kz = ma = m\frac{d^2z}{dt^2}$$

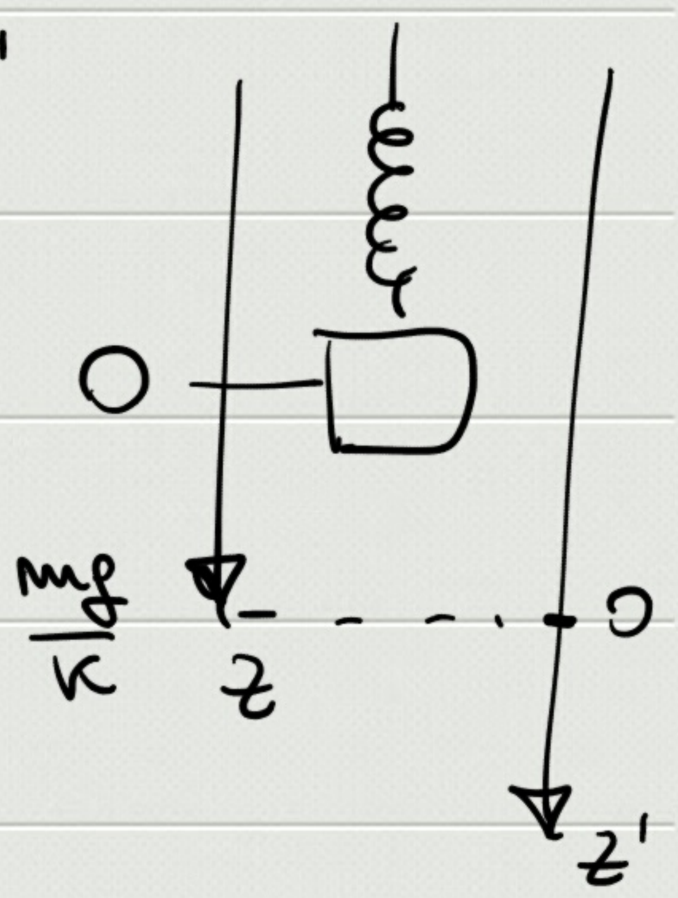
$$\boxed{\frac{d^2z}{dt^2} + \frac{k}{m}z - g = 0}$$

$$\frac{d^2z}{dt^2} + \omega^2 z = 0$$

$$\frac{k}{m}z - g = \omega^2 z' \Rightarrow \frac{k}{m}z'$$

$$\frac{k}{m}z - g = \frac{k}{m}z'$$

$$\Rightarrow z' = z - \frac{mg}{k}$$



$$z = z' + \frac{mg}{k}$$

$$\frac{d^2z}{dt^2} = \frac{d}{dt}\left(\frac{dz}{dt}\right) = \frac{d}{dt}\left(\frac{dz'}{dt}\right) = \frac{d^2z'}{dt^2}$$

$$\Rightarrow \frac{d^2z'}{dt^2} + \frac{k}{m}z' = 0 \Rightarrow z'(t) = A\sin(\omega t + \phi)$$

$$\omega^2 = \frac{k}{m} \Rightarrow \omega = \sqrt{\frac{k}{m}} = 10\ rad/s$$

$$z(t) = A\sin(\omega t + \phi) + \frac{mg}{k}$$

$$z(t) = A \sin(\omega t + \phi) + \frac{mg}{k} \qquad *$$

$z(0) = 0$

$v(0) = 0$

$$v(t) = \frac{dz}{dt} = A\omega \cos(\omega t + \phi)$$

$$\Rightarrow \begin{cases} 0 = A \sin\phi + \frac{mg}{k} \\ 0 = A\omega \cos\phi \end{cases} \qquad \phi = \frac{\pi}{2} \qquad \Rightarrow A = -\frac{mg}{k}$$

$$\boxed{z(t) = -\frac{mg}{k} \sin\left(\omega t + \frac{\pi}{2}\right) + \frac{mg}{k} = \frac{mg}{k}\left(1 - \cos\omega t\right)}$$

$\cos\omega t = -1$