

$$u^{n+1} = u^n + \frac{\Delta t}{2} (f^n + f^{n+1})$$

$$\underline{x} \quad u^{n+1} - \frac{\Delta t}{2} f^{n+1} = u^n + \frac{\Delta t}{2} f^n$$

$$f(x) = f_{(n+1)}$$

$$\underline{x} \quad \underline{u_{kemp}} \quad u^{n+1} - u^n - \frac{\Delta t}{2} f^n - \frac{\Delta t}{2} f^{n+1} = 0$$

$$v^{n+1} = v^n + \frac{\Delta t}{2} (f^{n+1} + f^n)$$

Si  $f$  es lineal  $\rightarrow F = AV$  (matriz por vector)

$$v^{n+1} = v^n + \frac{\Delta t}{2} (A v^{n+1} + A v^n)$$

$$(I - \frac{\Delta t}{2} A) v^{n+1} = (I + \frac{\Delta t}{2} A) v^n$$

$$v^{n+1} = (I - \frac{\Delta t}{2} A)^{-1} \cdot (I + \frac{\Delta t}{2} A) v^n$$

Para este caso que  $f$  es no lineal:

$v = \text{zeros}(4, N)$

$v[:, 0] = \text{zeros}(4, 1)$

$a = v[:, n]$

def  $G(x)$ :

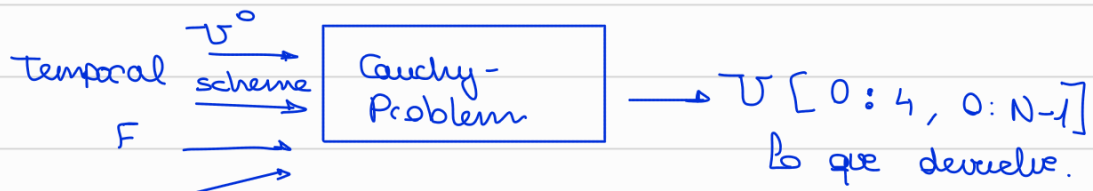
return  $\underline{x} - a - \frac{dt}{2} \cdot (f(a) + f(\underline{x}))$

Vector  
columna

Sería la  $F$  Kepler  
evaluada en  
 $n+1$ .

for  $n$  in range(1, N-1):

$v[:, n+1] = \text{Newton}(\text{func} = G, x_0 = v[:, n])$  scipy.optimize.newton



↳ vector (partición del segmento que quiero  
integrar desde 0 hasta T)