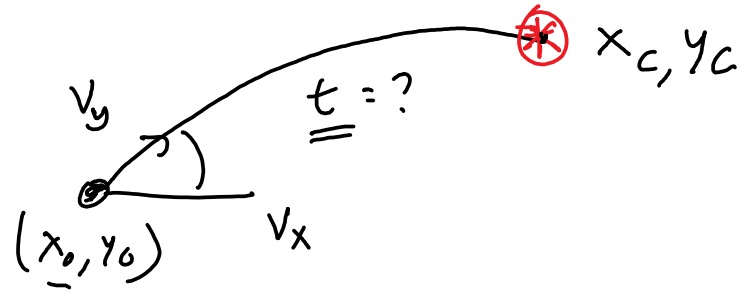


Find v_x, v_y such that the ball hits the target

① `[t, x] = ode45('rhs', x0, options)`

`options = ('events', @target)`

`target` $\left\{ \begin{array}{l} \text{value} \\ \text{isterminal} \\ \text{direction} \end{array} \right. = \begin{array}{l} x_{integrat} - x_c = 0 \\ y_{integrat} - y_c = 0 \end{array}$] fminsearch does not benefit this

Here time is implicit

fmincon → needs gradients $\frac{\text{constraints}}{\text{optimization variables}}$

→ $\left\{ \frac{\partial x_c}{\partial v_x}, \frac{\partial y_c}{\partial v_x}, \frac{\partial x_c}{\partial v_y}, \frac{\partial y_c}{\partial v_y} \right.$ are non-smooth.

Makes the problem non-smooth & fmincon has a hard time converging

② $(t, x) = ode45('vhs', x_0, options)$

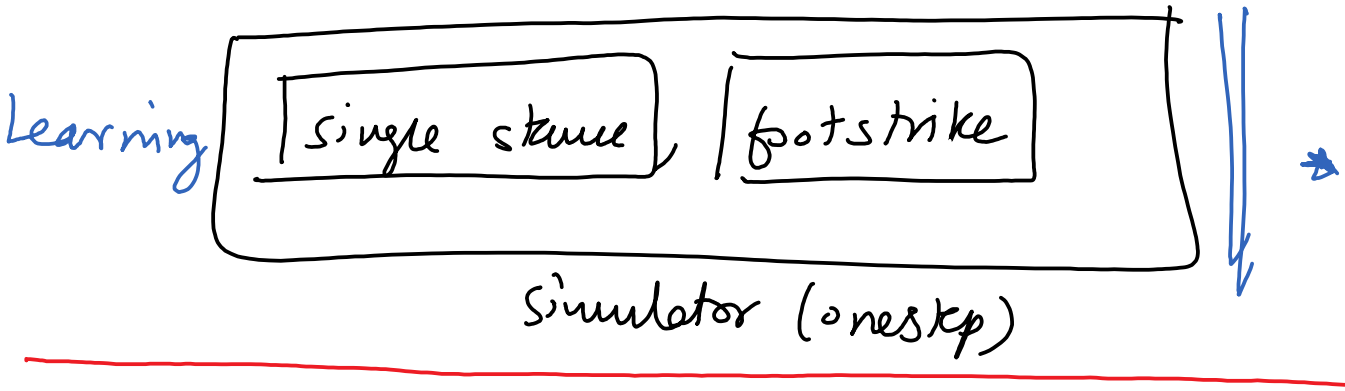
options ⟶ do not specify event

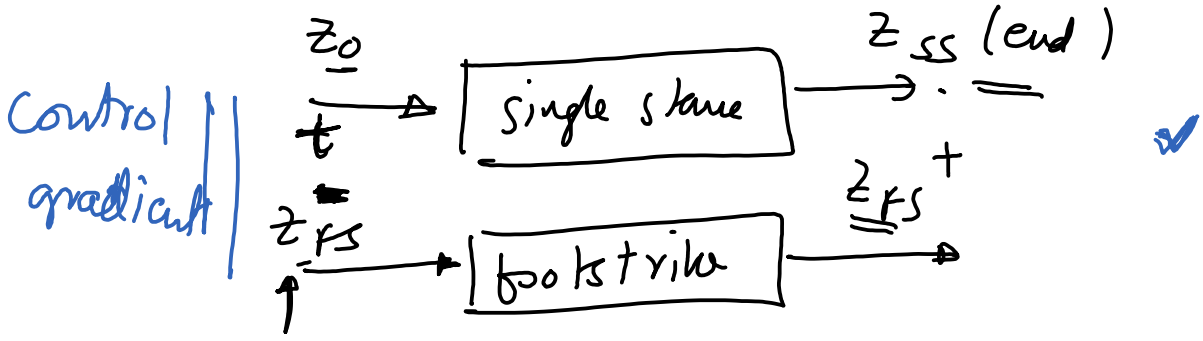
t = integration time as a free parameter

optimization variables V_x, V_y, t

constraints = $x_{int} - x_c = 0$
$y_{int_2} - y_c = 0$ }

Legged optimization





optimization variable z_0, t, z_{FS}

constraints. $z_1 = z_{ss}(\text{end}) - z_{FS} = 0$

$z_2 = z_{FS}^+ - z_0 = 0$

} constraints explicit

fmincon → $\frac{\partial z_1}{\partial z_0}, \frac{\partial z_1}{\partial z_{FS}}, \frac{\partial z_1}{\partial t}$

$\frac{\partial z_2}{\partial z_0}, \frac{\partial z_2}{\partial z_{FS}}, \frac{\partial z_2}{\partial t}$