Bungee Jumping

The dynamics of a person bungee jumping are governed by the equation below

$$\mathbf{m}\ddot{x} = F_{gravity} + F_{cord} + F_{drag} = -mg + b(x) - \frac{1}{2}\rho C_D A|\dot{x}|\dot{x}$$

where m is the body mass, g is gravity, *b(x)* is the spring force of the elastic cord, and the last term represents air resistance. The | | operator above denotes the absolute value operation.

Prior to jumping, the person is located at a height x_0 above the ground and is tied to an elastic bungee cord with spring constant k. The length of the unstretched cord is L. Once the bungee cord begins stretching (at $x < x_0 - L$), it provides a restoring spring force which can be characterized as

$$b(x) = \begin{cases} k\big((x_0 - L) - x\big), & if\ x < x_0 - L \\ 0, & if\ x \geq x_0 - L \end{cases}$$

So, the overall equation is

$$\mathbf{m}\ddot{x} = -mg + b(x) - \frac{1}{2}\rho C_D A|\dot{x}|\dot{x}$$

Create a model of the system dynamics and simulate using the parameters and initial conditions below. Plot the position of the person over time.

$m = 90$	$A = 0.5$
$g = 9.81$	$L = 20$
$k = 25$	$x_0 = 80$
$\rho = 1.2$	$\dot{x}_0 = 0$
$C_D = 0.6$	**Stop Time = 50**

Outputs

$x -$ Position

States

$x -$ Position

$\dot{x} -$ Velocity

Parameters

$m -$ Mass (90 kg)

$g -$ Gravity constant (9.81 m/s^2)

k − Spring constant of cord (25 N/m)

ρ − Air density (1.2 kg/m^3)

$C_D -$ Drag coefficient (0.6)

A − Frontal surface area of person (0.5 m^2)

$L -$ Length of unstretched bungee cord (20 m)