

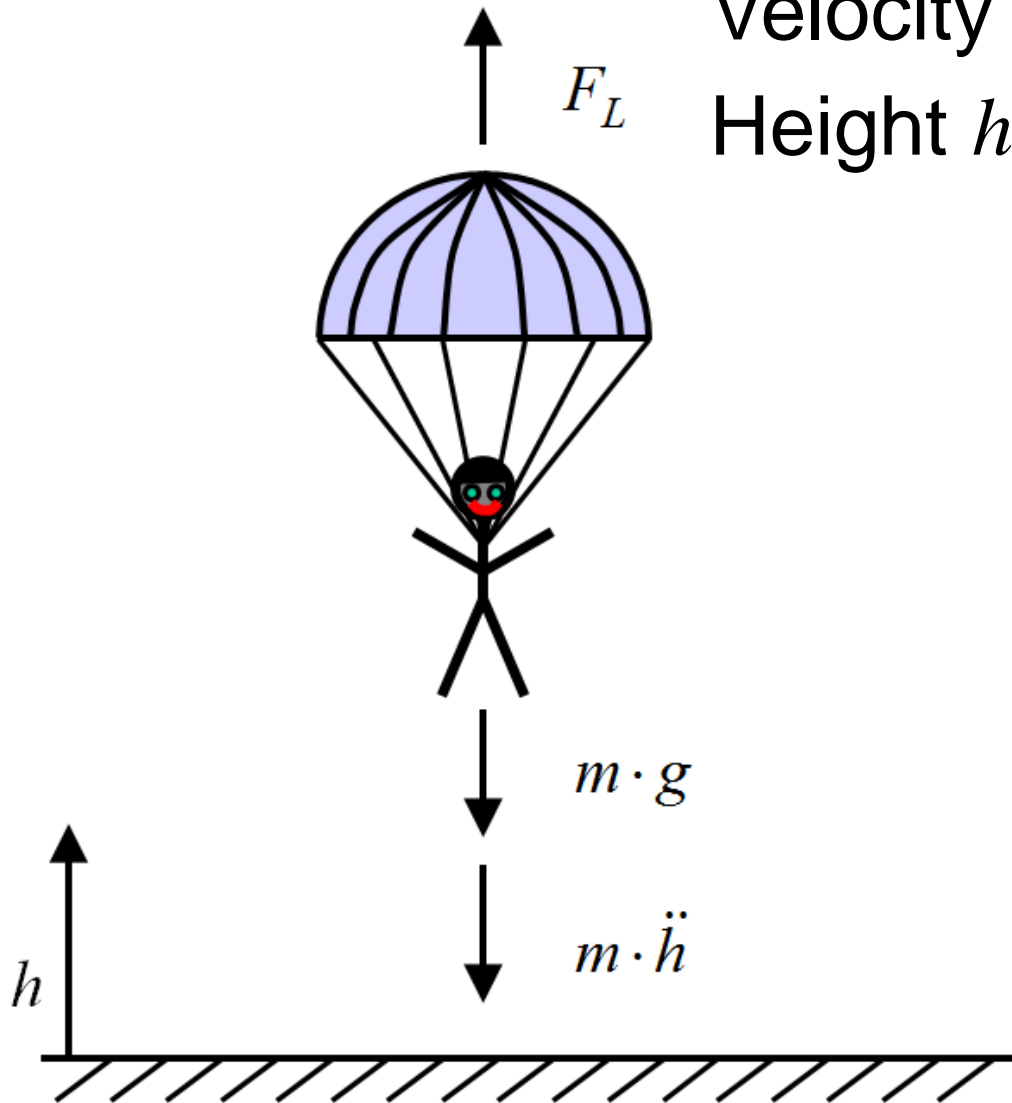
Solving Differential Equations Mechanical Systems

Faculty of Technology and Bionics

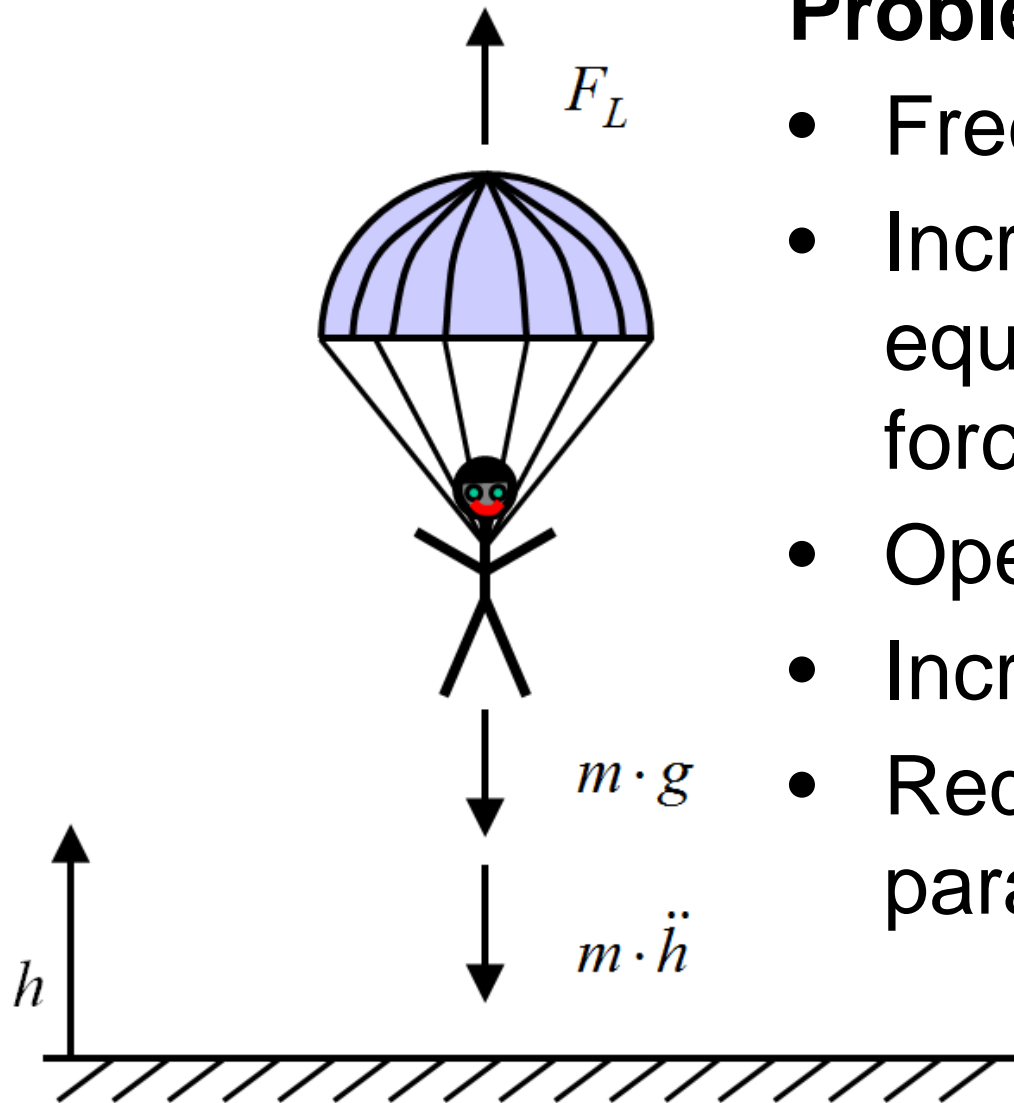
Problem: Parachutist

Velocity of fall v vs. time t diagram

Height h vs. time t diagram



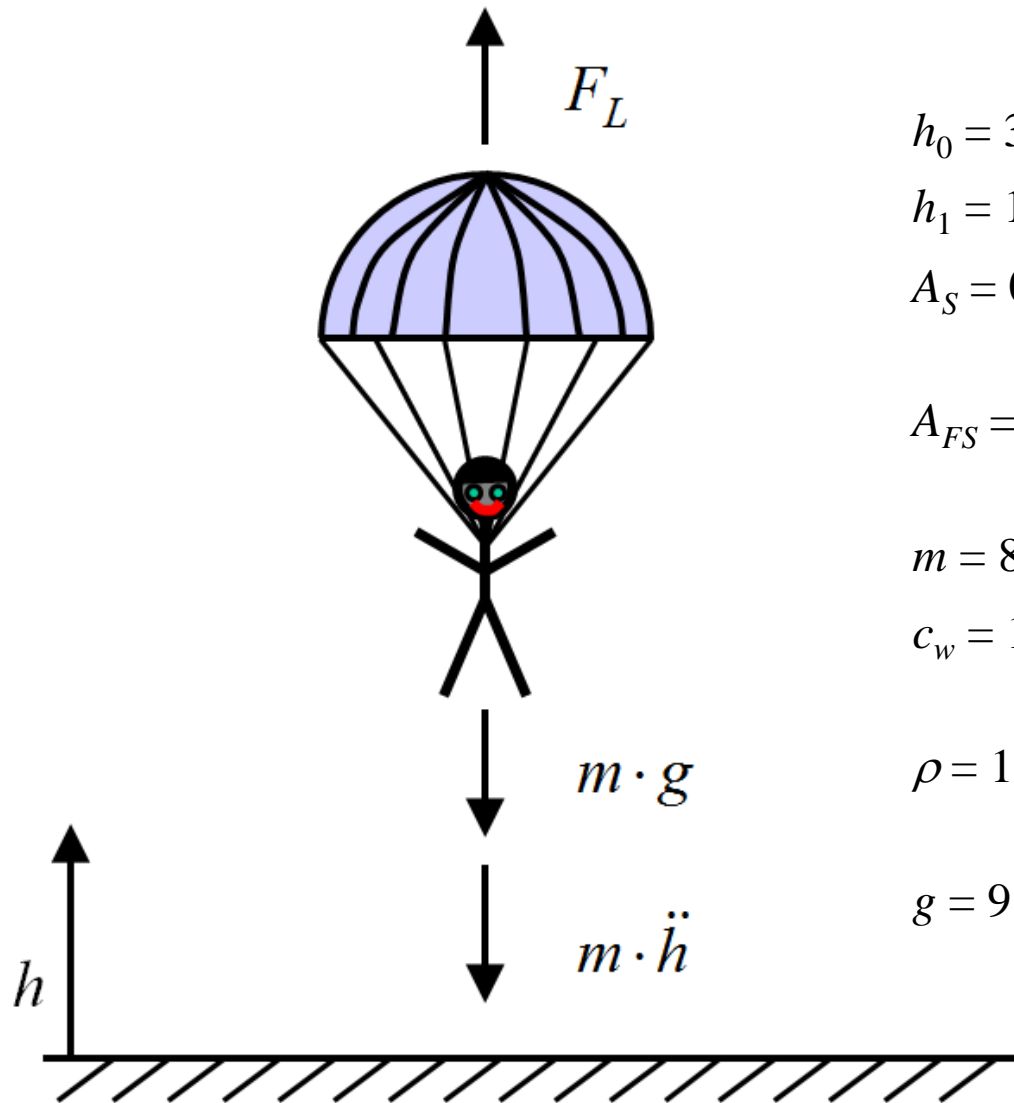
Problem: Parachutist



Problem description:

- Free fall at h_0
- Increased velocity until equilibrium between weight force and drag force
- Opening parachute at h_1
- Increased air resistance
- Reduced velocity of parachutist

Problem: Parachutist



$$h_0 = 3000 \text{ m}$$

Initial height of jump

$$h_1 = 1500 \text{ m}$$

Height when parachute opens

$$A_S = 0.5 \text{ m}^2$$

Cross section area of parachutist

$$A_{FS} = 30 \text{ m}^2$$

Cross section area of parachute

$$m = 85 \text{ kg}$$

Weight of parachutist

$$c_w = 1.3$$

Drag coefficient (identical for parachutist and parachute)

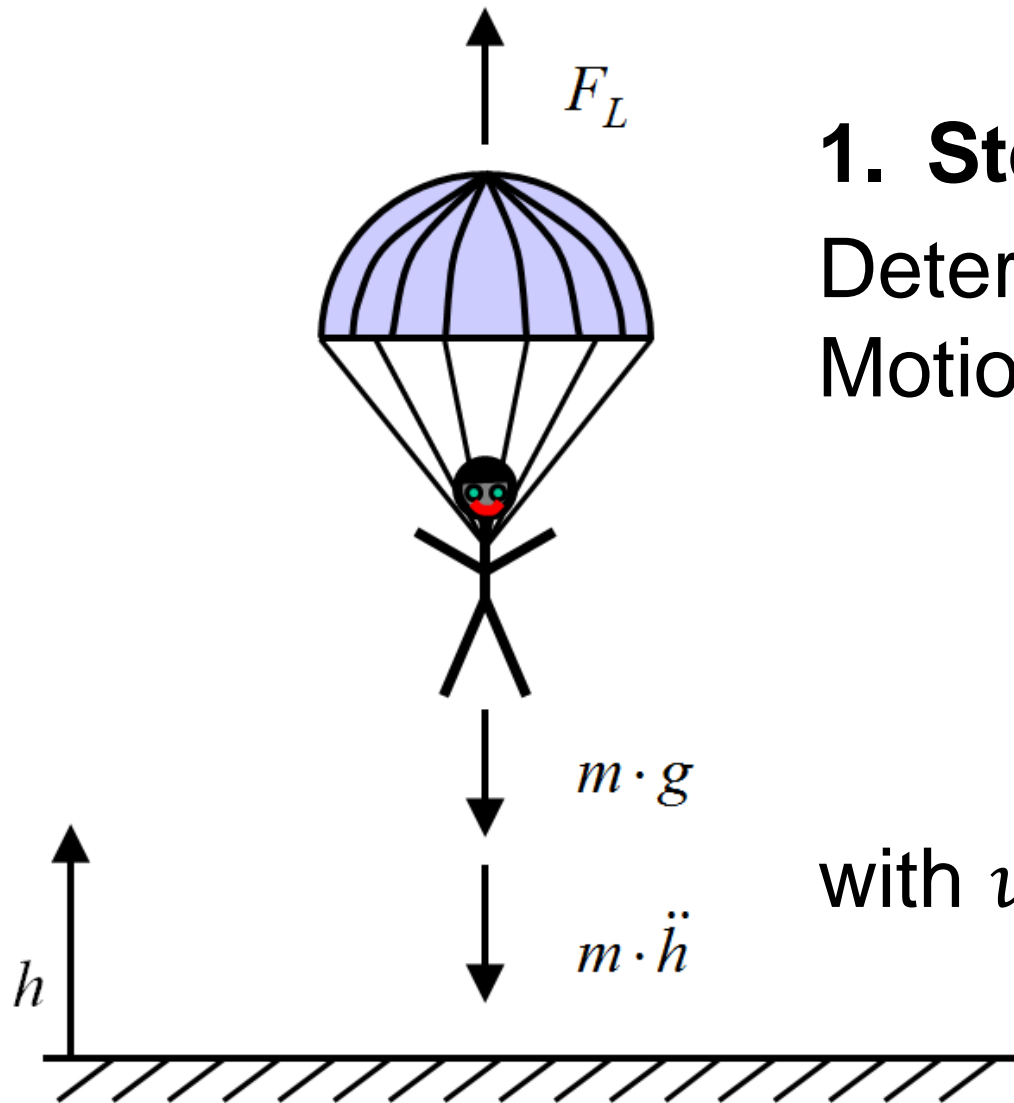
$$\rho = 1.2 \text{ kg/m}^3$$

Air density (constant over height)

$$g = 9.81 \text{ m/s}^2$$

Acceleration of gravity

Problem: Parachutist



1. Step

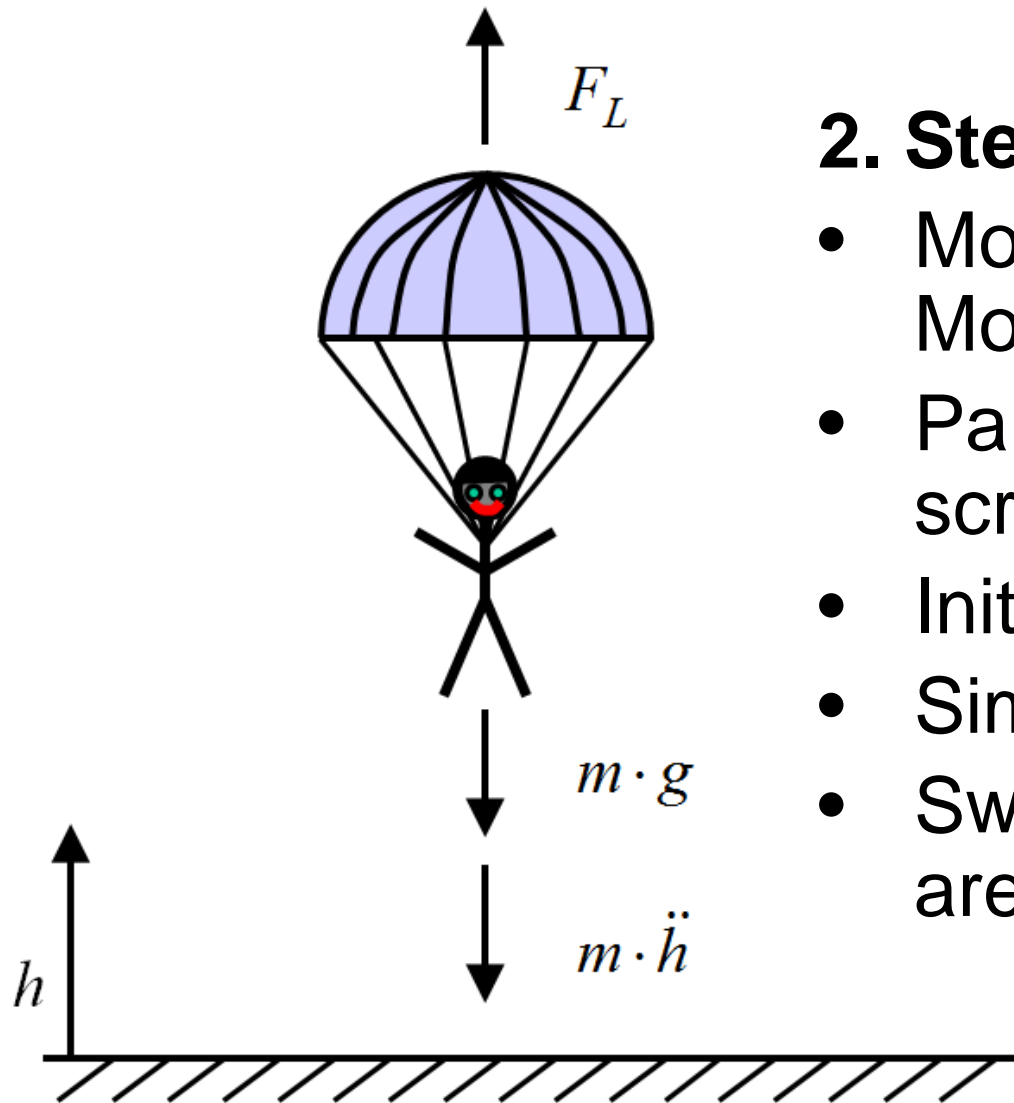
Determination Equation of Motion

$$m\ddot{h} = F_L - mg$$

$$F_L = c_w A \frac{\rho}{2} v^2$$

with $v = \dot{h}$

Problem: Parachutist

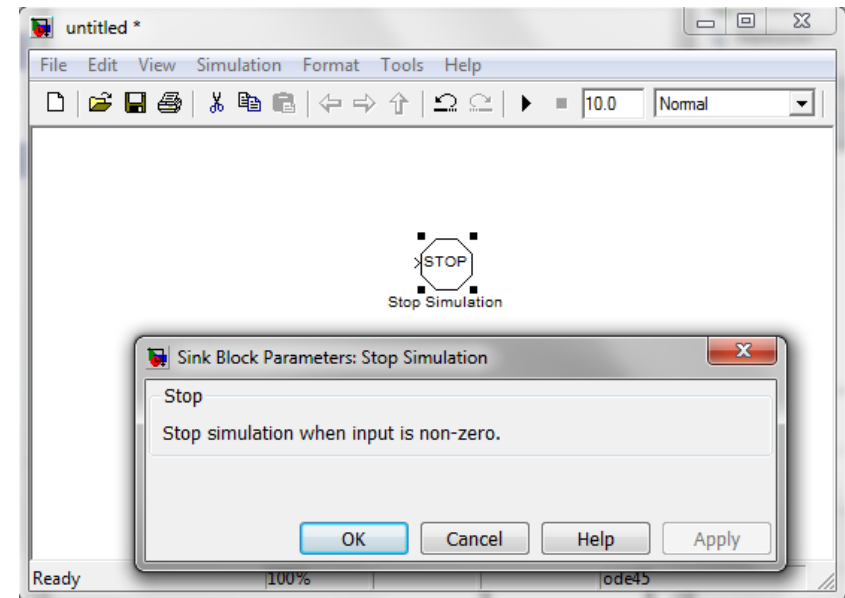
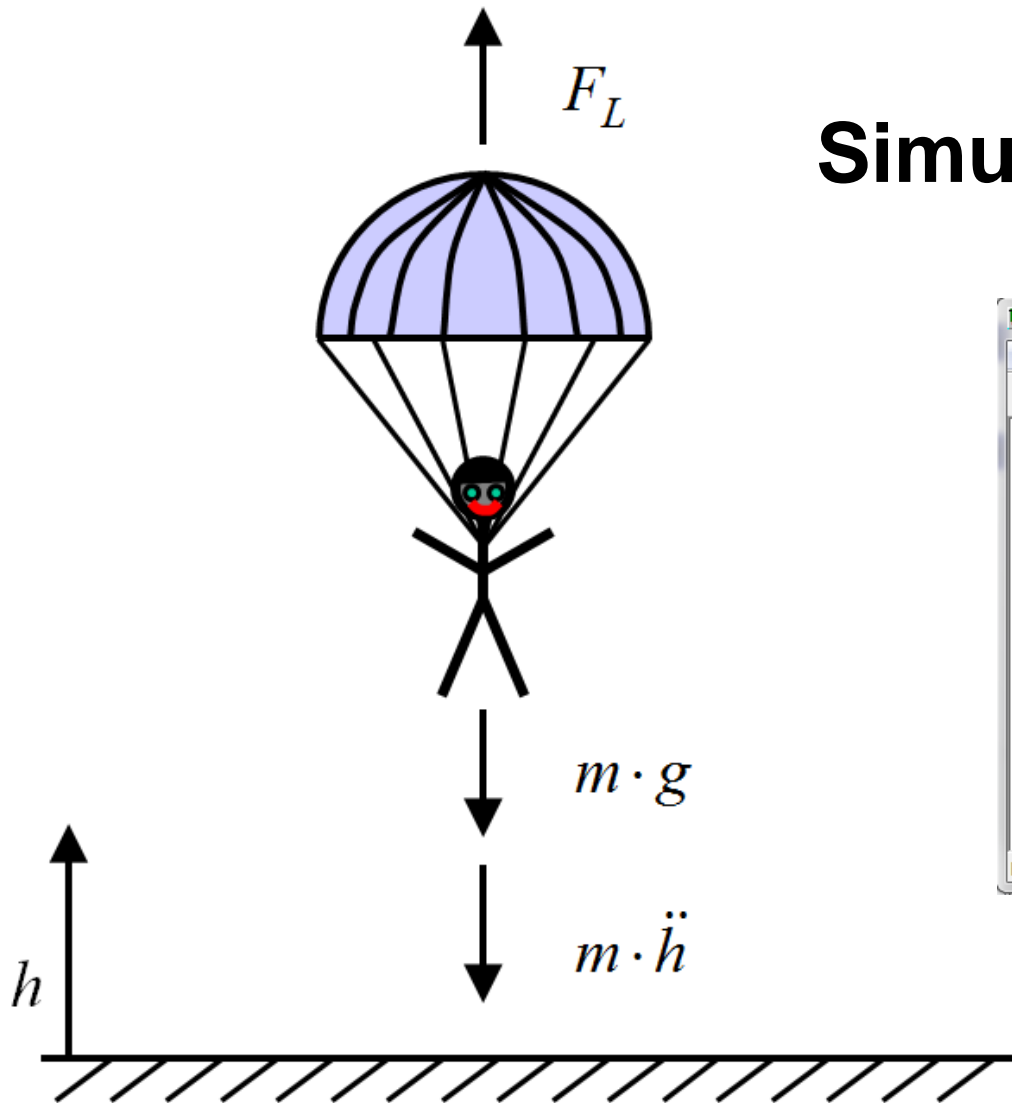


2. Step

- Modeling the Equation of Motion
- Parameter definition (in a script file)
- Initial values
- Simulation STOP condition
- Switching of cross section area

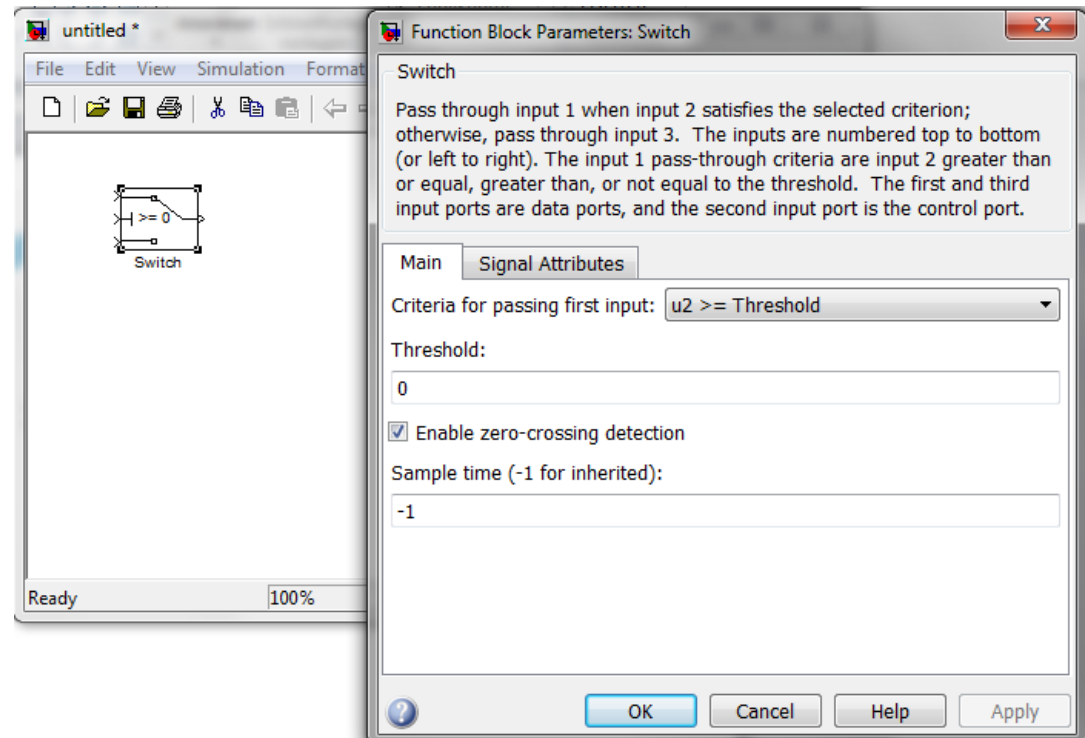
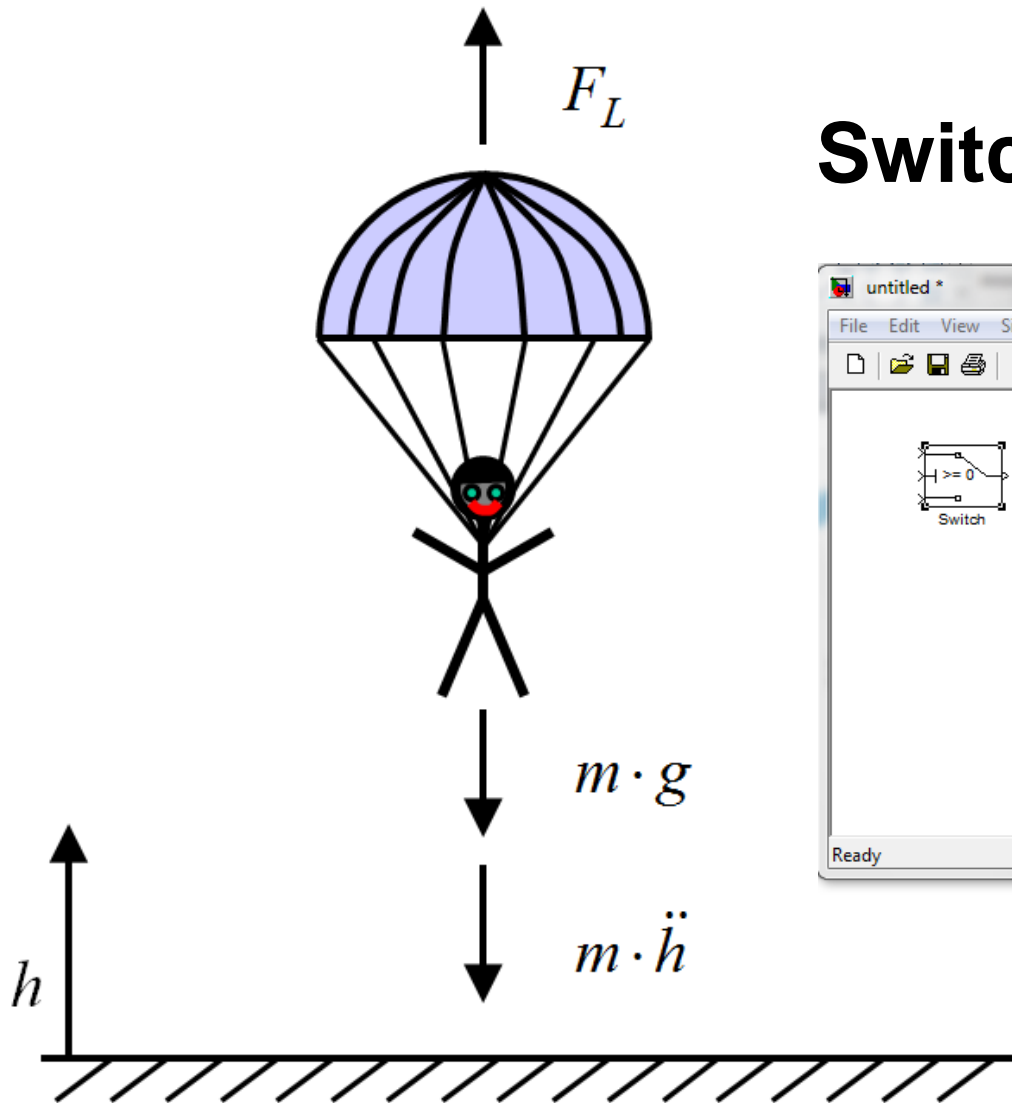
Problem: Parachutist

Simulation STOP condition



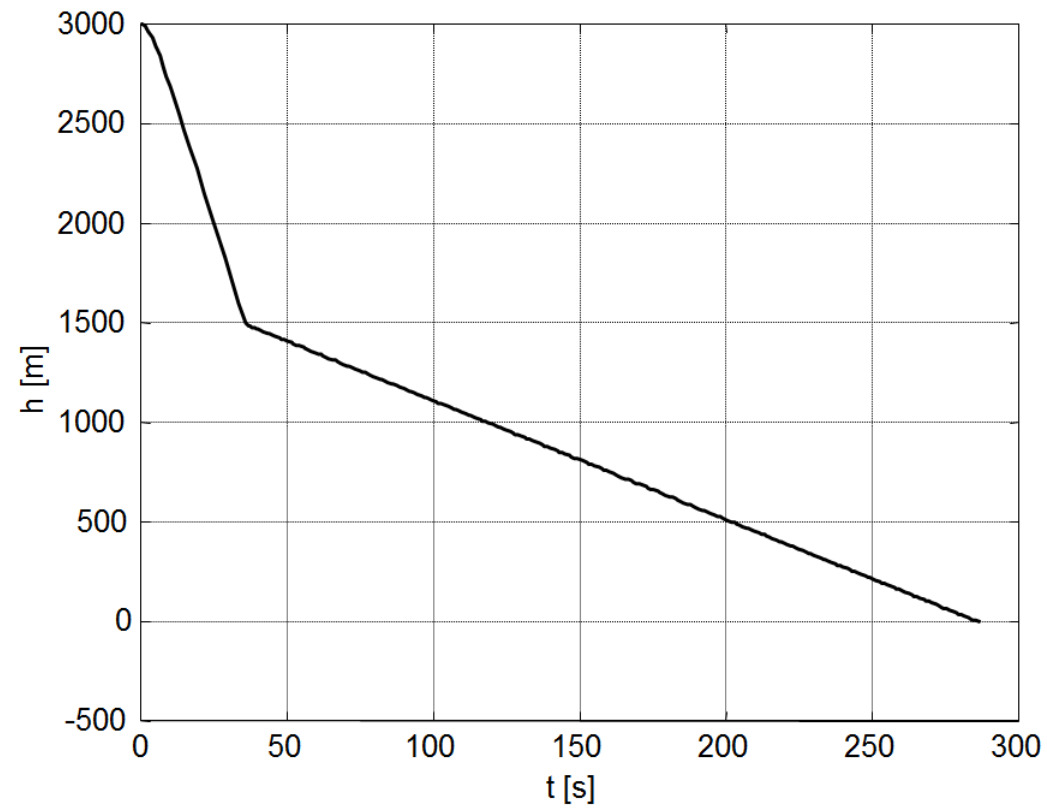
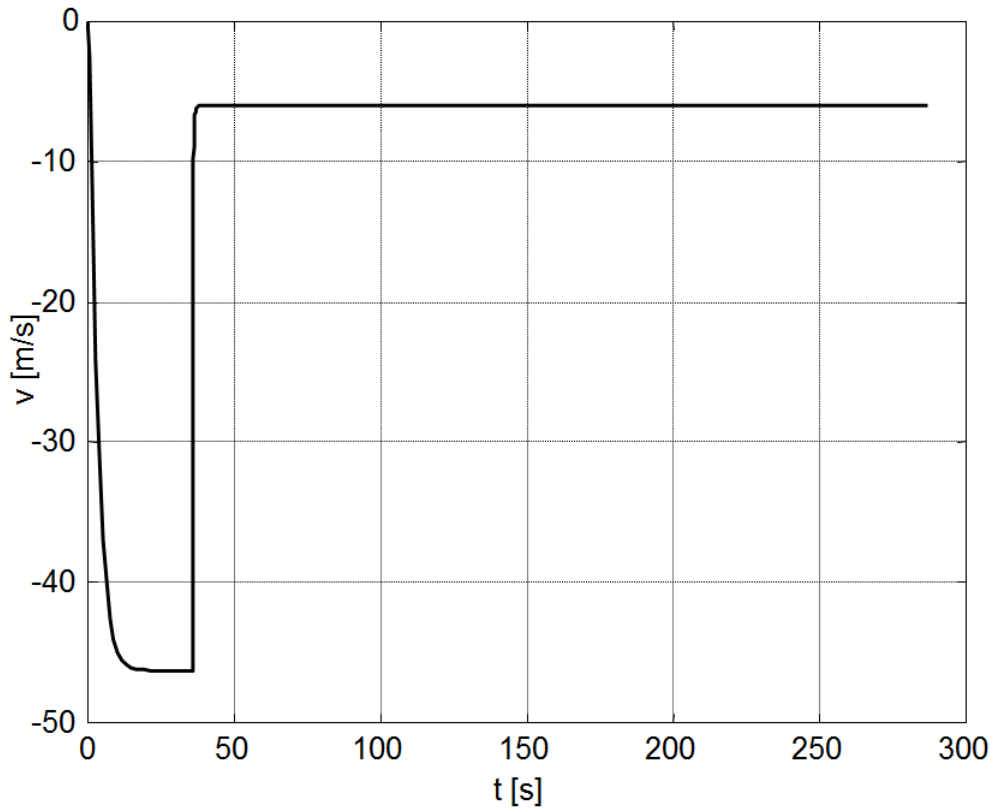
Problem: Parachutist

Switching



Problem: Parachutist

Simulation Results



Problem: Parachutist

Advanced Exercise

Implement a height dependent air density (linear interpolation between breakpoints)

Height [m]	Air density [kg/m ³]
0	1.225
1000	1.112
2000	1.007
3000	0.909