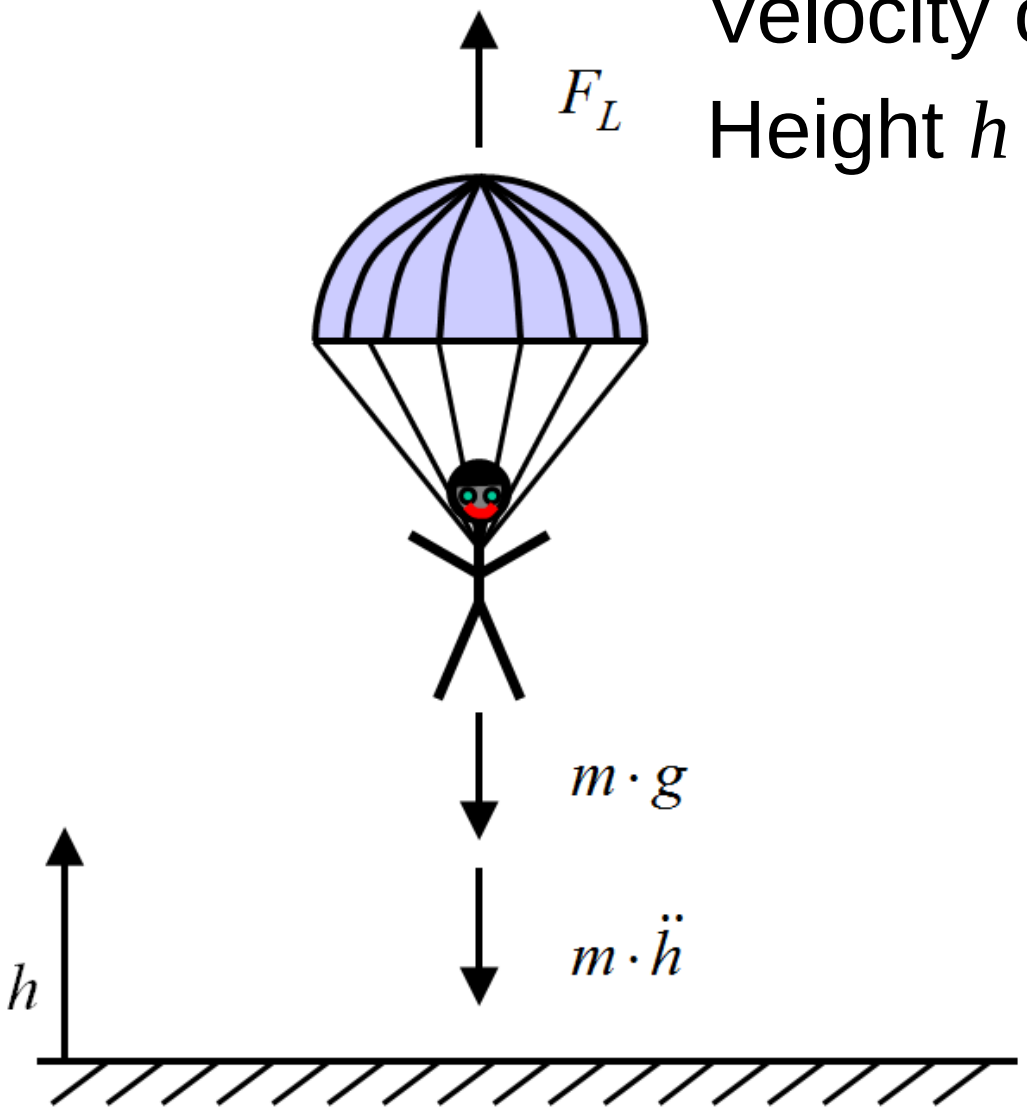
Solving Differential Equations Mechanical Systems

Faculty of Technology and Bionics

Problem: Parachutist



Velocity of fall v vs. time t diagram

Height h vs. time t diagram

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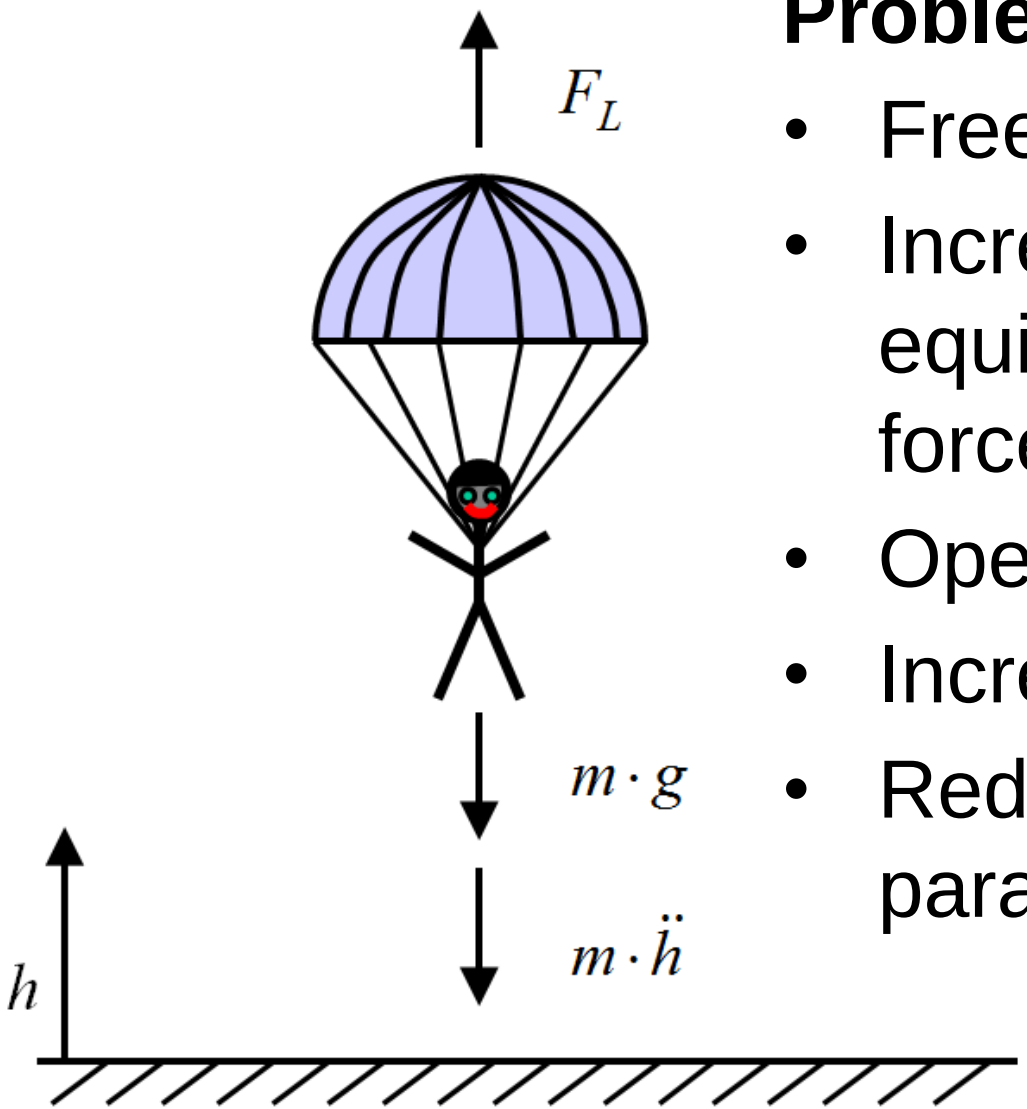

Problem description:

- 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

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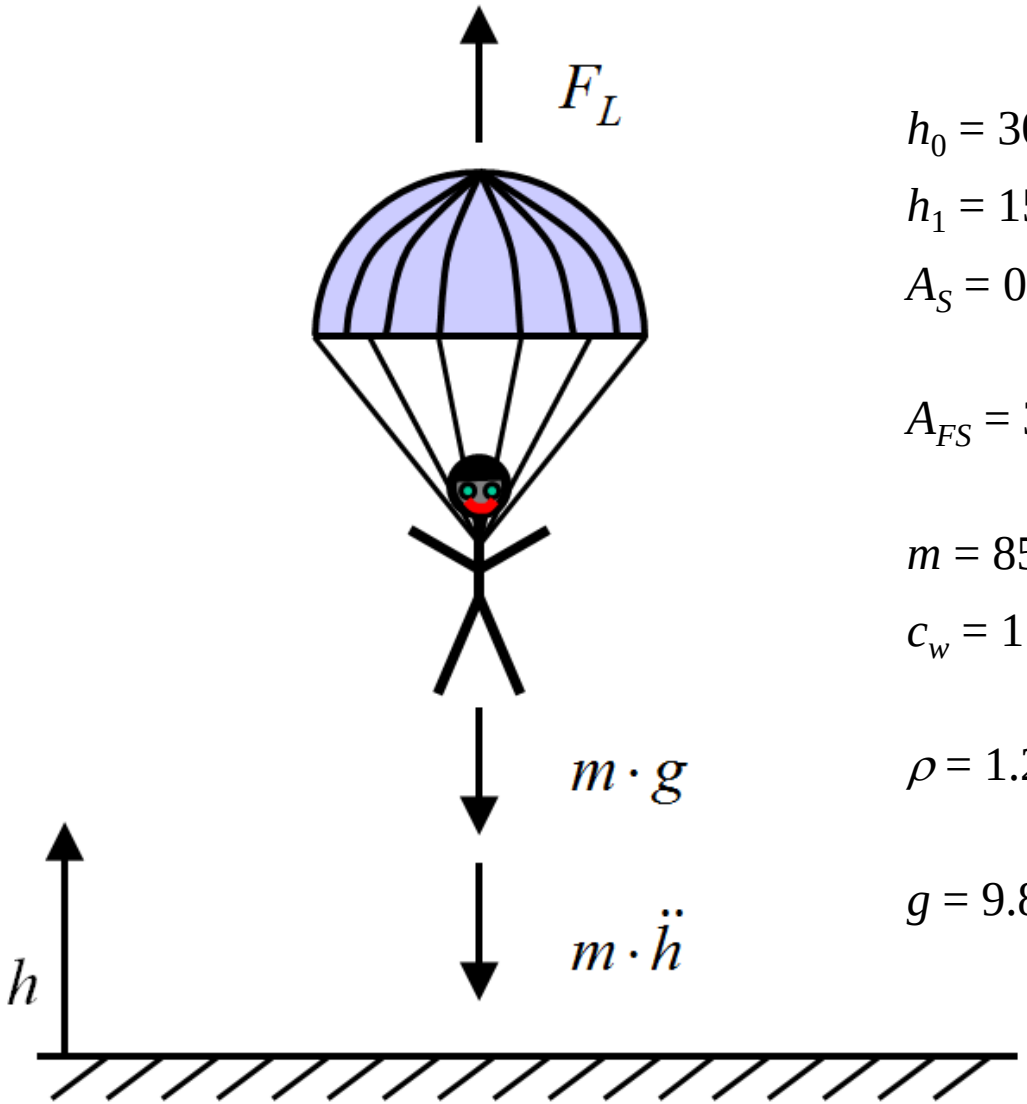

$h_0 = 3000$ m	Initial height of jump
$h_1 = 1500$ m	Height when parachute opens
$A_S = 0.5$ m²	Cross section area of parachutist
$A_{FS} = 30$ m²	Cross section area of parachute
$m = 85$ kg	Weight of parachutist
$c_w = 1.3$	Drag coefficient (identical for parachutist and parachute)
$\rho = 1.2$ kg/m³	Air density (constant over height)
$g = 9.81$ m/s²	Acceleration of gravity

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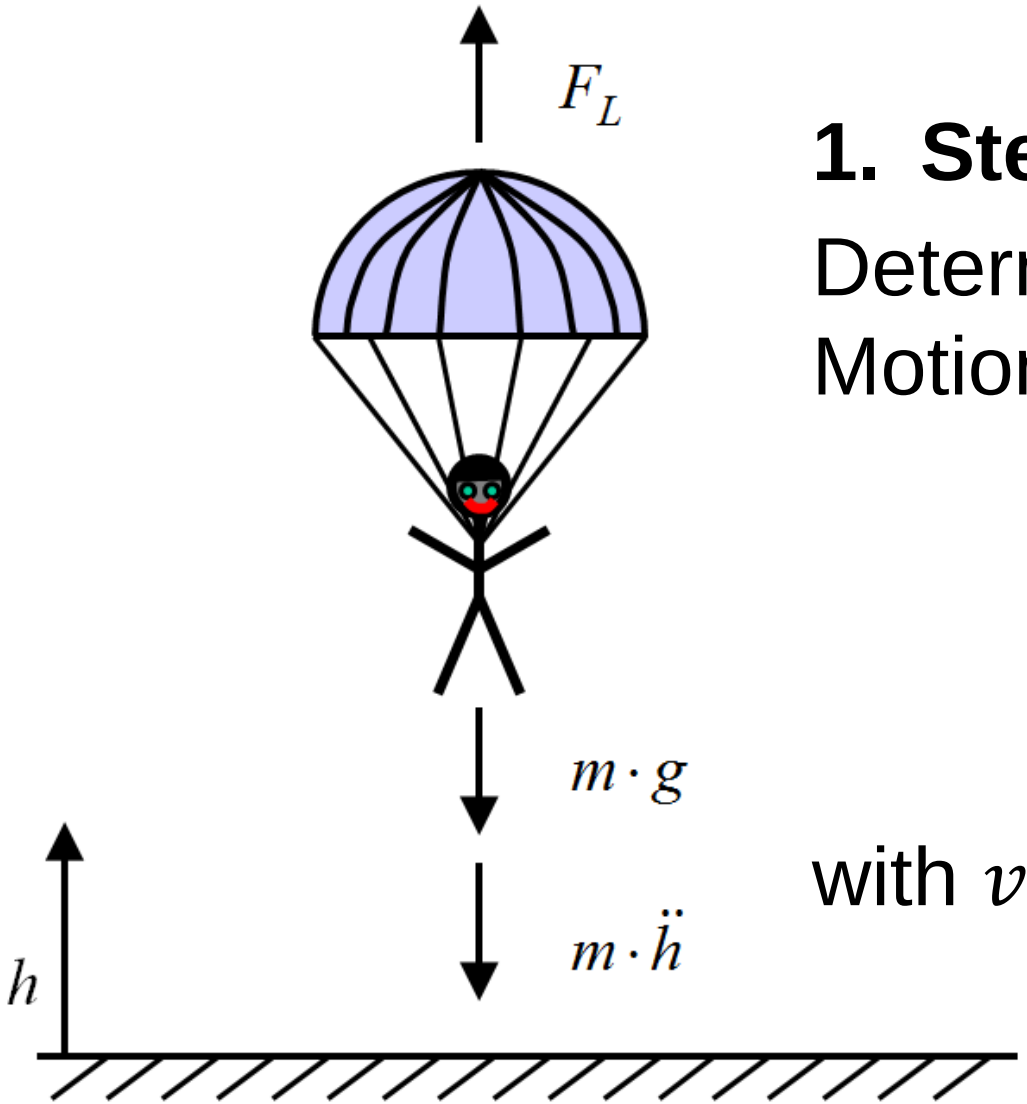

1. Step

Determination Equation of Motion

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

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

with $v = \dot{h}$

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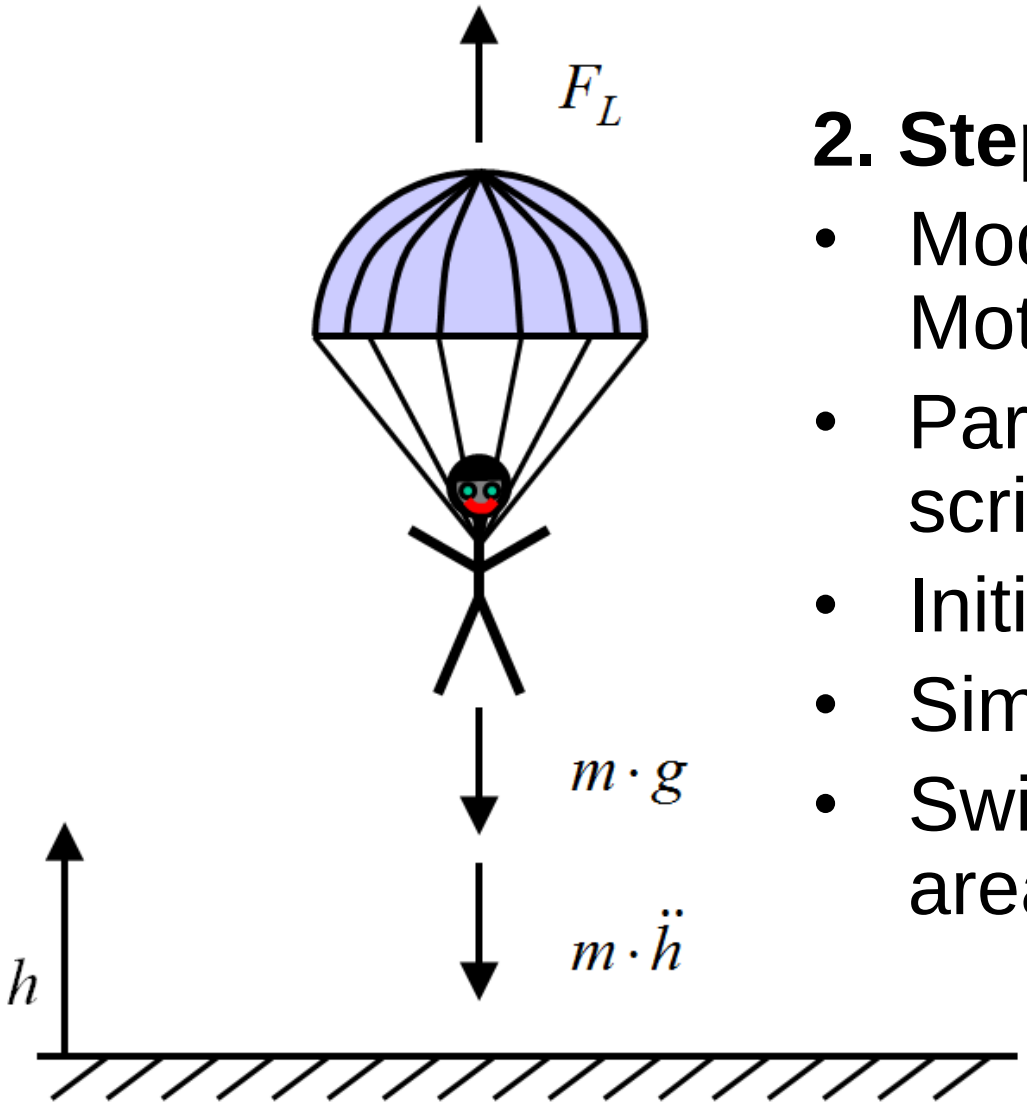
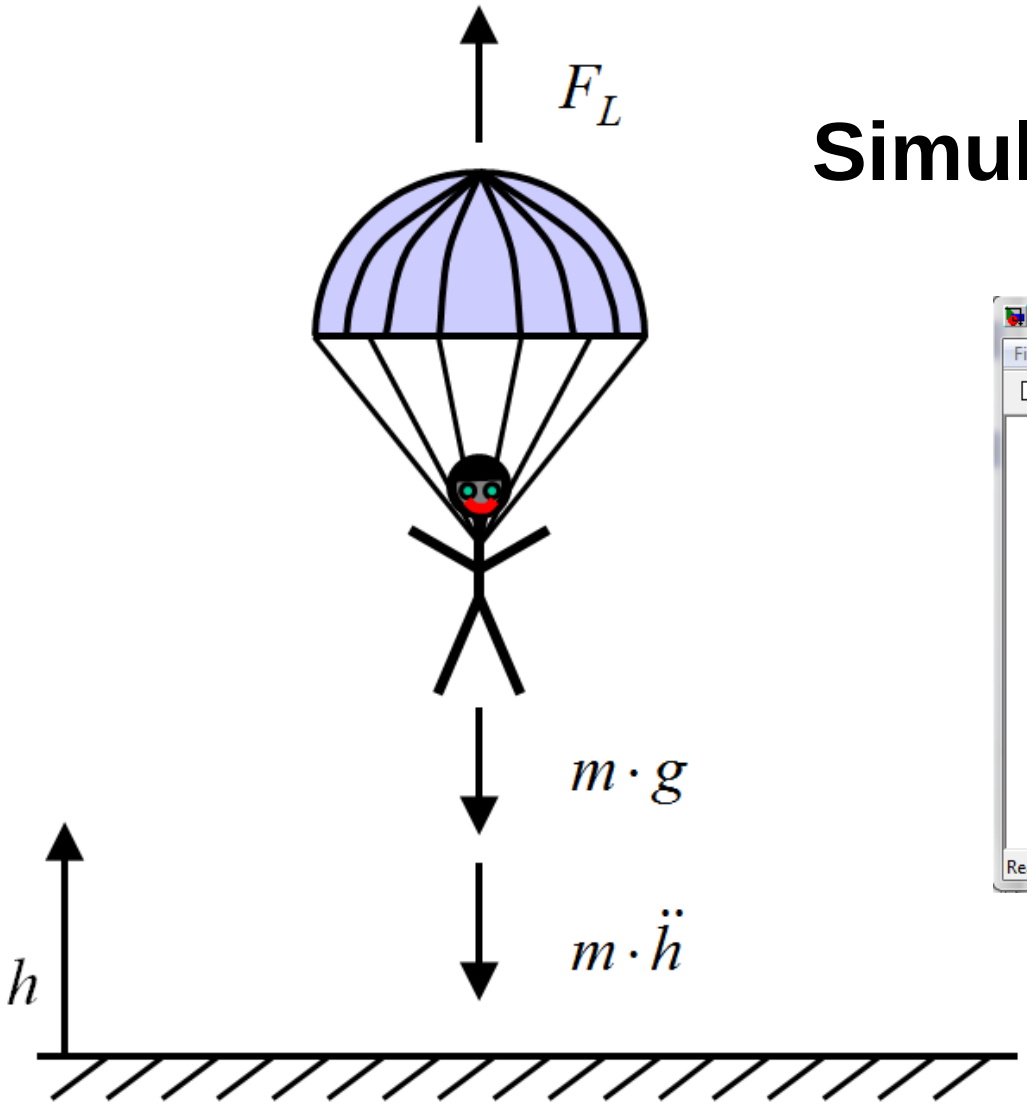


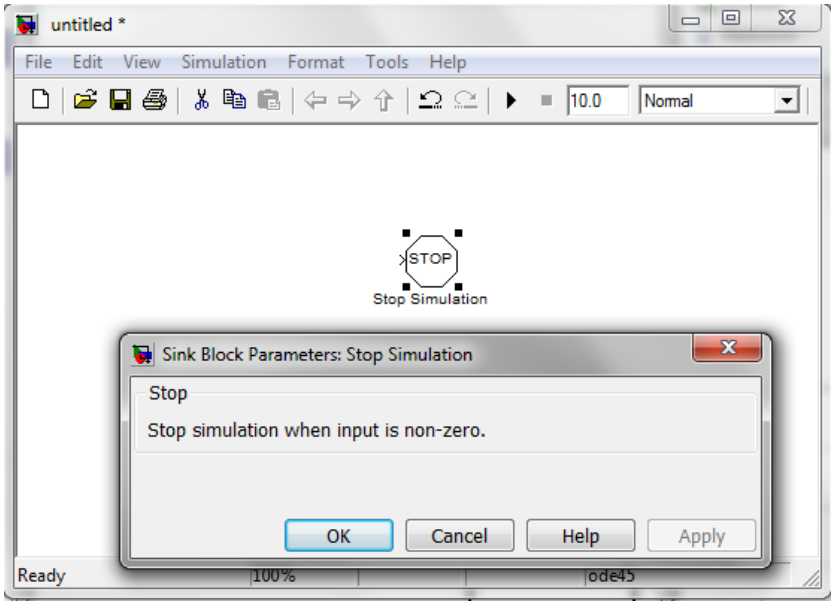
2. Step

- 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



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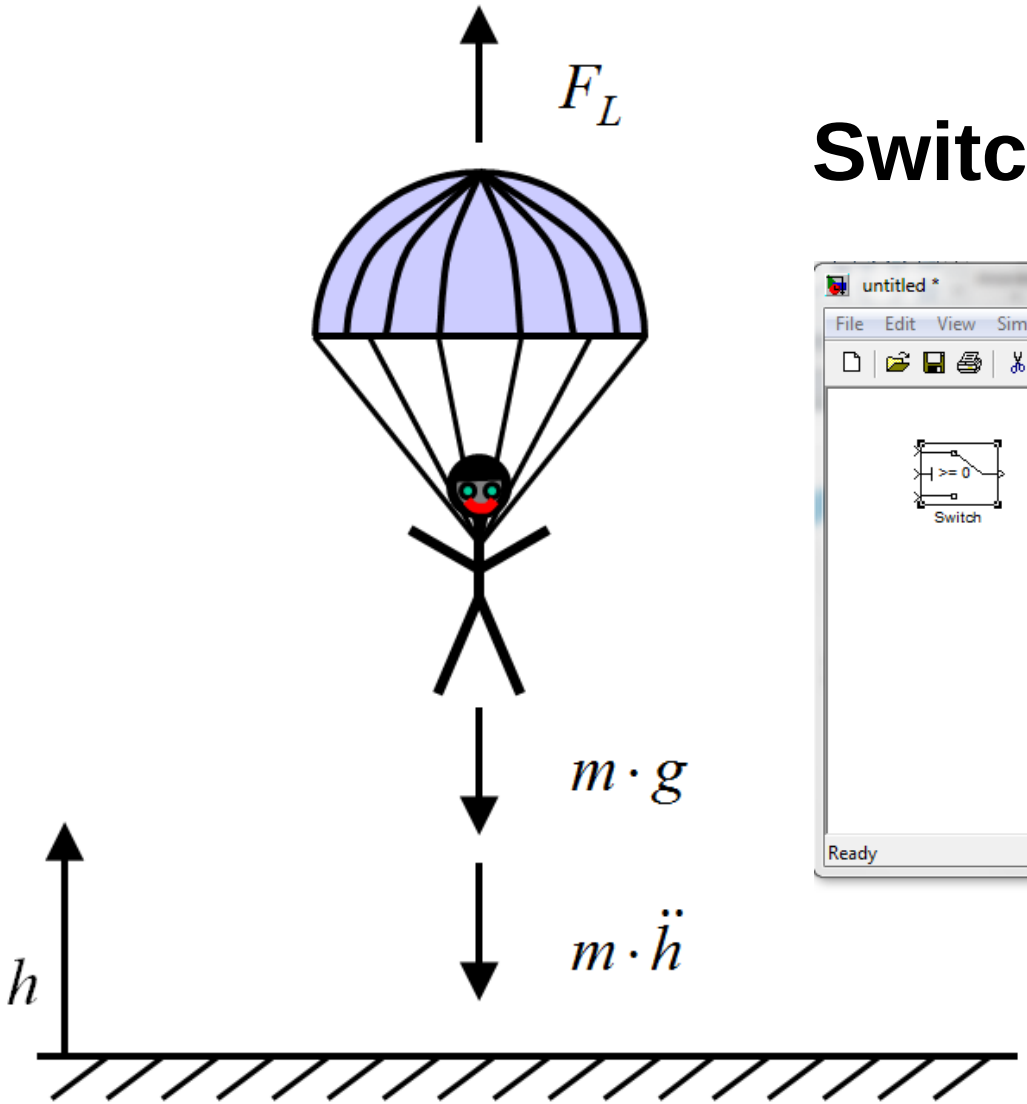
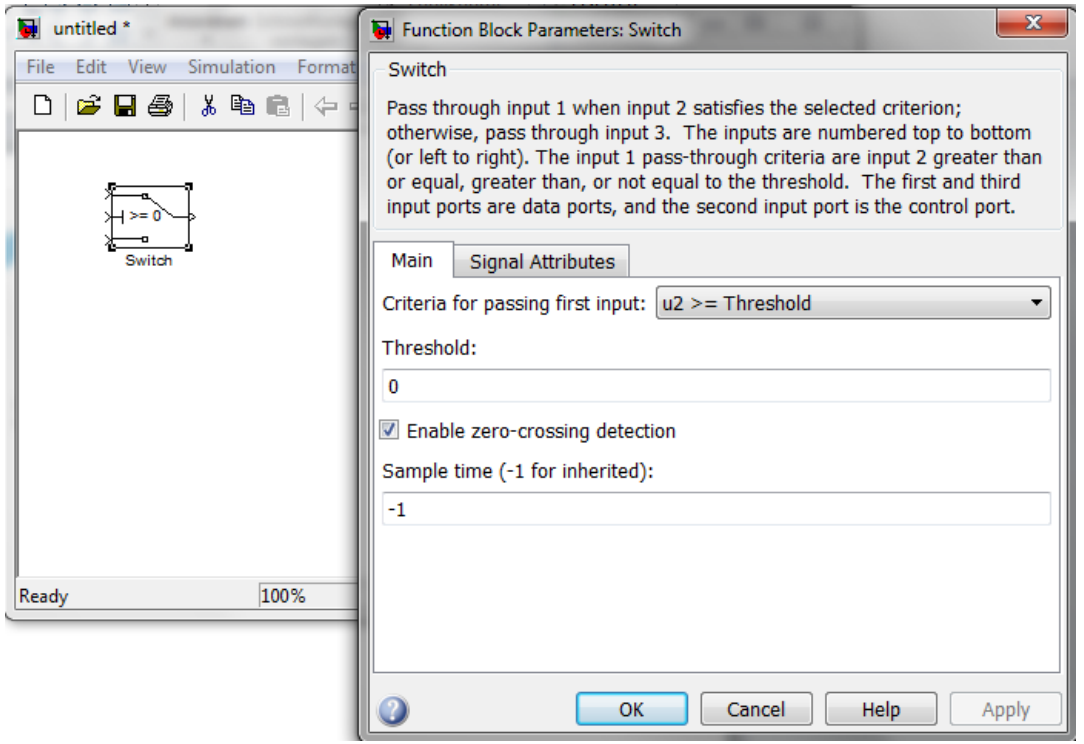
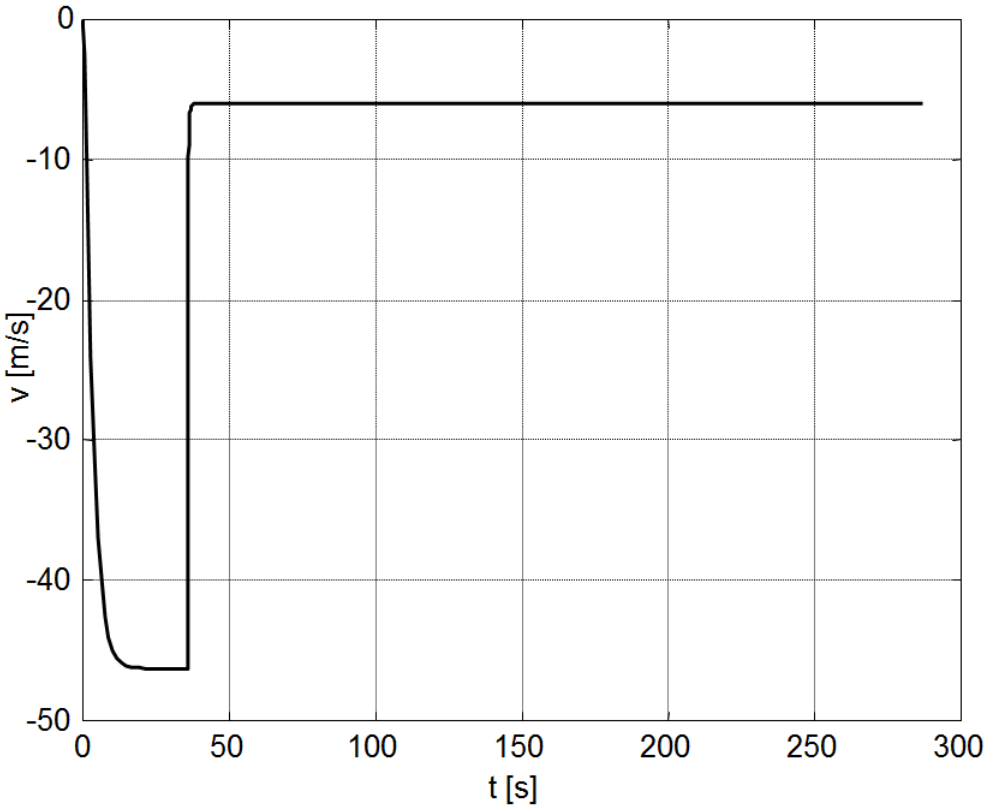


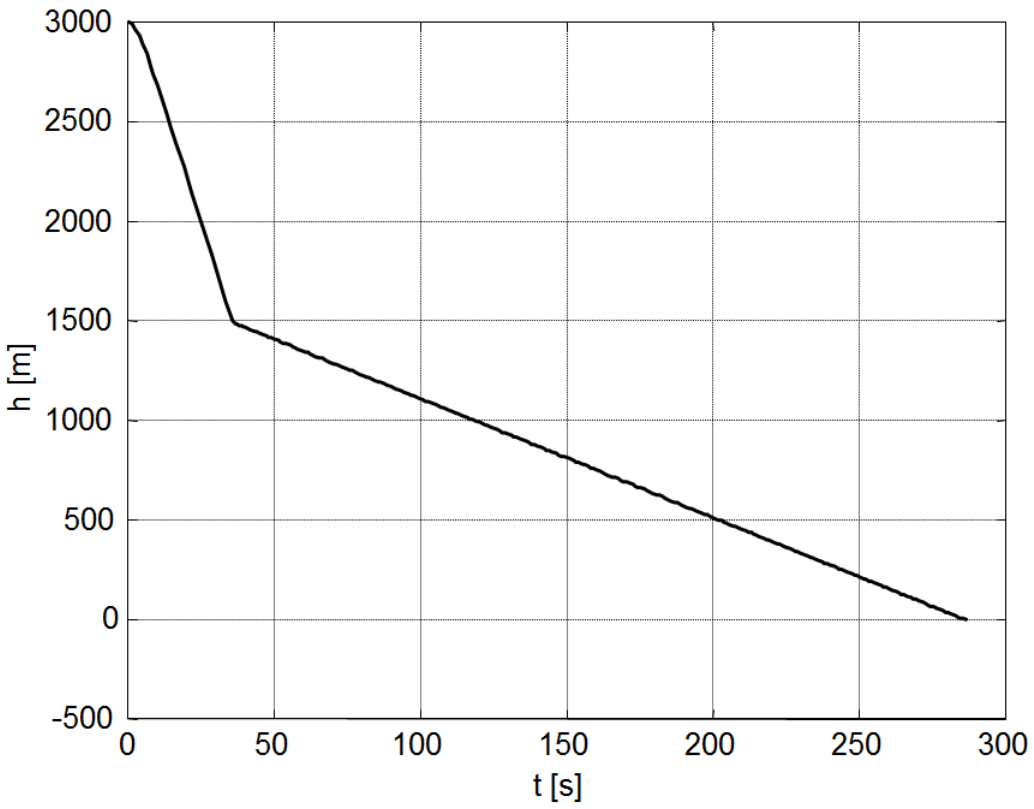
Switching



Problem: Parachutist

Simulation Results





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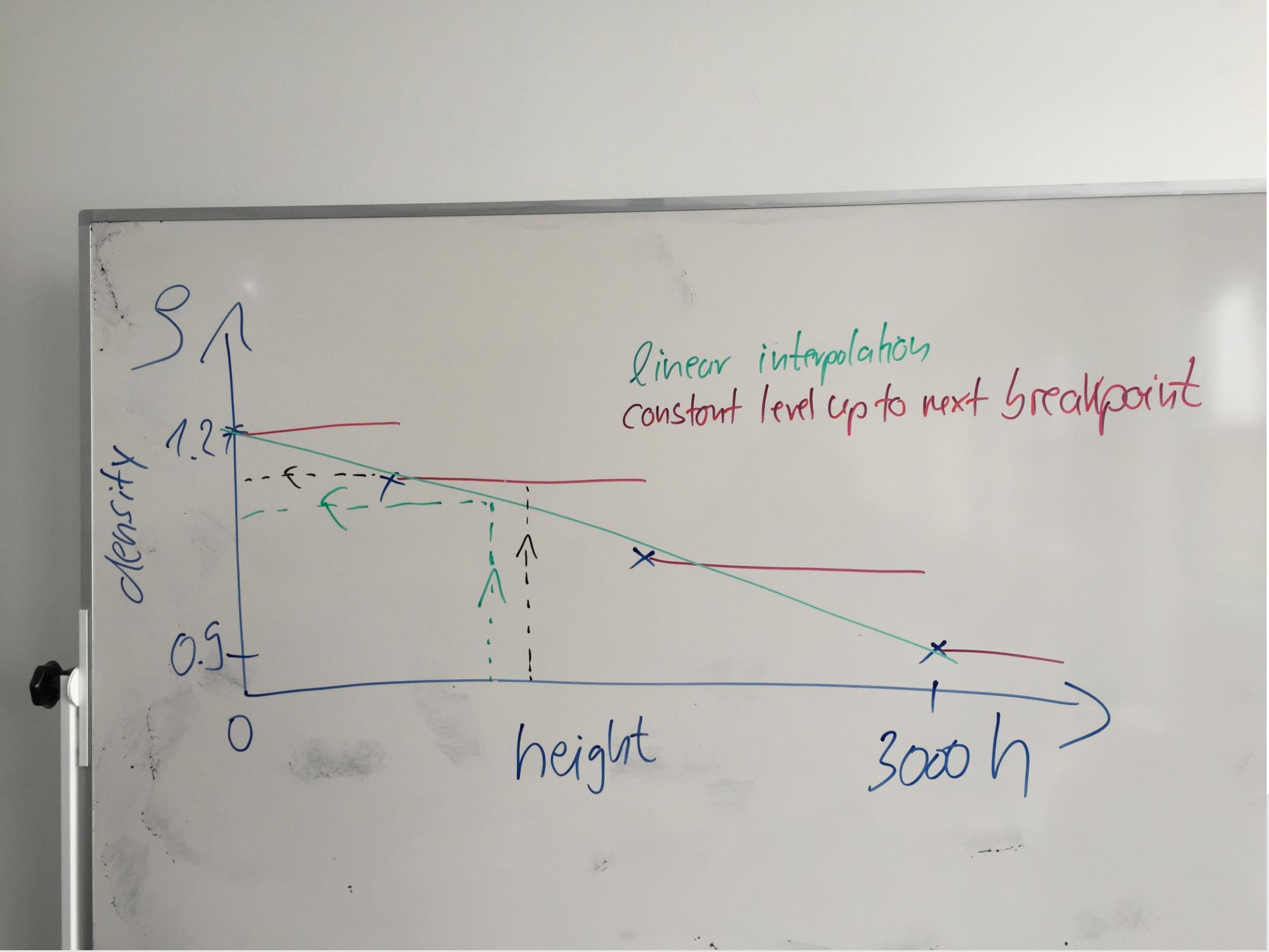
Advanced Exercise

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

Height [m]	Air density [kg/m³]
0	1.225
1000	1.112
2000	1.007
3000	0.909


ρ
1.2
density
0.9
0
height
3000 h
linear interpolation
constant level up to next breakpoint