

## Assignment

### Installation

First of all, install Dymola (commercial software). Fill out this [form](#) to download the demo (320 MB). After installation you HAVE to install a c-compiler, otherwise you cannot run any model. You can download and install it from this [link](#) (choose the C++ 2012 Express edition). Test your installation by running a demo (e.g. open File/Demos/Robot, then click Commands/Simulate and wait till you see a graph.)

### Prerequisites

Read carefully the following chapters of the open-access book [Modelica by Example](#) of Micheal M. Tiller:

1. [Basic equations](#): general introduction to the Modelica language, illustration of the model structure, basic concepts such as derivative, initialization, parameter, variable and type.
2. [One-Dimensional Heat Transfer](#): introduction to arrays and loop in Modelica.
3. [Polynomial Evaluation](#): introduction to function definition, protected variable and time.

Read carefully chapter 1, p.23 to 37, of the Dymola manual Volume 1 (can be found in your installation folder: C:\Program Files (x86)\Dymola 2015 FD01\Documentation \Dymola User Manual Volume 1) to get familiar with the Dymola environment (model editor, parameters change, simulation, ...).

### Description

This assignment aims at testing your comprehension of the basic Modelica concepts learned during the above mentioned reading by setting a model of a building and simulating its thermal behaviour. **Its completion is mandatory prior the crash-course attendance.**

Let us consider a simplified building as represented in Fig. 1. The building consists of walls, a window and a single room called *zone* which thermally interacts with the environment(ambient air  $T_{Amb}$ , the ground, and the sun. The building foundation is approximated by a thick concrete layer called *slab* separating the zone from the ground. On the right-hand side of the figure, a thermal model of the building is proposed using the resistance-capacitance approach. The heat transfer is approximated by a 1D conduction resistance and the heat storage by a heat capacity.  $C_{Zone}$  represents the thermal capacity of the zone (consisting of the internal walls, the furnitures, and a part of the external wall). The  $C_{Slab}$ 's represent the thermal capacities of the slab. Finally, the ground is discretized in  $n = 5$  layers, each of them having an identical heat capacity  $C_{Gro}[i]$ . Through the window, the sun heats up the room with a thermal power  $Q_{Sol}$ .

The value of the parameters is given in Table 1. Using the electrical analogy, the governing equations of the system are the following:

	RWall	RSlab1	RSlab2	RGro1[i]	RGro2[i]
Thermal resistance [ $K/W$ ]	0.00806	0.016	0.016	0.033	0.033
	CZone	CSlab	CGro[i]		
Thermal capacities [ $J/K$ ]	$2.4096 \times 10^8$	$3.36 \times 10^8$	$2.52 \times 10^8$		
	TGroIni	TGro[i](start)	TSlab(start)	TZone(start)	
Temperature [ $K$ ]	283.15	283.15	293.15	293.15	

Table 1: Building parameters.

**Thermal resistance:**  $T_1 - T_2 = R Q_{1 \rightarrow 2}$  with  $R$  the thermal resistance between node 1 and 2 and  $Q_{1 \rightarrow 2}$  the heat flow, positive defined from 1 to 2.

**Thermal capacity:**  $C \frac{dT}{dt} = Q$  with  $C$  the thermal capacity and  $Q$  the heat flow, positive defined flowing to the capacity.

**Conservation of energy (Kirchhoff):**  $\sum Q_i = 0$  or the sum of the heat flows through one node is zero.

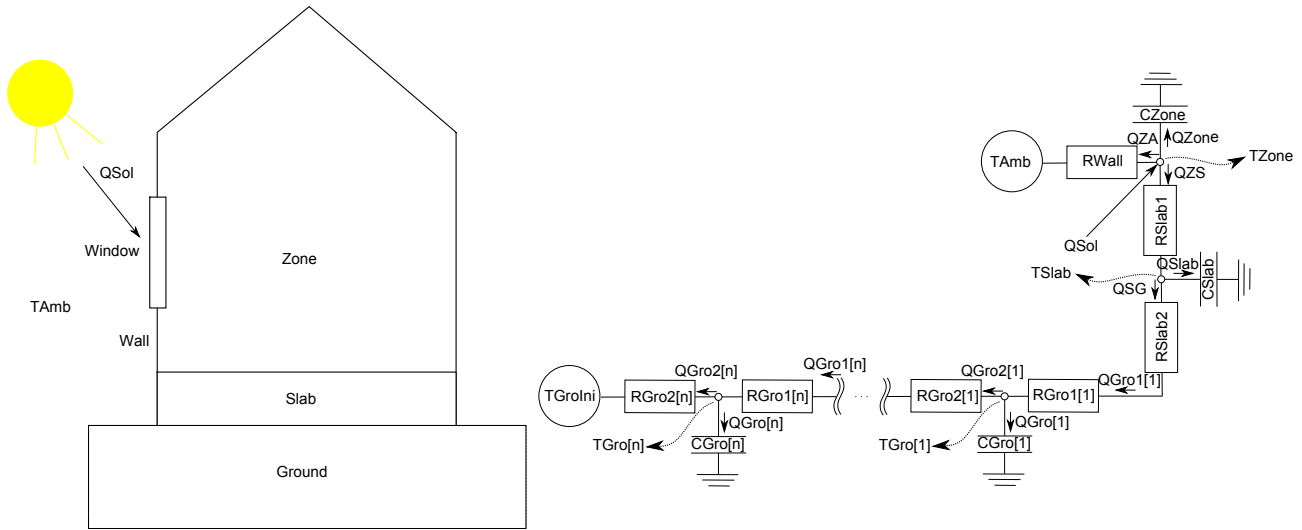


Figure 1: Building model.

## Questions

1. Apply what you have learned during your reading by setting up a model for the building using the above mentioned equations. Approximate the ambient temperature by a sine using following code:  $T_{Amb} = 10 * \cos(2 * 3.14 * \text{time} * 3 * 10^{(-8)}) + 276.15$  and the solar radiation by a trimmed cosine using:  $Q_{Sol} = \text{floor}(\cos(2 * \text{Modelica.Constants.pi} * \text{time}/86400) + 1) * 5000 * \cos(2 * \text{Modelica.Constants.pi} * \text{time}/86400)$ . What is the zone temperature after a year under these conditions?
2. (OPTIONAL): Try to obtain the same results using the components of the Modelica library instead of writing the equations yourself. This library is automatically loaded in Dymola and can be found on the left-hand side of the dymola window. For thermal components, look in the Library at Modelica.Thermal.HeatTransfer.Components.

**Good luck!**