

## Series 1

### Exercise 1

Consider the heating system of an individual house as consisting of an oil burner, a network of pipes and radiators and a thermostat containing the measurement and control element.

- a) Draw a block diagram for this control system
- b) Identify the main elements of the control loop
- c) Is the control problem a servo problem or a regulation problem?

### Exercise 2

Consider the following dynamic system:

$$\frac{dy(t)}{dt} = -2(t+1)y(t) + 3u(t), \quad y(0) = 2$$

- a) Is this system linear, stationary, causal and initially at rest?
- b) If this system is not causal, propose a modification of the equation so that it becomes causal. If it is causal, propose a modification such that it is no longer causal.

### Exercise 3

Consider a heated tank with constant internal volume as given below. Assume the area to be  $A_{th}$ , the thermal conductivity coefficient to be  $k_{th}$ .  $w$  is the mass flow rate. The density  $\rho$ , volume  $V$ , heat capacity  $c_p$  are known and constant.

- a) Write the energy balance for the case where the thermal exchange with the exterior is not negligible. Identify the characteristic quantities.
- b) Propose modifications to the model in the event that the contents of the tank are not homogeneous.

