Series 7

Exercise 1

The experimental measurements of the step response of a dynamic system are reported in the table below:

t [s]	0	…	1,8	2	2,2	2,4	2,6	2,8	3,0	3,2	3,4
$y(t)$	0	…	0	0	0,349	0,455	0,486	0,496	0,499	0,500	0,500

a) Evaluate graphically the transfer function of this system.
b) Determine its impulse response in analytical form.

Exercise 2

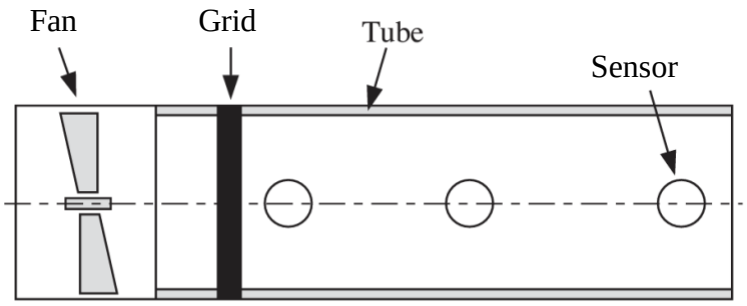
Consider the dynamic equation:

$$\ddot{y}(t) + k\dot{y}(t) + 4y(t) = u(t) \qquad y(0) = \dot{y}(0) = 0$$

a) Calculate the transfer function and determine its static gain and equivalent time constant.
b) Determining the qualitative form of the answer for $-10 \leq k \leq 10$ independently of $u(t)$.

Exercise 3

Consider an aerothermal channel traversed by a constant flow of air produced by a fan. The air is heated at the inlet of the tube by a fine grid whose power released is proportional to the control voltage u. A thermistor measurement provides a voltage u_m proportional to the temperature of the air at the outlet of the tube.



The installation is described technically as follows:
Tube: Inner diameter: 5 cm, length: 30 cm, position at the entrance of the tube where the air is heated by the grid: about 1 cm.

Grid: Ni–Cr wires, length: 1 m, diameter: 0.2 mm, density: 8 g/cm3, specific heat: 0.12 cal/g˚C, heat transfer coefficient at chosen airflow: 400W/m2K.
Air: Flow rate: 2.4 g/s, specific heat: 0.24 cal/g˚C, density: 1.2 kg/m^3.
Actuator: The electrical power supplied to the gate is proportional to the supply voltage u, with a proportionality factor $K_p = 7.36\ W/V$. This proportionality factor was chosen so as to experimentally obtain a unit static gain between the control voltage and the measurement voltage. Is this the case?
Sensor: The thermistor constitutes one branch of a measuring bridge, the output of which is the measuring voltage u_m. The sensor can be considered as a first-order dynamic element characterized by the static gain $K_m = \ 0.33\ V/^{\circ}C$ and the time constant $\tau_m = 0.2\ s$.

a) Model the aerothermal channel by carefully choosing the simplifying assumptions (*a priori* assumptions).
b) Choose the study point so that the ambient air at 20˚C is heated to 40˚C.
c) Determine the transfer function $U_m(s)/U(s)$ and the associated numerical values. Is it possible to simplify the obtained model (*a posteriori* assumptions).