Group Work

Modeling and Simulation of Aerospace Systems

AY 2021-2022

POLITECNICO MILANO 1863

Laboratory sessions - Assignments

Goals

- It is the main player in the final grade
- It combines the two parts of the class
- It is the ultimate test to verify your knowledge

Assignment evaluation

Weights	Fail	Poor	Good	Excellent
Report	• Major mismatches w.r.t. the assignment • Report awfully written	• Minor mismatches w.r.t. the assignment • Figures and tables not clear • English is poor	• Answers lengthy, but correct • Figures and tables clear • Good English	• Answers concise and clear • Figures and table clear and meaningful • Good English
Code	• Code does not run • Major algorithmic errors • Code not complete	• Minor algorithmic errors • Code not documented • Code takes unnecessary long to run	• Code runs smoothly • Code is fairly documented • Computational efficiency improvable	• Code runs smoothly • Code is well documented • Care is taken to account computational efficiency

Laboratory sessions

- Laboratory sessions <u>will not be recorded</u>
  - we are here to give you answers while you are working

- Timetable

16 Nov	10.30-13.00	B8.0.1 (+ Franzese's room)
17 Nov	08.30-10.00	Franzese's **(odd groups)** + Giordano's **(even groups)**
18 Nov	13.30-15.00	LM6 (+ Franzese's room)
23 Nov	10.30-13.00	B8.0.1 (+ Franzese's room)
24 Nov	08.30-10.00	Franzese's **(odd groups)** + Giordano's **(even groups)**
25 Nov	13.30-15.00	LM6 (+ Franzese's room)
…	…	NO CLASS
1 week before call (you will receive an email for the exact day)		**Group Work deadline**

Delivery of assignments

Assigment will be delivered by Webeep:

DEADLINE ⇨ Indicatively, one week before the call

1) Click on the link to load Group Work in your Overleaf

   https://bit.ly/MSAS_GW_21

2) Fill the report and be sure it is compiled properly
3) Download the PDF and merge it in a zipped file with MATLAB code. Rename it `GroupNN.zip`
4) Submit the compressed file by uploading it on Webeep **(one file for each group)**

Group Work - Topics

1 Exercise on Modeling and Simulation of an **electro-mechanical system**

1 Exercise on Modeling and Simulation of a **thermo-hydraulic system**

Preliminaries

Take the first letter of your surnames and convert them to a number following the alphabetical order (e.g., A = 1, B = 2, ..., Z = 26). Call these parameters a, b, and c. As an example, the group work of Bianchi, Neri, and Rossi leads to $a = B = 2$, $b = N = 14$, and $c = R = 18$. These parameters will be used in the following exercises.

Exercise 1

The electro-mechanical system in Figure 1 is constituted by an electric circuit that drives a mechanical part. A voltage source $v(t) = v_0\ \cos(\omega t)\ e^{-\beta t}$ is activated at $t = 0$. Assume a coefficient K_m such that $T(t) = K_m\ i(t)$ and $e(t) = K_m\ \Omega_1$, where T is the torque acting on the mechanical part, i the current in the circuit, and Ω_1 the angular velocity of the first disk. Considering $K_m = 100/a$; $R = 200 + b + c$; $v_0 = 2$ V; $\omega = 5$ Hz; $\beta = 0.2$ Hz; $L = 2$ mH; $J_1 = 0.5$ kg m^2; $J_2 = 0.3$ kg m^2; $b = 0.1$ kg m^2 s^{-1}; $k = 0.5$ Nm, it is asked to:

1) Derive the mathematical model of the system;

2) Determine the system eigenvalues;

3) Select and motivate the most appropriate integration scheme;

4) Show the system response until $t = 30$ s;

5) Setup, discuss, and run a procedure to find the values of K_m and R that allow matching the second disk angular velocity profile sampled at 10 Hz given in the file `Profile.txt`

Exercise 1

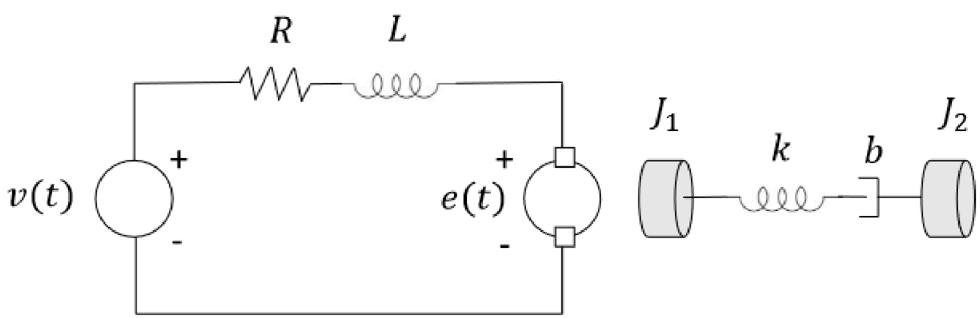


Figure 1: Electro-mechanical system.

Exercise 2

The hydraulic system in Figure 2b is made of a tank, a pump, a check valve, a distribution valve, a filter and two heat exchangers, plus the lines. The heat exchanger on the left is used to cool down an external system, having a temperature profile $T(t) = T_0 + k_T \cos(\omega t)$, and its wall is made up of three layers with different thermal properties, as depicted in Figure 2a. The exchanger on the right (cooler) removes the excessive heat from the fluid with a constant heat flux $\dot{Q}_c$. The pressure drop inside the heat exchangers can be modelled as a simplified Rayleigh flow, such that $P_{out} = e^{\dot{Q}/\kappa} P_{in}$. Assuming:

- Fluid: Water, incompressible fluid, $\rho = 1000$ kg/m^3, specific heat $c_w = 4186$ J/(kg $\cdot$ K)
- Lines: Coefficient of pressure drop across the check valve $k_{cv} = 2$, diameter of the lines $D = 20$ mm;
  - Branch T–1: Length $L_{T1} = 0.5$ m, friction factor $f_{T1} = 0.032$;
  - Branch 3–4: Length $L_{34} = 1.5$ m, friction factor $f_{34} = 0.032$;
  - Branch 5–6: Length $L_{56} = 0.2$ m, friction factor $f_{56} = 0.040$;
  - Branch 7–8: Length $L_{78} = 2.5$ m, friction factor $f_{78} = 0.035$;
  - Branch 9–10: Length $L_{91} = 2.5$ m, friction factor $f_{91} = 0.028$;
  - Branch 11–T: Length $L_{11} = 1$ m, friction factor $f_{11} = 0.032$.
- Tank: Adiabatic tank with constant pressure $P_T = 0.1$ MPa;

Exercise 2

- Pump:

  Pistons:

  - Number: $N = 9$;
  - Diameter: $D_p = 1.5$ cm
  - Diameter of the shaft: $d_p = 0.7$ cm
  - Nominal pressure: 5 atm

  Pilot piston:

  - Diameter: $D_k = 1$ cm
  - Control lever length: $l_c = 10$ cm
  - Maximum angle of the control plate: $\theta_{\max} = 20$ deg
  - Rotation speed: $n = 4000$ rpm
  - Equivalent mass: $m_k = 2$ kg
  - Pre-loaded force: $F_0 = 5$ N
  - Friction coefficient: $r_k = 1$ Ns/m
  - Diameter of the pipe: $d_k = 1$ mm
  - Pilot pipe head loss: $k_p = 2.5$

Exercise 2

- Distributor: Coefficient of pressure drop across the distributor $k_d = 15$, diameter $d_o = 10$ mm. At $t_0 = 0$ s the valve is half open; it is fully open after $\Delta t = 2$ s.

- Cooler: Diameter of the pipe $D = 20$ mm; Heat flux $\dot{Q}_c = 100$ W.

- Filter: Coefficient of pressure drop across the filter $k_f = 35$, leaking coefficient $k_l = 2.5\%$[1];

- Heat exchanger: Diameter of the pipe $D = 20$ mm, length of the pipe inside the exchanger: $L_e = 0.5$ m; exchange area $A_e = 1000$ cm^2; First layer thermal properties: $k_1 = 395$ W/(m $\cdot$ K), $\ell_1 = 1$ cm, second layer thermal properties: $k_2 = 310$ W/(m $\cdot$ K), $\rho_2 = 8620$ kg/m^3, $c_2 = 10a$ J/(kg $\cdot$ K), $\ell_2 = 2.5$ cm, third layer thermal properties: $k_3 = 125$ W/(m $\cdot$ K), $\ell_3 = 1$ cm, heat transfer coefficient with the fluid $h = 20$ W/(m^2 $\cdot$ K);

- $T_0 = 400$ K, $k_T = 2b$, $\omega = 5$ s^{-1}, $\kappa = 100c$ W;

- The temperatures are propagated instantaneously along the pipes;

- The heat exchanger layers have an initial temperature of 340 K.

Exercise 2

It is asked to:

1) Derive a lumped-approach physical model for the heat exchanger;

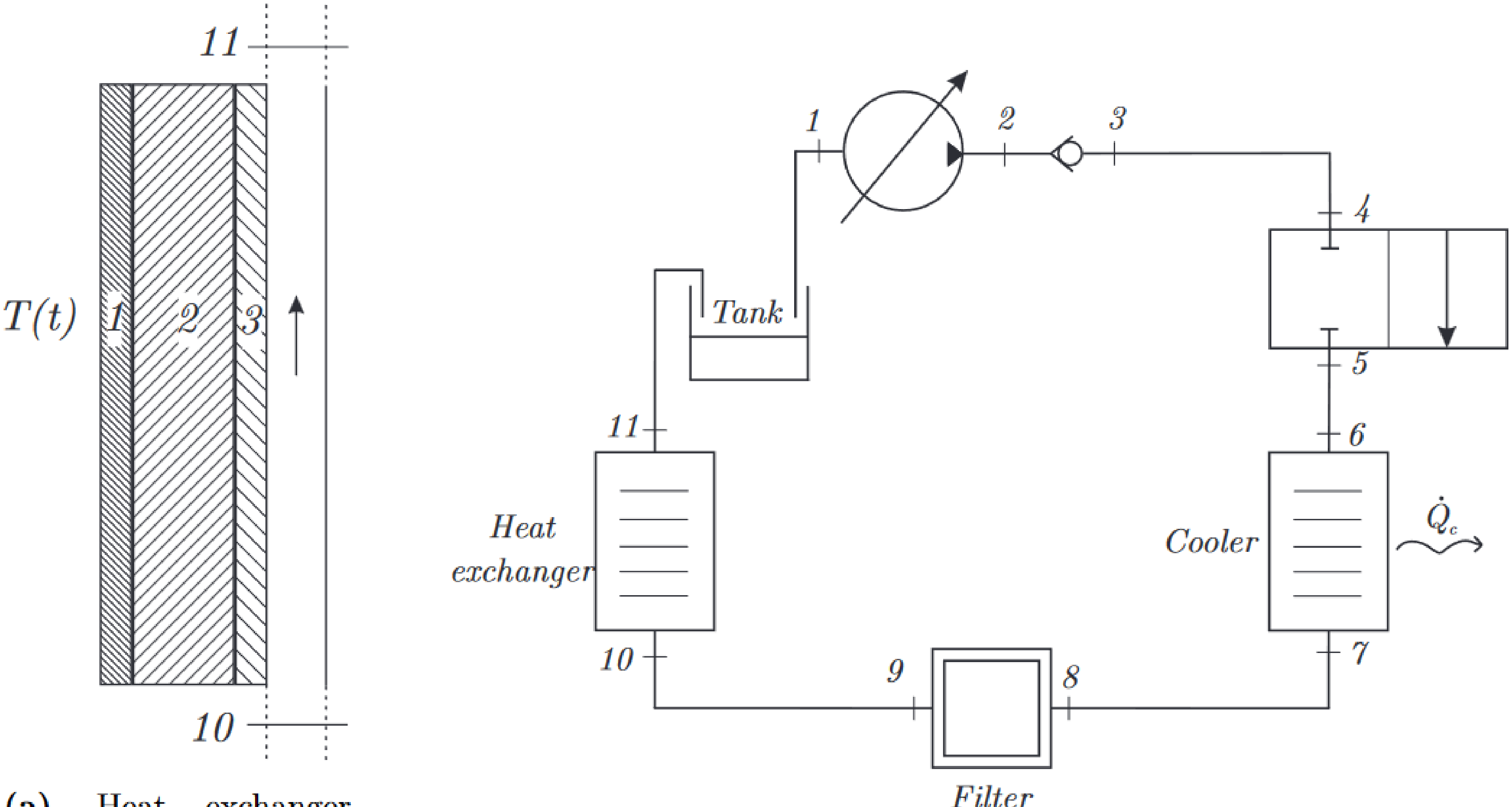
2) Derive the mathematical model of the whole system;

3) Select and motivate the most appropriate integration scheme;

4) Show the system response until $t = 25$ s;

5) Discuss at least one possible way to modify the system in order to keep the fluid temperature as close as possible to 20 °C.

Exercise 2



(a) Heat exchanger model close-up.

(b) Hydraulic system physical model

Figure 2: Thermo-hydraulic system. Assume any other missing data.