# 08.6 thermoflu.exe Exercises for Chapter 08 thermoflu

# Exercise 08.1 tinker

Draw a linear graph of the fluid system with schematic below.



# Exercise 08.2 tailor

Draw a linear graph of the fluid system with schematic below.



## Exercise 08.3 soldier

(a) Draw a linear graph of the fluid system with schematic below. (b) Draw a normal tree and identify the state variables and system order.



#### Exercise 08.4 tpain

Consider an apparatus with two chambers filled with gas at potentially different temperatures illustrated in Fig. exe.1. Temperature sensors are embedded in the two "sensor blocks," made of copper for low thermal resistance and made large enough to provide enough thermal capacitance to smooth out temperature fluctuations.<sup>4</sup> The "structural conduit" is made of steel, less thermally conductive, but conductive nonetheless. The conduit provides structure to the apparatus and is hollow to allow the sensor wires to run through.



Figure exe.1: a diagram of the two-chamber apparatus.

A concern with this apparatus is that the temperature in one chamber will affect the temperature in the other, most conspicuously by heat conducting through the structural conduit.

25 p.

<sup>&</sup>lt;sup>4</sup>This technique of adding capacitance for smoothing a signal is useful in all energy domains!

We will begin an analysis of the thermal isolation of the two chambers and temperature measurements. Develop a thermal lumped-parameter model as follows.

- a. Describe the lumped-parameter elements you will use to model the system.
- b. Draw a linear graph of the lumped-parameter model.
- c. Superimpose a normal tree on the graph, identify the system order, and choose the state variables.

### Exercise 08.5 dramp

Consider a device with four amplifiers in an array on a printed circuit board (PCB), as illustrated in Fig. exe.2. The amplifiers generate significant heat (as a byproduct), and they must be cooled. For this reason, each amplifier has mounted on top a heat sink device with fins. A fan forces airflow over the fins to dissipate the heat via convection.





Figure exe.2: Top view of four amplifiers in a chassis.

As the designer of the chassis housing the amplifiers, you would like to develop a lumped-parameter thermal model of the system to ensure that, under different heat generation loads, the amplifiers remain within their acceptable temperature range.

a. Describe the lumped-parameter elements you will use to model the system, including inputs.

- b. Draw a linear graph of the lumped-parameter model.
- c. Superimpose a normal tree on the graph, identify the system order, and choose the state variables.

#### Exercise 08.6 up

Consider the diagram of the first stages of a drinking water treatment plant shown in Fig. exe.3. The water to be treated comes from a reservoir and is pumped by Pump 1 into the coagulation tank. The suspended particles are too small to settle via gravity, and their generally negative charges repel each other, keeping them from clumping. Here a small amount of a chemical coagulant with positive charge is rapidly mixed in with paddles. Coagulation is the resultant clumping of the particles.



Figure exe.3: A water treatment plant.

The water with coagulated particles flows through a long, thin pipe and enters a series of 3 flocculation tanks. In the flocculation tanks, which mix at decreasing rates as the fluid progresses, the coagulated particles join into increasingly larger pieces called flocs. Note that the placement of the inlet and outlet of each tank has a sorting effect.

After the third tank, the water flows through a short, wide pipe into the sedimentation tank. Now the flocs are large enough to settle via gravity, and Pump 2 on the outlet pumps the water sans flocs to filtration and disinfection stages of the purification process.

35 p.

The quality of the process is highly dependent on the volumetric flow rates and pressures in the tanks. Develop a lumped-parameter linear graph model with the following steps:

- a. Describe the lumped-parameter elements you will use to model the system, including inputs.
- b. Draw a linear graph of the lumped-parameter model.
- c. Superimpose a normal tree on the graph, identify the system order, and choose the state variables.

Part IV Fourier analysis

# 09 four