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Process Dynamics – CPN321

Semester Test 1

Chemical Engineering
Engineering and the Built Environment

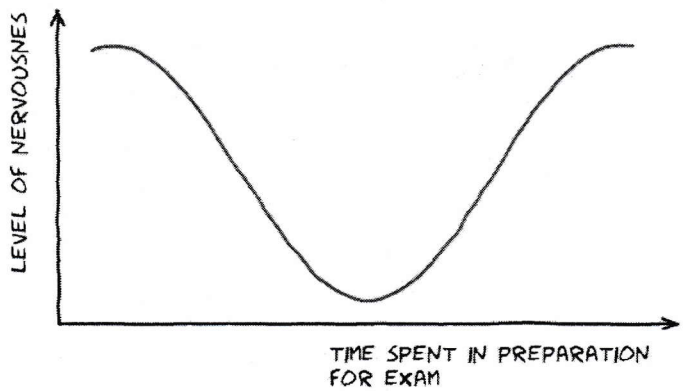
Examiner: Carl Sandrock

Date: 2017-08-24

Duration: 90 minutes Total: 90 Total Pages: 6

Instructions – Read carefully

• Answer all the questions. • This is a closed book test. All the information you may use is contained in the paper. • You may use the computer • Make sure that you motivate all your answers and write legibly.



sugarspiceandalgorithms.wordpress.com

1 Modelling

Google has packaged data center computers in shipping containers fitted with cooling fins as shown in Figure 1. You have been approached to develop a model of this system so that they can test control systems which will avoid overheating of the computers.

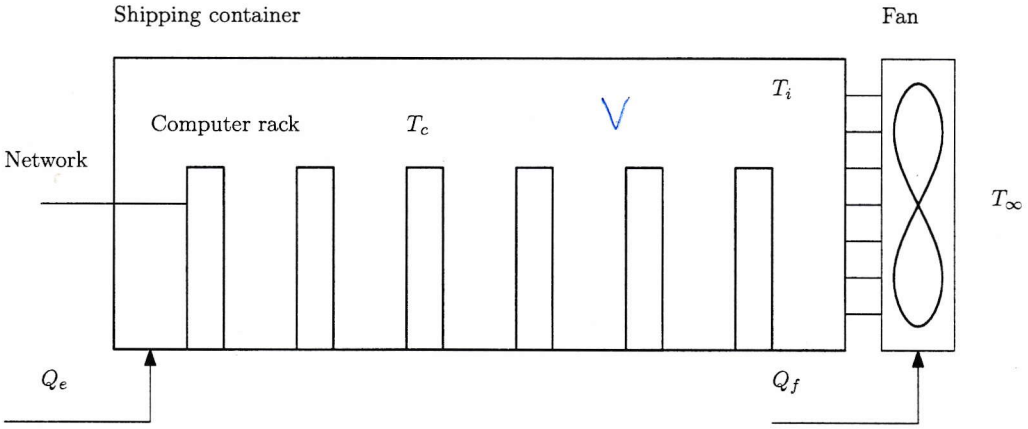


Figure 1: Data center in a shipping container

As a first approximation, you have made the following assumptions:

- The air inside the container is well-mixed and uniformly at a temperature of T_i.
- All the computer racks are at a single temperature T_c.
- All the electric power supplied to the computers Q_e is converted immediately to heat by the computers and is proportional to the rate of computation required by the network.
- The heat transfer coefficient h_f on the finned part of the container is proportional to the power supplied to the fan Q_f.

1. Derive a dynamic model of the system which will allow you to predict the temperature of the computers and the air in the container. [40]
2. Indicate each symbol in your model as a parameter, an input or an output. [5]
3. Show that specifying the parameters and inputs in the model completely specifies it. [5]
4. It is desired to control the temperature of the computers T_c. Comment on how feedback control could be used to achieve this. Discuss measurement and manipulated variables. [5]

Total for question 1: [55]

2 Simulation and linear analysis

Consider the following model:

$$y(t) = w(t) - u(t)\log_{10}[z(t)] \tag{1}$$

$$\frac{\mathrm{d}y}{\mathrm{d}t} = g(t) - cy(t) \tag{2}$$

$$\frac{\mathrm{d}g}{\mathrm{d}t} = \sin(t+1)z(t) - y(t) \tag{3}$$

1. If $c = 3$, $w(0) = 1$ and $g(0) = 2$, calculate the values of u and z if the system is at steady state at $t = 0$. Show your working if solving by hand or explain your steps in detail if using the computer. [5]

2. Linearise the equations above and express them in terms of deviation variables. Keep your answers in terms of symbols (don't use the values you calculated above) [10]

3. Find the transfer function between $W(s)$ and $G(s)$ [10]

4. Draw a block diagram on which all of the variables in the equations above appear. [10]

Total for question 2: [35]

Full Marks [90]

LaTeX 2_ε
www.latex-project.org