UNIVERSITY COLLEGE LONDON

EXAMINATION FOR INTERNAL STUDENTS

MODULE CODE	:	**ELEC216P**
ASSESSMENT PATTERN	:	**ELEC216PA**
MODULE NAME	:	**Programming and Control Systems**
DATE	:	**03 May 2017**
TIME	:	**10:00 am**
TIME ALLOWED	:	**3 hours**

This paper is suitable for candidates who attended classes for this module in the following academic year(s):

TURN OVER

SECTION 1 – Control Systems: Answer any TWO questions out of THREE from this section

1. Consider a field controlled d.c. motor whose transfer function is:

$$G(s) = \frac{50}{s(s+1)(s+10)}$$

It is to be driven by harmonic input $u(t) = \cos\omega t$.

(a) By writing $u(t)$ as a sum of two complex exponential signals or otherwise show:

$$U(s) = \frac{s}{(s-j\omega)(s+j\omega)}$$

[5 marks]

(b) Plot the pole-zero pattern for the output $X(s) = G(s)U(s)$ on a complex plane.

[5 marks]

(c) Do the partial fraction expansion for the output signal $X(s)$. If any of the signal amplitudes are complex, convert them into polar form.

[15 marks]

2. An open loop system comprises the coupled water tanks shown in Figure 2.1. The input to the system is flow q_{in}, the output is flow q_{out}, and the system variables are the heights of the water in the two tanks, h_1 and h_2. The flow in the pipe between the tanks is laminar and the outflow is also laminar. The system equations for a particular geometry of the tanks are:

$$\frac{dh_1}{dt} = -3h_1 + 3h_2 + q_{in}, \quad \frac{dh_2}{dt} = 3h_1 - 5h_2, \quad q_{out} = 2h_2$$

(a) Explain briefly what physical features of the water system cause the system equations to take the above form. Your answer should explain the significance of the fact that the flows are laminar and explain qualitatively how the positive or negative sign of each term arises.

[5 marks]

(b) Based on the system equations, draw an s-plane block diagram representing the system.

[10 marks]

(c) Convert the three system equations into the state-space form given below:

$$\frac{d\underline{\mathbf{h}}}{dt} = \mathbf{A}\underline{\mathbf{h}} + \mathbf{b}q_{in}, \quad q_{out} = \mathbf{c}\underline{\mathbf{h}}$$

with $\underline{\mathbf{h}} = \begin{pmatrix} h_1 \\ h_2 \end{pmatrix}$, $\mathbf{A}$ a 2×2 matrix, $\mathbf{b}$ a 2×1 vector and $\mathbf{c}$ a 1×2 vector of constants.

[10 marks]

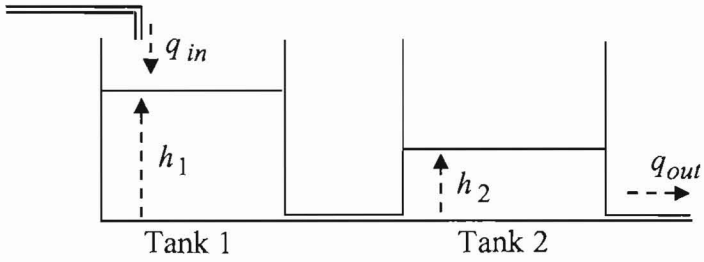

Figure 2.1. Open loop system comprising two interconnected water tanks.

3. (a) Figure 3.1 shows the Nichols plots of four different transfer functions. State what features of a system are represented by a curve on a Nichols plot. Explain what the grid is used for in the Nichols plot.

[5 marks]

(b) Copy the table below into your answer book. Complete the table by matching the Nichols plots to the open loop transfer functions given in the table. Explain all the reasons for your selections. If there is more than one feature leading you to your decision then every such feature should be mentioned.

[10 marks]

Open loop transfer function:	$\frac{1}{1+s}$	$\frac{10}{s(1+s)}$	$\frac{10e^{-0.25s}}{(1+s)(1+5s)}$	$\frac{10}{(1+s)(1+5s)}$
Matching Nichols' plot (**A**, **B**, **C** or **D**):				

(c) Sketch the form of the time trend expected for the *closed loop* response to a unit step for:
(i) The system whose Nichols plot is shown by curve B in Figure 3.1.
(ii) The system whose Nichols plot is shown by curve D in Figure 3.1.
Hints: Consider the system class and its implications for steady state errors, and also the overshoot and damping of the closed loop response.

[10 marks]

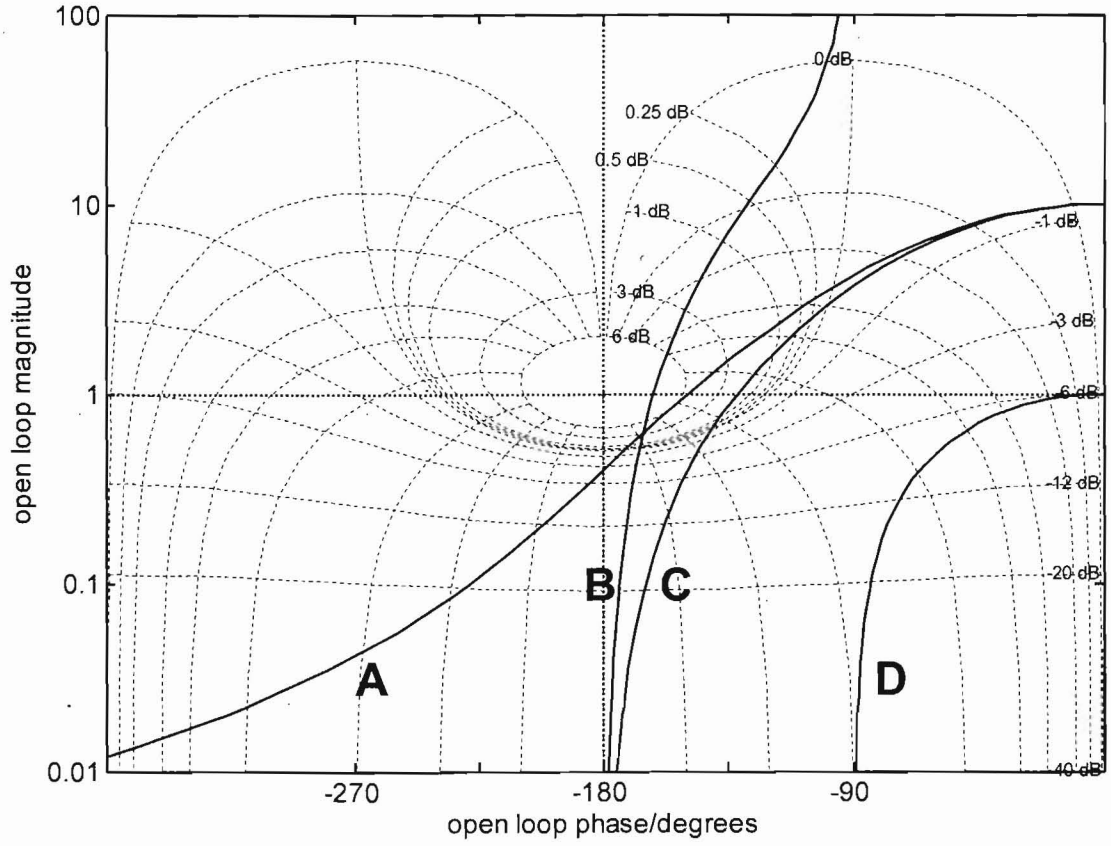

Figure 3.1. Nichols plots of four transfer functions: A, B, C and D.

CONTINUED

SECTION 2 – Programming: Answer any TWO questions out of THREE from this section

4. (a) What is an abstract class and what is an interface in Java?

[5 marks]

(b) Explain why making instance variables public is not a good practice in object-oriented software engineering. Which is the alternative approach to making such variables public and what does it achieve?

[8 marks]

(c) Write the constructor and *toString* methods of class *Point* which extends the abstract class *Shape*, then of class *Circle* which extends class *Point* and then of class *Cylinder* which extends class *Circle*. You should demonstrate and explain how you achieve reusability by re-using the methods of the respective superclass.

[12 marks]

5. (a) Explain the concepts of inheritance and composition and discuss the benefits they bring to object-oriented software engineering.

[7 marks]

(b) Write a *merge* method of an *OrderedList* class which takes as argument an external ordered list and merges it with the ordered list instance variable, keeping it ordered. *OrderedList* inherits from *List*, which includes methods such as *removeFromFront* and *removeFromBack*, and adds an *insert* method which inserts an *Object* argument in the right position to the list.

[10 marks]

(c) What is a queue data structure? Show how a *Queue* class can be easily implemented through inheritance from a *List* class.

[8 marks]

6. (a) What is concurrent program execution and how can it be supported in Java? Present briefly two example applications for which concurrent execution is necessary.

[7 marks]

(b) Write a *binarySearch* method that searches through an integer array for a given search key.

[12 marks]

(c) What is the computational complexity of the binary search algorithm? Explain how you arrived at your answer.

[6 marks]

END OF PAPER