GX751

OLLSCOIL NA hÉIREANN
GAILLIMH

NATIONAL UNIVERSITY OF IRELAND
GALWAY

SEMESTER II (SUMMER) EXAMINATIONS 2001

Unit CS313: Computational Physics

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Time allowed: ONE AND A HALF hours.	Answer TWO questions

CS313: Computational Physics

Q.1 Discuss the general process of sampling a Continuous Time (CT) signal x(t) to produce a Discrete Time (DT) sequence x[n]. Include explanations or definitions of the *Sampling Interval*, the *Sampling Theorem*, the *Nyquist (or Folding) Frequency*, and *Aliasing* in your account. [5 marks]

Explain the signal processing significance of the Fast Fourier Transform (FFT) in the analysis of DT sequences. Describe the use of the FFT in Mathcad, and outline the main Mathcad worksheet statements necessary to find and plot the double sided amplitude spectrum for the DT sequence: $x[n] = 1 + \cos(2\pi fnT)$, where $T = 0.1$ s, $f = 1.2$ Hz, and n runs from 0 to 63. Explain what *Spectral Leakage* is, and why it occurs. Hence make a rough sketch of what you expect this FFT spectrum to look like. [5 marks]

Q.2 Distinguish between Continuous Time Differential Equations (CT DFLE's) and Discrete Time Difference Equations (DT DE's). Briefly outline the general process whereby a DFLE is converted to a DE for numerical solution by computer methods (i.e., the process of *discretisation*). What are the basic problems inherent in this process? [4 marks]

Give brief details of the parameters required for the use of the Mathcad DFLE solver, *rkfixed*. Write the Mathcad statements necessary to compute the numerical solution of the DFLE given below for $0 \le t \le 4$ sec, when the input x(t) is a step function u(t). Use 100 steps in the solution, and assume that the system is in *Zero State* at $t = 0$. Explain how both the step response *and* the impulse response can be extracted and plotted from the solution matrix. [6 marks]

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 100y(t) = x(t)$$

Identify the general nature of this particular system, and make an approximate sketch of what you think its step response will look like.

p.t.o.

Q.3 Answer *TWO* parts only from (a), (b) and (c).

(a) Explain briefly the basic principles, and reasons, for using *Monte Carlo* techniques in the approximate solutions of scientific and mathematical problems. [5 marks]

Describe in general terms how the area (integral) under a function f(x) between fixed limits may be estimated by Monte Carlo methods. Take $f(x) = x + 3x^2$, evaluated between x = 1 and x = 2, as a specific example, and sketch out the statements necessary in a Mathcad worksheet to evaluate this integral by Monte Carlo techniques.

(b) Subroutines from two separate Visual Basic programs are shown below (for clarity, the prefix "l", denoting local variables, has been omitted). In each case, state what number will appear in the *Textbox* **txtResult**, after running each program, if the number initially typed into the *Textbox* **txtNumber** is 10. [5 marks]

```
Private Sub cmd_Calculate_Click ( )
Dim iFirst As Integer
Dim iSecond As Integer
Dim iThird As Integer
iSecond = Val (txtNumber.Text)
iThird =1
For iFirst = iSecond To 1 Step –1
iThird = iThird * iFirst
Next
txtResult.Text = FormatNumber (iThird)
End Sub
```

```
Private Sub cmd_Calculate_Click ( )
Dim sFirst As Single
Dim sSecond As Single
sFirst = 0
Do While sSecond < Val (txtNumber.Text)
sFirst =sFirst + 1
sSecond = 10 ^ sFirst
Loop
txtResult.Text = FormatNumber (sFirst)
End Sub
```

(c) Identify which of the following are *properties* and which are *controls* in Visual Basic: Name, Label, TextBox, and Caption. [5 marks]

Write a Visual Basic application (and sketch the form, showing the controls that you would use) to convert gas pressure expressed in milliBars to gas pressure expressed in Pascals (1 mBar = 100Pa).