GX 2076

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

Semester I Examinations 2005 / 2006

Exam Code(s)	3BA1 4IF1
Exam(s)	The BA Degree, The B.Sc. Degree (Information Technology)
Module Code(s)	CT317 CT423
Module(s)	Systems Approach Systems Theory
Paper No. Repeat Paper	I
External Examiner(s) Internal Examiner(s)	Prof. J.A. Keane, Prof. S. McClean Dr. Michael Madden Dr. Jim Duggan

Instructions: Answer any THREE Questions

Duration	2 HOURS
No. of Pages	4
Department(s)	Information Technology
Course Co-ordinator(s)	Dr. Michael Madden

Requirements:
Graph Paper

OLLSCOIL NA hÉIREANN
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SEMESTER I, WINTER 2005-2006 EXAMINATION

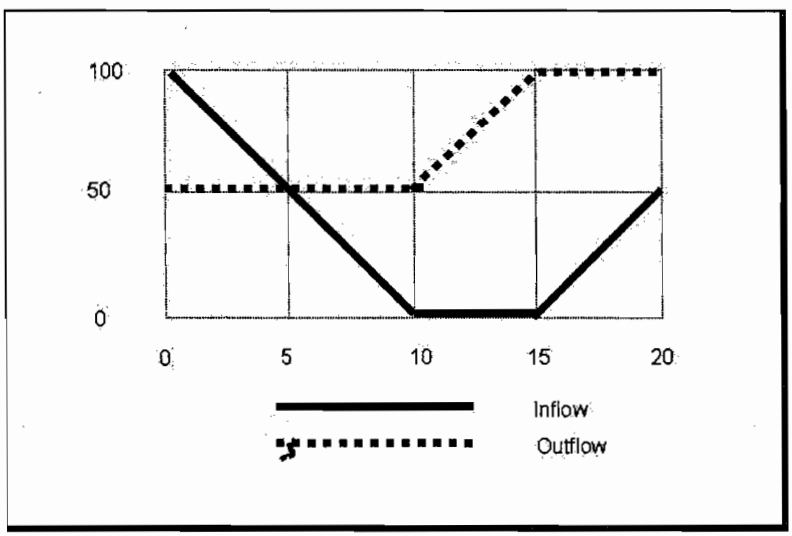
The B.A. Degree
Systems Approach (CT317)

The B.Sc. Degree Examination in Information Technology
Systems Theory (CT423)

Professor S. McClean
Professor J.A. Keane
Dr. M. Madden
Dr. J. Duggan

Time Allowed: 2 hours
Answer any THREE questions

1. Consider the inflow and outflow diagram to and from a stock, and assuming that the initial value of the stock is 100:



(a) Calculate and graph the net flow. (20% of marks)

(b) Graph the behaviour of the stock over time and predict its value after 20 time units. (50 % marks)

(c) With DT=2.5, use Euler's equation to predict the value of the stock after 20 time units. Comment on how a modeller might select a value for DT. (30% of marks)

2. (a) Based on the SI model, derive a stock and flow model (including equations) for product growth. The key variables in this model are: Potential Adopters, Adopters, Contact Rate, Adoption Fraction and Adoption Rate. Clearly show the feedbacks present in this model, and assume the following values:

Contact Rate (c)	3 people per person per week
Adoption Fraction/Infectivity (i)	0.25
Potential Adopters (P)	9999
Adopters (A)	1

(40% of marks)

(b) Define what is meant by "The Tipping Point", and for the SIR Model, derive the equation c i d (S/N) > 1, [where c = contact rate, i = infectivity, S = Susceptible Population, and N = Total Population].

(30% of marks)

(c) Contrast the strategies that are available to decision makers in order to ensure that an epidemic does not occur.

(30% of marks)

3. (a) Describe the purpose of the Causal Loop diagram, and highlight its strengths and weaknesses in terms of modelling complex systems.

(30% marks)

(b) Develop a causal loop diagram (with loop polarity) to model the dynamics of predator-prey interaction, based on the following problem description:

- As the number of prey increase, so to does the number of prey births, which in turn increases the number of prey.
- Prey deaths reduce the number of prey.
- As the number of prey deaths increase, so to does the number of predator births.
- An increase in predator births leads to an increase in the number of predators.
- An increase in predators leads to an increase in prey deaths.
- An increase in predators leads to an increase in predator deaths.
- An increase in predator deaths leads to a decrease in predators.

(40% marks)

(c) Compare and contrast the reference modes for both predator and prey under the following scenarios:

(i) There are no predators and
(ii) There are predators.

(30% marks)

4. (a) Describe the general stock and flow structure for negative feedback, state why it is used so widely in modelling dynamic systems, and explain the significance of the choice of adjustment time.

(40% marks)

(b) Derive causal loop diagrams (and calculate any loop polarity) that capture the feedback dynamics referred to by Bill Gates (CEO Microsoft) in this quotation:

> "This is a time period where now there's a broad awareness that Windows NT is by far the highest-volume general purpose server platform. The growth there continues to amaze us, and it's a positive feedback loop. As we got more applications, NT Servers got more popular. As it's gotten more popular, we've got more applications." [*Computer Reseller News, Sept. 1996*]

(30%marks)

(c) Sketch the response of a second order delay to a pulse input, and list the equations that model this form of delay. Discuss how a modeller would justify using a second order delay to model a given system.

(30% marks)

5. Construct a stock and flow model (showing feedbacks) and set of equations for the following problem. Where appropriate, justify the rationale for your formulation of equations (in particular, for the formulation of the hiring rate).

> An insurance company's claims processing department receives daily claims (orders/day) which must be processed. The processing rate is a function of the organisation's capacity (orders/day). The total capacity is based on the number of employees (people) and their productivity (orders per person per day).
>
> There are two classes of employees: rookies and experienced. Rookies – whose productivity is half that of experienced employees – progress to become experienced employees after a time delay of sixty days. Empirical results have shown that this time delay follows a third order delay distribution. There is an attrition rate of 5%, but this only applies to experienced employees. The company has a "no-layoff" policy, and the only mechanism it has to reduce the workforce is by attrition.
>
> The hiring rate is determined by establishing the desired level of employees (i.e. the ideal number required to deal with the backlog), the expected attrition rate, the current total number of employees and the hiring adjustment time (i.e. the classic stock management structure).