

**OLLSCOIL NA hÉIREANN
NATIONAL UNIVERSITY OF IRELAND, GALWAY**

SEMESTER I, WINTER 2002-2003 EXAMINATION

The B.A. Degree

Systems Approach (CT317)

The B.Sc. Degree Examination in Information Technology

Systems Theory (CT423)

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Time Allowed: 2 hours

Answer any THREE questions.

1. (a) Explain the following terms:

- Policy Resistance
- Positive Feedback
- Negative Feedback

(b) Derive causal loop diagrams that capture the positive feedback dynamics referred to by Bill Gates (CEO Microsoft) in these two quotations:

- "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*]
- "The biggest advantage we have is that good developers like to work with good developers." [*Microsoft Secrets 1995*]

2. An entire population (N) of networked computers can be divided into three categories:

Category	Description
Susceptible (S)	Computers that have not yet caught a virus, but may well to do so.
Infected (I)	Computers that are infected with a virus, and are likely to pass it on to others.
Recovered (R)	Computers that have recovered from a virus cannot pass it on to other computers. However, given the proliferation of new viruses, all recovered computers become susceptible again after a third order time delay of 10 time units.

Show the structure and equations of this epidemic model, based on the following assumptions.

- The **contact rate** (c) is the number of computers contacted per computer per time period. This value is 6 per computer per time period.
- The **infectivity** (i) is the probability that a computer becomes infected after contact with an infectious computer. This value is 0.25.
- The **total population** (N) is constant, and is the sum of the S, I and R. The initial values are S=9999 I=1 and R=0.
- The **delay distribution for recovery** is a second order exponential delay, with an average value of 2.
- The **delay distribution for the transition from recovered to susceptible** is third order exponential, with a time delay of 10 units.

3. (a) Based on the special case of S-shaped growth known as *logistic growth*, show the structure and equations for a model of internet usage growth over time. The variables to include in this model are: Population of Users, Carrying Capacity (People), GMax (Maximum growth rate), and Number of New Users (People/Time period).

(b) Sketch a phase plot showing the expected relationship between the Number of New Users and the Population of Users. How might this phase plot look if there were significant time delays present in the feedback structure?

4. (a) Making use of the general structure for managing a stock where there are no acquisition delays, derive the structure and equations that model two companies (A and B) connected in a supply chain. **Company A** reacts to orders from the marketplace (exogenous variable), and **Company B** reacts to orders from Company A.
- (b) If an acquisition delay existed between the companies (i.e. a **supply line** was present), list the variables that would have to be used by decision makers in Company A in order to minimise any potential oscillation in inventory.
5. Based on the input and output flow into a stock shown below (assume the stock at time=0 equals 100 units):
- Calculate, using graphical integration, the value of the stock at time = 20
 - Calculate, using Euler's method (either graphically or numerically), the stock value at time =20, with $DT = 5$ time units.

