EMBU UNIVERSITY COLLEGE

(A Constituent College of the University of Nairobi)

2015/2016 ACADEMIC YEAR

SECOND SEMESTER EXAMINATION

THIRD YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (ENVIRONMENTAL SCIENCE AND NATURAL RESOURCES MANAGEMENT)

SZE 303: MODELLING OF BIOLOGICAL SYSTEMS

DATE: APRIL 12, 2016 **TIME: 02:00-04:00**

INSTRUCTIONS: Answer any ten (10) questions (7 marks each)

1. The dynamics of wolves (predators) and rabbits (preys) populations in the Mt. Kenya forest ecosystem follows the **Lotka–Volterra predator prey model.** Currently, there are 70 wolves and 500 rabbits in the ecosystem. The changes in the population of the two species over time are as shown in the following model:

$$\frac{dy}{dx} = 0.8R - 0.005RW$$

$$\frac{dy}{dx} = -0.06W + 0.0001RW$$

a) Determine the equilibrium number of rabbits and wolves for the population (4 Marks)

b) State THREE assumptions of the Lotka–Volterra model (3 Marks)

2. a) Explain the significance of a structured walk-through in the modeling process? (4 Marks)

   b) Differentiate between type I and type II errors that occur during the model hypothesis formulation process (3 Marks)

3. Describe the procedure for the Monte Carlo method of model simulation for biological systems. (7 Marks)
4. An insect population has 4 stages: eggs, larvae, pupa, and adults. Transition between these states of development is regulated by temperature. Influx of eggs depends on the number of adults. Mortality occurs in all stages of development. Larval and pupal mortality is density-dependent.

   Required:

   a) Draw a Forrester diagram to represent the above system clearly showing the material and information flows. (4 Marks)

   b) Explain three common forms of errors in Forrester models. (3 Marks)

5. Distinguish between the following terms as used in modeling of biological systems

   a) Model verification and model validation (3 Marks)

   b) Stochastic and Deterministic models (2 Marks)

   c) Continuity testing and consistency testing (2 Marks)

6. Discuss the problems of parameter estimation through transformations. (7Marks)
7. Use appropriate parameter estimation methods to show how one would estimate parameters in the following models:
   a) The constants r and t in the natural population growth model

   $$N_t = N_O e^{rt}$$

   (4 Marks)

   b) The Michaelis constant K_M in the Michaelis–Menten model

$$v = \frac{V_{max}[S]}{K_M + S}$$

(3 Marks)

8. a) Explain the concept of model neighborhood stability with respect to an ecosystem

(2 Marks)

b) Describe the procedure of conducting a Neighborhood stability analysis

(5 Marks)

9. With the aid of mathematical models, explain three forms of negative feedbacks in biological models. (7 Marks)

10. a) State the law of mass action (1 Mark)

b) With aid of differential equations, explain the reaction rates for the following

i) Zero order kinetics (3 Marks)

ii) First order kinetics (3 Marks)

11. Discuss the techniques of goodness of fit testing for models. (7 Marks)

12. Explain the conditions necessary for model validation. (7 Marks)

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