

M. SC. MATHEMATICS EXAMINATION, 2023

(2nd Year, 2nd Semester)

MATHEMATICS

UNIT – 4.3

[MATHEMATICAL MODELLING OF BIOLOGICAL SYSTEM-II]

Time : 2 hours

Full Marks : 50

The figures in the margin indicate full marks.

(Symbols and notations have their usual meanings)

(Use a separate Answer-Script for each Part)

Part – I (Marks: 25)

Answer **Q.No.1** and *any two* from the remaining three questions.

1. a) Define feedback control.
- b) Formulate two different mathematical models expressing the definition of positive feedback control and negative feedback control for gaining insights of Biological avenues with suitable assumptions.
- c) Find out the disease-free equilibrium point from any of your formulated model. 2+4+3=9
2. a) What is co-operative phenomena? Define Allasteric effect.
- b) Formulate a mathematical model using co-operative phenomena in detail along with all the suitable assumptions. (2+2)+4=8

[Turn over

[2]

3. a) Using mass transfer rate constant along with explicit dependency of the reaction rate constant of the temperature, formulate a mathematical model on biodiesel production with suitable assumptions.
- b) Obtain the optimal control induced system of the previous model for maximization of production of biodiesel and finally, evaluate the Hamiltonian.

4+4=8

4. a) State and formulate the rocket railroad car problem induced with control.
- b) Obtain the geometric solutions of the system and interpret these findings mathematically. 4+4=8

Part – II (Marks: 25)

Answer **Q.No. 4** and *any two* from the rest.

1. a) What is meant by a chemostat?
- b) Formulate the model of microbial populations in a chemostat and discuss their Stability properties.

2+9

2. a) With suitable assumptions, write down the general balance law.
- b) What is Fick's law? Using Fick's law, write down the one-dimensional diffusion equation from the general balance law as derived above. 5+6

[3]

3. a) How are the characteristics of an individual determined?
- b) When two individual mate, what are the possible genotypes of the offspring?
- c) State and prove Hardy-Weinberg law. 2+3+6
4. Write down the importance of microbial kinetics. 3