Strathmore
UNIVERSITY

STRATHMORE INSTITUTE OF MATHEMATICAL SCIENCES

MASTER OF SCIENCE IN BIOMATHEMATICS

END OF SEMESTER EXAMINATION

BMA 8406: INFECTIOUS DISEASE MODELLING

15/8/2018 **Time: 2 Hours**

Instructions

1. This examination consists of FOUR questions.
2. Answer Question ONE (COMPULSORY) and any other TWO questions.

Question one (20 Marks)

a. In disease dynamics, in-host modeling gives more insight as compared to population level modeling. Discuss *(4marks)*

b. Differentiate between local and global stability as used in disease modelling. *(2marks)*

c. A researcher was working an a certain drug to be used in controlling a certain infection. She decided to work with her masters student. She split the students into two groups. In one group the student were required to analyse the effectiveness of the drug by use of mathematical models whereas in the other group they were required to test the drug with mice in a lab. Discuss the best approach. *(4marks)*

d. What do you understand by the term backward bifurcation in disease modeling. What is its implication? *(3marks)*

e. Why is the basic reproductive number important in disease modelling. *(2marks)*

f. What is incubation period in disease modelling dynamics. *(2marks)*

g. Differentiate between infection, infectious process and infectious disease in disease transmission dynamics. *(3marks)*

Question Two (20 Marks)

a. HIV is one of the main course of death in the sub-saharan Africa. When HIV virus gets to the body it targets the $CD4^+$T-cells which are produced at a constant rate from the Thymus. In addition, when the body sense the onset of infection, it activates the $CD8^+$T-cells so that they may kill the infected $CD4^+$T-cells. The $CD8^+$T-cells are recruited from the Thymus at a constant rate.

i. Describe the variables and parameters in the model and comment on the biological mean- ing of each term in the equations. *(7marks)*

ii. Formulate an in-vivo mathematical model to describe the dynamics of HIV. *(6marks)*

iii. Find the basic Reproductive number using the next generation matrix, interpret it and give a description on what interventions could be used to reduce the infection. *(7marks)*

Question Three (20 Marks)

a. The schematic diagram below represents the dynamics of EBOLA. Use it to answer the questions that follow.

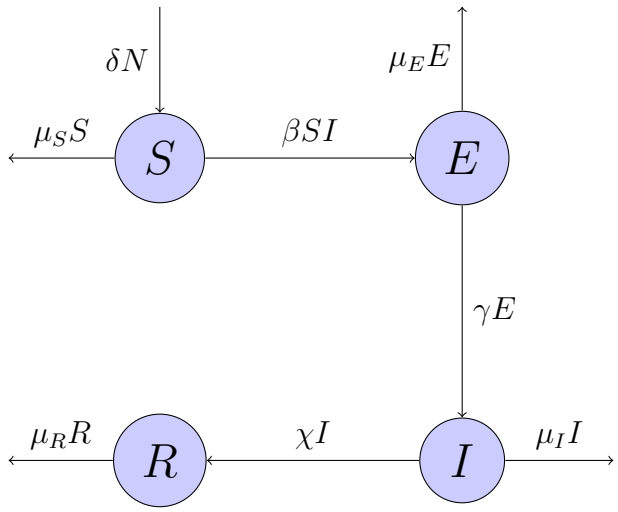

Figure 1: A compartmental representation of the Ebola Dynamics.

i. State some of the assumptions for the model. *(3marks)*

ii. Write the non-linear ordinary differential equations governing the dynamics of Ebola transmission. *(3marks)*

iii. Describe the variables and parameters in the model and comment on the biological meaningful of each term in the equations. *(7marks)*

iv. Show that the model is biologically meaningful and mathematically well posed. *(7marks)*

Question Four (20 Marks)

a. The dynamics of the transmission of Dengue Fever is assumed to be governed by the following system of nonlinear ordinary differential equations:

$$\begin{aligned}
\frac{dS_h}{dt} &= \lambda_h N - \mu_{S_h} S_h - \chi_h S_h I_v, \\
\frac{dI_h}{dt} &= \chi S_h I_v - \mu_{I_h} I_h - \gamma_h I_h, \\
\frac{dR_h}{dt} &= \gamma_h I_h - \mu_{R_h} R_h, \\
\frac{dS_v}{dt} &= \lambda_v N - \chi_v S_v I_h - \mu_v S_v, \\
\frac{dI_v}{dt} &= \chi_v S_v I_h - \mu_{I_v} I_v
\end{aligned}$$

i. Draw a flow diagram that would represent the disease dynamics as represented by the equations and comment on the biological meaning of each term in the equations. *(6marks)*

ii. State possible investigations that would be done using the model. *(2marks)*

iii. Discuss the interventions which can be applied in this disease dynamics and draw a flow diagram incorporating the interventions. *(8marks)*

iv. Re-formulate the Dengue Fever model. *(4marks)*