Instructions This is a take-home test. You are asked to respond to all questions in your own time until the due date and time. Correct answers to wrong questions are not creditable. Verbal discussions and idea sharing on the test questions are encouraged, but sharing text and/or results in any manner, shape or form is absolutely not and should be avoided at all costs. Your name on your test acts as a statement that you have neither received nor given any unauthorized help. Show your work.

Question 1 (50 points) For this question, locate the microarray dataset with series accession number GSE92913 entitled “Single six hours sleep deprivation causes glucose intolerance and hepatic steatosis” at the Gene Expression Omnibus website.

a) (5 points) Briefly describe the aims of the study and the contents of the dataset.
b) (10 points) Briefly describe the analysis tool GEO2R available at the web page for the dataset.
c) (20 points) Using GEO2R, identify the genes that are differentially expressed between the sleep deprived group and the control group with an adjusted $P$ value no greater than $10^{-3}$ and a fold change of at least 2.
d) (15 points) On the KEGG database, identify the pathways that are populated separately by the positively expressed and the negatively expressed genes in the sleep deprivation group and discuss the possible effects of sleep deprivation on the organism.

Question 2 (50 points) Using the dynamic elements of gene regulatory networks, design a network of interaction between genes in accordance with the following requirements:

- The system is turned on when the signal $S_X$ is activated for the start gene $X$, i.e. $S_X(t) = u(t)$.
- The initial concentration of gene $X$ at time $t = 0$ is at the steady state level.
- The initial concentrations of all remaining genes in the system are at zero, but their activation signals are always present.
- The outputs of the system consists of concentrations of three genes $Z_1$, $Z_2$ and $Z_3$ that exhibit non-overlapping pulses in a successive order; first $Z_1$, then $Z_2$ and finally $Z_3$.

a) (20 points) Draw the gene regulatory network and indicate the types of interactions.
b) (20 points) Write down the set of ordinary differential equations that govern the transient behavior of the system.
c) (10 points) Solve the system numerically and show the time-plots of all gene concentrations demonstrating the proper functioning of the system.