

# BM2053 Mathematical Models & Systems Biology

## Lab Exam

Duration: 90 mins

Total marks: \_\_\_\_

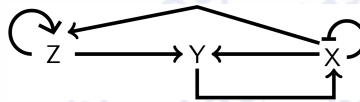
1. Write the answers clearly and within the space provided. Do not use a pencil to write answers.
2. You can use any resource, including the Internet. You are not allowed to talk to each other or anyone else (except invigilators in case of any doubt) either orally or electronically.
3. You cannot use your phone during the exam.

### Parameter values

Use only the following values wherever you need to solve the problems in this exam

- Hill's function parameters  $K = 2$  mM and  $n = 4$ .
- Protein synthesis and degradation rates  $\alpha = 5$  mM/s,  $\beta = 1$  /s
- At the nodes with two or more incoming arrows, you have to combine the signals using AND logic.

1. Consider the following gene regulatory network



- (a) Write down equations describing the concentrations of the proteins X, Y, and Z for this system. You only have to write the final equations and not the derivation. **(3 × 5)**

- (b) Write a Python program to numerically solve this system of equations to fill in the following table. You have to write the program in the Google Colab notebook shared with you over email. Please enter the numbers in the table up to three decimal places. (2 × 12)

|              | $x$ (in mM) | $y$ (in mM) | $z$ (in mM) |
|--------------|-------------|-------------|-------------|
| $t = 1.17$ s | 1.793       | 1.056       | 2.098       |
| $t = 2.13$ s | 0.755       | 0.525       | 0.924       |
| $t = 3.01$ s | 0.316       | 0.218       | 0.383       |
| $t = 3.94$ s | 0.125       | 0.086       | 0.151       |
| $t = 4.89$ s | 0.048       | 0.033       | 0.058       |

Here  $x$ ,  $y$ , and  $z$  represent the concentrations of proteins X, Y, and Z, respectively.

