

# BM5063 Mathematical Physiology and Systems Medicine

## Exam 3 Solution

### Instructions

1. In this exam, you can use one page of any handwritten material. Photocopies/prints/soft-copies are not allowed.
2. You are expected to answer these on your own. **Any reasonable signs of 'copying/plagiarism' will attract penalties.**
3. You have to provide answers within the space provided. No additional paper will be given.

### Questions

1. Recall the glucagon problem from the last problem set. Extend the glucose-insulin model developed in class to incorporate the effect of glucagon. **(20)**

#### Instructions

- (a) *Avoid unnecessary details and text, and give a concise answer.*
- (b) *You only have to provide the model equations and justification for terms.*
- (c) *You do not have to solve/analyze the system or identify fixed points.*

Glucagon, a peptide hormone released by  $\alpha$ -cells in the pancreas, stimulates glucose production in liver. Therefore, for glucose, we can write **(8)**

$$\dot{g} = m_{\text{meal}}(t) + m_{\text{liver}}(c) - sIg \quad (1)$$

where the glucose release from liver increases with glucagon levels, that is

$$m_{\text{liver}}(c) = \alpha_1 H_1(c). \quad (2)$$

Since glucagon does not affect insulin dynamics directly, we have **(4)**

$$\dot{I} = \alpha_2 H_1(g) - \beta_2 I. \quad (3)$$

Finally, glucagon release by  $\alpha$ -cells is also glucose dependent, where its rate of release decreases with increasing glucose levels. This gives **(8)**

$$\dot{c} = \alpha_3 H_2(g) - \beta_3 c. \quad (4)$$

Some reports also indicate a role of insulin on glucagon release from the pancreas. This can also be incorporated as

$$\dot{c} = \alpha_3 H_2(g) H_2(I) - \beta_3 c. \quad (5)$$