Name:
Roll Number:

BM5063 Mathematical Physiology and Systems Medicine

Exam 2 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. Metformin (commonly branded as *Glucophage*) is a first-line oral medication used to treat Type 2 diabetes by lowering blood sugar levels. It works by decreasing liver glucose production. For a patient, the doctor has prescribed 500 milligrams (mg) two times a day, taken with the morning and evening meals. Write down the equations for glucose dynamics for the patient before and after they start on the medication. Do not miss defining all the variables and parameters used in the equations separately. **(5+10+10)**

   As discussed in the class, in the absence of drug, we have

   $$\dot{g} = m(t) - sgI$$

   where $m(t) = m_{\text{meal}}(t) + m_{\text{liver}}(t)$ is the glucose input from meal and liver, s is insulin sensitivity, and I denotes the insulin levels.

   Once the patient starts taking Metformin, the glucose intake from the liver drops. Therefore, it should be reflected in the term $m_{\text{liver}}(t)$. One way of modeling it can be by taking

   $$m(t) = m_{\text{meal}}(t) + m_{\text{liver}}(t) f(M_f, t)$$

   where $f(M_f, t)$ is a function of the dosage of Metformin M_f. The function $f(x, t)$ should be a decreasing function of x and satisfy $f(0, t) = 1$. The dependence of $f(x, t)$ on time will come from the dynamics of the drug molecule.

2. For this patient, the fasting glucose and insulin levels are

   $$(g^*, I^*) = \begin{cases} (200.0\text{mg/dL}, 12.0\mu\text{U/mL}), & \text{before medication} \\ (110.0\text{mg/dL}, 3.5\mu\text{U/mL}), & \text{after medication} \end{cases}$$

   Based on insulin resistance, select the correct option from below and justify your choice. **(10+10)**

   (a) The doctor is likely to increase the metformin dosage
   (b) The doctor is likely to decrease the metformin dosage
   (c) The doctor is likely to keep the metformin dosage as it is
   (d) The doctor is likely to stop metformin

   Calculation of HOMA-IR for both cases gives

   (a) Before medication HOMA-IR $= \dfrac{g^* I^*}{405} = \dfrac{200 \times 12}{405} \approx 6$

   (b) After medication HOMA-IR $= \dfrac{g^* I^*}{405} = \dfrac{110 \times 3.5}{405} \lessapprox 1$

   Since the prescribed dosage of Metformin results in HOMA-IR< 1 which is within the safe limit. There is no need of change in the dosage.