BME 200
HW3

Follow the homework guidelines on the course webpage to answer the following.

1. Draw an appropriate control volume for:

(a) Analyzing blood flow in and out of the human heart
(b) Analyzing blood flow in and out of the left ventricle
(c) Analyzing air flow into and out of human lungs

2. Study the flow of blood through the heart using this https://upload.wikimedia.org/wikipedia/commons/a/ae/Circulation_of_Blood_Through_the_Heart.jpg. Veins bring blood into the heart via the atria. Arteries carry blood out of the heart via the ventricles. Answer the following questions:

(a) The heart is the system you want to analyze. Draw a control volume that can be used to analyze blood flow into and out of the heart.
(b) Write a mass balance equation for the heart during *passive filling*. Passive filling is the cardiac cycle stage in which blood flows into both atria and ventricles, but does not flow out of the heart because it is not contracting yet. Include a mass flow term for each artery and/or vein, as appropriate.
(c) Write a mass balance equation for the heart during *isovolumetric ventricular contraction*. Isovolumetric ventricular contraction is the phase of the cardiac cycle in which the ventricles begin to contract, and all valves are shut, so no blood flows into or out of the heart. Include a mass flow term for each artery and/or vein, as appropriate.

3. Assume that you have developed a tracer with first-order kinetics and $k = 0.3\ \text{s}^{-1}$.

(a) For any given mass, how long will it take the tracer concentration to drop by 50%?
(b) By 65%?

4. A 3 g IV injection of antibiotic is administered to a human with a plasma volume of 3 L. The antibiotic has a half-life of 1.75 hr in the plasma.

(a) Assuming a one-compartment model, determine the excretion rate constant, k_e.
(b) Using Matlab or Excel, graph the concentration of the antibiotic in the plasma from the time of a single injection to 8 hr.
(c) If the concentration of the drug is not to fall below 1/3 of the initial dosage at steady state, how often does the drug need to be given to maintain this minimum level?
(d) Assume periodic injections at the interval calculated in part (c). What is the average drug concentration?
(e) Assuming the same period as in (c), what is the maximum drug concentration?

5. Suppose a patient is given two 325 mg ibuprofen tablets. Ibuprofen has an absorption rate constant of $0.924\ \text{hr}^{-1}$ and an elimination rate constant of $0.347\ \text{hr}^{-1}$. Assume a two-compartment model, a bioavailability of 60%, and a plasma volume of 3 L.

(a) Using Matlab or Excel, graph the concentration of ibuprofen in the blood for 24 hours after ingestion.
(b) How long after ingestion of a single dose does the concentration in the plasma reach a maximum?
(c) If a new patient is told to take two tablets every 4 hours for 12 hours, what would you expect the plasma concentration to be after 12 hours?