Problem Set #1: Enzyme Kinetics

1. Let

$$B = \begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}, \ \vec{v} = \begin{pmatrix} v_a \\ v_b \end{pmatrix}.$$

(a) Show that if $B\vec{v} = \vec{0}$, and $\vec{v} \neq \vec{0}$, then $\det(B) = 0$.

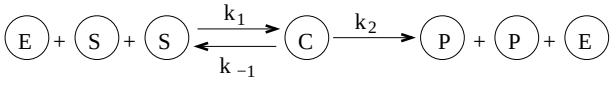
(b) Show that if $\det(B) = 0$, then

i. the rows of B are linearly dependent (one row is a constant multiple of the other row) and

ii. we can determine $\vec{v}$ only up to multiplicity (that is, $\vec{v}$ can be multiplied by any constant and still satisfy $B\vec{v} = \vec{0}$).

2. Using a method similar to the one used in class, derive the degree-2 Hill function for a cooperative reaction where the enzyme must bind two substrate molecules to create the complex. Under what conditions is it valid? Assume the enzyme molecule binds the two substrate molecules simultaneously.

The reaction diagram is:



3. Use Mathematica (or other software of your choice) to explore the equations for enzyme kinetics discussed in class (and reproduced below). Vary the parameters (including making them negative if you want) to make the steady state stable or unstable and the solution oscillatory or smooth. Plot your results as a function of time.

The equations are:

$$\frac{dS}{dt} = -S + (S + K_n - K_{max})C \quad (1)$$

$$\epsilon\frac{dC}{dt} = S - (S + K_n)C \quad (2)$$