# Bioengineering 498A: Systems and Synthetic Biology

Mar 6, 2009
Homework Assignment
Due: 13th March 2009

Points awarded for each question are indicated in square brackets. Return assignment with your name clearly indicated at the top of your answer sheet. [Total points: 100]. **All calculations must be shown.**

[25] **Question 1**. Prove that (no using Matlab) the following model contains no conserved cycles.

```
X0, X1, X2 and X4 are fixed species

J1:    $X0 -> S1; v;
J2: S1 + A -> $X1 + B; v;
J3: S1 + A -> $X2 + B; v'
J4:    $X4 -> A; v;
```

[25] **Question 2**. Derive the N, Nr, L0, L and Gamma matrices for the following network (without using Matlab):

```
X0, X1 and X2 are fixed species

J1:    $X0 -> S1; v;
J2: S1 + A -> $X1 + B; v;
J3: S1 + B -> $X2 + A; v;
```

[35] **Question 3**.

[25] a) Derive the N, Nr, L0, L and Gamma matrices for the following network (without using Matlab):

```
J1: S1 + S3 -> S2; v;
J2:      S2 -> S3 + S4; v;
J3:      S4 -> S6 + S5; v;
J4: S5 + S6 -> S1; v;
```

[5] b) From the information you gather on the Gamma matrix for the above network, redraw the pathway showing the composition of each species in terms of the elementary subgroups in the pathway (See slide 6 and 39 for examples).

[5] c) Show how you would use Matlab to derive the conservation laws for this pathway.

[15] **Question 4**. QR factorization is a stable way to factorize any matrix into a set of more elementary forms, Q and R. We can use QR to factorize a stoichiometry matrix, that is N = Q R, where Q and R have the following structures. The row dimensions of Q11 and Q21 correspond to the row dimensions of Nr and No respectively.

$$\mathbf{Q} = \begin{bmatrix} \mathbf{Q}_{11} & \mathbf{Q}_{12} \\ \mathbf{Q}_{21} & \mathbf{Q}_{22} \end{bmatrix} \quad \text{and} \quad \mathbf{R} = \begin{bmatrix} \mathbf{U} \\ \mathbf{0} \end{bmatrix}$$

Show that the application of QR factorization to the stoichiometry matrix lead to the following result (You can assume that Q11 is invertible):

$$\mathbf{L}_0 = \mathbf{Q}_{21}\mathbf{Q}_{11}^{-1}$$