Solutions

Exchange reactions: $v_1, v_2, v_3, v_8, v_{11}$.

Stoichiometric matrix:

```
S =

     1     0     0    -1     0     0     0     0     0     0     0
     0     1     0     0    -1     0     0     0     0     0     0
     0     0     1     0     0    -1     0     0     0     0     0
     0     0     0    -1     1     0     0     0     0     0     0
     0     0     0     0     1     1    -1     0     0     0     0
     0     0     0     1     0     0     0    -1     0     0     0
     0     0     0     1     0     0     0     0    -1     0     0
     0     0     0     0     0     0     1     0     0    -1     0
     0     0     0     0     0     0     0     0     1     1    -1
```

FBA problem:

$$\begin{aligned} &\max v_{11} \\ &\text{such that } S\mathbf{v} = \mathbf{0} \\ &0 \leq v_1, v_2, v_3 \leq 1 \end{aligned}$$

Matlab commands:

```
>> f'
ans =
     0     0     0     0     0     0     0     0     0     0     1

>> b'
ans =
     0     0     0     0     0     0     0     0     0

>> L'
ans =
     0     0     0  -Inf  -Inf  -Inf  -Inf  -Inf  -Inf  -Inf  -Inf

>> U'
ans =
     1     1     1   Inf   Inf   Inf   Inf   Inf   Inf   Inf   Inf

>> [X,v]=linprog(-f,[],[],S,b,L,U)
```

```
Optimization terminated.

X =

    1.0000
    1.0000
    1.0000
    1.0000
    1.0000
    1.0000
    2.0000
    1.0000
    1.0000
    2.0000
    3.0000


v =

   -3.0000
```

Note that since linprog minimizes, the objective function and result are given as opposite numbers. The maximum for v_{11} is hence 3. This solution is unique, because $v_1 = v_2 = v_3 = 1$ are already at upper limits.