# OME: Tutorial, Lecture 4

## Question 1

- **Commodity** 1: $d_1 = 3$
  - Net flow out of $b$ is $3$.
  - Net flow in to $d$ is $3$.
  - Net flow out of $c$ is $0$.
  - Net flow out of $p$ is $0$.
  - Flow conservation constrains have been preserved.
- **Commodity** 2: $d_2 = 7$
  - Net flow out of $a$ is $7$.
  - Net flow in to $q$ is $7$.
  - Net flow out of $b$ is $0$.
  - Net flow out of $p$ is $0$.
  - Flow conservation constrains have been preserved.
- **Commodity** 3: $d_3 = 4$
  - Net flow out of $b$ is $4$.
  - Net flow in to $c$ is $4$.
  - Net flow out of $p$ is $0$.
  - Net flow out of $q$ is $0$.
  - Flow conservation constrains have been preserved.

The maximum congestion is $166.\dot{6}\%$ along the edge $(b, c)$.

## Question 2

One unit of flow can be removed from the path $\langle b, c\rangle$ and applied to the path $\langle b, p, q, c\rangle$ (the maximum residual capacity along those edges). The edge $(b, c)$ remains the most congested, but the congestion is reduced to $(b, c)$ to $133.\dot{3}\%$.

## Question 3

The sum of edge capacities leaving the set of sources $\{a, b\}$ is $4 + 3 + 5 = 12$, and the total demand in the system is $3 + 7 + 4 = 14$. It is therefore impossible to achieve a maximum congestion lower than $14/12 = 7/6 \approx 1.17$.

*TODO: more detail may be added to this answer after it is covered in the lecture.*