**Last name** _____

**First name** _____

**LARSON—MATH 656—CLASSROOM WORKSHEET 24**
**Network Flows.**

**Organizational Notes**

1. Don't forget to send your Notes / Classroom worksheet after each class (make the email subject useful: like "Math 656 c24 notes").
2. The VCU Discrete Math Seminar is every Wednesday.
3. Read ahead! We're talking about Network Flow problems (Sec. 4.3)

**Review**

1. What is a *network*?
2. What is the *capacity* $c(e)$ of an edge $e$?
3. What are *source* and *sink* vertices?
4. What is a *flow*? What is $f^+(v)$ and $f^-(v)$?
5. What is a *feasible flow*? What are *capacity constraints*?
6. What are *conservation constraints*?
7. What is the *value* $val(f)$ of a flow $f$?
8. What is a *maximum flow*?
9. What is a $f$-augmenting path?
10. What is the *tolerance* of a path?

**Notes**

1. (**Lemma**) If $P$ is an $f$-augmenting path with tolerance $z$ then changing flow by $+z$ on edges followed forward by $P$ and by $-z$ on edges followed backward by $P$ produces a feasible flow $f'$ with $vaf(f') = val(f) + z$.

2. What is a *source/sink cut [S,T]*?

3. What is the *capacity*, $cap(S,T)$, of a cut [S,T]?

4. If $U \subseteq V(G)$, what is $f^+(U)$ and $f^-(U)$?

5. (**Lemma**) If $U$ is a set of nodes in a network, then the net flow out of $U$ is the sum of the net flows out of the nodes of $U$, that is,

$$f^+(U) - f^-(U) = \sum_{v \in U} [f^+(v) - f^-(v)].$$

6. (**Weak Duality**) If $f$ is a feasible flow and [S,T] is a source/sink cut, then $val(f) \leq cap(S,T)$.

7. What is the *minimum cut* problem?

8. What is the *Ford-Fulkerson labeling algorithm*?

9. (**Max-flow Min-cut Theorem (AKA Ford-Fulkerson Theorem**) In every network, the maximum value of a feasible flow equals the minimum capacity of a source/sink cut.