**CSC2401F Instructors: A. Borodin and C. Rackoff**
**Text: "Theory of Computational Complexity" by Ding-Zhu Du and Ker-I KO**

CSC2401 is an introductory level graduate course which is appropriate for all graduate students in Computer Science, as either a breadth course for those not primarily interested in theoretical aspects of computing or as a foundational course for those students who may be planning to focus on theoretical issues. For the most part we will be discussing basic issues in complexity theory but we will try to devote some time to some current research topics. Students can access previous versions of this course as perhaps the best indicator of what we intend to be doing. See www.cs.toronto.edu/~bor/2401f01 and www.cs.toronto.edu/~rackoff/2401f00.

Here follows a very tentative schedule of topics.

1. The multitape Turing machine model; time and space complexity measures and complexity classes.

2. The polynomial time complexity thesis.

3. The basic diaginaliztion technique; time (space) complexity class hierarchies.

4. Non determinstic computation.

5. The basic inclusions :

$$NC^1 \subseteq L \subseteq NL \subseteq P \subseteq NP \subseteq PSPACE \subseteq \bigcup_k DTIME(2^{n^k})$$

6. Logspace reducibility; STCON (directed graph s-t connectivity) is complete for $P$ wrt logspace reducibility.
   $NSPACE(s(n)) \subseteq DSPACE(s(n)^2)$.

7. $\overline{STCON} \in NL$ and hence $NL$ is closed under complementation.

8. $BHP$ (bounded halting problem), $CIRCUIT-SAT$, $SAT$, etc. etc. are complete for $NP$.

9. The polynomial hierarchy; alternative characterizations of $NP$ and $\Sigma_k^p$.

10. Boolean circuit complexity and non-uniform complexity measures size and depth.

11. Alternating Turing machines.
    $ATIME(logn) = uniformNC^1$ (log parallel time); $ASPACE(logn) = P$.

12. Provably hard natural languages.
    $TRE$ = totality of regular expressions (resp. $TERE$ = totality of extended regular expresssions) is complete for polynomial (resp, exponential) space.

13. Indirect diagonalization and time-space bounds.
    $SAT \notin DTISP(n^{\sqrt{2}-\varepsilon}, n^{o(1)})$.

14. Randomized computation; symbolic determinant; primality testing in $P$. $BPP \subseteq POLYSIZE$ and $BPP \subseteq \Sigma_2^p$.

15. $\#P$ (counting problems) and $IP$ (interactve proofs).