CSC2401F Instructor: A. Borodin
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. The first and main part of the course will be an introduction to complexity theory, discussing models of computation, time and space classes, reductions, randomization, complexity hierarchies, tradeoffs. The second part will contain some recent results pertaining to fundamental issues in complexity theory. 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/2401f02, and 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 Σ_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). $\#P$ in IP (leading to $IP = PSPACE$)..

16. Fixed Parameter Tractable Problems.