Topics:

1. Complexity
   (a) Definition of time and space complexity
   (b) Counting operations of algorithms
   (c) Role of the length of the input
   (d) Worst case, Best case, Average case time complexity
2. Solving summations
   (a) Using induction to prove results about summations
   (b) Using integrals to find bounds of summations
   (c) Common summations
3. Classification of functions $O(g(x))$, $\Omega(g(x))$, $\Theta(g(x))$, $o(g(x))$, and $\omega(g(x))$
   (a) Definition
   (b) Using the definition to classify functions
   (c) Proof that Θ is an equivalence relation
   (d) Properties: how the sets are related
   (e) Using limits to compare function growth
   (f) Ordering of common functions, including proofs for each one of the cases
4. Improving complexity
   (a) Lower bound for a problem
   (b) Upper bounds (algorithms)
   (c) Finding better lower and upper bounds (gap)
5. Divide and Conquer Algorithms
   (a) The steps of the divide and conquer strategy: divide, recursively solve, combine
   (b) Finding a recurrence relation describing the time complexity of divide and conquer algorithms
   (c) Example: Multiplication of two binary numbers
6. Recurrence Relations
   (a) Solving recurrence relations by iteration
   (b) Example: Mutliplication of two binary numbers
   (c) Proof of the Master Theorem
   (d) Solving recurrence relations using the Master Theorem

7. The sorting problem
   (a) Divide and conquer approaches
   (b) Quicksort using partition
   (c) Analysis of Quicksort (Best case, worst case)
   (d) Randomized Quicksort
   (e) The Mergesort algorithm
   (f) Analysis of the time complexity of Mergesort
   (g) Using Comparison Decision Trees to compute a lower bound for comparison based sorting
   (h) Optimality of algorithms
8. The Selection problem
   (a) Finding min, max, median as special cases of the selection problem
   (b) Lower bound for the Selection problem
   (c) Divide and Conquer algorithm for selection (randomized)
   (d) Divide and Conquer algorithm for selection (not randomized)
   (e) Recurrence relation for the (not randomized) Select algorithm