5. [12 pts] Consider the following NP completeness questions. Answer them with "some" "all" "none" or "unknown"

(i) Which Problems in P are also in NP? ("some" "all" "none" or "unknown")

(ii) Which Problems in NP-Hard are also in NP? ("some" "all" "none" or "unknown")

(iii) Which Problems in NP-Complete are in NP-Hard ("some" "all" "none" or "unknown")

(iv) If someone can solve an NP-Hard problem in Polynomial Time, then all NP and all NP complete problems can be solved in polynomial time. (true or false)

(v) At least 1 NP problem can be solved in polynomial time? (True or False)

(vi) NP-Complete problems are in P ("true" "false" or "unknown")

(vii) At least 1 NP problem can be solved in polynomial time? (True or False)

(viii) Which NP-Hard Problems are also NP-Complete? ("some" "all" "none" or "unknown")

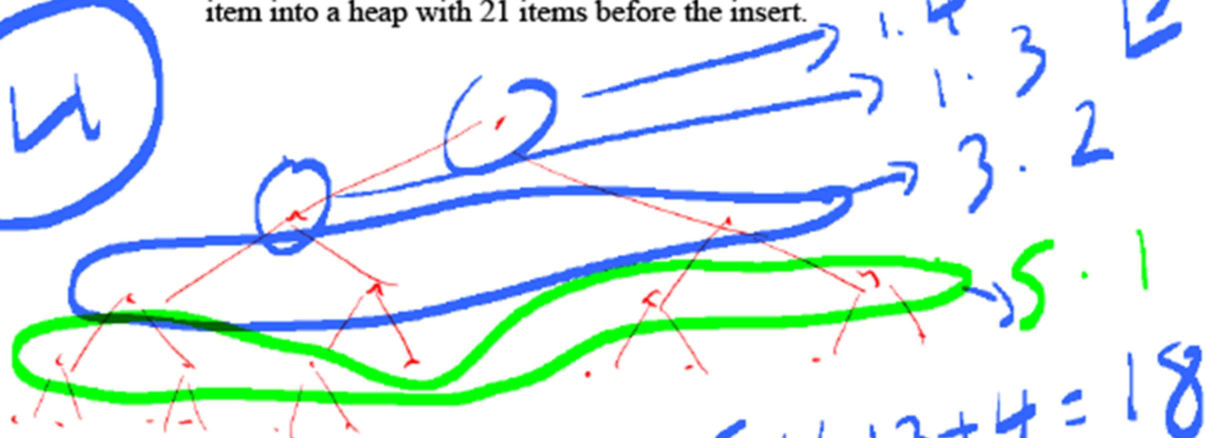
6. [8 pts] Consider a Heap:

(i) How many swaps in the worst case may be required to form a heap using the HEAPIFY algorithm from an array of 21 items?

18 — see work

(ii) How many swaps in the worst case may be required for inserting an item into a heap with 21 items before the insert.

4



5+6+3+4=18

4. [8 pts] Consider the heapify algorithm for creating a heap from an array of random integers:
   (i) How many swaps (maximum) may be required for an array of 3 integers?

   1

   (ii) How many swaps (maximum) may be required for an array of 7 integers?

   4

   (iii) How many swaps (maximum) may be required for an array of 15 integers?

   11

   (iv) How many swaps (maximum) may be required for an array of 31 integers?

   26

5. [8 pts] Consider the following NP completeness questions. spr 23 - on Test #3
   (i) Assume you can solve an NP-Complete problem in polynomial time and mark the following as "true" or "false" with this assumption:

   - All P problems can be solved in polynomial time?

     T

   - All NP problems can be solved in polynomial time.

     T

   - All NP-Complete problems can be solved in polynomial time.

     T

   - All NP-Hard Problems can be solved in polynomial time.

     F

   (ii) At least 1 NP problem can be solved in polynomial time? (True or False) T

   (iii) NP-Complete problems are in P ("true" "false" or "unknown") unknown

   (iv) Which NP-Hard Problems are also NP-Complete? ("some" "all" "none" or "unknown")

   Some

1. [8 pts] Consider the following NP completeness questions. Answer them with "some" "all" "none" or "unknown"

(i) Which Problems in NP are also in P? ("some" "all" "none" or "unknown")

Unknown

(ii) Which problems in NP are also in NP-Hard? ("some" "all" "none" or "unknown")

Some

(iii) If someone can solve the Circuit Sat problem in Polynomial Time, then all NP and all NP complete problems can be solved in Polynomial Time? (True or False)

<Skip - Circuit Sat problem not covered>

(iv) NP means Non-Polynomial? (True or False)

False - Nondeterministic Polynomial-time

(v) Some NP problems can be solved in polynomial time? (True or False)

True

(vi) Which NP-Hard Problems are also NP-Complete? ("some" "all" "none" or "unknown")

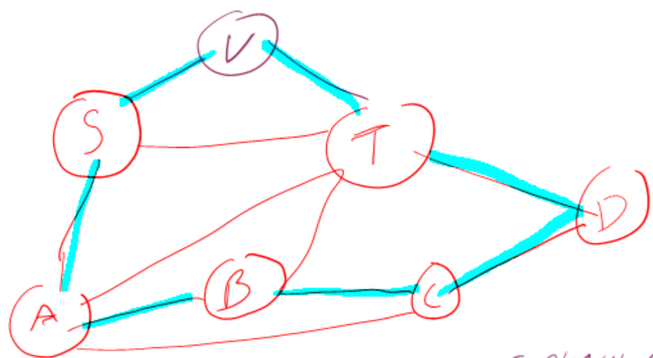
Some

2. [8 pts] Argue that the Hamiltonian Cycle is NP-Complete given that the Hamiltonian Path is NP-Complete

Hamiltonian cycle is NP since given a cycle, we can walk the graph and verify it in polynomial time.

Hamiltonian cycle is just as hard or possibly harder than the hamiltonian path problem since a solver for the hamiltonian cycle can solve the Hamiltonian Path problem. This is done by modifying the graph and putting a vertex between the start and finish vertices of the hamiltonian path being considered. Since a cycle must go through that new vertex, it will keep the start and finsh vertices together and show a path between them.

Example:



Start @ S
Stop @ T
Add V
Find Hamiltonian cycle
remove V + HP is S, A, B, C, D, T