1. Describe your implementation of LICM in pseudocode including any bonus optimizations. Also, give pertinent details about any statistical counters you collect and report.

   LICM LoadHoist

   Bonus: 1. StoreSink to all exits,

   2. CSE+DCE+InstructionSimplification+Redundant load store elimination

   Followed given pseudocode

   Computed LICM recursively over subloops, didn't store subloop information to save on space

   When encounter a Load inst, check if it can be hoisted to preheader

   BONUS: When encounter a Store inst, check if it can be pushed after all the exit blocks

   BONUS: Sink a Store Instruction:

   For all the exit blocks in Loop:

   make a new block

   place block after exit block

   clone store to that block, insert it before the terminator

   update DominatorTree

   erase store instruction

   BONUS: CSE Pass with DCE, Constant Propagation, redundant Load and Store elimination

   same as P2

   Tried out with InsertPreheader API but got Segmentation Faults so stopped.

2. How many instructions were moved using your implementation of Loop Invariant Code Motion?

LICMBasic	826
LICMLoadHoist	442
LICMNoPreheader	0
Bonus: LICMStoreSink	**1**
LICM_TOTAL	**1269**
CSEDead	205
CSEElim	1769
CSESimplify	820
CSELdElim	5023
CSEStore2Load	2970
CSEStElim	39
CSE_Total	**10826**
Total	**12095**

   LICM removed 1269 instructions, then

   CSE removed 10.5k instructions

   Totaling ~12k instructions

3. How many instructions were moved per loop on average? What happens to the average when you precede LICM with other optimizations, like mem-to-reg and CSE?

NumLoops	1309
LICM_TOTAL	**1269**
CSE_Total	10826
Total	12095
licm-avg-removed	**0.9694423224**
licm+cse avg remove	9.239877769

   LICM Average = Licm_Total / NumLoops

   = 1269/1309

= 0.97

On Average, 0.97 instructions were removed from the loop with LICM

LICM -> CSE Average = Total / NumLoops

= 12095/1309

= 9.23

On Average, my LICM+CSE pass removes ~9.23 instructions per loop

Note: CSE_Total works on the whole module and not specific to loop

What happens to the average when you precede LICM with other optimizations, like mem-to-reg and CSE?

Doing M2R-CSE-LICM

NumLoops	1309
LICM_TOTAL	**2458**
CSE_Total	701
Total	3159
licm-avg-removed	**1.87776929**
licm+cse avg remove	2.41329259

This boosts Licm average instruction removed by 2x

4. 566 only or 466 bonus: How many load instructions were moved versus non-load instructions?

licm-load	442
licm-nonload-insts	827
licm+cse-load	8435
licm+cse-nonload	3660

LICM Only:

Load vs Non load: 442 vs 827

LICM + CSE:

Load vs Non load: 8435 vs 3660

Link to spreadsheet data:

https://docs.google.com/spreadsheets/d/12KKxNSJq40N97u0OdJNIrcnKm7lrJ6B5Dbaxm6HFfgs/