March 19th, 2015

Instructions

1. Please enter your name in the space provided below. If you use additional pages, please type your name legibly on each of those pages.
2. TURN OFF CELL PHONES/LAPTOPS/TABLETS AND PLACE ON THE FLOOR
3. For some problems you may use the blank or marked space for your answers. Additional paper is provided upon request.
4. Time available: 1 hour and 30 minutes
5. Point value for this examination: 130 points *plus* 15 points extra credit.
   a. **Total max points (including extra credit): 145**
   b. **Total max points (without extra credit): 130**
6. No books, no laptops, no smartphones, no notes, and absolutely no collaboration.
7. You are strongly encouraged to ask the professor to clarify ambiguities/questions, should you encounter any.
8. Please write your answers in a **clear and legible** fashion.
9. **Adhere to the academic ethics & integrity code.**

STUDENT NAME:

Tyler Jackson

95 raw

113 adjusted (+19%)

Part I

3

Problem 1. [3 points]

Which intelligent agent approach does your textbook adopt? Circle the correct answer.

a. Agents whose behavior emulates that of a human being
b. Agents who think like humans
✓ c. Agents who act rationally by taking the best possible action in a situation
d. Agents whose thought-processes are rational, following a logicist approach

8

Problem 2. [12 points] T or NIL?

Nil a. Uniform cost search is a special case of BFS
T b. An admissible heuristic never overestimates the solution to the problem.
Nil c. An admissible heuristic is also always consistent
X T d. DFS is complete
X Nil e. BFS is complete as long as the branching factor is finite, even if the state space may exhibit some infinitely long paths
Nil f. DFS is optimal
X Nil g. DFS is an improvement over BFS with respect to the memory requirements
T h. IDS is complete when the branching factor is finite
Nil i. A* is a special case of uniform cost
X T j. Greedy best-first search is optimal
T k. Local beam search with *k=1* is equivalent to hill climbing
T l. Online search strategies are necessary for solving exploratory problems

Part II

9

Problem 3. [15 points] – Combinatorial and CSP

Given a 5-Queens problem, answer the following questions:

5 ✓ a. [5 pts] How many possible configurations (states) for the 5 queens are there, assuming exactly one queen per column? *Explain.* 5^5. Each Queen has 5 options. 5·5·5·5·5 ✓

b. [5 pts] Considering the heuristic function, **h**, equal to the number of distinct pairs of

0 ✗ queens attacking each other, directly or indirectly, what is the *maximum* value of this heuristic function, **max(h)**, for the 5-Queens problem? *Explain.* 4! . If they were all in the same row 4·3·2 = 24 ++

4 c. [5 pts] Looking at the 5-Queens problem from the perspective of a Constraint Satisfaction Problem (**CSP**), define the following:

✓ i. What is the type of constraints for this problem (unary, binary, higher-order, etc.)? Binary

5 = # of Queens ← ✗ ii. What are the variables, and how many are there? 25 variables. Whether or not a queen is on a piece

✓ iii. Are the variables discrete or continuous? Discrete

✓ iv. What is the domain for these variables? 1-5

✓ v. Is the domain finite or infinite? Finite => they can't partially be on a square.

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Problem 4. [30 points] – Uninformed Search

Consider a state space where the start state is number 1 and the successor function for state *n* returns two states: *2n* and *2n+1*.

5 ✓ a. [5 pts] Draw the portion of the state space for states 1 (root) to 15.

10 b. [20 pts] Suppose the goal state is 11. List the order in which nodes will be visited (expanded) for the following search strategies:

✓ i. [5 pts] Breadth-First Search

✓ ii. [5 pts] Depth-Limited Search with limit = 3

✗ iii. [10 pts] Iterative Deepening Search

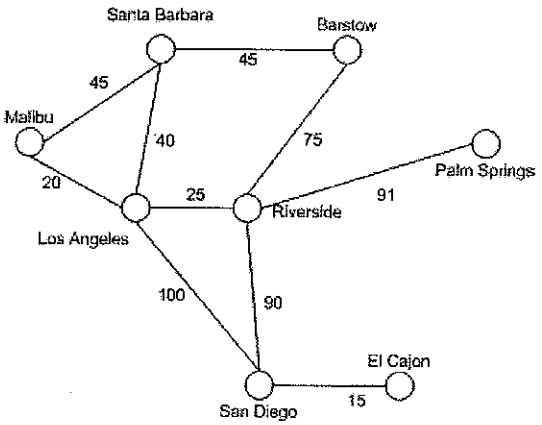
c. [5 pts] Would bidirectional search be appropriate for this problem? If so, describe how it would

3 work (i.e. define initial state, successor function, goal test). Also, what is the branching factor in each direction of the bidirectional search, if applicable?

0

Problem 5. [25 points] – Informed/Heuristic Search

Consider the simplified map of California (with actual distances) shown in the figure below/left, and the straight-line distances to Palm Springs in the table next to it.



Barstow	**55**
El Cajon	**80**
Los Angeles	**110**
Malibu	**130**
Palm Springs	**0**
Riverside	**90**
San Diego	**105**
Santa Barbara	**80**

[20 points] Build and show/draw the **search tree** for finding the shortest path **from Malibu to Palm Springs** using the **A*** search. When expanding a node, its successors are generated in ***alphabetical*** order (e.g. Barstow's successors are Riverside and Santa Barbara as the left and the right sub-tree accordingly). You must show the following:

a) Next to each node in the tree, print the *g*, *h*, and *f* values.
b) On the edges of the tree, show the step cost (the values are shown on the map).
c) Separately, print the list of nodes in the order you expanded them.

When expanding nodes with the same *f*-value use alphabetical ordering to break such ties (if any exist).

[5 points]: In the table above, if the SLD from Malibu to Palm Springs would have been 150, what can you say about the heuristic used?

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Problem 6. [20 points] – Local Search/GA

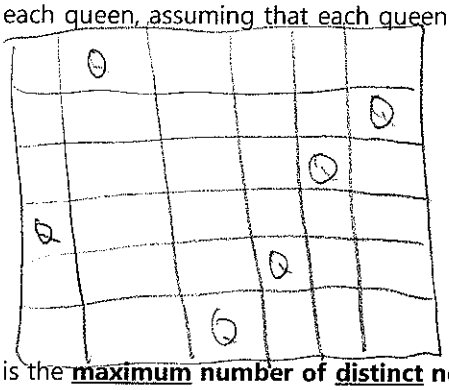
Consider the 6-Queens problem and the following population of four states/individuals. The notation represents the row number for each queen, assuming that each queen is located on a different column. (Row 1 is the bottom row).

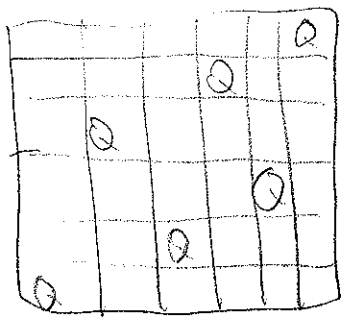
3	6	1	2	4	5

1	4	6	5	1	4

5	6	4	1	3	2

3	1	3	6	5	1





1 a. [4 pts] (*Counting*) What is the **maximum number of distinct non-attacking pairs** of queens for the 6-queens problem **in general**? Show your computation.

4 b. [4 pts] For each of the four individuals, **compute** the fitness function.
- ✓ Use the number of ***non-attacking*** pairs of queens (as max number of non-attacking pairs *minus* the number of attacking pairs).
- ✓ Use the blank chess boards shown at the end of this problem.

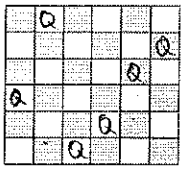
3 c. [3 pts] Apply selection on the above population assuming that only the three fittest individuals survive the process. **Which individual will be dropped?**
- ✓ To generate two pair of parents (population of four), from the three fittest, duplicate the individual with the lowest numeric value among these three, if you were to consider each state a *6-digit number*.

4 d. [4 pts] Preserving the initial top-down order of the individuals, apply crossover on the two pairs of parents (from above), as follows:
   i. For the first (top) pair of parents, the crossover point is between columns 3 and 4
   ii. For the second pair, the crossover point is between the 4th and 5th columns.

   Show the crossover process and the resulting offspring.

2 e. [2 pt.] From the top pair of offspring (in *d* above), select the individual with higher numeric value, and apply some random mutation to the *third column* (your choice for the value). Show the mutation applied and the resulting individual.

3 f. [3 pts] What particular mutation to the third column in *e.* above would generate a solution to the 6-queens problem, if any?



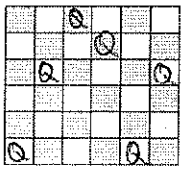
3	6	1	2	4	5

3 attacking pairs

2 + 1 = 3 attacking

12 non attacking ✓

12 − 3 = 9

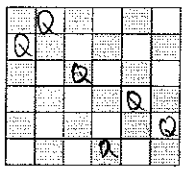


1	4	6	5	1	4

4 attacking pairs

1 + 2 + 1 = 4 attacking

11 non attacking ✓ 11 − 4 = 7

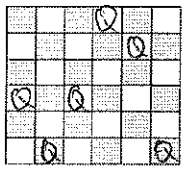


5	6	4	1	3	2

4 attacking pairs

1 + 2 + 1 = 4 attacking

11 non attacking ✓ 11 − 4 = 7



3	1	3	6	5	1

5 attacking pairs

2 + 1 + 2 + 1 = 5

10 ✓ 10 − 5 = 5

Initial Population ✓

incomplete calculation of the fitness function but correct numerators:

$\frac{12}{12+11+11+10} = \frac{12}{44} = 27\%$

$\frac{11}{12+11+11+10} = \frac{11}{44} = 25\%$

$\frac{11}{\cdots}$ ... 25%

$\frac{10}{\cdots}$ ... 23%

4, (5), 6 (7)

Z = (3 (4 (5) 6) ((7))) => 3, (4 (5) 6), ((7))

Z = 8 3 = (9,10) => 9,10

Part III

20

Problem 7. [20 points] – LISP

The following hierarchical list is given: L=((3 (4 (5) 6) ((7))) 8 (9 10)).

a. [2 pts] What is the length of this list? 3 ✓

b. [2 pts] What is the maximum depth of this list? 4 ✓

c. [16 pts] Fill in the six blank cells in the table below:

Points	Expression	Evaluates to?
2	(CAAR L)	3 ✓
3	✓ (Caadadar L)	**5**
2	(CAADDR L)	9 ✓
3	✓ (cdaddr L)	**(10)**
3	(CONS (CADDR L) 2)	((9,10), 2) ✓
3	(LIST (CADR L) (CDADDR L))	(8 (10)) ✓

Note: Remember that, for example, (CADR L) = (CAR (CDR l))

(Cdr L) = (8, (9,10))

(Cadr L) = 8

(cdar L) = ((4 (5) 6), ((7)))

(Cadar L) = (4, (5), 6)

(Cdadar L) = ((5), 6)

(Caadadar L) = (5)

CaadadarL = 5

(Cdr L) = (8, (9,10))

(Cddr L) = ((9,10))

Caddr L = (9,10)

(Cdaddr L) = (10)

20

Problem 8. [20 points] – F#

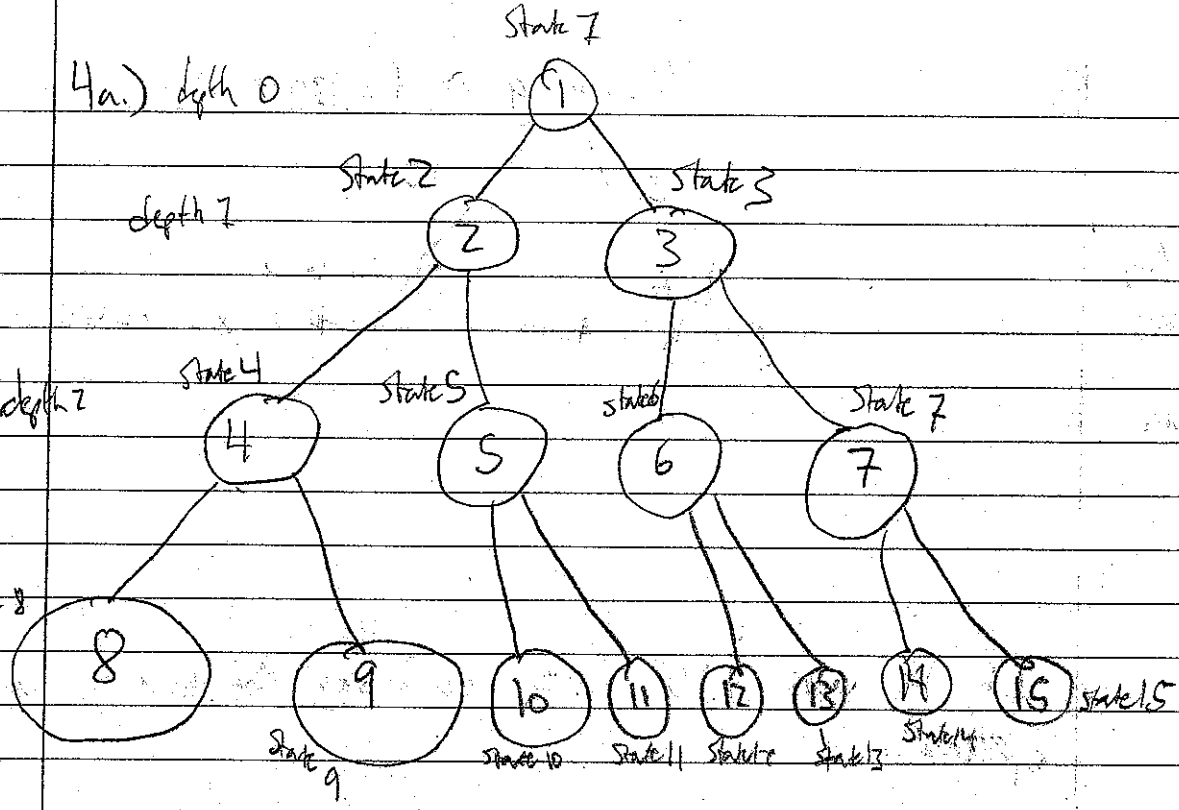
What output does the call to "**testMainFun**" function produce?

```
42    let procFun n =
43      let divs = [2; 3; 5; 7]
44      [for i in divs do
45         match n % i with
46           | 0 -> yield i
47           | _ -> ()
48      ]
49
50    let rec mainFun (x : int list) =
51      match x with
52        | [] -> []
53        | h::t -> mainFun t @ [procFun h]
54
55    let testMainFun () =
56      mainFun [6;4;9;10] |> printfn "%A"
```

(*Note*: The "@" operator appends two lists) [2;5] [3] [2] [2;3] → [2;5 3; 2; 2; 3] ✓ ✓

[2 3 2 2] → returns every number 6 4 9 10 are divisible by or just the first?

4a.) depth 0



b) i. 1, 2, 3, 4, 5, 8, 9, 10, 11 ✓

ii. 1, 2, 4, 8, 9, 5, 10, 11, ✓

iii. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 X

d=0: 1 d=2: 1, 2, 4, 5, 3, 6, 7

d=1: 1, 2, 3 d=3: 1, 2, 4, 8, 9, 5, 10, 11

c. Yes it would because every node has 2 branches and it is perfectly balanced. Initial state = 1, successor function = 2n for one direction and 2n+1 X for other direction. Branching factor = 2 for each direction. On each node another search would start. X

3p/5

5. Malibu $g=0$ $f=130$ $h=0$

20 / \ 40

LA
$g=20$ $h=20$ $f=110$

Santa Barbara
$g=40$ $f=80$ $h=40$

Mal
Los Ang
~~Barbara~~
Mal
Riverside

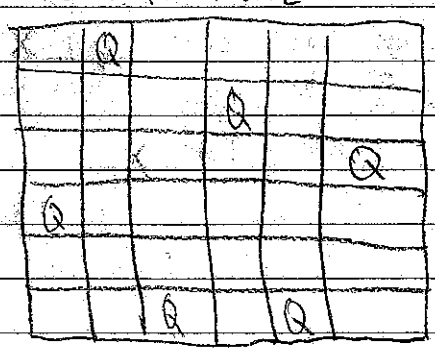
If it was ISO we could say the heuristic was optimal.

6. a.) 0 $5+4+3+2+1=15$
$4+4+3+2+1=14 \cdot 6 \cdot 5 = 720$?

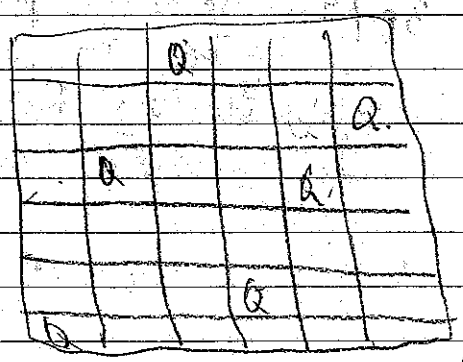
b. on test

c. The 4th would be dropped ✓
4 new individuals
3 6 1 2 4 5
1 4 6 5 1 4
1 4 6 5 1 4
5 6 4 1 3 2 ✓

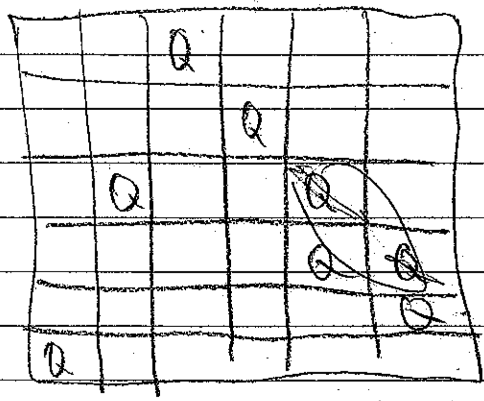
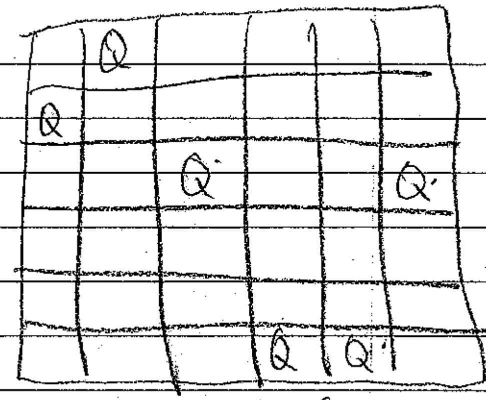
d



✓



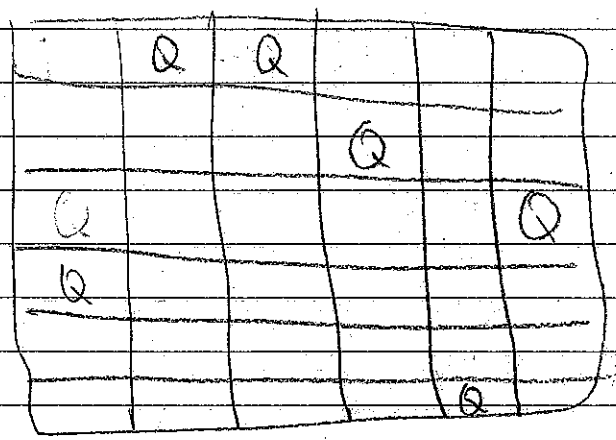
✓

e. 3 6 1 5 1 4

added 5 to col 3

3 6 6 5 1 4



I change it from 1 to 2 would help