Sample Final

You may not share information with other people during the exam.

Exam is closed notes, and no electronic devices may be used.

Questions are equally weighted.

You may choose one question to count as extra credit.
1. Binary

a. What is the binary number 10101101 in base ten?

b. What is the number 108 in binary?

c. Add these binary numbers, showing all carries.

\[
\begin{array}{c}
10011001 \\
+ 00111101 \\
\hline
\end{array}
\]

\[
\begin{array}{c}
10011001 \\
+ 00111101 \\
\hline
100111101
\end{array}
\]
2. Gates

For each scenario, provide a logical expression using only variables, and, or and not, as needed.

a.

x: I am in bed.

y: My spouse is in bed.

z: Sadie the dog is in bed.

When both my spouse and I are in bed, Sadie is in bed.

When I am in bed and my spouse is not, Sadie is in bed.

When I am not in bed but my spouse is, Sadie is in bed.

When neither my spouse nor I are in bed, Sadie is not in bed.

z = ?

b.

x: The downstairs lightswitch is in the up position.

y: The upstairs lightswitch is in the up position.

z: The hallway light is on.

When both lightswitches are up, the hallway light is off.

When both lightswitches are down, the hallway light is off.

When only the downstairs light switch is up, the hallway light is on.

When only the upstairs light switch is up, the hallway light is on.

z = ?
3. Duplicate Finder

We have one big pile of $n$ books.

a. How long does it take to check if any particular title is in the pile? Assume the pile is not sorted.

b. One way to look for duplicate books is to go through each of the books and, for each one, check to see whether its title is somewhere else in the file. How long does this algorithm take?

c. How long does it take to sort the pile by title?
4. Nested Items

What does the sprite say when the green flag is clicked in each of these scripts?

a. when [green flag] clicked
   set i ▼ to 2
   say i for 2 secs

b. when [green flag] clicked
   set i ▼ to 2
   say item 1 of box of stuff ▼ for 2 secs

c. when [green flag] clicked
   set i ▼ to 2
   say item ▼ item 1 of box of stuff ▼ of box of stuff ▼ for 2 secs

d. when [green flag] clicked
   define Selfie 6
   if not number1 = item ▼ number1 ▼ of box of stuff ▼ then
     Selfie ▼ item ▼ number1 ▼ of box of stuff ▼
   else
     say number1 ▼ for 2 secs

   box of stuff
   1 1
   2 3
   3 5
   4 4
   5 1
   6 8
   7 4
   8 7

   length: 8
5. Amdahl’s Coleslaw

We want to make the awesome CS8 coleslaw recipe available to all accepted students. We think it’ll be most effective if they are all handwritten and signed by the professor.

It takes a typical person 4 minutes and 30 seconds to write the recipe and 30 seconds for the professor to sign.

What is the speedup for each of these cases?

a. The professor does all of the writing by himself.

b. Nine TAs do the writing.

c. Eighty-one students in the class do the writing.
6. Deadlock

Categorize the protocols below by the worst kind of stuck that can happen if that protocol is followed to get plates. Answer from the perspective of the plates: A plate is “starved” if it stops being used. “putPlateinDishwasher” waits for the dishwasher to accept dirty dishes.

- **Every** ordering of events starves **everyone**.
- **Every** ordering of events starves **someone**.
- **Some** ordering of events starves **everyone**.
- **Some** ordering of events starves **someone**.
- **No** ordering of events starves **anyone**.

```plaintext
a. when needPlate
   repeat until havePlate
   grabPlateFromTopOfStackIfAvailable
   usePlate
   putPlateInDishwasher

b. when needPlate
   repeat until havePlate
   grabPlateFromTopOfStackIfAvailable
   usePlate
   putPlateInDishwasher

when dishwasherFull
   runDishwasher
   putPlatesOnTopOfStack

when needPlate
   repeat until havePlate
   grabPlateFromTopOfStackIfAvailable
   usePlate
   putPlateInDishwasher

when dishwasherFull
   runDishwasher
   putPlatesOnBottomOfStack
```
7. Calorie Counter

a. Say in words what query the following script answers.

b. What would it say for the data on the right?

<table>
<thead>
<tr>
<th>food</th>
<th>calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabanossi</td>
<td>279</td>
</tr>
<tr>
<td>Cabbage Roll, Stuffed</td>
<td>78</td>
</tr>
<tr>
<td>Cabbage, Bok Choy, Cooked, Fat Added In Cooking</td>
<td>50</td>
</tr>
<tr>
<td>Cabbage, Bok Choy, Cooked, Fat Not Added In Cooking</td>
<td>31</td>
</tr>
<tr>
<td>Cabbage, Bok Choy, Raw</td>
<td>11</td>
</tr>
<tr>
<td>Cabbage, Chinese Flowering, Cooked, Fat Added In Cooking</td>
<td>53</td>
</tr>
<tr>
<td>Cabbage, Chinese Flowering, Cooked, Fat Not Added In Cooking</td>
<td>33</td>
</tr>
<tr>
<td>Cabbage, Chinese Flowering, Raw</td>
<td>11</td>
</tr>
<tr>
<td>Cabbage, Chinese, Celery, Fat Added In Cooking</td>
<td>49</td>
</tr>
<tr>
<td>Cabbage, Chinese, Celery, Fat Not Added In Cooking</td>
<td>30</td>
</tr>
<tr>
<td>Cabbage, Chinese, Celery, Raw</td>
<td>8</td>
</tr>
<tr>
<td>Cabbage, Green, Cooked, Fat Added In Cooking</td>
<td>37</td>
</tr>
<tr>
<td>Cabbage, Green, Cooked, Fat Not Added In Cooking</td>
<td>16</td>
</tr>
<tr>
<td>Cabbage, Green, Raw</td>
<td>17</td>
</tr>
<tr>
<td>Cabbage, Mustard, Salted</td>
<td>14</td>
</tr>
<tr>
<td>Cabbage, Ns As To Type, Cooked, Fat Added In Cooking</td>
<td>40</td>
</tr>
<tr>
<td>Cabbage, Ns As To Type, Cooked, Fat Not Added In Cooking</td>
<td>19</td>
</tr>
<tr>
<td>Cabbage, Raw, Nfs</td>
<td>15</td>
</tr>
<tr>
<td>Cabbage, Red, Canned, Drained</td>
<td>35</td>
</tr>
<tr>
<td>Cabbage, Red, Cooked, Fat Added In Cooking</td>
<td>43</td>
</tr>
<tr>
<td>Cabbage, Red, Cooked, Fat Not Added In Cooking</td>
<td>22</td>
</tr>
<tr>
<td>Cabbage, Red, Pickled (Include Sweet &amp; Sour Cabbage)</td>
<td>91</td>
</tr>
<tr>
<td>Cabbage, Red, Raw</td>
<td>24</td>
</tr>
<tr>
<td>Cake Mix, Angel Food, Dry</td>
<td>374</td>
</tr>
<tr>
<td>Cake Mix, Banana, Dry</td>
<td>395</td>
</tr>
</tbody>
</table>
8. Read The Tree Leaves

a. Apply the decision tree shown here to the data from the previous question. How many examples end up in leaf 1? 2? 3?

b. Let’s say this decision tree has 70% accuracy on the training set. If a learning algorithm says it can achieve 85% accuracy by using a larger tree, should you believe it?

c. Which tree should be preferred, the one to the right or the one with the higher accuracy?
9. Hip Hops

a. What is the end-to-end bandwidth of this path?

b. What is the end-to-end latency of this path?
10. Balsamic Reduction

Below are some actual courses and requirements at Johnson and Wales University. For the purposes of this question, imagine that courses have prerequisites but also that there are some courses that you can take that disqualify you from taking other classes!

- If you take BPA1040 Introduction to Cakes, you can then take BPA2010 Specialty Cakes.
- If you take BPA1015 Classic Pastry, you can then take BPA1040 Introduction to Cakes.
- If you take BPA2626 Baking & Pastry Internship, you can get A.S. degree in Baking & Pastry Arts.
- If you have A.S. degree in Baking & Pastry Arts, you can then take BPA3025 Neo-Classic Desserts.
- If you have A.S. degree in Baking & Pastry Arts, you can then take BPA3340 Wedding Cake Design.
- If you take MATH0010 Basic Mathematics, you can then take MATH1020 Fundamentals of Algebra.
- If you take MATH1020 Fundamentals of Algebra, you can then take MATH3020 Discrete Mathematics.
- If you take BPA1015 Classic Pastry, you can then take BPA1035 Chocolates and Confections.
- If you take BPA3340 Wedding Cake Design, you can then take BPA4020 Advanced Wedding Cake Design.
- If you take MATH0010 Basic Mathematics, you can then take BPA1015 Classic Pastry.
- If you take BPA2010 Specialty Cakes, you can then take BPA2626 Baking & Pastry Internship.
- If you take CUL2626 Culinary Arts Internship, you **cannot** take BPA2626 Baking & Pastry Internship.
- If you take BPA3025 Neo-Classic Desserts, you can then take BPA4199 Advanced Pastry Internship.
- If you take BPA4199 Advanced Pastry Internship, you can then take BPA4030 Advanced Sugar Artistry.
- If you take MATH1020 Fundamentals of Algebra, you **cannot** get B.S. Baking & Pastry Arts.

a. Can you get your B.S. Baking & Pastry Arts if you take BPA1015 Classic Pastry? Why or why not?

b. Can you get your B.S. Baking & Pastry Arts if you take MATH3020 Discrete Mathematics? Why or why not?

c. Can you get your B.S. Baking & Pastry Arts if you take MATH0010 Basic Mathematics? Why or why not?
11. Halt! Or Not.

For each block below, list all inputs for which it will eventually halt.

a. 
```
define popper1 number1
set i to number1
repeat until i > 100
play sound pop
change i by 1
```

b. 
```
define popper2 number1
set i to number1
repeat until i > 20
play sound pop
change i by -2
```

c. 
```
define popper3 number1
set i to number1
repeat until not round i = i
set i to i / 2
play sound pop until done
```

d. 
```
define popper4 number1
set i to number1
repeat until i < 2
play sound pop until done
if not i mod 2 = 0 then
  set i to i + 1
else
  set i to i / 2
```
12. Error Correction

a. What is the simple checksum of 9206494?

b. What is the simple checksum of 6464646464646464646464646464646464646464646464?

c. You receive a message encoded with the pinpoint trick. You rearrange the digits into a square:

```
  2 1 2 9 4
  2 5 0 7 4
  1 4 9 6 0
  7 9 1 4 6
  2 4 2 6
```

Assuming a single digit was corrupted, what was the intended message?

d. You receive a message encoded with the pinpoint trick. You rearrange the digits into a square:

```
  4 5 3 3 5
  2 9 6 8 3
  5 1 8 5 9
  3 5 2 9 9
  4 0 9 5
```

Assuming a single digit was corrupted, what was the intended message?
Design a Huffman code (one bit pattern for each letter) that is optimized for transmitting the word “remorseless”.

a. Write the code tree for r, e, m, o, s, l.

b. How many bits is “remorseless” in your code?

c. What is the encoding for “eels”? 
14. Health-Services Note

When students miss class due to illness, they visit Health Services and are given a note to certify that they were evaluated. CS8 uses these notes to determine who is eligible for make-up quizzes or late hand-ins.

Unfortunately, these notes are very easily forged.

a. Explain how the cryptography we learned in class can be used to rectify this situation. The scheme should satisfy the following properties:

- Health Services can give a message to a student (via email, say). The note includes the name of the student and the date of the visit.
- The student can deliver it to CS8.
- CS8 can verify that the note came from Health Services and was not modified.

b. Why do you suppose such a scheme hasn’t been adopted?