Midterm Computer Organisation CSE1400

Please read the following information carefully!

- This exam consists of 16 multiple-choice questions. Each question is worth 250 points.
- You have 90 minutes to complete this exam.
- Before you hand in your answers, check that your multiple-choice form contains your name and student number, also filled in using the boxes.
- Opening this exam before you are instructed to start is **strictly prohibited**.
- The use of the book, notes, calculators, smart watches, and other aids is **strictly prohibited**.
- Note that the order of the letters next to the boxes on your multiple-choice sheet may **not always be A-B-C-D**!
- Fill in the answer form with **(dark) pencil** or **pen**. If you make a mistake on the answer form, you need to either erase the mistake or copy all answers to a new form.

1. History has shown that capitalism almost came to a grinding halt with respect to claiming the invention of the "digital computer". The patent was only awarded in 1973, when digital computers already entered their second generation.

   The lucky winner(s) of the IP lawsuit was/were:

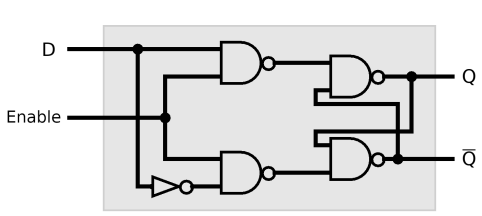
   A. John Atanasoff
   B. Mauchly and Eckert
   C. Howard Aiken
   D. Charles Babbage

2. In the past, the Netherlands could see some cold winters. In some cases snow would fall for days and temperatures would stay below 0 for weeks. These extreme conditions could cause a school to close prematurely or not even open at all. In the Netherlands, schools only have "ijsvrij" (a snow day) occur when certain conditions are hit.

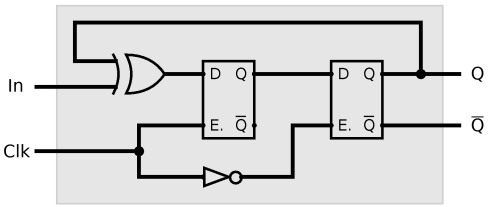
   The current temperature is stored in °C as T. T is represented as a 3 bit unsigned number $T = t_2 t_1 t_0$ where t_2 is the most significant bit; temperatures that are higher than 7 °C are stored as 111, temperatures that are below zero are stored as 000. On any particular day, students will have "ijsvrij" when temperature T drops below 3.

   Find a minimal Sum-of-Products equation that is only true when students have "ijsvrij".

   A. $\overline{t_2} \cdot t_1 + \overline{t_2} \cdot \overline{t_0}$
   B. $\overline{t_2} \cdot \overline{t_1} + \overline{t_1} \cdot \overline{t_0}$
   C. $\overline{t_2} \cdot \overline{t_1} + \overline{t_2} \cdot \overline{t_0}$
   D. $\overline{t_2}$



(a) A gated D-latch.



(b) Stephen's flip-flop circuit, using two D-latches from Figure 1a.

Figure 1

3. Stephen has built a flip-flop circuit using two gated D-latches, an XOR gate and a NOT gate, as shown in Figure 1b. Indicate what type of flip-flop Stephen has created, and whether it is positive (leading) edge or negative (trailing) edge triggered.

   A. Positive edge triggered master-slave D flip-flop
   B. Negative edge triggered master-slave D flip-flop
   C. Positive edge triggered T flip-flop
   D. Negative edge triggered T flip-flop

4. Which type of gate is represented in Figure 2?

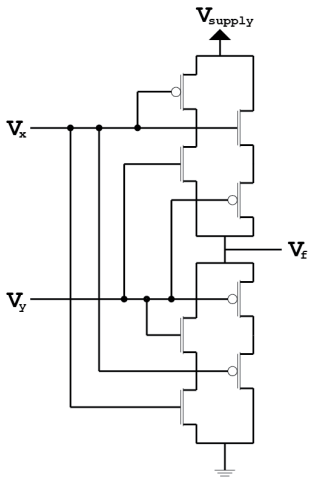
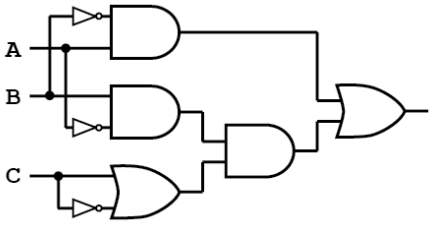


Figure 2

A. OR-gate
B. AND-gate
C. XOR-gate
D. NOR-gate

5. Layton's assistant Luke is still struggling with the notion of translating logic to circuits. He has been presented with 4 different layouts to choose from, which one computes the following function?
$f(A, B, C) = \overline{(A + \overline{B}) \cdot (\overline{A} + B \cdot (C + \overline{C}))}$

A.


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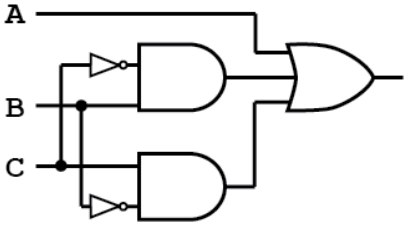
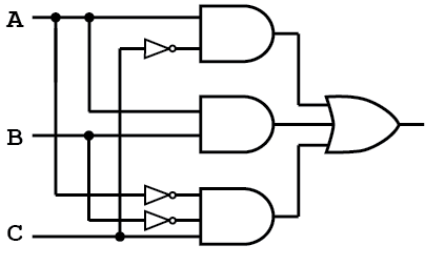
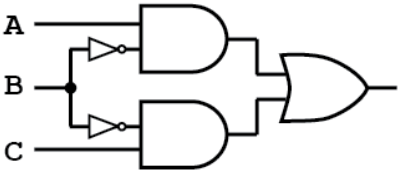
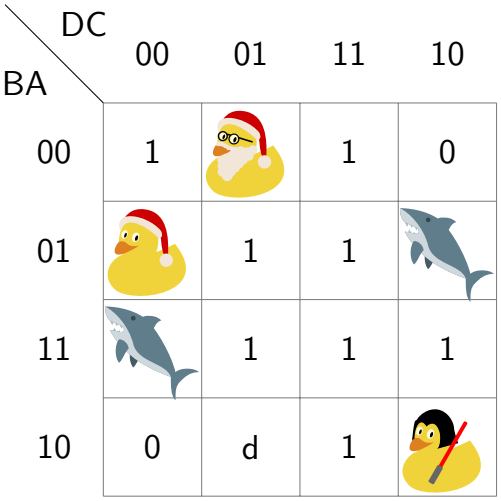


B.


D.


6. The ducks and sharks rally that began at the Reasoning & Logic multiple-choice test is still going strong. With renewed slogans like "Dear sharks, apologies for our earlier remarks!" they still hope to re-establish peace between the factions.

   Unfortunately their rally has also made them walk straight over a Karnaugh map. All we know is that the map represents a function with 3 (min)terms (T) and 5 variables (V). Which of the following is possible given these ducks and sharks?



   A. All the ducks stepped on "don't cares", and the sharks stepped on zeroes.
   B. All the ducks stepped on ones, and the sharks stepped on ones.
   C. All the ducks stepped on zeroes, and the sharks stepped on "don't cares".
   D. All the ducks stepped on "don't cares", and the sharks stepped on ones.

7. You are following a course with Professor Alex as teacher. In his course, you can score points towards your final grade in all kinds of ways. So far, you have obtained 11100011_2 points from doing quizzes, AAD_{16} points worth of lab exercises, and 3241_5 points at the exam. Alex says that you can earn even more points if you can correctly calculate your final score! What is your total number of points earned so far?

   A. 3331_{10}
   B. 3406_{10}
   C. 3630_{10}
   D. 3679_{10}

8. Prof. dr. Hook is tasked with improving the new floating point standard created by the CSE1400 team last year to be used for storing grades efficiently. The improvements should make sure that a grade between 1 and 10 (inclusive) can be represented exactly to a quarter grade point, for example: 9.75, 8.25, 5.75.

   How many bits should he pick for the sign bit, mantissa, and exponent? Assume the exponent is represented as an unsigned integer.

   A. 1 sign bit, 4 mantissa bits, 2 exponent bits
   B. no sign bit, 5 mantissa bits, 2 exponent bits
   C. no sign bit, 4 mantissa bits, 2 exponent bits
   D. 1 sign bit, 4 mantissa bits, 3 exponent bits

9. When using a digital circuit that adds two four-bit 2's complement numbers ($a_3a_2a_1a_0$ and $b_3b_2b_1b_0$) that produces a four-bit sum ($s_3s_2s_1s_0$), it is possible that a positive or negative overflow occurs when adding together two numbers that are very large.

   If you were to calculate whether a positive or negative overflow has occurred based on the input and output signals, which formulas should you use to do so?

   A. Positive overflow: $a_3 \cdot b_3 \cdot s_3$; Negative overflow: $\overline{a_3} \cdot \overline{b_3} \cdot \overline{s_3}$
   B. Positive overflow: $\overline{a_3} \cdot b_3 \cdot s_3$; Negative overflow: $a_3 \cdot \overline{b_3} \cdot s_3$
   C. Positive overflow: $a_3 \cdot b_3 \cdot \overline{s_3}$; Negative overflow: $\overline{a_3} \cdot \overline{b_3} \cdot s_3$
   D. Positive overflow: $\overline{a_3} \cdot \overline{b_3} \cdot s_3$; Negative overflow: $a_3 \cdot b_3 \cdot \overline{s_3}$

10. Sonic the Porcupine is in the process of building a clock-based electronic circuit. Sonic being Sonic, he wants the circuit to work as fast as possible. Sonic knows that the speed of his circuit depends on the maximum number of logic gates that a signal needs to propagate through, so he has already optimised his circuit in such a way that the longest signal propagation path through his circuit is at most 10 gates between the input and the output wires.

    With every rising edge of the clock signal, the state of the gates will change. During the time that the signal propagates through the gates, the output signal will be unstable. Sonic knows that the output signal cannot be stable all the time, but he does want the output of the circuit to be stable for at least $95\,\%$ of the time.

    The propagation delay of each gate is 0.05 ns and the transition time of each gate is negligible. What is the maximum clock frequency that Sonic's circuit can operate with?

    A. 40 MHz
    B. 100 MHz
    C. 400 MHz
    D. 1 GHz

11. Mr. Johnson has a digital counter clock on his desk that increments its displayed value by one every hour. However, he would like to use this counter instead to count down to an important event involving a country leaving a specific group of countries.[1]

    The clock's current value is $0001\ 0011\ 0011\ 0111$ (BCD) and the important event will occur at hour $0001\ 1000\ 1001\ 0100$ (Excess-2048) if the clock would just continue counting.

    With what value should the countdown clock start when it is programmed to count down to the event (in 2's complement)?

    A. $0000\ 0101\ 0101\ 1101$
    B. $0000\ 1011\ 0101\ 1011$
    C. $0001\ 0101\ 1100\ 1101$
    D. $0001\ 1011\ 0101\ 1011$

[1] Any resemblance to actual persons, living or dead, or actual events is purely coincidental.

12. Hannah commutes to EEMCS using public transport every day. She wants to make sure that she is following the shortest route, because less travel time means more time to study. To do so, she wants to find out all travel times in seconds of all possible routes. She knows that there are no reasonable routes through the Netherlands that take more than 10000 seconds. Hannah figured she would have to use the least number of bits possible to store each travel time.

    Which number representation should she choose?

    A. Binary Coded Decimal
    B. Excess-10000
    C. Two's complement
    D. Unsigned integer

13. Which of the following statements is **true** about an IEEE-754 32-bit number?

    A. $1/0$ is not representable as an IEEE-754 number.
    B. $2^{64} \cdot 2^{-64}$ is not representable as an IEEE-754 number.
    C. $2^{64} \cdot 2^{64}$ is not representable as an IEEE-754 number.
    D. $2^{100} + 2^{100}$ is not representable as an IEEE-754 number.

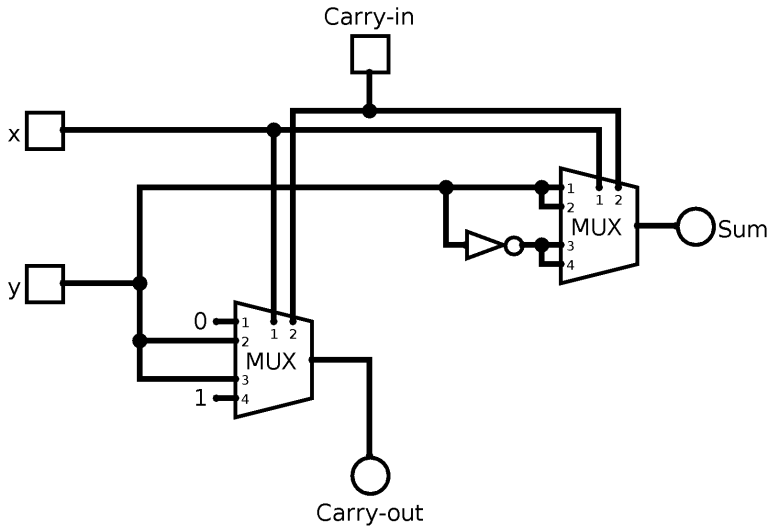


Figure 3: Boole's circuit, containing a mistake

14. André-Marie Ampère and George Boole are participating in the annual Circuit Olympics (CO). One of the challenges is to build a full adder circuit component with only multiplexers and NOT gates. Boole comes up with a design in the blink of a CPU cycle and proudly shows it to Ampère. However, Ampère replies with laughter, as he immediately spots a mistake in Boole's design. What should change in Boole's design (shown in Figure 3) to be a correct full adder?

    A. Switch the select inputs for the multiplexer that outputs the sum
    B. Switch the select inputs for the multiplexer that outputs the carry-out
    C. Switch data inputs 1 and 3 for the multiplexer that outputs the sum
    D. Switch data inputs 2 and 4 for the multiplexer that outputs the sum

15. The CO-42 standard, invented last year by CSE1400 instructors to replace IEEE-754, returns this year due to popular request with a few changes. CO-42B works the same way as IEEE-754, with the following specifications:

    - There are 20 bits in total,
    - the exponent is 8 bits representing the exponent in excess-127,
    - the mantissa is 11 bits,
    - one sign bit.

    What is the decimal value represented by $1\ 10000110\ 10010101000$.

    A. 101.25

    B. -202.5

    C. -101.25

    D. -149

16. A student just wrote the following snippet of 64-bit assembly code (AT&T syntax, so the order of the operands is "*source, destination*"):

```
1          foobar:
2                  push    %rbp
3                  mov     %rsp, %rbp
4
5                  push    $8
6                  mov      , %rcx
7                  mov     , %rax
8                  add     %rcx, %rax
9
10                 mov     %rbp, %rsp
11                 pop     %rbp
12
13                 ret
14         main:
15                 push    $1
16                 push    $2
17                 push    $4
18                 call    foobar
```

    Unfortunately, there is a fly sitting on her screen, hiding some memory address at lines 6 and 7. What memory addresses is the fly covering, such that the value 5 ends up in the %rax register after the call to `foobar` in the `main` routine?

    A. -8(%rbp) and -24(%rbp)

    B. 8(%rbp) and 24(%rbp)

    C. -16(%rbp) and -32(%rbp)

    D. 16(%rbp) and 32(%rbp)

End of exam