Q: Why are binary digits so small?

A: When they eat, they only get 1/8 of a byte each

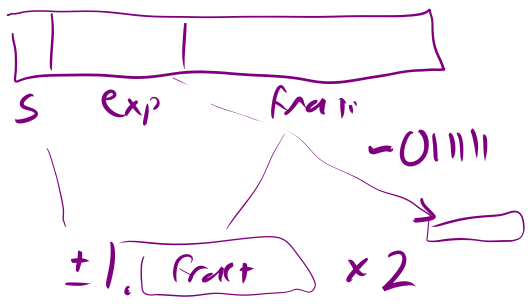
✗ ray-clock-ID-thing

basics Pro/con parent

✓ 2018 A Q12

bitfiddle << set >> clear flip

✓ flours



✓ 2019 Q5

✓ 3-input Mux

✓ 2018P 6-8 proof

✓ 2018P Q9

✓ 2019 Q10

✓ 2018P Q10

✓ our ISA - Hex, reserved

✓ endian

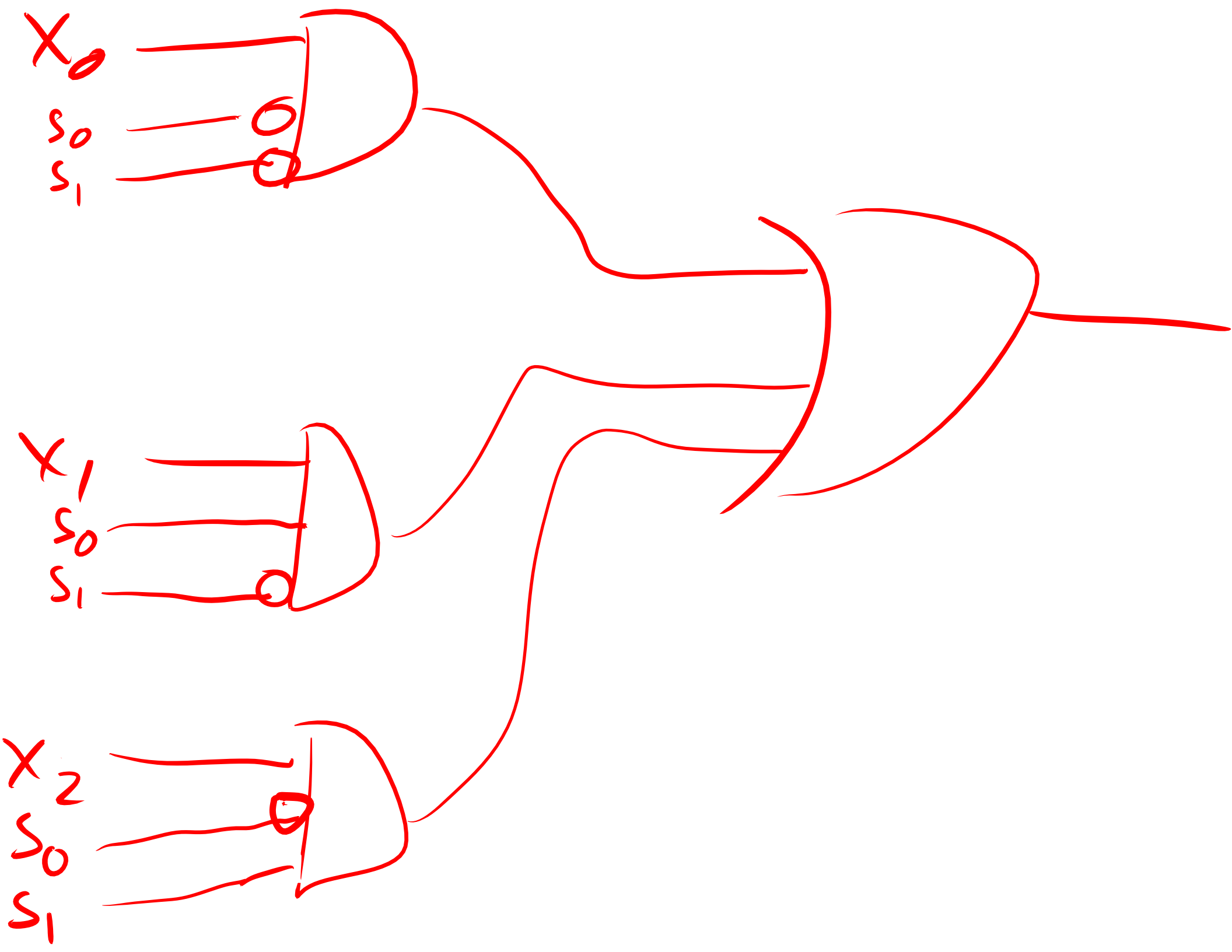
✓ 2018P Q12

✓ Q2 Q4

2018 P 6, 8, 9, 10, 12

2018 A 12

2019 5, 10


X0
S0
S1
X1
S0
S1
X2
S0
S1

endian

> 8 bit value
w/o distinct parts

0x|00|01|23|45

little end

big end

byte-addressable memory

address	45	little-endian
addr+1	23	
addr+2	01	
addr+3	00	

00 big endian

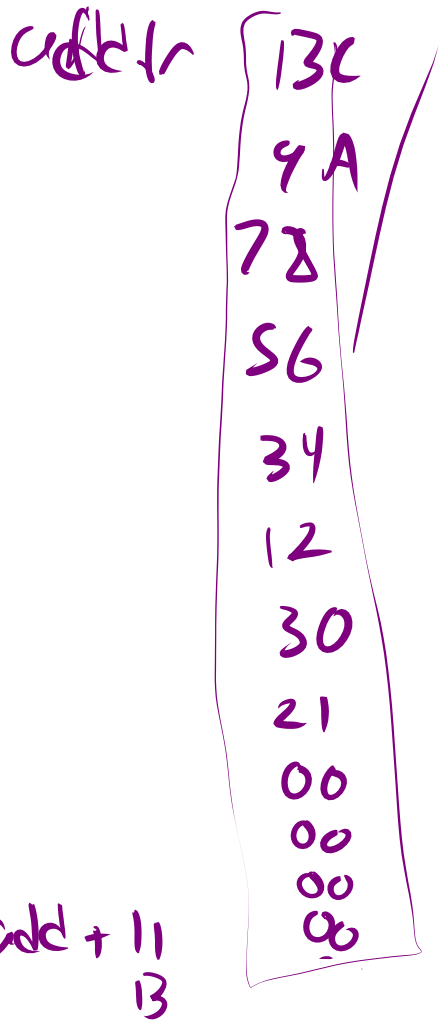
01

23

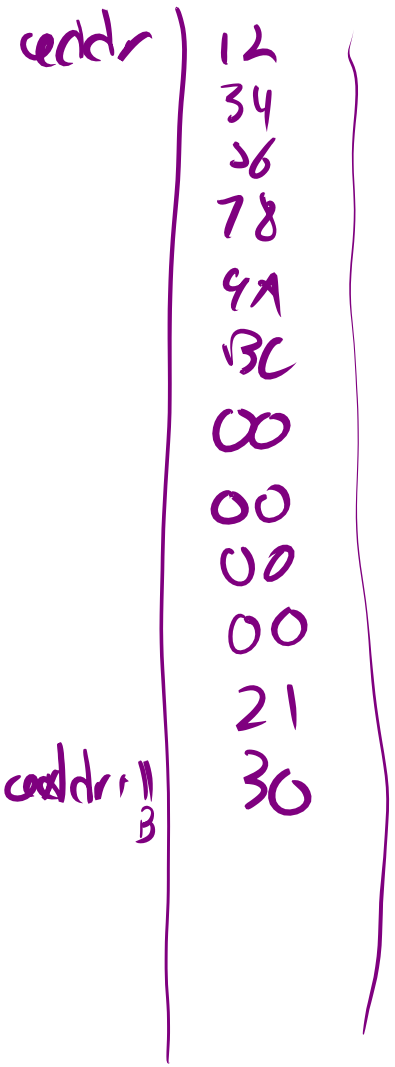
45

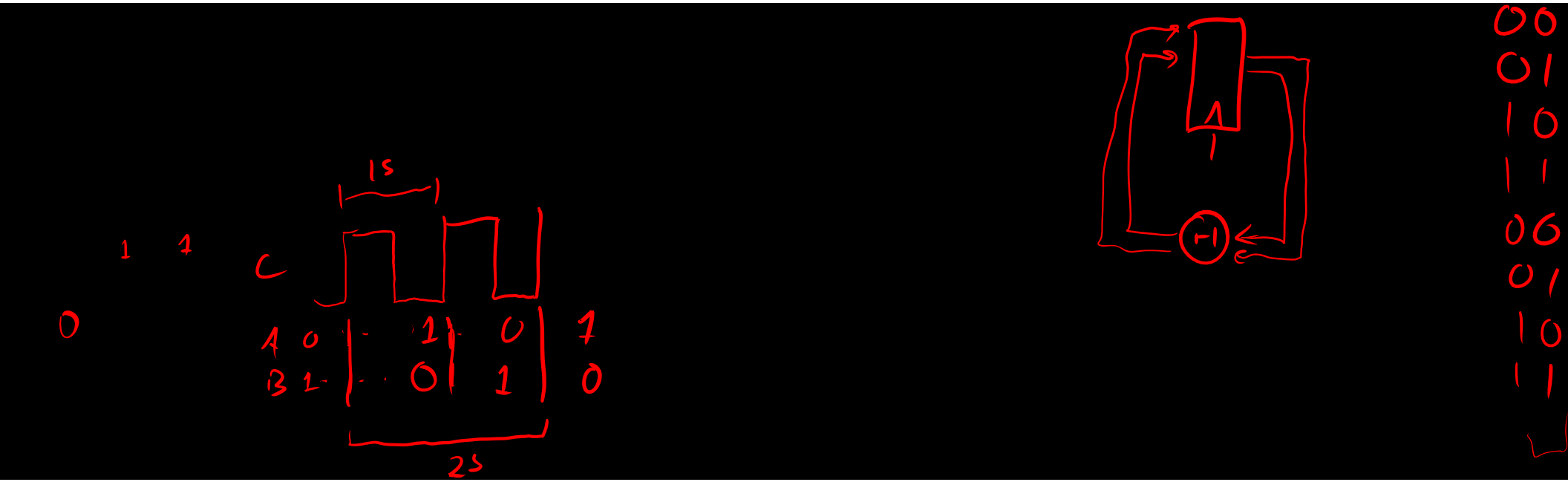
[0x123456789ABC / 0x0000000002130]

LE



BE




1s
2s
A
r=1

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Letters go in the boxes unless otherwise specified (e.g., for **C** 8 write "C" not "8").
Write Letters clearly: if we are unsure of what you wrote you will get a zero on that problem.
Bubble and Pledge the exam or you will lose points.
Single-select by default: Multiple select are all clearly marked; answer them by putting 1 or more letters in the box, or writing "none" if none should be selected.
Mark clarifications: If you need to clarify an answer, do so, and also add a ⋆ to the top right corner of your answer box.

.....

Question 1 [2 pt]: What is 0xC2 in decimal?

Answer:

Information for questions 2–5
The following assume 8-bit 2's-complement numbers. For each number, bit 0 is the low-order bit, bit 7 is the high-order bit.

Question 2 [2 pt]: (see above) Complete the following sum, showing your work (carry bits, etc)

```
  0 0 0 1 1 1 0 0
+ 0 0 1 1 1 1 1 0
-----------------
```

Question 3 [2 pt]: (see above) If you add two negative numbers, you have experienced overflow if

A the carry resulting from adding bit 7 is 0
B the carry resulting from adding bit 7 is 1
C the result is negative
D the result is positive

Answer:

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.....

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Answer:

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  0 0 0 1 1 1 0 0
+ 0 0 1 1 1 1 1 0
-----------------
```

Question 3 [2 pt]: (see above) If you add two negative numbers, you have experienced overflow if

A the carry resulting from adding bit 7 is 0
B the carry resulting from adding bit 7 is 1
C the result is negative
D the result is positive

Answer:

Information for questions 4–5
The following ask about **biassed** signed integers.

Question 4 [2 pt]: (see above) If the high-order bit of a **biassed** number is `1`, then the value it represents is

A `< 0`
B `<= 0`
C `== 0`
D `!= 0`
E `>= 0`
F `> 0`

Answer:

Question 5 [2 pt]: (see above) If the high-order bit of a **biassed** number is `0`, then the value it represents is

A `< 0`
B `<= 0`
C `== 0`
D `!= 0`
E `>= 0`
F `> 0`

Answer:

Information for questions 6–11
Each question gives two expressions of 32-bit two's-compliment integers `x` and `y`. If the two are equivalent for all `x` and `y`, write "same"; otherwise, write an example `x` (and `y` if used in the expressions) for which the two are different.
_____ add example

$\sim x+1 = -x \quad \equiv \quad -x-1 = \sim x$

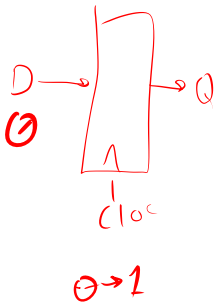
Question 6 [2 pt]: (see above)
`x + y` and `~((-x) + (~y))` *(note that's two ~ and one -)*

$-(-x + (-y-1)) - 1 \qquad (x + y + 1) - 1 = x+y$

Same

Question 7 [2 pt]: (see above)
`x + x + x` and `(x<<1) + x`

Question 8 [2 pt]: (see above)
`!x` and `1 & ~((x>>16) | (x>>8) | (x>>4) | (x>>2) | (x>>1) | x)`



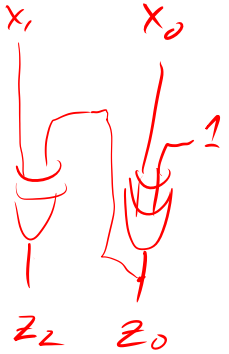
Question 9 [2 pt]: The register type we discussed in class (the positive-edge-triggered D flip-flop) has inputs `D` and `clock` and output `Q`. What signals need to be provided to `D` and `clock` to change `Q` from `1` to `0`? Assume `D`, `clock`, and `Q` are all `1` before your description is used.

Answer: D = 0

clock = 0 then 1

Question 10 [2 pt]: Draw a 4-bit decrement circuit: that is, a set of logic gates with 4 input wires (x_0 though x_3) and four output wires (z_0 through z_3) such that the output is numerically 1 less than the input ($z = x + -1$).

1100
- 1
1



Information for questions 11–12

Suppose we extended the ISA simulator you wrote in Lab 04 and PA 03 with the following code:

```
if (reserved == 1 && icode == 1) {
  M[oldPC + 1] = M[oldPC + 2];
  return oldPC + ____;
}
```

1 | 0x01 |
a icod A B
9

Question 11 [2 pt]: (see above) What number should be placed in the `return` statement where the code above has `____`?

Answer:

Question 12 [2 pt]: (see above) Using the new instruction, write a program that moves a value from address `0x12` to address `0x34`. Answer in hexadecimal bytes, separated by spaces.

Answer: 90 34 12

M[0x34] = M[0x12]

Information for questions 13–14

Suppose we extended the ISA simulator you wrote in Lab 04 and PA 03 with the following code:

```
if (reserved == 1 && icode == 2) {
    R[a] = M[M[oldPC + 1] + R[b]];
    return oldPC + ____;
}
```

Question 13 [2 pt]: (see above) What number should be placed in the `return` statement where the code above has `____`?

Answer:

Question 14 [2 pt]: (see above) Suppose there is an array of bytes starting at address `0x40`. Using the new instruction, write a program that reads into R_3 the byte at index R_0 of that array. Answer in hexadecimal bytes, separated by spaces.

Answer: _____

Question 15 [2 pt]: If the 32-bit number `0x12345678` is stored in **big-endian** at address `0x20`, what is the value of the byte at address `0x22`? Answer in hexadecimal.

Answer:

Question 16 [2 pt]: If you read the bytes [`ba`, `98`] as an unsigned **little-endian** 16-bit number, what is that number? Answer in hexadecimal.

Answer: 0x 98 ba

Question 17 [2 pt]: Which of the following are true statements about back doors? **Select all that apply** by putting 1 or more letters in the box. If none are true, write "none" in the box.

A They can allow others to control your computer without your knowledge.
B They can be added to a large project by one or two people with relatively little work.
C They can be hidden in a way that makes them very hard to find.
D They can be added in hardware.
E They can be added in compilers.
F They can be added in software.

Answer:

Information for questions 18–19
We discussed in class about patenting an ISA. These questions are about that and related ideas.

Question 18 [2 pt]: (see above) Why would copyrighting an ISA not be sufficient intellectual property protection to prevent clone products being created?

Answer: _____

_____

Question 19 [2 pt]: (see above) Many people consider patents an important way to fuel invention and share knowledge. Why?

Answer: _____

_____

.....

Pledge:

On my honor as a student, I have neither given nor received aid on this exam.

_____
Your signature here

COA1 Exam 1 – Fall 2018

Name: _____ Computing ID: _____

Letters go in the boxes unless otherwise specified (e.g., for **C** 8 write "C" not "8").
Write Letters clearly: if we are unsure of what you wrote you will get a zero on that problem.
Bubble and Pledge the exam or you will lose points.
Single-select by default: Multiple select are all clearly marked; answer them by putting 1 or more letters in the box, or writing "none" if none should be selected.
Mark clarifications: If you need to clarify an answer, do so, and also add a ⋆ to the top right corner of your answer box.

.....

Question 1 [2 pt]: What is 140 in hexadecimal?

Answer:

Information for questions 2–5
The following assume 8-bit 2's-complement numbers. For each number, bit 0 is the low-order bit, bit 7 is the high-order bit.

Question 2 [2 pt]: (see above) Complete the following sum, showing your work (carry bits, etc)

```
  0 0 1 1 0 0 1 1
+ 0 1 1 0 0 1 1 0
-----------------
```

Question 3 [2 pt]: (see above) If you add two positive numbers, you have experienced overflow if

A the carry resulting from adding bit 7 is 0
B the carry resulting from adding bit 7 is 1
C the result is negative
D the result is positive

Answer:

Information for questions 4–5
The following ask about **2's complement** signed integers.

Question 4 [2 pt]: (see above) If the high-order bit of a **2's complement** number is `0`, then the value it represents is

A `< 0`
B `<= 0`
C `== 0`
D `!= 0`
E `>= 0`
F `> 0`

Answer:

Question 5 [2 pt]: (see above) If the high-order bit of a **2's complement** number is `1`, then the value it represents is

A `< 0`
B `<= 0`
C `== 0`
D `!= 0`
E `>= 0`
F `> 0`

Answer:

Information for questions 6–11
Each question gives two expressions of 32-bit two's-compliment integers `x` and `y`. If the two are equivalent for all `x` and `y`, write "same"; otherwise, write an example `x` (and `y` if used in the expressions) for which the two are different.
———— add example

Question 6 [2 pt]: (see above)
`x + y` and `((x & y)<<1) + (x ^ y)`

Question 7 [2 pt]: (see above)
`(x<<2) + (x>>1)` and `((x<<3) + x)>>1`

Question 8 [2 pt]: (see above)
`x | (x>>1)` and `x ^ (x>>1)`

Question 9 [2 pt]: The register type we discussed in class (the positive-edge-triggered D flip-flop) has inputs `D` and `clock` and output `Q`. If `Q` was `0` before, which of the following will leave it `0`?

Select all that apply by putting 1 or more letters in the box. If none are true, write "none" in the box.

A keeping `clock` at `0`, transition `D` from `0` to `1`
B keeping `clock` at `1`, transition `D` from `1` to `0`
C keeping `D` at `0`, transition `clock` from `0` to `1`
D keeping `D` at `1`, transition `clock` from `1` to `0`

Answer:

Question 10 [2 pt]: Draw a 3-input multiplexer circuit: that is, a set of logic gates with 3 input wires (x_0 through x_2), two selection wires (s_0 and s_1), and one output wire (z) such that $z = x_i$ if $s = i$; it may do anything you wish if $s = 3$.

Information for questions 11–12

Suppose we extended the ISA simulator you wrote in Lab 04 and PA 03 with the following code:

```
if (reserved == 1 && icode == 1) {
  M[M[oldPC + 1]] = R[a];
    return oldPC + ____;
}
```

Question 11 [2 pt]: (see above) What number should be placed in the `return` statement where the code above has `____`?

Answer:

Question 12 [2 pt]: (see above) Using the new instruction, write a program that moves the contents of register 3 into address `0x20`. Answer in hexadecimal bytes, separated by spaces.

Answer: _____

Question 13 [2 pt]: If the 32-bit number `0x12345678` is stored in **little-endian** at address `0x20`, what is the value of the byte at address `0x22`? Answer in hexadecimal.

Answer:

Question 14 [2 pt]: If you read the bytes [`fe`, `dc`] as an unsigned **big-endian** 16-bit number, what is that number? Answer in hexadecimal.

Answer:

Question 15 [2 pt]: Which of the following is a reason why we should trust that our computer chips do not contain back-doors?
Select all that apply by putting 1 or more letters in the box. If none are true, write "none" in the box.

A There's so much code out there, if there was a back door some code would have found it.
B Back doors are hard to build and slow computers down.
C Back doors are created by programmers, not hardware designers.
D Chips are built by the joint efforts of thousands of people. If a back door was added, one of them would have leaked that to the press.

Answer:

Question 16 [2 pt]: Copyrights can protect a description of an ISA, but not the ISA itself. If ISAs are considered to be inventions, patents could protect them, preventing others for using the same ISA (without paying royalties) until the patent expires (typically after 20 years).

Opinions about the patentability of ISAs are varied. Provide one reason for and one reason against the patentability of an ISA. Note that "I want free computers" is not a sufficient reason against…

Pro-patent: _____

_____

Anti-patent: _____

_____

Pledge:

On my honor as a student, I have neither given nor received aid on this exam.

_____
Your signature here

COA1 Exam 1 – Fall 2019

Name: _____ Computing ID: _____

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Bubble and Pledge the exam or you will lose points.
Single-select by default: Multiple select are all clearly marked; answer them by putting 1 or more letters in the box, or writing "`none`" if none should be selected.
Page-at-a-time Grading: We scan your exam and grade each page separately. Do not refer to other pages, scrratch paper, etc., in your answer.
Mark clarifications: If you need to clarify an answer, do so, and also add a ⋆ to the top right corner of your answer box.

.....

Question 1 [2 pt]: What is `0x3D` in decimal?

Answer:

Question 2 [2 pt]: What is `0b1100101000111110` in hexadecimal?

Answer:

Information for questions 3–4
The following assume 8-bit 2's-complement numbers. For each number, bit 0 is the low-order bit, bit 7 is the high-order bit.

Question 3 [2 pt]: (see above) Complete the following sum, showing your work (carry bits, etc)

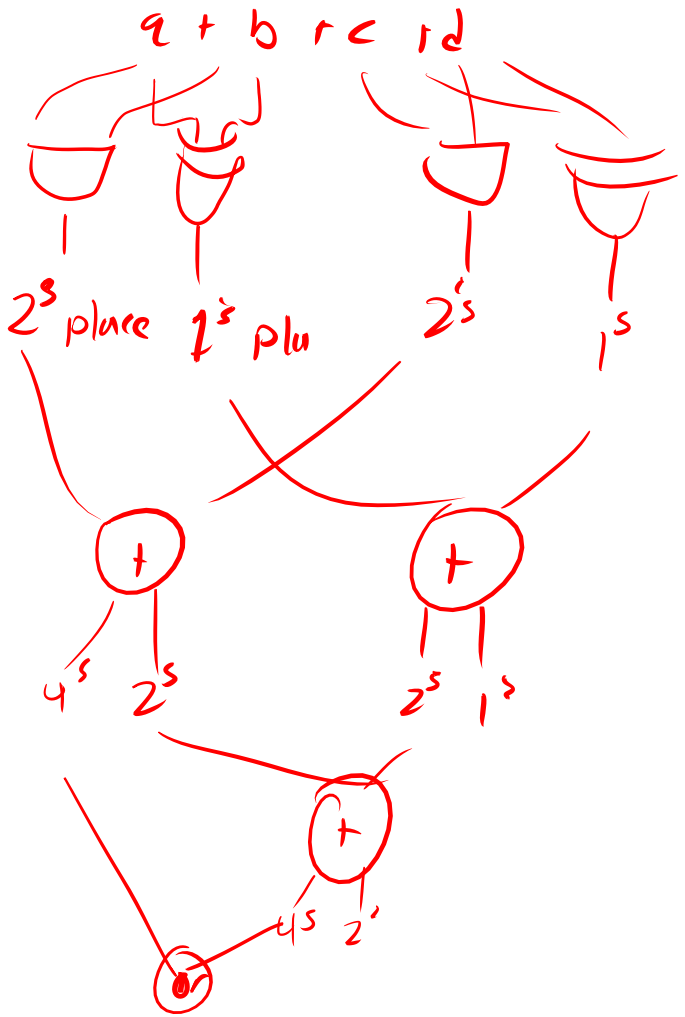
```
  1 1 0 0 0 1 0 0
+ 1 0 0 1 1 1 1 0
-----------------
```

Question 4 [2 pt]: (see above) We call it overflow if the correct mathematical answer cannot fit in the available bits. Which of the following *can* experience overflow?
Select all that apply by putting 1 or more letters in the box.

A positive + positive
B positive + negative
C negative + positive

Answer:

Question 5 [4 pt]: Draw a 4-input adder for single-bit values: that is, a set of logic gates with 4 input wires (no need to name them) each representing a number between 0 and 1 and a multi-bit output z, composed of wires z_0 through $z_{...}$ (where z_0 is the low-order bit, z_1 the next, etc., up to the number of wires needed for this task). The gates should ensure that z = the sum of all four inputs.



Question 6 [2 pt]: A normalized floating-point number is positive if

A the high-order bit is 0
B the high-order bit is 1
C the high-order bit of the exponent is 0
D the high-order bit of the exponent is 1
E the exponent is not 0
F the high-order bit of the fraction is 0
G the high-order bit of the exponent is 1
H the fraction is not 0

Answer:

Information for questions 7–9
Each question gives two expressions of 32-bit two's-compliment integers `x` and `y`. If the two are equivalent for all `x` and `y`, write "same"; otherwise, write an example `x` (and `y` if used in the expressions) for which the two are different.

Question 7 [2 pt]: (see above)
`x ^ y ^ x` and `x + y - x`

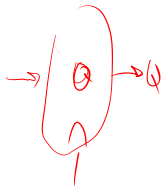
Question 8 [2 pt]: (see above)
`x + y` and `(x & y) + (x | y)`

Question 9 [2 pt]: (see above)
`(x & 0xF0000000) | (x >> 4)` and `(x >> 4)` *(that's an* `F` *followed by seven* `0`*s)*

Question 10 [2 pt]: We discussed registers as a key component of circuits and the only component that uses a clock. The clock is used to

A enable storage of values
B limit when changed input is remembered in storage
C decide when stored values become visible in output
D control when circuits can access stored values

Answer:



Information for questions 11–12
Suppose we extended the ISA simulator you wrote in Lab 03 with the following code:

```
if (reserved == 1 && icode == 3) {
    M[R[a]] = M[R[b]];
    return oldPC + ____;
}
```

Question 11 [2 pt]: (see above) What number should be placed in the `return` statement where the code above has `____`?

Answer:

Question 12 [2 pt]: (see above) Using the new instruction, write a program that moves a byte from memory at address r_2 to memory at address r_1. Answer in hexadecimal bytes, separated by spaces.

Answer: _____

Information for questions 13–14
Suppose an array of two 32-bit values (`[0xabcdef01, 0x7645231]`) is stored at address `0x200`. What byte is stored at address `0x204`? Answer in hexadecimal.

Question 13 [2 pt]: (see above) Assume little-endian storage.

Answer:

Question 14 [1 pt]: (see above) Assume big-endian storage.

Answer:

Question 15 [2 pt]: Why might an ethical engineer put a back-door in processor or software product?
Select all that apply by putting 1 or more letters in the box.

A for debugging
B to advanced remote support
C because the client isn't trustworthy
D by mistake (they're hard to avoid)
E because management insisted on it

Answer:

Question 16 [2 pt]: Copyrights can protect a description of an ISA, but not the ISA itself. If ISAs are considered to be inventions, patents could protect them, preventing others for using the same ISA (without paying royalties) until the patent expires (typically after 20 years).

Opinions about the patentability of ISAs are varied. Provide one reason for and one reason against the patentability of an ISA. Note that "I want free computers" is not a sufficient reason against…

Pro-patent: _____

_____

_____

_____

Anti-patent: _____

_____

_____

_____

Pledge:

On my honor as a student, I have neither given nor received aid on this exam. I will not discuss the content of this exam, even in vague terms, with *anyone* other than current course staff, until Friday 4 October 2019.

_____

Your signature here