

PRINT your name: _____,
(last) (first)

PRINT your student ID: _____

You have 110 minutes. There are 5 questions of varying credit (100 points total).

Question:	1	2	3	4	5	Total
Points:	12	18	18	40	12	100

For questions with **circular bubbles**, you may select only one choice.

- Unselected option (completely unfilled)
- Only one selected option (completely filled)

For questions with **square checkboxes**, you may select one or more choices.

- You can select
- multiple squares (completely filled)

Anything you write that you ~~cross-out~~ will not be graded. Anything you write outside the answer boxes will not be graded.

If an answer requires hex input, make sure you only use capitalized letters! For example, `0xDEADBEEF` instead of `0xdeadbeef`. Please include hex (`0x`) or binary (`0b`) prefixes in your answers unless otherwise specified. For all other bases, do not add any prefixes or suffixes.

Read the following honor code and sign your name.

I understand that I may not collaborate with anyone else on this exam, or cheat in any way. I am aware of the Berkeley Campus Code of Student Conduct and acknowledge that academic misconduct will be reported to the Center for Student Conduct and may further result in, at minimum, negative points on the exam and a corresponding notch on Nick's Stanley Fubar demolition tool.

SIGN your name: _____

Q1 True/False**(12 points)**

Q1.1 (1.5 points) TRUE or FALSE: If you wanted to store the integer 0xDEADBEEF in a little-endian system in C, you would have to write `int x = 0xEFBEADDE;`

 TRUE FALSE

Q1.2 (1.5 points) TRUE or FALSE: When possible, the C compiler by default attempts to store data at aligned addresses (ex. 4 byte objects stored at an address that is a multiple of 4), even if it creates “gaps” of unused memory.

 TRUE FALSE

Q1.3 (1.5 points) TRUE or FALSE: The compiler converts code written in a higher-level language like C into a lower-level language like RISC-V.

 TRUE FALSE

Q1.4 (1.5 points) TRUE or FALSE: The symbol and relocation tables are discarded after the assembler runs, since all labels get converted into byte offsets.

 TRUE FALSE

Q1.5 (1.5 points) TRUE or FALSE: It is possible to use 9 bits to represent 513 unique values.

 TRUE FALSE

Q1.6 (1.5 points) TRUE or FALSE: Typically, signed integers are stored in sign-magnitude representation in order to simplify arithmetic operations performed on these numbers.

 TRUE FALSE

Q1.7 (1.5 points) TRUE or FALSE: All base RISC-V 32-bit instructions share the same two least significant bits.

 TRUE FALSE

Q1.8 (1.5 points) TRUE or FALSE: Branch instructions can represent a larger immediate value than I-type instructions.

 TRUE FALSE

Q2 Short Answer

(18 points)

Q2.1 (3 points) Convert -12 to an 8-bit two's complement representation.
Express your answer in binary, including the relevant prefix.

Q2.2 (3 points) Convert $2^{32} - 15$ to a 32-bit unsigned representation.
Express your answer in hexadecimal, including the relevant prefix.

For the following three subparts, assume that we are working with a binary floating point representation, which follows IEEE-754 standard conventions, but which has 3 exponent bits (and a standard exponent bias of -3) and 4 significand bits.

Q2.3 (3 points) Convert -12 to its floating point representation under this floating point system.
Express your answer in binary, including the relevant prefix.

Q2.4 (3 points) What is the largest non-infinite number that can be represented by this system?
Express your answer in decimal.

Q2.5 (3 points) What is the smallest positive number that can be represented by this system?
Express your answer as an odd integer multiplied by a power of 2.

Q2.6 (3 points) Translate the following RISC-V instruction into its corresponding hexadecimal value.
`ori t6 s0 -12`

Q3 Trouble With Definitions**(18 points)**

Note: we think this is the trickiest question on the exam.

Define statements can be useful, but it's important to be careful when using them.

```
1 #include <stdio.h>
2 #include <stdlib.h>
3 #define abs(x) ((x) < 0 ? -(x) : (x))
4 #define f(a,b) a*b/4
5 int main() {
6     int a = 10;
7     printf("Question 3.1: %d\n", a^2);
8     int i = 0xA6004F4E;
9
10    printf("Question 3.2: 0x%X\n", i|(i<<4));
11    printf("Question 3.3: 0x%X\n", abs(i));
12
13    int b = 10;
14    printf("Question 3.4: %d\n", f(0+1, b));
15    printf("Question 3.5: %d\n", f(1+0, b));
16
17    int k = 100;
18    int* kptr = &k;
19    printf("Question 3.6: %d\n", f(k+,kptr));
20    return 0;
21 }
```

The %d format modifier outputs an integer in decimal. The %X format modifier outputs an integer as a hexadecimal string, using capital letters for A-F.

This code compiles. What is printed by this code? Please write your answers in the answer boxes provided on the next page.

(Question 3 continued...)

Each line is worth 3 points.

Question 3.1:

Question 3.2:

Question 3.3:

Question 3.4:

Question 3.5:

Question 3.6:

Q4 Lost in Translation**(40 points)**

Consider the following Python class:

```
1 class Vector:
2     def __init__(self, x, y):
3         self.x = x
4         self.y = y
5     def transform(self, f):
6         return Vector(f(self.x), f(self.y))
```

Q4.1 (20 points) We want to translate this code to C. Fill in the following C code. Assume all allocations succeed. For full credit, your solution must use the minimum amount of memory required.

```
1  #include <stdlib.h>
2
3  typedef struct Vector {
4      int x;
5      int y;
6  } Vector;
7
8  _____ *transform(Vector *self, int (*f)(int)) {
9
10     _____ newVector = _____;
11
12     newVector _____ x = _____;
13
14     newVector _____ y = _____;
15
16     return _____;
17 }
```

(Question 4 continued...)

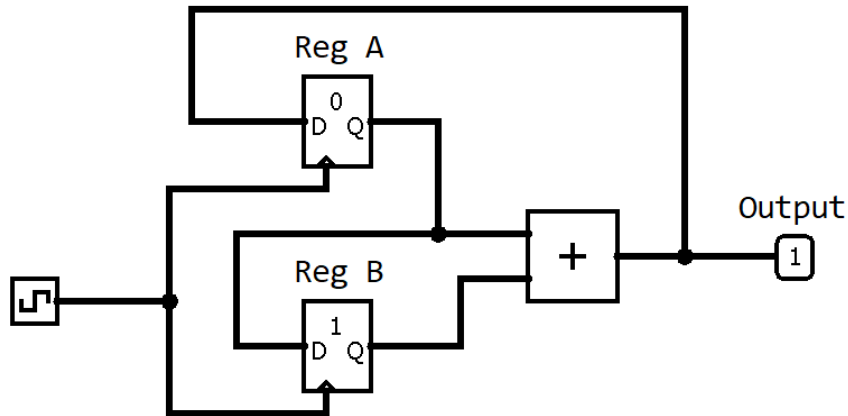
Q4.2 (20 points) Translate the `transform` function to RISC-V. The function takes inputs `self` in `a0` and `f` in `a1`, and returns output in `a0`. You may assume that `Vector` is as defined in the C code. You may also assume that you have access to `malloc`, and that `malloc` and `f` each receive their argument in `a0`, and return their result in `a0`. Your solution MUST fit within the lines provided.

```
1  transform:
2    addi sp sp _____
3
4
5
6
7
8
9
10   jal _____ malloc
11
12
13   jalr _____
14
15
16   jalr _____
17
18
19
20
21
22
23   addi sp sp _____
24   ret
```

Q5 Circuitous Logic

(12 points)

Consider the following circuit:



All data wires (wires not connected to the clock) are 8 bits wide.

Q5.1 (8 points) Assume that the circuit is in the above state at clock cycle 0; register A is currently storing 0, register B is currently storing 1, and the circuit is outputting 1. **For this part only**, assume that the clock period is significantly longer than any propagation delays and register setup/hold/clk-to-q time. Write the outputted values (in decimal) from clock cycles 1 to 8.

Cycle 1	Cycle 2	Cycle 3	Cycle 4
<input style="width: 60px; height: 30px;" type="text"/>	<input style="width: 60px; height: 30px;" type="text"/>	<input style="width: 60px; height: 30px;" type="text"/>	<input style="width: 60px; height: 30px;" type="text"/>
Cycle 5	Cycle 6	Cycle 7	Cycle 8
<input style="width: 60px; height: 30px;" type="text"/>	<input style="width: 60px; height: 30px;" type="text"/>	<input style="width: 60px; height: 30px;" type="text"/>	<input style="width: 60px; height: 30px;" type="text"/>

Q5.2 (4 points) Assume that the circuit has the following delays:

Register clk-to-q time	3ns
Register setup time	2ns
Register hold time	1ns
Adder propagation delay	4ns

Wires are assumed to have no propagation delay. What is the minimum clock period needed for this circuit to have the same behavior as in Q5.1?

ns

(Optional) The Finish Line

(0 points) You've reached the end of the exam! If there's anything you'd like to tell course staff, let us know here!

(0 points) What are their names?



(0 points) What else are they selling? (fill in the sale table)

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