

CS 286-002 – Computer Organization & Architecture

Midterm Exam

Fall, 2026 (**PARTIAL SOLUTIONS**)

3:00-4:15 P.M.
October 14, 2026

This exam is a closed textbook and closed note exam. There are **5** questions in this exam. You have 75 minutes to finish the questions. Please write your answers on separated pieces of papers. To avoid grading problems, please staple your solutions in the ascending order in the question number. All the questions in this exam are mandatory (no optional question).

Notice 1: Please carefully read each question and follow the requirement(s) in each question. Failing to follow the requirement(s) may cause minor or major penalties. If you answered anything not asked by a question, you will not get much credit.

Notice 2: It is your responsibility to present your solutions in such a way that Dr. Fujinoki can read your writing. It is assumed that whatever important idea(s) in your solutions is clearly presented or even emphasized.

Student ID (the last four digits): _____

QUESTION #1 (15 minutes) – 4 points for each of the five questions below:

(1) If a necessary condition is satisfied, what conclusion can we draw?

We can't draw any conclusion.

(2) What is the essential difference between “li \$a0, 1024” and “la \$a0, 1024” instructions?

“li” loads the given constant (immediate) to a register as a two’s complement integer, while “la” loads the given constant (immediate) to a register as an unsigned integer.

(3) What are the three different types of “program files”? Which format do processors understand?

Three different types of program files are:

- ① Source-code files in high-level programming languages
- ② Source-code files in assembly languages
- ③ Binary executable files

Processors understand (can execute) only binary executable files

(4) What is the primary purpose of “assembly source code files”?

By developing source code files (or by understanding source code files) in an assembly language, we expect the following advantages:

- (by understanding how processors execute programs) debugging will be easy (or improving debugging skills).
- (by understanding how processors execute programs) performance optimizations are possible (or they will be easy).

(5) What is the binary bit pattern of +9 (in decimal) in the bias of 127? Assume that the bit pattern consists of 8 bits. Show all your work.

- $+13_{(10)} = 8 + 1 = 00001001_{(2)}$
- ‘0’ in Bias of 127 = “0111 1111”

$$\begin{array}{r} 0000\ 1001 \\ +\ 0111\ 1111 \\ \hline 1000\ 1000_{(2)} \end{array}$$

The binary bit pattern of +9 (in decimal) in the bias of 127 = “10001000”.

QUESTION #2 (10 minutes) – 20 points

Suppose that you wrote the following statements in C/C++:

```
int my_int_01;  
unsigned int my_int_02;  
  
void main (void)  
{  
    my_int_02 = 41232;  
  
    my_int_01 = my_int_02;  
  
    printf("my integer: %d\n", my_int_01);  
}
```

Assuming that the computer that runs this program is a 16-bit architecture computer (i.e., the registers in its processor(s) are all 16 bits), what number will you see when you print the value of “my_int_01” in the program?

Note that “%d” in the **printf** statement means “print it as a decimal number”.

Show all your work to find the number (i.e., please explain how you got the number).

QUESTION #3 (15 minutes) – 20 points

Our favorite program runs in (exactly) 8.2 seconds on processor A, which has a 1.2GHz clock (its clock cycle rate = 1.2GHz). A processor designer is trying to build another processor, processor B, which will run this program in (exactly) 5.7 seconds. The designer has determined that processor will achieve the goal (i.e., run the program in 5.7 seconds) by a substantial increase in the clock rate. However, the substantial increase in the clock rate will affect the rest of the processor’s design, causing processor B to require 1.39 times as many clock cycles as processor A for this program.

What clock rate should we tell the designer target for processor B to run the program in 5.7 seconds?

Show all your work.

QUESTION #4 (20 minutes) – 30 points, 3 points for each of the 10 questions

Is each of the following statements true or false? Please choose either TRUE or FALSE (no “it depends”). It is your responsibility to clearly indicate which option you chose. For this question, you should answer either TRUE or FALSE below (no need to provide answers in separate paper).

- (1) Given N bits for sign-magnitude integers, the maximum (positive) and the minimum (negative) numbers are $+ (2^{(N/2)} - 1)$ and $- 2^{(N/2)}$.
- [TRUE FALSE]
- (2) Fixed-point fraction numbers and sign-magnitude integers have a fixed interval between two numbers that can be accurately represented.
- [TRUE FALSE]
- (3) Processors with a lower clock rate (referred as “Processor A”) execute the same binary programs faster than the processors with a higher clock rate (referred as “Processor B”), if A’s CPI is higher than that of B.
- [TRUE FALSE]
- (4) When a value (a value meant to human users) assigned to an “*unsigned integer*” variable is copied to an “*int*” variable, the value will never be correctly copied (again, as a value mean to human users) to the “*int*” variable.
- [TRUE FALSE]
- (5) Source code files written in a high-level programming language are first translated to assembly source code files and then, the assembly source code files are translated to binary executable files by a compiler.
- [TRUE FALSE]
- (6) Binary executable machine codes and assembly instructions are in one-to-one relationship, although assembly instructions and statements in a high-level programming language are in many-to-one relationship respectively.
- [TRUE FALSE]
- (7) For scalar, super-scalar, pipeline, and super-pipeline datapaths processors, super-scalar, all of them can possibly achieve CPI 1.0 or lower.
- [TRUE FALSE]
- (8) In two’s complement integers, it is possible for a result of a mathematical operation to be in error even if the carry flag is not raised.
- [TRUE FALSE]
- (9) Each instruction takes less time to execute (the actual time a processor spends for executing one instruction) by a pipeline processor than by a scalar processor (assuming that all other aspects of the processors being the same).
- [TRUE FALSE]

- (10) The IEEE-754 floating-point standard uses “the normalized format” for saving one bit in the exponent bits (which will improve the accuracy).

[TRUE FALSE]

QUESTION #5: Challenging Question – 20 points

What is the difference between the (29,360,135)-th and the (29,360,136)-th tiniest negative numbers (we called the difference “interval”) in IEEE-754 floating point number system (i.e., “single precision IEEE-754 floating point numbers)?

Note: Show your work (most of the credit goes to showing a correct work)

