

CSU0033 Operating Systems, Midterm Exam

Department of Computer Science and Information Engineering

National Taiwan Normal University

April 7, 2024

Solution

- Exam time: 15:40–17:30.
- 100 points in total. Write your answers in the answer sheets. No need to return this problem sheet.
- Clearly label your answer.
- Except for the True/False questions, state how you derive your answer.

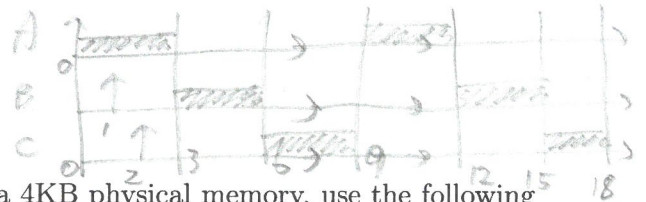
1. (25 points) For each of the following statements, answer T if you think it is true; otherwise, answer F. No need to show your reasoning here.

- F (a) (5 points) In OS terminology, by *returning-from-trap* the system will raise the privilege level from user mode to kernel mode.
- F (b) (5 points) A *page fault* will occur when the OS cannot perform address translation from the TLB.
- F (c) (5 points) When the OS performs a context switch from process *A* to process *B*, the OS would save its kernel register values into the PCB of process *B*.
- T (d) (5 points) The design of a multi-level feedback queue prevents job starvation by resetting a job's priority to the top.
- T (e) (5 points) When a user-space program prints out the memory address of one of its local variables, the printed address is a virtual address.

7 2. (10 points) Suppose we have four virtual pages (labeled 0, 1, 2, 3) and ^{two} three empty physical frames. Consider the following VPN access sequence: $1 \rightarrow 0 \rightarrow 2 \rightarrow 1 \rightarrow 0 \rightarrow 2 \rightarrow 0 \rightarrow 3$. How many page faults will occur if the system uses the LRU replacement policy?

14 3. (15 points) Consider the following three jobs. Using the RR scheduling policy (scheduling quantum = 3), what would be the average turnaround time of these three?

- Job A: arrival time = 0; job length = 6
- Job B: arrival time = 1; job length = 6
- Job C: arrival time = 2; job length = 6



4. (15 points) Given a 512-byte address space and a 4KB physical memory, use the following segment registers information to translate the virtual address $0x16c$ to its physical address. Write your answer in hexadecimal, or write 'segmentation fault' if you think the translation is illegal. No need to consider the size of the information beginning at each address.

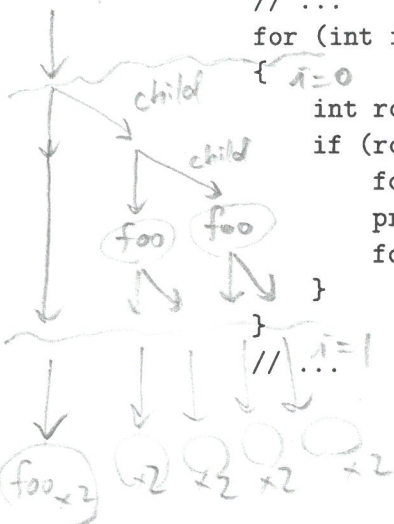
Segment	Base	Size (byte)	Grows Positive?
Code ₀₀	0x723	100	1
Heap ₀₁	0x921	100	1
Stack ₁₁	0xb20	30	0

$$12 + 14 + 16 = 3 = 14$$

12 5. (15 points) Consider the following C function. Assuming no failure, how many "foo"s will this part of the code print?

```
// ...
for (int i = 0; i < 2; i++)
{
    int rc = fork();
    if (rc == 0) {
        fork();
        printf("foo ");
        fork();
    }
}
```

main process

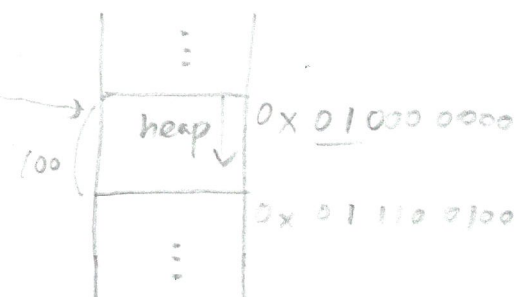
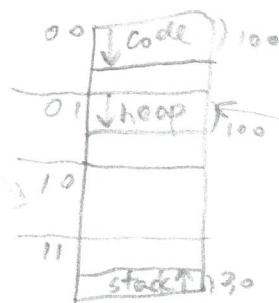


$0x16c$

$$\equiv 0x000101101100$$

$$(100)_{10} = 0x64$$

$$= 0x01100100$$



- 3 6. (5 points) Pick all the correct statement(s) from the following four, or write NONE if you think none of them is correct. Points will be given only if you have made the correct judgement on every statement. Watch out for the logic.

- ☒ 1. A zombie process is a parent process whose children processes all have terminated and did not call a `wait()` for it.
- ☒ 2. A zombie process is a child process whose parent process has terminated and did not call a `wait()` for the child. *← the child process might be still running!*
- ☒ 3. A process becomes a zombie if it has finished its execution but its original parent process is still running and has not called a `wait()`.
- ☒ 4. A process becomes a zombie if its original parent process has terminated before the process has finished its execution. *← the process may be adopted by init before dying.*

- 0x2e4 7. (15 points) Perform an address translation using a two-level page table. Some assumptions:

- The page size is 32 bytes.
- Physical memory consists of 128 pages. A physical address requires 12 bits.
- The address space for a process has 1024 virtual pages. Assume that there is only one process to be considered.

The PTE is 8 bits and the format is VALID PFN6 ... PFN0, starting from the MSB. The PDE is 8 bits and the format is VALID PT6 ... PT0, starting from the MSB. Figures 1 and 2 show a hexadecimal dump of some pages of memory. In each page dump, the first byte is shown on the left; the last byte, on the right. Suppose that the page table directory (aka the page directory) is held in page 118 (decimal). Translate the virtual address 0x5224 into the corresponding physical address. Write your answer in hexadecimal.

This is the end of the midterm exam questions.
Turn to the following two pages for Figures 1 and 2.

```
page 12: 1b 0e 04 11 07 01 12 1e 18 16 04 11 13 17 0d 01 1c 08 16 0e 18 0a 02 0d 0e 18 0c 14 0b 16 05 1b
page 13: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 14: 0d 1a 0b 03 14 0a 11 17 0e 16 13 1a 17 1b 17 08 0f 17 18 16 1a 19 10 13 01 0e 16 1c 1a 0d 07 1b
page 15: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 16: 09 0d 1c 14 17 0a 09 0c 07 00 08 1c 01 0f 07 17 01 0f 16 0e 04 1b 00 1c 19 1b 1a 0b 13 0e 12 0b
page 17: 1a 06 0d 09 13 10 1a 0d 0b 14 17 1c 09 1b 1e 1e 04 0b 17 19 01 0c 16 17 10 06 0c 01 09 0d 19 12
page 18: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 19: 7f 81 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 20: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 21: 19 09 1c 16 18 1e 14 14 19 14 0d 15 02 18 01 1d 14 1d 13 0c 0f 0d 02 19 05 06 0a 15 0c 09 12 09
page 22: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 23: 0a 19 06 03 03 01 08 11 19 0a 0b 08 11 08 09 18 11 08 03 18 15 19 07 10 1c 12 1d 05 1e 01 0c 00 19 15
page 24: 1b 11 03 1e 12 17 18 07 10 05 12 0d 18 03 06 0b 00 0c 1d 1a 05 19 06 07 13 09 06 02 05 05 1c 01
page 25: 11 00 1d 00 17 18 0b 19 05 18 11 1a 18 18 1a 07 00 05 17 10 0f 0e 00 1c 11 12 0f 1b 0e 10 18 04
page 26: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 27: 16 00 0b 16 00 0c 0a 0f 13 02 1a 08 17 04 02 06 02 07 04 02 1a 10 0f 0f 19 01 01 14 00 0f 13 1a
page 28: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 29: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 30: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 31: 14 0d 05 19 11 1d 10 13 0d 12 1c 1e 14 0d 01 1a 0c 0b 01 01 0c 1e 16 15 14 08 05 12 01 12 0f 10
page 32: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 33: 07 1e 13 01 19 08 0b 04 19 02 16 0c 15 09 02 1c 14 05 1e 1c 05 00 12 04 16 0e 15 11 17 19 12 12
page 34: 1e 1b 0b 1d 1c 04 13 06 0a 09 06 12 06 0a 04 08 18 08 1e 03 00 07 0f 09 0c 17 14 07 1b 0b 11 0b
page 35: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 36: 13 16 03 00 0c 05 12 04 0f 0e 1e 09 08 0a 14 07 07 16 10 02 1a 03 09 10 0e 17 04 14 05 03 15 18
page 37: 17 01 00 0d 1b 13 0b 1e 15 19 1a 01 06 18 0c 1b 02 1d 13 0c 19 10 0e 05 18 04 09 02 00 09 01 0e
page 38: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 39: 11 02 01 1b 0b 0b 1e 16 04 10 0e 12 08 08 1d 12 11 15 17 05 18 0e 04 09 1e 1a 1c 0f 13 0c 16 10
page 40: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 41: 14 12 19 06 18 18 04 04 12 1e 13 0d 0f 19 10 10 12 1c 18 1a 08 12 19 16 1d 1c 03 0f 0b 06 0f 1e
page 42: 0f 09 00 19 17 1b 17 0c 1c 07 07 0e 15 03 01 1c 00 17 0e 1d 1a 0e 10 15 08 00 1e 10 18 10 02 03
page 43: 7f 7f 7f 7f e1 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 44: 7f 7f dd 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 45: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 46: 13 09 03 09 0b 0e 10 1c 14 0d 0f 18 13 0c 0b 16 14 0a 04 05 00 16 1a 11 00 0a 06 03 12 1a 1a 19
page 47: 7f 7f 7f 7f 7f b1 bf 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 48: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 49: 0d 13 16 12 0b 0f 0f 0b 09 02 02 04 02 0b 1e 0c 1c 15 1c 14 1d 18 02 00 1d 0a 14 1d 1e 10 0a 12
page 50: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 51: 01 17 1d 11 14 19 1a 19 0f 02 18 1a 15 09 1e 13 09 18 06 07 1c 01 1a 0c 11 15 1b 06 02 0f 06 0d
page 52: 11 11 19 03 13 0a 11 19 07 1d 02 11 10 07 11 0e 0d 16 00 0b 18 04 1a 06 15 05 0d 0d 02 15 0e 15
page 53: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 54: 01 0d 14 17 1a 02 0d 16 08 19 1e 0a 12 01 14 1d 18 0a 1c 00 11 01 0c 08 03 1b 19 10 05 0f 06 11
page 55: 1e 16 0c 1c 11 19 0a 0b 15 17 15 04 0d 09 07 03 17 04 0a 00 15 13 02 1d 1e 17 18 15 00 08 07 00
page 56: 03 1a 14 15 14 17 0d 08 06 03 1d 15 13 12 0d 10 01 15 0d 02 1d 0f 00 07 09 0f 00 0c 14 14 0a 16
page 57: 0e 12 00 04 17 08 1a 0c 14 0b 00 14 09 11 15 11 05 05 19 1b 0a 13 1d 04 0f 18 14 11 18 0b 06 09
page 58: 05 0a 18 10 1e 03 1b 1c 0a 1c 08 15 0a 10 13 1a 0a 02 08 16 0a 0e 14 0c 1b 0c 0e 1b 01 0b 14 14
page 59: 7f 7f 7f 82 7f 7f 7f 7f a4 7f 7f 7f 7f 7f fd 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
```

Figure 1: Part I of the memory dump of the physical pages.

```
page 77: 0f 19 07 09 07 09 1a 0e 1c 0f 0c 13 01 0e 0a 0e 0c 14 14 00 10 0c 0b 05 19 05 08 0a 1c 0e 04 06
page 78: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 79: 19 10 13 0d 02 17 17 04 09 15 15 05 0c 0b 10 19 04 0b 1c 05 05 18 13 0e 0e 01 13 08 0d 1c 0f 0c
page 80: 01 0f 0c 05 1e 02 01 09 12 11 15 11 0e 1e 03 0e 0a 1e 0f 0f 18 1e 14 01 04 03 01 01 1d 0c 17 08
page 81: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 82: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 83: 06 12 0f 10 0a 1c 09 0b 05 08 04 13 00 07 19 1a 0a 16 19 14 13 17 09 0a 07 07 0f 10 05 02 00 06
page 84: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 85: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 86: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 87: 03 02 14 04 14 0d 14 09 12 02 1a 18 0b 14 02 13 07 1d 03 00 1b 15 13 02 0d 16 02 18 12 03 10 0c
page 88: 07 0a 11 1d 04 09 08 09 0f 19 05 16 0d 11 0f 12 05 13 0c 18 12 0c 1e 05 00 03 15 02 16 02 09 13
page 89: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 90: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 91: 14 02 0c 13 1b 09 02 16 1a 11 16 0a 09 03 03 18 19 11 10 0f 18 02 06 04 1e 0f 15 09 19 18 0c 1e
page 92: 13 0f 08 11 1e 14 1b 06 16 16 02 19 05 06 01 14 04 1e 00 19 17 11 11 18 13 04 18 0a 12 0f 1c 0c
page 93: 17 00 13 09 0e 07 06 1d 0e 06 14 1b 0f 12 19 1b 0e 11 04 04 1d 07 10 06 03 08 0d 07 1c 09 1c 14
page 94: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 95: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 96: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 97: 16 18 0f 10 0e 0e 06 11 1a 07 0c 0b 09 1c 16 02 10 0a 0b 03 12 0b 15 03 10 0d 13 01 18 10 07 05
page 98: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 99: 1a 08 03 12 07 1e 0d 1b 07 02 13 15 07 1c 1e 15 1e 1e 04 16 17 16 0a 10 12 1a 01 0b 09 18 03 01
page 100: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 101: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 102: 17 19 0d 10 02 0e 13 1d 1b 0a 17 1a 1d 15 0a 1b 00 11 0e 1b 13 06 05 01 17 18 0b 06 11 06 10 0a
page 103: 10 1e 17 0a 1e 0b 05 02 0e 06 1c 1d 06 03 10 05 10 19 07 0d 1b 0d 0a 1b 19 1b 15 0c 15 19 13 07
page 104: 7f db 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 105: 00 07 16 02 12 1a 0e 15 11 1b 1e 12 16 15 19 0c 14 0c 1a 19 0a 10 1e 16 06 0e 02 08 18 05 13 17
page 106: 17 0f 06 1e 09 13 19 05 01 18 16 05 09 13 11 1a 0e 05 17 0c 08 04 07 03 04 10 03 05 15 05 17 00
page 107: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 108: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 109: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 110: 01 0e 0d 11 12 03 1a 06 07 01 06 12 0e 1d 19 0b 09 0f 08 0b 14 06 1d 1b 14 16 1e 0e 0c 14 18 0d
page 111: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 112: 17 19 0a 17 00 0f 09 09 1e 00 1d 14 1e 0c 1b 11 11 13 08 12 05 01 16 00 1c 07 1c 09 16 0a 15 05
page 113: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 114: 12 0d 10 04 05 0d 06 0e 00 02 16 0d 0f 16 0b 01 18 12 14 13 1e 0b 17 0b 11 14 09 02 0e 16 12 0d
page 115: 08 0d 00 03 0a 0b 15 04 0e 1a 03 06 0a 11 1d 06 0e 12 19 1c 1b 05 0a 01 01 0c 0d 12 1d 03 1d 15
page 116: 03 06 06 04 04 0f 15 0e 10 15 19 1e 15 0f 01 09 05 1d 16 03 0a 0d 13 1e 0a 15 0c 1c 0f 17 12 16
page 117: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 118: ca f1 fc bc 89 c6 86 e8 ac e2 8b bb 7f a8 be 7f ab c3 7f 7f 96 84 eb 7f af fa 93 ec 7f d5 8a f9
page 119: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
page 120: 07 08 05 1d 18 0a 0d 19 12 12 0c 12 00 05 1a 1c 11 14 0d 0b 12 18 1c 07 0e 0d 17 1b 1e 14 12 03
page 121: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 122: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
page 123: 09 0d 1e 0f 09 10 05 11 02 10 03 01 17 0f 04 0c 1b 0b 08 0e 1b 13 0e 13 0a 1c 08 06 0f 18 17 14
page 124: 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f 7f
```

Figure 2: Part II of the memory dump of the physical pages.