# CS 544 Exam 1 (15%) - Fall 2025

Instructors: Meena Syamkumar and Tyler Caraza-Harter
First/Given Name: _____. Last/Surname: _____
Net ID: _____ @wisc.edu
Fill in these fields (left to right) on the scantron form (use pencil):

1. LAST NAME (surname) and FIRST NAME (given name), fill in bubbles
2. IDENTIFICATION NUMBER is your Campus ID number, fill in bubbles
3. Under A of SPECIAL CODES, tell us about the nearest person (if any) to your left. 0=no person to the left in your row, 1=somebody you do not know is there, 2=somebody you do know is there.
4. Under B of SPECIAL CODES, do the same as B, but for the person to your right
5. **Under C of SPECIAL CODES, write 1 and fill in bubble 1**. This is very important!

Make sure you fill all the special codes above accurately in order to get graded.

You have 60 minutes to take the exam. Use a #2 pencil to mark all answers. When you're done, please hand in these sheets in addition to your filled-in scantron. You may not sit adjacent to your friends or other people you know in the class (having only one empty seat is considered "adjacent"). You may only reference your notesheet. You may not use books, your neighbors, calculators, or other electronic devices on this exam. Please turn off and put away portable electronics now.

If multiple answers are correct, choose the best answer.

Do not communicate with anybody besides the teaching team about questions or answers until exam grades have been posted.

(Blank Page for You to Do Scratch Work)

**Q1. The old version of a protocol buffer for a gRPC call looks like this:**

```
message ExampleReq {
        int32 x = 1;
        int32 y = 2;
}
```

A newer version adds a field `int32 z = 3;` If a client using the old version makes a call that does not include `z` to a server using the new version, what happens?
(A) the server crashes
(B) the server ignores the request
(C) the server uses a default value for `z`
(D) the server returns an error to the client

**Q2. A cache hit takes 1s and a cache miss hits takes 10s. You add more memory, so that the hit rate increases from 80% to 90%. Of median latency, mean latency, and p99 latency, which, if any will improve?**

(A) median only (B) mean only (C) p99 only (D) mean and p99 (E) all will improve

**Q3. If you want high-throughput access for data on a hard drive, where would you want the data on the platter?**

(A) inner track (B) outer track (C) all tracks provide same throughput

**Q4. Which of the following are byte addressable?**

(A) only memory (B) only disk (C) both memory and disk

**Q5. Which storage devices have moving parts?**

(A) only HDD (B) only SSD (C) HDD and SSD

**Q6. You want to connect from a browser on your laptop to Jupyter running in a container on your VM. You take the following steps:**

1. Write a command in the Dockerfile to launch Jupyter on port 2894
2. Use `-L localhost:4929:localhost:3536` to establish the SSH tunnel
3. Use `-p ????:2894` in the `docker run ...` command
4. Enter `http://localhost:4929/` in the browser

What should `????` be in step 3?
(A) 8888 (B) 5000 (C) 4929 (D) 3536 (E) 2894

**Q7. Which storage device usually costs less, in terms of $/GB?**

(A) HDD (B) SSD

**Q8. True/False: when a thread is holding a lock during a critical section, the scheduler WILL NEVER context switch to another thread in the same process.**

(A) True (B) False

**Q9. How many cache hits are there for the following workload?**

A, B, E, A, A, A, F, B

Assume LRU eviction and cache size 3.

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

**Q10. Using protocol buffers, you store value y in an intX type (X could be 32, 64, etc). What determines how many bytes the value will consume when serialized?**

(A) how big y is (B) how big X is

**Q11. What value(s) could possibly be printed?**

```
x = 9
def task():
    global x
    x += 2
t = threading.Thread(target=task)
t.start()
print(x)
t.join()
```

(A) only 9 (B) 9 or 11 (C) only 11 (D) only 2 (E) 9 or 2

**Q12. How many cache hits are there for the following workload?**

C, A, E, C, B, A, A, A

Assume FIFO eviction and cache size 3.

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5

**Q13. You send 10 requests to a system that uses a cache, and measure the average time it takes per request. The result is 15ms. What kind of metric is this?**

(A) latency (B) bandwidth (C) capacity (D) throughput

**Q14. You are running a VM on a cloud that is using a NAT. What should `????` be?**

docker run -p ????:443:443 -d myapp

The internal IP is 10.128.0.6 and the external IP is 35.226.202.103. You want Internet users to be able to visit your site that is hosted by your container.

(A) 10.128.0.6 (B) 35.226.202.103 (C) 127.0.0.1

**Q15. In a Dockerfile, how do you specify the program that should launch (by default) when a container starts?**

(A) `EXEC` (B) `RUN` (C) `CMD` (D) `DO`

**Q16. You run two Docker containers with the following port forwarding configurations:**

- Container 1: `docker run -p w:x -d myapp1`
- Container 2: `docker run -p y:z -d myapp2`

Which scenarios (if any) would result in a port conflict?
(A) only w=y (B) only x=z (C) both w=y AND x=z (D) both w=x AND y=z (E) none of the above

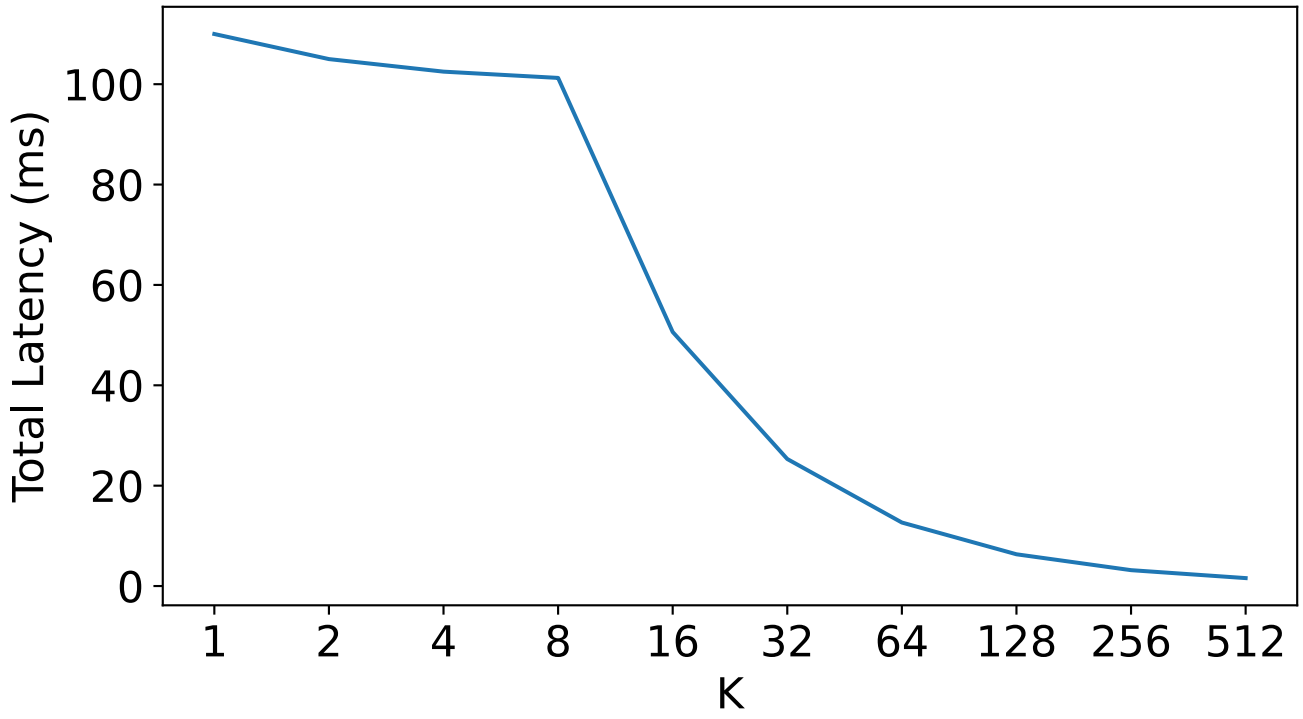
**Q17. True/False: if your multi-threaded program is written in pure Python (for example, no C, Fortran, etc.), and you are using a Python interpreter with a GIL (global interpreter lock), you still need to define your own locks to protect concurrent access to objects used by your program.**

(A) True (B) False

**Q18. What does the cacheline size appear to be?**

An array `arr` contains int32 entries. The plot shows the total time to run this loop:

```
for (int i = 0; i < arr.Length; i += K) arr[i] *= 3;
```




(A) 16 (B) 32 (C) 64 (D) 128 (E) 256

**Q19. Assume `total` starts at 0, and two threads are running concurrently. For simplicity, assume: there is a single CPU core, context switches only occur between Python bytecode instructions, and code/instructions within a single thread are not re-orderded by any system (such as the compiler or CPU).**

```
# thread 1
load total
load 1
SUBTRACT
store total

# thread 2
load total
load 2
ADD
store total
```

What is the smallest possible final `total`?

(A) -1 (B) 0 (C) 1 (D) 2 (E) 4

**Q20. The following Python library is complete, except that locking has only been used for `f` and `g`. Which other functions must acquire the lock to avoid race conditions?**

```
lock = threading.Lock()
x = 1
y = 2
z = 3

def f():
    global x, y
    with lock:
        x += y

def g():
    global x
    with lock:
        x += z

def A():
    print(x)

def B():
    print(y)

def C():
    print(z)
```

(A) A only (B) B only (C) C only (D) A and B (E) A, B, and C

**Q21. What Linux tool can help you see what process is using a port?**

(A) ls (B) ns (C) os (D) ps (E) ss

**Q22. With gRPC, what generated code does a client use to make calls?**

(A) servicer code (B) stub code

**Q23. For which kind of container is "docker logs" necessary to view stdout?**

(A) attached containers (B) detached containers

**Q24. You do NOT have swap enabled on your VM. For what kind of mappings could data be evicted from physical memory?**

(A) only file-backed (B) only anonymous (C) both file-backed and anonymous (D) none of the above

**Q25. Which processes (if any) will be async?**

```
A && B &> C
```

(A) only A (B) only B (C) A and B (D) none are async