
CSE 3421

Introduction to Computer Architecture

Final Review

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The Final Exam will be at **8:00 am, December 10, Friday**

- The exam is closed book and closed notes for 1 hour and 45 minutes
- A calculator is needed
- Location: **This Classroom**
- The format of the exam is in the same style of the homework and midterm. There will be 6 questions.

Scope of the Exam

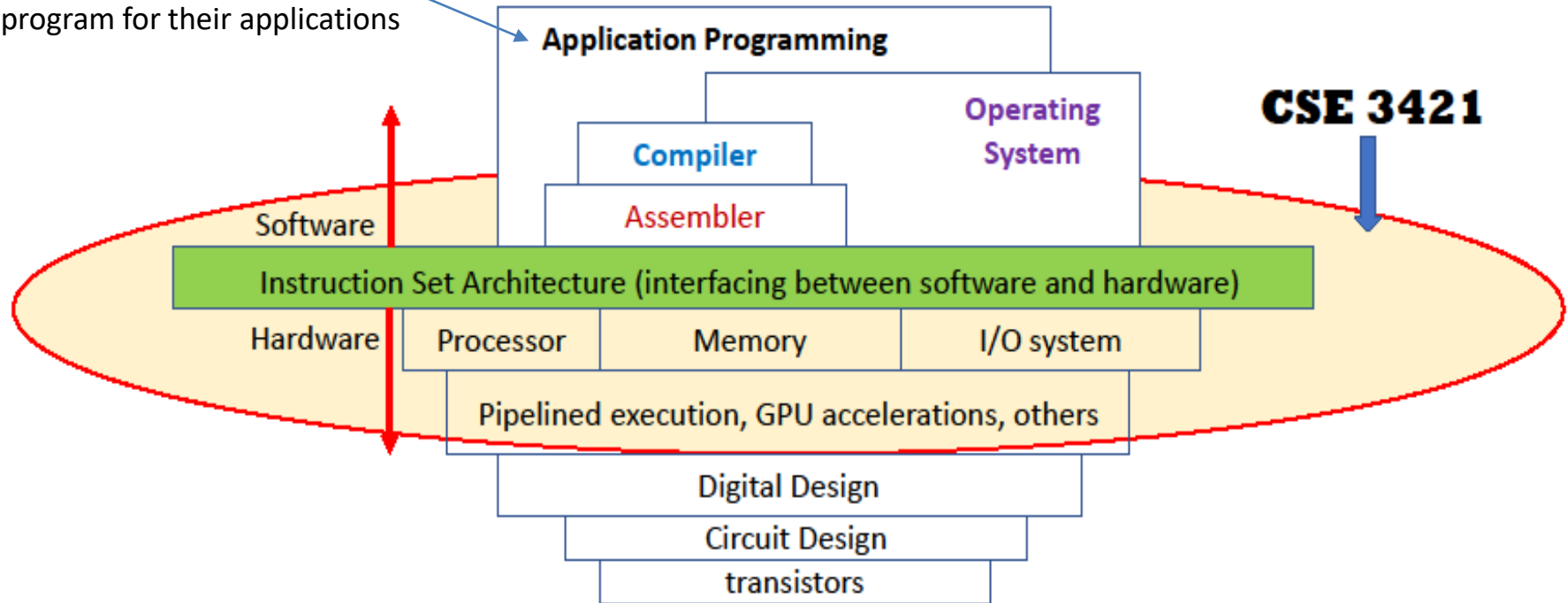
- If you understand the **lectures**, **discussions** in the class, **homework problems**, and **midterm exam**, you should do very well in the final exam.
- All the topics in the class will be in the scope the exam
 1. **Computing performance**
 2. **Instruction set architecture**
 3. **CPU design (control, pipeline, branch prediction)**
 4. **Number representations in computers (arithmetic)**
 5. **Memory hierarchy, registers, cache, DRAM**
 6. **Storage (hard disks and SSD)**
 7. **Plus all the additional notes in concepts**
- Pay attention to Pipeline and Arithmetic
 - We did not cover them in the midterm exam

Anatomy of the Architecture is Essential

- Question Examples in Concept definition.
 - For a given status, such as writing and saving a text file, compiling a program, debugging a program, running a program and others, what **space** or **spaces** are get involved in, what are related **architecture operations**?
 - **addressing relationships** among mem/storage devices: registers, L1-L3 caches, TLB, DRAM, row buffer, tracks and sectors in hard disks, blocks in SSD, et, al.
 - **Unique characteristics** (merits and limits) of critical devices, e.g., cache, DRAM, SSD, GPU, and others.
- We learn **principles**, laying the foundation for innovative technologies

Where is CSE 3421 in Computing Ecosystem?

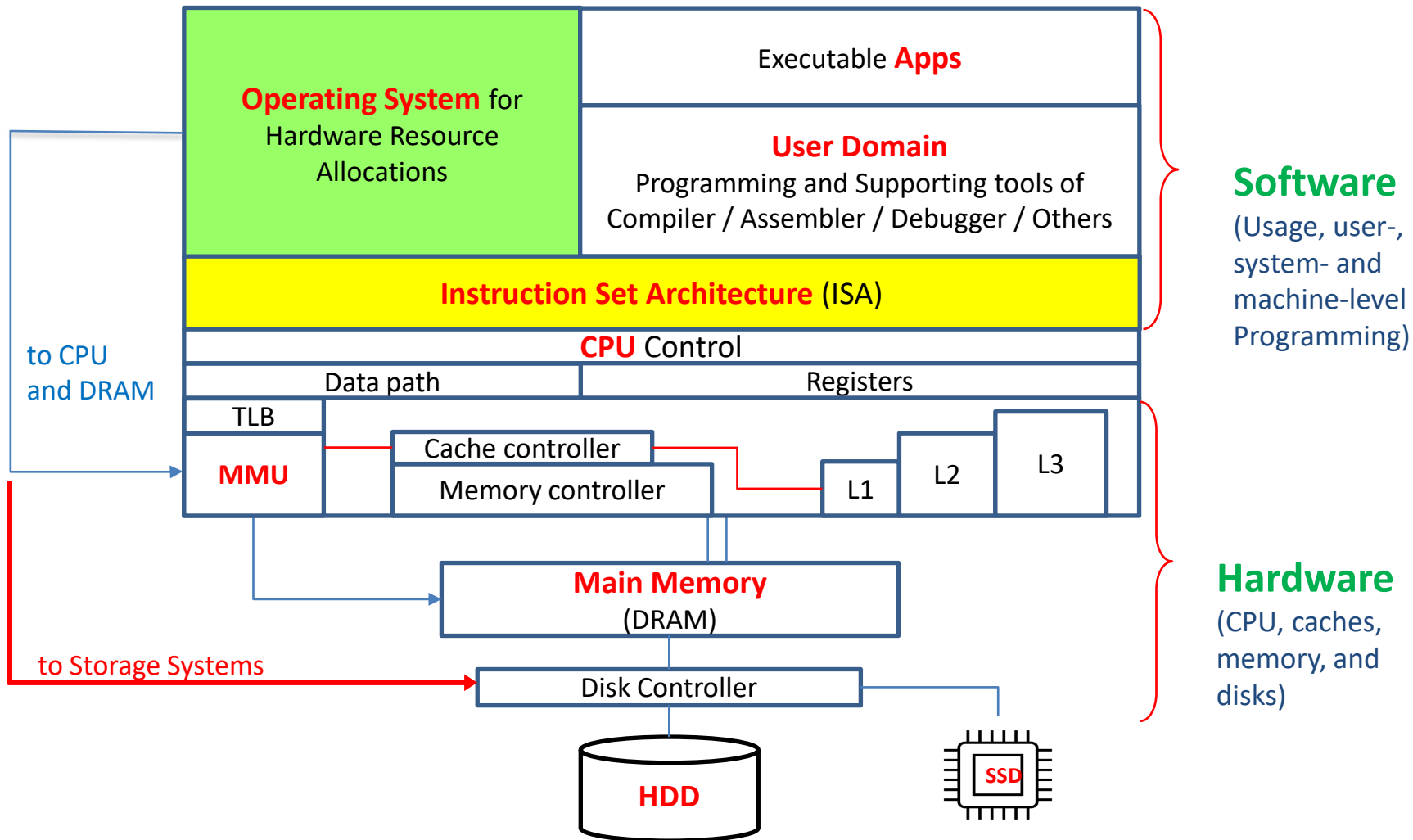
Increasingly more people can program for their applications



■ We cover three spaces:

- **Virtual space:** app programs and tools (e.g., compiler), executable code
- **Physical memory space:** CPU, pipeline, cache, buffer cache, memory system
- **Storage space:** virtual memory, page table, file systems, hard disks and SSD

The Entire Hardware-Software Stack (where is your expertise?)



Qualification for a Good Programmer

“What makes a **programmer** a good one, is mostly the ability to shift **levels of abstraction**, from low level to high level, to see something **in the small** and to see something **in the large**.”

A quote from **Donald Knuth**, *Dr. Dobb's Journal*, 1996



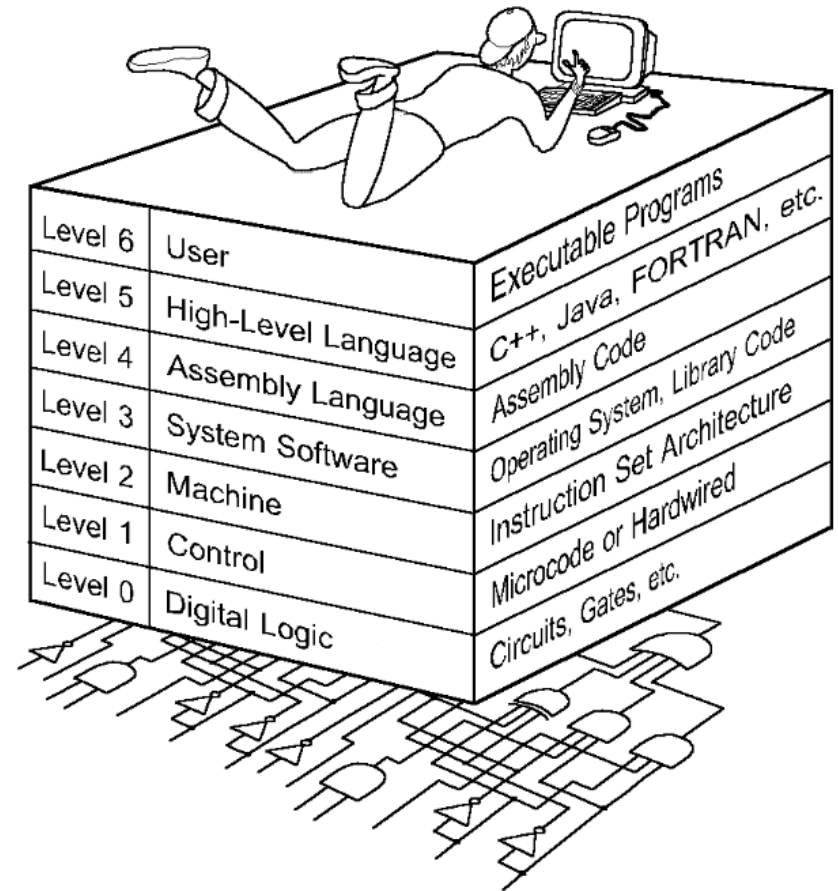
CSE3421 emphasizes on **related principles**

Moore's Law well Supports Abstractions

- Abstractions are designed for **isolations**
 - Application level: **machine independent programs**
 - Compiler helps machine dependent optimizations
 - ISA hides hardware complexity
- **OS allocates space and time resources** for computing tasks in an underlined machine by different policies
- **Cache block allocation** is predefined and automatic in hardware
- Following the principle of Adam Smith:
 - Economic growth is rooted in the increasing of **division of labors**, ...
- Abstractions only work well under Moore's Law
 - Continued performance improvement **at the circuit level**
 - all levels of abstraction get benefits

A deep hierarchy from users to the circuit

- ❑ Each virtual machine layer is an abstraction of the level below it.
- ❑ The machines at each level execute their own particular instructions, calling upon machines at lower levels to perform tasks as required.
- ❑ Computer circuits ultimately carry out the work.
- ❑ This class covers **levels 1, 2, and 3, plus some 4.**



Interactions among abstractions are most critical Today

- In Post-Moore's Law Era, performance improvement by
 - Collaborative optimizations from multiple levels
 - Hardware accelerations, such as GPU
 - Exploiting locality at different levels of memory hierarchy
- Application programming must understand underlying architecture and system software
 - Key-Value store causes a lot of random memory accesses
 - Replacement algorithms only exploit temporal locality
 - ...
- OS must adaptively consider both architecture and applications
 - OS controlled cache partitioning in multicore LLC
 - Understand application patterns for best resource allocation
 -
- Application- and systems-aware hardware design
 - Hybrid CPU/GPU design
 - Hybrid SSD/HDD design (Hystor) ...

Basic Performance Metric and Calculation

- The questions will be at the level of homework and midterm.
- Make sure you understand them thoroughly.
 - Do calculation carefully

Understanding basic MIPS instructions and Program Flow

- No assembly programming requirement
- Understanding the basic concepts and being able to trace simple programs

Computer Arithmetic

- Understanding the basic concepts and being able to manipulate different number representations
- Make sure you understand the lecture and the homework

Pipelined Execution

- Understanding the basic concepts: from single cycle to multistage pipelined design
 - How is the stage length of a pipelined machine determined?
 - What are the differences between non-pipelined and pipelined?
- Be able to identify hazards and give solutions.
- Make sure you understand the lectures and homework

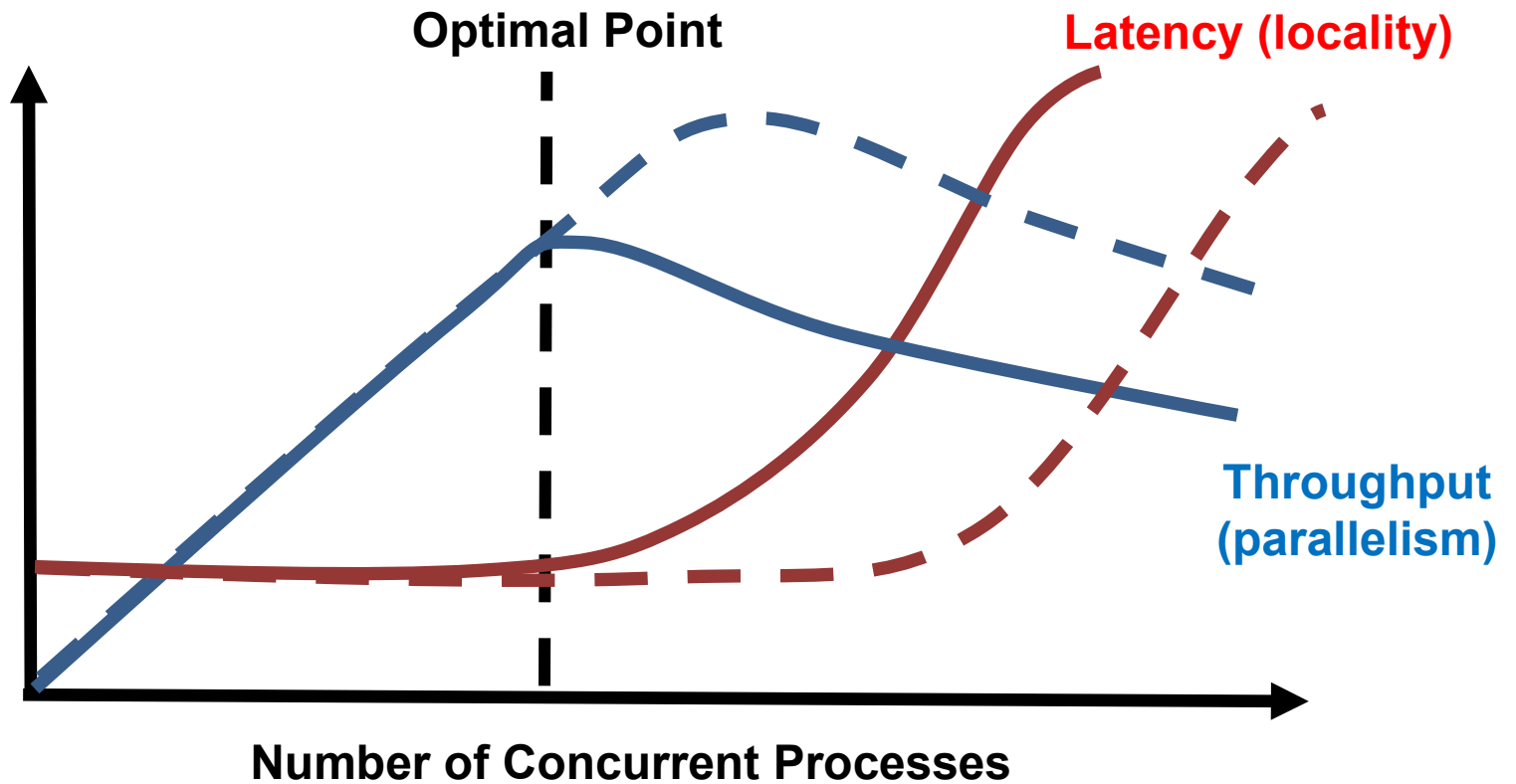
Cache design and Memory Systems

- Be able to map the memory addresses for direct, set-associative, multicolumn, and fully associative caches.
- Cache capacity calculation
- Relationships between cache and DRAM memory
- Make sure you understand lectures, midterm and homework

Hard Disk Drive (HDD) and Solid-State Drive (SSD)

- Basic concept of **data access time** in HDD: sequential and random accesses and others
- **SSD internals**: page write, block erase, write amplifications, garbage collections, ...

Basic Principle of Computing System Advancement: High **Throughput** and Low **Latency**



Three Major Areas in our Fields

Infrastructure

**Hardware/networking/
system management**

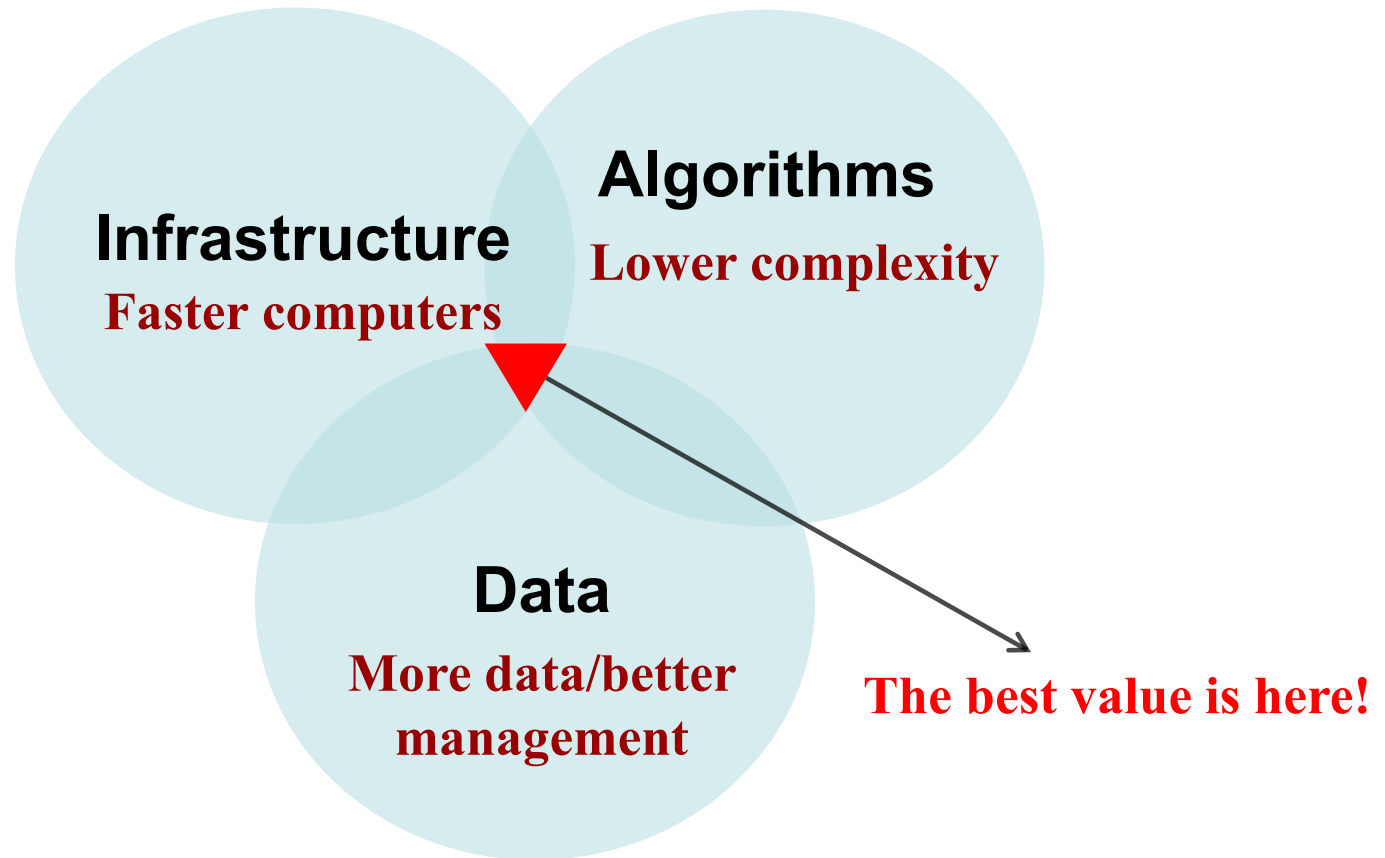
Algorithms

**Tasks in any area for
computer to execute**

Data

**Input for computing
and its management**

Best value comes from the best fit among the three



Final Words

- Write your constructive comments for this class, which will help me to finalize the book
- I hope you have had productive learning experiences in the class. I enjoy many group and individual discussions with you
- Best wishes to you who are graduating!
- Good Luck to the exam!