Tel Aviv University, Faculty of Engineering

Syllabus for the course:

0595.4495: Introduction to Computer Structure and Operating Systems

Spring 2017

Lectures: Gadi Oxman, gdaliaox@post.tau.ac.il

Recitations: Kostya Berestizhevsky, kostyanoob@gmail.com

Credit points: 3.5 (3 hours lecture, 1 hour recitation)

Perquisites: 0595.1821 (Programming 2 – C), 0595.3561 (Digital Logic Systems), 0595.2510 (Data Structures and Algorithms).

Main topics: Instruction Set Architecture. Computer Arithmetic. The Processor. Cache. Processes and Threads. Deadlocks. Memory Management. File Systems. Input/Output.

Course requirements:

Requirement	Details	Grade percentage
Homework exercises	Must submit 7 out of 8 exercises. The best 7 will be used for grading.	15%
Midterm		25%
Final exam		60%

Bibliography:

1. David A. Patterson, John L. Hennessy, "Computer Organization and Design", Morgan Kaufman Pub., 5th edition, 2014

2. Andrew S. Tanenbaum, Herbert Bos, "Modern Operating Systems", Pearson, 4th edition, 2014

3. Remzi H. Arpaci-Dusseau, Andrea C. Arpaci-Dusseau, “Operating Systems: Three Easy Pieces”, Arpaci-Dusseau Books, version 0.90, March 2015. Available Online: http://pages.cs.wisc.edu/~remzi/OSTEP/

Tentative Schedule

	Subject	Date	Book
1	Introduction to CS	Mar 19	[1] Chapter 1
2	Instruction Set Architecture	Mar 26	[1] Chapter 2, Appendix A
3	Computer Arithmetic	Apr 2	[1] Chapter 3
Pesach vacation		Apr 9	
Pesach vacation		Apr 16	
4	The Processor I	Apr 23	[1] Chapter 4
5	The Processor II	Apr 30	[1] Chapter 4
6	The Memory Hierarchy	May 7	[1] Chapter 5
7	Introduction to OS Processes & Threads I	May 14	[2] Chapter 1 [2] Chapter 2
8	Processes & Threads II	May 21	[2] Chapter 2
9	Memory Management	May 28	[2] Chapter 3
	Midterm Exam	June 2	
10	File Systems	June 4	[2] Chapter 4
11	Input/Output	June 11	[2] Chapter 5
12	Deadlocks	June 18	[2] Chapter 6
13	Case study: The Linux OS	June 25	[2] Chapter 10
	Exam Moed A	July 7	
	Exam Moed B	July 30	

Detailed topics:

Introduction to CS

Computer Structure introduction: History of computers. Classes of Computers. Computer Hardware Review. Moore's law. Power trends. Flynn's Taxonomy. Amdahl's Law. CPI and the processor performance equation. Integrated circuit cost.

Instruction Set Architecture

Operations. Operands. Signed and Unsigned Numbers. Encoding Instructions. Logical Operations. Branches. Addressing Modes. Procedures. Subroutines. Stack. Compiler. Assembler. Linker. DLL. RISC vs CISC.

Computer Arithmetic

Addition. Subtraction. Multiplication. Division. Floating Point.

The Processor

Datapath: PC, ALU, Registers, Mux. Control: Micro-coded and Hard-wired. Single Cycle Implementation. Pipelining. Classic 5-stage RISC pipeline. Structural Hazards. Data Hazards. Control Hazards. Resolving Hazards: Stalling, Forwarding.

Cache

The memory hierarchy. Structure and operation of a direct mapped cache. Cache performance modeling equations. Associative caches. Replacement algorithms. Write policy. Multilevel caches. Software optimizations.

Introduction to OS

Operating Systems introduction: History of OS. Classes of OS. Concepts: Processes, Address Spaces, Files, I/O, Protection, The Shell. System Calls. OS structure.

Processes and Threads

The Process: Model, Creation, Termination, Hierarchies, States, Implementation, Modeling Multiprogramming.

The Thread: Usage, Classical Model, POSIX Threads. Implementation: User Space, Kernel Space, Hybrid. Scheduler Activations. Pop-Up Threads. Making Single-Threaded Code Multithreaded.

Interprocess Communication: Race Conditions. Critical Regions. Mutual Exclusion with Busy Waiting. Sleep and Wakeup. Semaphores. Mutexes. Monitors. Message Passing. Barriers. Avoiding Locks: Read-Copy-Update.

Scheduling: Batch Systems. Interactive Systems. Real-Time Systems. Policy vs Mechanism. Thread Scheduling.

Classical IPC Problems: The Dining Philosophers. The Readers and Writers.

Memory Management

Early computers. Address spaces abstraction: Swapping, Managing Free Memory.

Virtual Memory: Paging, Page tables, Speeding Up Paging, TLB, Page Tables for Large Memories.

Page Replacement Algorithms: Optimal, Not Recently Used, FIFO, Second-Chance, Clock Page, LRU, Working Set, WSClock.

Design Issues: Local vs Global Allocation. Load Control. Page Size. Separate Instruction and Data Spaces. Shared Pages. Shared Libraries. Mapped Files. Cleaning Policy. Virtual Memory Interface.

Implementation Issues: OS involvement. Page Fault Handling. Instruction Backup. Locking Pages. Backing Store. Separation Policy and Mechanism.

File Systems

Files: Naming. Structure. Types. Access. Attributes. Operations. File System Calls.

Directories: Single Level. Hierarchical. Path Names. Directory Operations.

Implementation: Layout. Files. Directories. Shared Files. Log Structured FS. Journaling FS. Virtual FS.

Management and Optimization: Disk Space. Backups. Consistency. Performance. Defragmenting Disks.

Examples: MS-DOS, Unix V7, CD-ROM.

Input/Output

Hardware: Devices. Controllers. Memory Mapped I/O. Direct Memory Access. Interrupts.

Software: Goals. Programmed I/O. Interrupt-Driven I/O. I/O Using DMA.

I/O Software Layers: Interrupt Handlers. Device Drivers. Device Independent I/O. User Space I/O Software.

Disks: Hardware. Formatting. Arm Scheduling Algorithms. Error Handling. Stable Storage.

Clocks: Hardware. Software. Soft Timers.

User Interfaces: Keyboard, Mouse, Monitor, Input/Output Software.

Deadlocks

Resources: Preemptable. Nonpreemptable. Acquisition. Condition for Resource Deadlocks. Deadlock Modeling. The Ostrich Algorithm. Deadlock Detection. Deadlock Recovery. Deadlock Avoidance: Resource Trajectories, Safe and Unsafe States, The Banker's Algorithm. Deadlock Prevention. Other Issues: Two-Phase Locking. Communication Deadlocks. Livelock. Starvation.

Case Study: The Linux OS

Unix History. Overview. Processes. Memory Management. Input/Output. File System. Security.