Høyskolen Kristiania

Digital Technology Spring 2022

TK1104-1 22H

Lecturer: Toktam Ramezanifarkhani

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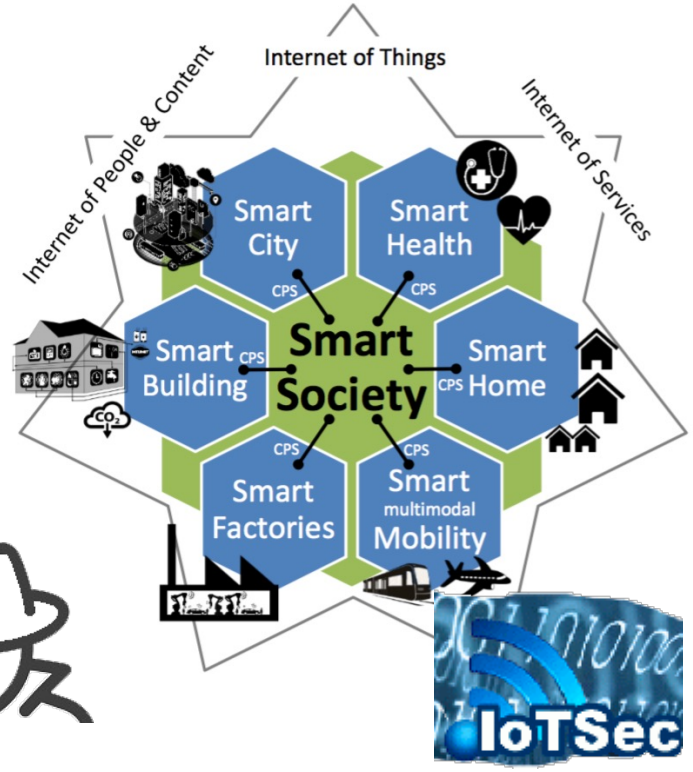
About The Lecturer

Høyskolen Kristiania

UiO : Department of Informatics
University of Oslo

- Associate Professor in Cyber Security at Department of Technology at Kristiania University College
- Associate Professor at Department of Informatics University of Oslo (UiO)

- Researcher/Postdoc
- ConSeRNS: Strategic Research Initiative for Concurrent Security and Robustness for Networked Systems, Reliable Systems (PSY) (UiO)
- Section for Autonomous Systems and Sensor Technologies of the University of Oslo (UiO)
- Precise Modeling and Analysis group of the University of Oslo (UiO)
- Computer Emergency Response Teams (CERT) at Amirkabir University of Technology



- **Ph.D.**
  - IT– Information Security
- **Master of Science**
  - IT– Information Security
- **Bachelor of Science**
  - Computer Engineering – Software Engineering

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TA: ?

Introduction

What is the course content?

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- Information Technology Fundamentals
  - Sort of like computer literacy for the IT person
  - Computer hardware (assembling a computer)
  - Computer organization – the role of the CPU, memory, I/O, storage
  - The binary number system, Boolean logic
  - Operating systems (Linux/Unix and Windows/DOS), process management, file systems, services, booting and initialization, virtual memory, accounts and permissions
  - Computer networks, Information, Information security
  - Programming
  - IT careers

Digital Technology (TK1104)

Høyskolen Kristiania

- After successfully completing this course, you will acquire:
- Learning Outcomes for the students
  - **Knowledge**
    - to describe the **historical development** leading to today's **computers and networks**;
    - to **define and use** the **most common concepts describing and analysing** computer systems and networks
    - to describe the principles and **methods for digital coding of various forms of information,** and what possibilities and limitations are present
    - to **describe the architecture and** organisation of computer systems and networks
    - to **explain the role of an operating system** and decompose the **functionality of the main elements** process/thread **administration** (scheduling + real time handling), memory administration (virtual memory etc.), file administration, I/O-administration
    - to use the **TCP/IP model to explain and analyse data communication through the Internet**

The course program

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12 lessons with 2 hours of teaching and 2 hours of supervised practice

- The practice hours immediately after the lecture
- There will be a tutor available for digital sessions if any, check the announcements

Exam

- 6 hours individual home exam • Pass / fail
- Self-work is IMPORTANT!

Self-work

- The syllabus states 200 hours of work in this course
- 48 hours of lectures and exercises
- For example:
  - hours of preparation and work in connection with lectures; 10 hours for EVERY lecture
  - rehearsal previous lecture
  - preparation and follow-up to ensure learning
  - E.g. 42 hours preparation for the exam
  - Complete the assignments

Curriculum?

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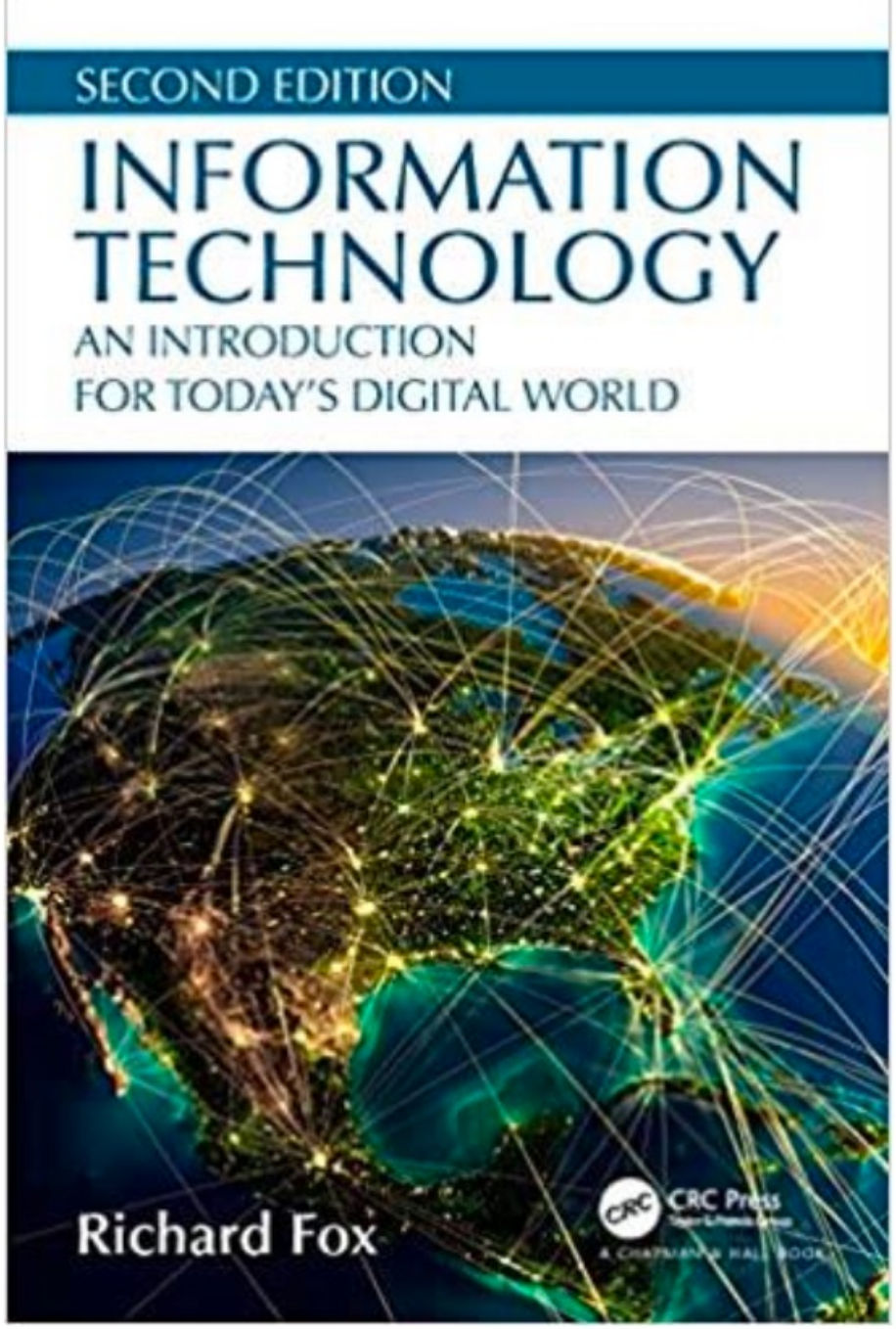
- The syllabus is all lectures in the course (there is no separate textbook that must be purchased)
- The syllabus is also able to answer all assignments that are given in the course during exercises
- The exercises are often a summary of the lecture, and some sets are multiple choice assignments of different structure.
- In addition, there will be a number of more open assignments, both as self-study and text assignments that are more similar to what you get on the exam
- Where relevant, there are also practical exercises
- There is a compendium on the subject page that briefly covers the majority of the most important competence goals (authored by former lecturer)



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Curriculum book

- INFORMATION TECHNOLOGY, SECOND EDITION (Richard Fox 2021)

ISBN-13: 978-0367820213 ISBN-10: 0367820218

- The lectures are «syllabus», so there will be no questions that are only in the book on the exam
- Very good book that covers most of the syllabus; CPU and Memory, Storage and I / O, Binary Number System, Operating System, Computer Networks
- Can be purchased here: https://www.amazon.com/Information-Technology-Richard-Fox/dp/0367820218/

Additional literature

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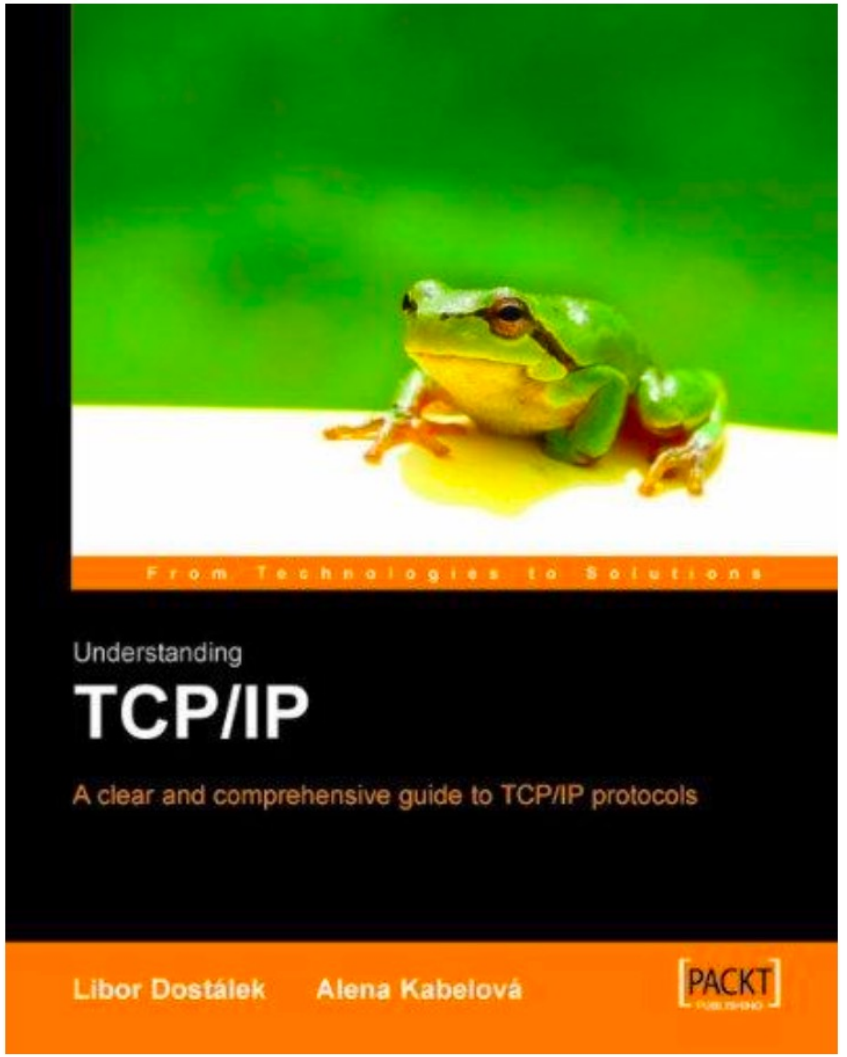
- The syllabus book is a bit thin on TCP / IP, those who are interested in books that go more in depth on networks can find many good books on Amazon
- I recommend this for those who study intelligent systems and programming in the Technology line:
- Understanding TCP / IP
- But note that this again goes much deeper than what is the syllabus in this subject. Fairly affordable book, but only for those who want to go more in depth



Sessions

Overview of lectures

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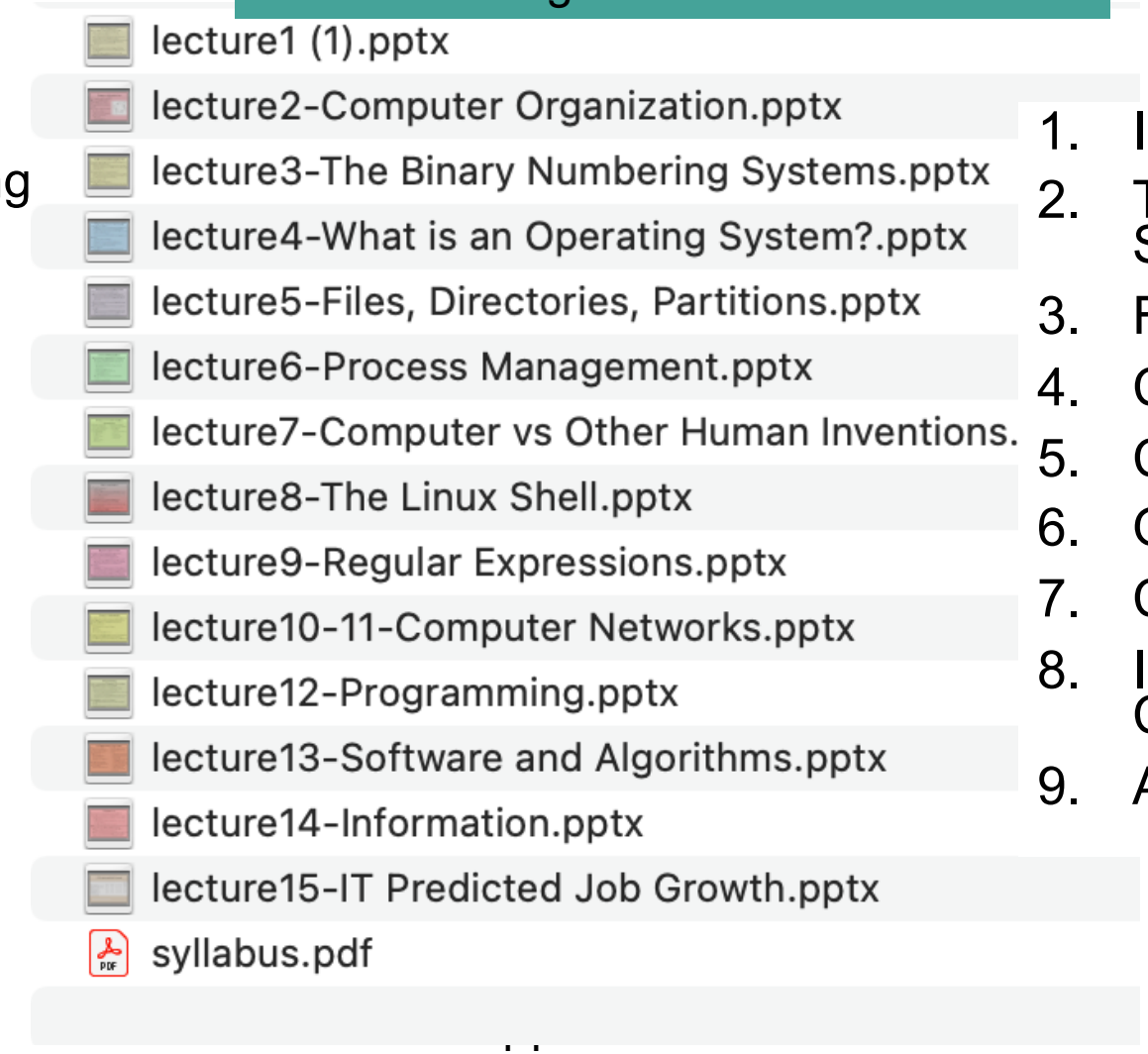
KUC last years

Introduction to the course
1: Binary data
2: Character sets, encoding media
3: Computer architecture
4: Computer structure
5: Operating System
6: World Wide Web I
7: The application team
8: Transport team
9: The Network Team
10: Link team
(Rehearsal lecture)
Exam

Northern Kentucky University
Department Computer Science
Home Page for **Richard Fox**



1. Introduction Of DT
2. The Binary Numbering Systems
3. Formats, Files, TXTmedia
4. Computer Organization
5. Computer Architecture
6. Operating System (2)
7. Computer network (2)
8. Information security and Cryptography
9. Assignment presentation

Overview of lectures

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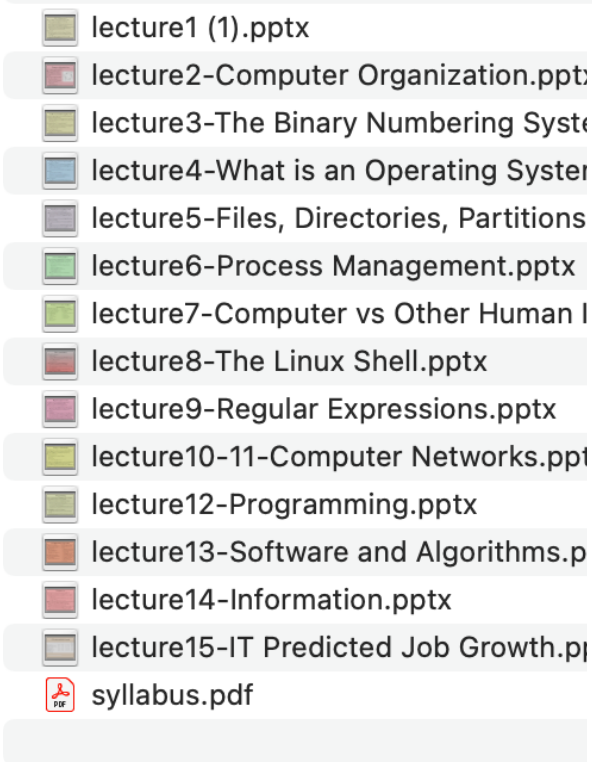

1. Introduction Of DT
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8. Information security and Cryptography
9. Assignment presentation

1. Introduction Of DT-Computer assembly
2. The Binary Numbering Systems
3. Computer Architecture – Boolean algebra

4 Organization-Hardware

5. Computer Program Instruction

6,7 Operating System (2)

8,9,10,11 Computer network (4)

12 Rehearsal - Information security and Cryptography

How to FAIL This Course!

- 12 Lectures - 12 Labs
- The students who do not pass this class
  - They do not complete lab assignments
  - They do not complete the work assignment
  - They do not study for the final exam - 100% of your grade
  - They do not take the course seriously

  - Don’t fall into the bad habits
  - Study keep up with readings
  - Hand in all lab assignments
  - Prepare for the final exam

Work requirement - assignment

- What's new in Digital technology
- Group Work of max 3

- Research on related topics and news in each category of the course syllabus
-
- Prepare a short presentation, 5-10 slides
  - First page the title and the group introduction
  - Last page the references
  - Published date (recent),
  - The rest must explain the topic

Tas – To be completed

OSLO FØRSTEKLASSE TK1104: Digital Teknologi
Navn
Arsalaan Sulman
Rune-Daniel Jacobsen
Samuel Gonzales
Jack Xia
Aryub Naqid

	13-15 Rune-Daniel Jacobsen	17-19
KUN-A3-01		Samuel Gonzales
KUN-A3-03		Jack Xia
T34-TAR-200		Arsalaan Sulman
Online (Bergen)		

Today's learning activities

- Lecture
  - Introduction
- Lab
- Your reflections on jamboard, **Mentimeter, padlet, etc.**

- **Lets know you:**
  - Go to www.menti.com

Digital Technology Jobs

System Administration

- Account management
- Password management
- File protection management
- Installing and configuring new hardware
- Troubleshooting hardware
- Installing and configuring software
- Updating software
- Providing documentation and support
- System-level programming (scripting)
- System-level security
- IT Support
  - Documentation, manuals, website support (wikis, FAQs), A/V demos
  - Training
  - Help desk support

Examples of IT Roles

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Role	Job/Tasks
System Administrator	Administer the computers in an organization; install software; modify/update operating system; create accounts; train users; secure system; troubleshoot system; add hardware
Network Administrator	Purchase, configure and connect computer network; maintain computer network; troubleshoot network; secure network from intrusion
Database Administrator	Install, configure and maintain database and database management system; back up database; create accounts; train users
Web Administrator	Install, configure and maintain web site through web server; secure web site; work with developers
Web Developer	Design and create web pages and scripts for web pages; maintain web sites
Security Administrator	Install, configure and administer firewall; create security policies; troubleshoot computer system (including network); work proactively against intrusions

Skills for the Successful IT Person

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Skill	Description	Example(s)
Troubleshooting, problem solving	• Detect a problem • Diagnose its cause • Find a solution (means of fixing it)	• Poor processor performance • Disk space full • Virus or Trojan horse infection
Knowledge of operating systems	• Operating system installation • Application software installation • User account creation • System monitoring	• Versions of Linux • Versions of Unix • Windows • Mac OS
System level programming	• Shell scripts to automate processes • Manipulating configuration files for system services	• Bash, Csh scripts • DOS scripts • Ruby scripts • C/C++ programs

Continued

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Skill	Description	Example(s)
System security	• Ensuring proper system security is in place • Following or drafting policies for users • Monitoring for threats	• Configuring a system firewall • Installing antiviral/anti-malware software • Examining log files for evidence of intrusion and system security holes • Keeping up with the latest security patches
Hardware	• Installing and configuring new hardware • Troubleshooting, replacing or repairing defective hardware	• Replacing CPUs and disk drives • Connecting network cables to network hubs, switches, routers

Be Prepared

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- Keep up with new trends in technology
  - Be a self-starter
  - Be curious
  - Be willing to learn on your own
- You might be on call 24/7
- Behave ethically at all times
  - Know the difference between ethical and unethical behavior
- Reflect: what are ethical and unethical behavior? Any example?

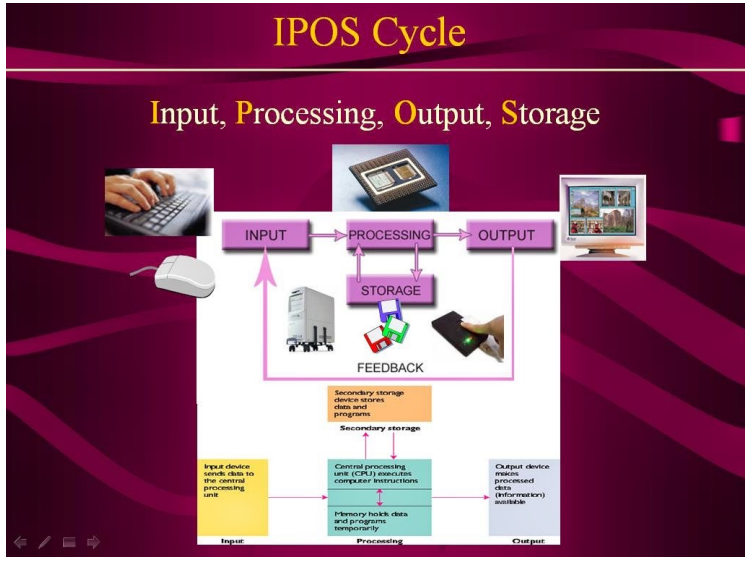
  Reflect in padlet.

What is a Computer?

What is a Computer?

- Electronic device
- General purpose (executes any type of program)
- Stores data
- Performs the IPOS Cycle

- Examples:
  - Supercomputers
  - Mainframes/minicomputers
  - Personal computers/laptops
  - Notebook computers
  - Handheld devices
- What about these
  - Smart phones
  - Mp3 players
  - Electronic book readers

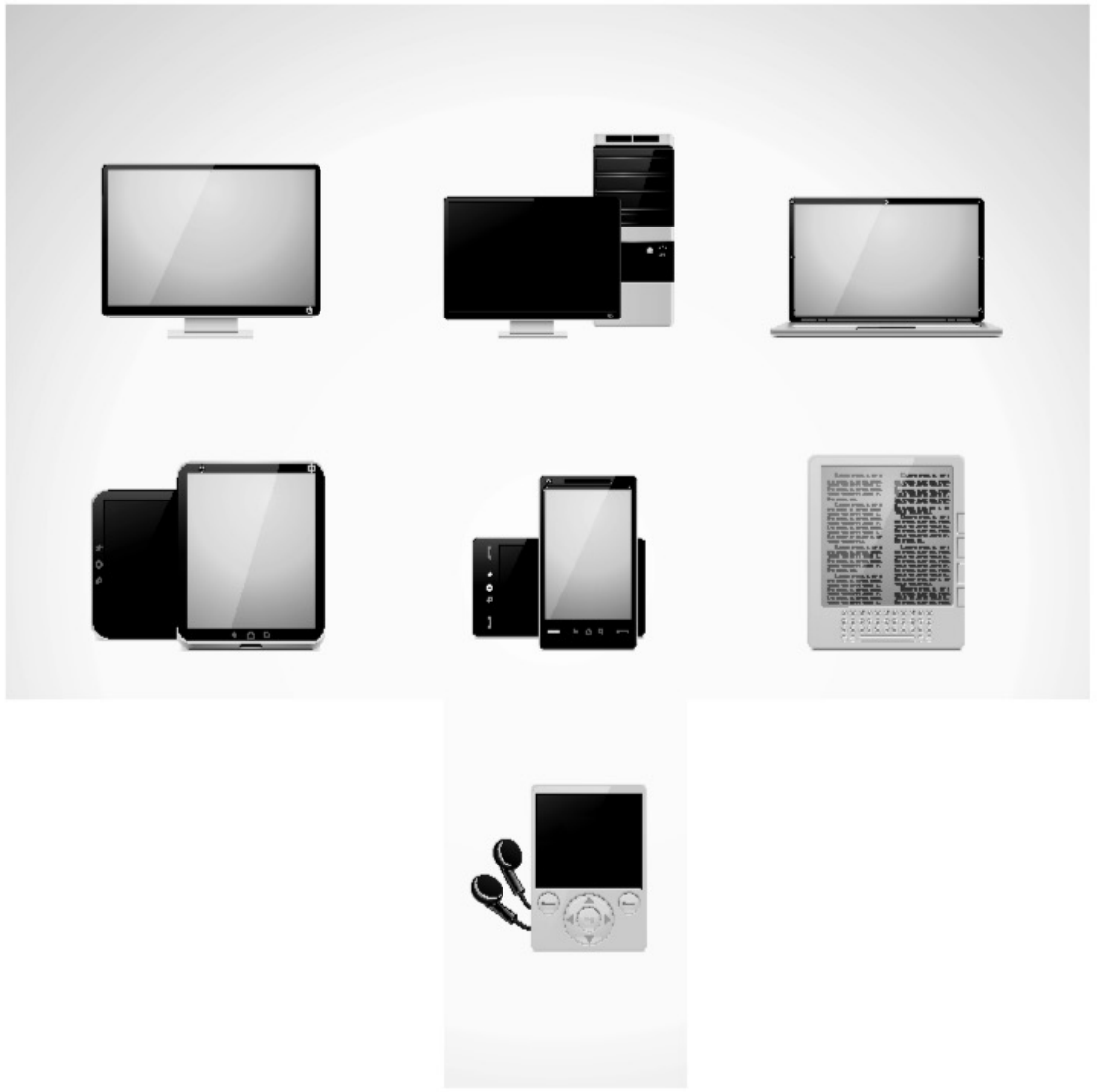


TYPES OF COMPUTERS

- TYPES OF COMPUTERS || MICROCOMPUTER || MINICOMPUTER || MAINFRAME COMPUTER || SUPERCOMPUTER

- https://www.youtube.com/watch?v=fscCXPXd7YA

- watch the video and try to answer the questions:
- https://www.youtube.com/watch?v=vvrdgwDnMQA



Computers Today

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- Computers were easily identifiable
  - Expensive
  - Required clean room environments
  - People connected to them via network and terminals
- Not so today
  - Computers of any size
  - Wireless provides Internet access
  - Go anywhere and still have access
  - Billions of processors in our world

Computer - main division

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- The computer system can be divided into 2 main parts
- Hardware
  - Electronic and electro-mechanical components that make the computer environment work
  - Input / Output, Storage (HD, RAM), Calculation (CPU, GPU)

- Software
  - Applications that take advantage of the capabilities that the hardware provides to perform special tasks
  - Applications are programs that are made in languages that the computer "understands"

Components of a Computer

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- Processor
- Storage
  - Short term (memory)
    - SRAM
    - DRAM
    - ROM
  - Long term
    - Hard disk
    - Optical disk
    - Floppy disk
    - Flash drive
    - Magnetic tape
- I/O devices
- The system unit
- The motherboard, which contains
  - The CPU
  - CPU cooling unit
  - Extra processors (optional)
  - Memory chips for RAM, ROM
  - Connectors (ports) for peripherals
  - Expansion slots for peripheral device cards
  - ROM BIOS (booting, basic input & output instructions)
  - Power supply connector
- Disk drives
- Fan units
- Power supply

Storage Sizes

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Size	Meaning	Example
1 bit	A single 0 or 1	Smallest unit of storage, might store 1 black & white pixel or 1 true/false value, usually we have to combine many bits to create anything meaningful
1 byte (1B)	8 bits	We might store a number from 0 to 255 or -128 to 127, or a single character (letter of the alphabet, digit, punctuation mark)
1 word	32 or 64 bits	One piece of data such as a number or a program instruction
1KB	1024 bytes	We might store a block of memory in this size
1MB	~1 million bytes	A small image or a large text file, an mp3 file of a song might take between 3 and 10 MB, a 50 minute tv show highly compressed might take 350MB
1GB	~1 billion bytes	A library of songs or images, dozens of books, DVD requires several GB of storage (4-8GB)
1TB	~1 trillion bytes	A library of movies

CPU - Central Processing Unit

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- The processor

  (The "performing" part of the computer)
- Often called the computer's 'brain', as a main engine («calculator»).
- Consists of circuits and electronics that can perform tasks (instructions)
- The instructions can process data
- Pair of terms: instruction <-> data

I/O Devices (Peripherals)

Software

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- Programs
- Step-by-step instructions to the computer
- To run the program, the program must be written in the computer's machine language
- We write programs in high level languages
  - C/C++, Java, Python, Ruby, C#, Visual Basic, etc
- We translate programs from high level to machine language using language translator programs
  - compilers, interpreters, assemblers

Example Program

- Compare 2 numbers and output the larger
- In English:

Input number1
Input number2
Compare the two numbers
If the first is greater
    than the second
Then output number1
Otherwise output number2

- In C code:

```
scanf("%d", &number1);
scanf("%d", &number2);
if(number1 > number2)
     printf("%d is greater", number1);
else printf("%d is greater", number2);
```

Function-oriented model

- Layer 5 User program level
- Layer 4 Compiler level / interpreter
- Layer 3 Operating system level
- Layer 2 Instruction level
- (Layer 1 Microinstruction level)
- Layer 0 Digital circuit level

Here we focus on what kind of tasks are solved at different levels.
- 0-2 is HW
- 3-5 is SW

Applications

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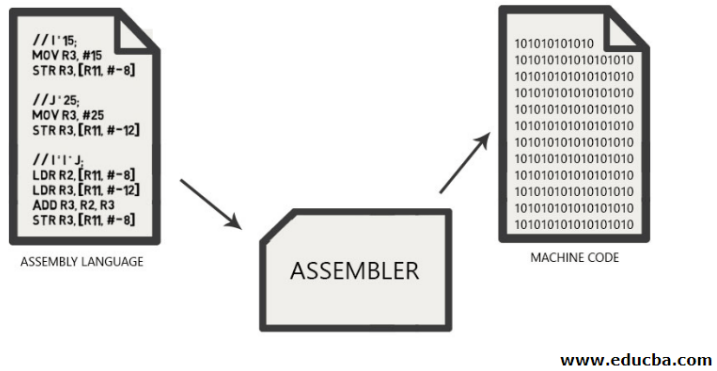
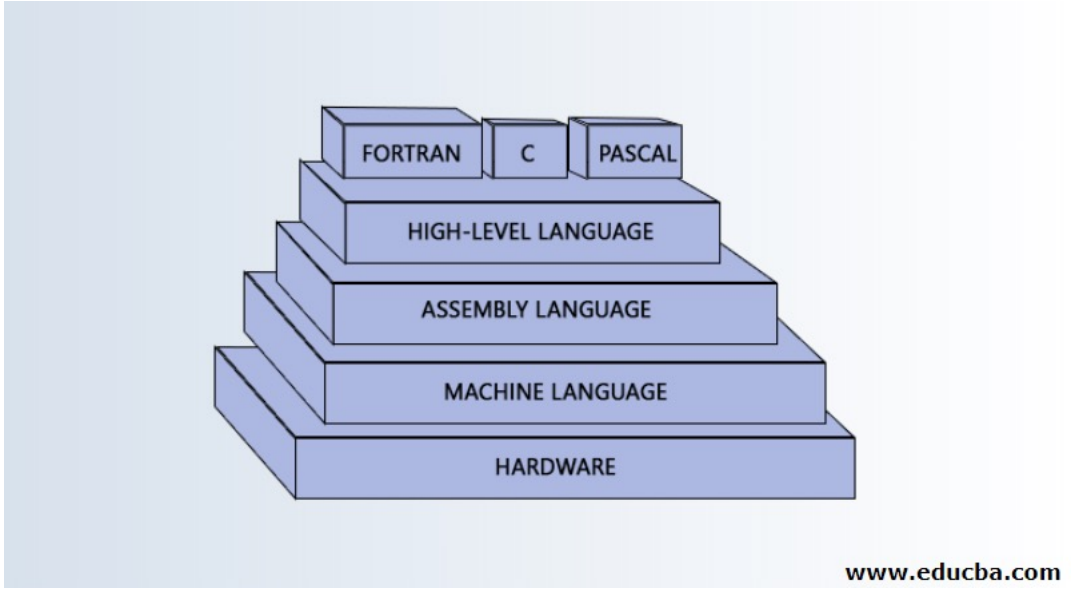
- Word processing (Word, Notepad, ...)
- Spreadsheet (Excel, ...)
- Database systems (Oracle, Access, ...)
- Graphics (PhotoEditor, ...)
- Browser (Chrome, Internet Explorer, ...)
- Electronic mail (Outlook, ...)
- Special programs
- Virus checks, multi-media, programming tools, ...

Processor operation



- Instructions for the processor = programming
  - Retrieved from the processor from memory (RAM)
- Machine language (IA32, IA64, etc.)
  - Assembler language (each command corresponds to a machine instruction: mov eax, [00AF3B13])
- Low level language
  - C, C ++ (and more)
  - Compiled over to machine instructions
- High level language
  - C #, JAVA (and many others)
  - Interpreted in an environment (eg a virtual machine)
- Other languages
  - Excel, SQL, scripting language



Users

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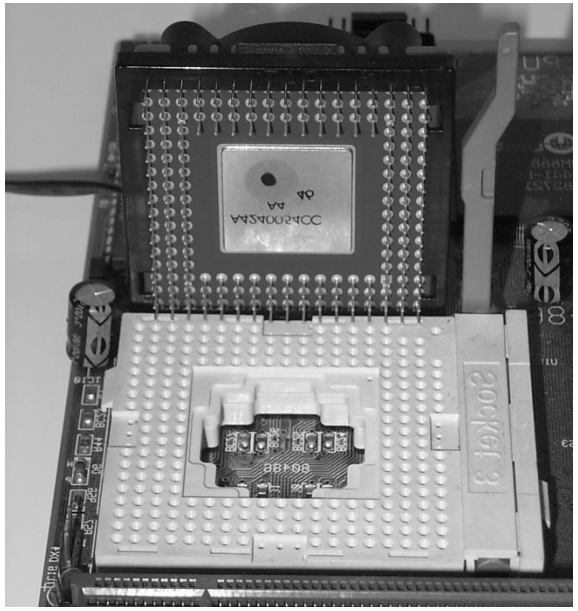
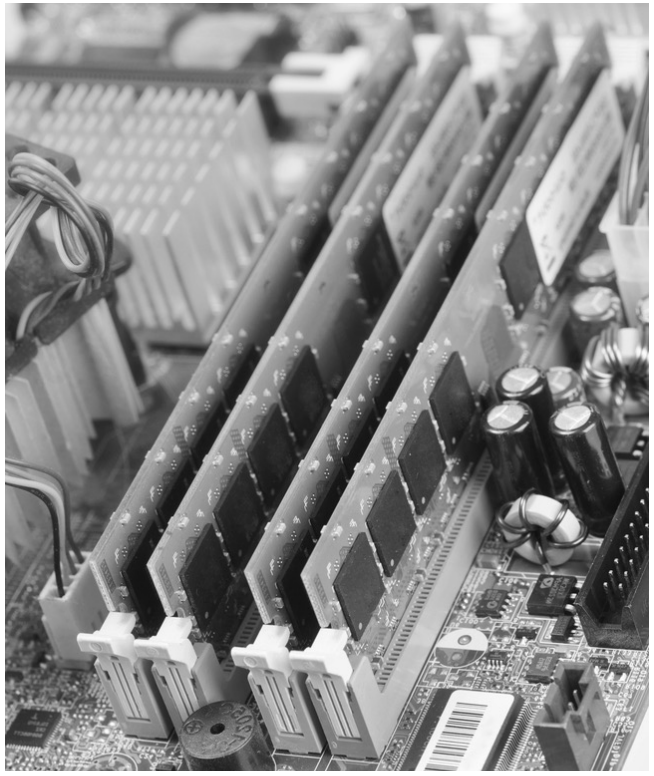
- Initiates the processes that computers run
- Uses interactivity
  - Makes computer usage more enjoyable
- Early users were engineers and programmers of the computers
- That changed in the 60s
- Today, nearly everyone is a user

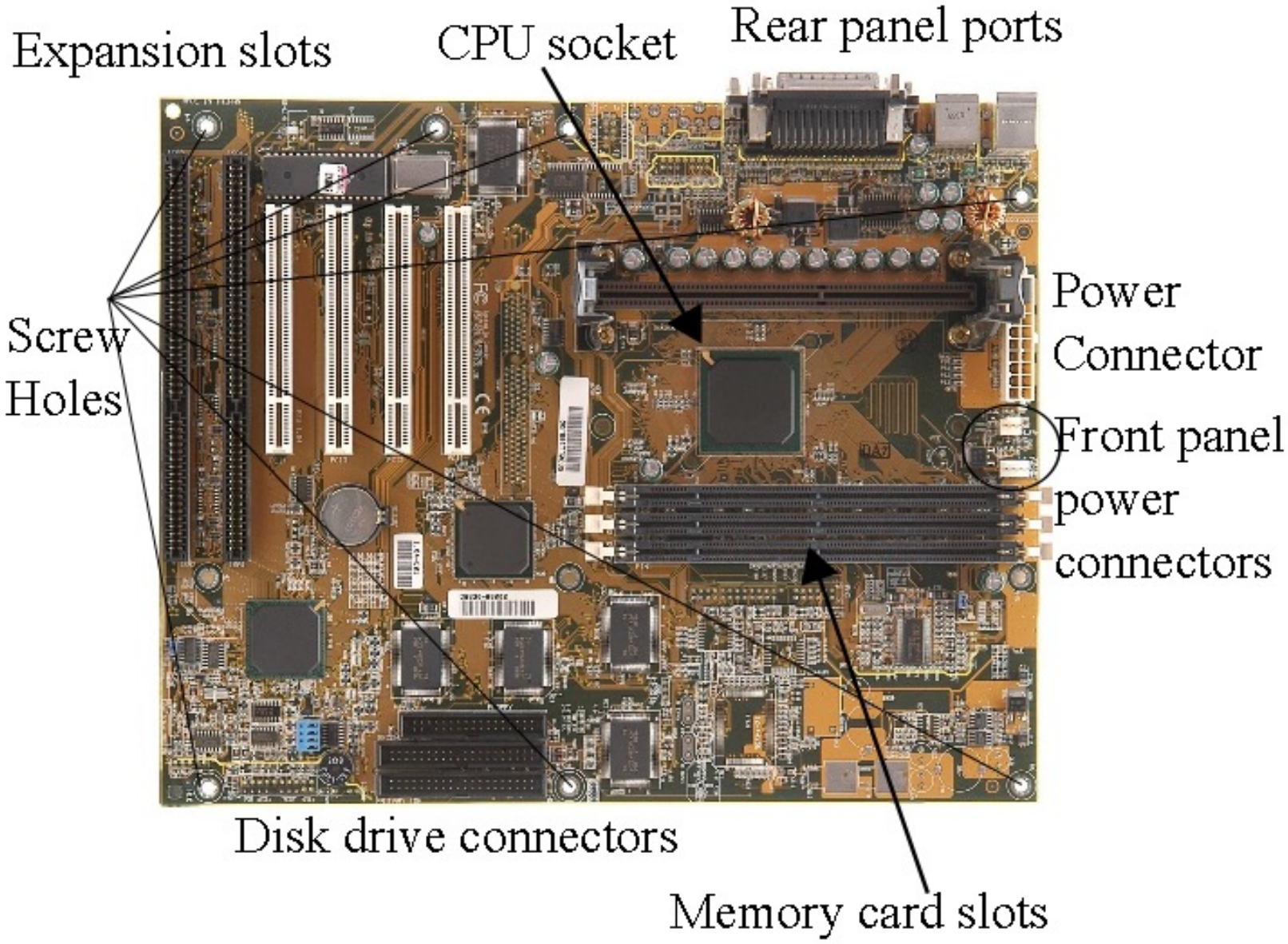
Computer Hardware

- Microprocessor – the CPU on 1 chip
  - Pins on one side to plug into motherboard CPU slot
  - Cooling unit sits on top
- Memory – individual chips placed on circuit board
  - Slip circuit board into memory slot(s)
- System bus – part of the motherboard





Motherboard Explained



System Unit

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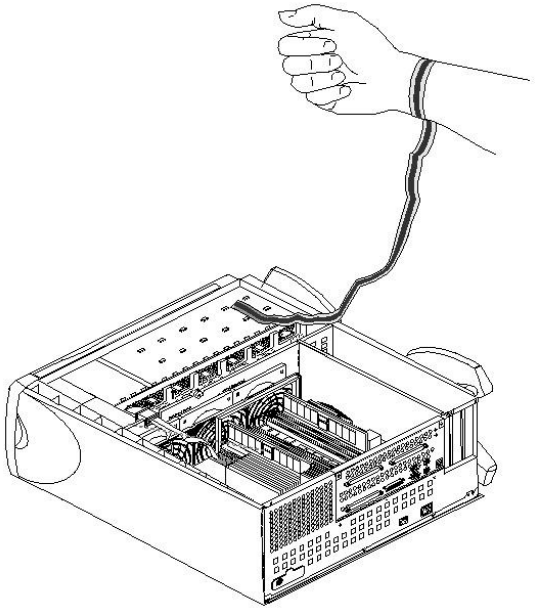
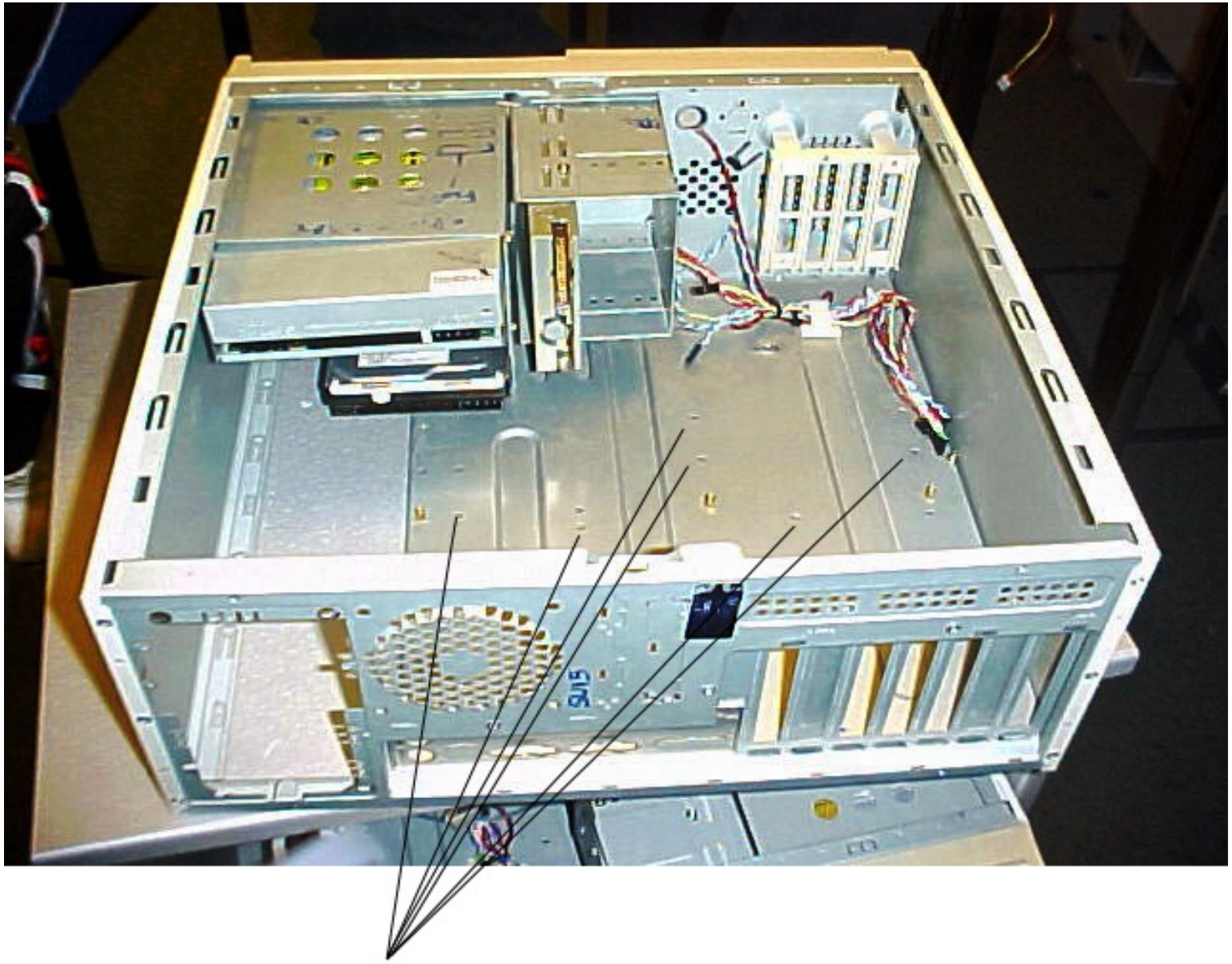
- Case into which
  - You place the motherboard
  - Fan(s)
  - Disk drive units
  - Power supply
  - Internal MODEM connected to motherboard directly
- Peripheral devices connect to motherboard through ports in system unit

System Unit

Insert motherboard to rest on top of standoffs





Screw holes for standoffs

https://www.youtube.com/watch?v=ea_bs5G1yYU&t=95s

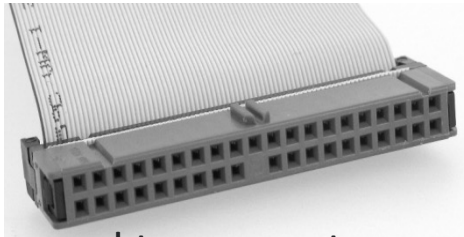
Hard Drive

Multiple platters

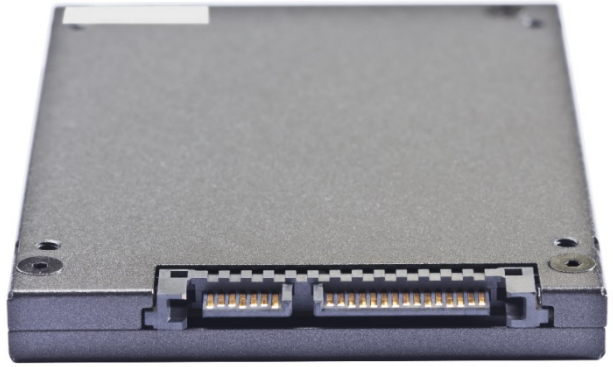
1 read/write head
per surface

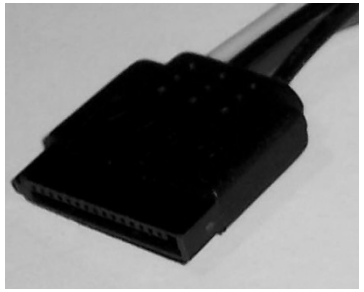
All disks spin in unison
by central spindle

IDE and Serial Advanced Technology Attachment (SATA) use different connectors



IDE refers to the types of cables and ports used to connect some hard drives and optical drives (CDs, DVDs, and BDs (Blu-ray discs)) to each other and to the motherboard. An IDE cable, then, is a cable that meets this specification.

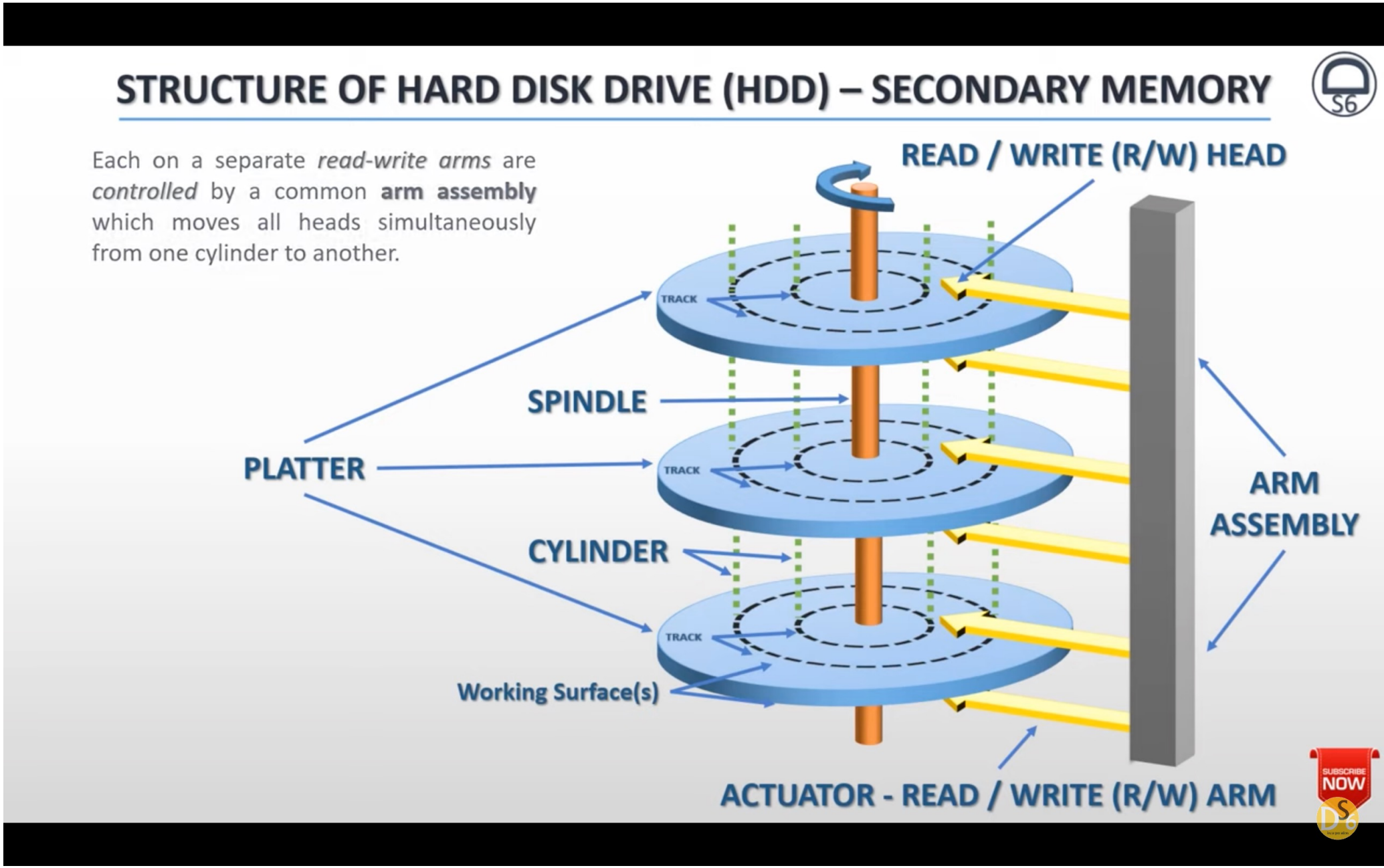




https://www.youtube.com/watch?v=oEORcCQ62nQ

Hard Drive (2)

https://www.youtube.com/watch?v=oEORcCQ62nQ



Power Supply

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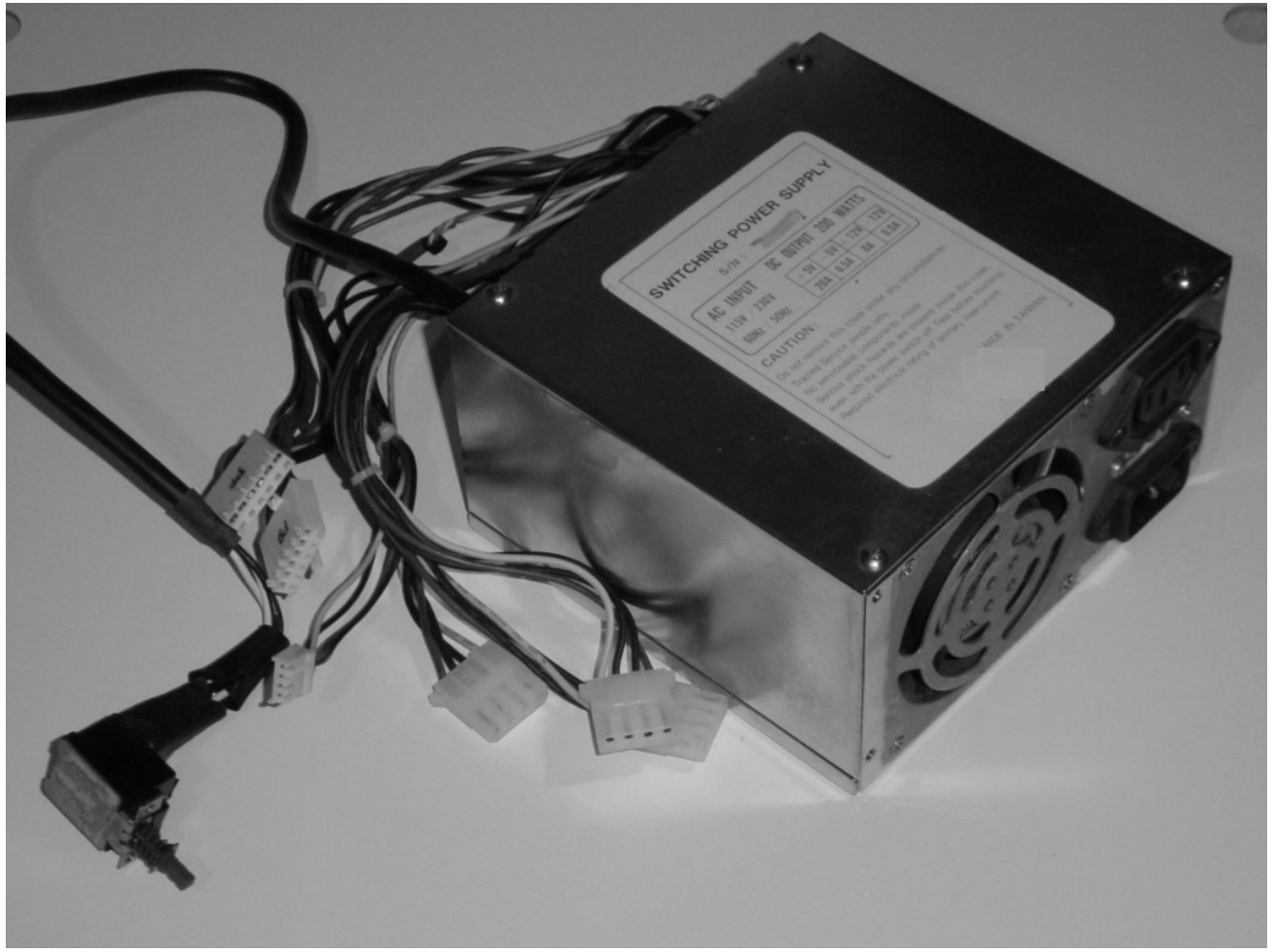
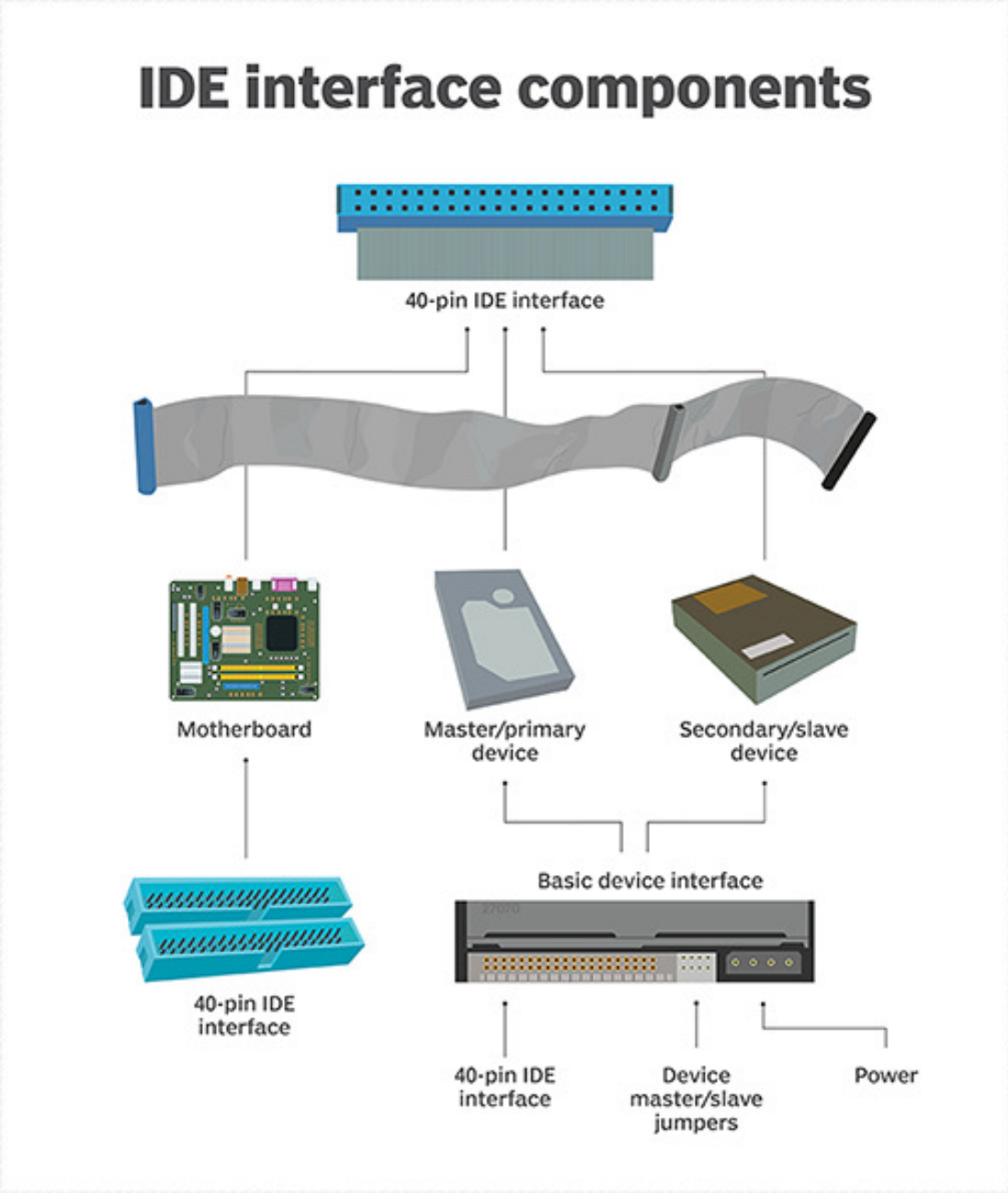
With cables connect to drives, fan and motherboard



Computer Assembly

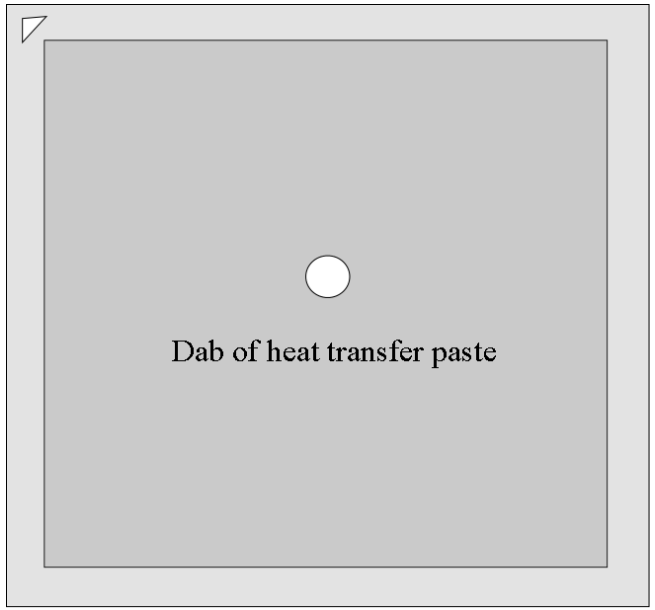
- Prepare system unit
  - Identify the components to assemble
  - Remove system unit side panel
  - Screw in standoffs
- Prepare motherboard
  - Wear grounding strap
  - Insert CPU
  - Use a dab of thermal energy paste
  - Attach cooling unit to CPU and plug in to motherboard
  - Attach memory circuit board(s)

https://www.youtube.com/watch?v=ea_bs5G1yYU&t=95s



CPU Cooling Unit

- Place a “pea-sized” dab of heat paste on the surface of the CPU
- Inserted into holes around CPU



- Plug cooling unit’s power
- Connector into motherboard socket

How to build a PC: The Tech Report guide

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- How to install new RAM to a Laptop PC
https://www.youtube.com/watch?v=mHeiFsNa0Es

- How to use an Antistatic Wristband to handel static electricity
Wear grounding strap
https://www.youtube.com/watch?v=_m_F4j-oQaU

- Assembling a PC tutorial:
https://techreport.com/review/23624/how-to-build-a-pc-the-tech-report-guide/
https://www.youtube.com/watch?v=ea_bs5G1yYU&t=95s
https://www.youtube.com/watch?v=znx_jCKLwXw

- Q/A:
  - https://abcsir.blogspot.com/2019/04/class-7-chapter-3.html

Main points with computers

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- Speed:

  perform missions very fast

- Reliability:
  - They do not make mistakes (except when something is wrong with the computer or a human can make a mistake, or ...!)
- Storage capability:

  They can store large amounts of information (data) over a long period of time

- Price:

  They get better and better at a lower price

- Size:

  They are getting smaller and smaller

A system understanding of a PC system

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- Performance is as much about moving data and instructions quickly between components as it is about processing them quickly

- Fast CPU on a motherboard with slow and cramped buses thus gives (still) poor performance, and vice versa.

- The goal is a balanced system

The end

Practice lessons

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- Questionnaire (PDF), it is recommended that you work in groups during the practice hours
- Primarily repetition of the lecture to ensure good learning
- Some exercises are practical - make the theory a little easier to understand / remember
- Write down answers - full (you need it in 3 months for exam preparations ...)
- Search different sources online to learn the topics in more depth! You need in depth to UNDERSTAND the topic, not just cradle the foils ...
- YES, "new material" appears in the exercises !!
- YES, you can get (directly and indirectly) questions from the exam exercises

Next week

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- Data representation
- Number systems / Boolean algebra / Coding / decoding
- Homework
- 8-4-2-1, 8.4.2.1., 8 4 2 1 -> LEARN !!!!!!!!
- 128-64-32-16- 8- 4- 2- 1
- 1 0 1 0 0 1 1 0 = ????
- Find pen and paper !!!!
- Most of what we do next time is much easier to achieve on a sheet of paper than trying to do on the "screen"

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For optional self-study

For those who want to learn some topics in more depth to better understand, here are some extra topics related to today's teaching, it must be expected some personal work to understand these topics.
There will be no questions on the exam from these, and this is therefore not considered to be part of the syllabus.

Computer (PC) with accessories

What is information?

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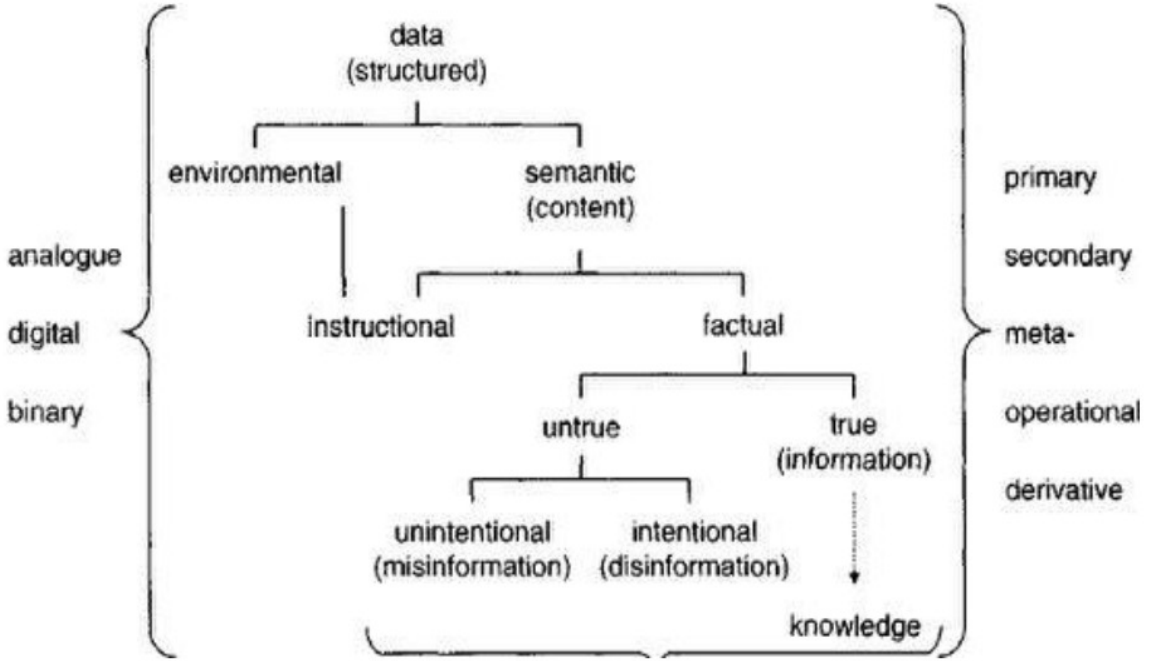
- Used in many many different meanings - two extremes are:
- Information Theory (Shannon, 1948): Entropy (self-information) H = k * lg (N),

  N = number of characters in the character set,

  k number of characters in the message.
- Popular: data understood in a context, "meaningful data"



- The Windows calculator claims that

(√2) 2-2 =?

- Computers "always" work with final precision !!!
- Moving numbers are an encoding format!

Units and sizes

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- Bit (b) - 0 or 1
- • Byte (B) = 8 bits
- • Kilo = 103 = 1000 ≈ 1024 = 210
- • 1 km = 1000 m, 1 mm = 1/1000 m
- • For the sake of simplicity, we "cheat" a little!
- • k = 1000, Ki = 1024, (assume that K = 1024 also)
- Kilobyte / KibiByte (KiB) = 210 bytes = 1024 bytes
- Megabyte / MibiByte (MiB) = 220 bytes = 1024 KB = 1048576 bytes
- Gigabyte / GibiByte (GiB) = 230 bytes = 1024 MB = 1073741824 bytes
- • Heart (Hz) = events per second
- • MIPS = Mega instructions per second.
- • FLOPS = Mega floating point operations per second
- • kbps = 1000 bit / second (bit rate, «bandwidth»)

History

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• The modern computer can be seen as a solution to three (historically) different problems:

1) The calculation problem

• how to perform complex calculations quickly and reliably

2) The mass data problem

• How to store and process large amounts of data

3) The regulatory problem

• How to control and automate industrial o.a. processes

Calculators

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- Abacus (ca -3500)
- ”Tabeller”
- John Napier, 1600 (staver)
- Willian Oughtree, 1622 (regnestav)
- ”Tannhjul-maskiner” • Pascal, 1642
- Leibniz, 1694

Calculators 2

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- Mechanical
  - Charles Babbage (1791 - 1871)
  - Difference Engine - 1822
  - Analytical Engine - 1833
  - AugustaAdaKing, countess of Lovelace
- Electromechanical
  - Zuse, 1936-
  - Atanasoff, 1940-

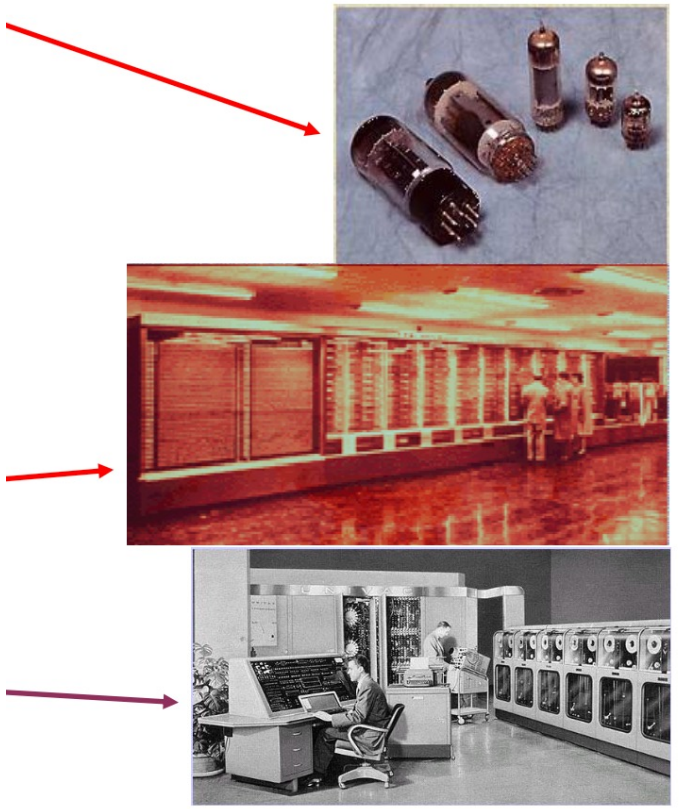
Typical historical presentation

Division into generations / eras based on:

- New hardware
- New applications
- "Cow evolution of machine and soft goods"

1st Generation (1940-1950)

- Electromechanical relays and radio tubes (vacuum tube)
- Conrad Zuse
- Z1-1936; Z4–1945
- Plank Calculus
- Alan Turing
- Universal Touring Machine-1937
- Colossus-1943
- HowardH.Aiken
- (Mark 1) - 1944
- John Presper Eckert & John W. Mauchly
- ENIAC-1944
- John von Neumann • EDVAC-1945
- UNIVAC-1951



Thomas Watson 1943

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- Thomas Watson, president IBM, 1943:
- *“I think there is a world market for maybe five computers”*

2nd Generation (1950 - 1964)

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- Transistor - 1947
- The first compiler (A-0, Grace Hopper) - 1951
- IBM 701 - 1953
- IBM and the "Seven Dwarfs": Sperry-Rand, Burroughs, Control Data, Honeywell

...

- Fortran - 1957
- Cobol, Lisp, Algol, ...
- IBM 1401 - 1960. Computer "T-Ford"

3rd Generation (1964 - 1971)

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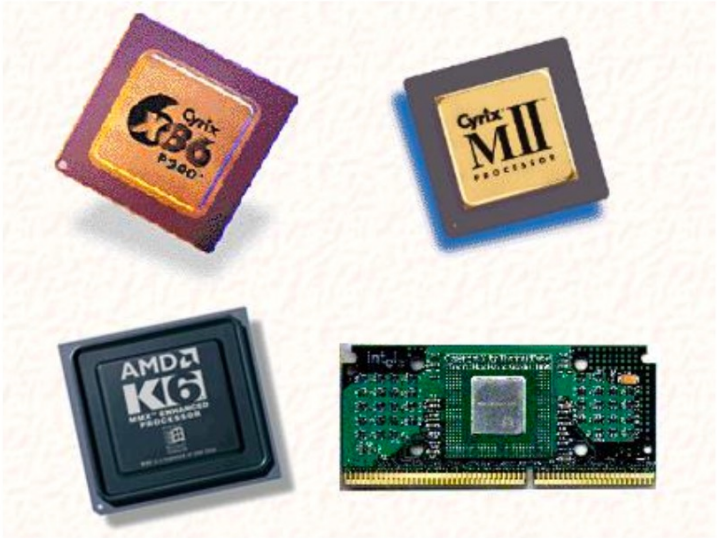
- Integrated circuit - 1958
- Basic (interpreted language!) - 1964 • IBM 360 - 1964
- Intel - 1968
- Interactive terminals !!!
- ARPAnet - 1969
- PDP, DEC, Data General, ..

4. Generasjon (1971 -)

- Microprocessor
- Intel 4004 - 1971
- IBM 370 - 1971 • MVS, VM
- UNIX - 1971
- Altair 8800 - 1975
- Apple, Radio Shack, Commodore • VisiCalc
- WWW - 1991



Modern PC (1981-)

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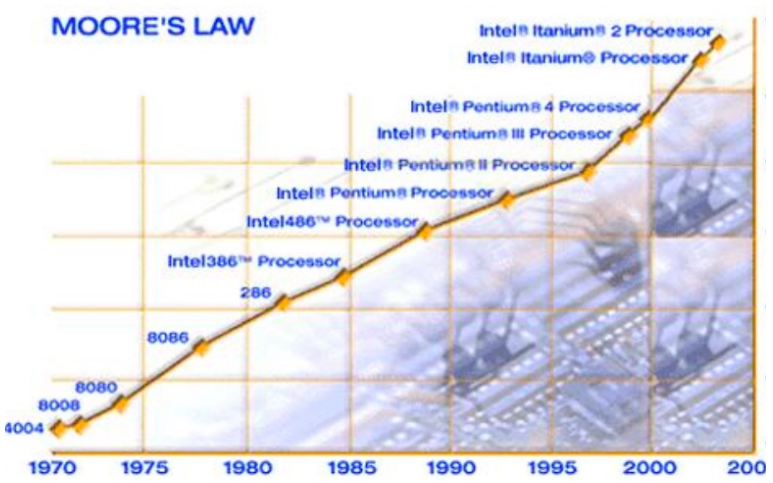
- IBM PC, DOS - 1981
- Apple Macintosh - 1984
- Windows 1 - 1985; 3.0 - 1991 • Linux 1.0 - 1994
- Java 1.0 - 1995
- Moore's "law"
- Processor "performance" doubles (approximately) every two years
- Number of transistors per
- cm2 doubles approximately every 2 years



Processor - CPU

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- 1971 - Intel 4004
- 1973 - Intel 8008, 8080 (Altair)
- 1981 - IBM PC, 8086, 8088, 4 MHz
- 8086: 16 bit data bus, 20 bit address bus = 1 MB
- 8088: 8 bit data bus
- 1982 - 80286, 8 MHz
- 24 bit address bus = 16 MB
- 1985/86 - 80386, 12-40 MHz
- 1-4 GB virtual memory
- 0.8µm
- Multitasking; Real Mode, Protected Mode

Processor - CPU

Høyskolen Kristiania

- 1985 - 80386, 12.5 - 30 MHz
- 32 bit data bus and address bus (4 GB)
- Virtual Real Mode
- SX (1988); 16 bit external data bus, 24 bit address bus
- 1989 - 80486, 25 - 50 MHz (DX2, DX4) • Built-in floating point co-processor
- 8 KiB cache
- CISC and RISC

Processor - CPU

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- 1993 - Pentium, 75 MHz →
- RISC is approaching CISC
- Dual Independent Bus, L1 and L2 cache, Dynamic Execution • MMX (Multimedia = mass calculation in parallel.
- 2001
- Pentium 4 passes 2 GHz
- Intel Itanium (Merced), 64 bit processor → McKinley • AMD takes the private 64 bit market
- Not just Intel
- AMD, VIA (Cyrix), +++
- Apple (MacIntosh), Alpha, SPARC, +++
- As of 2013, Video Cards is in the process of taking over for supercomputers!

Intel® Core™ i7 Processor

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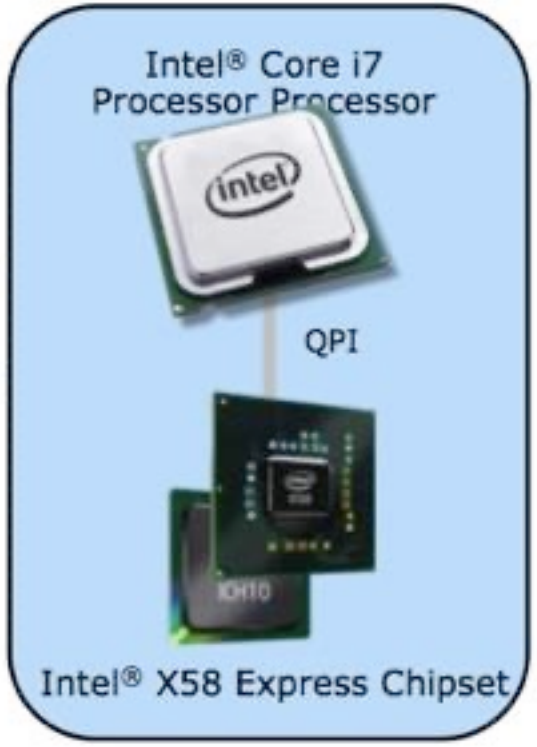
Performance/Features:

- 8 processing threads via Intel® Hyper-Threading Technology (Intel® HT)
- 4 cores
- Intel® Turbo Boost Technology operation
- Intel® QuickPath Interconnect (Intel® QPI) to Intel® X58 Express Chipset
- Integrated Memory Controller (IMC) – 3ch DDR3
- 7 more SSE4 instructions
- Overspeed Protection Removed



Socket:

- New LGA1366 Socket

Power:

- 130W TDP
- VRD 11.1

Platform Compatibility:

- Intel® X58 Express Chipset
- ICH10 / ICH10R

Targeted Segment:

- Extreme and performance demanding users
- Ultimate gaming, multimedia creation, compute intensive applications

- L1 & L2 per cores, L3 common

el® Core™ i7 Processor

via Intel®
nology
chnology
connect
8
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Høyskolen Kristiania