581305-6
Computer Organization I
(Tietokoneen toiminta)

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Computer Organization I

- Course area and goals
- Course learning methods
  - Study circle course
  - Web course
  - Learning methods used in this course
- Ttk-91 example computer
  - Titokone simulator
  - TitoTrainer environment
- Computer Organization I vs. II

Learning Goals

- To understand basic features of a computer system, from the point of view of the executing program
- To understand, how a computer systems executes the program given to it
- To understand the storage methods and locations of the program code and data
- To understand the execution time program presentation
- To understand the role and basic functionalities of the operating system

- **The goal is learning**, not credit units, or passing
  – Start preparing for the course exam now!

http://www.cs.helsinki.fi/u/kerola/tito/kurssikuvaukset/2008_8/oppimistavoitteetE.pdf

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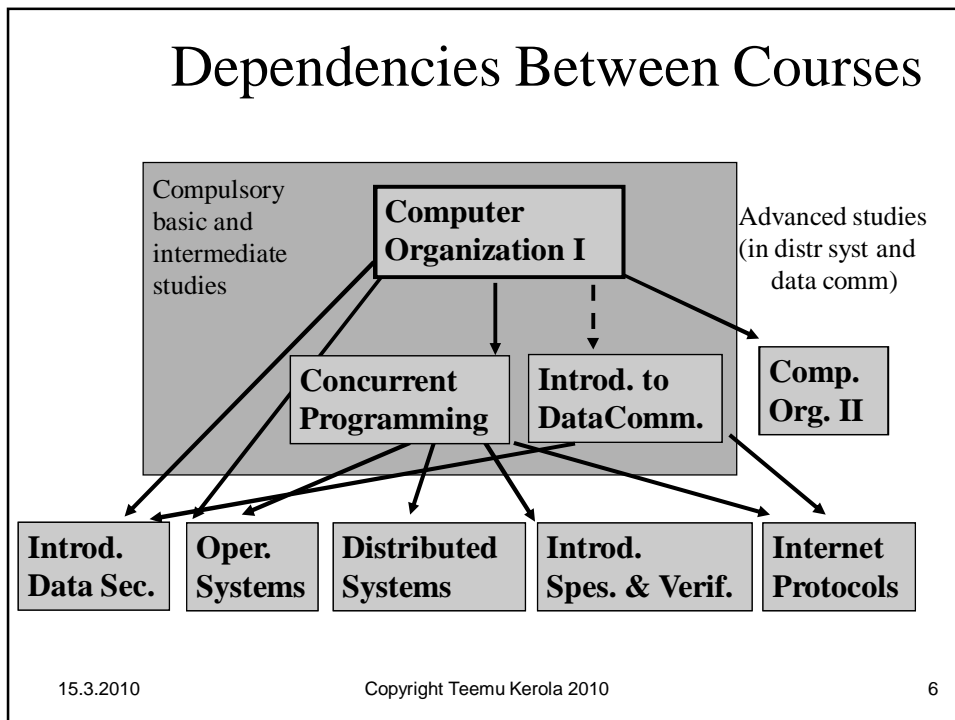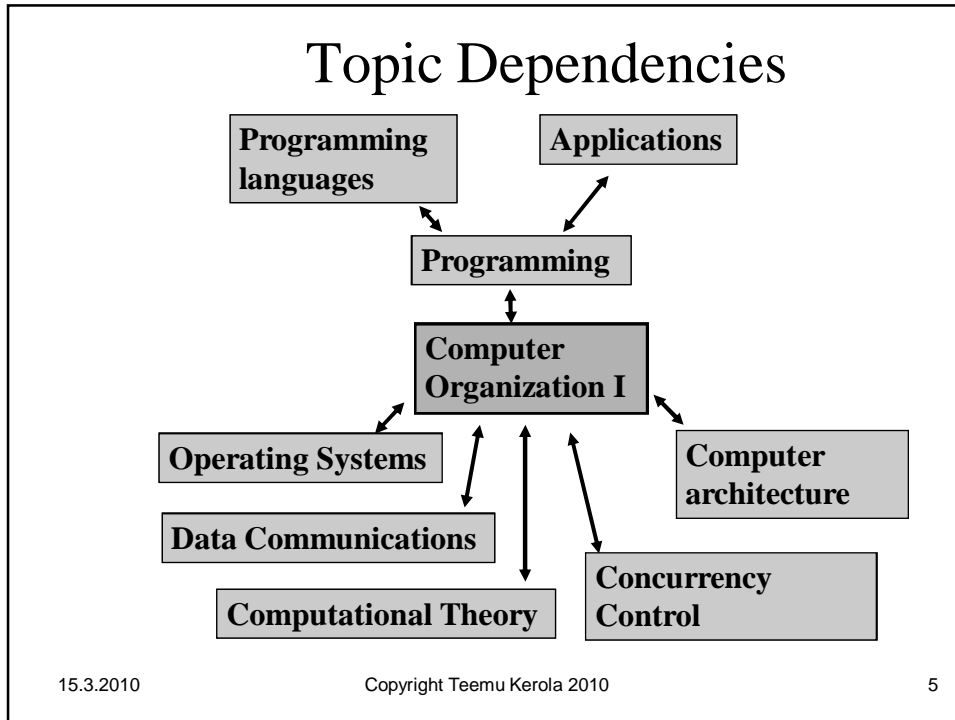

What good is it for?

- Program execution speed is based on <u>machine instructions</u> executed by the processor (CPU), and not in the program presentation in high level language (C, Pascal, Java)
- Understanding higher level topics is easier, once one first understands what happens at lower levels of the system

> Why should one compile Java programs (byte code)?
> What does it mean to compile Java programs?
> What does it mean to execute Java programs?
> What does it mean to execute C programs?
> Why does one need operating systems (OS)?
> What does the OS do? How is it structured?

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Topic Dependencies

Programming languages

Applications

Programming

Computer Organization I

Operating Systems

Computer architecture

Data Communications

Concurrency Control

Computational Theory

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Dependencies Between Courses

Compulsory basic and intermediate studies

Computer Organization I

Advanced studies (in distr syst and data comm)

Concurrent Programming

Introd. to DataComm.

Comp. Org. II

Introd. Data Sec.

Oper. Systems

Distributed Systems

Introd. Spes. & Verif.

Internet Protocols

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CO-I (4 op), Credit options

- Web course based on study circles
  - starting lecture, summary lecture   "Ordinary course"
  - Web lectures, text books, practice problems
  - Titokone, Titotrainer
  - In study circles
    - Homeworks, discussion problems, projects
    - Group meetings (with instructors and others),
    - Web discussions, chats (peer students, instructors)
  - Course exam
  - Makeup exam
    - 1st final exam after the course exam
- Final exam
  - Text books [Stal10 ja Tane10]
  - Programming with ttk-91 symbolic assembly language
    - Titokone, TitoTrainer
  - Based on material used in previous course

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Study circles

- Group work, team work
  - It is better to study in a team than alone
  - Peer student support
  - Study circles formed in the first group meeting
- Student centred learning
  - The student has responsibility on learning
  - Instructor facilitate learning
  - Instructors give good environment for learning
- Different types of team work
  - Solving homework problems independently and then discussing them in study circles
  - Projects
  - Any other co-operative work for this course

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Creation of Study Circles

- Possibly the largest problem in study circle courses
  - "Jack promised, but did not do and he was not accessible. And then Mary did most of it. This is not right! Boohoo!"
- Study circles are formed in the 1st group meeting
  - Goals should be similar
    - Easy in real life: "you will finish it or …"
  - Think about your goals before the 1st group meeting
    - Do I want to make the extra project?
    - Do I want to learn a lot, or just pass the course?
  - Discuss and agree on common goals before agreeing on forming a study circle
    - Finally, sign the "Study Circle Contract"
    - Email the lecturer the names of students in your study circle
- Keep up with your agreement
  - Inform the study circle immediately, if you will not continue
  - Get quickly rid of students who do not work as agreed on

http://www.cs.helsinki.fi/u/kerola/tito/k2010/opintopiiri_sopimusE.html

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Web course

- Significant part of the course is in web
  - Web lectures, practice problems, TitoTrainer problems
  - Information, slide copies, problems, results
- Web course $\neq$ distance learning
  - Starting lecture and final lecture in lecture hall
  - Weekly group meetings at the CS dept
  - Other study circle meetings at the CS dept
  - Some learning modules can be done remotely via web

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Web lectures

- Self study material in web, just for learning
  - Like a lecture, but own pace
  - Like a book, but with sound and animations
  - No bookkeeping on material use
  - No direct credit for course grade
- Lectures 1-4 also in English
  - Lectures 5-11 only in Finnish
- Material production
  - Teemu Kerola 2004-2005
  - Macromedia Authorware software
- Use   https://www.cs.helsinki.fi/i/kerola/tito/verkkoluennot/lu01e/lu01e.htm
  - Browser plug-in in Windows
    - CS dept, home
  - Windows-server in Linux environments at CS dept

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Summary and discussion lectures

- Only in Finnish, sorry!

- Summary of topics for previous week
- Group discussions on some topics

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Practice Problems

- Practice problems
  - Self evaluation
    - Do it only after you think you know the material
    - Do I understand it now?
    - Check only some part of the material, no guarantees!
  - Use of it does not directly affect your grade
    - No bookkeeping on material use
    - No credit toward course grade

https://www.cs.helsinki.fi/i/kerola/tito/kertaus/pract.html

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Homework problems

- Just like normal homework problems
- Learning happens when you solve the problems and discuss them
  - Study topic area first before trying out the problems
  - Work on the problems independently before discussing them
  - Reading a complete solution or giving one to peer student is wasting a good problem!
- Affect your grade
  - You get homework points (hwp) for completed problems
  - Only for those present in practice sessions (group meetings)

http://www.cs.helsinki.fi/u/kerola/tito/k2010/harjoitukset/lh1E.html

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Practice Session

- Students are split into "tables"
  - Each table should have for each problem at least one student who has solved it
- Discuss all homeworks in tables
  - There are no common presentations for all
  - You may assume that each student has familiarized themselves to the problems and at least tried to solve them
  - Assistant helps when needed
- Model solutions are available later in the meeting
  - Including extra discussion items
- Everybody is present until the end
- In the English speaking practice session all students may end up in an English speaking table
  - Some of the tables may still be in Finnish

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Ttk-91 Example Computer

- Auvo Häkkinen, 1991
  - Tietokoneen toiminta –kurssi 1991 (CO-I 1991)
- Simple computer architecture
  - Specification level just perfect for this course
- Simple (symbolic) assembly language
  - Easy to learn, not too many machine instructions
  - Good for the course goals
- Goals
  - Understand, what type of code the processor uses
  - Understand, how the system executes programs

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Titokone

- Java program, that simulates the ttk-91 computer and its operating system
  - Works the same way as a real hardware implementation of a ttk-91 architecture and its operating system
  - Original design and implementation
    - Software development project Koski, Spring 2004
- Contains
  - Ttk-91 symbolic assembly language assembler (compiler)
  - Ttk-91 emulator, that can execute assembled ttk-91 programs
  - Integrated software debugger
  - Animator that visualizes ttk-91 instruction execution
  - Graphical user interface

http://www.cs.helsinki.fi/u/kerola/tito/titokone/asennus/asennusE.html

http://www.cs.helsinki.fi/u/kerola/tito/titokone/kayttoohje/manual.html

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TitoTrainer   http://db.cs.helsinki.fi/titotrainer2/

- Software built "on top" of Titokone
- Implement ttk-91 programs or parts of them
  - Same programs run also directly in Titokone
- Program correctness is checked automatically
- Affects your grade
  - You get points toward your grade for completed problems
    - A few problems as homeworks
    - More problems in project pr1

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Project pr1 (12 pp)

- Solve as many TitoTrainer problems as you can
  - Solve some problems each week
    - Problems at the same level as in homeworks?
- Grading
    - 1 pp, when 22 problems solved
      - Includes problems solved as homeworks
    - 7 pp, when 40 problems solved
    - 12 pp, when 50 problems solved

http://www.cs.helsinki.fi/u/kerola/tito/k2010/projektit/proj1E.html

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Project pr2 (16 pp)

- Come up with a new practice problems
  - In two parts, each with one practice problem (8 pp)
- Goal is deeper understanding on some topics
  - Other course components may be needed as background knowledge
    - Web lectures, text books, homeworks, discussion problems
- Grading
  - Instructor evaluates based on the report and functionality
  - You get project points (pp, e.g. 8 pp) in three parts
    - Basic points (2 pp) for just completing the project
    - Grade (0-6 pp) depending on the quality of work
    - Participation points (max ±2 pp) based on you participation
      - Study circle determines this part!

http://www.cs.helsinki.fi/u/kerola/tito/k2010/projektit/proj2E.html

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Univ of Helsinki Moodle

https://moodle.helsinki.fi/

- Common
  - Shared discussion groups
  - A discussion group to coordinate doing homeworks (and other studies) together
- Study Circle Groups
  - Own closed discussion group
  - Wiki?
  - What else?

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Completing a web course based on study circles

- Study weekly topics   read
  - Self study with web lectures   hear
    - Learn the basics well from lectures   think
  - Read the text book the same topics, with different approach read
  - Deepen your knowledge with summary lectures   discuss
- Check your learning with self evaluation   do   evaluate
  - Do practice problems, homeworks, TitoTrainer problems   do
- Participate in study circle
  - Discuss homeworks   discuss
  - Weekly group meeting   do   think
  - Continue projects
  - Study circle meet face-to-face or in the web   discuss
- Take course exam   read   evaluate

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Evaluation

- Self evaluation
  - Practice problem after each topic
    - Do not affect your grade
  - Homeworks and TitoTrainer problems every week
    - Do I understand or not?
    - What is there still to learn and how do I do it??
    - Affect your grade
- Course exam
  - Gives a fixed time goal for learning
  - Covers all topics given in course description
    - Topics learned in independent study as well as in study circle work using various learning methods
  - Evaluates learning
    - Most of the grade based on this
    - Must reach certain level (50%) to pass the course

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Grading

- Good work is awarded
- Diligence and knowledge is awarded
- Course component maximum grade points

Homeworks *minimum requirement 1 p*	**6 p**
Projects TitoTrainer problems (pr1: 12 pp) Make Practice problems (pr1: 16 pp) (super-diligent participation +4p) *minimum requirement 1 p*	**14 p** (16 p)
Course exam, make-up exam *minimum requirement 20 p*	**40 p**
Total *minimum requirement 30 p*	**60 p**

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Learning material

- Lectures
  - Lecture notes pdf's
- Web lectures and 1-4 in English (in web)
- Text books
  - Stallings: Computer Org. and Architecture, 9th Ed., 2010
  - Tanenbaum: Structured Computer Organization, 5th Ed, 2010
- Practice problems (in web)
- Titokone simulator (in web)
- TitoTrainer (in web)
- Homeworks and projects (in web)
- Moodle
- Schedule page (in web)
- Course exam (results in web)

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WWW Information

- Course home page   http://www.cs.helsinki.fi/u/kerola/tito/
- Course schedule
  - Everything is found linked to here

            http://www.cs.helsinki.fi/u/kerola/tito/k2010/aikatauluE.html

- Part of material is in CS departmental Intranet
  - Web lectures (Authorware)
  - Practice problems
  - Course statistics (hwp, pp, exam points)
  - Everyone need CS dept id's
    - Those minoring in CS must first have the UNIX-id (so called cc-id) from the University IT department, obtained from your own department

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Course contents

- Lecture 0:   Course contents, structure, and organization
- Web lecture 1: System structure
- Web lecture 2: Ttk-91 and the simulator for it
- Web lecture 3: Assembly language programming
- Summary lecture   (in Finnish)
- Web lecture 4: Assembly language subroutine implementation
- Web lecture 5: CPU and bus   (in Finnish)
- Web lecture 6: Data presentation   (in Finnish)
- Summary lecture   (in Finnish)
- Web lecture 7: Error recovery and internal memory   (in Finnish)
- Web lecture 8: Program implementation in the system (in Finnish)
- Summary lecture   (in Finnish)
- Web lecture 9: External memory, I/O   (in Finnish)
- Web lecture 10: Compilation, linking and loading   (in Finnish)
- Summary lecture   (in Finnish)
- Web lecture 11: Interpretation and emulation   (in Finnish)
- Lecture 12: Summary

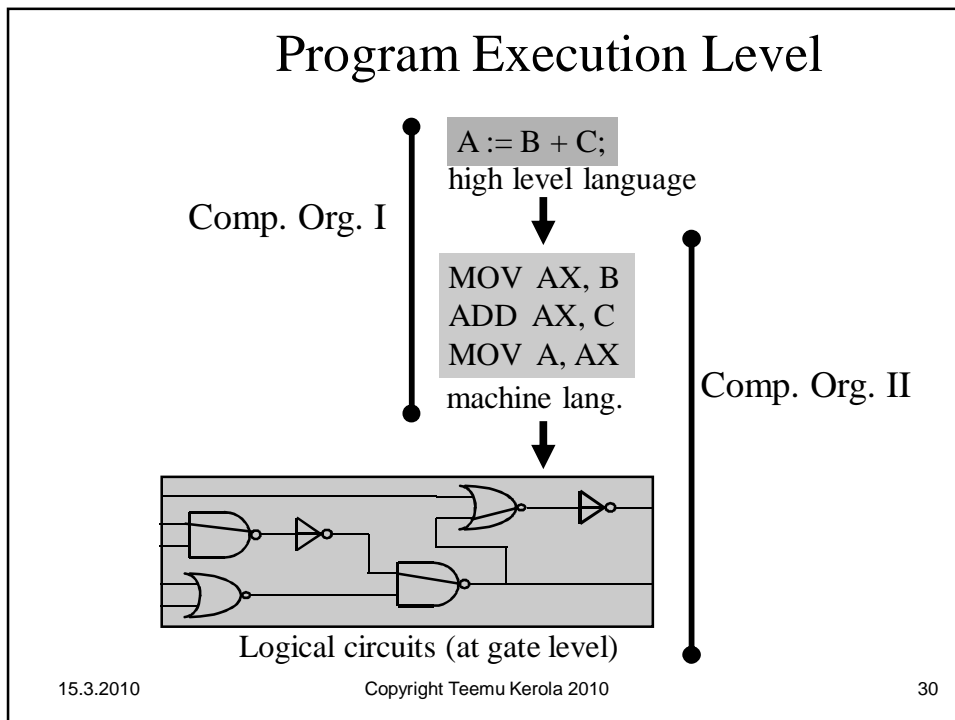15.3.2010   Copyright Teemu Kerola 2010   27
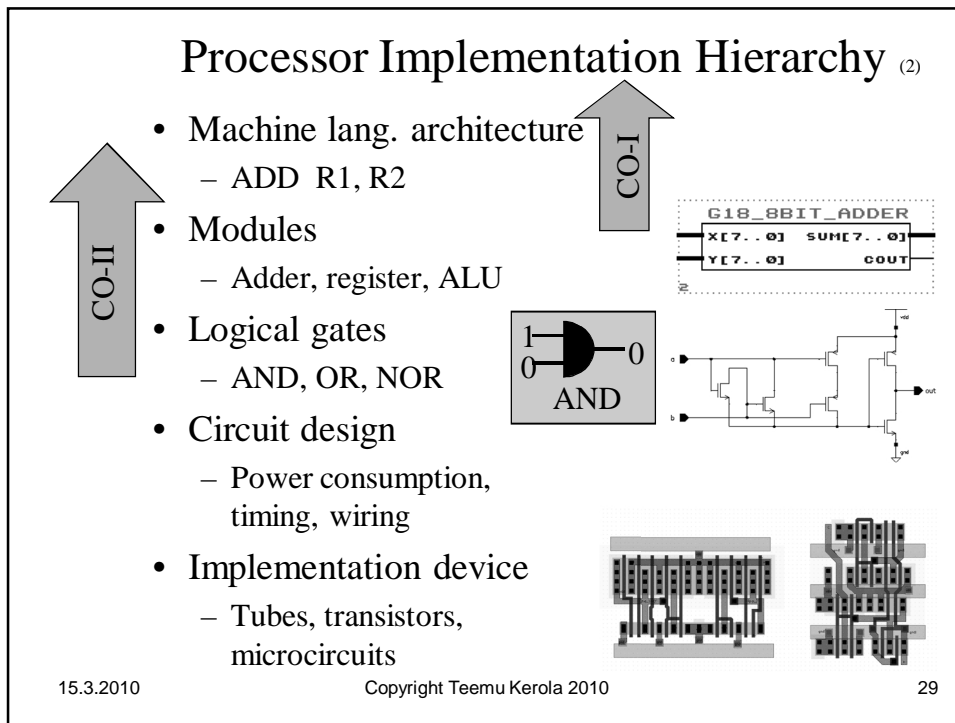
CO-I vs. CO-II
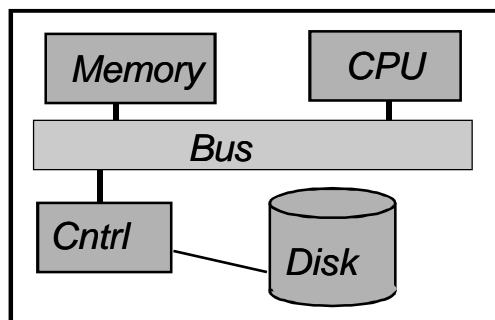
CO-I: What happens in the system?
        What does OS do??

CO-II: How is CPU and memory implemented?
        How does the clock pulse cause execution?

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Processor Implementation Hierarchy (2)

- Machine lang. architecture
  - ADD R1, R2
- Modules
  - Adder, register, ALU
- Logical gates
  - AND, OR, NOR
- Circuit design
  - Power consumption, timing, wiring
- Implementation device
  - Tubes, transistors, microcircuits

CO-I

CO-II

```
G18_8BIT_ADDER
X[7..0]   SUM[7..0]
Y[7..0]        COUT
```

1
0   AND   0

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Program Execution Level

Comp. Org. I

A := B + C;
high level language

MOV AX, B
ADD AX, C
MOV A, AX
machine lang.

Comp. Org. II

Logical circuits (at gate level)

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Motto

- "It is not good exercise, if you do not sweat"
- However, this is not a marathon!
- Altogether some 12 h / week (?)
  + exam preparation + exam
  - Before: Total some 80 h / 2 sw course (2 work weeks)
  - Now: Total some 107 t / 4 cu course

5 yrs / 300 cu = 1 yr / 60 cu = 1600 h / 60 cu
= 26.67 h / 1 cu = 107 h / 4 cu

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