Programming in C

Jan Faigl

Department of Computer Science
Faculty of Electrical Engineering
Czech Technical University in Prague

Course Organization

B3B36PRG – Programming in C

Overview of the Lecture

- Part 1 – Course Organization
  - Organization
  - Course Goals
  - Means of Achieving the Course Goals
  - Evaluation and Exam
  - Communication
  - Tools and Academic Network Services

Part I

Part 1 – Course Organization

Course and Lecturer

B3B36PRG – Programming in C

- Course web page https://cw.fel.cvut.cz/wiki/courses/b3b36prg
- Submission of the homeworks – **BRUTE** Upload System

  https://cw.felk.cvut.cz/brute and individually during the labs.
- Lecturer:
  - prof. Ing. **Jan Faigl**, Ph.D.
    - Department of Computer Science – http://cs.fel.cvut.cz
    - Artificial Intelligence Center (AIC) http://aic.fel.cvut.cz
    - Center for Robotics and Autonomous Systems (CRAS) http://robotics.fel.cvut.cz
    - Computational Robotics Laboratory (ComRob) http://comrob.fel.cvut.cz

Teachers

- RNDr. **Ingrid Nagyová**, Ph.D.
- MSc. **Yuliia Prokop**, Ph.D.
- Ing. **Martin Zoula**

Course Organization and Evaluation

- B3B36PRG – Programming in C; Completion: Z,ZK; Credits: 6

  Z – ungraded assessment, ZK – exam

  1 ECTS credit is about 25–30 hours per semester, six credits is about **180 hours per semester**
  - Contact part (lecture and labs): 3 hours per week, i.e., 42 hours in the total
  - Exam including preparation: *10 hours*
  - Home preparation (first **book reading** and followed by homeworks) approx **9 hours per week** *Median load*

- **Ongoing work during the semester**
  - Homeworks *mandatory,* ***optional****, and* ***bonus parts***
  - **Semestral project** – multi-thread computational applications.
- Exam test and implementation exam – verification of the acquired knowledge and skills from the teaching part of the semester. *An independent work with the computer in the lab (class room).*

- Attendance to labs, submission of homeworks, and semestral project.

- **Consultation** - If you do not know, or spent too much time with the homework, consult with the instructor/lecturer.
  - **Maximize the contact time during labs and lectures, ask questions, and discuss.**

Lectures – Spring Semester Academic Year 2024/2024

- Schedule for the academic year 2023/2024.

  `https://intranet.fel.cvut.cz/cz/education/harmonogram.html`

- Lectures:
  - Dejvice, Lecture Hall No. T2:D3-209, Tuesday, 16:15-17:45.
- 14 teaching weeks - (19.2.–26.5.2024); 13 weeks in practice.
  - National holiday – 01.04.2024 (Monday).
  - National holiday – 01.05.2024 (Wednesday).
  - National holiday – 08.05.2024 (Wednesday).
  - Rector's day – 14.05.2023 (Tuesday).
  - Thursday 09.05.2024 – classes as on Wednesday (odd teaching week).

Resources and Literature

- **Textbook**

„C Programming: A Modern Approach" (King, 2008)

C Programming: A Modern Approach, 2nd Edition, *K. N. King*, W. W. Norton & Company, 2008, ISBN 860-1406428577

The main course textbook

- **During the first weeks, take your time and read the book!**

The first homework deadline is 16.03.2024.

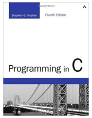
- Lectures – support for the textbook, slides, comments, and **your notes**.

Demonstration source codes are provided as a part of the lecture materials!

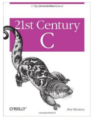
- Laboratory exercises – gain practical skills by doing homeworks (yourself).

Further Books

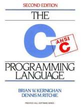
- Programming in C, 4th Edition, *Stephen G. Kochan*, Addison-Wesley, 2014, ISBN 978-0321776419



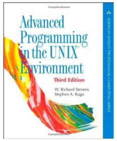
- 21st Century C: C Tips from the New School, *Ben Klemens*, O'Reilly Media, 2012, ISBN 978-1449327149



- The C Programming Language, 2nd Edition (ANSI C) , *Brian W. Kernighan, Dennis M. Ritchie*, Prentice Hall, 1988 (1st edition – 1978)

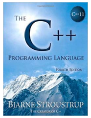


- Advanced Programming in the UNIX Environment, 3rd edition, *W. Richard Stevens, Stephen A. Rago* Addison-Wesley, 2013, ISBN 978-0-321-63773-4

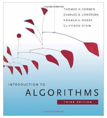


Further Resources

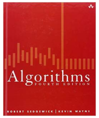
- The C++ Programming Language, 4th Edition (C++11) , *Bjarne Stroustrup*, Addison-Wesley, 2013, ISBN 978-0321563842



- Introduction to Algorithms, 3rd Edition, *Cormen, Leiserson, Rivest, and Stein*, The MIT Press, 2009, ISBN 978-0262033848



- Algorithms, 4th Edition , *Robert Sedgewick, Kevin Wayne*, Addison-Wesley, 2011, ISBN 978-0321573513



Course Goals

- Master (yourself) programming skills.

  Labs, homeworks, exam
- Acquire knowledge of C programming language
- Acquire experience of C programming to use it efficiently

  Your own experience!
- Gain experience to read, write, and understand small C programs
- Acquire programming habits to write
  - easy to read and understandable source codes
  - reusable programs
- Experience programming with
  - Workstation/desktop computers – using services of operating system

    E.g., system calls, read/write files, input and outputs
  - Multithreaded applications
  - Embedded applications – `STM32F446 Nucleo`

Teaching Programming

„Separating Programming Sheep from Non-Programming Goats"

`http://blog.codinghorror.com/separating-programming-sheep-from-non-programming-goats`

`http://www.eis.mdx.ac.uk/research/PhDArea/saeed/paper1.pdf`

- Effective methods of teaching programming have been sought since the early days of computers.

  More than 50 years.

- Yet, it seems that every basic programming course is difficult and about 30 %–60 % of students fail it for the first attempt. a

  Success rate in the PRG is much higher.

  2022/2023: 73 % (97 % of awarded credits, 72)

  2021/2022: 60 % (97 % of awarded credits, 75)

  2020/2021: 60 % (95 % of awarded credits, 97)

  2019/2020: 73 % (97 % of awarded credits, 91)

- **The basic concept is to understand the principle of assigning a value to a variable!**

  It mainly about undertstanding the memory representation and access to it, which is very direct in C.

The Assignment Principle

- Writing a program to assign values to variables *a* and *b* and then assigning variable *b* to *a*.

Assigning a value to a variable

```c
int a = 10;
int b = 20;

a = b;
```

- What are the values of the variables *a* and *b*?

a. a = 20, b = 0
b. a = 20, b = 20
c. a = 0, b = 10
d. a = 10, b = 10
e. a = 30, b = 20
f. a = 30, b = 0
g. a = 10, b = 30
h. a = 0, b = 30
i. a = 10, b = 20
j. a = 20, b = 10

Program actually "only" moves and modifies numeric values in memory based on defined conditions!

Program is a “Recipe”

- Program is “recipe” – a sequence of steps (calculations) describing the process of solving a problem.
- Programming is the ability to **independently**
  - **Create programs**;
  - **Decompoose** problems into smaller units;
  - build larger programs from **subparts** to solve a complex problem.

B3B36PRG – is an opportunity to learn and gain these skills.

Teaching Programming in B3B36PRG

- Our aim is to build your experience and develop your programming skills.
  - Programming vs. algorithmization;
  - Programming is the "craft" of how to implement an algorithm correctly.
  - **Functional is not enough - the program must be correct too!** *Expected input vs. what the user can input.*
- The learning load is therefore spread over the course of the semester.
  - Practice assignments and homework deadlines.
- Systematic development of programming skills throughout the semester is essential.

  Typically, there is time at the beginning of the semester to understand the principles (reading the textbook)!
- Without knowing the constructs and basic commands, you cannot program effectively.
- Know and know how to use (not "stick"). *Dependence on whisperer or Co-pilot!*
  - Starting with relatively simple tasks to learn programming constructs and how to organize source code. *Code clarity and the ability to navigate code efficiently!*
  - *The assignments can always be implemented based on the topics covered the lectures/labs.*

    Solutions with more advanced constructs may be more elegant(shorter), but may not provide the necessary insight.
  - In the first lectures we cover the necessary knowledge, which is further deepened.
    - Exercises complement the lectures and give more space for practical learning.
- You can choose a practical way of absorbing programming knowledge from examples, which is suitable to complement theoretical preparation from textbook(s).

Overview of the Lectures

1. Course information, Introduction to C programming *K. N. King: chapters 1, 2, and 3*
2. Writing your program in C, control structures (loops), expressions *K. N. King: chapters 4, 5, 6, and 20*
3. Data types, arrays, pointer, memory storage classes, function call *K. N. King: chapters 7, 8, 9, 10, 11, and 18*
4. Data types: arrays, strings, and pointers *K. N. King: chapters 8, 11, 12, 13, and 17*
5. Data types: Struct, Union, Enum, Bit fields. Preprocessor and Large Programs *K. N. King: chapters 10, 14, 15, 16, and 20*
6. Input/Output – reading/writting from/to files and other communication channels, Standard C library – selected functions *K. N. King: chapters 21, 22, 23, 24, 26, and 27*
7. Parallel and multi-thread programming – methods and synchronizations primitives
8. Multi-thread application models, POSIX threads and C11 threads
9. C programming language wrap up, examples such as linked lists
10. *Accuracy and Speed of Calculation*
11. *ANSI C, C99, C11 and differences between C and C++* Introduction to C++.
12. Quick introduction to C++
    Reserve *(Rector's day)*
13. *Resource Ownership in C++*

All supporting materials for the lectures are available at
`https://cw.fel.cvut.cz/wiki/courses/b3b36prg/start`
Read slides, **textbook**, or even watch the recorded lectures before the lecture contact time!

Homework and Other tasks

- Independent work to gain practical experience.
- Assignment at the lectures and defined submission date. All assignments are defined.
- Submission of homework through BRUTE.

  https://cw.felk.cvut.cz/brute
  - Uploading the archive with the necessary source files.
  - Verify the correctness of the implementation with automated tests.
  - Penalties for exceeding the number of uploads.

    Submit correct codes, not "only" code that passes tests!
  - Plagiarism detection

    The aim of solving the problems is to get your own experience!
- Tasks are designed to be achievable. Plan and keep track of time, consult early.
- Independent work and mastery of techniques and knowledge is the key to successful completion of the course.

  Continuous work and problem solving!
- If you do not understand something, **ask**!

  If you make mistakes you learn, if you do not make mistakes you already know!

Homeworks

- 1+7 homeworks - seven for the workstation.

`https://cw.fel.cvut.cz/wiki/courses/b3b36prg/hw/start`

1. HW 00 – **Testing** (1 point) *1 h*
2. HW 01 – **ASCII Art** (2 points) *3 h*

   Coding style penalization – up to -100% from the gain points.
3. HW 02 – **Prime Factorization** (2 points + 4 points bonus) **Coding style** *4 h + 4 h (bonus)*
4. HW 03 – **Caesar Cipher** (2 points + 2 points bonus) **Coding style** *3 h + 3 h (bonus)*
5. HW 04 – **Text Search** (2 points + 3 points optional) *5 h*
6. HW 05 – **Matrix Calculator** (2 points + 3 points optional + 4 points bonus) **Coding style!** *6 h + 5 h (bonus)*
7. HW 06 – **Circular Buffer** (2 points + 2 points optional) *5 h*
8. HW 07 – **Linked List Queue with Priorities** (2 pts + 2 pts optional) *7 h*
   - All homeworks must be submitted to award an ungraded assessment *Total about 42–47 hours.*

     Late submission is penalized!

- Coding style needs to be learn, penalization is to motivate you thinking about it and learn the craft of coding.

  If you improve over the semester, penalization can be compensated at the end.

Semestral Project

- A combination of control and computational applications with multithreading, communication, and user interaction.

  https://cw.fel.cvut.cz/wiki/courses/b3b36prg/semestral-project/start

- Mandatory task can be awarded up to **20 points**.
- Bonus part can be awarded for additional **10 points**.

  Up to 30 points in the total for the semestral project.

- Minimum required points: 10!

Deadline – best before 17.05.2024.

Further updates and additional points might be possible!

Deadline – 19.05.2024.

- Expected required time to finish the semestral project is about 30–50 hours.

Homework Assignment – **BRUTE**

- **BRUTE** – Bundle for Reservation, Uploading, Testing and Evaluation
  - Formal check – compiling the program.
  - Functionality and correctness testing – **checking output for a given input**.
    - Public inputs and corresponding outputs / non-public inputs.
  - Test the program yourself before uploading it.
    - Using the available inputs and outputs.
    - Creating your own inputs and debugging the program.
    - Creating inputs **with the included input generator**.
    - Verifying the output **with the attached test or reference program**.
- Understanding the code and checking possible states.
  - **For each line, you should be able to answer why it is there and what it does!**
  - For **each function or input retrieval** from the user, parse the possible input values or **function return values**!
    - If the input or return value is critical in terms of functionality, **check the input and/or the appropriate action**, e.g., output a message and exit the program.

For example, the expected input is a number and the user enters something else.

Tasks and **BRUTE**

- Tasks are not just about submitting an implementation that passes the BRUTE tests.
  - The goal is not to submit tasks in BRUTE, it is to verify the program functionality.
  - BRUTE is a tool to continuously check your progress and gained knowledge.
  - The goal is to learn to **independently program** functional programs correctly.
- Tasks are all about gaining **gradual experience** with specific constructs.
  - All of the task assignments have been implemented many times, and even generative AI can do it.

    In this course you have the opportunity to understand C programming through your own implementation of assignments. **The task successful submission is a means to reach the goal, not the goal itself**.
- Tasks are very similar in relative difficulty. It is important to solve the tasks independently and to learn the sub-skills. Absolutely, the tasks get progressively more and more difficult!
- Rather than struggling too long by your own, ask (on Discord), for practice or **consultation**.
- Tasks HW01–HW03 and HW05 are checked for correctness and code clarity.
  - Focused on consistency, readability, and **modularity** (splitting into functions).

    In terms of training and learning, try to split even a seemingly trivial program into multiple functions.
  - *The motivation is not to spend too much time with coding without significant progress.*

Course Evaluation

Point Source	Maximum Points	Required Minimum Points	
Assignment	25	*All assignments must be turned in.*	25
Bonus Assignment	10	-	
Labs (MCU)	6	-	
Semester project	30		**10**
Exam test	20		†**10**
Implementation exam	20		10
Total	111	55	

†If you fail the implementation and score exam test for 13 or more points, the following exam term is only for the implementation, and vice versa, if you do not ask otherwise.
55 points is solid E, not borderline, but solid. The exam test (and implementation) is not corrected but evaluated, the scoring is upper bound, i.e., it might contain less points than evaluated.

- The course can be passed with **ungraded assessment** and **exam**.
- All homeworks must be submitted and they have to pass the mandatory assessment.

Grading Scale

Grade	Points	Mark	Evaluation
A	≥ 90	1	Excellent
B	80–89	1,5	Very Good
C	70–79	2	Good
D	60–69	2,5	Satisfactory
E	50–59	3	Sufficient
F	$<$50	4	Fail

- Expected results
  - Timely submission of all homework with required and optional assignments (35 points).
  - Semestral project (20 points) and bonus assignments (5–10 points).
  - Exam test (15+ points). 15 and more points is respectable result!
  - Exam implementation (20 points).
  - **95+ points** and more (A – Excellent) – with small imperfection.
  - **76 points** (C – Good) for 20% loss .

76 and more points represents a solid background for further development of your programming skills.

Communicating Any Issues Related to the Course

- Ask the lab teacher or the lecturer.
- Use e-mail for communication.
  - Use your faculty e-mail.
  - Put PRG or B3B36PRG to the subject of your message.
  - Send copy (Cc) to lecturer/teacher.
- *Discord channel*.

Computers and Development Tools

- Computer labs - network boot. Sync your files using, e.g., ownCloud, gdrive, ssh, ftp.
  - **You have to set your password via** `https://felk.cvut.cz` **– rooms of Dept. of Computer Science.**
  - **You need the access for implementation exam.**
- Compilers **gcc** or **clang**. `https://gcc.gnu.org` or `http://clang.llvm.org`
- Project building **make** (GNU make). *Examples of usage on lectures and labs.*
- Text editor – `gedit`, **atom**, **sublime**, **vim**. `https://atom.io/`, `http://www.sublimetext.com/` `http://www.root.cz/clanky/textovy-editor-vim-jako-ide`
- **Visual Studio Code** – `code` – great for editing and terminal based compilation.
- C/C++ development environments – **WARNING: Do Not Use An IDE** at the beginning, to become familiar with the syntax. `http://c.learncodethehardway.org/book/ex0.html`
  - **Visual Studio Code**; CLion – `https://www.jetbrains.com/clion`; `Code::Blocks`, `CodeLite`, `NetBeans (C/C++)`, `Eclipse-CDT`.
- **Embedded development for the Nucleo**.
  - `ARMmbed` – `https://os.mbed.com/platforms/ST-Nucleo-F446RE/`
  - `https://studio.keil.arm.com/`
  - `System Workbench for STM32` (based on Eclipse); `direct cross-compiling` using makefiles.

Services – Academic Network, FEE, CTU

- `http://www.fel.cvut.cz/cz/user-info/index.html`
- Cloud storage ownCloud – `https://owncloud.cesnet.cz`
- Sending large files – `https://filesender.cesnet.cz`
- Schedule, deadlines – FEL Portal, `https://portal.fel.cvut.cz`
- **FEL Google Account** – access to `Google Apps for Education`

  See `http://google-apps.fel.cvut.cz/`
- Gitlab FEL – `https://gitlab.fel.cvut.cz/`
- Information resources (IEEE Xplore, ACM, Science Direct, Springer Link)

  `https://dialog.cvut.cz`
- Academic and campus software license

  `https://download.cvut.cz`
- National Super Computing Grid Infrastructure – MetaCentrum

  `http://www.metacentrum.cz/cs/index.html`