

Welcome!

COMP2521 24T2
Data Structures and Algorithms

COMP2521 24T2

Introduction

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course introduction
tools of the trade

Slides adapted from those by Kevin Luxa 2521 24T1

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Tools

to get you thinking like a *computer scientist*
not just a programmer

- know and understand *fundamental* data structures, algorithms
- reason about *applicability + effectiveness*
- analyse behaviour/correctness of programs

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We assume that you can:

- Produce a correct C program from a specification
- Use fundamental control structures (sequence, selection (`if`), iteration (`while`))
- Use fundamental C data types and data structures (`char`, `int`, `double`, arrays, structs, pointers, linked lists)

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- data structures: trees, graphs, hash tables, tries
- data structure/algorithm analysis: time/space complexity
- sorting and searching techniques
- graph algorithms

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By the end of this course, you should be able to:

- Implement solutions to a wider range of problems
- Analyse performance characteristics of algorithms
- Analyse performance characteristics of data structures
- Make decisions about appropriate data structures and algorithms

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Lecturer Sim Mautner

Admin Ethan Brown, Kevin Luxa

Tutors <https://cgi.cse.unsw.edu.au/~cs2521/24T2/team>

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Website <https://webcms3.cse.unsw.edu.au/COMP2521/24T2/>

Email cs2521@cse.unsw.edu.au

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Lectures
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Four hours of lectures per week

- Monday 11:00–13:00
 - In person in Clancy Auditorium
 - If you're enrolled online, but would like to attend in person, please do, there's plenty of space.
 - Also livestreamed via YouTube
 - Link to livestream on the lectures page
 - Feel free to ask questions in the chat
 - Recordings will be on YouTube
- Thursday 11:00–13:00
 - Online only
 - Otherwise the same as Monday
- present a brief overview of theory
- demonstrate problem-solving methods
- give practical demonstrations

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Weekly one-hour tutorials

- tutorials start in week 1
 - run every week, except flex week
 - online classes are via Blackboard Collaborate
- tutorials clarify lecture material
- work through problems related to lecture topics
- questions available (usually) the week before
- answers available Friday evening

To get the best out of tutorials

- read and attempt the problems yourself beforehand
- don't keep quiet in tutorials... talk, discuss, ...
- ask if you don't understand something

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Each tutorial is followed by a two-hour lab class

- several exercises, mostly small implementation/analysis tasks
- aim to improve your coding and analysis skills
- give you experience applying algorithms and techniques
- done individually, unless specified
- submitted via `give`, before Monday ~~17:00~~^{12:00pm} the following week
- many labs have a handmarking component (see spec for details)
 - handmarking completed by showing your work to your tutor in the lab **within two weeks of the lab**
- worth 15% of your final mark, best 7 of 8 labs used to calculate the 15%

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Weekly quizzes

- on WebCMS
- questions about previous week's lectures
- different kinds of questions
 - multiple choice, multiple select, fill-in-the-blank...
- aim to test your knowledge and understanding of the theory
- done individually
- due Monday ~~17:00~~^{12:00pm} the following week
- worth 10% of your final mark, best 7 of 8 quizzes used to calculate the 10%

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Two assignments

- each worth 15% of your final mark
- give you experience applying algorithms to larger problems
- done individually
- will *always* take longer than you expect
- don't leave them to the last minute
- help sessions will be available to assist with assignments
 - will be very busy in the last days before an assignment is due

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Tools

Labs, quizzes and assignments all have the same late penalty

- UNSW standard late penalty
- **0.2%** of the maximum mark taken from your raw mark for each hour late
 - equivalent to 4.8% per day
- submissions later than 5 days not allowed (automatically enforced)

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Due to the UNSW standard late penalty allowing late submissions up to 5 days after the deadline, along with extensions for special consideration:

- sample solutions for labs will be released 12 days after the due date
- marks for labs will be released a week after the due date
- answers and marks for quizzes will be released 5 days after the due date
- sample solutions for assignments are not released
- marks for assignments are released in two parts
 - automarking will be released a week after the due date
 - handmarking (style, automarking adjustments) takes longer and will be released 2 weeks after the automarking

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- 3 hour in-person exam, during exam period
- Made up of two components:
 - theory : you must demonstrate understanding of the topics taught in the course
 - practical : you must be able to produce C programs to a specification
- You must score at least 18/45 (40%) on the final exam to pass the course
- You must score at least 25% on each of the two components of the exam to pass the course

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- Hurdle requirements:
 - You must score at least 18/45 (40%) on the final exam to pass the course
 - You must score at least 25% on each of the two components of the exam to pass the course
- Rationale:
 - Demonstrates that you've achieved the purpose of the course
 - The 40% hurdle alone, enables students to pass the course with only a strong understanding of theory *or* strong practical skills
 - *Both* these aspects are required in order to complete COMP2521 as well as to have an adequate foundation for the courses for which COMP2521 is a prerequisite
 - What I understand the content, and usually program well, but simply can't get my code to work during the exam?

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- Have you been impacted by unforeseen adverse circumstances?
- Has it affected your ability to complete coursework?
- You can apply for special consideration via myUNSW
- Find out how to apply here:
<https://student.unsw.edu.au/special-consideration>

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Summary:

15% labs

10% quizzes

15% assignment 1

15% assignment 2

45% final exam

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To pass you must:

- score at least 50/100 overall
- score at least 18/45 on the final exam
- score at least 25% on each of the two components (theory and practical) of the final exam

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- Labs, quizzes and assignments must be entirely your own work
- Plagiarism will be checked for and penalised
- Plagiarism may result in suspension from UNSW
- Scholarship students may lose their scholarship
- International students may lose their visa
- Supplying your work to any other person may result in loss of all your marks for the lab/assignment

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- Use of generative AI tools, e.g., GitHub Copilot, ChatGPT, with the intention of generating answers/solutions for assessment tasks is not permitted
- Use of generative AI tools for learning is permitted
 - You must still be critical of any response you get from these tools
- Generative AI tools have great potential to assist coders, but use of them requires good understanding of the language/system

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- Ed forum
- Weekly consultations
 - Starting from week 2
 - Day and time to be announced on Thursday
 - For clarification of course content
- Help sessions
 - Starting from week 2 or week 3 (details to come on Thursday)
 - Schedule on course website
 - For help with labs and assignments

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- Check your email regularly
 - Announcements will be sent to your email
 - Your tutor will send you emails
 - Reminders of unsubmitted work will be sent to your email
- Read the spec before asking questions
 - Don't ask questions that are already answered in the spec
- Attempt to debug your program yourself before asking for help
 - Debugging may involve **adding print statements** or using **gdb** to check the state of the program at various points, or **drawing diagrams** to visualise the program's execution

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- Regular announcements/updates
- Lecture slides released before lectures... some of the time...
 - Some lectures will closely follow lecture slides, others will not. Some lectures will have more detailed slides, others will not.
- Minimal typos/mistakes in lecture slides
- Tutorial questions/lab exercises released on time (by the weekend before)
- Assignments released on time
- Assignments marked on time

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- Keep up with lectures
Labs and quizzes require you to know content from recent lectures
- Attend tutorials, *especially* if you are falling behind
Tutors will not judge you for falling behind
- Always try to *understand*, instead of just memorise
Understanding something makes it easier to remember
Exam questions will be different from what you've seen
- Programming is a skill that improves with practice
The more you practice, the easier labs, assignments and the exam will be

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Programming is like swimming.

- It doesn't matter how many hours you spend watching someone swim and watching someone teach swimming, at some point you need to get into the water.
- Effort over time:
 - Approach 1: 2 hours a day, 5 days a week, for 10 weeks
 - Approach 2: 10 hours a day for the 10 days leading up to the exam
 - These two are not equal!!

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Engage, ask questions, go to consults, do practice exercises...

You can improve if you put in the effort!

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We'd love to get your feedback throughout the term!
<https://forms.office.com/r/riGKCze1cQ>



Feedback is also collected via myExperience at the end of the term.

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COMP2521 material drawn from...

- slides and memes by Kevin Luxa (COMP2521 24T1)
- slides by Jashank Jeremy (COMP2521 19T0)
- slides by Angela Finlayson (COMP2521 18x1)
- slides by John Shepherd (COMP1927 16s2)
- slides by Gabriele Keller (COMP1927 12s2)
- lectures by Richard Buckland (COMP1927 09s2)
- slides by Manuel Chakravarty (COMP1927 08s1)
- notes by Aleks Ignjatovic (COMP2011 '05)
- slides and books by Robert Sedgewick

The Tools of the Trade

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Compilation

Sanitizers

valgrind

make

	<pre>gcc -o prog prog.c</pre>
	<pre>clang -Wall -Werror -g -fsanitize=address,leak,undefined -o prog prog.c</pre>

COMP2521 uses the clang compiler. Basic compilation command:

```
clang -Wall -Werror -g -o prog prog.c
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 - Prevents compilation if there are warnings

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- `-Wall` enables (almost) all warnings
 - Catches many possible syntax errors
- `-Werror` turns warnings into errors
 - Prevents compilation if there are warnings
- `-g` preserves information useful for debugging
 - Line numbers, function and variable names, etc.

{Address, Leak, Memory, Thread, DataFlow, UndefinedBehavior}Sanitizer

a family of compiler plugins, developed by Google
which instrument executing code with sanity checks
use-after-free, array overruns, value overflows, uninitialised values, and more

you've been using ASan+UBSan already: *dcc* uses them!
usable on your own *nix systems (Linuxes, BSDs, 'macOS') too!

- Detects invalid memory accesses, such as:
 - Out-of-bounds array accesses
 - Use-after-free errors
 - Double-free errors
 - ...and many others
- To use AddressSanitizer, compile with `-fsanitize=address`
 - Our Makefiles compile with AddressSanitizer by default

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```
#include <stdio.h>
```

```
#define SIZE 5
```

```
int main(void) {  
    int arr[SIZE];  
    int i = 0;  
    while (scanf("%d", &arr[i]) == 1) {  
        i++;  
    }  
    ...  
}
```


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```
=====  
==2848814==ERROR: AddressSanitizer: stack-buffer-overflow on address 0x7ffc9a6b8b74  
at pc 0x00000043ab36 bp 0x7ffc9a6b8a00 sp 0x7ffc9a6b8180  
WRITE of size 4 at 0x7ffc9a6b8b74 thread T0  
#0 0x43ab35 in scanf_common(void*, int, bool, char const*, __va_list_tag*) (/imp  
ort/glass/2/.../asan+0x43ab35)  
#1 0x43b98b in __isoc99_scanf (/import/glass/2/.../asan+0x43b98b)  
#2 0x4c805f in main /import/glass/2/.../asan.c:9:12  
#3 0x7f0c20c7ed09 in __libc_start_main csu/.../csu/libc-start.c:308:16  
#4 0x41e2b9 in _start (/import/glass/2/.../asan+0x41e2b9)  
  
Address 0x7ffc9a6b8b74 is located in stack of thread T0 at offset 52 in frame  
#0 0x4c7f5f in main /import/glass/2/.../asan.c:6  
  
This frame has 1 object(s):  
[32, 52) 'arr' (line 7) <== Memory access at offset 52 overflows this variable  
HINT: this may be a false positive if your program uses some custom stack unwind mec  
hanism, swapcontext or vfork  
(longjmp and C++ exceptions *are* supported)  
SUMMARY: AddressSanitizer: stack-buffer-overflow (/import/glass/2/.../asan+0x43ab35)  
in scanf_common(void*, int, bool, char const*, __va_list_tag*)
```

- Detects memory leaks
- To use LeakSanitizer, compile with `-fsanitize=leak`
- Example of error that would be caught by LeakSanitizer:

```
#include <stdlib.h>

int main(void) {
    int *a = malloc(sizeof(int));
    *a = 42;
    // free(a);
}
```

- Detects uninitialized memory access
- To use MemorySanitizer, compile with `-fsanitize=memory`
- Example of error that would be caught by MemorySanitizer:

```
#include <stdio.h>

int main(void) {
    int arr[10];
    arr[0] = 42;
    if (arr[1] == 0) {
        printf("zero\n");
    }
}
```

- Detects wide range of undefined behaviours
- To use UndefinedBehaviorSanitizer, compile with `-fsanitize=undefined`
- Example of error that would be caught by UndefinedBehaviorSanitizer:

```
#include <limits.h>
#include <stdio.h>

int main(void) {
    int a = INT_MAX;
    printf("%d\n", a + 1);
}
```

- finding memory leaks
... not free'ing memory that you malloc'd
- finding memory errors
... illegally trying access memory

```
$ valgrind ./prog
```

```
...
```

```
==29601== HEAP SUMMARY:
```

```
==29601==      in use at exit: 64 bytes in 1 blocks
```

```
==29601==    total heap usage: 1 allocs, 0 frees, 64 bytes allocated
```

```
==29601==
```

```
==29601== LEAK SUMMARY:
```

```
==29601==    definitely lost: 64 bytes in 1 blocks
```

Valgrind doesn't play well with ASan. Compile without ASan if you want to use it.

Can't be bothered typing long compilation commands?

make lets you specify
rules, dependencies, variables
in a Makefile

to define what a program needs to be compiled

With a Makefile, all you need to do to compile is to type
make

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