

# Course Overview

**Data Structures**  
**C++ for C Coders**

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# Course overview

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## What does the data structure mean?

- **Data structures:**
  - **methods to store and organize data** in a computer so that it can be used efficiently.
  - A key to designing efficient **algorithms**.
- **Algorithms:**
  - methods for solving a problem
- **Data structures & algorithms** are **the fundamentals of programming**.
  - To become a good computer scientist or engineering it is essential to master the **data structures and algorithms** and learn to apply them to the real world problems.

← which is complicated or complex.

# Course overview

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## What is this course?

- Intermediate-level course.
- Programming **after** programming for problem solving with applications.

topic	data structures and algorithms
concepts	algorithms, time-complexity, array and structure
<b>data types</b>	linked list, array, stack, queue, trees, union-find, bag, priority queues
sorting	selection sort, quick sort, merge sort, heap sort
searching	binary search tree, hashing
graph	BFS, DFS

# Why study data structures?

Their impact is broad and far-reaching

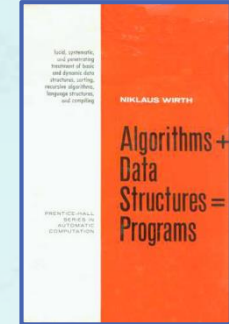
- **Internet** Web search, packet routing, distributed file sharing, ...
- **Social networks** News feeds, advertisements, ...
- **Computers** Circuit layout, file system, compilers, ...
- **Computer graphics** Movies, video games, virtual reality, ...
- **Multimedia** MP3, MP4, JPG, DivX, HDTV, face recognition, ...
- **Security** Cell phones, e-commerce, voting machines, ...
- **Biology** Human genome project, protein folding, ...
- **Physics** N-body simulation, particle collision simulation, ...



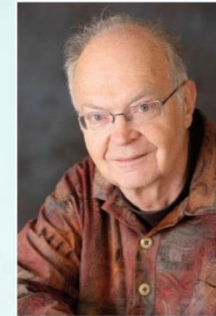
# Why study data structures?

To become a proficient programmer.

" Algorithms + **Data Structures** = Programs. " — *Niklaus Wirth*



" An **algorithm** must be seen to be believed. " — *Donald Knuth*



Donald E. Knuth, winner of the Katayanagi Prize for Research Excellence.

" I will, in fact, claim that the difference between a bad programmer and a good one is whether he considers his code or his data structures more important. Bad programmers worry about the code. Good programmers worry about **data structures** and their **relationships**. "

— *Linus Torvalds* (creator of Linux)



# Why study data structures?

## Algorithms – Old roots, new opportunities.

- Study of **algorithms** dates at least to Euclid.
- Formalized by Church and Turing in 1930s.
- Some important **algorithms** were discovered by undergraduates in a course like this.
- Then, why **data structures**?  
It always comes with algorithms like its shadow.

### Ex. Fast Fourier Transform(FFT) Algorithm

Joseph Fourier(1768-1830) used for heat-transfer computation.

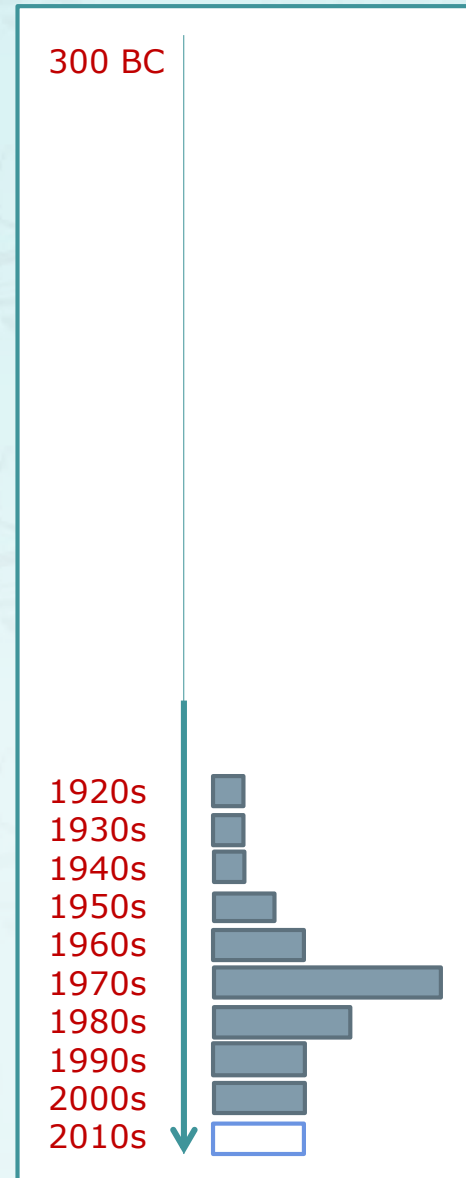
1805 – invented by Carl Friedrich Gauss.

1965 – popularized by James Cooley(IBM) and John Tukey(Princeton).

1986 – JPEG(Joint Photographic Experts Group) was formed.

1992 – issued the first standard of JPEG using DCT

Discrete cosine transform – another form of FFT.





# Why study data structures?

They may unlock the secrets of life and of the universe.

Computational models are replacing math models in scientific inquiry.

Ex. Fourier Transform → Fast FT algorithm → Image Processing → **JPEG/MPEG**

1805

1965

1992

## Fourier Series & The Fourier Transform

Joseph Fourier 1768 - 1830



What is the Fourier Transform?

Fourier Cosine Series for even functions and Sine Series for odd functions

The continuous limit: the Fourier transform (and its inverse)

The spectrum

Some examples and theorems

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) \exp(i\omega t) d\omega \quad F(\omega) = \int_{-\infty}^{\infty} f(t) \exp(-i\omega t) dt$$

Prof. Rick Trebino, Georgia Tech

~ old century science  
(formula based)

```
RECURSIVE-FFT(a)
1  n ← length[a]           ▷ n is a power of 2.
2  if n = 1
3    then return a
4  ωn ← e2πi/n
5  ω ← 1
6  a[0] ← (a0, a2, ..., an-2)
7  a[1] ← (a1, a3, ..., an-1)
8  y[0] ← RECURSIVE-FFT(a[0])
9  y[1] ← RECURSIVE-FFT(a[1])
10 for k ← 0 to n/2 - 1
11   do yk ← yk[0] + ω yk[1]
12     yk+(n/2) ← yk[0] - ω yk[1]
13     ω ← ω ωn
14 return y                 ▷ y is assumed to be column vector.
```

21th century science  
(algorithm based)

# Why study data structures?

- Their impact is broad and far-reaching.
- Old roots, new opportunities.
- To solve problems that could not otherwise be addressed.
- For intellectual stimulation.
- To become a proficient programmer.
- They may unlock the secrets of life and of the universe.
- For fun and profit..





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