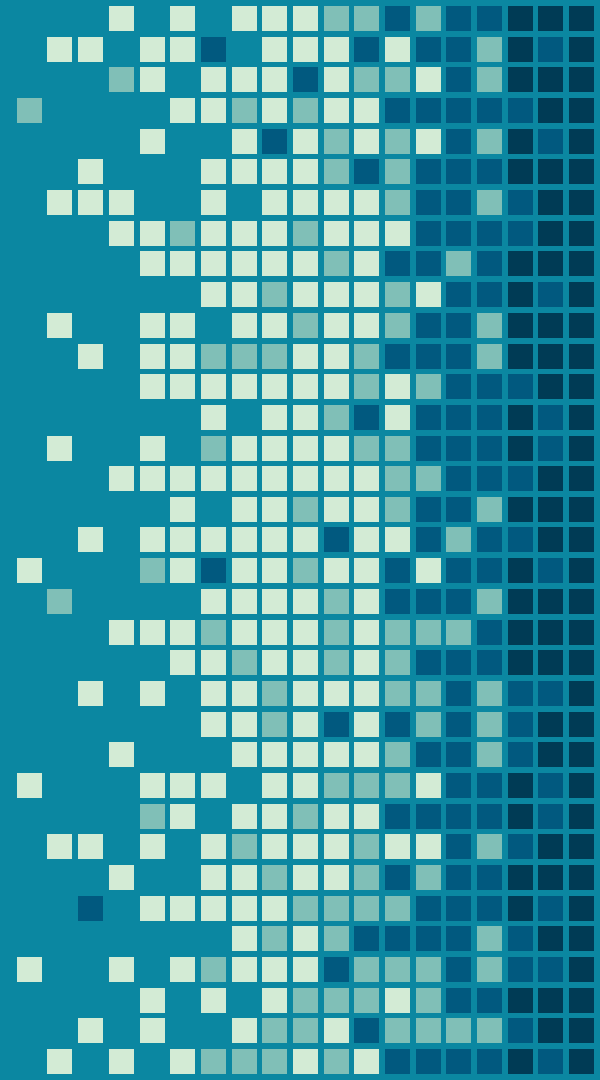


# INTRODUCTION TO COMPUTING

Michael D'Argenio – [mjdargen@ncsu.edu](mailto:mjdargen@ncsu.edu)  
Electrical Engineering – SS 2019 – Duke TIP



# WHAT IS A COMPUTER?



- 
- “A computer is a machine that can be instructed to carry out sequences of arithmetic or logical operations automatically.”

# A computer is a machine that can:

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1. Accept input
2. Execute a procedure
3. Produce output

# Computer must have:

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- Input/Output or I/O
- Processor
- Memory (requirement for modern computers)

# Programming

---

- How we tell processors what to do.
- Programming can either be
  - Mechanical
  - Hardware
  - Software

# How computers differ from machines:

---

1. Machines amplify or extend our physical abilities while computers amplify and extend our mental abilities.
2. Machines are designed to perform a few specific tasks while computers can be programmed to perform many tasks.

There exists very simple computer models that provide the framework to perform any possible computation.

# HISTORY OF COMPUTING



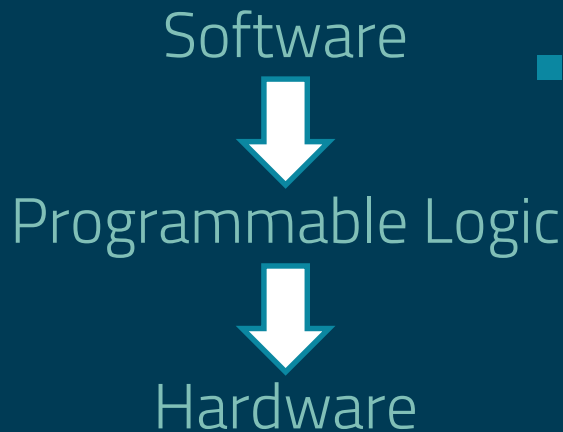
# Crash Course History of Computing

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- [https://youtu.be/O5nskjZ\\_Gol](https://youtu.be/O5nskjZ_Gol)
- <https://youtu.be/LN0ucKNX0hc>

# HOW IS IT ELECTRICAL ENGINEERING?

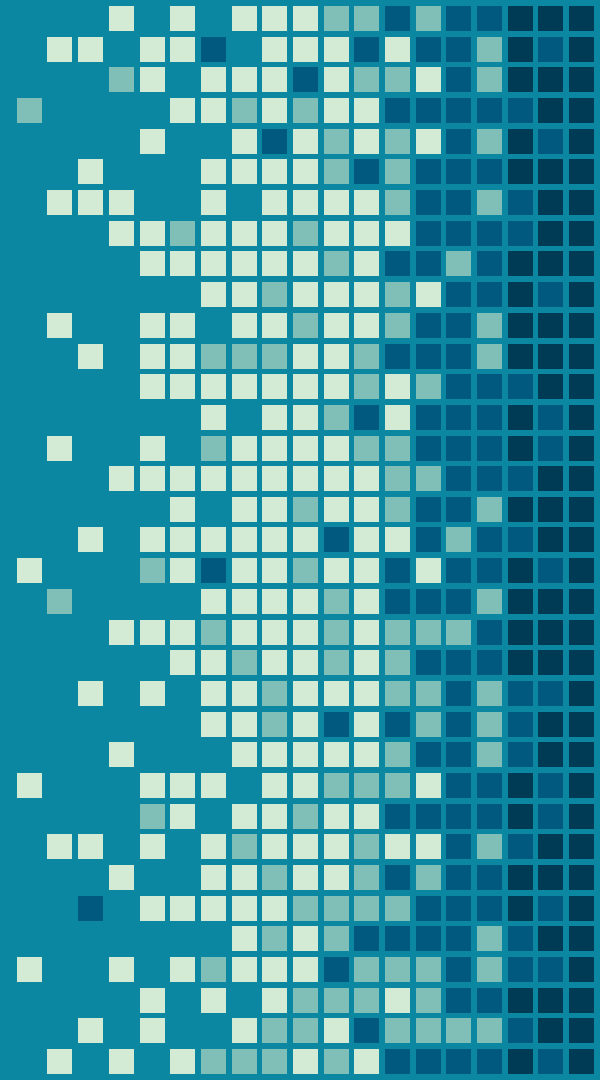
# LEVELS OF ABSTRACTION



Fundamental Theorem of Software Engineering:

"We can solve any problem by introducing an extra level of indirection." – Andrew Koenig

# INTRO TO THE WORLD OF COMPUTING



# The World of Computing

- Computers are dumb.
  - They do exactly what we tell them to do, nothing more.
  - If something is wrong, 99.99999999% of the time:
  - It is because we told it to do the wrong thing OR
  - We told it to do the right thing in the wrong way.
- Approach:
  - Build understanding from the bottom up.

**Bits → Gates → Processor → Instructions → C Programming**

# Two Recurring Themes

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- Abstraction
  - Productivity enhancer – don't need to worry about details.
  - Can drive a car without knowing how the internal combustion engine works... until something goes wrong!
  - Where is the spark plugs? What is a spark plug?
  - Important to understand the components and how they work together.
- Hardware vs. Software
  - It's not either/or – both are important components of a computer system.
  - Even if you specialize in one, you should understand capabilities and limitations of both.

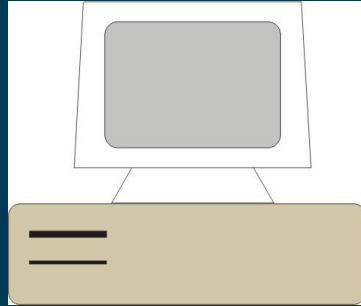
# Big Idea #1: Universal Computing Device

- All computers, given enough time and memory, are capable of computing exactly the same things.



Smart phone

=



Workstation

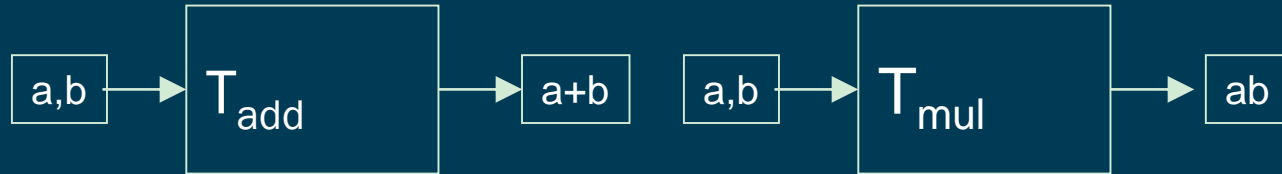
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Supercomputer

# Turing Machine

- Mathematical model of a device that can perform any computation – Alan Turing (1937)
  - ability to read/write symbols on an infinite “tape”
  - state transitions, based on current state & input
- Every computation can be performed by some Turing machine. (*Turing's thesis*)



*Turing machine that adds*

*Turing machine that multiplies*

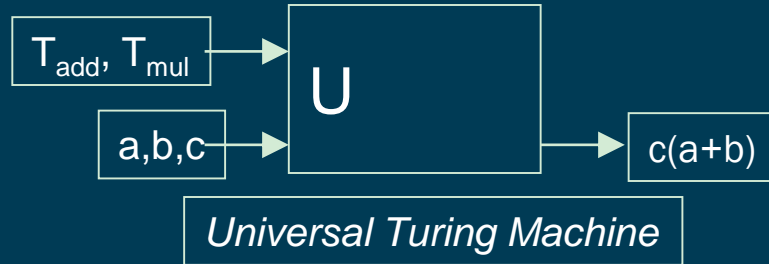
For more info about Turing machines, see  
[http://www.wikipedia.org/wiki/Turing\\_machine/](http://www.wikipedia.org/wiki/Turing_machine/)

For more about Alan Turing, see  
<http://www.turing.org.uk/turing/>



# Universal Turing Machine

- A machine that can implement all Turing machines -- this is also a Turing machine!
  - inputs: data, plus a description of computation

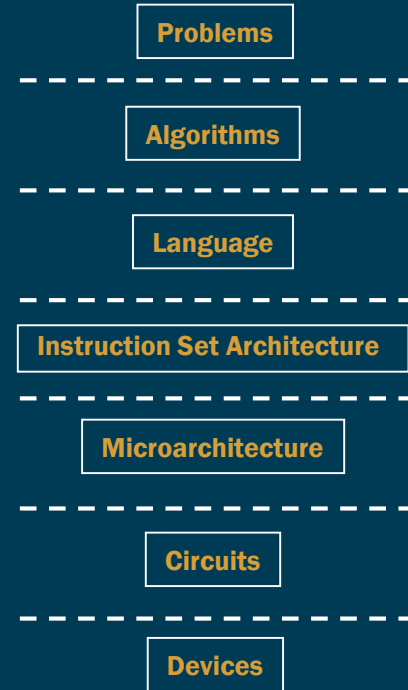
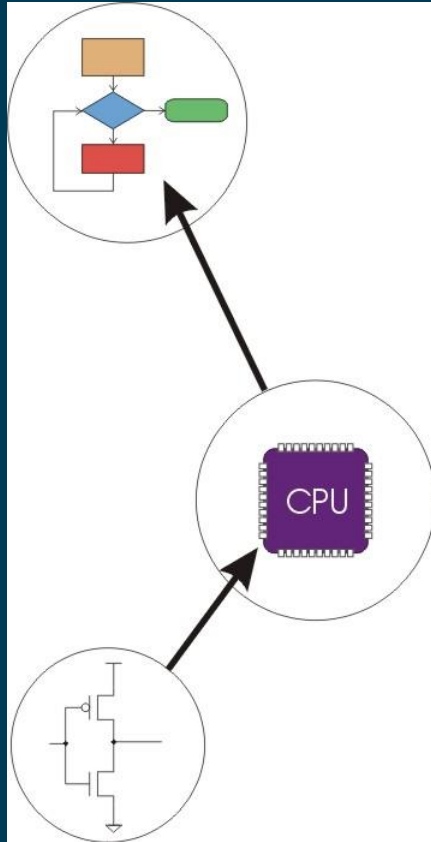


- U is programmable – so is a computer!
  - instructions are part of the input data
  - a computer can emulate a Universal Turing Machine
- *A computer is a universal computing device.*

# From Theory to Practice

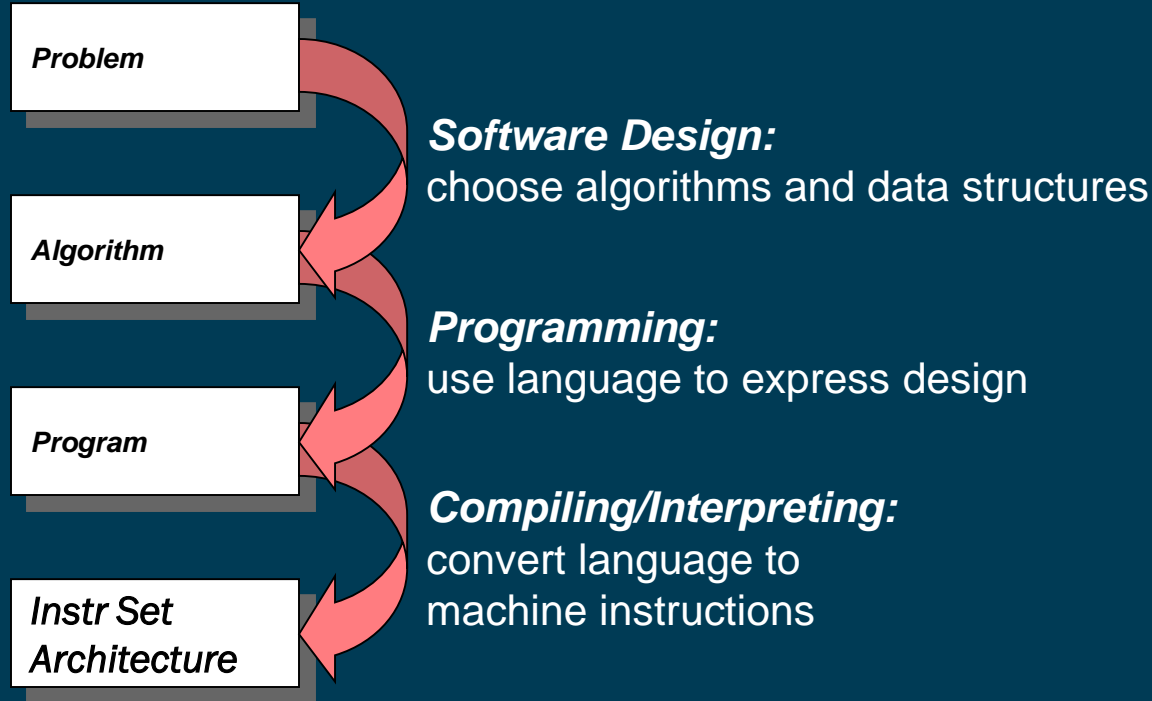
- In theory, a computer can *compute* anything that's possible to compute given enough *memory* and *time*.
- In practice, *solving problems* involves computing under constraints.
  - time
    - weather forecast, next frame of animation, ...
  - cost
    - cell phone, automotive engine controller, ...
  - power
    - personal electronics, remote sensors, ...

# Big Idea #2: Transformation betw. Layers

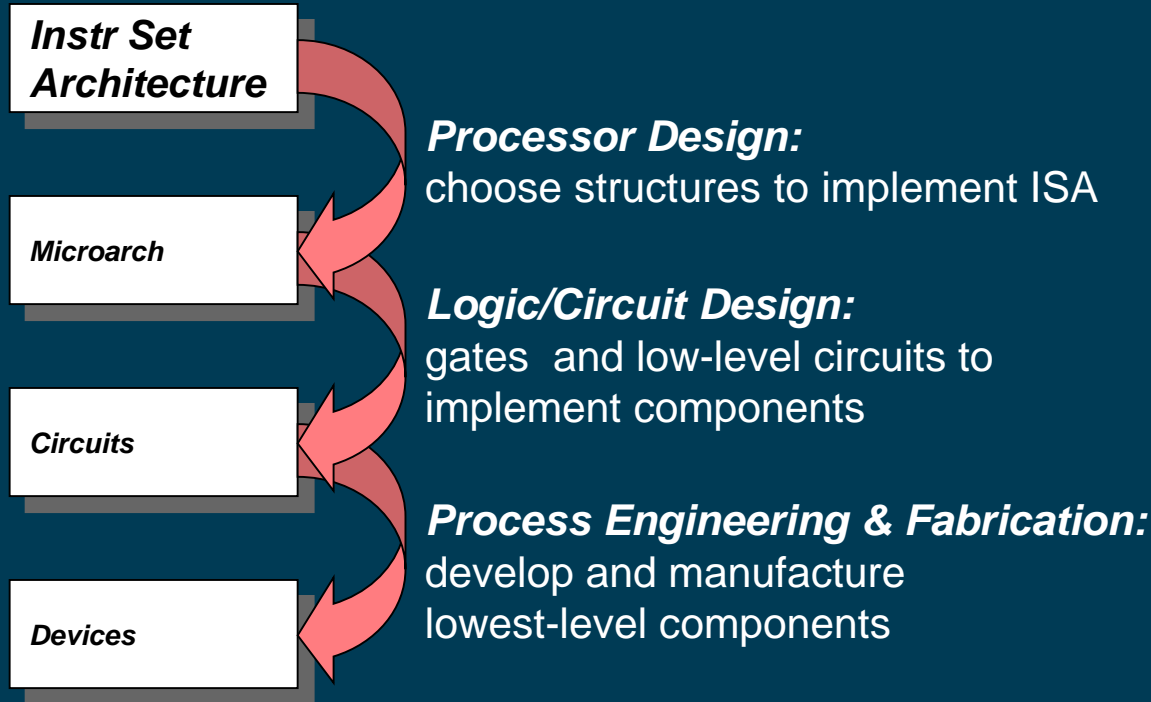


# How to solve problems using a computer?

A systematic sequence of transformations between levels of abstraction.



# Deeper and Deeper...



# Descriptions of Each Level

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- **Problem Statement**
  - stated using "natural language"
  - may be ambiguous, imprecise
- **Algorithm**
  - step-by-step procedure, guaranteed to finish
  - definiteness, effective computability, finiteness
- **Program**
  - express the algorithm using a computer language
  - high-level language, low-level language
- **Instruction Set Architecture (ISA)**
  - specifies the set of instructions the computer can perform
  - data types, addressing mode

# Descriptions of Each Level (cont.)

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- **Microarchitecture**
  - detailed organization of a processor implementation
  - different implementations of a single ISA
- **Logic Circuits**
  - combine basic operations to realize microarchitecture
  - many different ways to implement a single function (e.g., addition)
- **Devices**
  - properties of materials, manufacturability

# Many Choices at Each Level

