

Objectives

- Computer's representations of data types

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Review

- What is the special name for sequences, like newlines, tabs, ...?
 - How do we represent them in strings?
- How can we get fine-grained control over how our data is displayed?
 - What is that called?
 - How do we write them?

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Representations of Data

- Computer needs ways to represent different types of data
 - Eventually, all boils down to 1s and 0s
- Computer needs to translate between what humans know to what computer knows and back again



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Seems like a divergence on strings but just wait...

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Decimal Representations

- Decimal is base 10
- Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- Each *position* in a decimal number represents a *power of 10*

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Decimal Representations

- Decimal is base 10
- Digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- Each *position* in a decimal number represents a *power of 10*
- Example: 54,087

5	4	0	8	7
10^4	10^3	10^2	10^1	10^0

- $= 5 \cdot 10^4 + 4 \cdot 10^3 + 0 \cdot 10^2 + 8 \cdot 10^1 + 7 \cdot 10^0$
- $= 5 \cdot 10,000 + 4 \cdot 1000 + 0 \cdot 100 + 8 \cdot 10 + 7 \cdot 1$

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Number Representations

Characteristic	Decimal	Binary
Base	10	2
Digits	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	0, 1
Position represents	Power of 10	Power of 2

- Binary: two values (0, 1)
 - Like a light switch (either **off** or **on**) or booleans (either True or False)
- 0 and 1 are *binary digits* or **bits**
 - 64-bit machine: represents numbers (and other data) with 64 bits

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Binary Representation

- Binary number: 1101

1	1	0	1
2^3	2^2	2^1	2^0

- $= 1*2^3 + 1*2^2 + 0*2^1 + 1*2^0$

- $= 1*8 + 1*4 + 0*2 + 1*1$

➤ Decimal value: 13

Practice: what is the decimal value of the binary number **10110**?

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Binary Representation

- Binary number: 10110

1	0	1	1	0
2^4	2^3	2^2	2^1	2^0

- $= 1*2^4 + 0*2^3 + 1*2^2 + 1*2^1 + 0*2^0$

- $= 1*16 + 0*8 + 1*4 + 1*2 + 0*1$

➤ 22

Generalize this process into an algorithm...

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Algorithm: Converting Binary → Decimal

Accumulator design pattern

1. Read in the binary number as a string
 - The starting exponent will be the length of the string-1
2. Initialize the result to zero
3. For each bit in the binary number
 - Multiply the bit by the appropriate power of 2
 - Add this to the result
 - Reduce the exponent by 1
4. Display the result

Implement algorithm
`binaryToDecimal.py`

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Algorithm: Converting Decimal → Binary

Given the decimal as an integer...

1. Initialize the result to the empty string
2. Repeat until the decimal is 0:
 - `result = str(decimal % 2) + result`
 - `decimal = decimal // 2`
3. Display the result

Try out algorithm with 22 as input
Practice implementing this algorithm

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String Representations

- A **string** is a *sequence* of characters
- Each character is stored as a binary number
- **ASCII** (American Standard Code for Information Interchange) is one standard encoding for characters
 - Limitation: ASCII is based on the English language
 - Cannot represent other types of characters
 - Handout is just a subset
- Unicode is a new standard

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ASCII Table Handout

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ASCII Questions

- Lowercase letters are represented by what range of numbers?
- Uppercase letters are represented by what range of numbers?
- What is the difference between the decimal encoding of 'M' and 'N'?
 - Between 'm' and 'n'?

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ASCII Questions

- Lowercase letters are represented by what range of numbers?
 - 97—122
- Uppercase letters are represented by what range of numbers?
 - 65—90
- What is the difference between the decimal encoding of 'M' and 'N'?
 - Between 'm' and 'n'?
 - 1

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Translating to/from ASCII

- Translate a character into its ASCII numeric code using **built-in function** `ord`
 - `ord('a')` ==> 97
- Translate an ASCII numeric code into its character using **built-in function** `chr`
 - `chr(97)` ==> 'a'

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`ascii_table.py`
`ascii.py`

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Encryption

- Process of encoding information to keep it secure
- One technique: Substitution Cipher
 - Each character in message is replaced by a new character

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Caesar Cipher

- Replace with a character X places away
 - X is the **key**
- Julius Caesar used technique to communicate with his generals
- “Wrap around” within the lowercase letters
- Write program(s) to do this in next lab

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Caesar Cipher

- Using the ASCII handout, what would be the encoded messages?

Message	Key	Encoded Message
apple	5	
zebra	5	
the eagle flies at midnight	-5	

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Caesar Cipher

Message	Key	Encoded Message
apple	5	fuuqj
zebra	5	ejgwf
the eagle flies at midnight	-5	ocz zvb gz agdzn vo hdyidbco

What is your algorithm for the encoding process?
How would you *decode* an encrypted message?

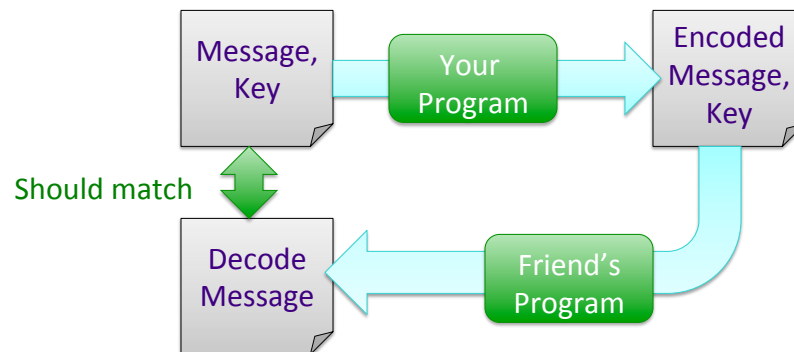
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Next Lab

- Write an encoding/decoding program
 - Encode a message
 - Give to a friend to decode



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Caesar Cipher (Partial) Algorithm

- For each character in the message
 - Check if the character is a space; if it is, it stays a space
 - Otherwise
 - Convert the character to its ASCII value
 - Add the key to that value
 - Make sure that the new value is a "valid" ASCII value, i.e., that that new value is in the range of lowercase letter ASCII values
 - If not, "wrap around" to adjust that value so that it's in the valid range
 - Convert the ASCII value into a character

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This is a lot! Let's break it down...

Lab 7: Pair Programming

Findley	Jordan
Parker	Margaret
Ryan	Lindsey
Lizzie	Chase
Robert	Anna
Ben	Chas
Mary-Frances	Harris
Alison	Ian
Kalady	Joseph
Rachel	Olivia
Davis	Andrew

Anna	Robert
Chase	Lizzie
Harris	Mary-Frances
Andrew	Davis
Chas	Ben
Lindsey	Ryan
Olivia	Rachel
Margaret	Parker
Ian	Alison
Jordan	Findley
Joseph	Kalady

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Same pairing in each table

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Looking Ahead

- Pre Lab 7
- Lab 7 next week
- Broader Issue - Cryptography

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