DATA 3464: Fundamentals of Data Processing

Wrangling text

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Topic overview

- Text file formats and character encodings
- Extracting features from (un)structured text
- Regular expressions

Resources used:

- Python documentation
- Joel on Software Blog Post

What is a text file?

- Any file is just a sequence of **bytes**
- The file **extension** is somewhat meaningless
- Text files contain only human-readable **characters**
- **Binary files** are everything else, including:
  - Images
  - PDFs
  - Word documents*
  - Executables

Technically word docs are just zip files with XML (structured text) inside

Character encodings

> There are three hard problems in computer science:
>
> 1) Converting from PDF,
>
> 2) Converting to PDF, and
>
> 3) O3[illegible]
>
> —Marseille Folog

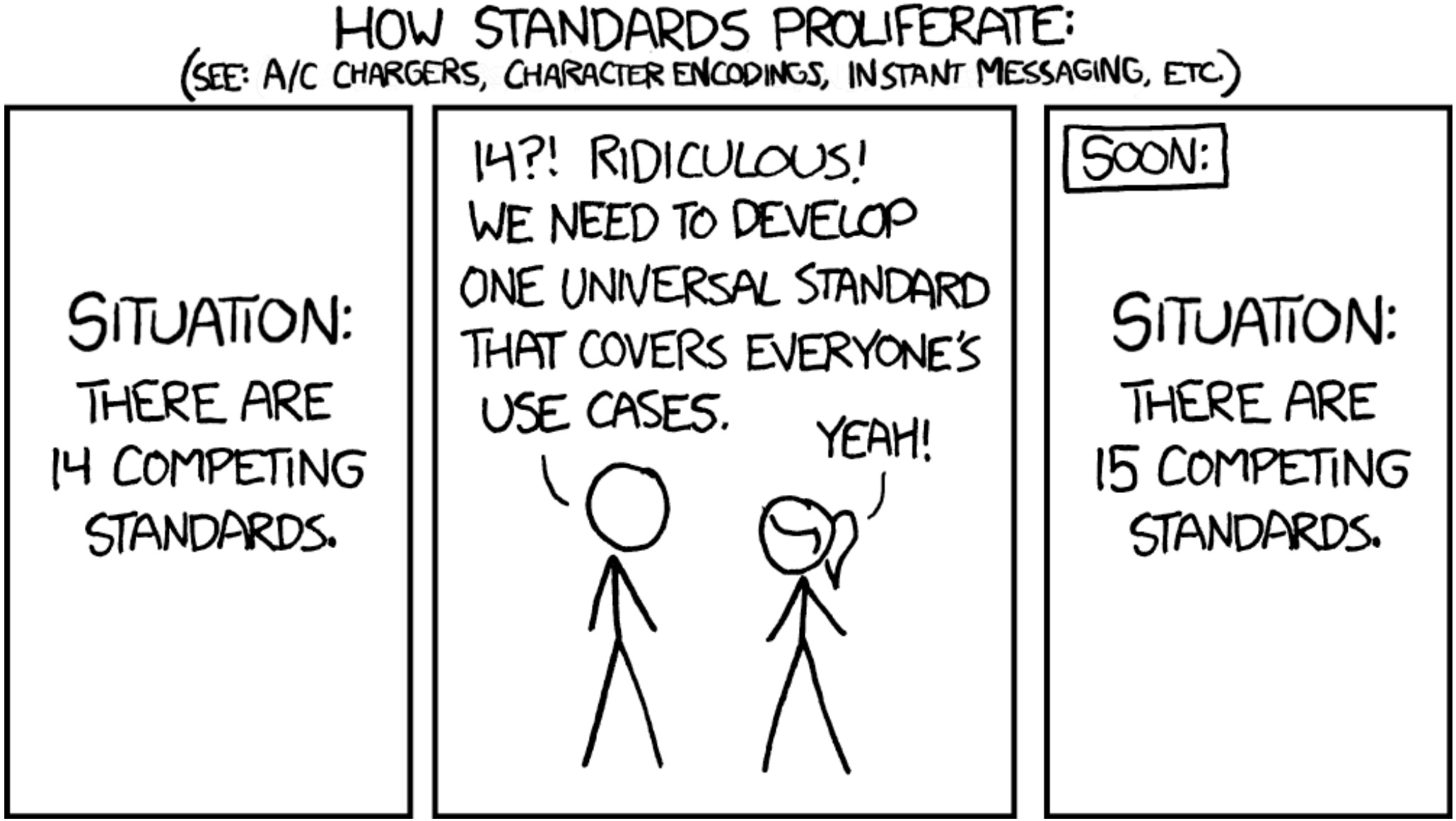
- To properly read a text file, we need to know its **encoding**
- Character encodings define how bytes are interpreted
- Turns out this is surprisingly complicated

Quote from PikePDF documentation

ASCII

- American Standard Code for Information Interchange (1963)
- 7-bit encoding (128 characters)
- First 32 are **control characters** (e.g., newline, tab)
- Then punctuation, digits, uppercase letters, lowercase letters
- Most computers use 8-bit bytes, so there's a whole 128 characters "left over"

> *This is a very English-centric character set!*



https://xkcd.com/927/

Unicode to the rescue

- In the 1980s things were already getting out of hand
- The **Unicode consortium** published a standard in 1993 that assigned a **code point** to every character they could think of (297,334 as of Unicode 17.0)
- Currently, the most common encoding is UTF-8
  - "Unicode Transformation Format – 8-bit"
  - How can 297k characters be represented in only 8 bits?
- The first 128 characters are 1 byte each and align with ASCII
- After that, 2-4 bytes per character are used

> *There's also UTF-16 and UTF-32, but now we need to deal with endianness*

Line endings

- Say we agree to use UTF-8 👍
- A text file is still just a big long string of **bytes**
- Humans like things to be orderly and readable with **line breaks**

System	Abbreviation	Escape sequence	Code point
Pre-OS X Mac	CR (carriage return)	`\r`	U+000D
Unix	LF (line feed)	`\n`	U+000A
Windows	CRLF	`\r\n`	U+000D U+000A

- Result: chaos, but we've mostly settled on LF (`\n`)

Why am I telling you all this?

- As data scientists, you will need to ingest data from various sources
- You **will** encounter character encoding and/or line ending issues
- You don't need to memorize all this, but recognizing that an issue exists will go a long ways towards fixing it

> *Example: misadventures with "smart" quotes*

Where we left off on March 5

Portable document format

- The PDF specification was first published in 1993
- PDFs are like a "digital paper" that can contain text, images, vector graphics, and more (like JavaScript, forms, and weirdly, 3D models)
- We use them for all sorts of things because the **appearance** is consistent
- They are absolutely terrible for pretty much everything else

Some useful PDF packages:

- pdfminer.six: extract text and metadata
- pdfplumber: built on pdfminer.six, layout aware text extraction
- pikepdf: low level PDF manipulation
- pymupdf: more low level PDF manipulation
- and many (many) more!

> *DATA 3463 covers more about PDFs, including OCR. The main focus in this class is on fixing the issues and dealing with edge case*

Hypertext markup language

- Much simpler than PDFs, but still not great for data exchange
- Markup languages are structured text files that define how content *should* be displayed, but it's not always consistent
- Most of the internet is UTF-8 encoded HTML
- We can try to extract text with something like BeautifulSoup
    - Again, more on web scraping in DATA 3463

Back to text

- Assuming we've got text from somewhere, we probably want to:
  - Organize it into a structured format (csv, database, json)
  - Identify specific features (postal codes, dates, names)
- Need to deal with encoding issues, garbled sentences, mixed up tables, and all the other bizarre ways things go wrong
- There is no magic flowchart for this! Lots of trying things, seeing what happens, dealing with a few edge cases at a time

> *One really useful tool is **regular expressions*** 🔨

Regular expressions

The card game?

Note: card groupings and colours are logical where possible, but sometimes just random

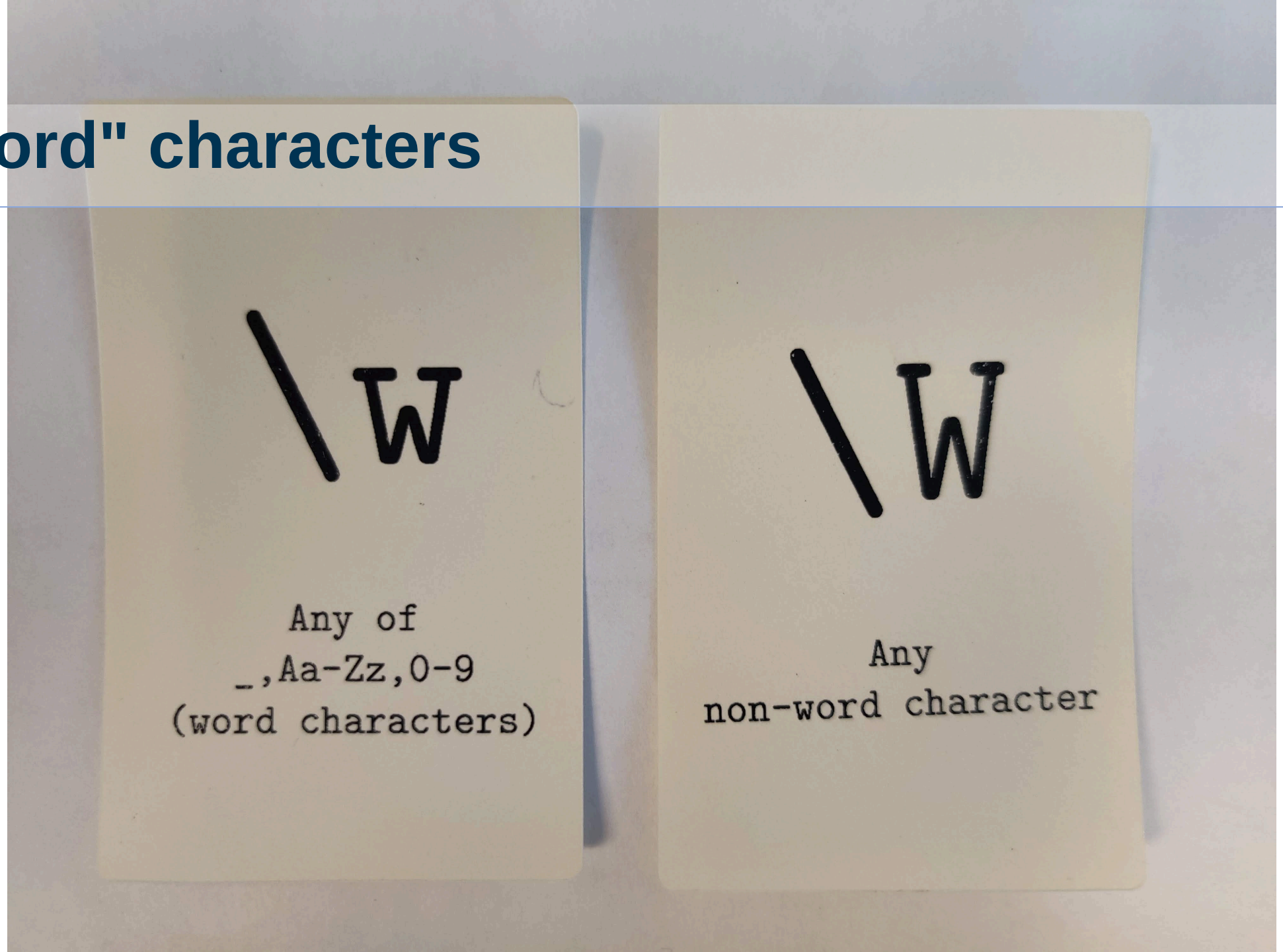
Basic characters

A literal character
e.g. A, x, 4, ?

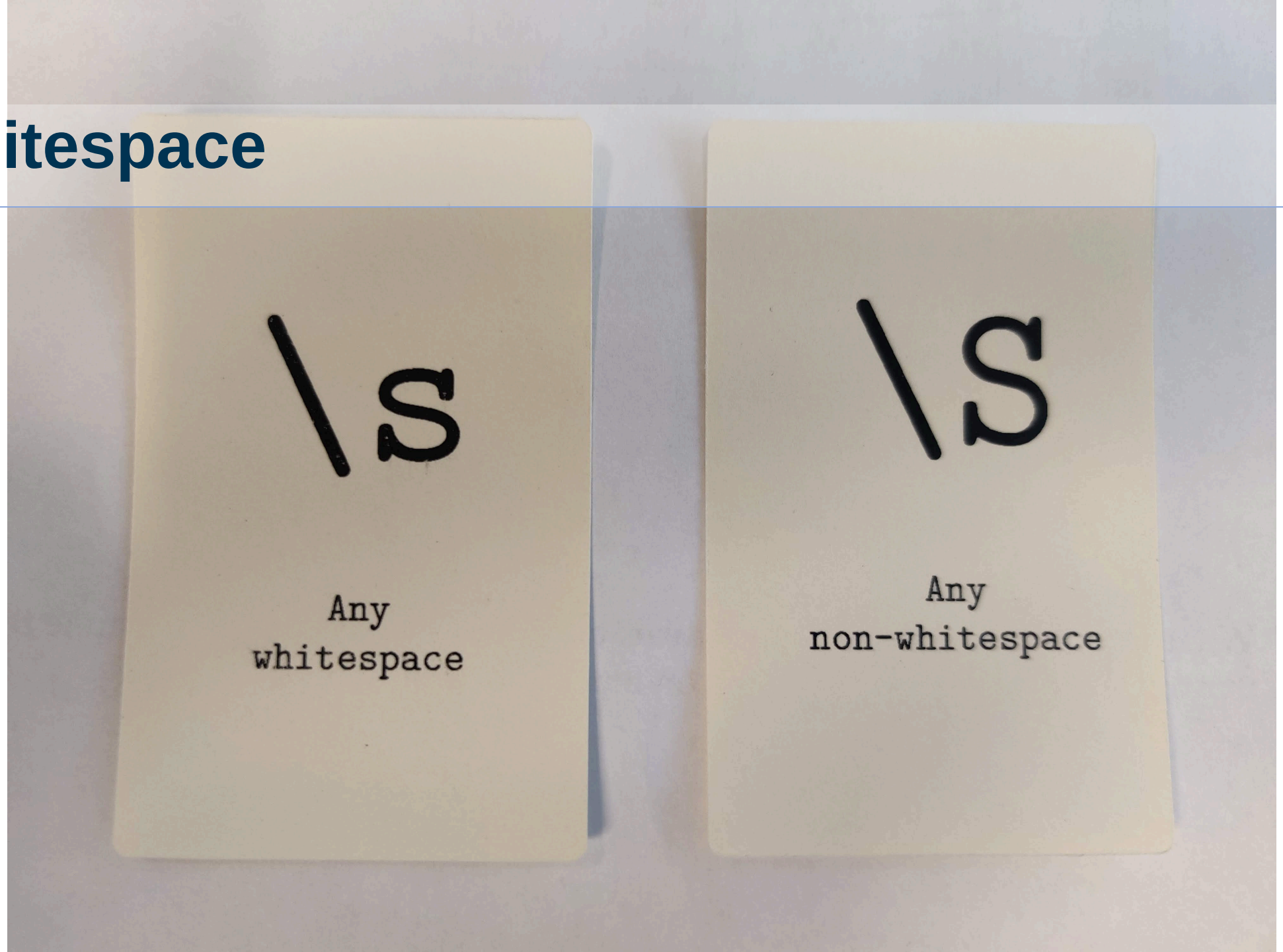
Escape character

Any digit

"Word" characters



Whitespace



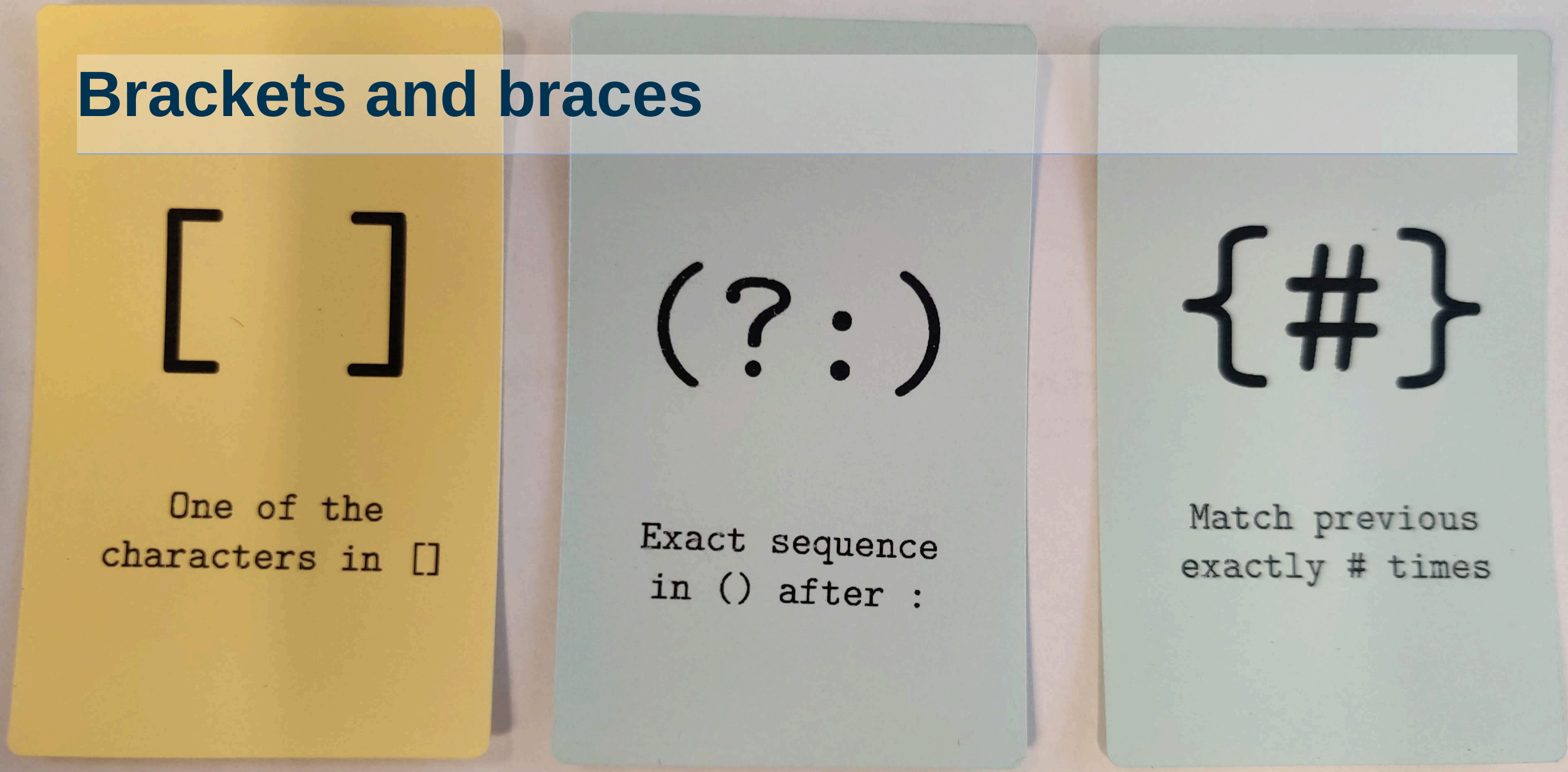
Quantifiers

0 or more

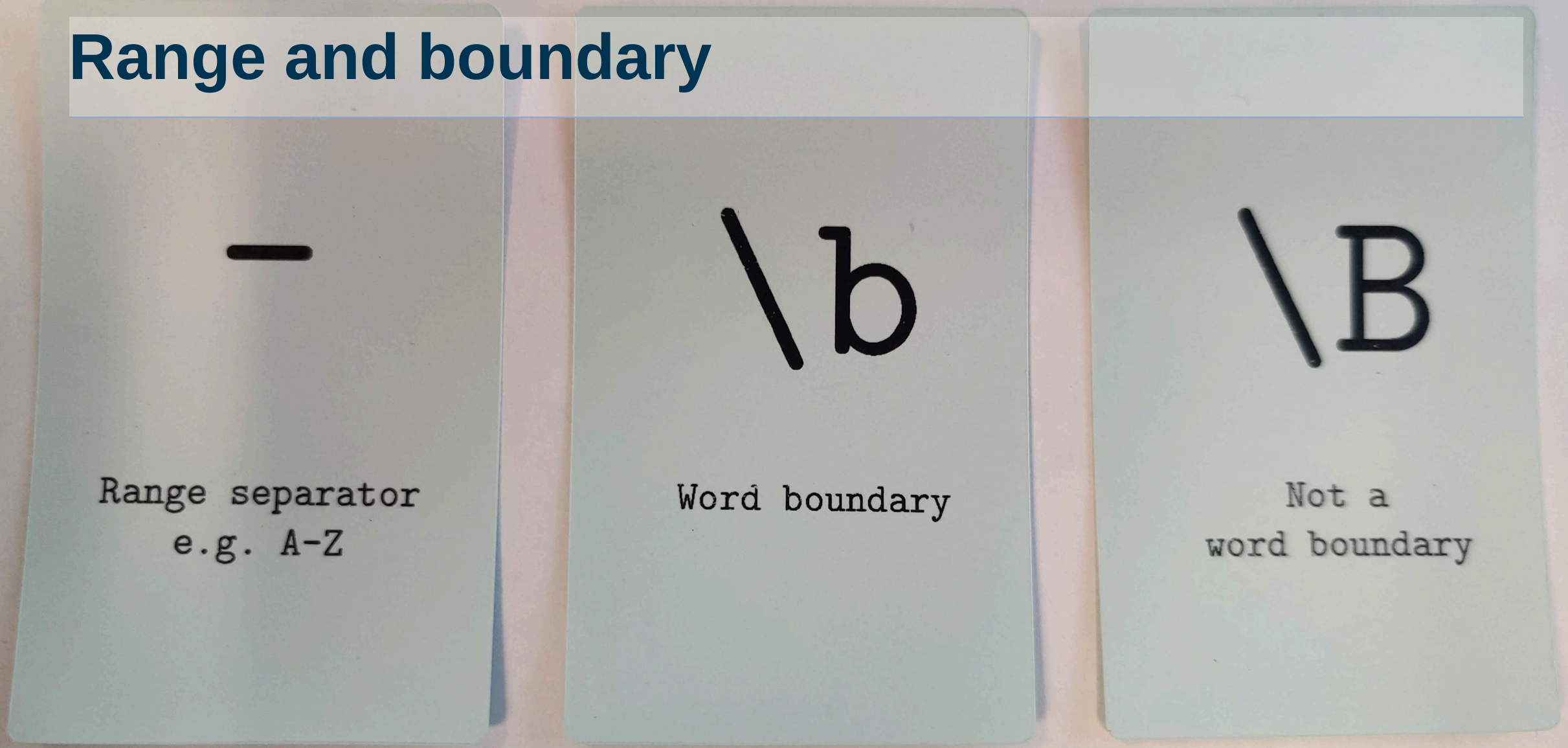
1 or more

0 or 1

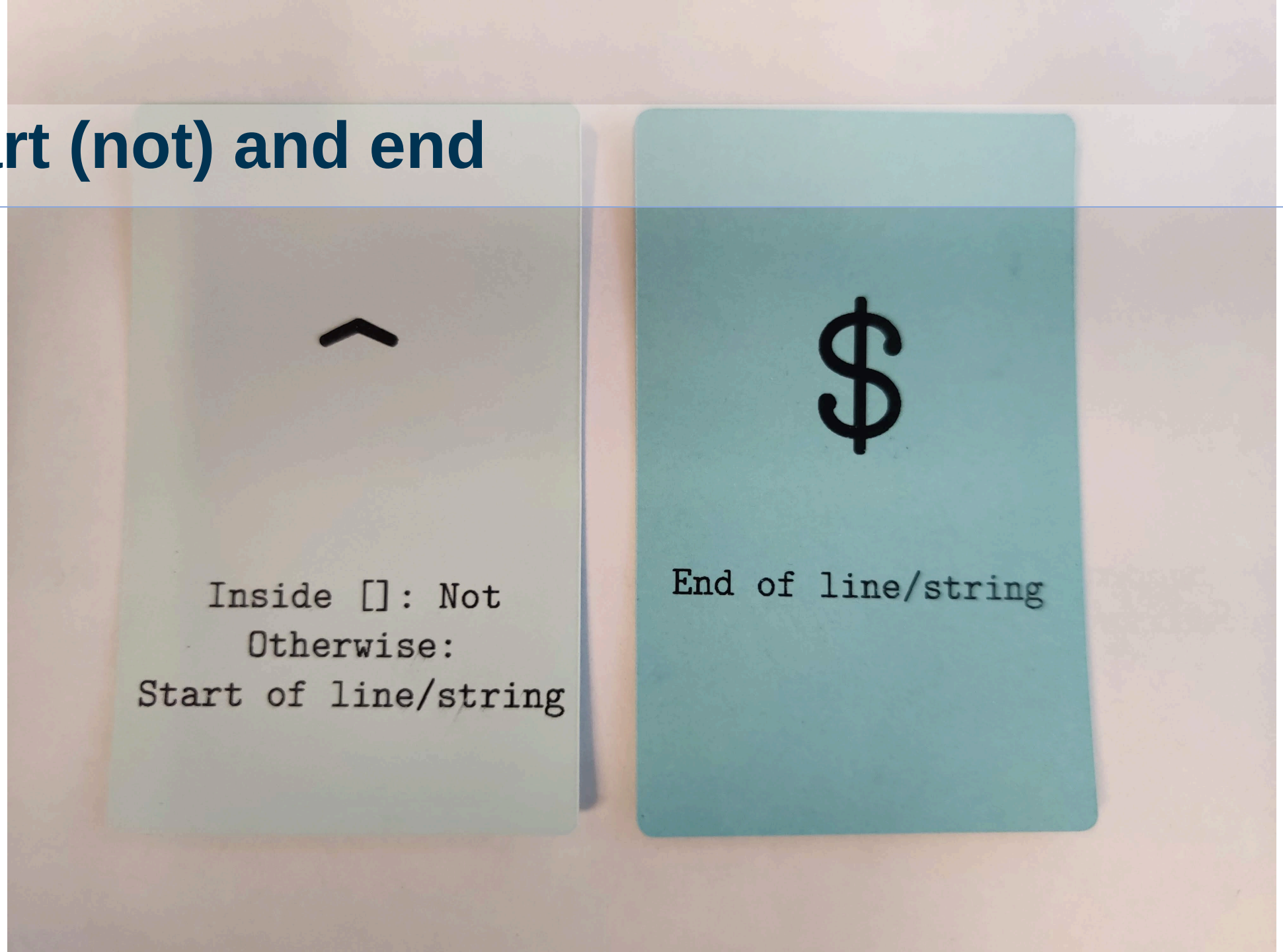
Brackets and braces



Range and boundary



Start (not) and end



Where we left off on March 10

Capturing groups

- Seems weird that `(?:...)` is so verbose, why not just `(...)`?
- Even more common than grouping is **capturing**: `(...)`
- This lets us save part of the match for later

> *Examples:*
>
> - *extract the dollar amount from a $$ string*
> - *extract the area code from a phone number*
> - *extract the domain from an email address*

Regex tools

- Regex101 for quickly testing, debugging, and learning
- re module for using regexes in Python
- grep for searching through files on the command line
- sed for doing regex-based find and replace on the command line
- Regex the card game for learning and fun?

Case study: Cloudflare outage

In July 2019, a poorly formed regex in Cloudflare's firewall rules caused CPU usage to spike and websites to come crashing down worldwide. The cause? This regex:

```
(?:(?:\"|'|\]|\}|\\|\d|(?:nan|infinity|true|false|null|undefined|symbol|math)|\`|\-|\+)+[)]*;?((?:\s|-|~|!|{}|\|\||\+)*.*(?:.*=.*)))
```

- Regex engines perform **backtracking** to check for multiple match possibilities
- This particular string led to **catastrophic backtracking**
- Moral of the story: test carefully, both positive and negative

Coming up next

- Assignment 3: curate a dataset
- A primer on data cards
- Intro to signals and images