# Regular Expressions

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# Introduction

# Regular Expressions

A sequence of characters that forms a **search pattern**.

Used in:

- Data validation.
- Search and Replace.
- Parsing.

# Variants

- There are **several** different regular expression **processors**.
- All of them translate regular expressions into a Nondeterministic Finite Automaton (**NFA**).
- But can have slightly **different syntaxes**.

# Matching

- Matching is the process of **applying** a regular expression **pattern** to a text string and finding strings that are represented by that pattern.
- When **validating**, we normally expect the **whole** string to match the pattern.
- When **searching**, we expect a **substring** of that string to match the pattern.

# References

- Online Regular Expression Tester
- Regular Expressions Tutorial
- Regex Golf
- Regex Crossword
- Mail RFC822 Regexp

# Literal Characters

# Literal Characters

A literal character matches the first occurrence of that character in the string.

```
a
```

I ate an apple.

You can tell the processor to **match all occurrences** if needed.

I ate an apple.

# Literal Characters

A series of literal characters, matches those same characters in the same order.

```
at
```

I ate an apple.

# Special Characters

There are twelve characters that have special meanings in regular expressions:

```
\ ^ $ . | ? * + ( ) [ {
```

To match any of these symbols, you need to escape them with a **backslash**.

```
\+
```

1+1=2

All other characters should **not** be escaped as the backslash also has special meaning.

# Non-Printable Characters

- **\t** – tab
- **\r** – carriage return
- **\n** – line feed

# Character Classes

# Character Classes

A character class, or set, matches **only one** out of several characters.

```
gr[ae]y
```

Matching all occurrences:

gray or grey

# Ranges

You can use an hyphen to specify ranges in a character class.

```
[0-9a-fA-F]
```

This matches all digits from 0 to 9 and all letters (both in lowercase and uppercase).

The cat is inside the box.

# Negated

A **caret**(`^`) after the opening square bracket negates the character class.

```
[^A-Za-f]
```

This matches all letters except those in uppercase and from *a* to *f*.

The cat is inside the box.

# Special Characters

Inside a character class, the only special characters are:

```
] \ ^ -
```

All others do not need to be escaped.

# Shorthand Character Classes

- **\d** digit – the same as **[0-9]**
- **\w** word character – the same as **[A-Za-z0-9_]**
- **\s** whitespace character – the same as **[ \t\r\n\f]**
- **\D** not a digit – the same as **[^0-9]** or **[^\d]**
- **\W** not a word character – the same as **[^A-Za-z0-9_]** or **[^\w]**
- **\S** not a whitespace character – the same as **[^ \t\r\n\f]** or **[^\s]**

# Dot

The **dot**(.) matches any character except line breaks.

```
c.t
```

The cat is inside the box.

# Zero Length Matches

# Anchors

Anchors can be used to specify the position of the matched string.

- The **caret**(^) matches the position before the first character in the string.
- The **dollar sign**($) matches right after the last character in the string.
- We can use both anchors to validate a string.

```
boys$
```

Matching all occurrences:

Everyone knows boys will be **boys**

# Word Boundaries

- The metacharacter **\b** is an anchor.
- It matches at a position that is called a *word boundary*.
- It always produces a zero-length match.
- This allows you to do whole word searches.

```
\bis\b
```

This island **is** beautiful.

# Alternation

# Alternation

The **vertical bar**(|) allows you to match a single regular expression out of several possible regular expressions.

```
cat|dog
```

Matching all occurrences:

I like both **cat**s and **dog**s.

# Quantifiers

# Optional Items

The **question mark**(?) makes the preceding token in the regular expression optional.

```
colou?r
```

Matching all occurrences:

Do you write **color** our **colour**s?

# Repetition quantifiers

Repetition **quantifiers** allow the preceding token to repeat:

- The **star**(*) allows the token to repeat 0 or more times.
- The **plus**(+) allows the token to repeat 1 or more times.

```
[0-9]+
```

My phone number is 12345.

The **question mark**(?) is also a repetition **quantifier** that allows the token to repeat 0 or 1 times.

# Custom Repetitions

Using **curly brackets**({}) we can specify the maximum and minimum number of repetitions:

Repeat exactly 9 times:

```
[0-9]{9}
```

Repeat between 1 and 3 times:

```
[0-9]{1,3}
```

Repeat at least twice:

```
[0-9]{2,}
```

Repeat at most three times:

```
[0-9]{,3}
```

# Repetitions are Greedy

By default, regular expression processors try to match as many characters as possible when handling repetitions.

```
<.+>
```

This tea is **strong good /strong**.

This might cause unexpected effects.

# Lazy Repetitions

To make repetitions lazy, we add a **question mark**(?) after the repetition operator.

```
<.+?>
```

Matching all occurrences:

This tea is strong good /strong .

# Being lazy is hard work!

The reason why repetitions are greedy by default, is because being lazy forces the processor to **backtrack** more often.

An **alternative** would be using **negated classes**:

```
<[^>]+>
```

Matching all occurrences:

This tea is <strong>good</strong>.

# Grouping and Capturing

# Grouping

Putting part of a pattern inside **parentheses** creates a group.

Groups can be used to apply **quantifiers** and **alternation** to specific parts of the pattern.

```
((https?|ftp)://)?www\.example\.com
```

Matching all occurrences:

ftp://www.example.com or just www.example.com

# Capturing

Groups are automatically **captured** and **numbered**.

This allow you to **extract** different parts of the matched expression.

```
(cats|dogs) are (lazy|smart)
```

i think **cats are lazy**

- Group #0: cats are lazy
- Group #1: cats
- Group #2: lazy

The **complete** match is always group **#0**.

# Capturing

## Other Example

```
((https?|ftp)://)?www\.example\.com
```

http://www.example.com

- Group #0: http://www.example.com
- Group #1: http://
- Group #2: http

# Non Capturing

Sometimes we want to create a group without capturing it. To do that we start the group with a **question mark**(?) and a **colon**(:):

```
(?:(?:https?|ftp)://)?www\.example\.com
```

http://www.example.com

- Group #0: http://www.example.com

# Backreferences

# Backreferences

Backreferences can be used to match the same text twice.

Some regular expression processor use **\n** to reference captured groups while other use **$n**.

Number with at least 3 digits and where the first number is the same as the last:

```
([0-9])[0-9]+\1
```

1231

# Backtracking

# Backtracking

Although regular expression processors are greedy, they can backtrack if they fail to find a match.

```
([0-9])[0-9]+\1
```

41231

Here, the processor starts by matching the 4 but when it fails to find another 4 in the text it backtracks and tries to start with the 1.

4**1231**

# Lookaround

# Lookahead and lookbehind

**Lookahead** and **lookbehind** are **zero-length assertions** (just like the start and end of line and word boundaries)

- These are also called **lookaround** assertions.
- They match characters but then **give up the match** without consuming the characters.
- They only **assert** whether a match is possible or not.

# Positive lookahead

Using **?=** we can match something followed by something else:

```
(cat|dog)(?=s)
```

Matches *cat* or *dog* if followed by an *s*:

My dog is not like other dogs.

# Negative lookahead

Using **?!** we can match something followed by something else:

```
(cat|dog)(?!s)
```

Matches *cat* or *dog* if not followed by an *s*:

All the cats are smarter than my **cat**.

# Positive lookbehind

**?<=** tells the processor to temporarily **step backwards** in the string and check if the text inside the lookbehind can be **matched** there.

```
(?<=is)land
```

Matches *land* if preceded by *is*:

England is part of an island.

# Negative lookbehind

**?<!** Tells the processor to temporarily **step backwards** in the string and check if the text inside the lookbehind **cannot** be matched there.

```
(?<!some)thing
```

Matches *thing* if it is not preceded by *some*:

There is something about this thing.

# Nondeterministic Finite Automaton

# Regular Expressions are NFAs

**D**eterministic **F**inite **A**utomaton (DFA) are finite state machines where:

- each of its transitions is **uniquely** determined by its **source** state and **input** symbol, and
- reading an input symbol is **required** for each state transition.

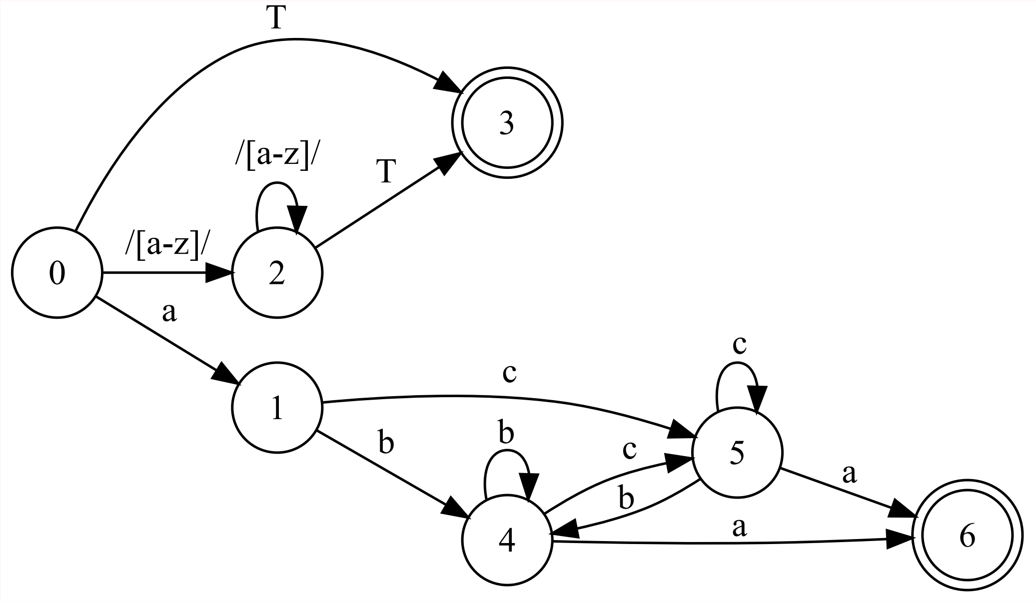
Non-deterministic Finite Automaton don't need to obey these restrictions.

Regular expressions can easily be transformed into NFAs. And NFA can easily be transformed into DFAs.

https://cyberzhg.github.io/toolbox/nfa2dfa

# Example

```
(a(b|c)+a)|([a-z])*T
```



# In HTML

In HTML, input elements have a pattern attribute that can contain a regular expression pattern specifying the allowed values of the field.

```
<      type="text" pattern="\d{9}|\d{3}-\d{3}-\d{3}">
```

# In PHP

# Patterns

- PHP uses Perl-Compatible Regular Expressions (PCRE)
- In PHP, patterns must be delimited by either **forward-slashes** (/), **hash** signs (#) or **tildes** (~).

```
/ab|c/
```

- This means that the chosen delimiter must be **escaped** inside the pattern.
- You may add pattern modifiers after the ending delimiter.

```
/ab|c/i
```

For example, the **i** pattern modifier makes the pattern case **insensitive**.

# preg_match

```
int preg_match ( string $pattern , string $subject [,       &$matches ])
```

The preg_match, searches *subject* for a match to the regular expression given in *pattern*.

- If matches is provided, then it is filled with the results of the search.
- Returns 1 if the pattern matches given subject, 0 if it does not and false if an error occurred.

```php
<?php
  preg_match('/(\d{4})(?:-(\d{3}))?/', '4100-122', $matches);
  print_r($matches);
?>
```

```
Array
(
    [0] => 4100-122
    [1] => 4100
    [2] => 122
)
```

# preg_match_all

```
int preg_match_all ( string $pattern , string $subject [,       &$matches ])
```

The preg_match_all, searches *subject* for **all** matches to the regular expression given in *pattern*.

- If matches is provided, then it is filled with all the results of the search in a multi-dimensional array.
- Returns the number of full pattern matches and false if an error occurred.

```php
<?php
  preg_match_all('/(\d{4})(?:-(\d{3}))?/', '4100-122 4200', $matches);
  print_r($matches);
?>
```

```
Array
(
    [0] => Array ([0] => 4100-122 [1] => 4200)
    [1] => Array ([0] => 4100 [1] => 4200)
    [2] => Array ([0] => 122 [1] => )
)
```

# preg_replace

```
mixed preg_replace ( mixed $pattern , mixed $replacement , mixed $subject )
```

The preg_replace function, searches *subject* for matches to *pattern* and replaces them with *replacement*.

- The replacement can contain backreferences in the form $n or ${n}.

```php
<?php
      preg_replace('/(cat|dog)/', 'my $1s', 'dog are dog');
?>
```

```
my dogs are my dogs
```

# Validation

Using the **preg_match** function, we can easily validate data using regular expressions:

```
                        ($element) {
           preg_match ("/^\d{9}|\d{3}-\d{3}-\d{3}$/", $element);
}
```

Don't forget the beginning and end of string anchors.

# Cleaning

You can also use the **preg_replace** function to clean up input data before storing it in the database.

```
$text = preg_replace('/[^\w\d\s\.!,\?]/', '', $_GET['text']);
```

# In Javascript

# Patterns

- In javascript, patterns must be delimited by **forward-slashes** (/).
- This means that the forward-slashes must be **escaped** inside the pattern.
- You may add modifiers after the ending delimiter:

The **g** modifier is used to perform a global match (find all matches).

The **i** modifier is used to perform a case insensitive match.

# test

```
regexObj.test(str)
```

The test function, tests for a match in a string. It returns true or false.

```
console.log(/(\d{4})(?:-(\d{3}))?/.test('4100-122'));
```

```
true
```

# match

```
str.match(regexp)
```

The match function, executes a search for a regular expression in a string.

```
console.log('4100-122 4200'.match(/(\d{4})(?:-(\d{3}))?/));
console.log('4100-122 4200'.match(/(\d{4})(?:-(\d{3}))?/g));
```

```
["4100-122", "4100", "122", index: 0, input: "4100-122 4200"]
["4100-122", "4200"]
```

# search

```
str.search([regexp])
```

If successful, search returns the index of the first match of the regular expression inside the string.

```
console.log('My zip code is 4100-122'.search(/(\d{4})(?:-(\d{3}))?/));
```

```
15
```

# replace

```
str.replace(regexp, replacement)
```

- The replacement can contain backreferences in the form $n.

```
console.log('dog are dog'.replace(/(cat|dog)/, 'my $1s'));
console.log('dog are dog'.replace(/(cat|dog)/g, 'my $1s'));
```

```
my dogs are dog
my dogs are my dogs
```

# Validation

Using the **test** function, we can easily validate data using regular expressions:

```
                         (element) {
          /^\d{9}|\d{3}-\d{3}-\d{3}$/.test(element);
}
```

Don't forget the beginning and end of string anchors.