Black Magic with Regular Expressions

Jakob Westhoff

Zend Webinar
20. November 2012

Qafoo
passion for software quality

About Me

Jakob Westhoff

About Me

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Qafoo

passion for software quality

About Me

Jakob Westhoff

- PHP Professional since 2001
- JavaScript Professional since 2006
- Trainer and Consultant
- Author of articles and a book
- Regular speaker at technology conferences

Terminology

Terminology

- 🟥 RegExp
- 🟧 Subject
- 🟩 Match

Engine Flavors

PCRE

PCRE

=

Perl Compatible Regular Expressions

PCRE

PCRE

=

Perl Compatible Regular Expressions

- Library that PHP utilizes

RegExp

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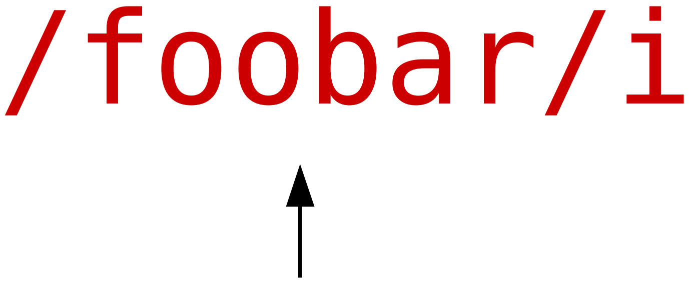
Basic structure of a RegExp

```
/foobar/i
```

Basic structure of a RegExp



```
/foobar/i
```

- Pattern
  - Description of the matching Strings

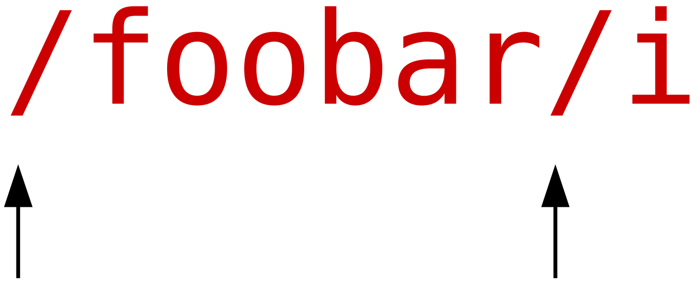
Basic structure of a RegExp

```
/foobar/i
```

↑

- Modifier
  - Additional Options

Basic structure of a RegExp



```
/foobar/i
```

- Delimiter
  - Enclosure of Pattern
  - Divider between Pattern and Modifier

Basic structure of a RegExp

```
(foobar)i
```

- Delimiter
  - PCRE allows arbitrary Brackets
    - () [] {}

Metacharacters

Metacharacters

- Certain characters inside a RegExp Pattern have got a special meaning

```
([We]b \s* Te+c.no)
```

Quantifier

- Quantifiers specify Repetitions of the previous character or group

```
(We*b Te+ch?n{1,3}o)
```

Quantifier

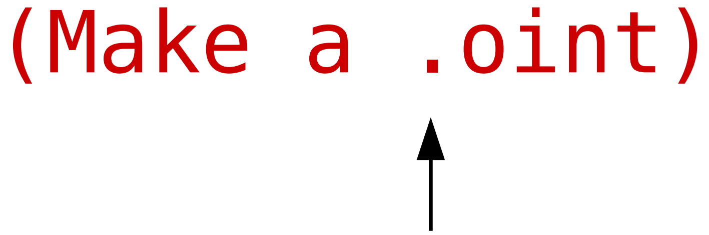
- Quantifiers specify Repetitions of the previous character or group

```
(We*b Te+ch?n{1,3}o)
```

- `*` Any number of occurrences (0 → ∞)
- `+` One occurrence minimum (1 → ∞)
- `?` Not at all or one time (0 → 1)
- `{x,y}` Between x and y (x → y)

The Dot

- The Dot (.) matches any character
  - Everything except newline



```
(Make a .oint)
```

Character Classes

```
([abcdef]+)
```

- Character classes define a Set of arbitrary characters

Character Classes

```
([a-cd-f]+)
```

- Ranges can be defined
- One Character Class may contain multiple Ranges

Character Classes

```
([^abcdef]+)
```

- A Character Class can be negated
- The newline character is part of the negation

Alternatives

- Logical OR

```
(Open|Source)
```

Alternatives

- Logical OR

```
(Open|Source)
```

```
Open
```

Alternatives

- Logical OR

`(Open|Source)`

`Open` ✓

Alternatives

- Logical OR

```
(Open|Source)
```

`Open` ✓

`Source` ✓

Alternatives

- Logical <u>OR</u>

```
(Open|Source)
```

`Open`	✓
`Source`	✓
`Open Source`	

Alternatives

- Logical OR

↓

`(Open|Source)`

`Open` ✓

`Source` ✓

`Open Source` ✓

Subpattern

Subpattern

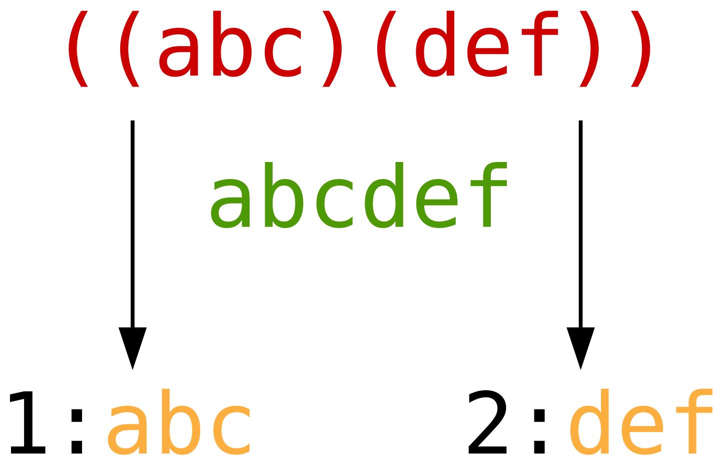
- Pattern can be divided using parenthesis

```
((abc)(def))
```

```
abcdef
```

Subpattern

- Pattern can be divided using parenthesis



```
((abc)(def))
abcdef
1:abc    2:def
```

- Subpatterns may be used to extract parts of the match

Subpattern Options

- Subpattern may be used to set options/modifiers for a certain area of the Regular Expression

```
((?#I am a comment subpattern.))
```

Subpattern Options

- Setting options for a subpattern

```
(?OptionPattern)
```

    - Abstract syntax for any option

Subpattern Options

- Setting the case-insensitive modifier using a subpattern option

```
(((?i)[a-z]+) [a-z]+)
```

Subpattern Options

- Setting the case-insensitive modifier using a subpattern option

```
(((?i)[a-z]+) [a-z]+)
```

```
Jakob westhoff
```

Subpattern Options

- Setting the case-insensitive modifier using a subpattern option

```
(((?i)[a-z]+) [a-z]+)
```

```
Jakob westhoff
```
✓

Subpattern Options

- Setting the case-insensitive modifier using a subpattern option

```
(((?i)[a-z]+) [a-z]+)
```

```
Jakob westhoff  ✓

Jakob Westhoff  ✗
```

Named Subpattern

Named Subpattern

- Subpatterns may be named

```
((?P<firstname>Jakob))
```

  - The P Option is used for naming subpatterns

Named Subpattern

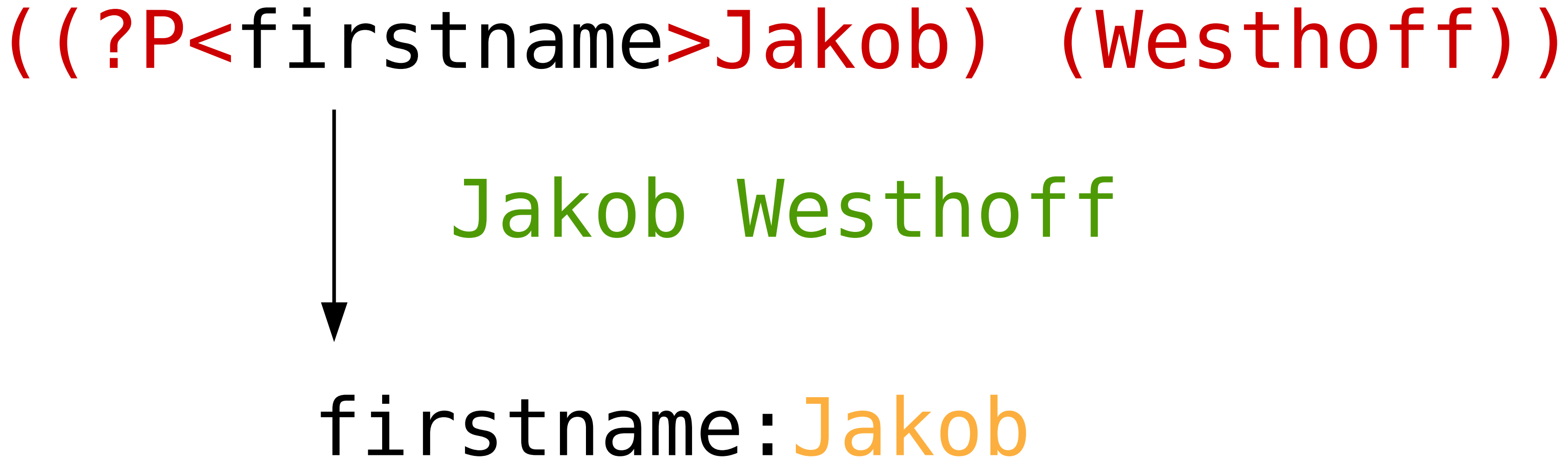
```
((?P<firstname>Jakob) (Westhoff))
```

Named Subpattern

```
((?P<firstname>Jakob) (Westhoff))
```

```
Jakob Westhoff
```

Named Subpattern



```
((?P<firstname>Jakob) (Westhoff))
```

Jakob Westhoff

firstname:Jakob

- Access to extraction using the subpatterns name is possible

Non grouping Subpattern

- Subpattern can be used without being a group

```
((?:Jakob))
```

↑

- The question mark followed by a colon (?:) creates a non grouping subpattern

Non grouping Subpattern

- Why are non grouping subpatterns useful?

Non grouping Subpattern

- Why are non grouping subpatterns useful?

```
((?:Jakob|Veronika) Westhoff)
```

Non grouping Subpattern

- Why are non grouping subpatterns useful?

```
((?:Jakob|Veronika) Westhoff)
```

```
  Jakob Westhoff      ✓
Veronika Westhoff     ✓
```

Non grouping Subpattern

- Why are non grouping subpatterns useful?

```
((?:Jakob|Veronika) Westhoff)
```

```
  Jakob Westhoff      ✓
Veronika Westhoff     ✓
```

  - No clobbering of extracted matches

Assertions

Anchors

- Anchors are part of the family of Assertions in Regular Expressions
- They are used to assert certain conditions without affecting the match
- Anchors: Beginning and end of the Subject

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

Anchors

- `^` Beginning of the Subject
- `$` End of the Subject

```
(Apple)i
```

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

```
(Apple)i
```

```
Apple
```

Anchors

- `^` Beginning of the Subject
- `$` End of the Subject

```
(Apple)i
```

```
Apple
```

✓

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

```
(Apple)i
```

```
Apple       ✓

Pineapple
```

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

`(Apple)i`

`Apple` ✓

`Pineapple` ✓

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

`(^Apple)i`

`Apple`	✓
`Pineapple`	✗

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

```
(Apple$)i
```

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

```
(Apple$)i

Apple        ✓
```

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

```
(Apple$)i

Apple        ✓

Apple-pie
```

Anchors

- `^` Beginning of the Subject
- `$` End of the Subject

↓

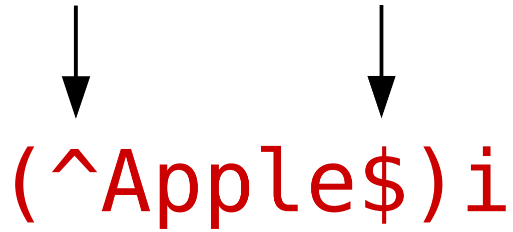
```
(Apple$)i
```

```
Apple      ✓

Apple-pie  ✗
```

Anchors

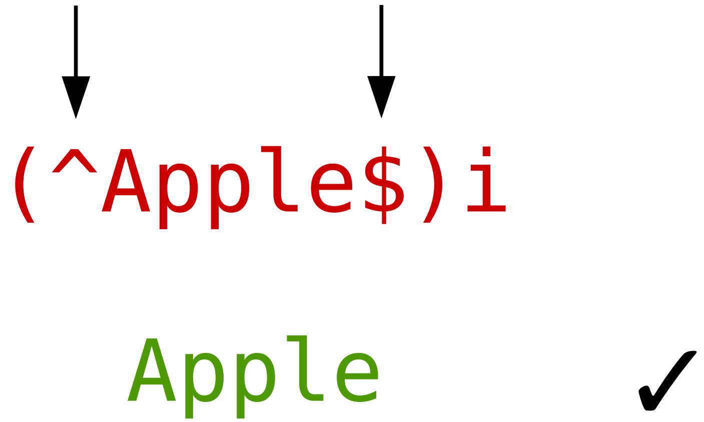
- ^ Beginning of the Subject
- $ End of the Subject



```
(^Apple$)i
```

Anchors

- ^ Beginning of the Subject
- $ End of the Subject



```
(^Apple$)i
```

Apple ✓

Anchors

- ^ Beginning of the Subject
- $ End of the Subject

```
(^Apple$)i
```

Apple	✓
Apple-pie	✗
Pineapple	✗

Other Assertions

- Custom assertions can be created
- The ?= Option is used for this

Other Assertions

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```
([a-z]+(?=,))i
```

Other Assertions

- Custom assertions can be created
- The ?= Option is used for this

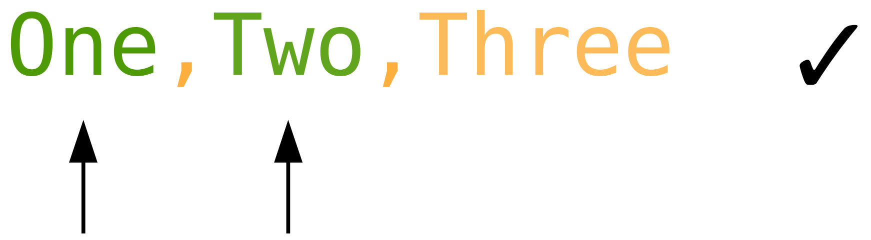
```
([a-z]+(?=,))i
```

```
One,Two,Three   ✓
   ↑
```

Other Assertions

- Custom assertions can be created
- The ?= Option is used for this

```
([a-z]+(?=,))i
```

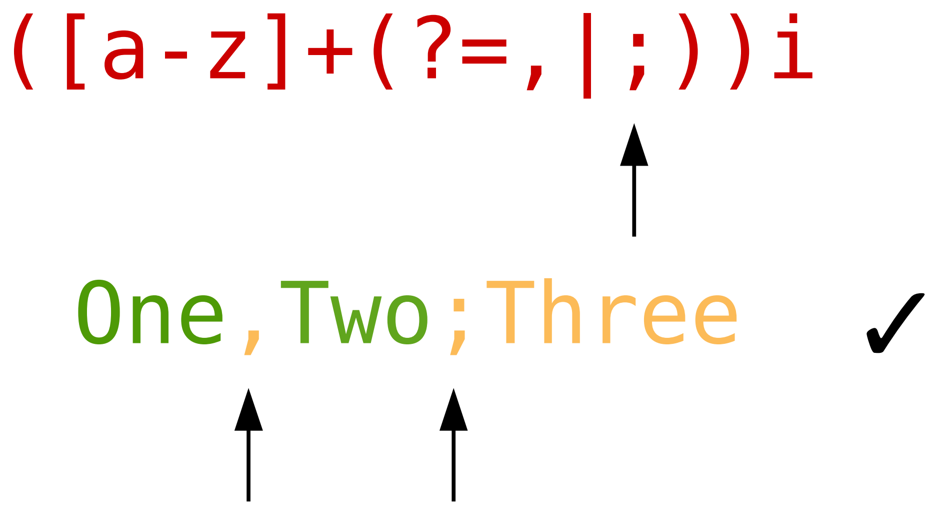


One,Two,Three ✓

- Useful in combination with `preg_match_all`

Other Assertions

- Custom assertions can be created
- The ?= Option is used for this



```
([a-z]+(?=,|;))i

One,Two;Three   ✓
```

- Alternatives may be used

Other Assertions

- Negative Assertions are possible
- The `?!` Option is used for this

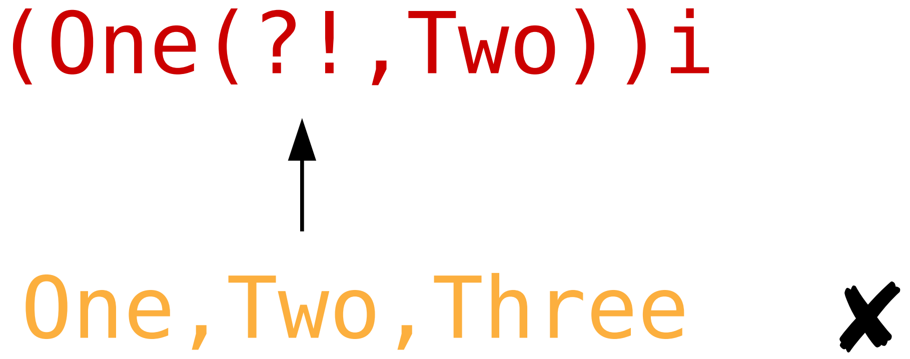
Other Assertions

- Negative Assertions are possible
- The ?! Option is used for this

```
(One(?!,Two))i
```

Other Assertions

- Negative Assertions are possible
- The ?! Option is used for this



```
(One(?!,Two))i
```

```
One,Two,Three
```

✗

Other Assertions

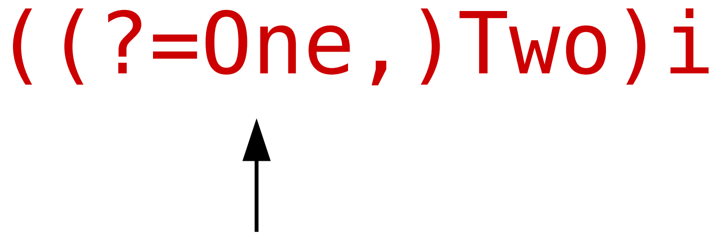
- Negative Assertions are possible
- The `?!` Option is used for this

```
(One(?!,Two))i
     ↑
One,Two,Three   ✗

One,Three   ✓
```

Other Assertions

- Assert on something before the cursor



```
((?=One,)Two)i
```

Other Assertions

- Assert on something before the cursor

```
((?=One,)Two)i
```

```
Three,Two,One
```

Other Assertions

- Assert on something before the cursor

```
((?=One,)Two)i
```

```
Three,Two,One
```

✗

Other Assertions

- Assert on something before the cursor

```
((?=One,)Two)i

Three,Two,One    ✘
One,Two,Three
```

Other Assertions

- Assert on something before the cursor

```
((?=One,)Two)i
```

```
Three,Two,One     ✗
One,Two,Three     ✗
```

Other Assertions

- Assert on something before the cursor

```
((?=One,)Two)i

Three,Two,One     ✗
One,Two,Three     ✗

Why?
```

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Other Assertions

- Assert on something before the cursor

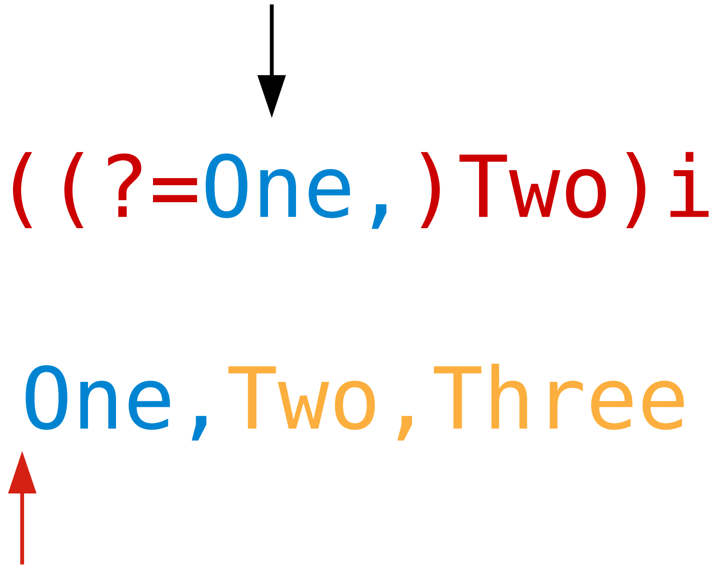
```
((?=One,)Two)i

One,Two,Three
↑
```

passion for software quality

Other Assertions

- Assert on something before the cursor

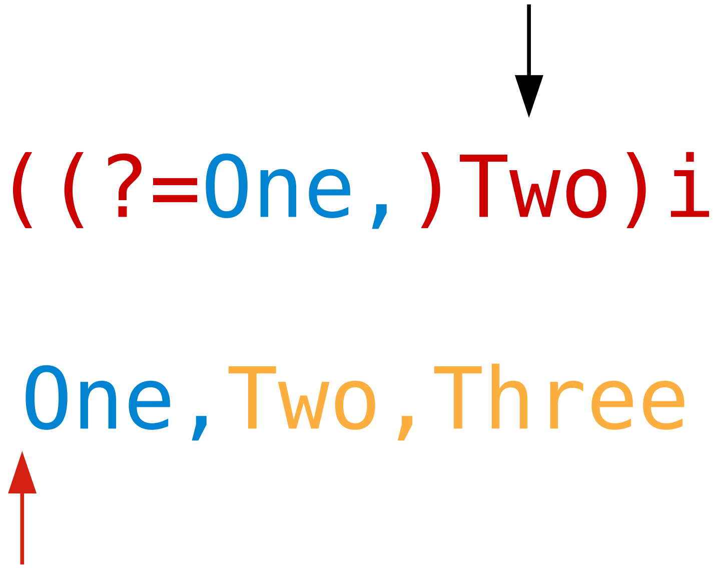


```
((?=One,)Two)i

One,Two,Three
```

Other Assertions

- Assert on something before the cursor

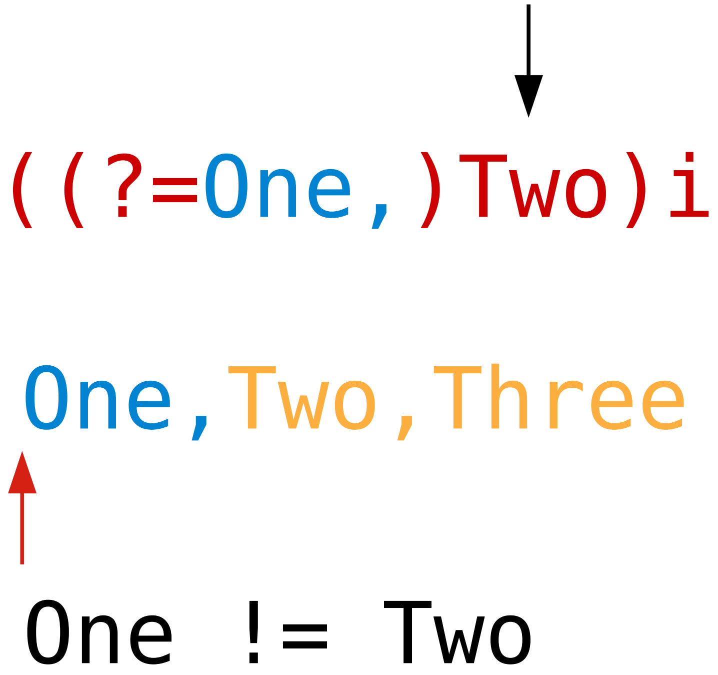


```
((?=One,)Two)i

One,Two,Three
```

Other Assertions

- Assert on something before the cursor



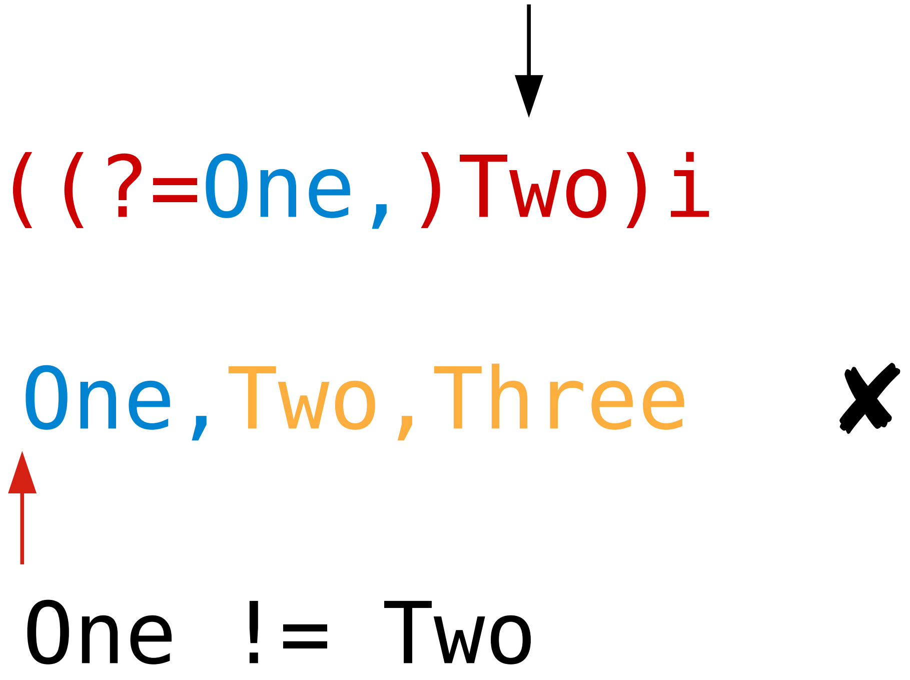
```
((?=One,)Two)i

One,Two,Three

One != Two
```

Other Assertions

- Assert on something before the cursor



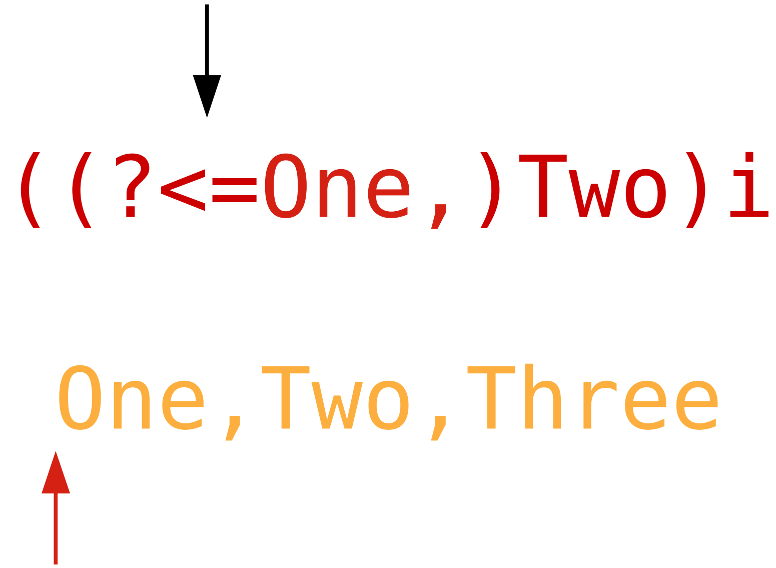
```
((?=One,)Two)i

One,Two,Three     ✗

One != Two
```

Other Assertions

- Look-Behind Assertions to the rescue
- Option: ?<=

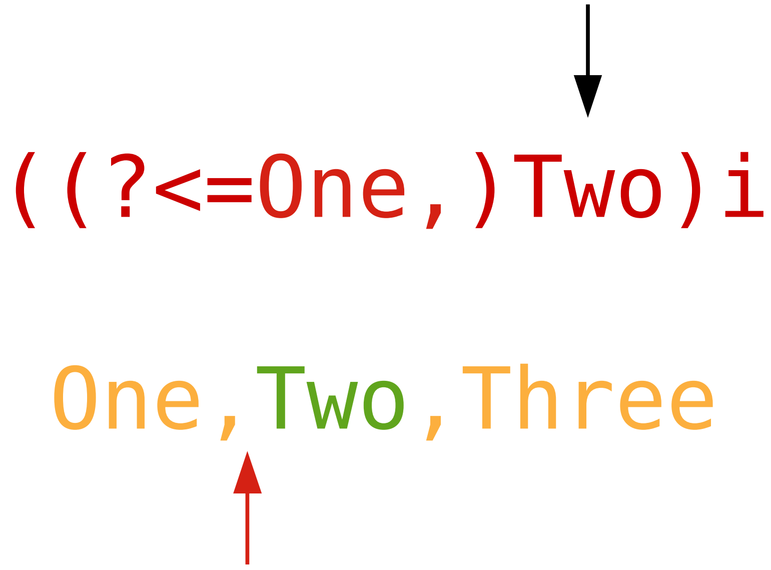


```
((?<=One,)Two)i
```

```
One,Two,Three
```

Other Assertions

- Look-Behind Assertions to the rescue
- Option: ?<=

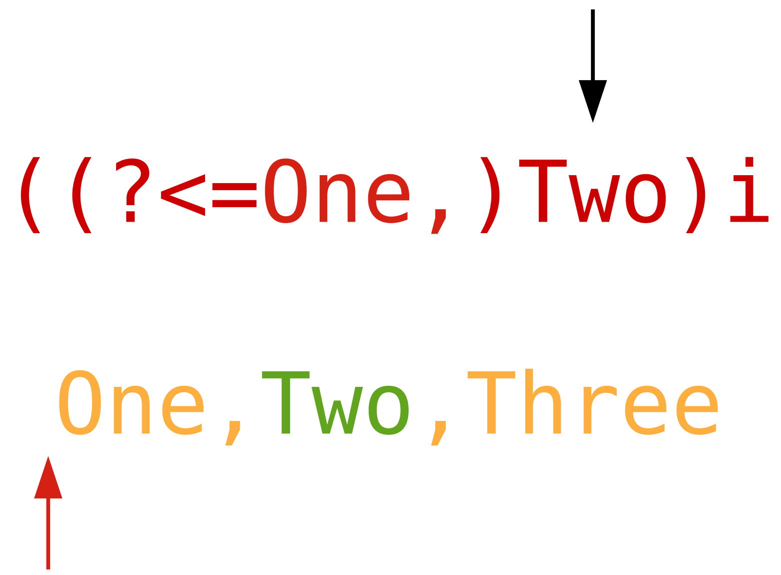


```
((?<=One,)Two)i

One,Two,Three
```

Other Assertions

- Look-Behind Assertions to the rescue
- Option: `?<=`

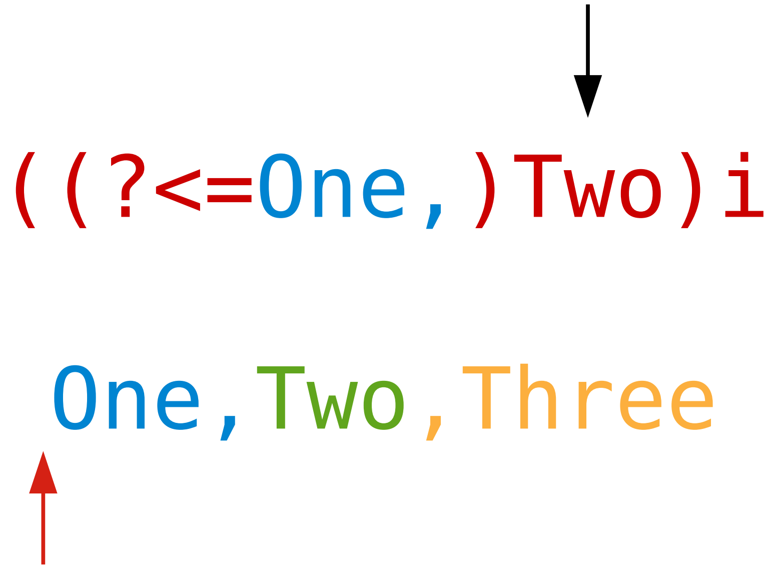


```
((?<=One,)Two)i
```

```
One,Two,Three
```

Other Assertions

- Look-Behind Assertions to the rescue
- Option: ?<=

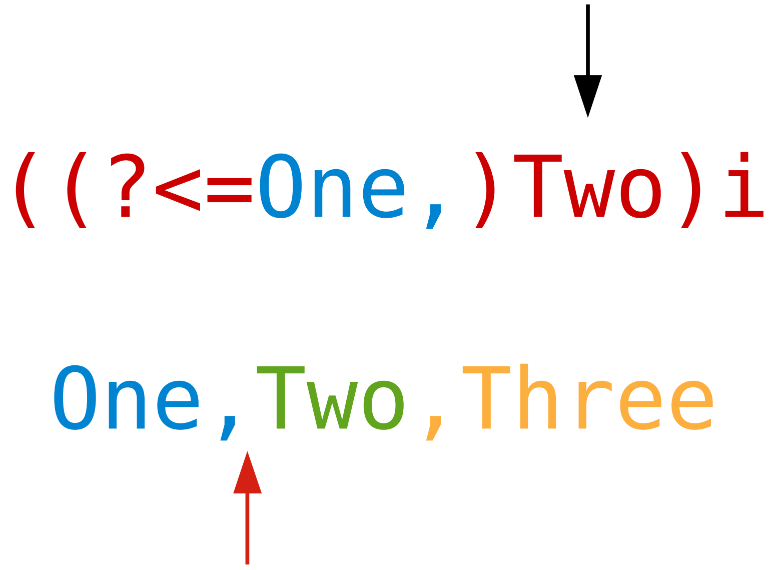


```
((?<=One,)Two)i
```

```
One,Two,Three
```

Other Assertions

- Look-Behind Assertions to the rescue
- Option: `?<=`

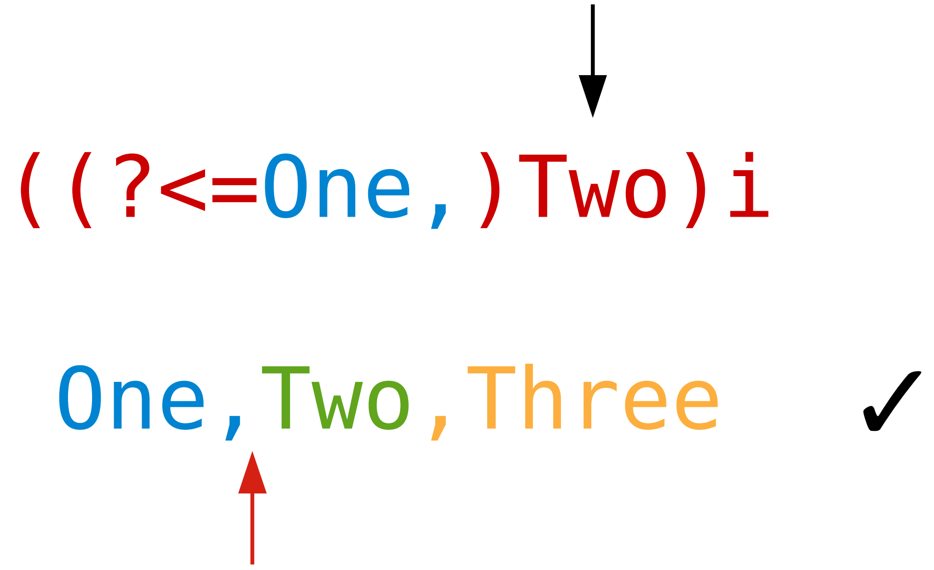


```
((?<=One,)Two)i
```

```
One,Two,Three
```

Other Assertions

- Look-Behind Assertions to the rescue
- Option: ?<=



```
((?<=One,)Two)i
```

```
One,Two,Three    ✓
```

Other Assertions

- Negative Look-Behind is possible
- Option: `?<!`

```
((?<!One,)Two)i
```

Other Assertions

- Negative Look-Behind is possible
- Option: `?<!`

↓

```
((?<!One,)Two)i
```

```
One,Two,Three
```
✗

Other Assertions

- Negative Look-Behind is possible
- Option: `?<!`

```
((?<!One,)Two)i
```

```
One,Two,Three      ✗
Three,Two,One      ✓
```

Unicode

Unicode

- UTF-8 Mode
  - Modifier u

```
(^abcdef$)u
```

- Valid UTF-8 needed in pattern and subject

Unicode

- UTF-8 Encoding
    - Bytes for all ASCII codes (0-127) identical
    - 2-4 Bytes used for further characters (Codepoints)
- Codepoints
    - Each Codepoint is considered to be <u>one</u> character

Unicode

Русский

Unicode

```
(\x{0420})u
```

Русский

Unicode

```
(\x{0420})u
```

Русский

↑

- `\x` Specify certain Unicode codepoints

Unicode

```
([\x{0400}-\x{A697}]+)u
```

Русский

- `\x` Specify certain Unicode codepoints
- Works within character classes

Unicode

```
(\p{Cyrillic}+)u
```

Русский

- \x Specify certain Unicode codepoints
- Works within character classes
- Predefined unicode character classes exist

Unicode

```
(\p{Cyrillic}+)u
```

Русский 한국어

- `\x` Specify certain Unicode codepoints
- Works within character classes
- Predefined unicode character classes exist

Unicode

```
(\p{L}+)u
```

Русский 한국어

- `\x` Specify certain Unicode codepoints
- Works within character classes
- Predefined unicode character classes exist

Performance

Performance

- The PCRE engines utilizes backtracking

Performance

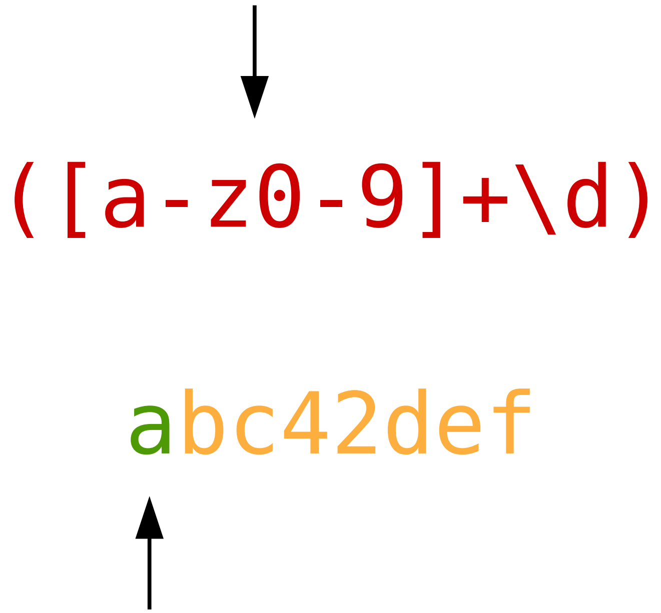
- The PCRE engines utilizes backtracking

```
([a-z0-9]+\d)
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking



```
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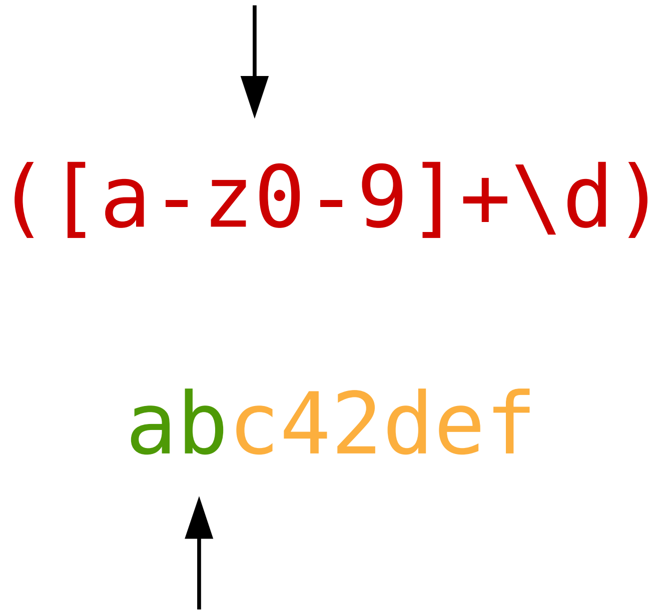
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking

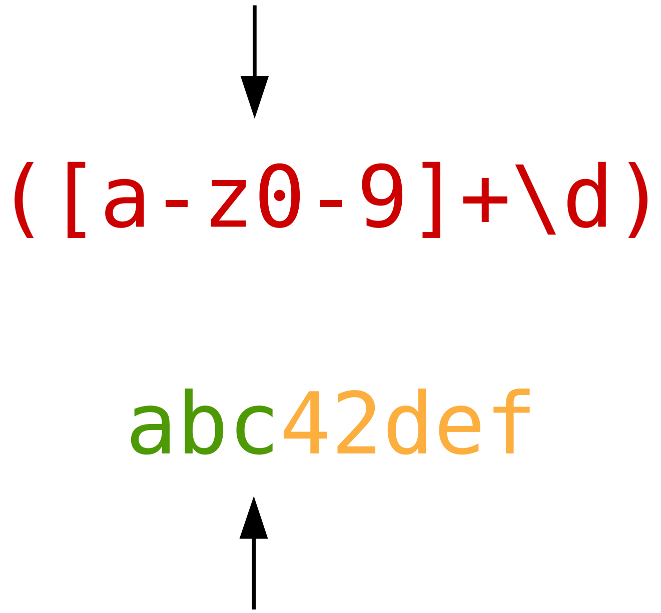


```
([a-z0-9]+\d)

abc42def
```

Performance

- The PCRE engines utilizes backtracking

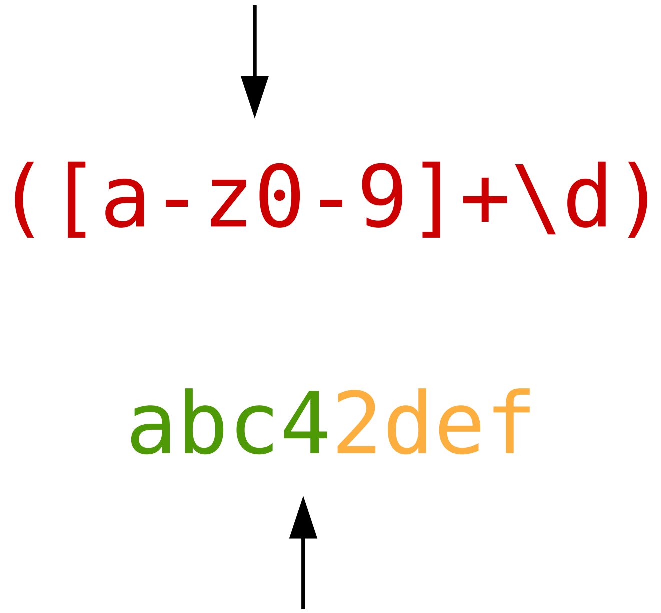


```
([a-z0-9]+\d)
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking

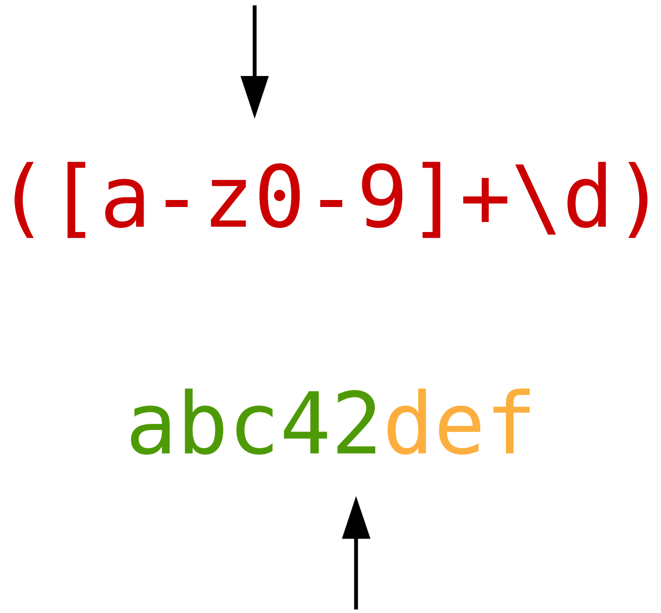


`([a-z0-9]+\d)`

`abc42def`

Performance

- The PCRE engines utilizes backtracking

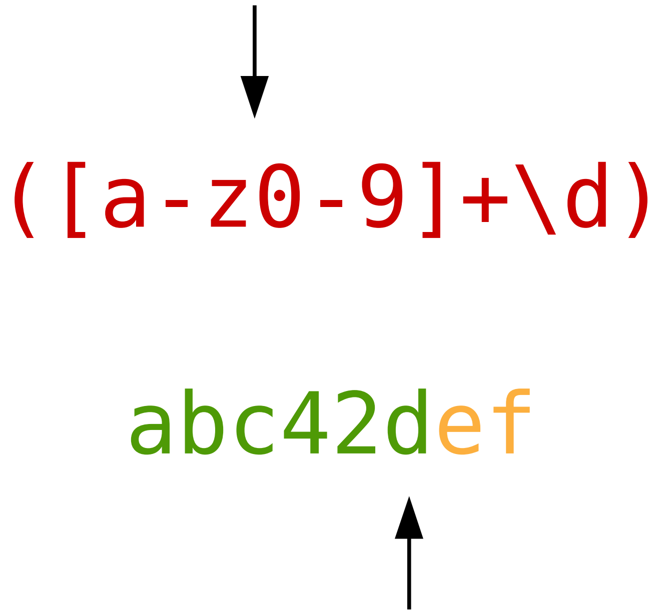


```
([a-z0-9]+\d)
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking

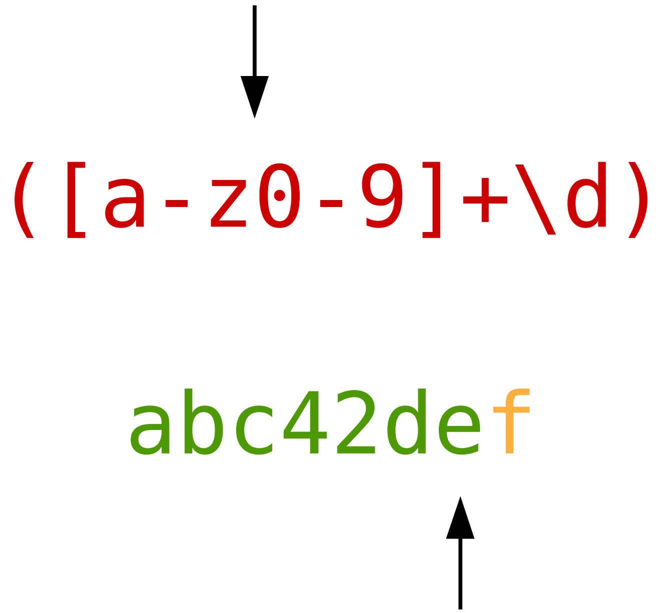


```
([a-z0-9]+\d)
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking



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([a-z0-9]+\d)

abc42def
```

Performance

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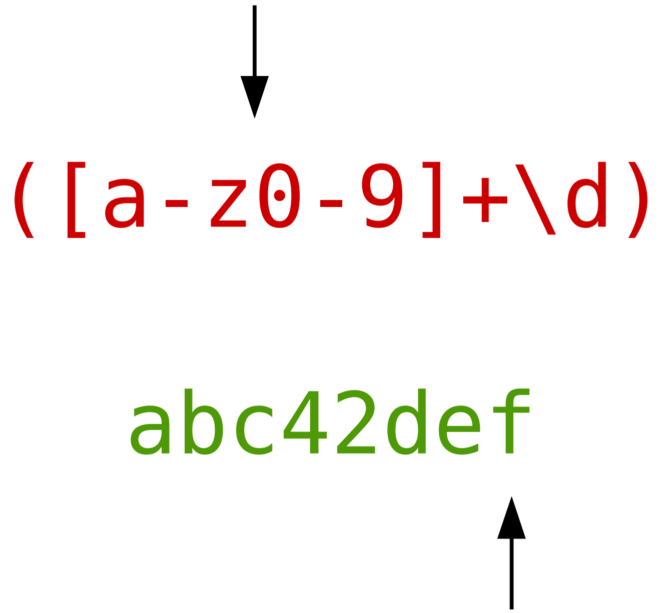

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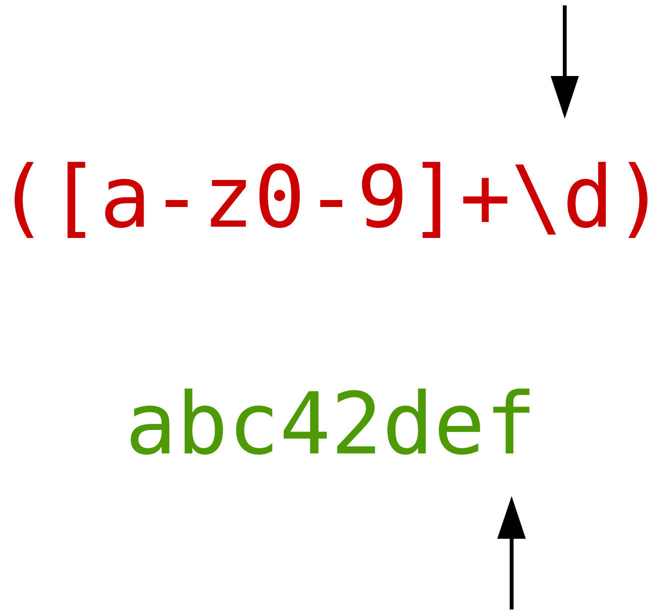
abc42def
```

Performance

- The PCRE engines utilizes backtracking

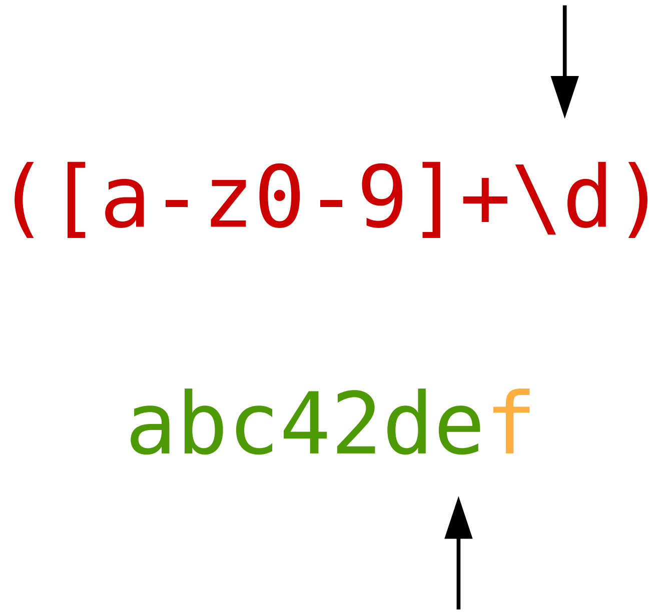


```
([a-z0-9]+\d)
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking

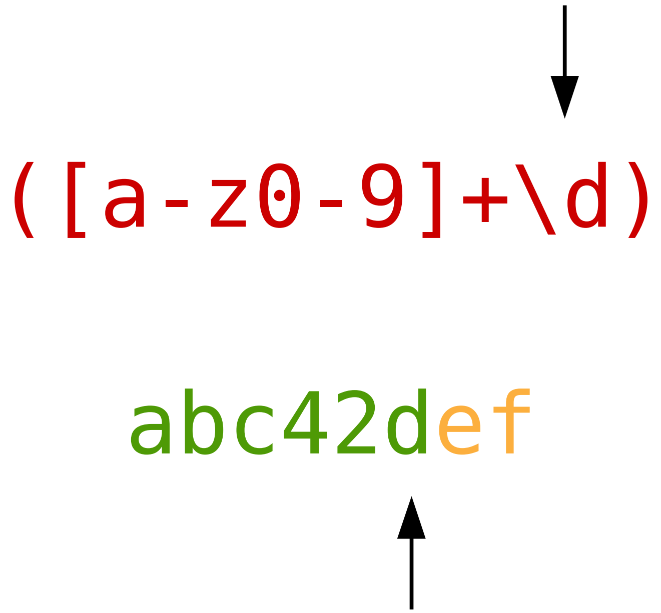


```
([a-z0-9]+\d)

abc42def
```

Performance

- The PCRE engines utilizes backtracking

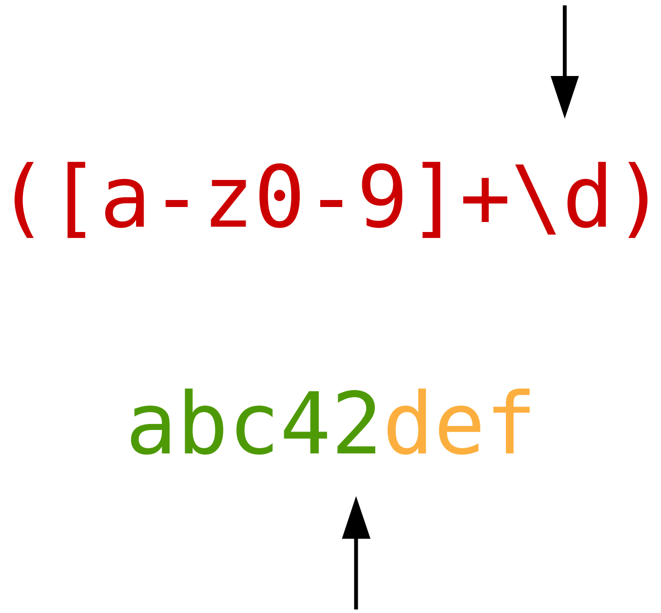


```
([a-z0-9]+\d)
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking



```
([a-z0-9]+\d)
```

```
abc42def
```

Performance

- The PCRE engines utilizes backtracking

```
([a-z0-9]+\d)
```

```
abc42def          ✓
```

Performance

```
([a-z0-9]+\d)
```

- Because of non disjunct character sets this match is quite slow

Performance

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([a-z0-9]+\d)
```

- Because of non disjunct character sets this match is quite slow

Can it be optimized?

Greediness

- Usually the PCRE engine is greedy

- It tries to consume as much characters as possible to create a match

Greediness

- Advise the engine to be ungreedy
  - Modifier U

```
([a-z0-9]+\d)U
```

Greediness

- Advise the engine to be ungreedy
  - Modifier U

```
([a-z0-9]+\d)U
```

  - Question mark (?) after a quantifier

```
([a-z0-9]+?\d)
```

Greediness

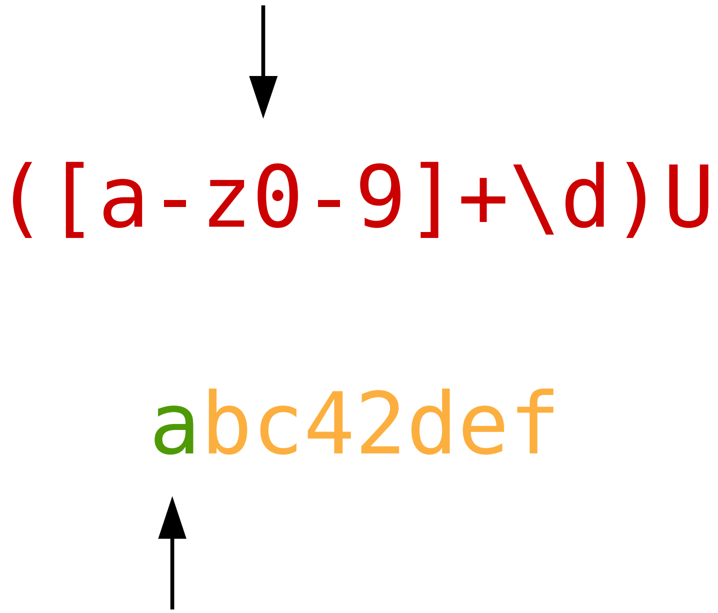
- Impact on the previous example

```
([a-z0-9]+\d)U
```

```
abc42def
```

Greediness

- Impact on the previous example

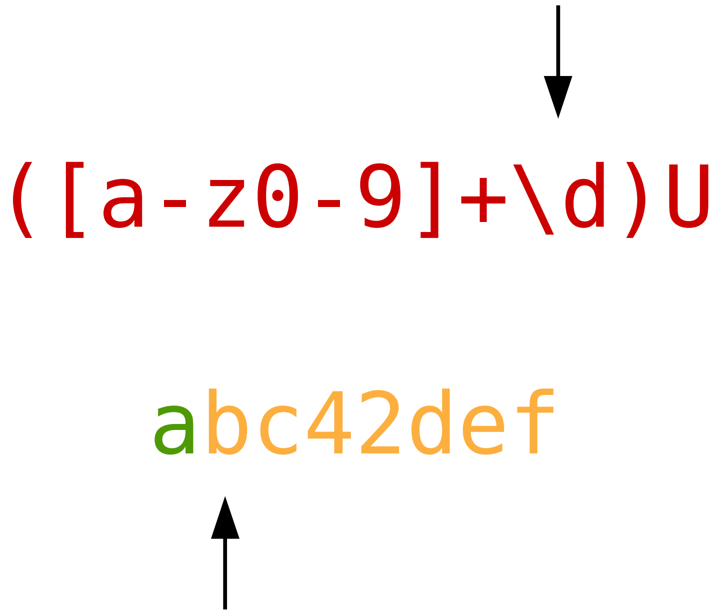


```
([a-z0-9]+\d)U

abc42def
```

Greediness

- Impact on the previous example



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([a-z0-9]+\d)U

abc42def
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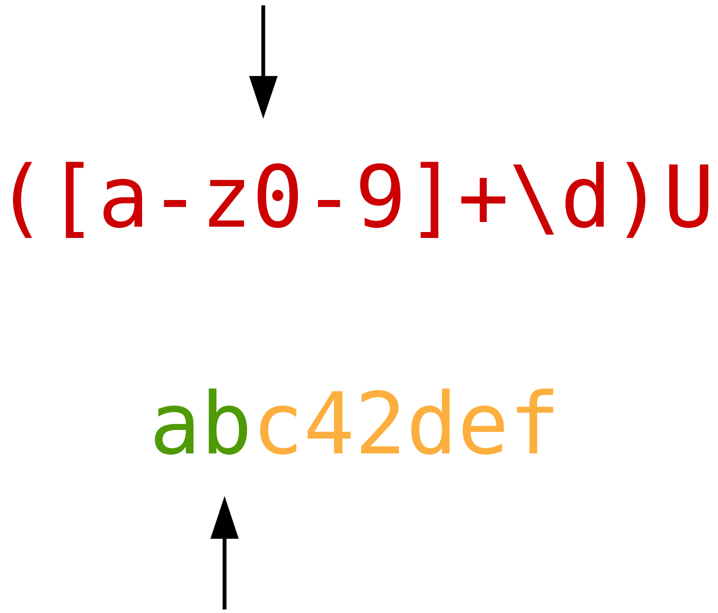
Greediness

- Impact on the previous example

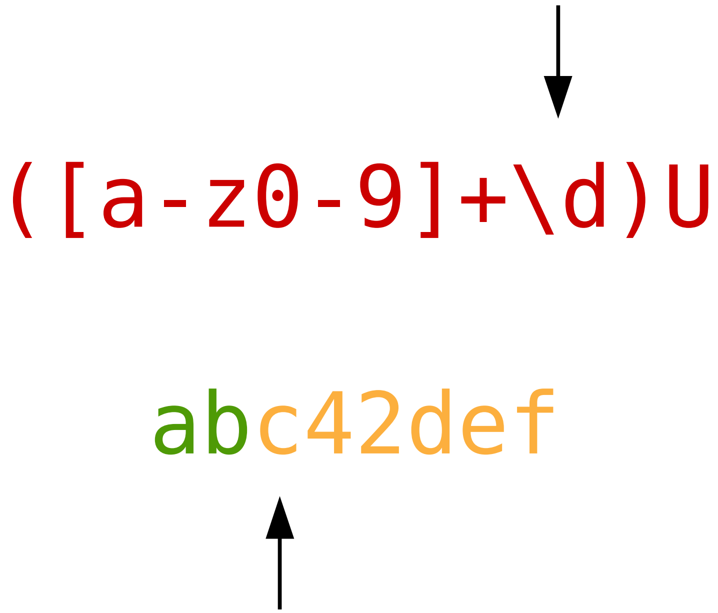


```
([a-z0-9]+\d)U

abc42def
```

Greediness

- Impact on the previous example



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([a-z0-9]+\d)U
```

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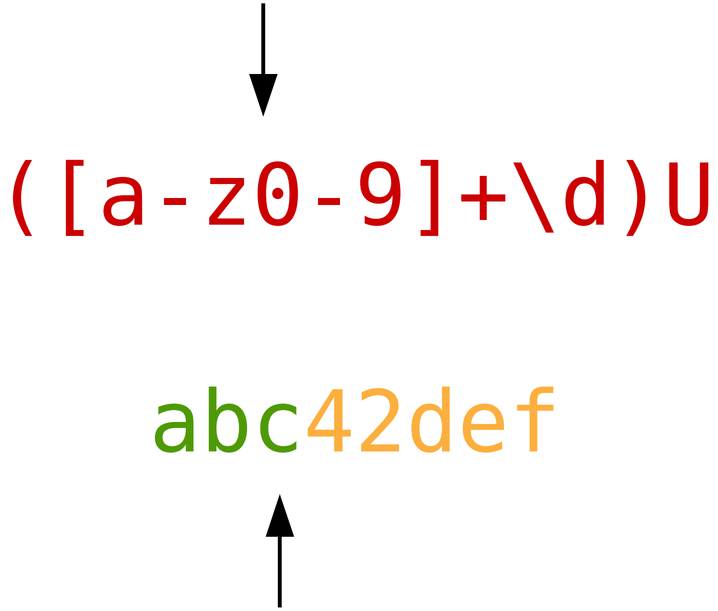
abc42def
```

Greediness

- Impact on the previous example



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([a-z0-9]+\d)U
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```
abc42def
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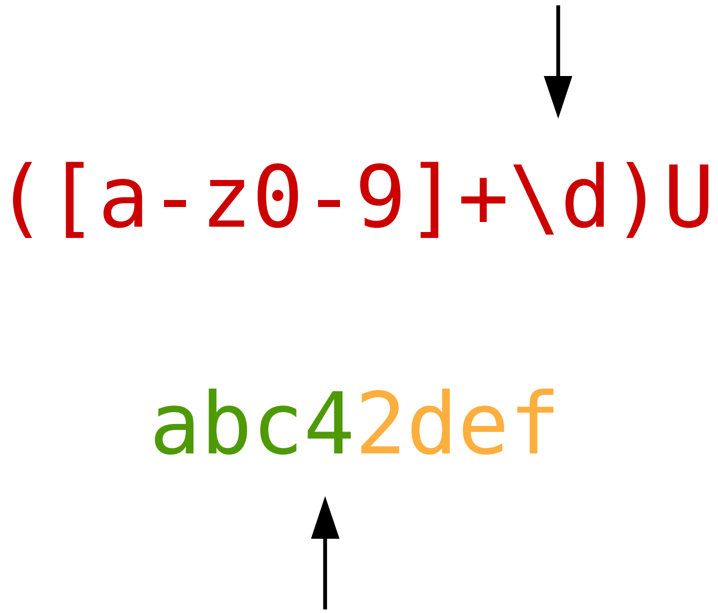
Greediness

- Impact on the previous example



```
([a-z0-9]+\d)U

abc42def
```

Greediness

- Impact on the previous example

```
([a-z0-9]+\d)U

abc42def        ✓
```

Greediness

- Impact on the previous example

```
([a-z0-9]+\d)U
```

```
abc42def        ✓
```

- May produce different results than a greedy match

Greediness

- Ungreedy matching is not always faster than greedy matching
- In most situations it is even slower
- Can produce different matches than greedy matching

Atomic Groups

- Another possibility of controlling backtracking are Atomic Groups

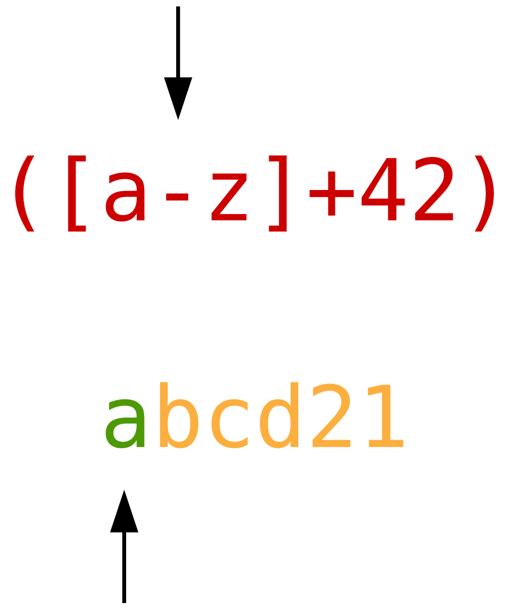
- Explicitly disable backtracking for a certain area of the Regular Expression

Atomic Groups

```
([a-z]+42)
```

```
abcd21
```

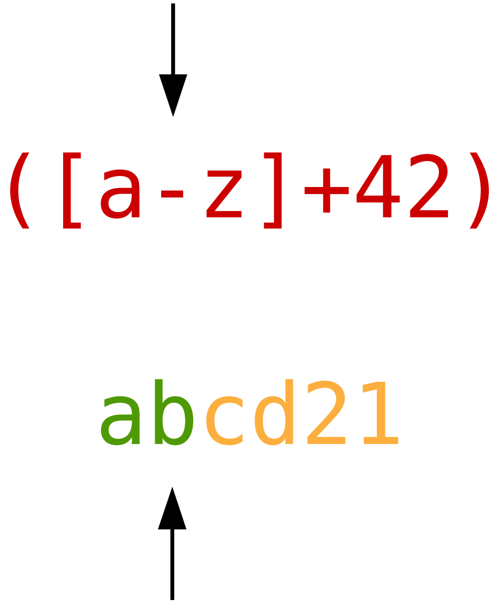
Atomic Groups



```
([a-z]+42)
```

```
abcd21
```

Atomic Groups



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([a-z]+42)
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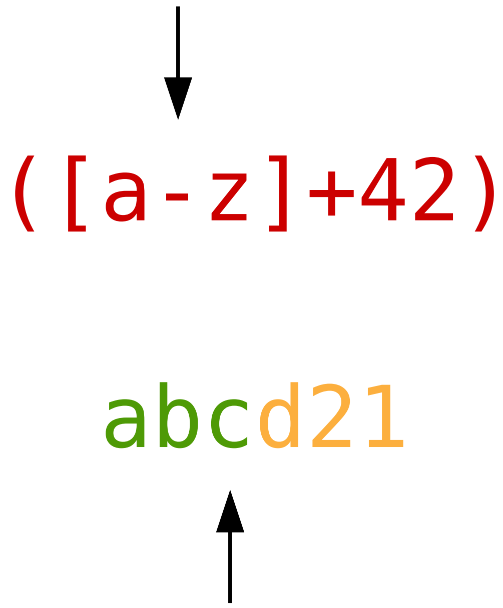
abcd21
```

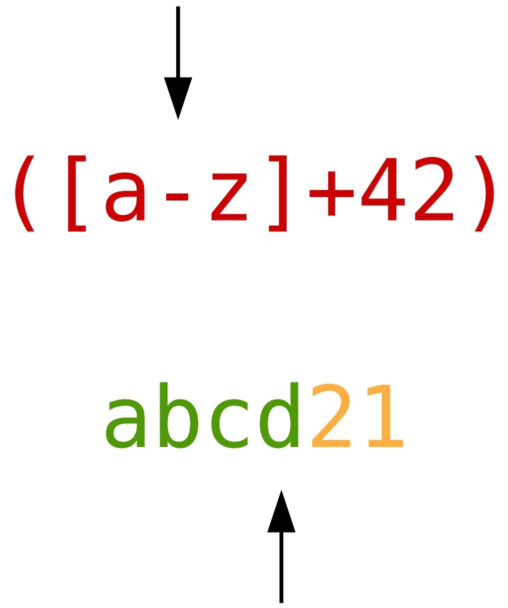
Atomic Groups



```
([a-z]+42)
```

```
abcd21
```

Atomic Groups



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```

```
abcd21
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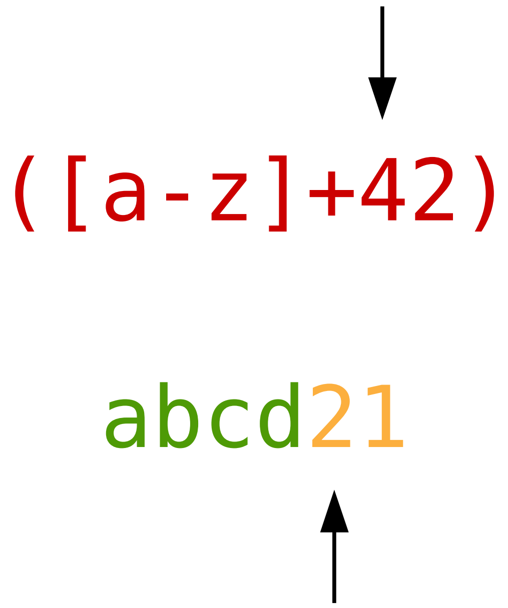
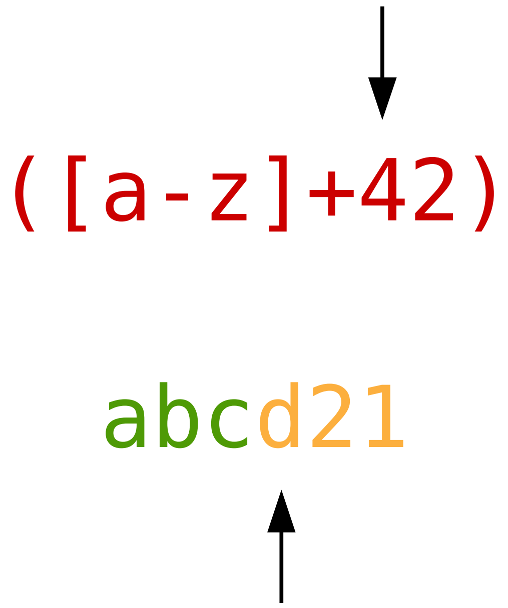
Atomic Groups



```
([a-z]+42)
```

```
abcd21
```

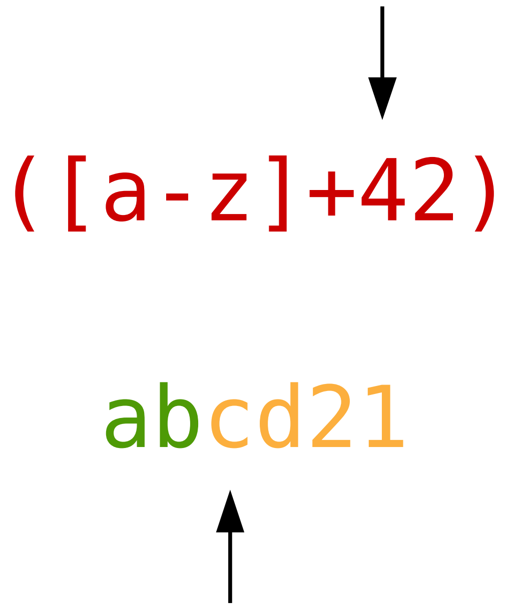
Atomic Groups



`([a-z]+42)`

`abcd21`

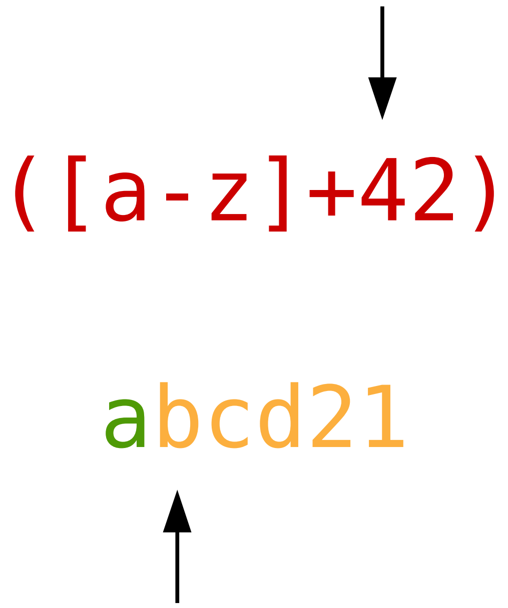
Atomic Groups



```
([a-z]+42)
```

```
abcd21
```

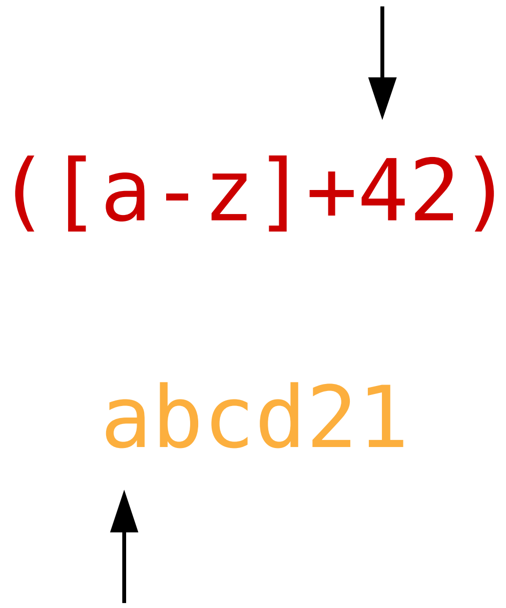
Atomic Groups



```
([a-z]+42)
```

```
abcd21
```

Atomic Groups



`([a-z]+42)`

`abcd21`

Atomic Groups

```
([a-z]+42)
```

```
abcd21
```
✗

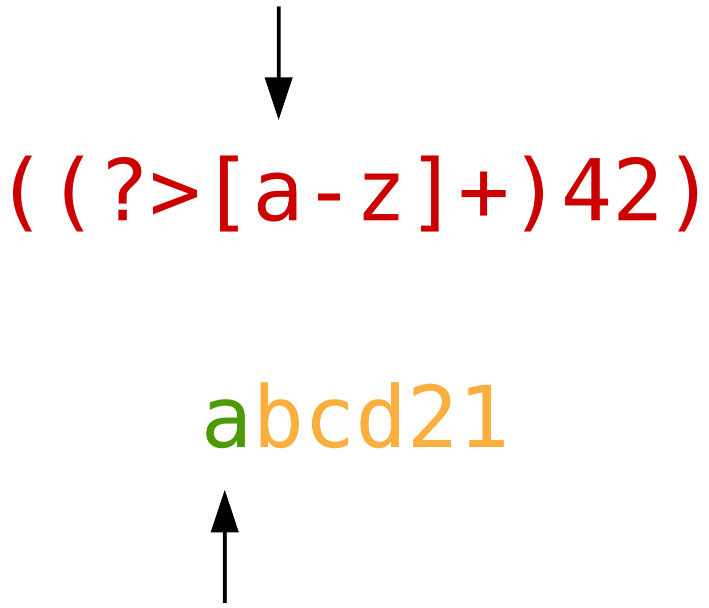
Atomic Groups

```
((?>[a-z]+)42)
```

```
abcd21
```

- Atomic Groups are enabled using a Subpattern option

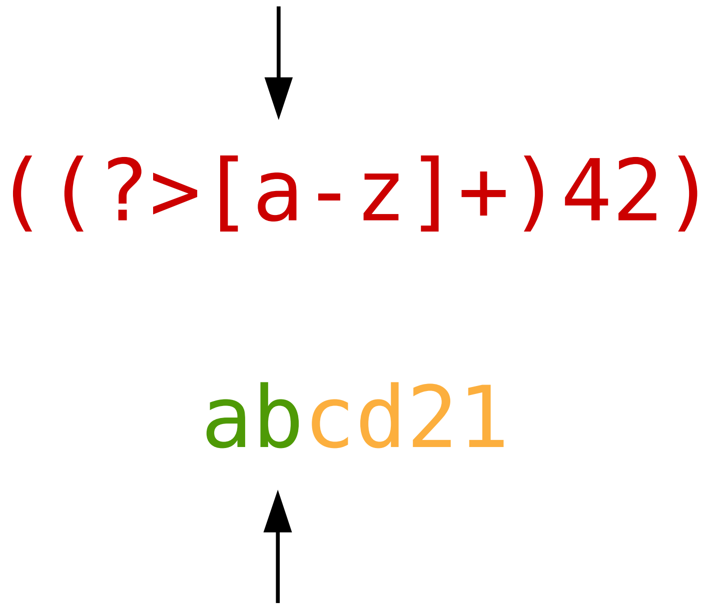
Atomic Groups



```
((?>[a-z]+)42)
```

abcd21

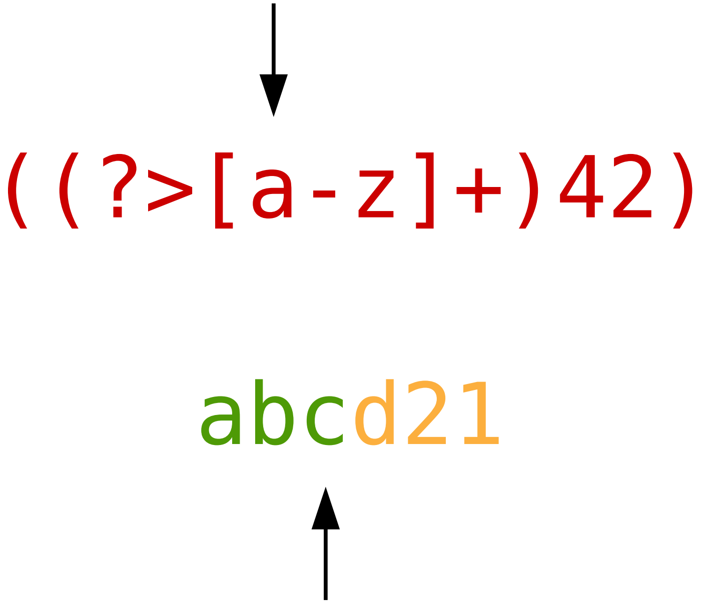
Atomic Groups



((?>[a-z]+)42)

abcd21

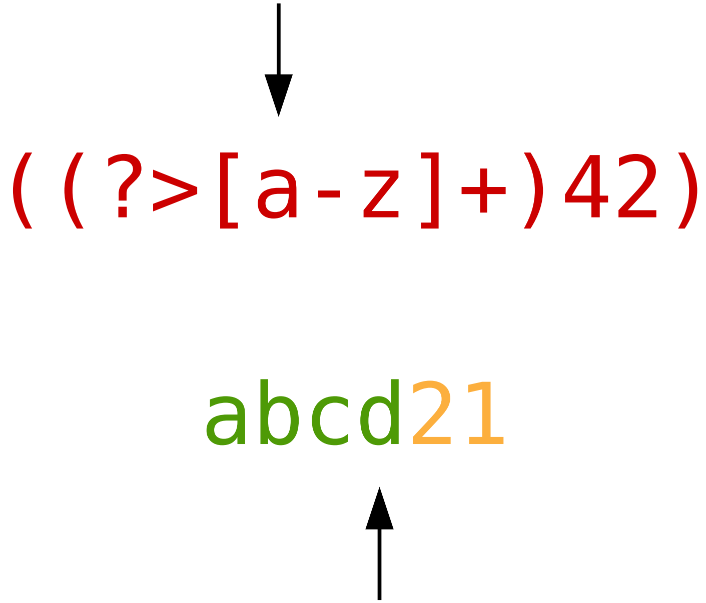
Atomic Groups



```
((?>[a-z]+)42)
```

```
abcd21
```

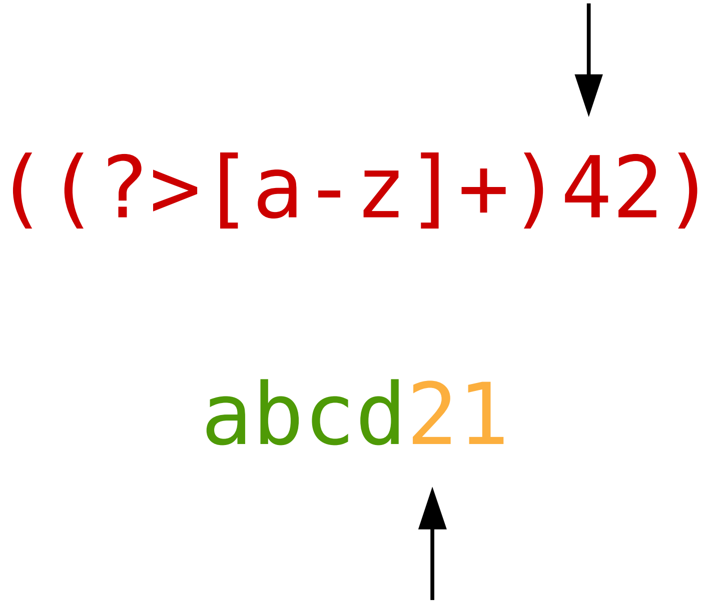
Atomic Groups



```
((?>[a-z]+)42)
```

```
abcd21
```

Atomic Groups



```
((?>[a-z]+)42)
```

```
abcd21
```

Atomic Groups

```
((?>[a-z]+)42)
```

```
abcd21    ✗
```

- No backtracking allowed for this subpattern, therefore immediate abort

Atomic Groups

- Backtracking may be prohibited on a per quantifier basis as well
  - + Possessive Quantifier

```
([a-z]++42)
```

Performance

- PCRE has a default limit of backtracking steps to use

- Can be configured while compiling the library (Default: 1,000,000)

- Can be configured in certain runtime environments

Thanks for your attention.

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Twitter: @jakobwesthoff

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passion for software quality