Python for scientific research

Pattern matching and text manipulation

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1 multiline = """This is a
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3 multiline2 = '''Another
4 multiline string'''
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String literals

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- UTF-8 and ASCII are encodings which specify how characters translate into 0s and 1s

Example encoding: ASCII

USASCII code chart

b_7 b_6 b_5 → / Bits ↓	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_4 b_3 b_2 b_1 / Row ↓ Column →	0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SUB	*	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	k	{
1 1 0 0	12	FF	FS	,	<	L	\	l	|
1 1 0 1	13	CR	GS	-	=	M	]	m	}
1 1 1 0	14	SO	RS	.	>	N	^	n	~
1 1 1 1	15	SI	US	/	?	O	_	o	DEL

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- Here, `\xc3` and `\xb3` are escape sequences that together encode ç as a hex number (see UTF-8 tool)
- The original UTF-8 string can be recovered from `bytes.decode()`

```
1 back_2_utf8 = str_ascii.decode('utf-8') # back to UTF-8
2 # "Let's go to Gijón!"
```

Escaping the escape sequences

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2 # C:\new_file.csv
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- or by using a raw string literal (prefix: `r"..."`)

```
1 windows_path = r"C:\new_file.csv"
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str_subject = "Great rockpools at Swanpool beach"
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str_subject.rfind("pool") # 23
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  - Lots of other `str.isX()` functions available. As we see later, however, regular expressions often preferable to search for patterns in text

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3 for i in range(len(s)):
4
5     if i + 10 <= len(s):
6         if s[i:i+2].isdigit() and s[i+2] in ".-" and s[
              i+3:i+5].isdigit() and s[i+5] in ".-" and s[
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7              day = s[i:i+2]
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10             print(year + "-" + month + "-" + day)
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- Gets complicated quickly
- Breaks down for single digit months/days, e.g., `8.9.1980`

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7 # regular expression (given as a r"" [raw literal] string)
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       [-.](\d{4})", string=s)
9
10 # print the result
11 for date in all_dates:
12     print(date[2] + "-" + date[1].zfill(2) + "-" + date[0].
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5 print(re.findall(pattern=regex, string=str_to_match)) #
      ['1foo','2foo']
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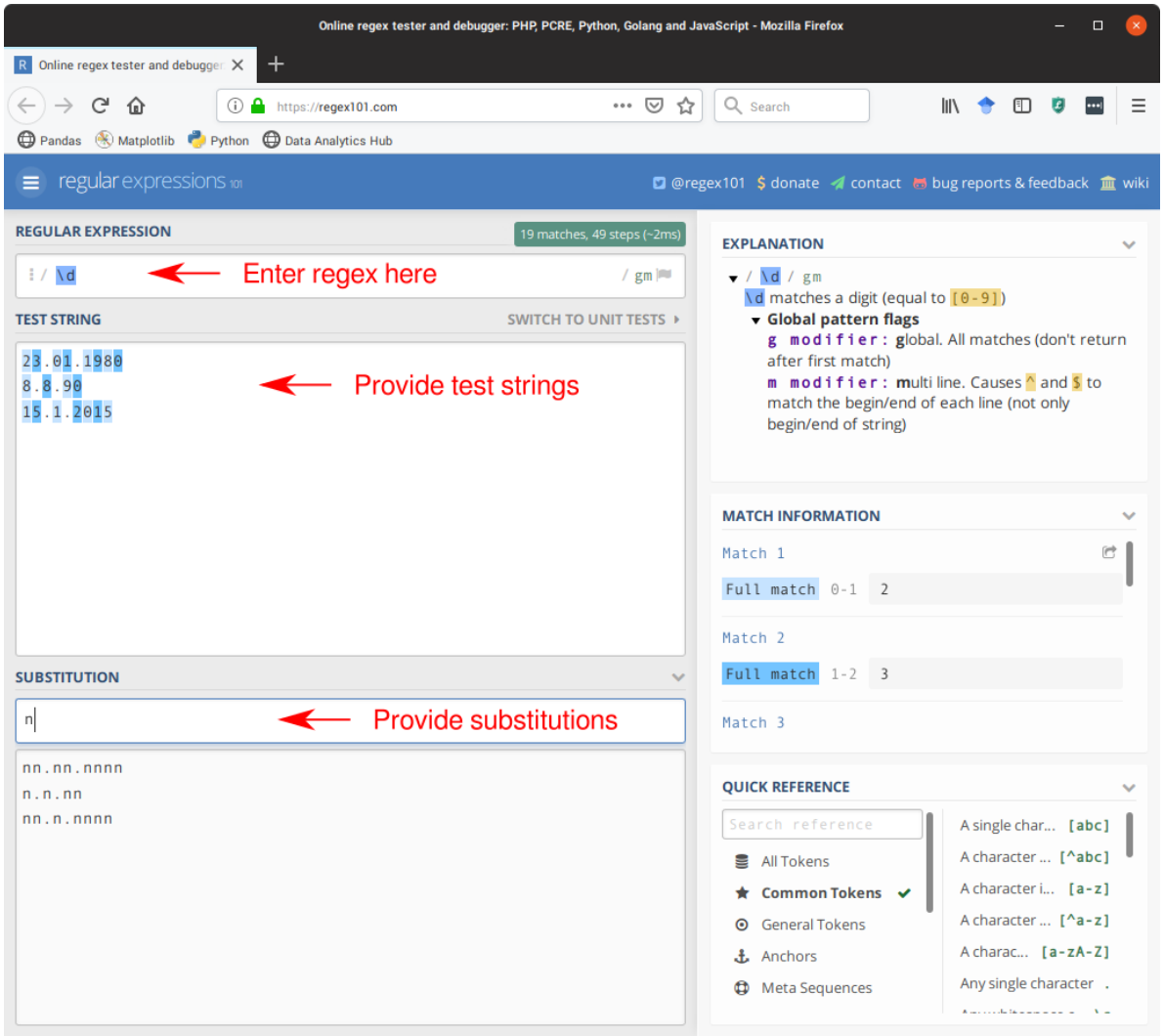
Testing regular expressions

- Practice regular expressions at `https://regex101.com/`



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5 m.start() # Match position in string: 37
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```
1 str_to_match = "Factor levels are snafoo, foosna and
      foo"
2 regex = r"\bfoo\b" # regex
3 m = re.search(pattern=regex, string=str_to_match) #
      Factor levels are snafoo, foosna and bar
4 m.group(0) # obtain the complete match
5 m.start() # Match position in string: 37
```

- `\B` does not match a word boundary

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)

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```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
- ^ matches the start of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(pattern=regex, string=str1)
4 m.start() # match position in string: 0
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
- ^ matches the start of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(pattern=regex, string=str1)
4 m.start() # match position in string: 0
```

- $ matches end of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"foo$" # regex matching the last foo
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
- ^ matches the start of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(pattern=regex, string=str1)
4 m.start() # match position in string: 0
```

- $ matches end of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"foo$" # regex matching the last foo
3 m = re.search(pattern=regex, string=str1)
4 m.start() # match position in string: 14
```

Regular expressions: syntax II

The syntax for different patterns:

- . matches any character (except a newline)
- ^ matches the start of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"^foo" # regex matching the first foo
3 m = re.search(pattern=regex, string=str1)
4 m.start() # match position in string: 0
```

- $ matches end of a string

```
1 str1 = "foo snafoo funfoo"
2 regex = r"foo$" # regex matching the last foo
3 m = re.search(pattern=regex, string=str1)
4 m.start() # match position in string: 14
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
1 str1 = "the number 60 is larger than 59"
2 regex = r"[0-5][0-9]" # matches 00 to 59
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
str1 = "the number 60 is larger than 59"
regex = r"[0-5][0-9]" # matches 00 to 59
m = re.search(pattern=regex, string=str1)
m.group(0) # '59'
```

- `[^...]` matches characters not in the range

```
seq1 = "cccgggtaacccg"
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
str1 = "the number 60 is larger than 59"
regex = r"[0-5][0-9]" # matches 00 to 59
m = re.search(pattern=regex, string=str1)
m.group(0) # '59'
```

- `[^...]` matches characters not in the range

```
seq1 = "cccgggtaacccg"
regex = r"[^cg]" # do not match c or g
```

Regular expressions: syntax III

The syntax for different patterns:

- `[...]` matches a range of characters

```
str1 = "the number 60 is larger than 59"
regex = r"[0-5][0-9]" # matches 00 to 59
m = re.search(pattern=regex, string=str1)
m.group(0) # '59'
```

- `[^...]` matches characters not in the range

```
seq1 = "cccgggtaacccg"
regex = r"[^cg]" # do not match c or g
m = re.search(pattern=regex, string=seq1)
m.group(0)  # 't', first match when using re.search()
```

Regular expressions: repetitions

Specify number of times patterns are matched

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- $*$ matches preceding regex 0 or more times

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```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
```

Regular expressions: repetitions

Specify number of times patterns are matched

- $*$ matches preceding regex 0 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['', '', '',
      '', '', '', '', '', '60', '', '500', '', '', '', '',
       '', '3000', '']
```

Regular expressions: repetitions

Specify number of times patterns are matched

- $*$ matches preceding regex 0 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['', '', '',
      '', '', '', '', '', '60', '', '500', '', '', '', '',
       '', '3000', '']
```

- $+$ matches preceding regex 1 or more times

Regular expressions: repetitions

Specify number of times patterns are matched

- * matches preceding regex 0 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['', '', '',
      '', '', '', '', '', '60', '', '500', '', '', '', '',
       '', '3000', '']
```

- + matches preceding regex 1 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d+" # matches 1 or more occurrences of
      numbers
```

Regular expressions: repetitions

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```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['', '', '',
      '', '', '', '', '', '60', '', '500', '', '', '', '',
       '', '3000', '']
```

- $+$ matches preceding regex 1 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d+" # matches 1 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['60', '500',
       '3000']
```

Regular expressions: repetitions

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```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['', '', '',
      '', '', '', '', '', '60', '', '500', '', '', '', '',
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1 str1 = "numbers 60, 500 and 3000"
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      numbers
3 re.findall(pattern=regex, string=str1) #  ['60', '500',
       '3000']
```

- ? matches preceding regex 0 or 1 times

Regular expressions: repetitions

Specify number of times patterns are matched

- * matches preceding regex 0 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['', '', '',
      '', '', '', '', '', '60', '', '500', '', '', '', '',
       '', '3000', '']
```

- + matches preceding regex 1 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d+" # matches 1 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['60', '500',
       '3000']
```

- ? matches preceding regex 0 or 1 times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d?" # matches 0 or 1 occurrences of numbers
```

Regular expressions: repetitions

Specify number of times patterns are matched

- * matches preceding regex 0 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d*" # matches 0 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['', '', '',
      '', '', '', '', '', '60', '', '500', '', '', '', '',
       '', '3000', '']
```

- + matches preceding regex 1 or more times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d+" # matches 1 or more occurrences of
      numbers
3 re.findall(pattern=regex, string=str1) #  ['60', '500',
       '3000']
```

- ? matches preceding regex 0 or 1 times

```
1 str1 = "numbers 60, 500 and 3000"
2 regex = r"\d?" # matches 0 or 1 occurrences of numbers
3 re.findall(pattern=regex, string=str1) # ['', '', '',
      '', '', '', '', '', '6', '0', '', '', '5', '0', '0',
       '', '', '', '', '', '3', '0', '0', '0', '']
```

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

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- `{n}` match preceding regex exactly n times

Regular expressions: repetitions continued

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Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
```

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(pattern=regex, string=str1) # ['60', '500',
      '3000', '5000']
```

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(pattern=regex, string=str1) # ['60', '500',
      '3000', '5000']
```

- `*?`, `+?`, `??`, `{m,n}?` minimize the number of times a pattern matches

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1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(pattern=regex, string=str1) # ['60', '500',
      '3000', '5000']
```

- `*?`, `+?`, `??`, `{m,n}?` minimize the number of times a pattern matches

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1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}?" # matches numbers of 2 to 4 digits,
      favoring minimal numbers
```

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3 re.findall(pattern=regex, string=str1) # ['60', '500',
      '3000', '5000']
```

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```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}?" # matches numbers of 2 to 4 digits,
      favoring minimal numbers
3 re.findall(pattern=regex, string=str1) # ['60', '50',
      '30', '00', '50', '00']
```

Regular expressions: repetitions continued

Specify number of times patterns are matched (continued)

- `{n}` match preceding regex exactly n times
- `{n,m}` match preceding regex minimally n and maximally m times

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}" # matches numbers of 2 to 4 digits
3 re.findall(pattern=regex, string=str1) # ['60', '500',
      '3000', '5000']
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- `*?`, `+?`, `??`, `{m,n}?` minimize the number of times a pattern matches

```
1 str1 = "numbers 5, 60, 500, 3000, 50000"
2 regex = r"\d{2,4}?" # matches numbers of 2 to 4 digits,
      favoring minimal numbers
3 re.findall(pattern=regex, string=str1) # ['60', '50',
      '30', '00', '50', '00']
```

Regular expressions: functions

- `re.compile()` compiles a regular expression before applying it. Speeds things up when same regex is used a lot of times

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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
```

Regular expressions: functions

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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 regex = r"\dfoo" # regex
```

Regular expressions: functions

- `re.compile()` compiles a regular expression before applying it. Speeds things up when same regex is used a lot of times
- `re.findall()` matches all occurrences of a pattern
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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 regex = r"\dfoo" # regex
4 m = re.search(pattern=regex, string=str_to_match) #
      returns a Match object
```

Regular expressions: functions

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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 regex = r"\dfoo" # regex
4 m = re.search(pattern=regex, string=str_to_match) #
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5
6 m.group(0) # '1foo'
7
8 regex = r"\dbar" # another regex which does not match
```

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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 regex = r"\dfoo" # regex
4 m = re.search(pattern=regex, string=str_to_match) #
      returns a Match object
5
6 m.group(0) # '1foo'
7
8 regex = r"\dbar" # another regex which does not match
9 re.search(pattern=regex, string=str_to_match) # None
```

Regular expressions: functions II

- `re.sub()` replaces occurrences of patterns in a string

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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
```

Regular expressions: functions II

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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 # and remembers the digit using a group ()
4 regex = r"(\d)foo" # regex
```

Regular expressions: functions II

- `re.sub()` replaces occurrences of patterns in a string

```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 # and remembers the digit using a group ()
4 regex = r"(\d)foo" # regex
5 # replace foo by bar but keep the digit
6 replacement = r"\1bar" # regex
```

Regular expressions: functions II

- `re.sub()` replaces occurrences of patterns in a string

```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 # and remembers the digit using a group ()
4 regex = r"(\d)foo" # regex
5 # replace foo by bar but keep the digit
6 replacement = r"\1bar" # regex
7 re.sub(pattern=regex, repl=replacement, string=
      str_to_match) # Factor levels are 1bar, 2bar and foo
```

Regular expressions: functions II

- `re.sub()` replaces occurrences of patterns in a string

```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 # and remembers the digit using a group ()
4 regex = r"(\d)foo" # regex
5 # replace foo by bar but keep the digit
6 replacement = r"\1bar" # regex
7 re.sub(pattern=regex, repl=replacement, string=
      str_to_match) # Factor levels are 1bar, 2bar and foo
```

- Everything within `()` (a group) is stored in memory

Regular expressions: functions II

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```
1 str_to_match = "Factor levels are 1foo, 2foo and foo"
2 # pattern that matches '1foo', '2foo' etc but not 'foo'
3 # and remembers the digit using a group ()
4 regex = r"(\d)foo" # regex
5 # replace foo by bar but keep the digit
6 replacement = r"\1bar" # regex
7 re.sub(pattern=regex, repl=replacement, string=
      str_to_match) # Factor levels are 1bar, 2bar and foo
```

- Everything within `()` (a group) is stored in memory
- Group contents can be recalled in the replacement, using `\1`,`\2`,`\3`, etc

Regex exercise

- Use https://regex101.com/ to write dates in `"23.01.1980,29-03-2019"` as `"1980-01-23,2019-03-29"`

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Regex exercise

- Use https://regex101.com/ to write dates in "23.01.1980,29-03-2019" as "1980-01-23,2019-03-29"
- Then try to do it in Python
- In Python, that is:

```
1 two_dates = "23.01.1980,29-03-2019"
2 date_regex = r"(\d{1,2})[.-](\d{1,2})[.-](\d{4})"
3 date_substitution = r"\3-\2-\1"
4 re.sub(pattern=date_regex, repl=date_substitution,
      string=two_dates)
5 # 23-01-1980,29-3-2019
```

Another regex exercise

- Use https://regex101.com/ to match the words 'pit', 'spot', 'spate', but not 'pt', 'Pot', 'peat', 'part'

Another regex exercise

- Use https://regex101.com/ to match the words 'pit', 'spot', 'spate', but not 'pt', 'Pot', 'peat', 'part'

```
1    regex = r"s?p(i|o|a)te?"
```