

Fundamentos de Programação

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Summary

- Boolean expressions
 - The bool type
 - Relational operators
 - Logical operators
 - Properties
- Conditional execution
 - If statement
 - If-else
 - If-elif-else
- Conditional expression

Boolean expressions

- A **boolean expression** is an expression that is either true or false.

```
>>> n = 5          # this IS NOT a boolean expression!
>>> n == 5         # this IS a boolean expression!
True
>>> 6 == n         # this is another boolean expression.
False
```

- True and False are special values that belong to the type bool.
- Boolean values may be stored in variables.

```
>>> isEven = n%2==0
```

- May be converted to string.

```
>>> str(isEven)
'False'
```

- Or to integer.

```
>>> int(False)    # 0
>>> int(True)     # 1
```

Null and empty values convert to False:

```
>>> bool(0)        # False
>>> bool(0.0)      # False
>>> bool('')       # False
>>> bool([])       # False
```

Other values convert to True:

```
>>> bool(1)        # True
>>> bool('False')  # True  (surprise!)
>>> bool([False]) # True  (surprise?)
```

Relational and logical operators

- **Relational operators** produce boolean results:

```
x == y      # x is equal to y
x != y      # x is not equal to y
x > y       # x is greater than y
x < y       # x is less than y
x >= y      # x is greater than or equal to y
x <= y      # x is less than or equal to y
x < y < z   # x is less than y and y is less than z (cool!)
```

- There are three **logical operators**: and, or, not.

```
x>=0 and x<10      # x is between 0 and 10 (exclusive)
0<=x and x<10      # same thing
x==0 or not isEven and y/x>1
```

Properties

- Remember these properties:

$x == y$	\Leftrightarrow	$\text{not } (x != y)$	\Leftrightarrow	$y == x$
$x != y$	\Leftrightarrow	$\text{not } (x == y)$	\Leftrightarrow	$y != x$
$x > y$	\Leftrightarrow	$\text{not } (x \leq y)$	\Leftrightarrow	$y < x$
$x \leq y$	\Leftrightarrow	$\text{not } (x > y)$	\Leftrightarrow	$y \geq x$

- And these (where A, B, C are boolean):

$\text{not } (\text{not } A)$	\Leftrightarrow	A
$\text{not } (A \text{ and } B)$	\Leftrightarrow	$(\text{not } A) \text{ or } (\text{not } B)$
$\text{not } (A \text{ or } B)$	\Leftrightarrow	$(\text{not } A) \text{ and } (\text{not } B)$
$A \text{ or } B$	\Leftrightarrow	$B \text{ or } A$
$A \text{ and } B$	\Leftrightarrow	$B \text{ and } A$
$A \text{ or } (B \text{ and } C)$	\Leftrightarrow	$(A \text{ or } B) \text{ and } (A \text{ or } C)$
$A \text{ and } (B \text{ or } C)$	\Leftrightarrow	$(A \text{ and } B) \text{ or } (A \text{ and } C)$

Precedence rules

- Arithmetic > relational > not > and > or.

$x \leq 1 + 2 * y ** 3 \text{ or } n \neq 0 \text{ and not } 1/n \leq y$

$(\underline{x \leq 1 + 2 * y ** 3}) \text{ or } (\underline{n \neq 0 \text{ and not } 1/n \leq y})$

$(x \leq (\underline{1 + 2 * y ** 3})) \text{ or } ((\underline{n \neq 0}) \text{ and } (\underline{\text{not } 1/n \leq y}))$

$(x \leq (1 + (\underline{2 * y ** 3}))) \text{ or } ((n \neq 0) \text{ and } (\text{not } (\underline{1/n \leq y})))$

$(x \leq (1 + (2 * (\underline{y ** 3})))) \text{ or } ((n \neq 0) \text{ and } (\text{not } ((\underline{1/n}) \leq y)))$

Short-circuit evaluation

- Operators `and` and `or` only evaluate the second operand if needed!

`A and B` # if A is false then A, otherwise B

`A or B` # if A is true then A, otherwise B

- This is called **short-circuit evaluation**.
- It can be very useful:

`1/n>2 and n!=0` # `ZeroDivisionError` if `n==0`

`n!=0 and 1/n>2` # False if `n==0`, `1/n` not evaluated

`n==0 or 3/n<4` # True if `n==0`, `3/n` not evaluated

- But notice that the order of the operands is important!

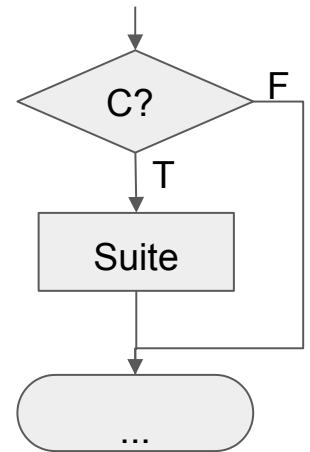
Conditional execution (1)

- **Conditional statements** allow the program to check conditions and change its behavior accordingly.

- The simplest form is the `if` statement:

```
if condition:  
    suite_of_statements  
...
```

- The *condition* should be a boolean expression.
 - (It may be of any type, and is implicitly converted to `bool`, but this is confusing and should be avoided.)
- The *suite of statements* is executed if the condition is true. If not, execution continues after those statements.
- The suite must have one or more *indented* statements.

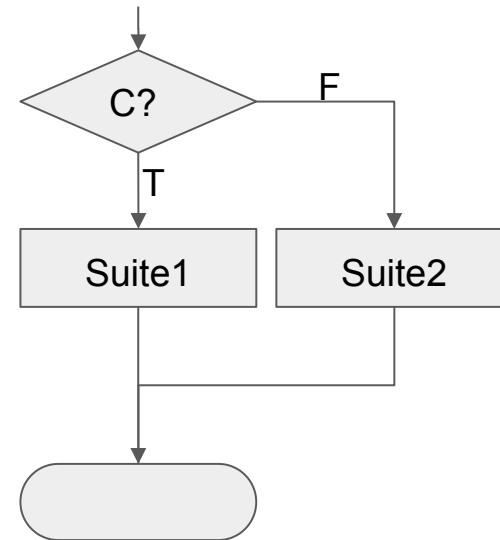


Conditional execution (2)

- A second form of the `if` statement is alternative execution, in which there are two alternative paths and the condition determines which one gets executed.

```
if x%2 == 0:
    print('x is even')
else:
    print('x is odd')

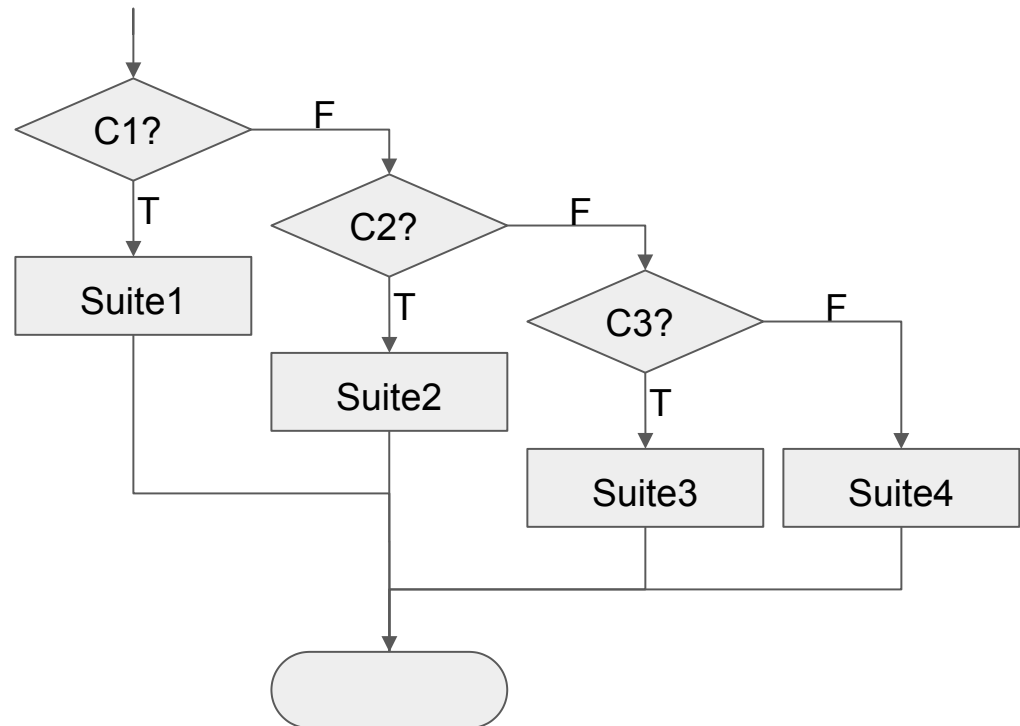
#END
```



Conditional execution (3)

- Sometimes there are more than two alternatives and we need more than two branches (chained conditional).

```
if x < 10:  
    mark = 'Poor'  
elif x < 13:  
    mark = 'Reasonable'  
elif x < 17:  
    mark = 'Good'  
else:  
    mark = 'Excelent'  
  
print(mark)
```



Conditional statement semantics

- Which conditions select each suite of statements?

```
if C1:
    Suite1      ← Suite1 is executed iff C1
elif C2:
    Suite2      ← Suite2 is executed iff  $\neg C1 \wedge C2$ 
elif C3:
    Suite3      ← Suite3 is executed iff  $\neg C1 \wedge \neg C2 \wedge C3$ 
else:
    Suite4      ← Suite4 is executed iff  $\neg C1 \wedge \neg C2 \wedge \neg C3$ 

Rest           ← is always executed
```

Nested conditional statements

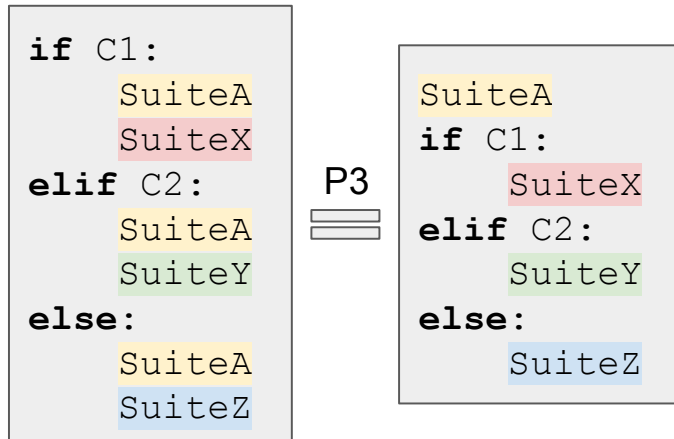
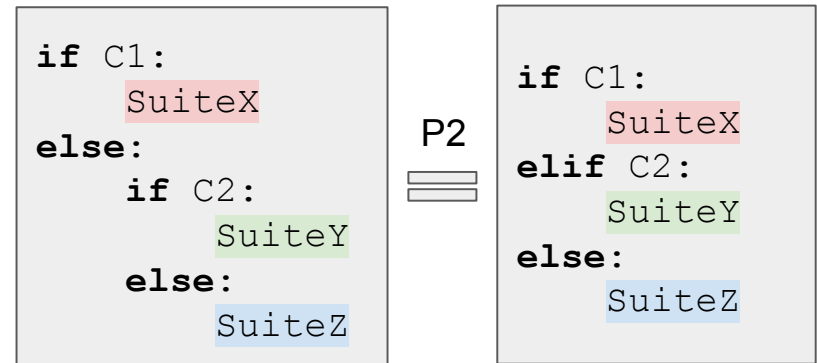
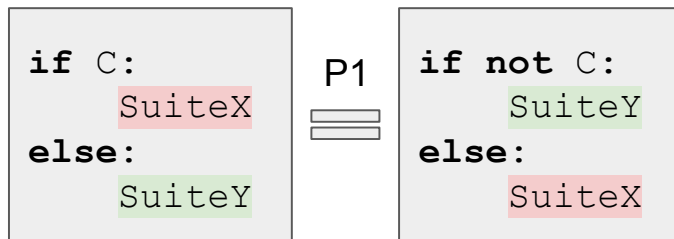
- Conditional statements may be nested within each other.

```
if y > 0:
    if x > 0:
        quadrant = 1
    else:
        quadrant = 2
else:
    if x < 0:
        quadrant = 3
    else:
        quadrant = 4
```

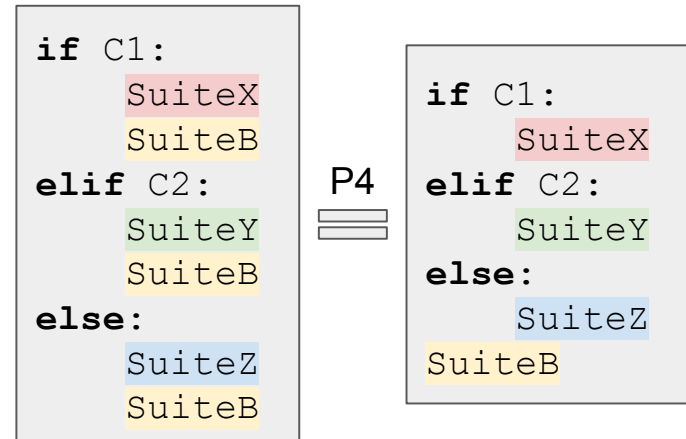
- Although the indentation makes the structure apparent, deeply nested conditionals become difficult to read.
- If possible, apply equivalence properties to simplify nested conditional statements.

Program equivalence properties

For *well-behaved* suites of statements, the following properties apply.



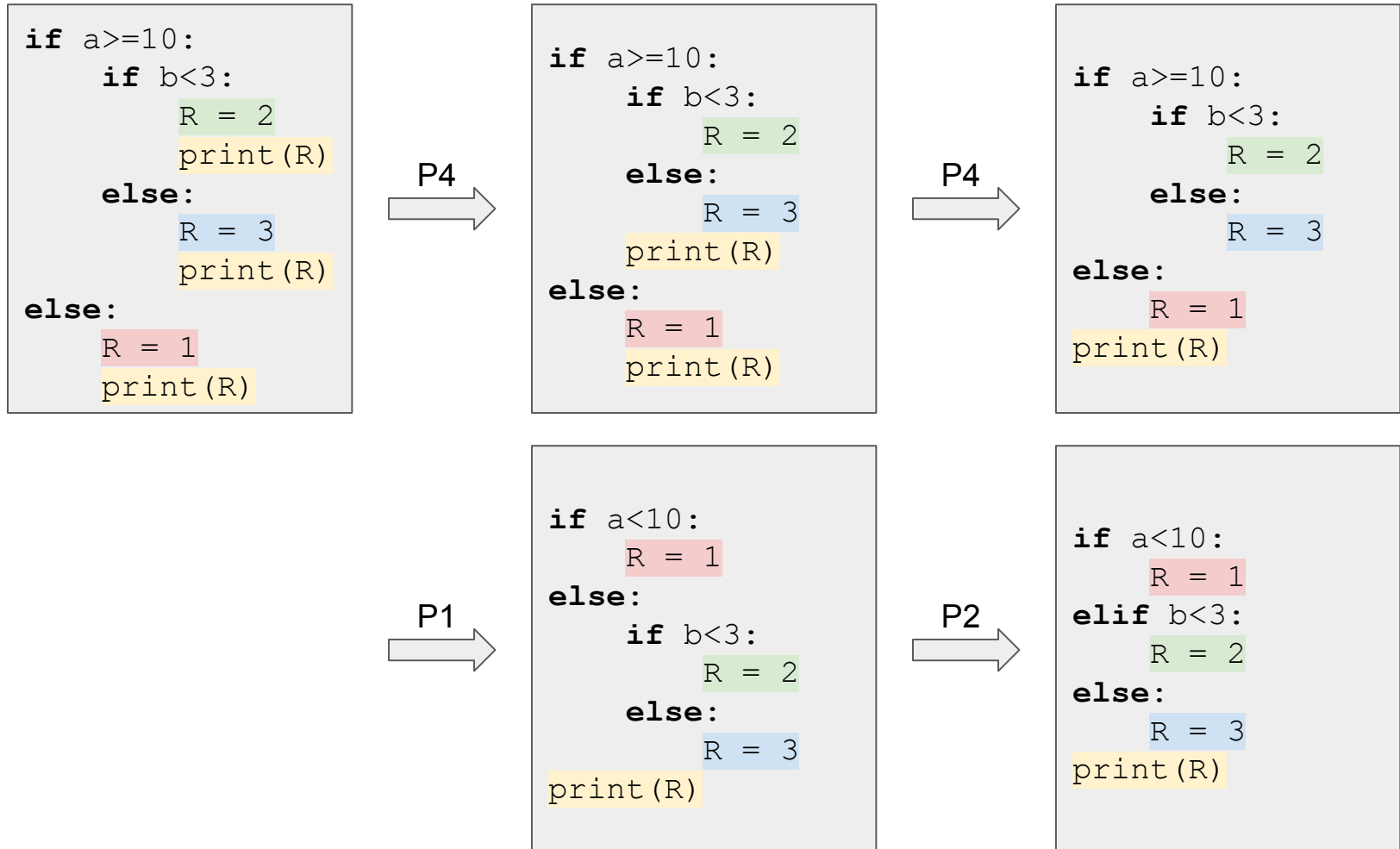
(If C1, C2 have no side effects.)



(If C1, C2 have no side effects.)

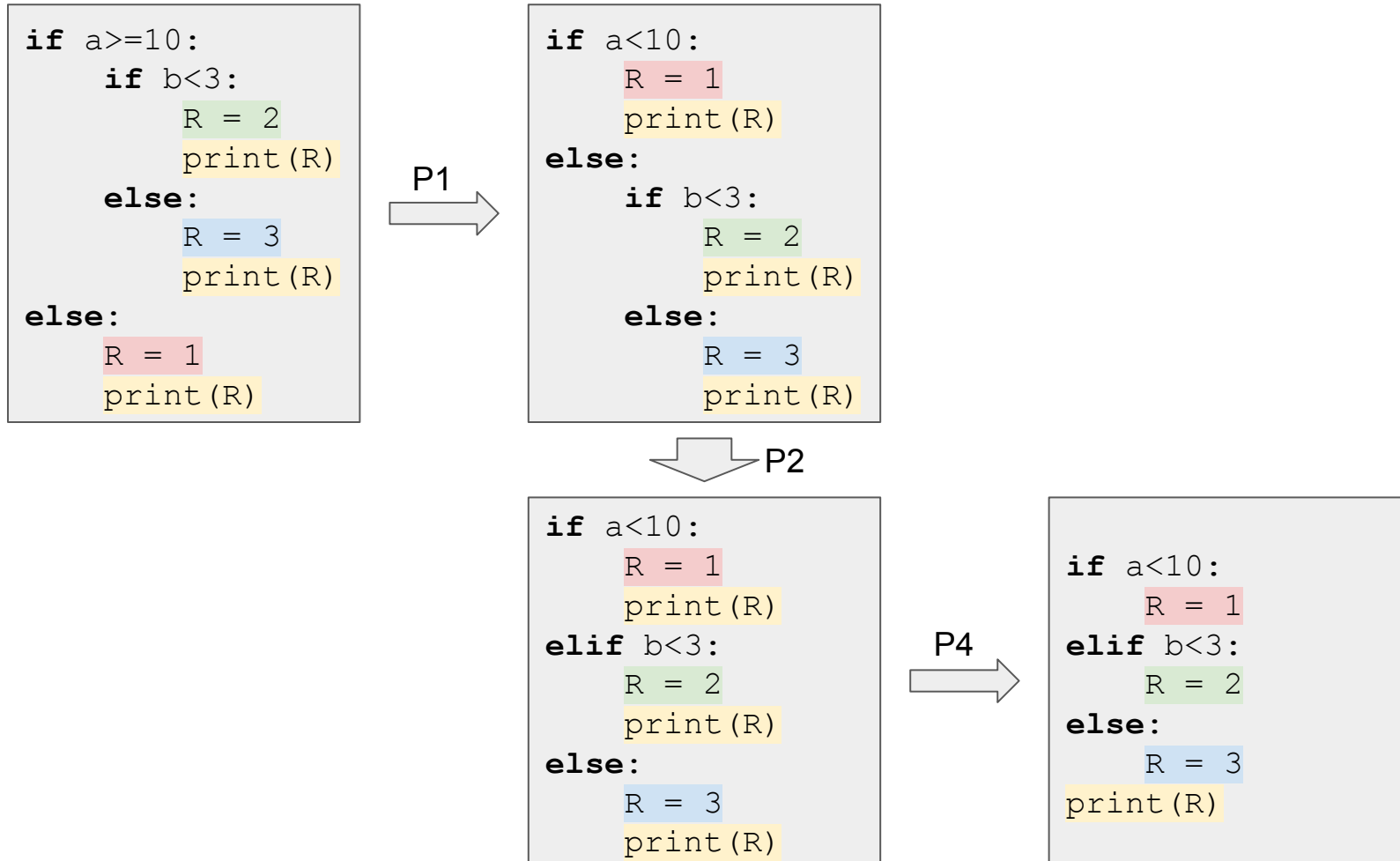
Example: code simplification

- Applying equivalence properties may simplify the code.



Example: code simplification

- Applying equivalence properties may simplify the code.



Conditional expression

- Python also includes a conditional expression, based on a ternary operator:

```
expression1 if condition else expression2
```

- Uses keywords **if** and **else**, but it is an *expression*!
- The condition is evaluated first.
- If true, then expression1 is evaluated and is the result.
- If false, then expression2 is evaluated and is the result.

```
n = int(input("number? "))  
msg = "odd" if n%2!=0 else "even"  
print(n, "is", msg)
```