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Decision Logic

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Lecture Topics

- Boolean Logic and Expressions
  - Relational Operators and Expressions
  - Logical Operators and Expressions
  - Operator Precedence
- If Statements
  - Else Clauses
  - Elif Clauses
- Nested If Statements
- Variable Scope
- String Comparison

Colors/Fonts

- Variable Names – Brown
- Literals – Blue
- Keywords – Orange
- Operators/Punctuation – Black
- Functions – Purple
- Comments – Gray
- Modules – Pink

Source Code – **Consolas**
Output – Courier New

Relational Operators

- == Equal
- != Not Equal
- > Greater Than
- < Less Than
- >= Greater Than or Equal To
- <= Less Than or Equal To

- Can only be used to compare primitive data types.
- Each operator returns a Boolean value: true/false.

Relational Expressions

- A ***relational expression*** is an expression using a relational operator.
  - 1 == 5
  - 7 != 3
  - 16 > 5
  - 56 < 22
  - 10 >= 10
  - 9 <= 5
- A relational expression is a type of ***Boolean expression***.
  - A Boolean expression is one that evaluates to True or False.

Equality Operator ==

- Returns **true** if the operands are the same value.
- Returns **false** if the operands are different values.

```
i = 8
j = 10
result1 = i == j
```

false

```
k = 10
m = 10
result2 = k == m
```

true

Inequality Operator !=

- Returns **true** if the operands are different values.
- Returns **false** if the operands are the same value.

```
i = 8
j = 10
result1 = i != j
```

true

```
k = 10
m = 10
result2 = k != m
```

false

Greater Than Operator >

- Returns **true** if the first operand is larger than the second operand.
- Returns **false** if the first operand is equal to or smaller than the second operand.

```
i = 8
j = 10
k = 10
m = 11
result1 = i > j   false
result2 = j > k   false
result3 = m > i   true
```

Less Than Operator <

- Returns **true** if the first operand is smaller than the second operand.
- Returns **false** if the first operand is equal to or larger than the second operand.

```
i = 8
j = 10
k = 10
m = 11
result1 = i < j   true
result2 = j < k   false
result3 = m < i   false
```

Greater Than or Equal To Operator >=

- Returns **true** if the first operand is equal to or larger than the second operand.
- Returns **false** if the first operand is smaller than the second operand.

```
i = 8
j = 10
k = 10
m = 11
result1 = i >= j   false
result2 = j >= k   true
result3 = m >= i   true
```

Less Than or Equal To Operator <=

- Returns **true** if the first operand is equal to or smaller than the second operand.
- Returns **false** if the first operand is larger than the second operand.

```
i = 8
j = 10
k = 10
m = 11
result1 = i <= j   true
result2 = j <= k   true
result3 = m <= i   false
```

Logical Operators

- A ***logical operator*** connects two or more Boolean expressions or values into one **True** or **False** result.
  - Or, in the case of the logical not operator, reverse the logic of a Boolean expression or value.

`and` **`or`** **`not`**

- All three operators are keywords.
- A ***logical expression*** is an expression using a logical operator.

AND

- Evaluates to true if and only if both Boolean expressions are true.
- AND Truth Table:

B_1	B_2	B_1 and B_2
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

And Operator

```
b1 = False
b2 = False

result = b1 and b2
```

false

B_1	B_2	B_1 and B_2
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

And Operator

```
b1 = False
b2 = True

result = b1 and b2
```

false

B_1	B_2	B_1 and B_2
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

And Operator

```
b1 = True
b2 = False

result = b1 and b2
```

false

B_1	B_2	B_1 and B_2
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

And Operator

```
b1 = True
b2 = True

                    true
result = b1 and b2
```

B_1	B_2	B_1 and B_2
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

OR

- Evaluates to true if at least one of the Boolean expressions is true.
- OR Truth Table:

B_1	B_2	B_1 or B_2
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Or Operator

```
b1 = False
b2 = False

result = b1 or b2
```

false

B_1	B_2	B_1 or B_2
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Or Operator

```
b1 = False
b2 = True

                    true
result = b1 or b2
```

B_1	B_2	B_1 or B_2
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Or Operator

```
b1 = True
b2 = False

                    true
result = b1 or b2
```

B_1	B_2	B_1 or B_2
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

Or Operator

```
b1 = True
b2 = True

                    true
result = b1 or b2
```

B_1	B_2	B_1 or B_2
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

NOT

- Inverts/Negates a Boolean expression.
- NOT Truth Table:

B_1	not B_1
FALSE	TRUE
TRUE	FALSE

Not Operator

```
b1 = True

result = not b1
```

false

B_1	not B_1
FALSE	TRUE
TRUE	FALSE

Not Operator

```
b1 = False

result = not b1
```

true

B_1	not B_1
FALSE	TRUE
TRUE	FALSE

Logical Operator Precedence

1. **not** Operator
2. **and** Operator
3. **or** Operator

Logical Operator Precedence

```
b1 = False
b2 = True
b3 = False

result = not b1 or b2 and b3
```

- What is the value of the result variable?

Logical Operator Precedence

```
b1 = False
b2 = True
b3 = False
```

```
                          false       true        false
result = not b1 or b2 and b3

           True or b2 and b3

           True or False

                True
```

Logical Operator Precedence

```
b1 = False
b2 = True
b3 = False

result = not b1 or b2 and b3 and not b2 or b3
```

- What is the value of the result variable?

Operator Precedence

0.	**( )**	Expressions in parentheses are always evaluated first.
1.	**not**, **-**	Not Operator, Unary Negation/Negative Numbers (-5)
2.	****	Exponent
2.	*, /, //, %	Multiplication, Float Division, Integer Division, Modulus
3.	+, -	Addition, Subtraction
4.	<, >, <=, >=	Less than (or equal), Greater than (or equal)
5.	==, !=	Equal to, Not equal to
6.	**and**	And Operator
7.	**or**	Or Operator
8.	=, +=, -=, *=, /=, %=	Assignment and Combined Assignment

Operator Precedence

```
num1 = 4
num2 = 5
b1 = False

result = not b1 and num1 + num2 >= 9
```

- What is the value of the result variable?

Operator Precedence

```
num1 = 4
num2 = 5
b1 = False

result = not b1 and num1 + num2 >= 9
         True and num1 + num2 >= 9
         True and 9 >= 9
         True and True
         True
```

Operator Precedence

```
num1 = 4
num2 = 5
b1 = False

result = b1 or num1 + num2 == 9
```

- What is the value of the result variable?

Operator Precedence

```
b1 = False
b2 = False
b3 = False

result = not b1 or b2 and b3
```

- What is the value of the result variable?

Operator Precedence

```
b1 = False
b2 = False
b3 = False

result = not(b1 or b2) and b3
```

- What is the value of the result variable?

If Statements

- An ***if statement*** tests a Boolean expression and will only execute its instructions if the expression evaluates to true.
  - The code will be "skipped" if the Boolean expression evaluates to false.
- The syntax for an if statement in Python is shown below.

```
if Boolean Expression :
  #code that will be
  #executed if the Boolean Expression
  #evaluates to True
```

Indent one tab.

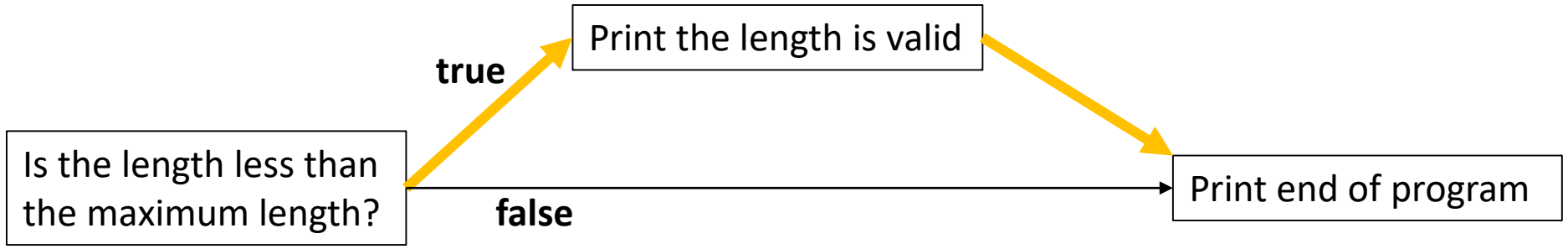
- The Boolean expression as part of an if statement forms a ***conditional expression***.

If Statements

```
length = 80
max_length = 100

if length < max_length :
  print("This is a")
  print("valid length.")

print("End of program.")
```

true

```
This is a
valid length.
End of program.
```

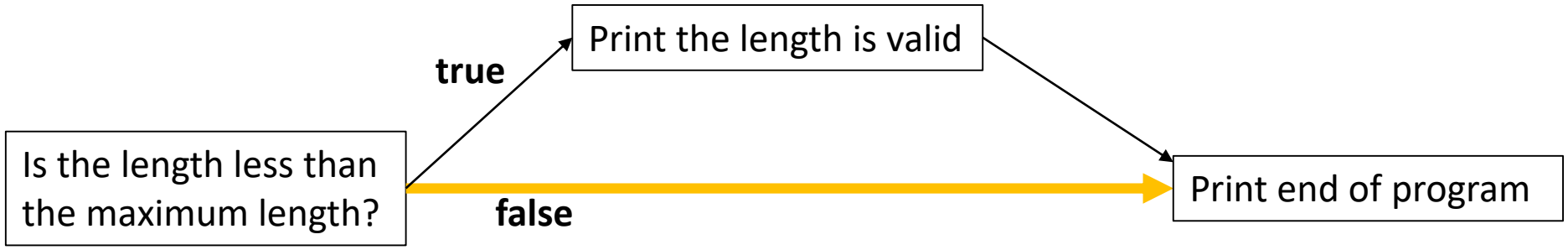


If Statements

```
length = 180
max_length = 100

if length < max_length :
  print("This is a")
  print("valid length.")

print("End of program.")
```

false

```
End of program.
```



If Statements

```
length = 50
max_length = 100

if length >= 0 and length < max_length :
   print("This is a")
   print("valid length.")

print("End of program.")
```

```
This is a
valid length.
End of program.
```

Else Clauses

- An ***else clause*** is a set of instructions that will only execute when its associated if statement's Boolean expression evaluates to false.
- The syntax for an else clause in Python is shown below.

```
if Boolean Expression :
    #code that will be
    #executed if the condition
    #evaluates to True
else :
    #code that will be
    #executed if the condition
    #evaluated to False
```

Else Clauses

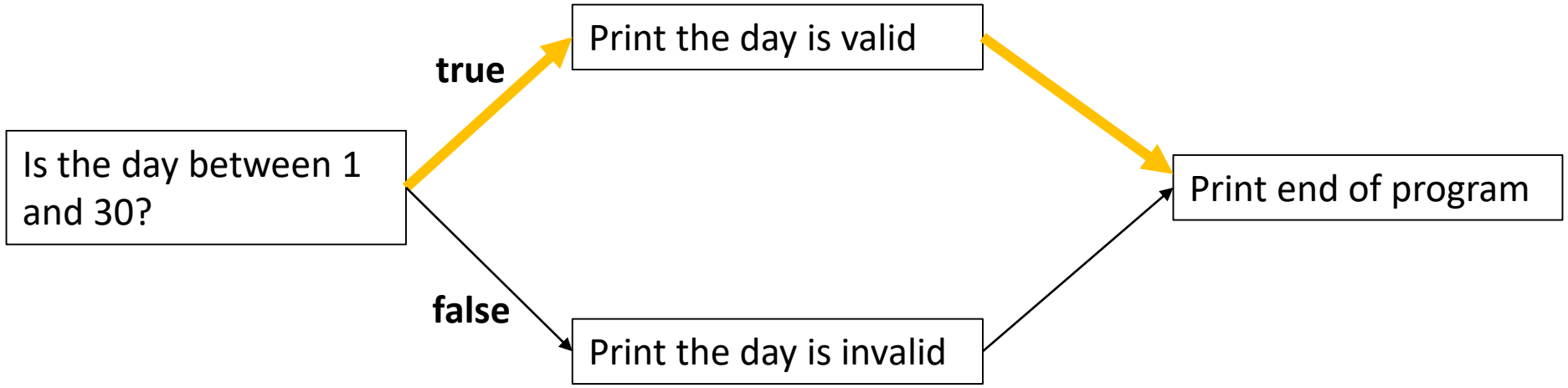
```
day = 10

if day > 0 and day <= 30 :
  print("This is a valid")
  print("day in September.")
else :
  print("This is not a valid")
  print("day in September.")

print("End of program.")
```

true

```
This is a valid
day in September.
End of program.
```

Else Clauses

```
day = 10
```



Else Clauses

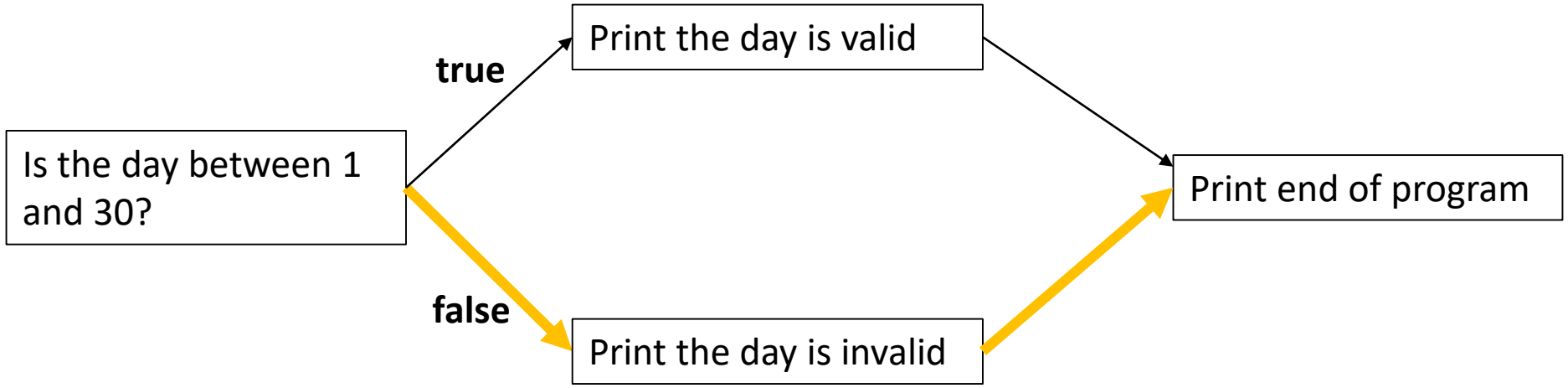
```
day = 31

if day > 0 and day <= 30 :
  print("This is a valid")
  print("day in September.")
else :
  print("This is not a valid")
  print("day in September.")

print("End of program.")
```

false

```
This is not a valid
day in September.
End of program.
```

Else Clauses

```
day = 31
```



Elif Clauses

- An ***elif clause*** (short for “else if”) is an additional if statement that allows testing alternative Boolean expressions.
- The syntax for an elif clause in Python is shown below.

```
if Boolean Expression 1 :
    #code that will be executed if the expression
    #evaluates to True
elif Boolean Expression 2 :
    #code that will be executed if Boolean Expression 1 was False
    #and this Boolean Expression 2 evaluates to True
else :
    #code that will be executed if no previous expressions
    #evaluated to True
```

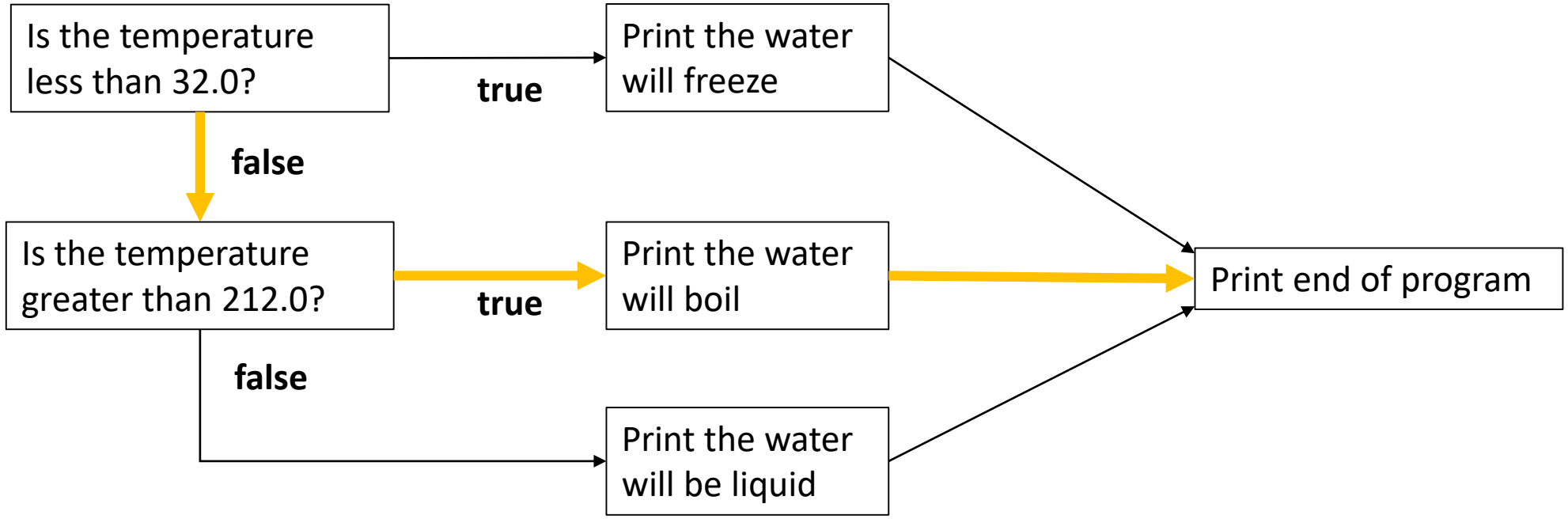
Elif Clauses

```
    temp = 215.5

false if temp <= 32.0 :
        print("Water will freeze.")
true  elif temp >= 212.0 :
        print("Water will boil.")
      else :
        print("Water will be liquid.")

      print("End of program.")
```

```
Water will boil.
End of program.
```

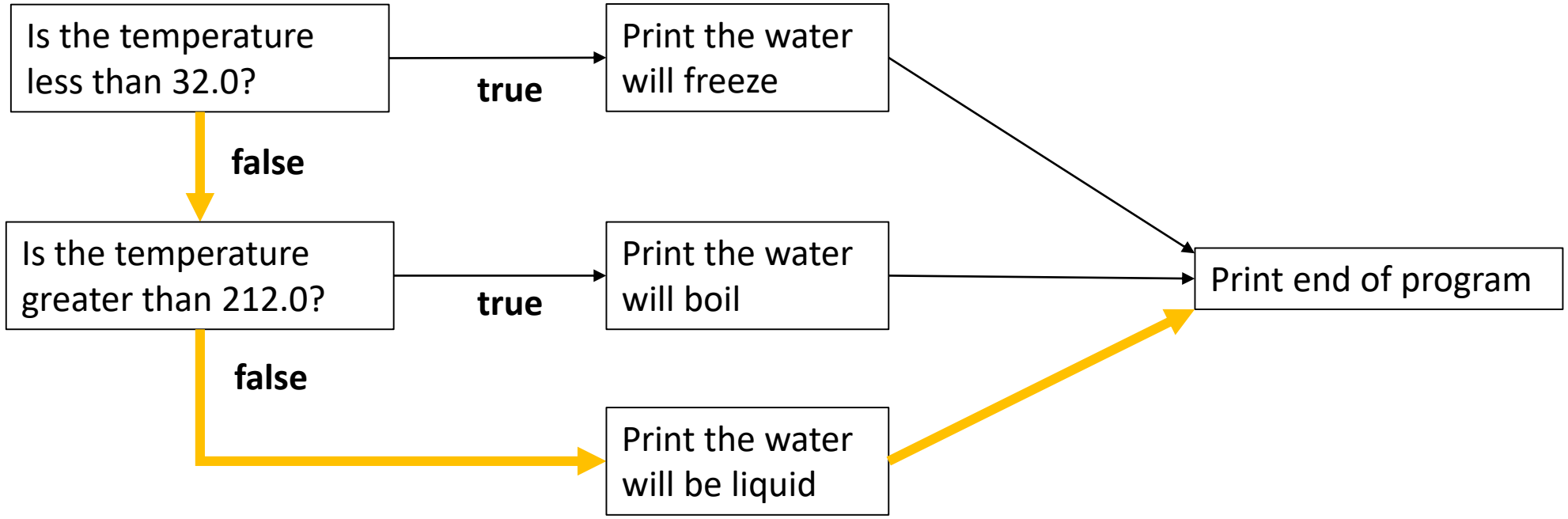
Elif Clauses

```
temp = 215.5
```



Elif Clauses

```
temp = 55.7
```



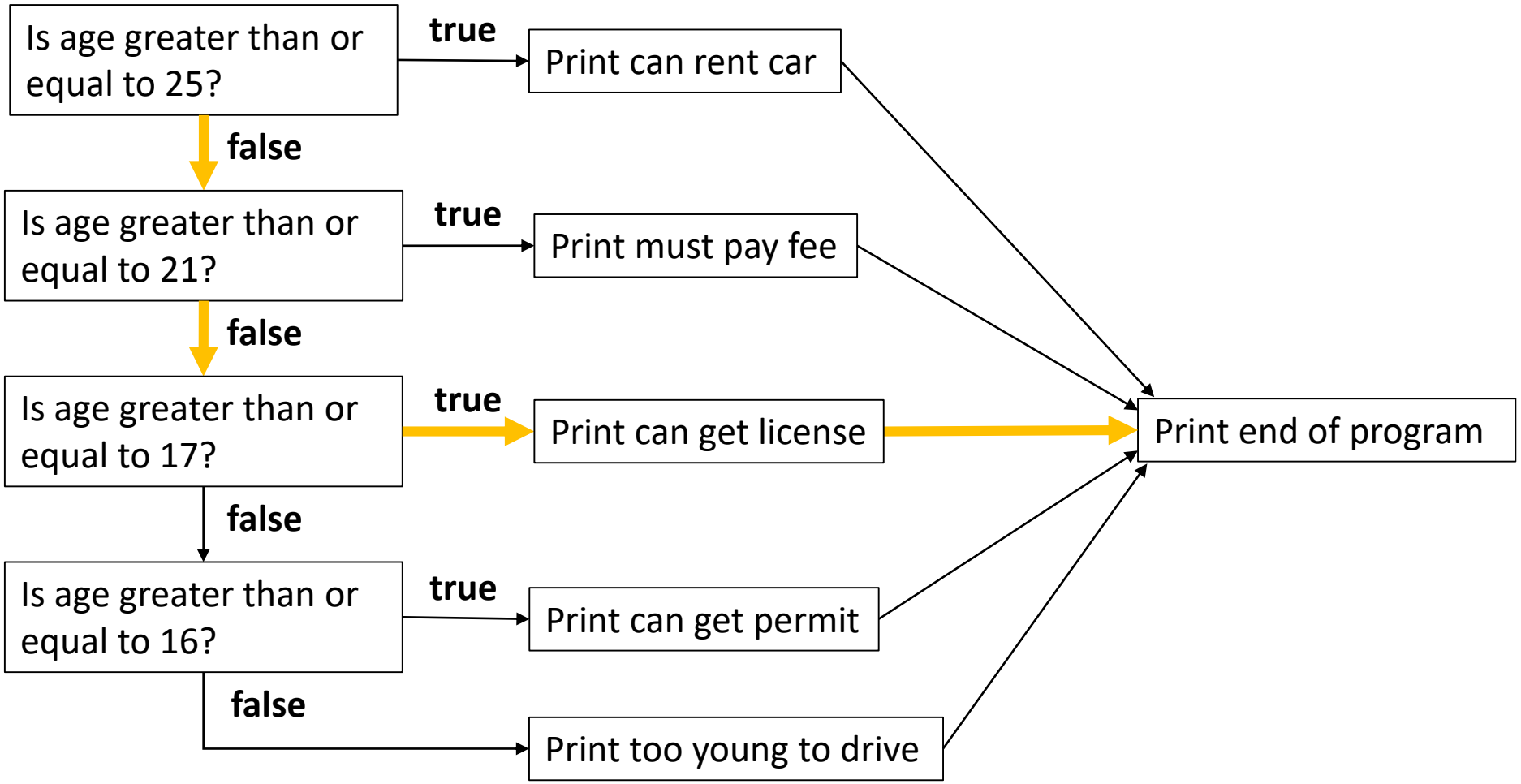
Elif Clauses

```
    age = 19

false if age >= 25 :
        print("Can rent a car.")
false elif age >= 21 :
        print("Must pay underage driver fee.")
true  elif age >= 17 :
        print("Can get a license.")
      elif age >= 16 :
        print("Can get a permit.")
      else :
        print("Too young to drive.")

      print("End of program.")
```

```
Can get a license.
End of program.
```

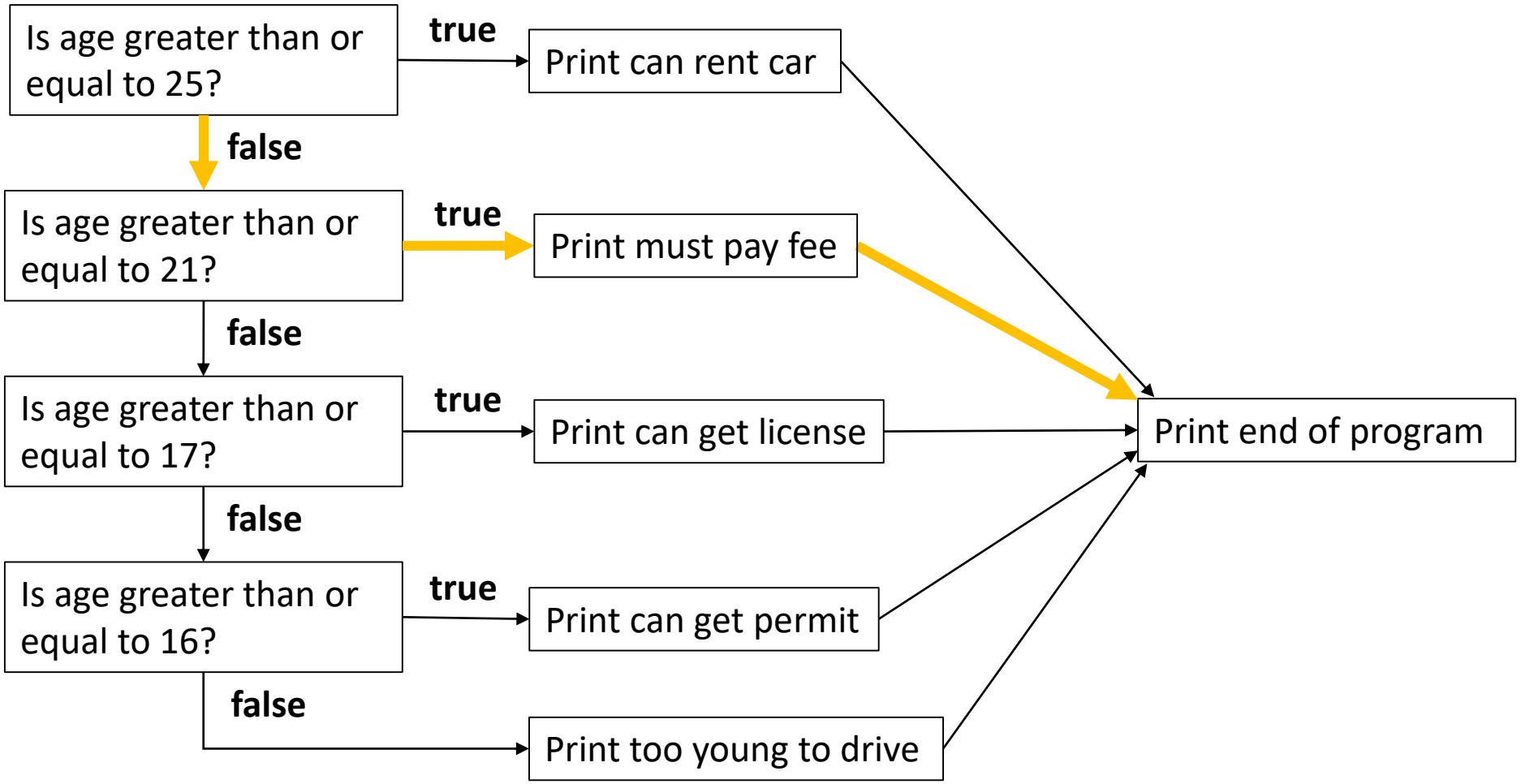
Elif Clauses

age = 19



Elif Clauses

age = 23



If Statement and Elif/Else Clause Rules

- If Statements
  - **Must** always be first.
  - May be followed by any number of elif statements.
  - May be followed by one else statement.
- Elif Clauses
  - Optional.
  - **Must** follow an if statement or elif clause.
  - No limit to the number of elif clauses.
  - May be followed by one else clauses.
- Else Clauses
  - Optional.
  - **Must** follow an if statement or elif clause.
  - Only one else clause.
  - **Always** the last clause.

Nested If Statements

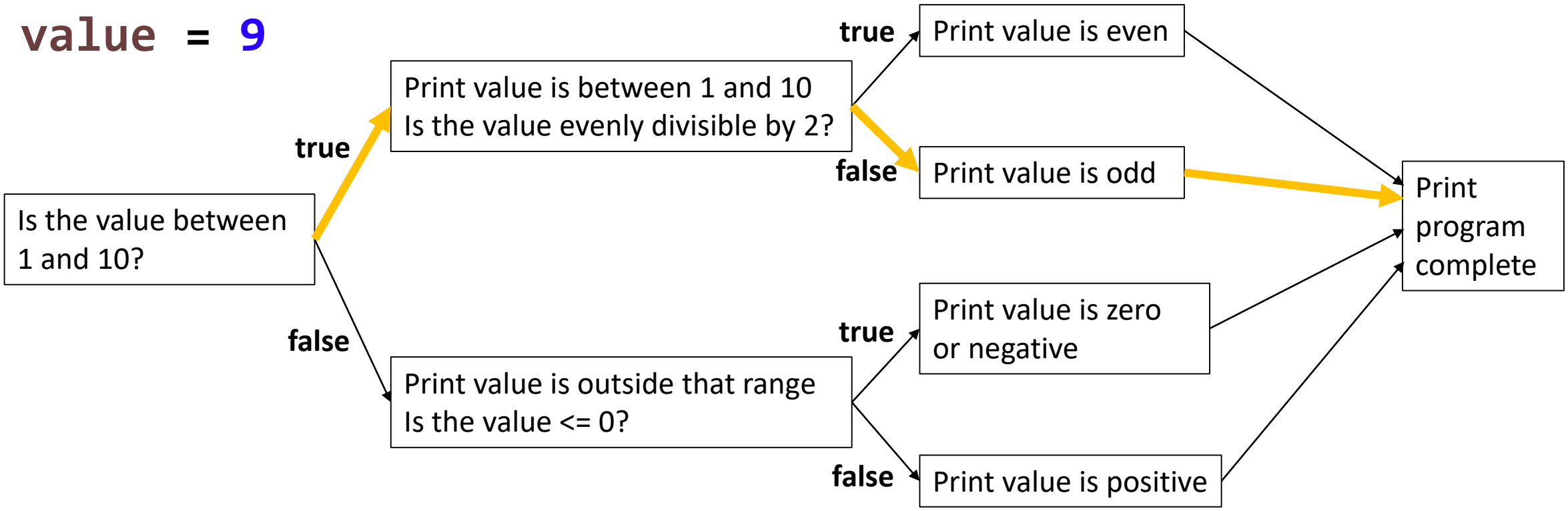
- A ***nested if statement*** is an if statement within the body of an if statement or else clause.
- Be sure you indent properly.

```
if Boolean Expression 1 :
    #code that will be executed if expression 1 is true
    if Boolean Expression 2 :
        #code that will be executed if expression 2 is true
    else :
        #code that will be executed if expression 2 is false
else :
    #code that will be executed if expression 1 is false
```

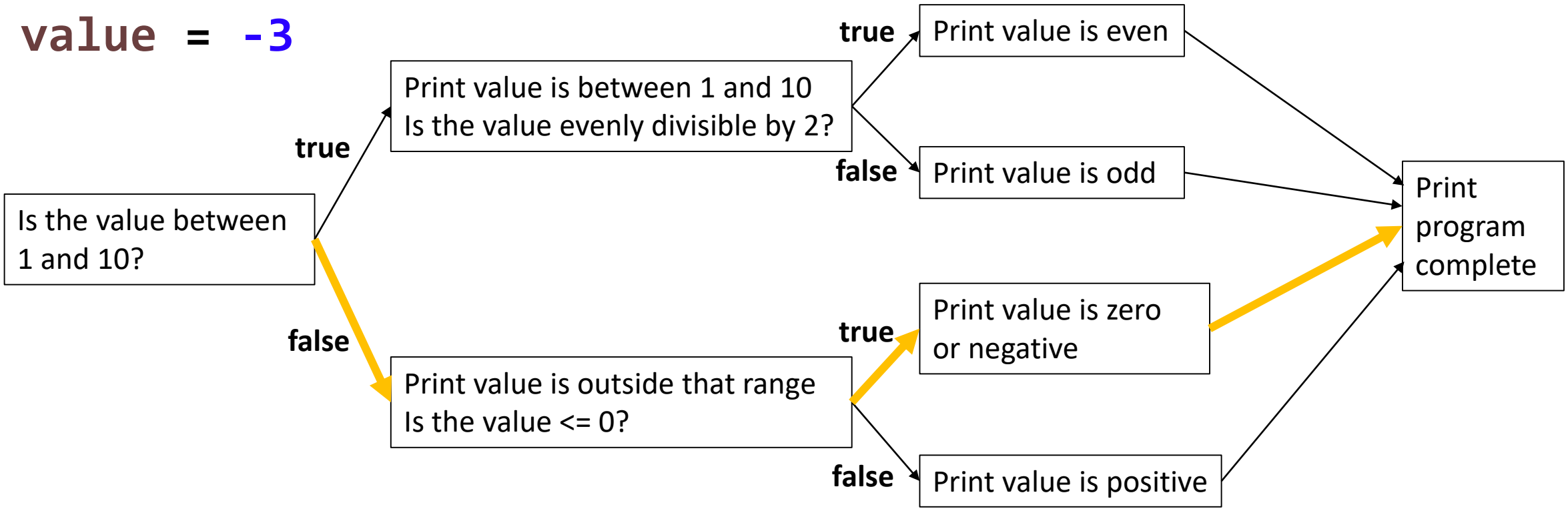
Nested If Statements

```
value = 9

if value >= 1 and value <= 10 :
  print("Your value is between 1 and 10.")
  if value % 2 == 0 :
    print("Your value is even.")
  else :
    print("Your value is odd.")
else :
  print("Your value is outside the range of 1 and 10.")
  if value <= 0 :
    print("Your value is zero or negative.")
  else :
    print("Your value is more than 10.")

print("Program complete")
```

Nested If Statements



Nested If Statements



Variable Scope

- Variables declared outside of and prior to an if statement or associated clause can be used in any of the statements.

```
total_amount = 21.0

print("Total cost with shipping:")
if total_amount >= 30.0 :
  print("$", format(total_amount, ".2f"), sep="")
else :
  print("$", format(total_amount + 10.0, ".2f"), sep="")
```

false

```
Total cost with shipping:
$31.00
```

Variable Scope

- Variables declared inside of an if statement or associated clause can *sometimes* be used outside that of that if statement or clause's code.
- It may only be used/accessed when its containing statement or clause was the one executed.

```
        total_amount = 31.0

false   if total_amount < 30.0 :
            amountPlusShipping = total_amount + 10.0

        print(amountPlusShipping)
```

Error

String Comparison

- == Compares if two strings are equal
- != Compares if two strings are not equal
- < Determines if the first string lexicographically* precedes the second
- > Determines if the first string lexicographically succeeds the second
- <= Determines if the first string is equal to or lexicographically precedes the second
- >= Determines if the first string is equal to or lexicographically succeeds the second

*- Lexicographical order is like alphabetical order, but uppercase letters come before lowercase letters.

- Dog lexicographically precedes dog
- dOg lexicographically precedes dog

String Comparison (Equality)

```
string1 = "Cats"
string2 = "Cats"

if string1 == string2 :
  print("The Strings are equal")
```

true

```
The Strings are equal
```

String Comparison (Equality)

```
string1 = "Cats"
string2 = "cats"

if string1 == string2 :
  print("The Strings are equal")
```

false

```
(No output)
```

String Comparison (Inequality)

```
string1 = "Cats"
string2 = "cats"

if string1 != string2 :
  print("The Strings are not equal")
```

true

```
The Strings are not equal
```

String Comparison (Inequality)

```
string1 = "Cats"
string2 = "Cats"

if string1 != string2 :
  print("The Strings are not equal")
```

false

```
(No output)
```

String Comparison (Less Than)

```
string1 = "Cats"
string2 = "Dogs"

if string1 < string2 :
  print("Cats precedes Dogs")
```

true

```
Cats precedes Dogs
```

String Comparison (Greater Than)

```
string1 = "Cats"
string2 = "Dogs"

if string1 > string2 :
  print("Cats comes after Dogs")
```

false

```
(No output)
```

String Comparison (Greater Than)

```
string1 = "cats"
string2 = "Cats"

if string1 > string2 :
  print("cats comes after Cats")
```

true

```
cats comes after Cats
```

String Comparison (Starting text)

- The string's **startswith** function checks to see if the String begins with the value provided.

```
hello = "Hello World!"

if hello.startswith("H") :
  print("This string starts with an H")
```

true

```
This string starts with an H
```

String Comparison (Starting text)

- The **startswith** function is case sensitive.

```
hello = "Hello World!"

if hello.startswith("h") :
    print("This string starts with an h")
```

false

```
(No output)
```

String Comparison (Starting text)

```
hello = "Hello World!"

if hello.startswith("Hello W") :
    print("This string starts with Hello W")
```

true

```
This string starts with Hello W
```

String Comparison (Ending text)

- Similar to the **startswith** function, the string's **endswith** function tests if a string *ends* with a particular character sequence.

```
hello = "Hello World"

if hello.endswith("d") :
   print("This string ends with d")
```

true

```
This string ends with d
```

String Comparison (Ending text)

- The **endswith** function is case sensitive.

```
hello = "Hello World"

if hello.endswith("D") :
  print("This string ends with D")
```

false

```
(No output)
```