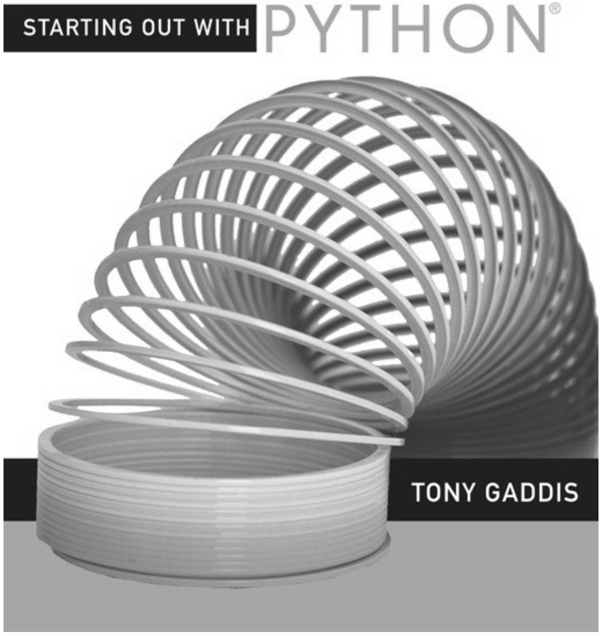
Topic 4: Decisions

Recommended Readings



- Chapter 4

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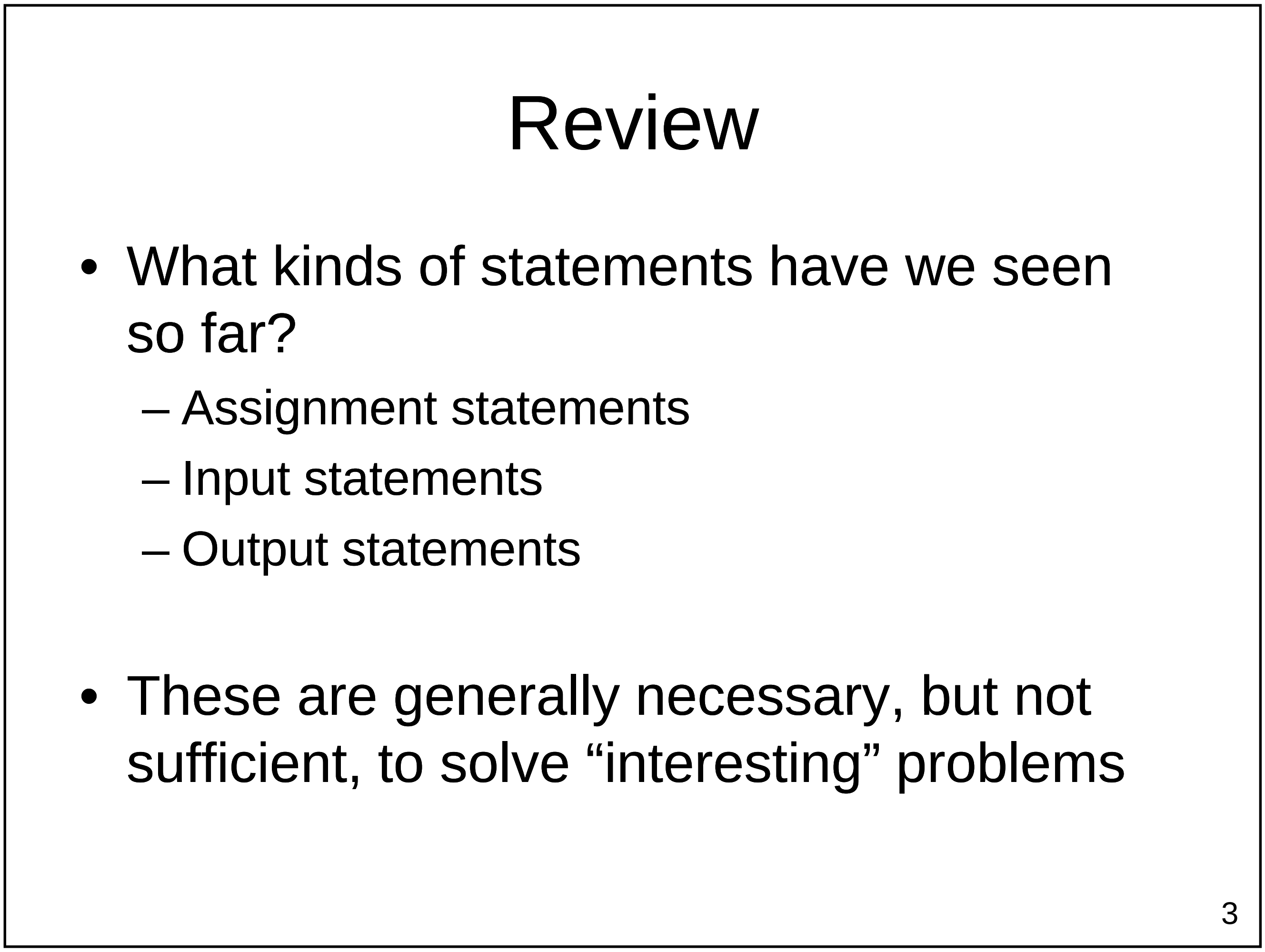
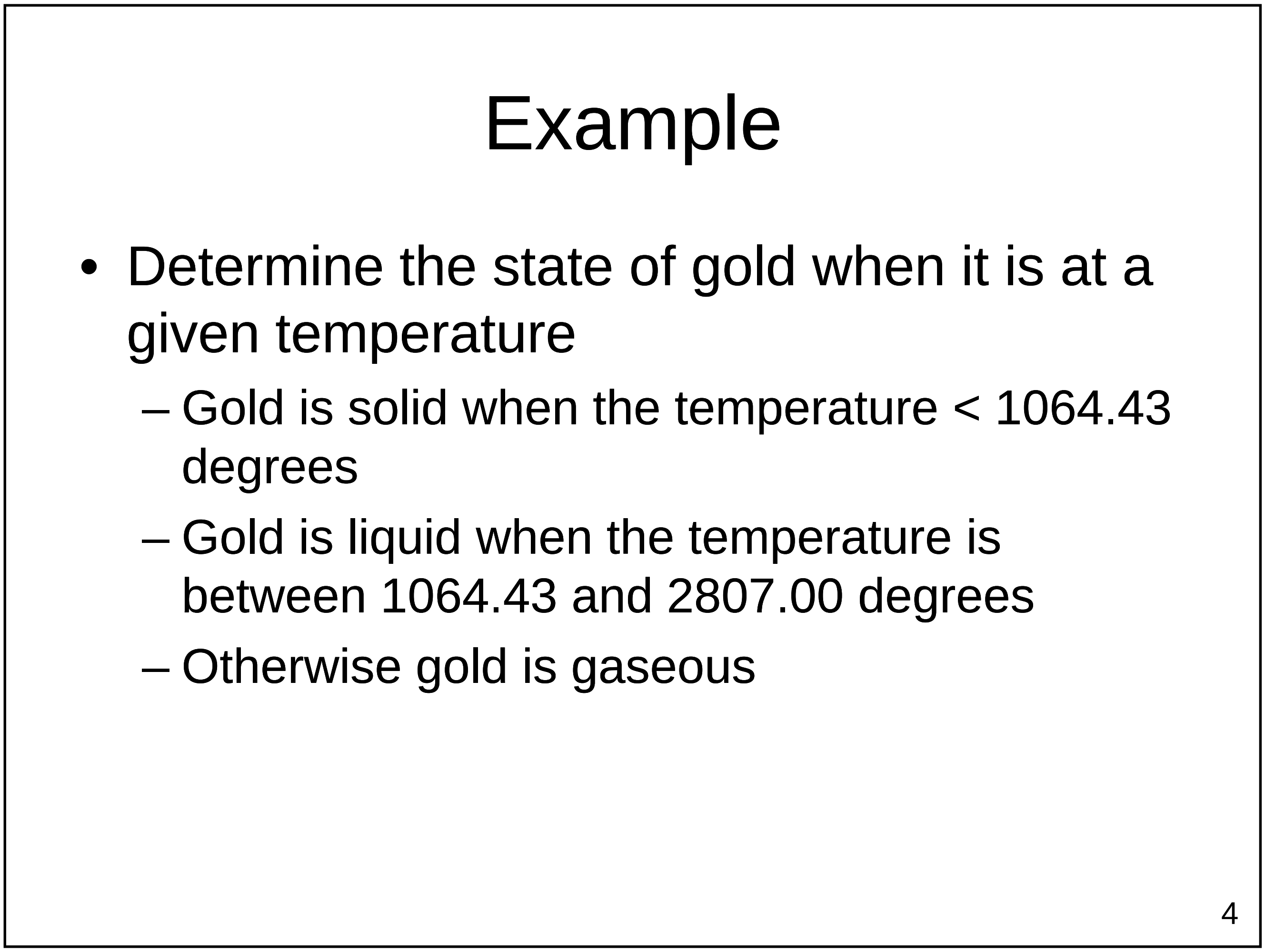


Review

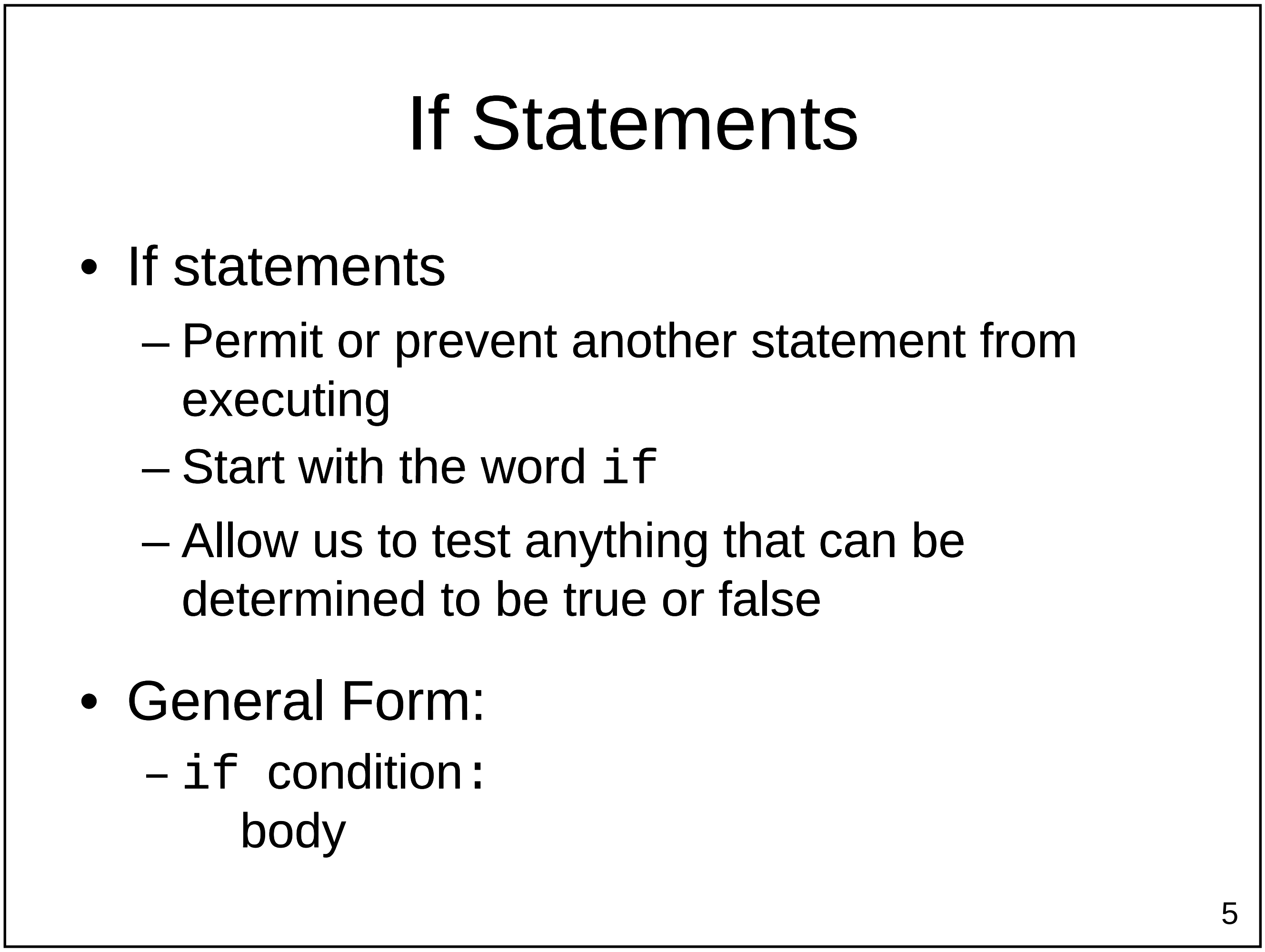
- What kinds of statements have we seen so far?
  - Assignment statements
  - Input statements
  - Output statements

- These are generally necessary, but not sufficient, to solve “interesting” problems



Example

- Determine the state of gold when it is at a given temperature
  - – Gold is solid when the temperature < 1064.43 degrees
  - – Gold is liquid when the temperature is between 1064.43 and 2807.00 degrees
  - – Otherwise gold is gaseous

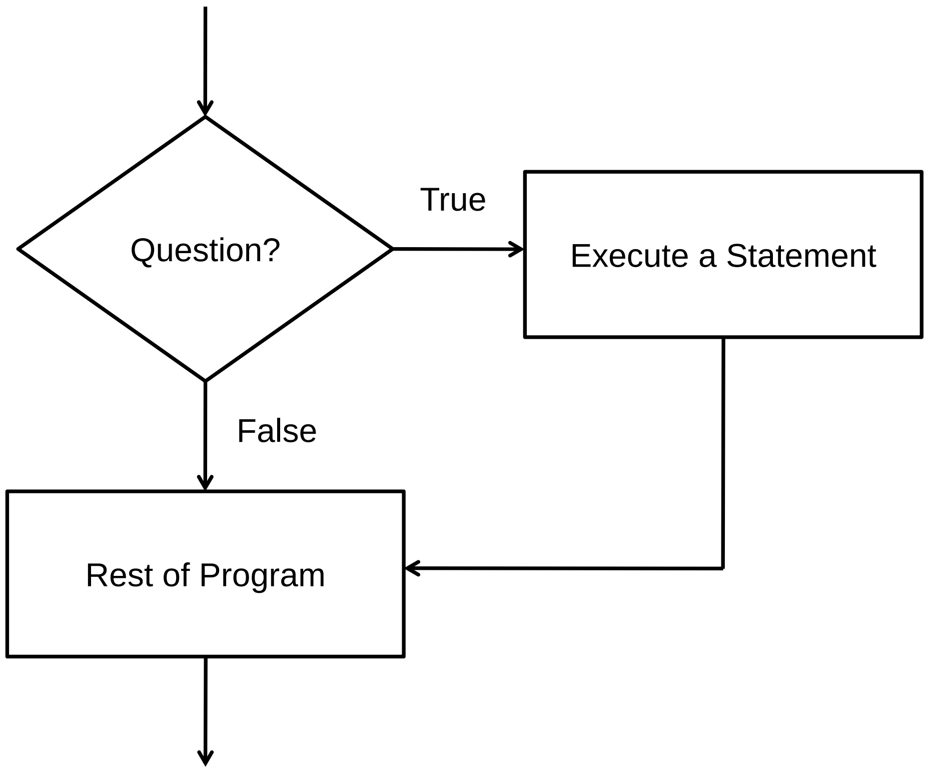


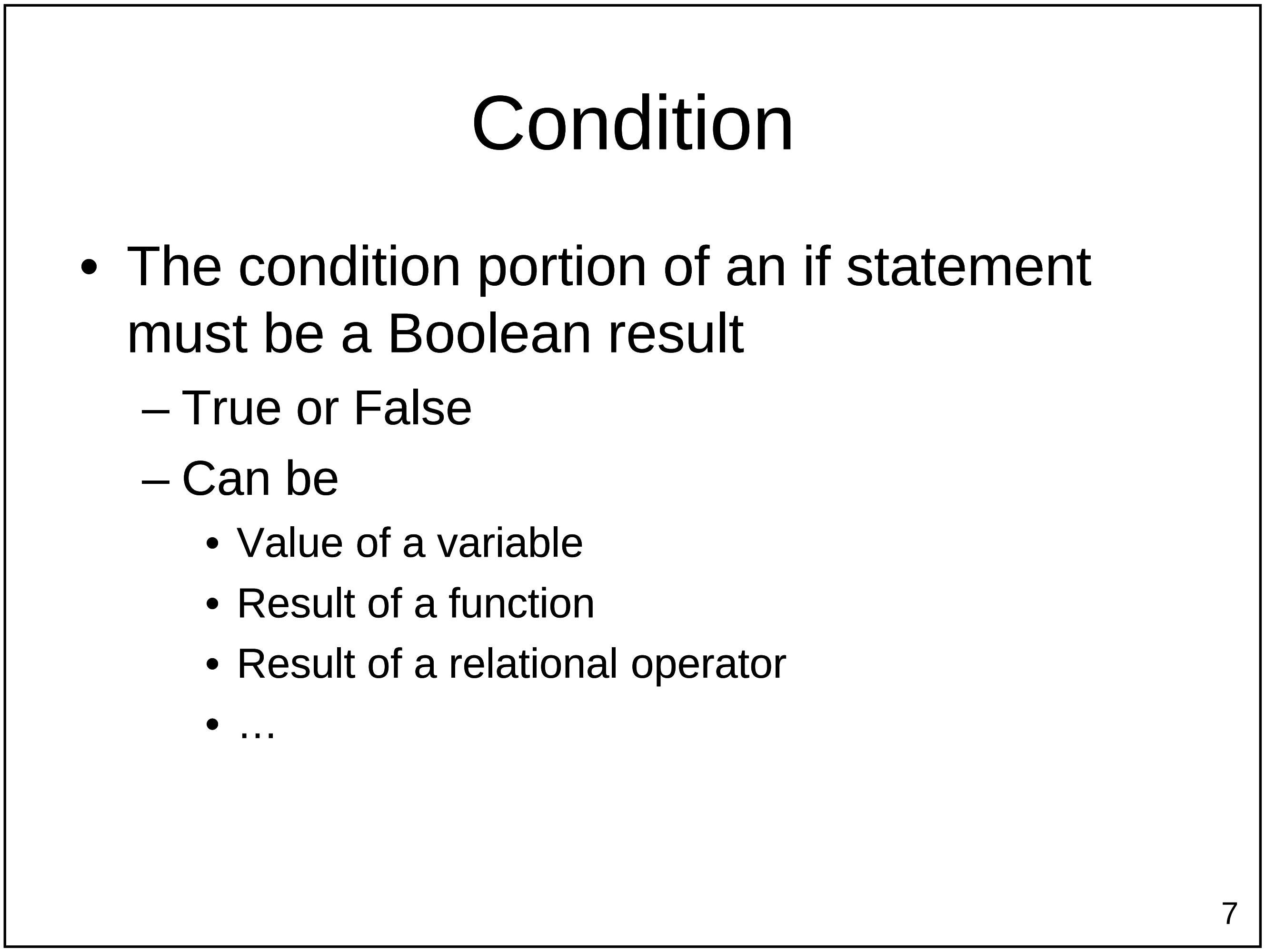
If Statements

- If statements
  - Permit or prevent another statement from executing
  - Start with the word `if`
  - Allow us to test anything that can be determined to be true or false
- General Form:
  - `if` condition`:`

    body

Decisions





Condition

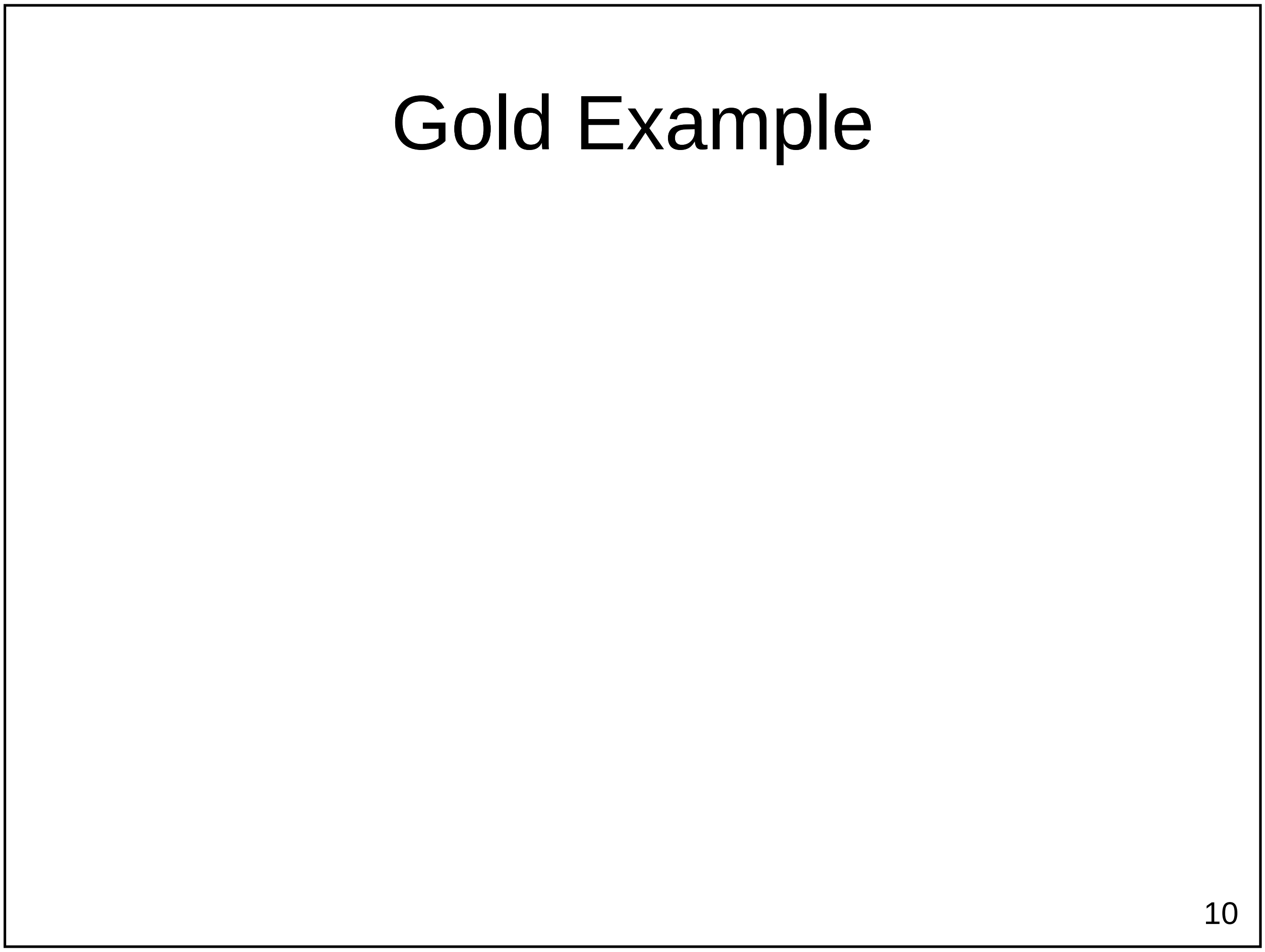
- The condition portion of an if statement must be a Boolean result
  - True or False
  - Can be
    - Value of a variable
    - Result of a function
    - Result of a relational operator
    - …

Relational Operators

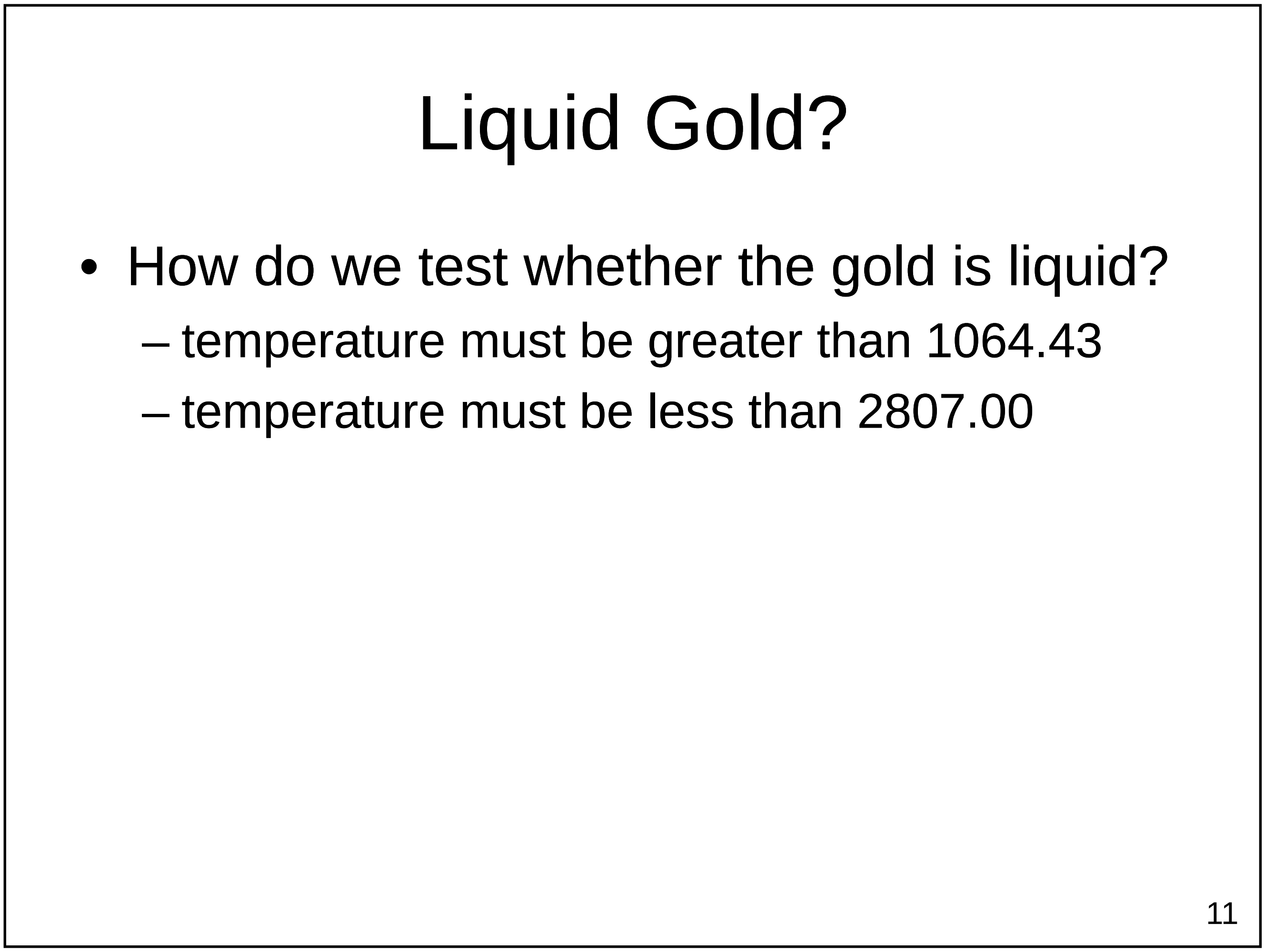
- Relational operators compare two values
  - Result will be true or false
  - Operators:
    - <   less than
    - >   greater than
    - <=   less than or equal
    - >=   greater than or equal
    - ==   equal
    - !=   not equal

Relational Operations

- Values tested can be
  - Variables
  - Literals
  - Results from functions
  - Expressions
  - …
- Types tested can be
  - Integers, Floats, Booleans, Strings
  - …

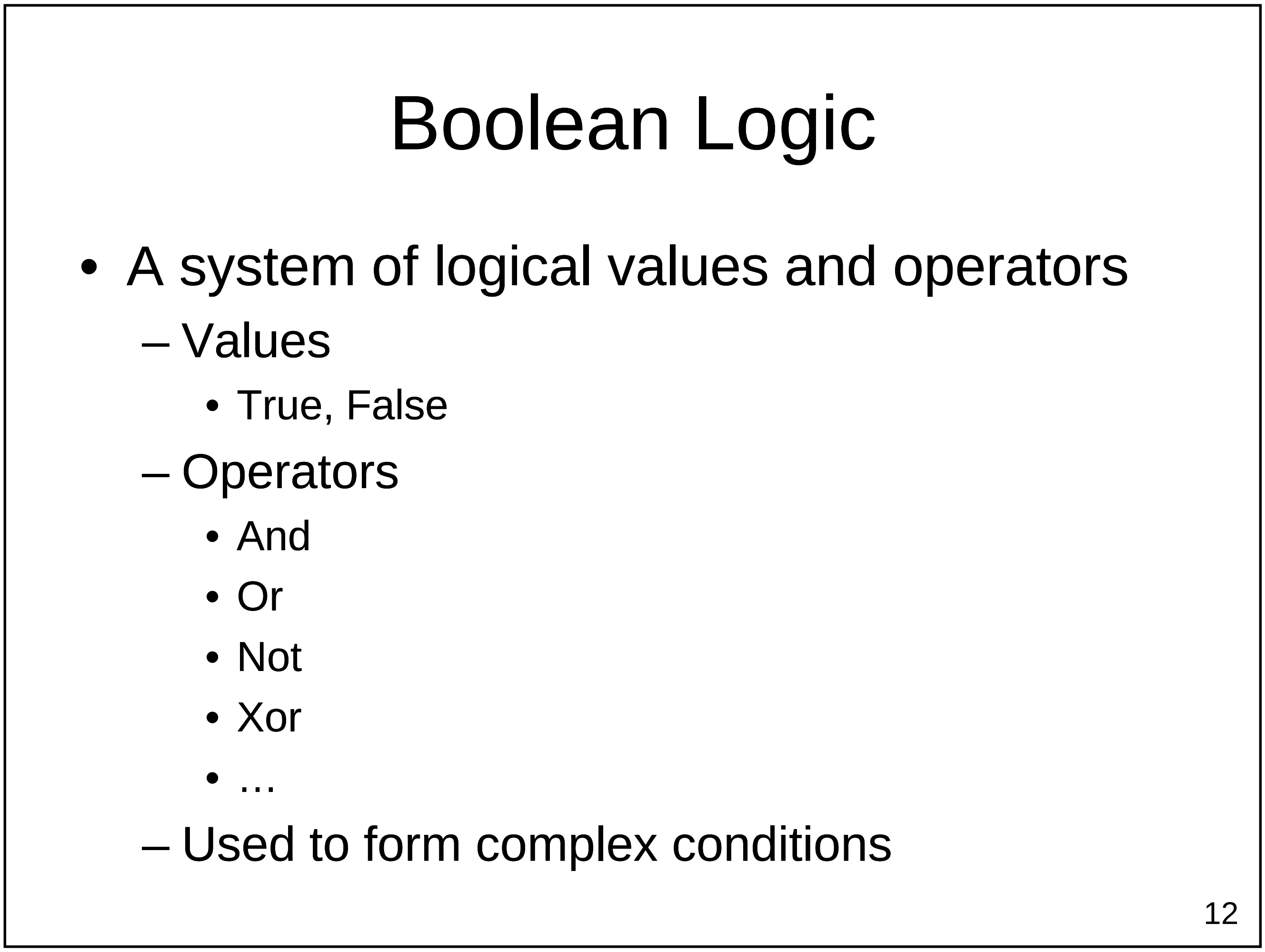


Gold Example



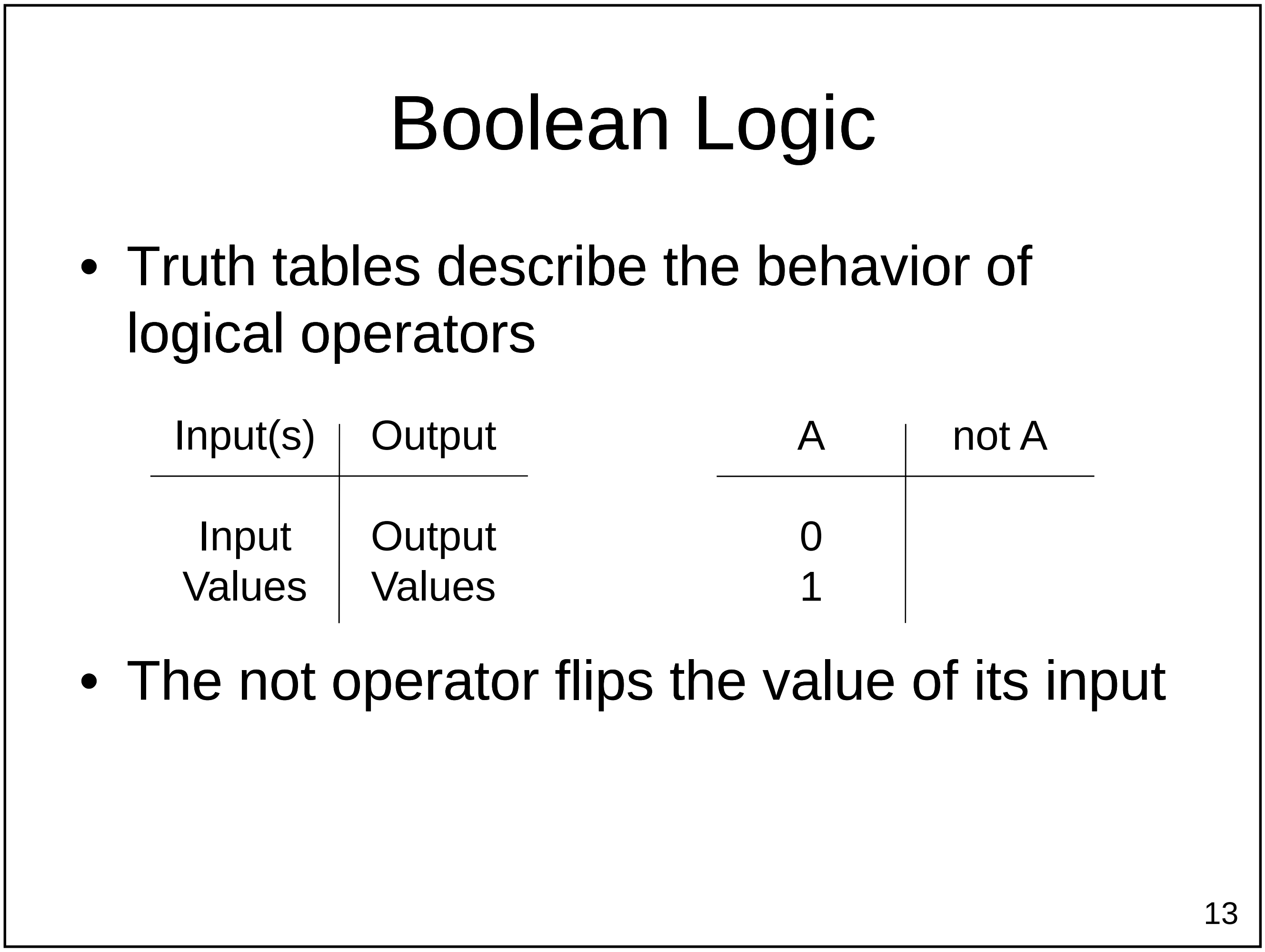
Liquid Gold?

- How do we test whether the gold is liquid?
  - – temperature must be greater than 1064.43
  - – temperature must be less than 2807.00



Boolean Logic

- A system of logical values and operators
  - – Values
    - True, False
  - – Operators
    - And
    - Or
    - Not
    - Xor
    - …
  - – Used to form complex conditions



Boolean Logic

- Truth tables describe the behavior of logical operators

Input(s)	Output
Input Values	Output Values

A	not A
0	
1	

- The not operator flips the value of its input

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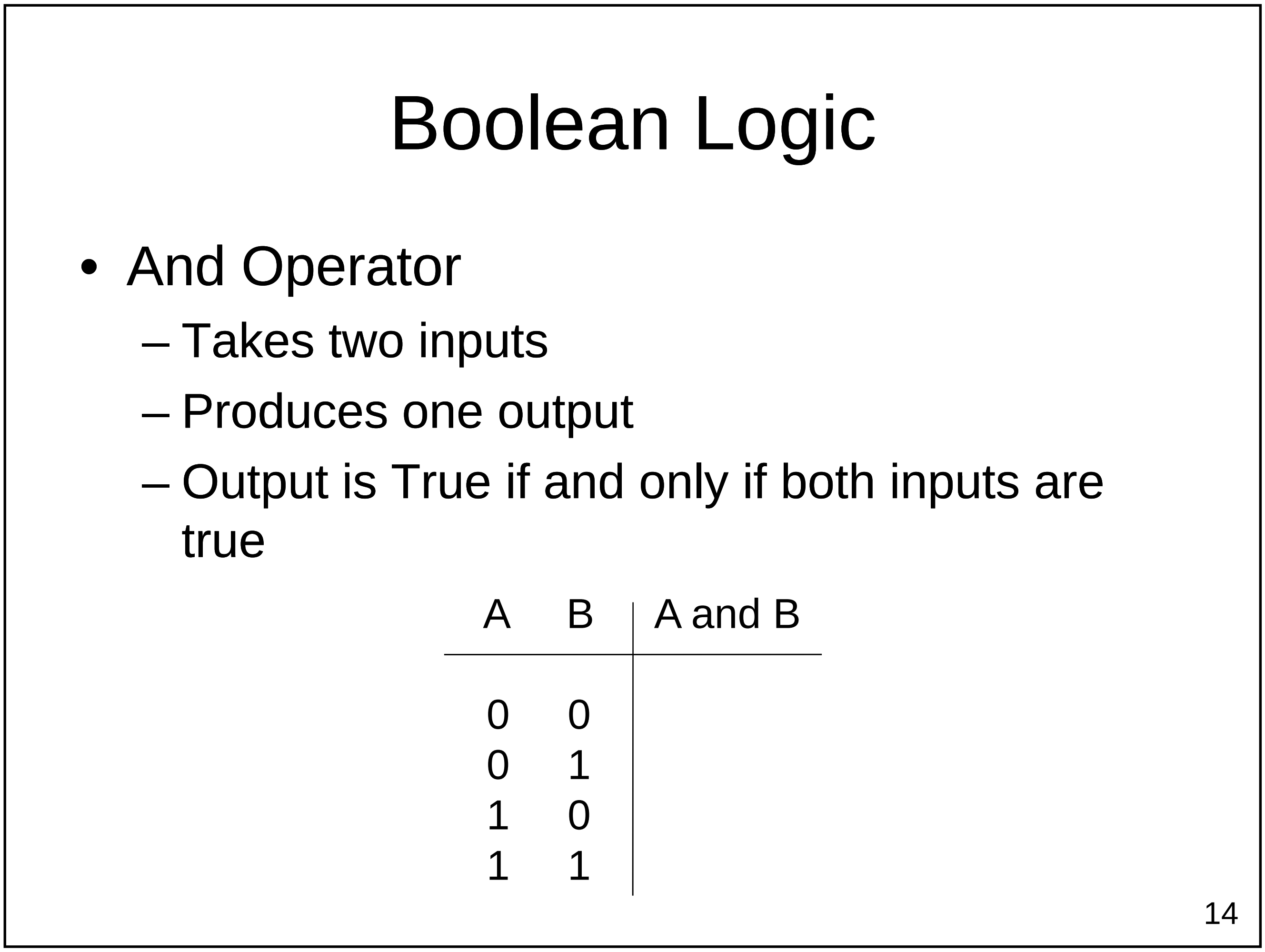


Boolean Logic

- And Operator
  - Takes two inputs
  - Produces one output
  - Output is True if and only if both inputs are true

A	B	A and B
0	0	
0	1	
1	0	
1	1	

Boolean Logic

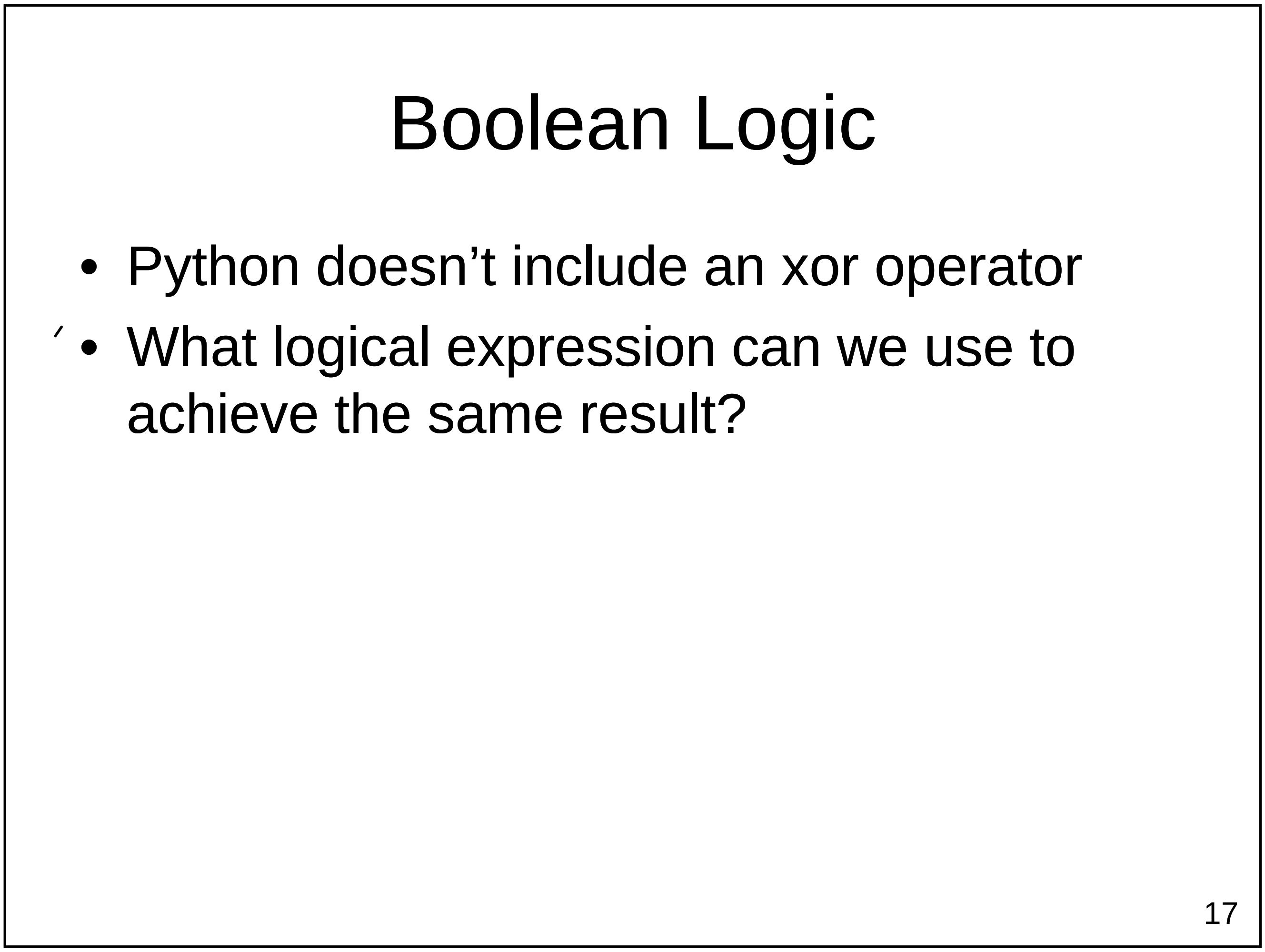
- Or Operator
  - Takes two inputs
  - Produces one output
  - Output is True if one input is true (or both inputs are true)

A	B	A or B
0	0	
0	1	
1	0	
1	1	

Boolean Logic

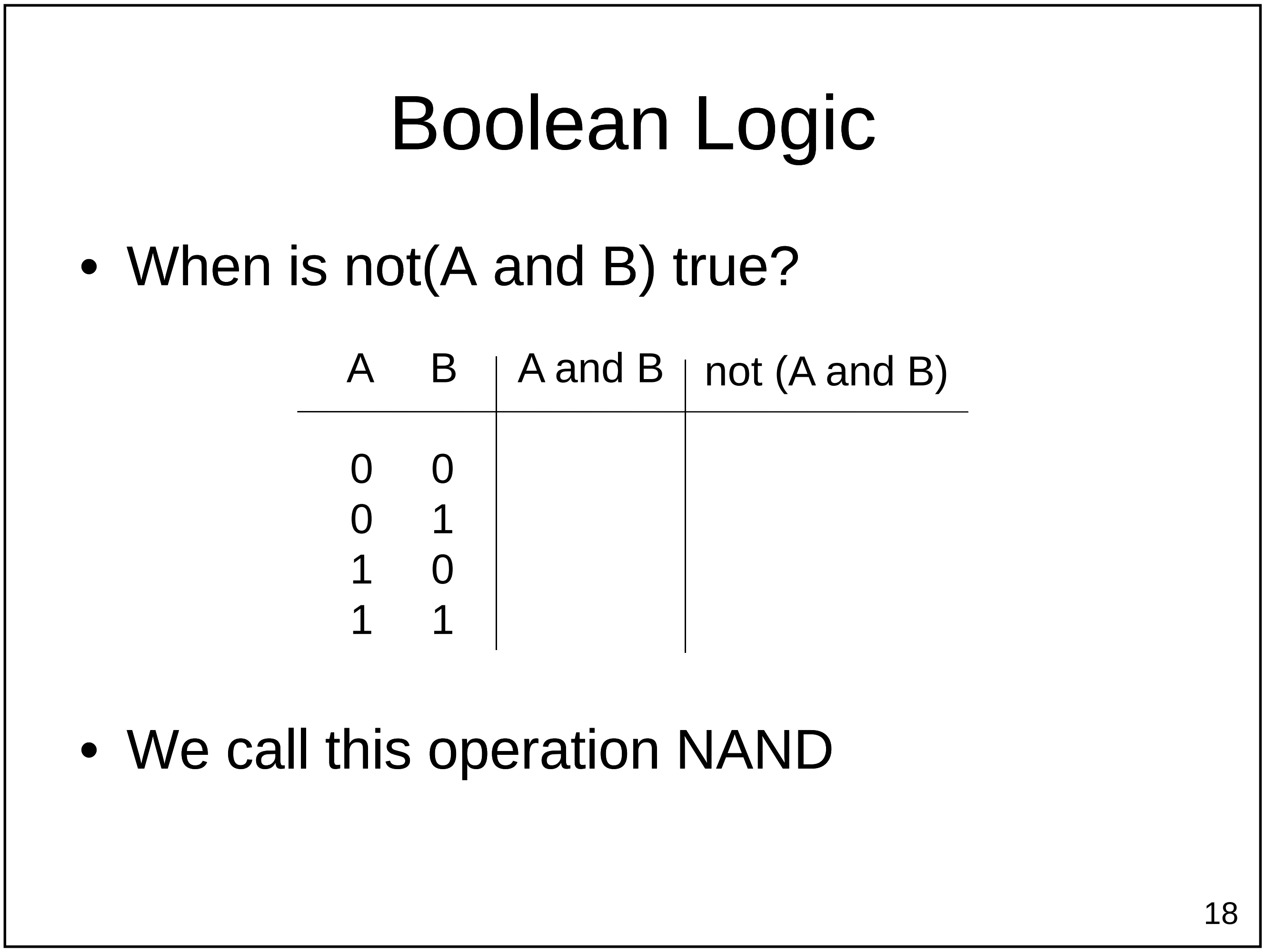
- Exclusive Or Operator
  - Takes two inputs
  - Produces one output
  - Output is True if exactly one input is true

A	B	A xor B
0	0	
0	1	
1	0	
1	1	



Boolean Logic

- Python doesn’t include an xor operator
- What logical expression can we use to achieve the same result?

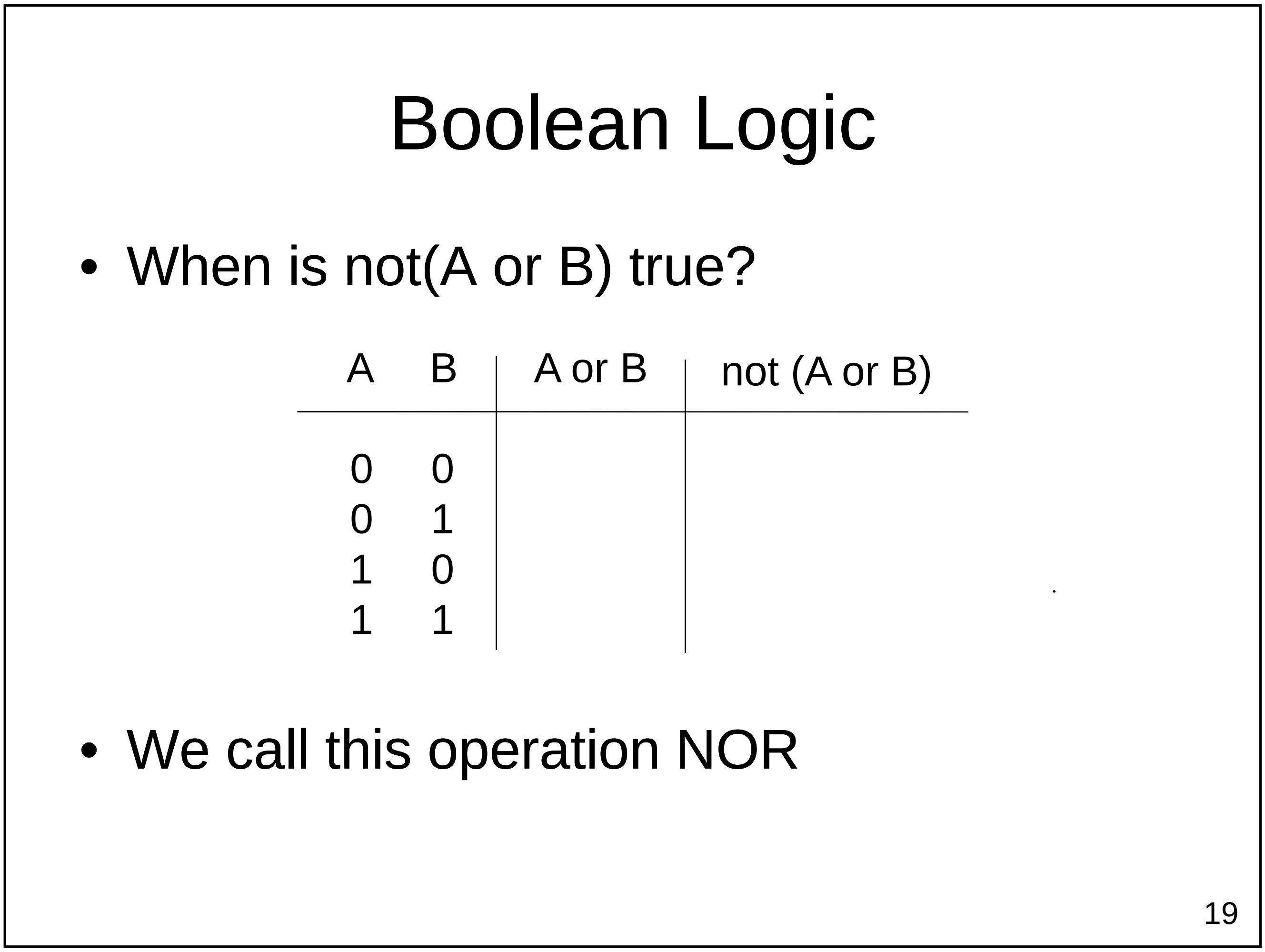


Boolean Logic

- When is not(A and B) true?

A	B	A and B	not (A and B)
0	0		
0	1		
1	0		
1	1		

- We call this operation NAND



Boolean Logic

- When is not(A or B) true?

A	B	A or B	not (A or B)
0	0		
0	1		
1	0		
1	1		

- We call this operation NOR

Boolean Logic

- Example:
  - – Construct a truth table for A and (B or not C):

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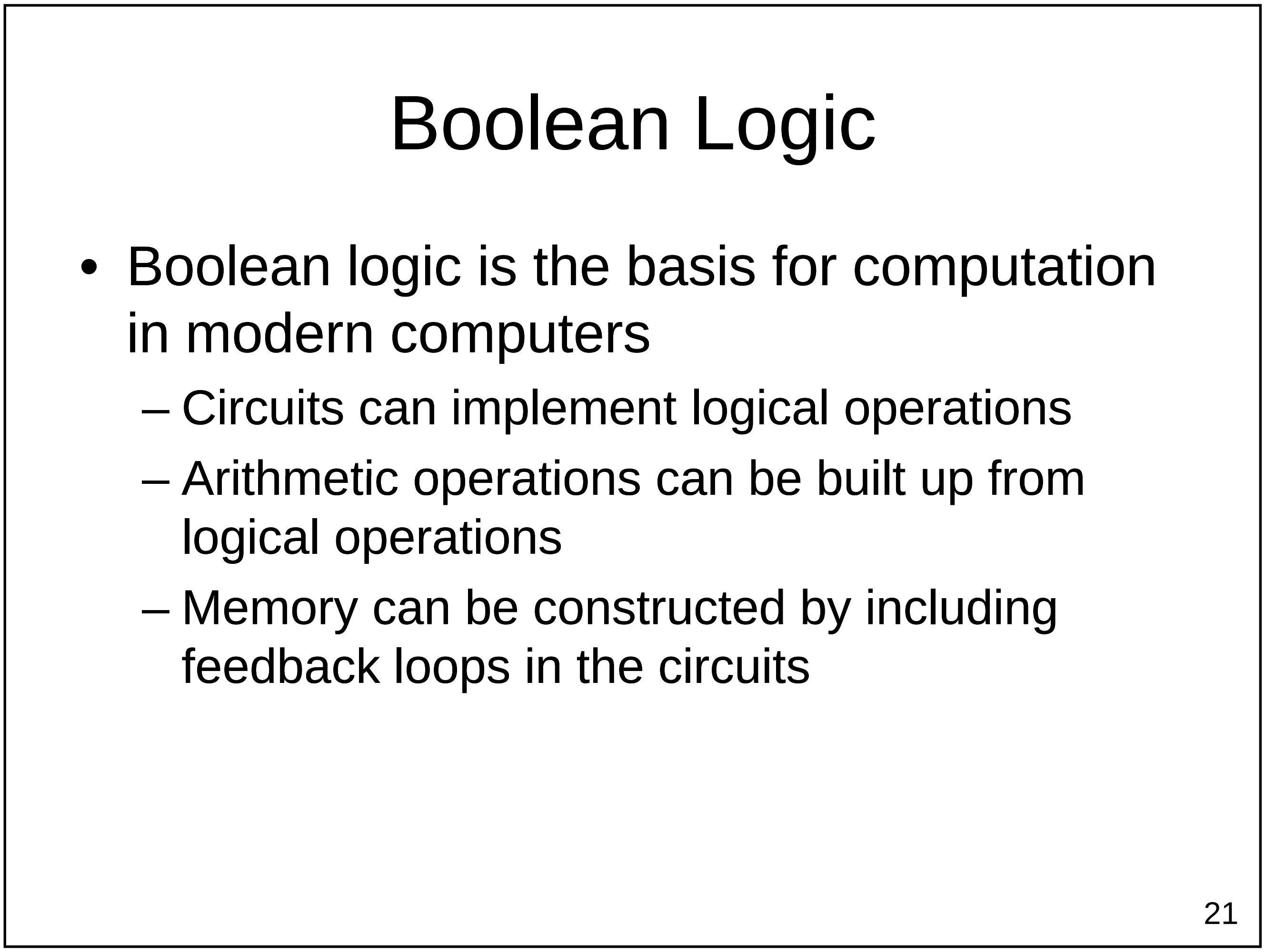
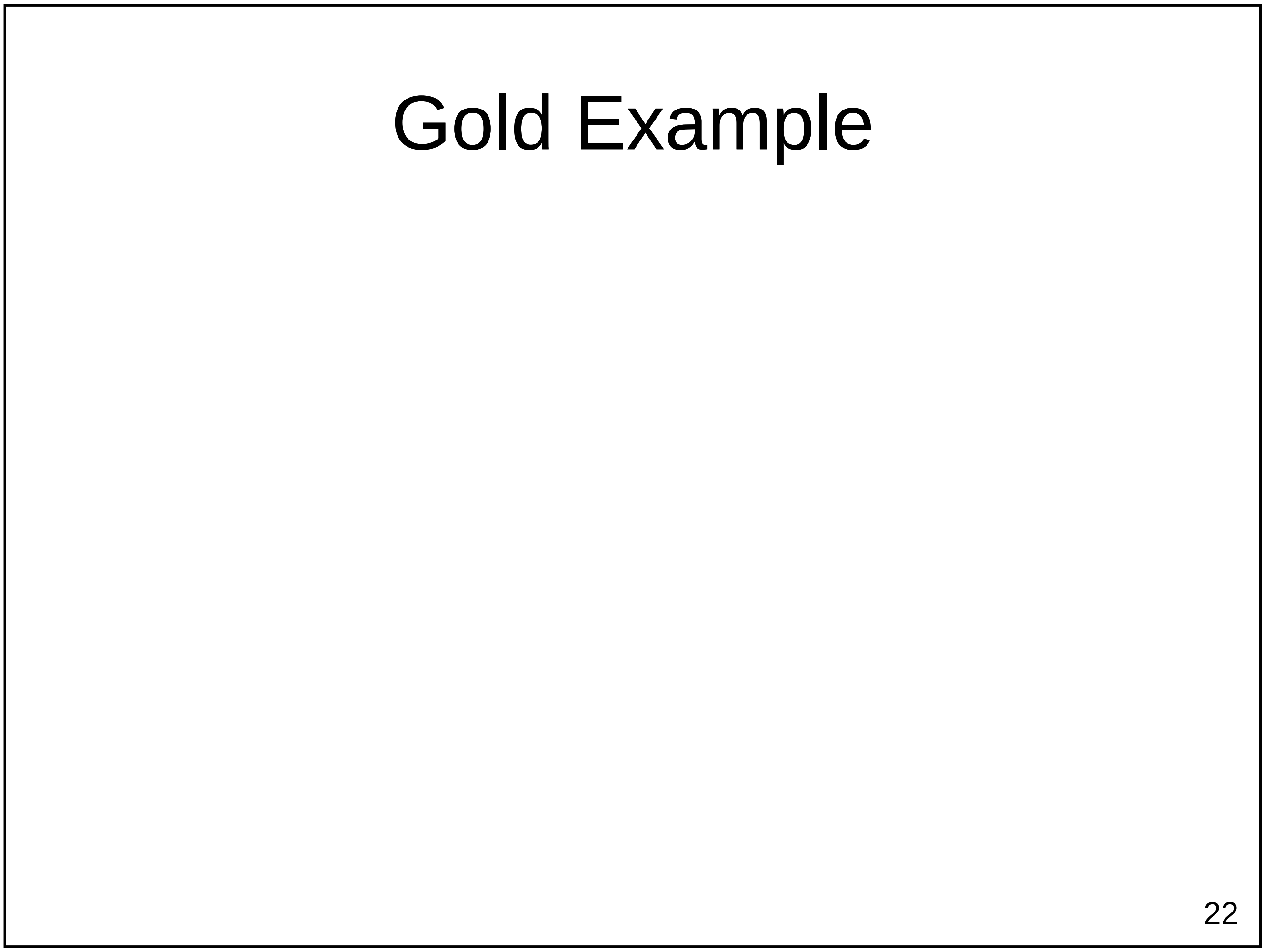


Boolean Logic

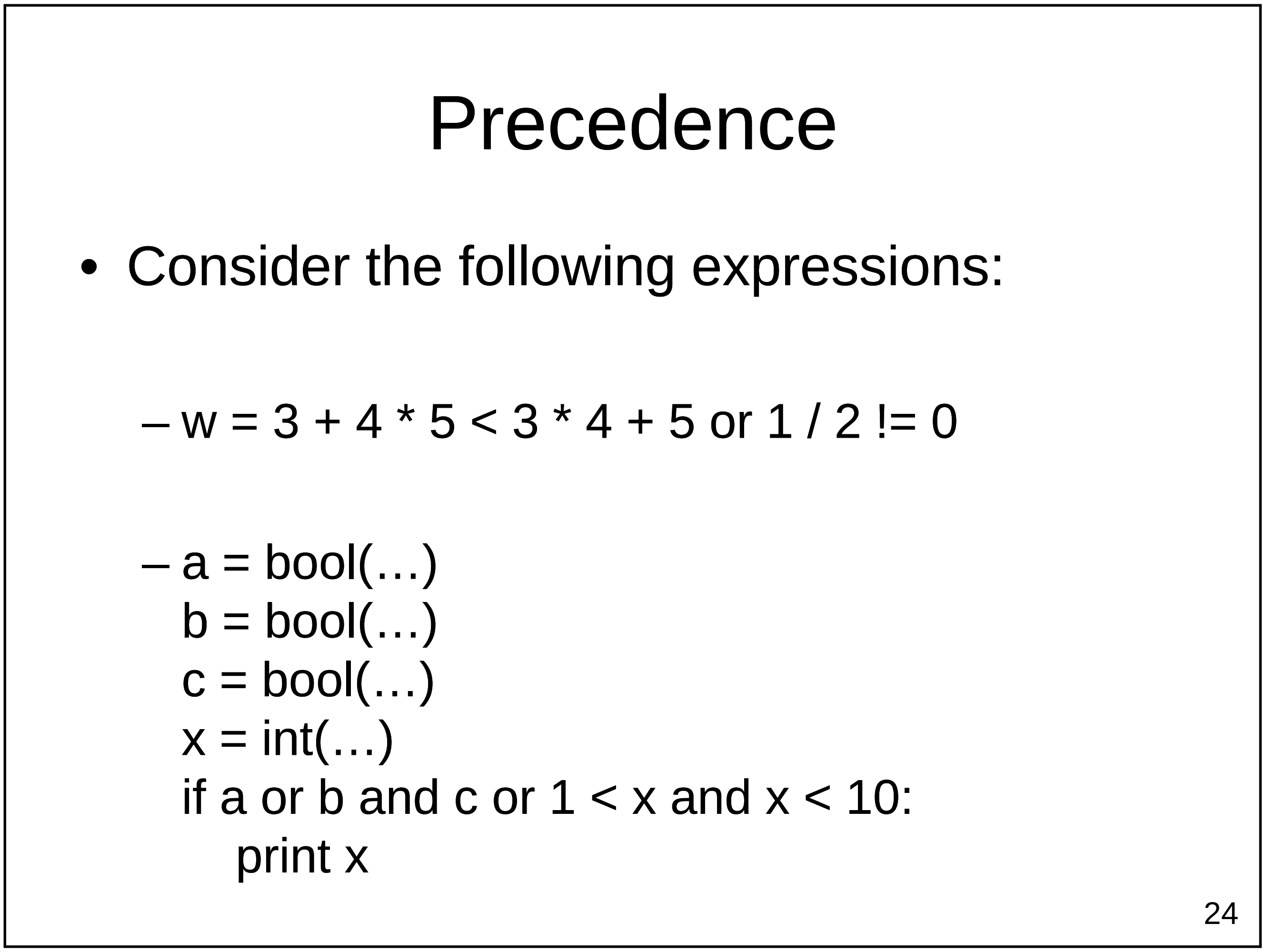
- Boolean logic is the basis for computation in modern computers
  - Circuits can implement logical operations
  - Arithmetic operations can be built up from logical operations
  - Memory can be constructed by including feedback loops in the circuits



Gold Example

Precedence

- Relational and logical operators have lower precedence than mathematical operators
  - Mathematical Operators
  - Relational Operators
  - not
  - and
  - or

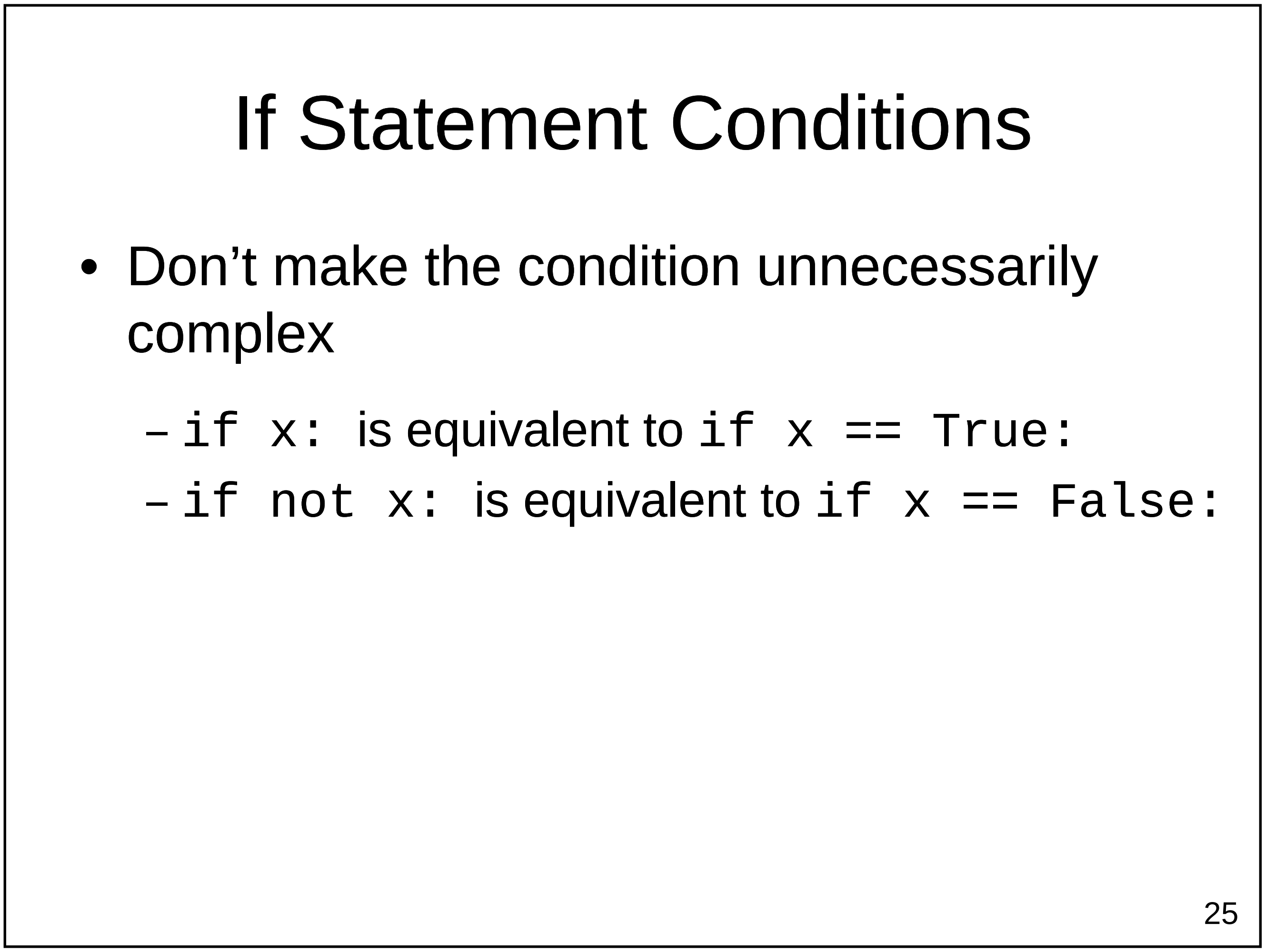


Precedence

- Consider the following expressions:

  -
    ```
    w = 3 + 4 * 5 < 3 * 4 + 5 or 1 / 2 != 0
    ```

  -
    ```
    a = bool(…)
    b = bool(…)
    c = bool(…)
    x = int(…)
    if a or b and c or 1 < x and x < 10:
        print x
    ```



If Statement Conditions

- Don’t make the condition unnecessarily complex
  - `if x:` is equivalent to `if x == True:`
  - `if not x:` is equivalent to `if x == False:`

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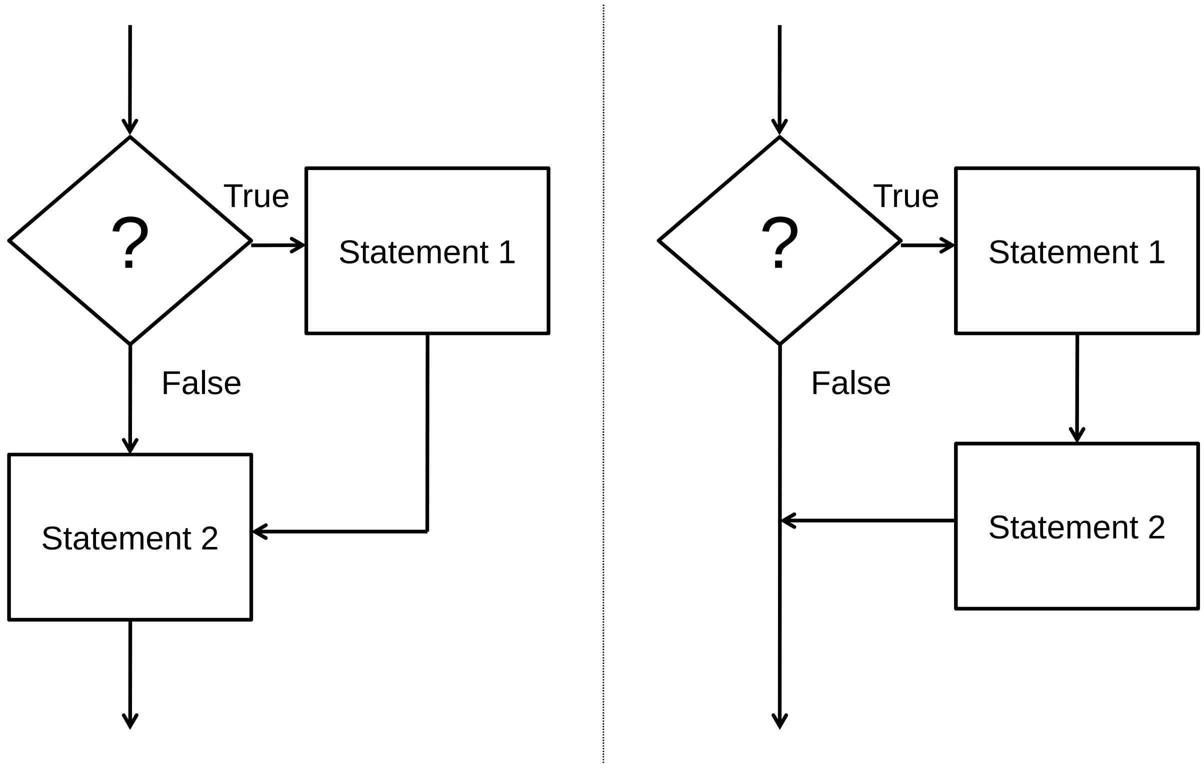
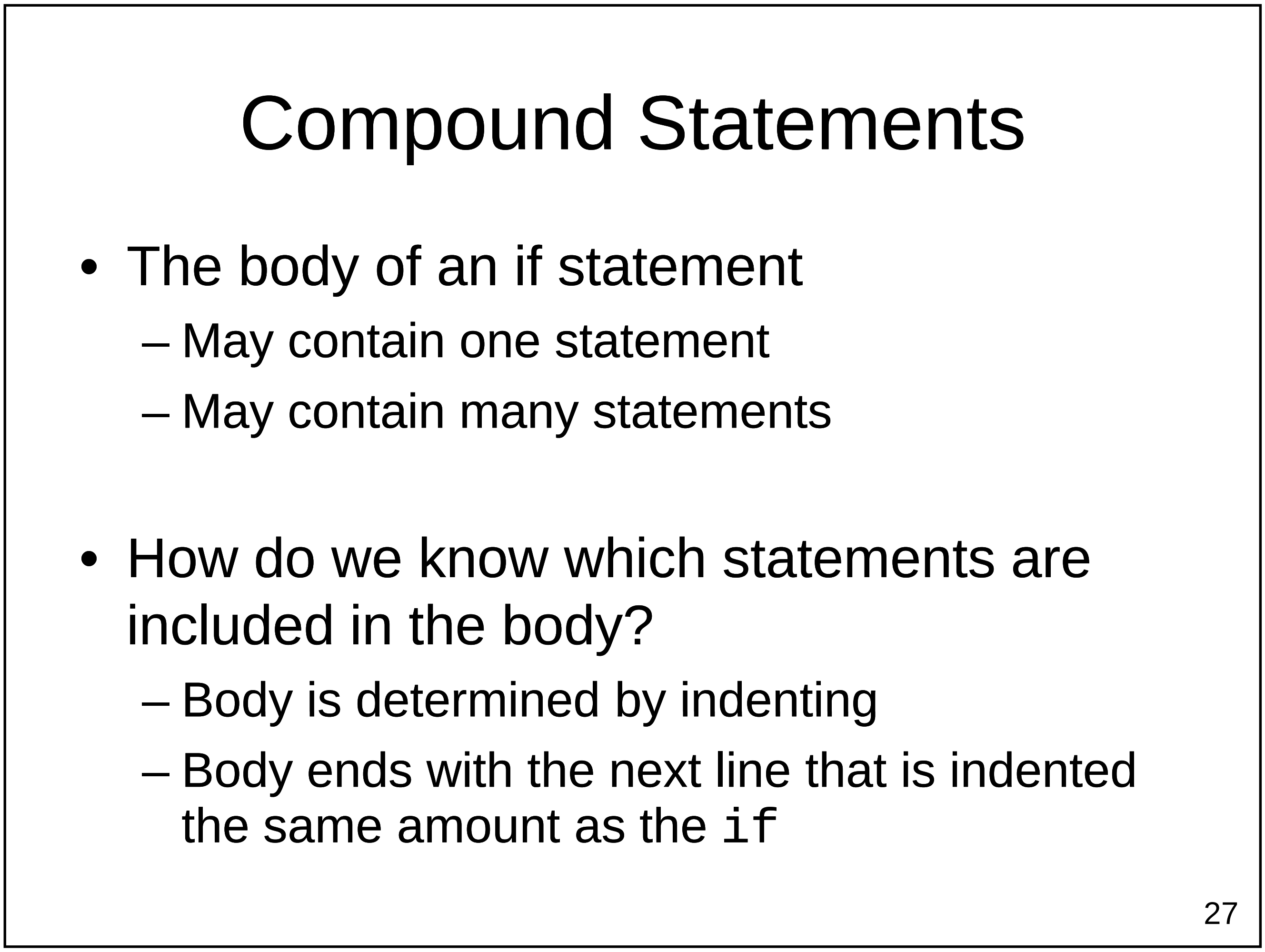
Compound Statements

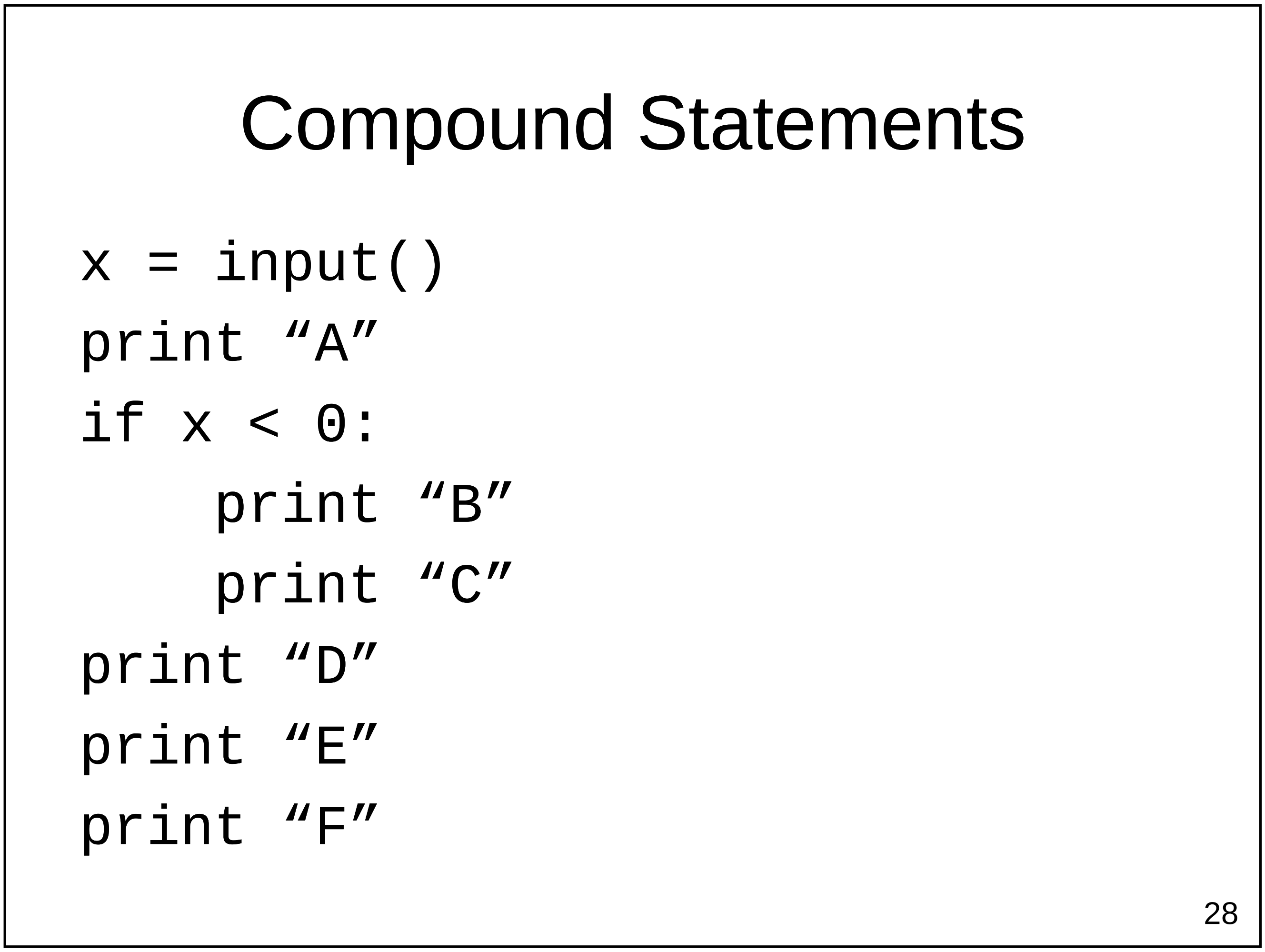




Compound Statements

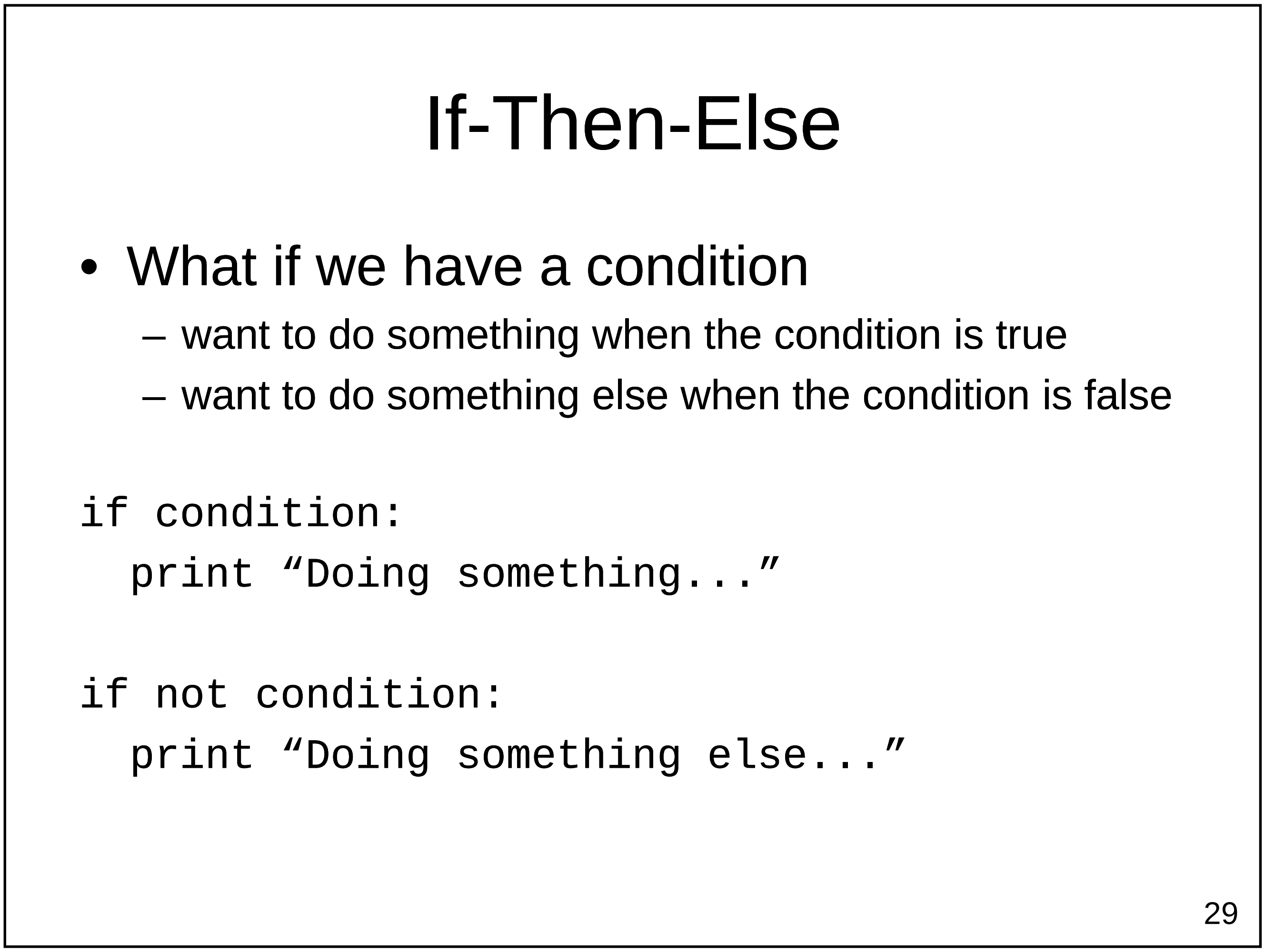
- The body of an if statement
  - May contain one statement
  - May contain many statements

- How do we know which statements are included in the body?
  - Body is determined by indenting
  - Body ends with the next line that is indented the same amount as the `if`



Compound Statements

```
x = input()
print “A”
if x < 0:
    print “B”
    print “C”
print “D”
print “E”
print “F”
```



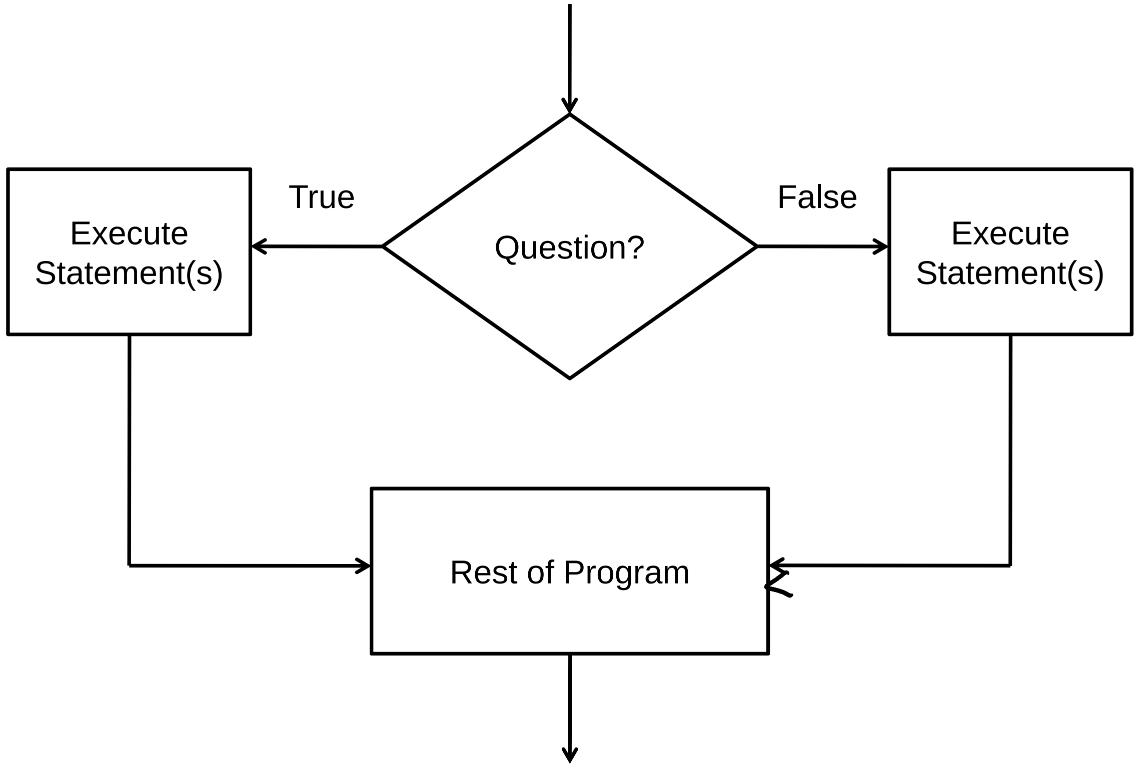
If-Then-Else

- What if we have a condition
  - want to do something when the condition is true
  - want to do something else when the condition is false

```
if condition:
  print “Doing something...”

if not condition:
  print “Doing something else...”
```

If-Then-Else



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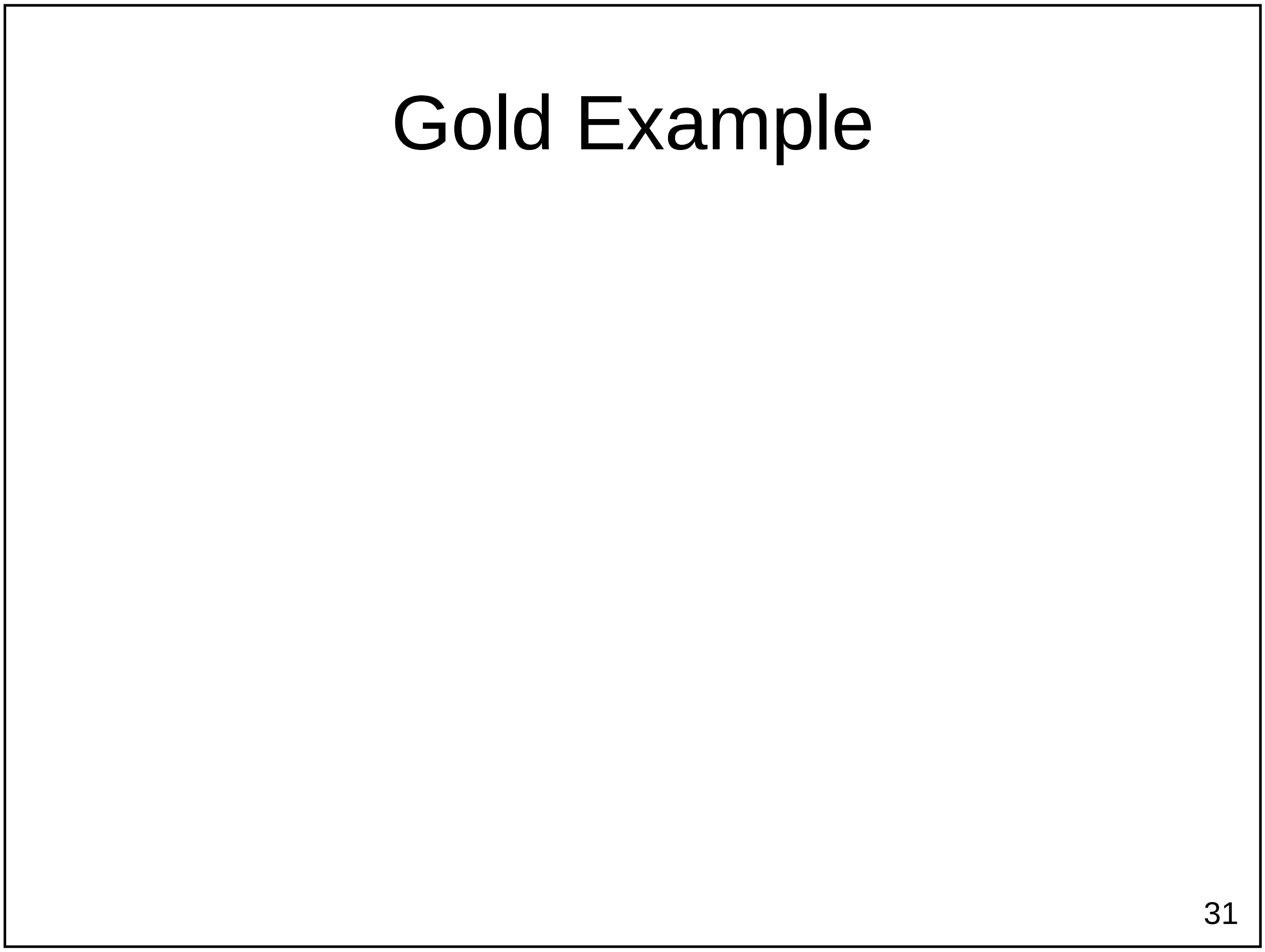
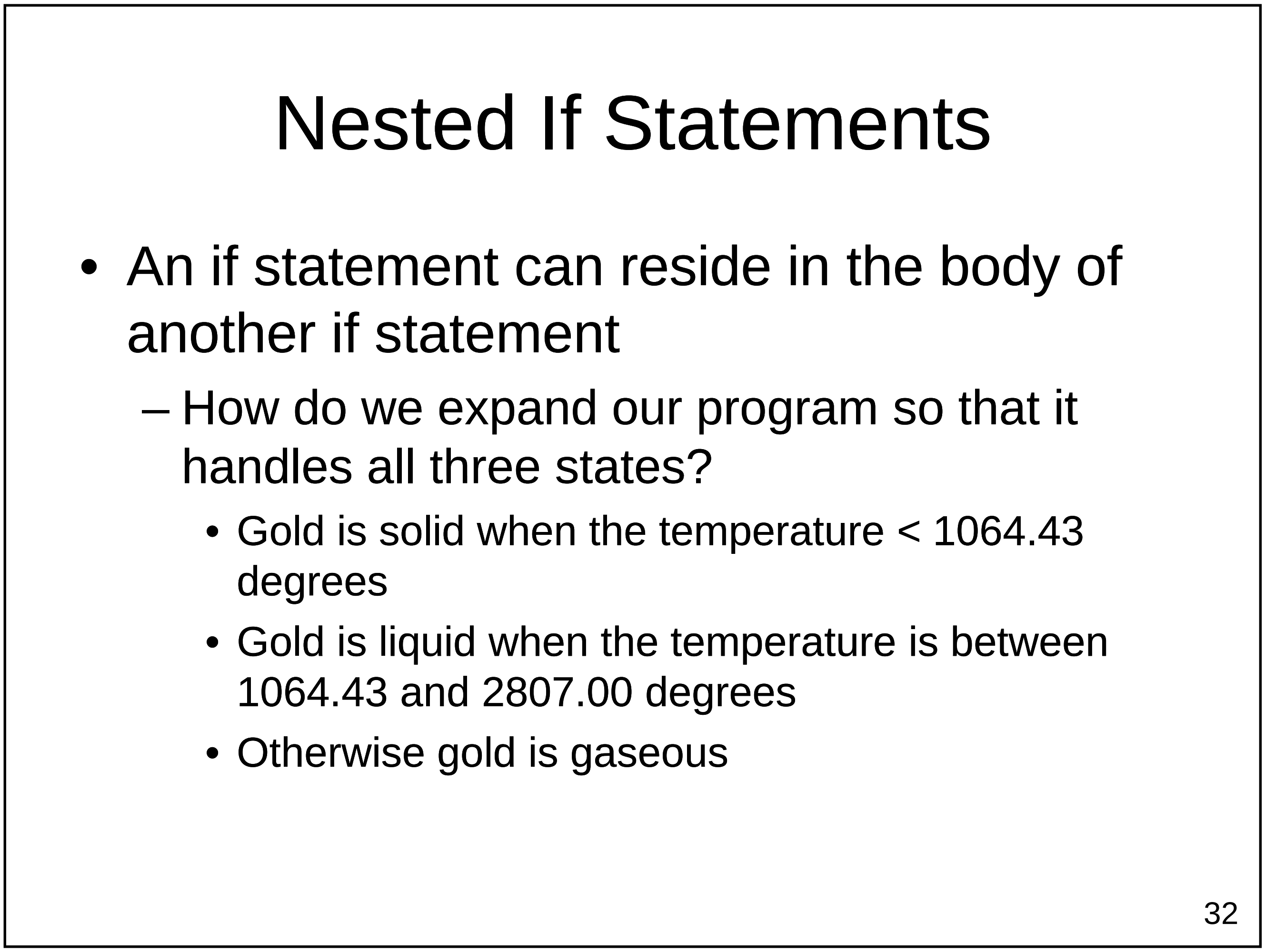
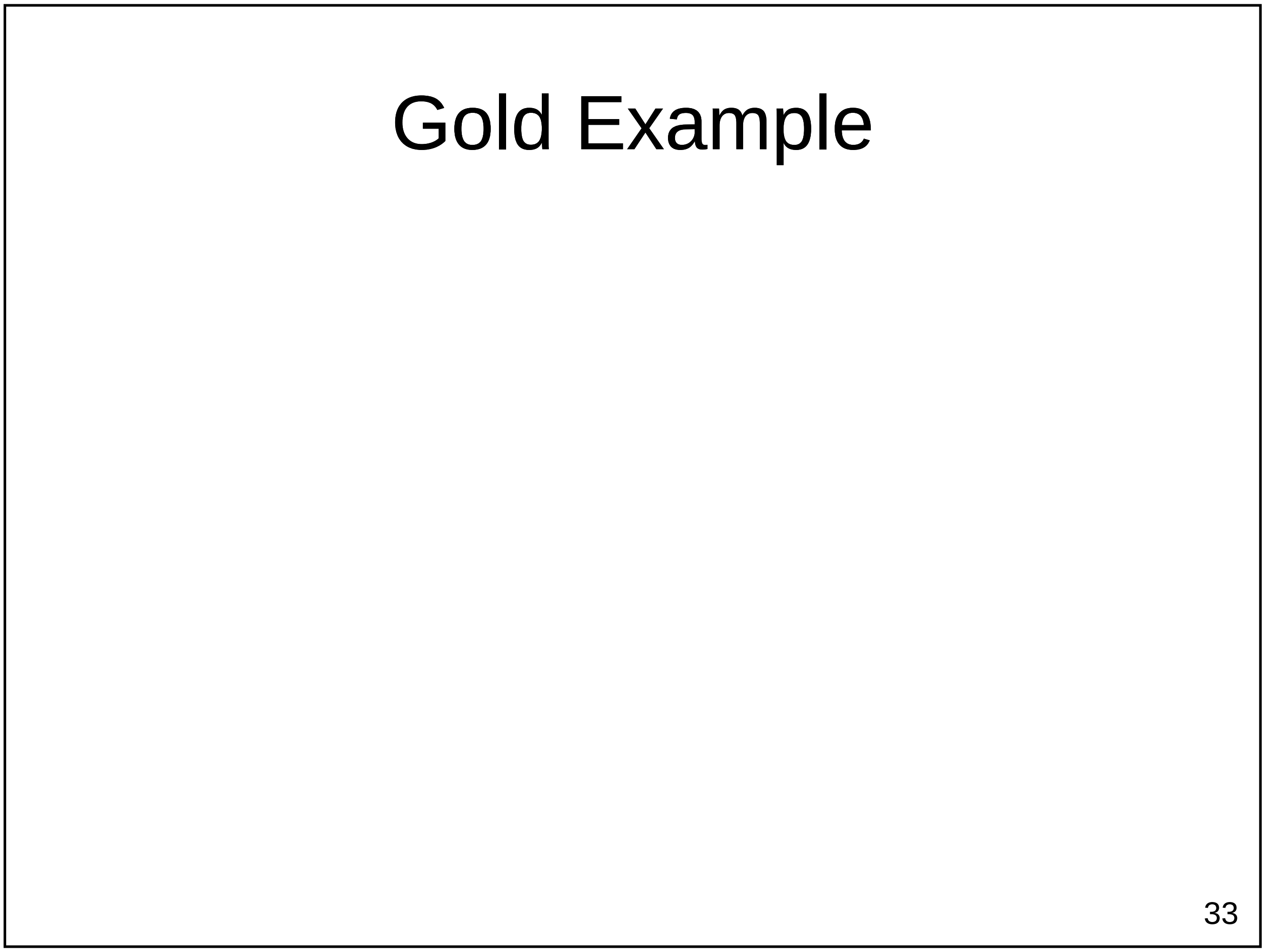


Gold Example



Nested If Statements

- An if statement can reside in the body of another if statement
  - How do we expand our program so that it handles all three states?
    - Gold is solid when the temperature < 1064.43 degrees
    - Gold is liquid when the temperature is between 1064.43 and 2807.00 degrees
    - Otherwise gold is gaseous



Gold Example

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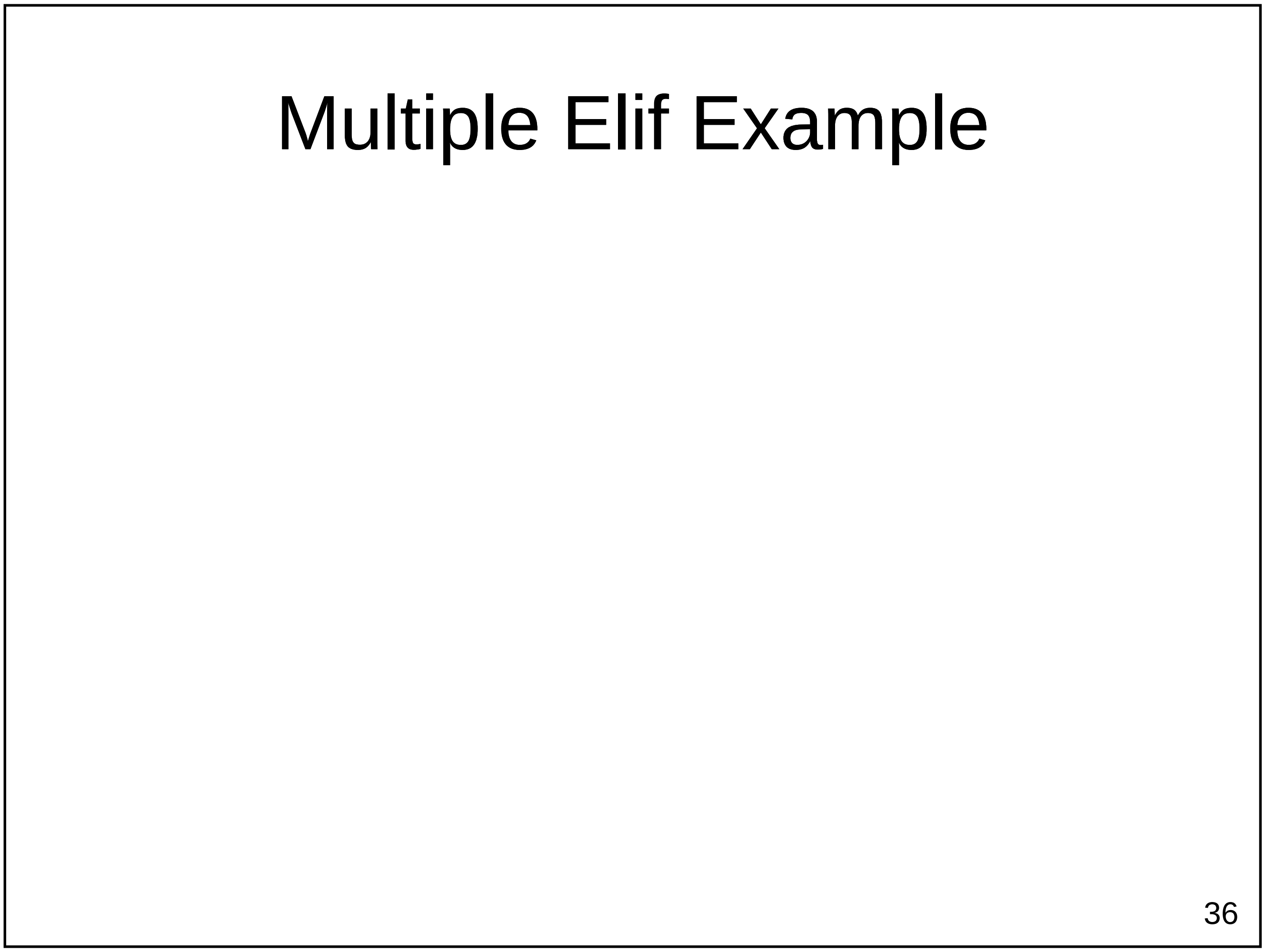
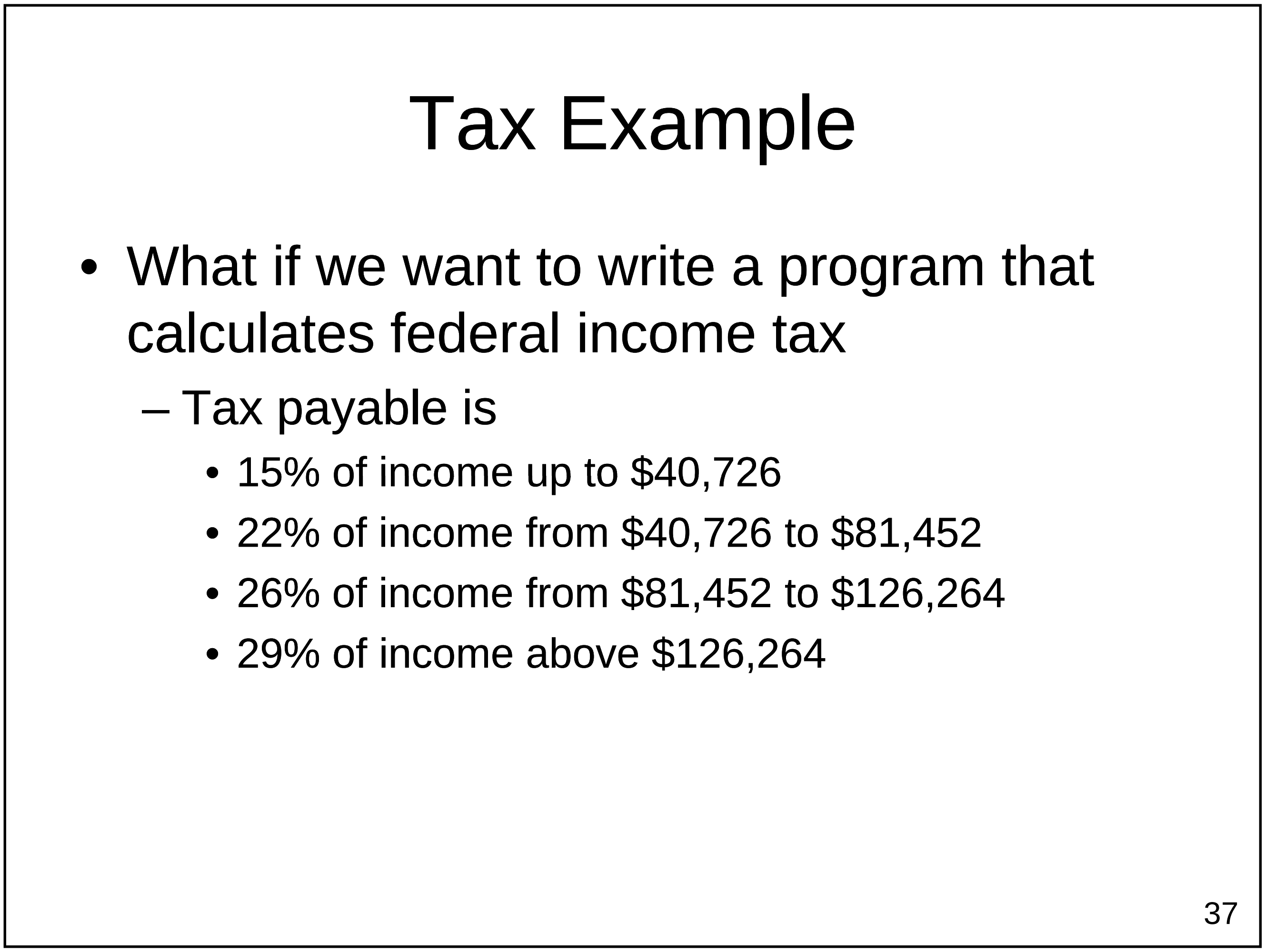
If-Then-Elif-Else

- Allows exactly one of several options to execute
  - Conditions are tested sequentially until one evaluates to True
  - Body of the condition is executed
  - No further conditions are considered

Gold Example

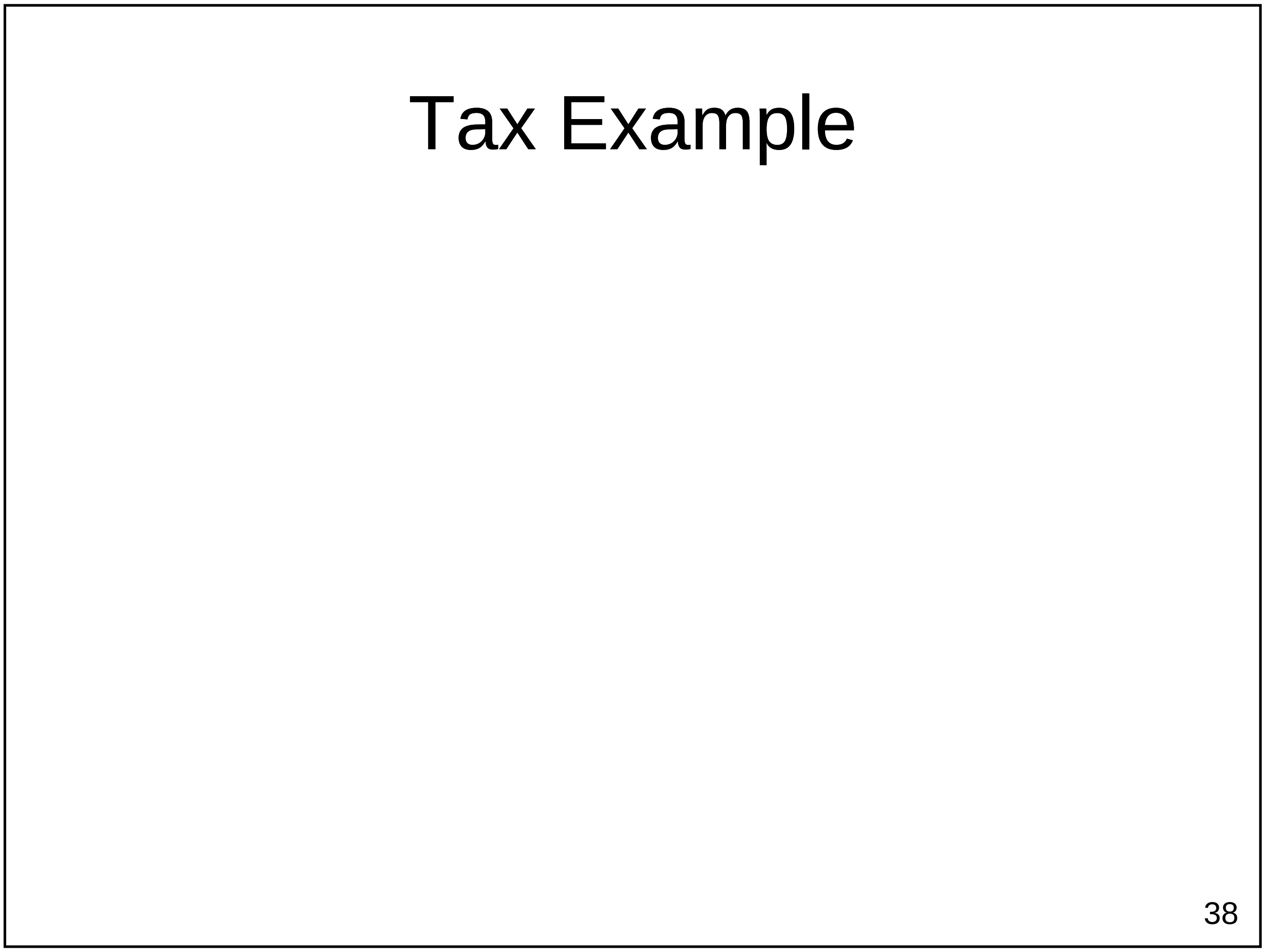


Multiple Elif Example

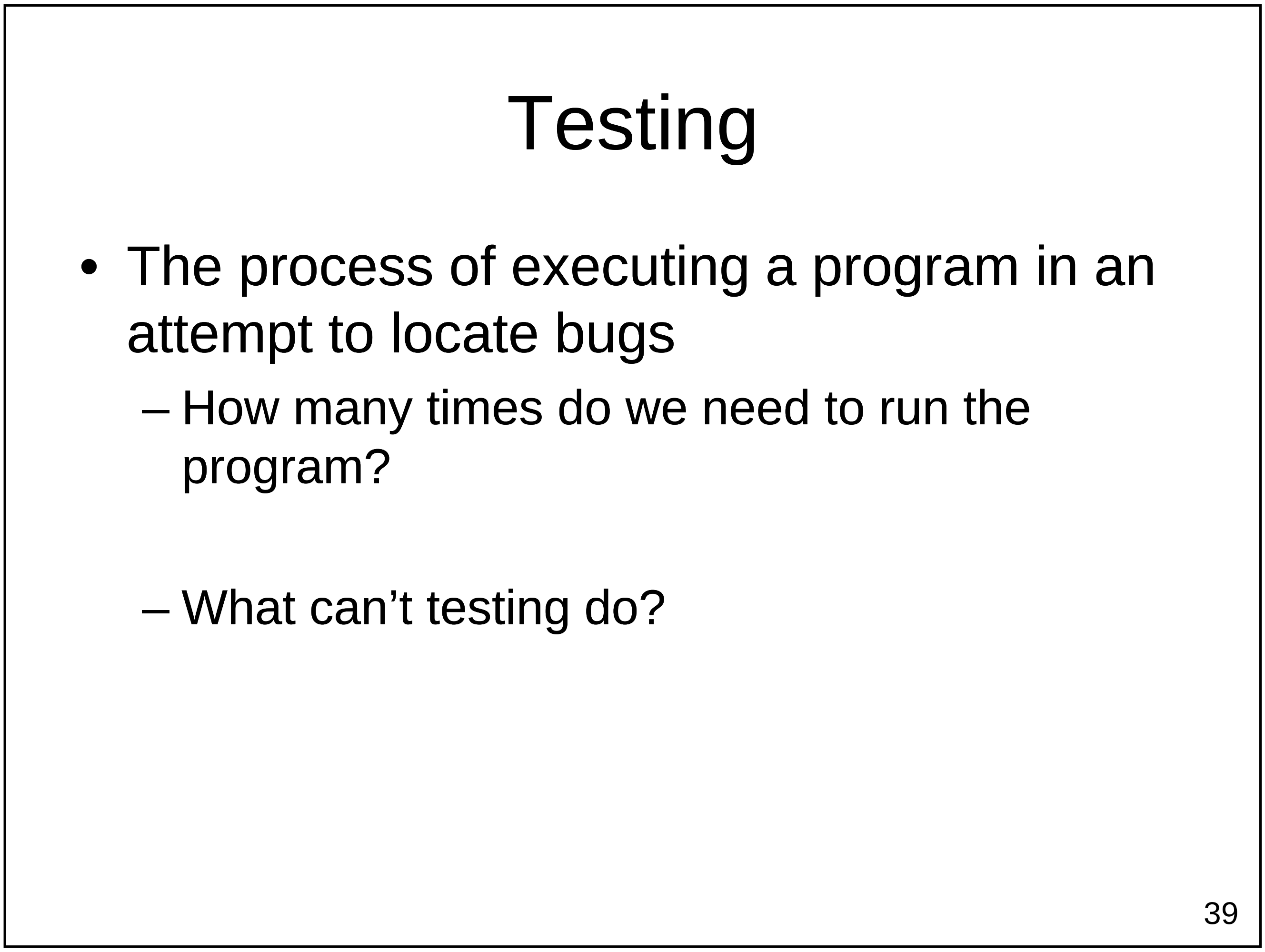


Tax Example

- What if we want to write a program that calculates federal income tax
  - Tax payable is
    - 15% of income up to $40,726
    - 22% of income from $40,726 to $81,452
    - 26% of income from $81,452 to $126,264
    - 29% of income above $126,264

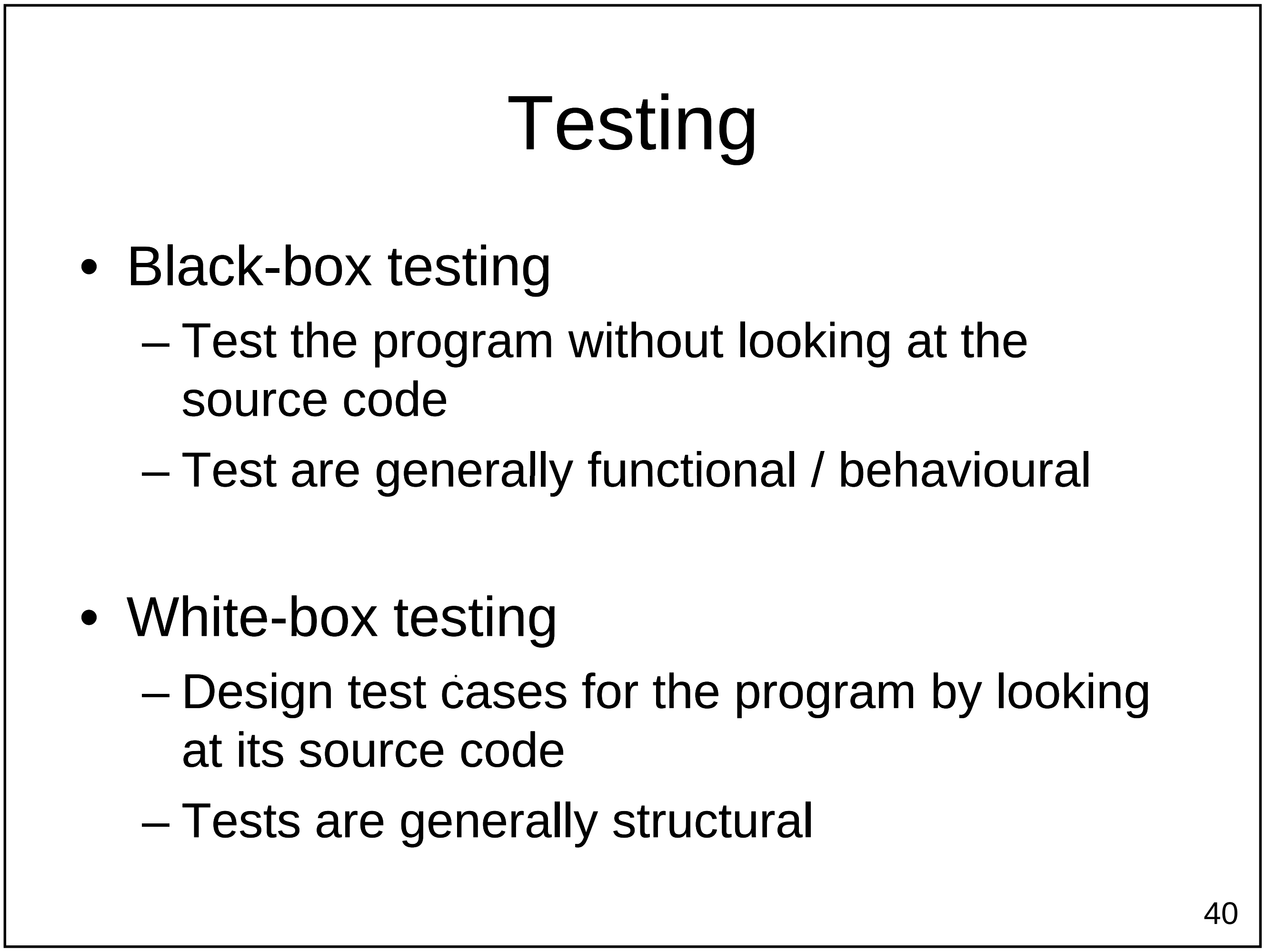


Tax Example



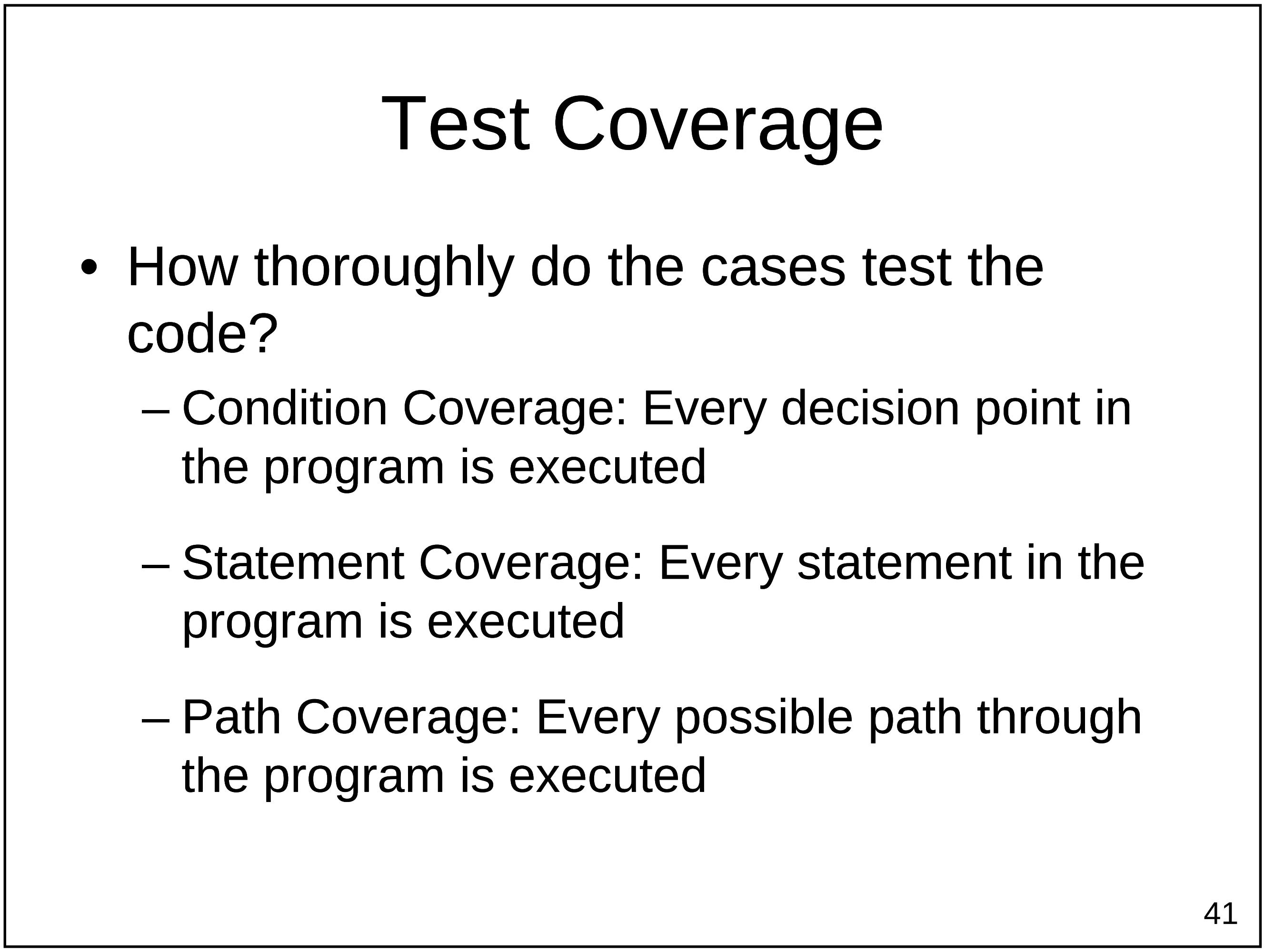
Testing

- The process of executing a program in an attempt to locate bugs
  - How many times do we need to run the program?
  - What can’t testing do?



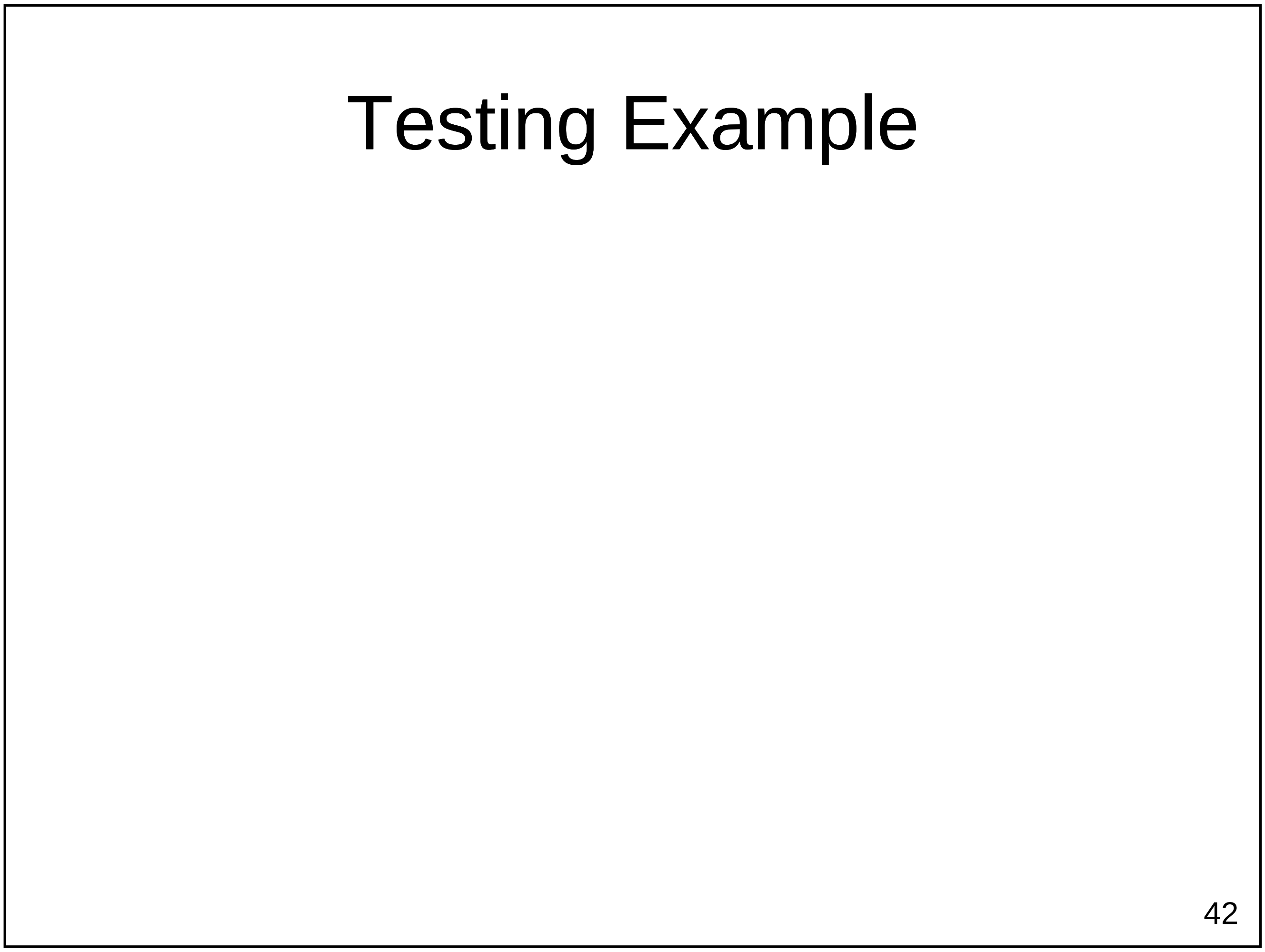
Testing

- Black-box testing
  - Test the program without looking at the source code
  - Test are generally functional / behavioural
- White-box testing
  - Design test cases for the program by looking at its source code
  - Tests are generally structural



Test Coverage

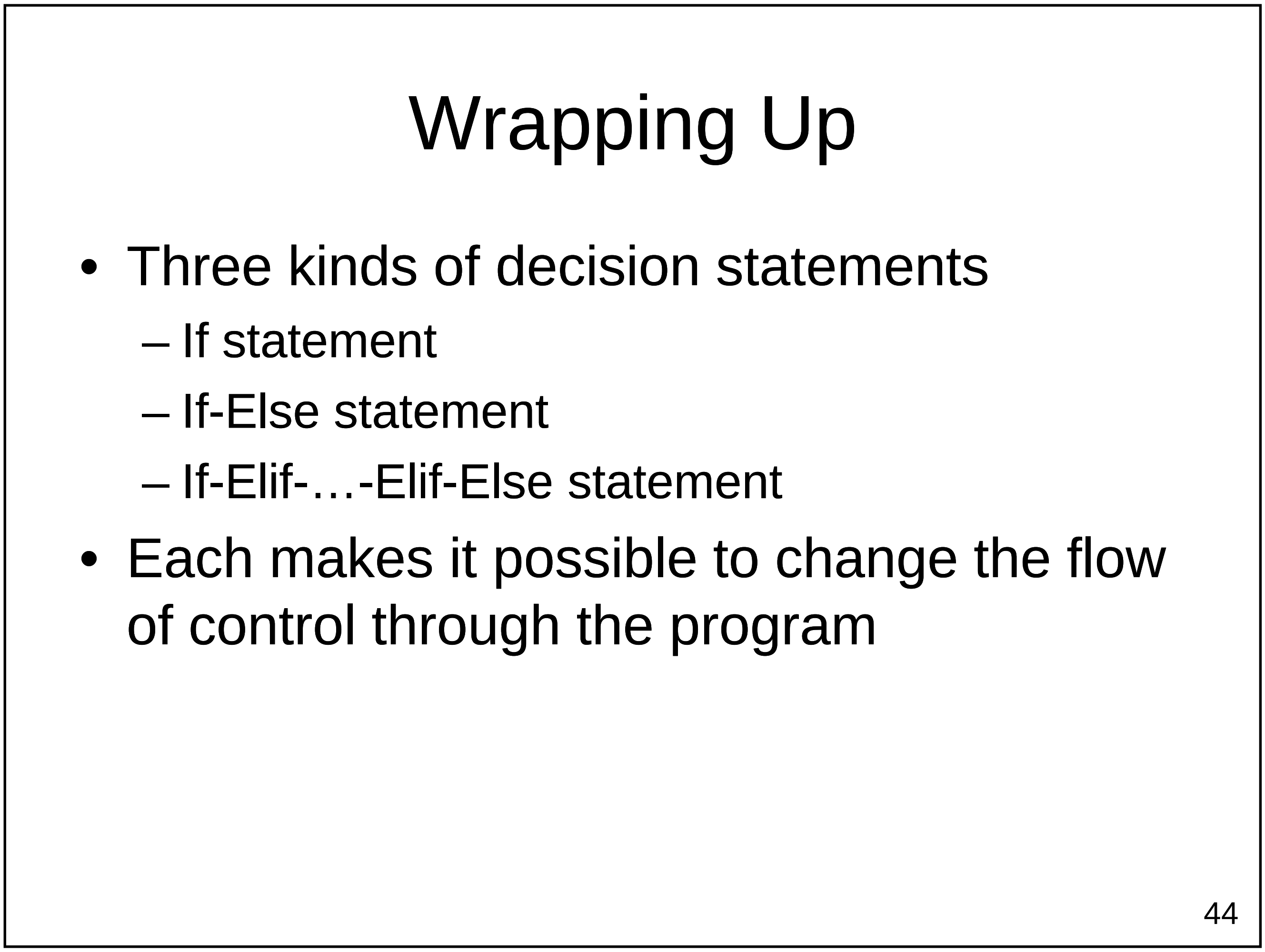
- How thoroughly do the cases test the code?
  - Condition Coverage: Every decision point in the program is executed
  - Statement Coverage: Every statement in the program is executed
  - Path Coverage: Every possible path through the program is executed



Testing Example

The Dangers of Floating Point Numbers

- Floating point numbers approximate real numbers
  - Can cause problems when testing for equality

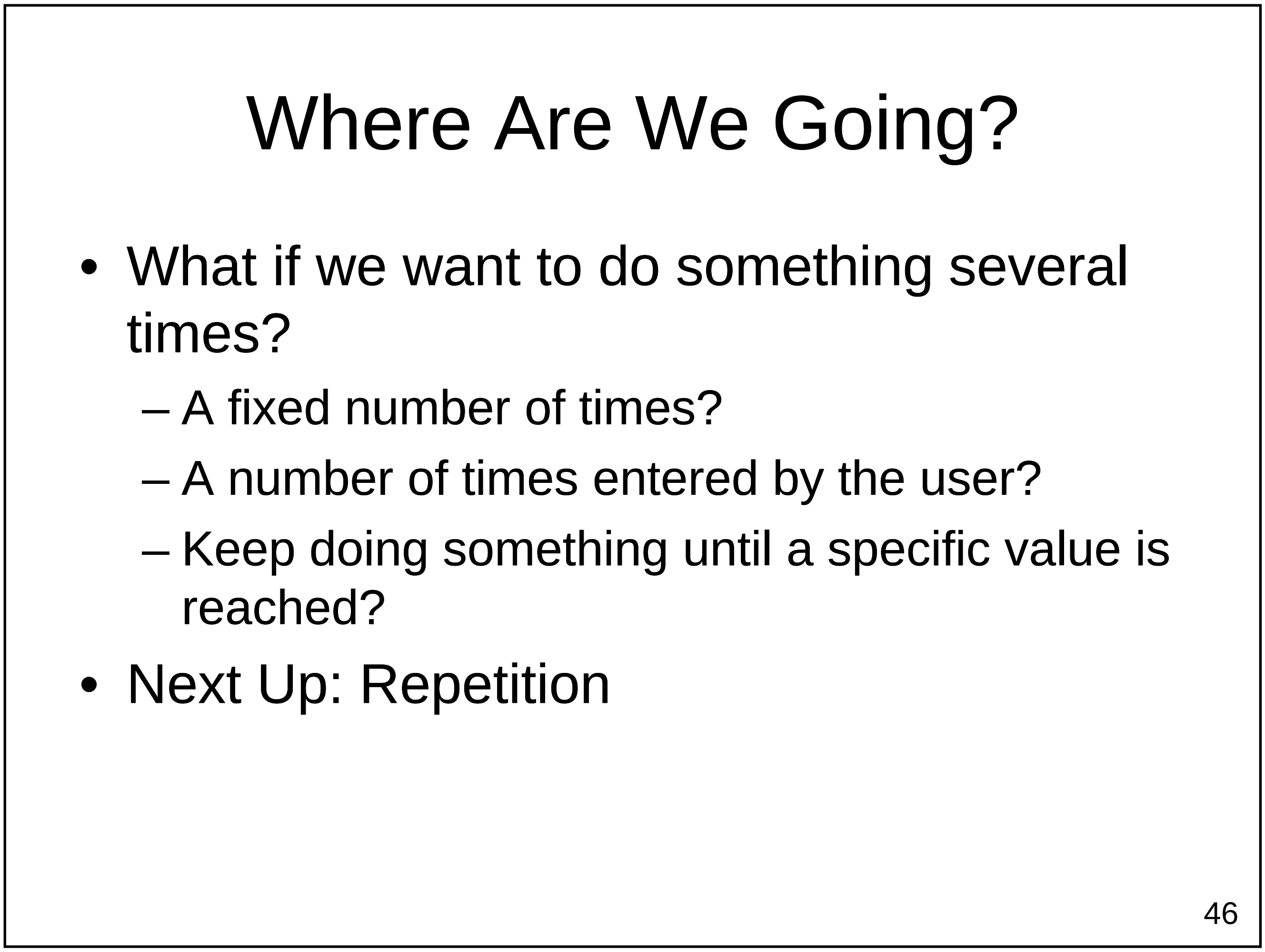


Wrapping Up

- Three kinds of decision statements
  - If statement
  - If-Else statement
  - If-Elif-…-Elif-Else statement
- Each makes it possible to change the flow of control through the program

Wrapping Up

- More complex control flow requires
  - Additional design
  - Additional testing
    - Black box
    - White box



Where Are We Going?

- What if we want to do something several times?
  - – A fixed number of times?
  - – A number of times entered by the user?
  - – Keep doing something until a specific value is reached?
- Next Up: Repetition