

CONTROL STRUCTURES



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Transforming Education; Transforming Lives

Comparison Operators

- It is common practice to compare things in computing.
- Comparison operators enable us to do that, they return a True or False value.
- Enable logic in the computer

Comparison Operators

Operator	Name	
=	Equals	True if two values are the same 5 = 5 is True, 4 = 5 is False
>	Greater than	True if value on left is greater than value on the right. 4 > 5 = True, 5 > 4 is False
<	Less than	True if value on left is smaller than value on the right. 4 < 5 = True, 5 < 4 is False
>=	Greater than or equal to	True if value on left is greater than or equal to value on the right.
<=	Less than or equal to	True if value on left is smaller than or the same as the value on the right.
<>	Not equal to	True if the two values are not the same. 5 <> 4 is True, 5 <> 5 is False

Control Structures

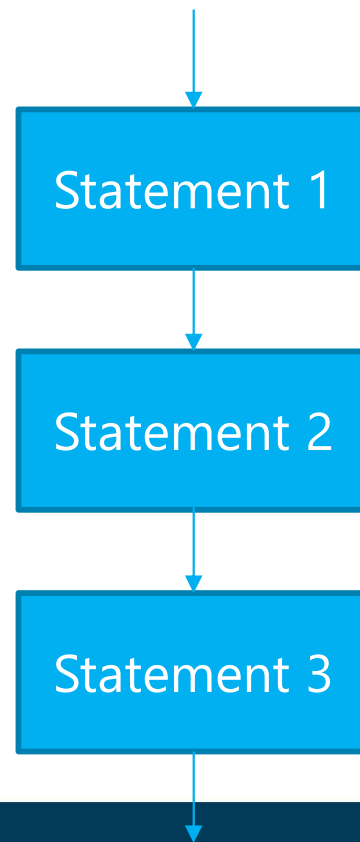
- What if we wanted to make the following changes to the simple algorithms we have been writing:
 - In the Student Credits problem, if student has a enough credits display a congratulations message, otherwise display credits left
 - The Shopping Basket Calculator: allow the user to enter any number of Item prices they want.
- We need control structures!

Control Structures

- So far we have looked at simple solutions to problems.
- They start at a beginning and continue in a sequential order (one-step after the other).
- In computing, this is usually not enough to describe the steps of a solution.
- There are three main types of control when defining the order of steps in a computer solution:
 - Sequence
 - Selection
 - Repetition

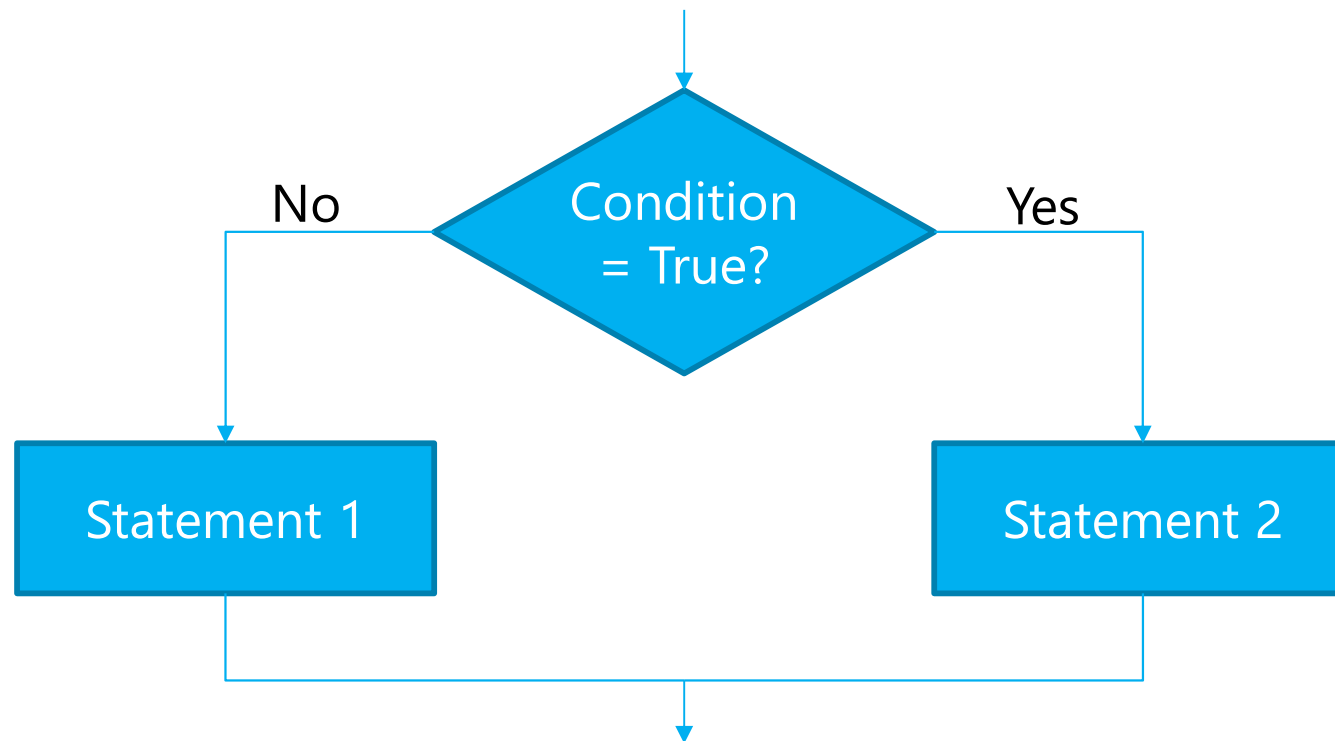
Sequence

- This is what we have been doing so far.
- Start at a beginning and execute steps one after the other in **sequence** (serial) order.

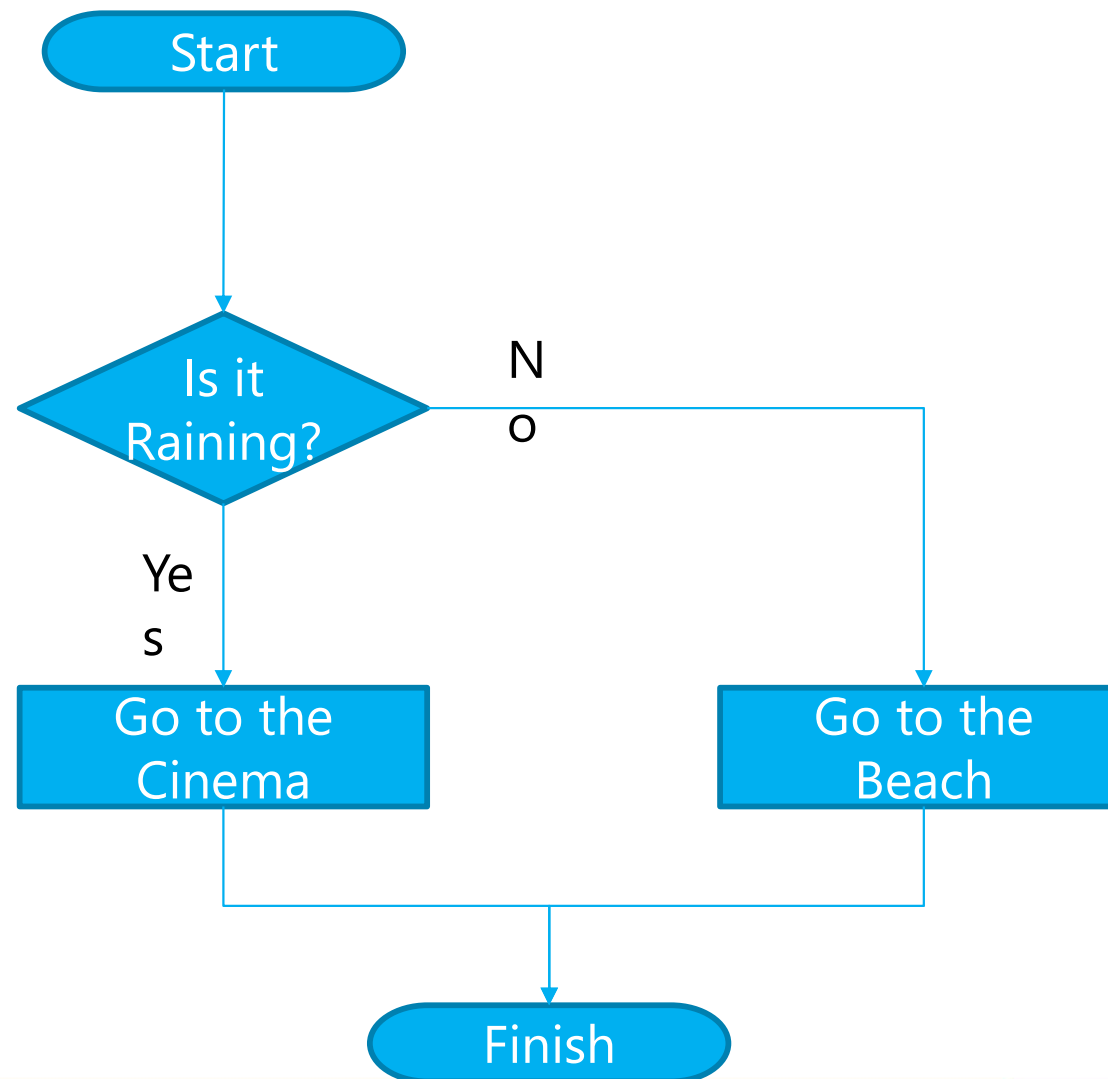


Selection (Decision)

- Choose the statement (branch) to execute is selected based on a condition.
- The **Selection** statement is also called a **Branch** or **Decision**

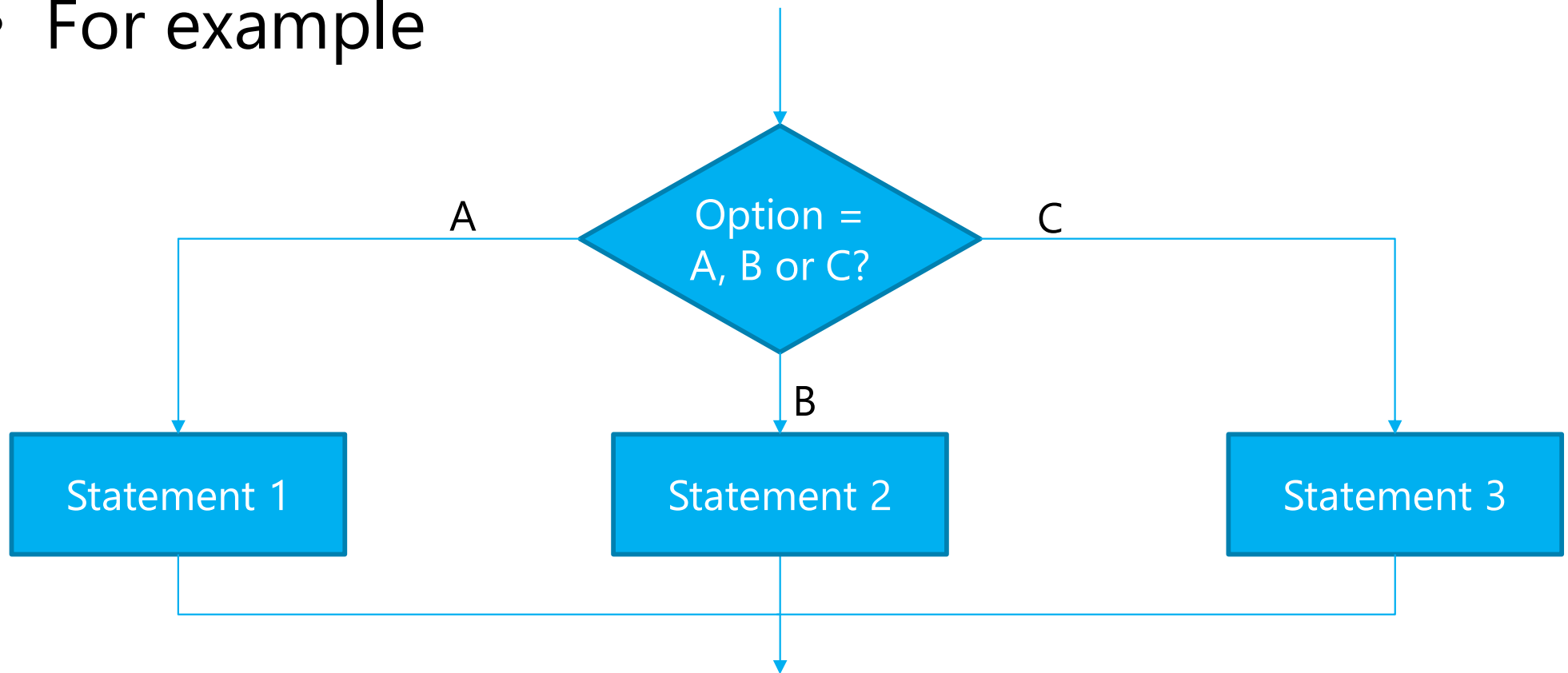


Selection (Decision) A Simple Example



Selection

- You can have multiple branches in a Selection control statement.
- For example



Pseudocode and Control Structures

- We know how to write pseudocode for Sequence statements.
- What about for Selection and Repetition?

Pseudo code - Selection

- Scenario 1
 - A system prompts for a number and then displays whether it is an odd or an even

Possible Answer

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 **THEN** condition
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

Possible Answer & Trace Table

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 THEN
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

test with three numbers: 4, 7, and 10

Step	Action	num	Condition Checked	Output
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Possible Answer & Trace Table

test with three numbers: 4, 7, and 10.

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 THEN
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

Step	Action	num	Condition Checked	Output
1	Display "Enter a number ?"			"Enter a number ?"



Possible Answer & Trace Table

test with three numbers: 4, 7, and 10.

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 THEN
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

Step	Action	num	Condition Checked	Output
1	Display "Enter a number ?"			"Enter a number ?"
2	Input num	4		



Possible Answer & Trace Table

test with three numbers: 4, 7, and 10.

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 THEN
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

Step	Action	num	Condition Checked	Output
1	Display "Enter a number ?"			"Enter a number ?"
2	Input num	4		
3	IF (num%2) == 0 THEN	4	(4 % 2) == 0	



Possible Answer & Trace Table

test with three numbers: 4, 7, and 10.

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 THEN
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

Step	Action	num	Condition Checked	Output
1	Display "Enter a number ?"			"Enter a number ?"
2	Input num	4		
3	IF (num%2) == 0 THEN	4	(4 % 2) == 0	
4	Display "Even number"	4	True	"Even number"



Possible Answer & Trace Table

test with three numbers: 4, 7, and 10.

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 THEN
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

Step	Action	num	Condition Checked	Output
1	Display "Enter a number ?"			"Enter a number ?"
2	Input num	4		
3	IF (num%2) == 0 THEN	4	(4 % 2) == 0	
4	Display "Even number"	4	True	"Even number"
5	Display "Enter a number ?"			"Enter a number ?"
6	Input num	7		
7	IF (num%2) == 0 THEN	7	(7 % 2) == 0	
8	ELSE	7	False	
9	Display "Odd number"	7		"Odd number"

Possible Answer & Trace Table

test with three numbers: 4, 7, and 10.

1. Display "Enter a number ?"
2. Input num
3. **IF** (num%2) ==0 THEN
4. Display "Even number"
5. **ELSE**
6. Display "Odd number"
7. **END IF**

Step	Action	num	Condition Checked	Output
1	Display "Enter a number ?"			"Enter a number ?"
2	Input num	4		
3	IF (num%2) == 0 THEN	4	(4 % 2) == 0	
4	Display "Even number"	4	True	"Even number"
5	Display "Enter a number ?"			"Enter a number ?"
6	Input num	7		
7	IF (num%2) == 0 THEN	7	(7 % 2) == 0	
8	ELSE	7	False	
9	Display "Odd number"	7		"Odd number"
10	Display "Enter a number ?"			"Enter a number ?"
11	Input num	10		
12	IF (num%2) == 0 THEN	10	(10 % 2) == 0	
13	Display "Even number"	10	True	"Even number"



Pseudo code - Selection

- Scenario 2
 - A student enters a mark and system predicts the grade based on the following scheme
 - 0 to 40 -> F
 - 41 to 60 -> D
 - 61 to 70 -> C
 - 71 to 80 -> B
 - 81 to 100 -> A

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40) **THEN** Condition 1
4. Display "F" Condition 2
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D" Condition 3
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C" Condition 4
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B" Condition 5
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **END IF**

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **END IF**

Now what happens if the user enters '105' or a negative number?

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. Display "Invalid mark"
15. **END IF**

Now what happens if the user enters '105' or a negative number?

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. Display "Invalid mark"
15. **END IF**

consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. **Display "Invalid mark"**
15. **END IF**

Step	Action	mark	Condition Checked	Output
1	Display "Enter a mark:"			"Enter a mark:"
2	Input mark	35		
3	IF mark ≥ 0 AND mark ≤ 40	35	35 ≥ 0 AND 35 ≤ 40 (True)	
4	Display "Grade: F"	35	True	"Grade: F"

consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. **Display "Invalid mark"**
15. **END IF**

5	Display "Enter a mark:"			"Enter a mark:"
6	Input mark	50		
7	IF mark ≥ 0 AND mark ≤ 40	50	50 ≥ 0 AND 50 ≤ 40 (False)	
8	ELSE IF mark ≥ 41 AND ≤ 60	50	50 ≥ 41 AND 50 ≤ 60 (True)	
9	Display "Grade: D"	50	True	"Grade: D"

consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. **Display "Invalid mark"**
15. **END IF**

10	Display "Enter a mark:"			"Enter a mark:"
11	Input mark	65		
12	IF mark ≥ 0 AND mark ≤ 40	65	65 ≥ 0 AND 65 ≤ 40 (False)	
13	ELSE IF mark ≥ 41 AND ≤ 60	65	65 ≥ 41 AND 65 ≤ 60 (False)	
14	ELSE IF mark ≥ 61 AND ≤ 70	65	65 ≥ 61 AND 65 ≤ 70 (True)	
15	Display "Grade: C"	65	True	"Grade: C"

consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. Display "Invalid mark"
15. **END IF**

16	Display "Enter a mark:"			"Enter a mark:"
17	Input mark	75		
18	IF mark ≥ 0 AND mark ≤ 40	75	75 ≥ 0 AND 75 ≤ 40 (False)	
19	ELSE IF mark ≥ 41 AND ≤ 60	75	75 ≥ 41 AND 75 ≤ 60 (False)	
20	ELSE IF mark ≥ 61 AND ≤ 70	75	75 ≥ 61 AND 75 ≤ 70 (False)	
21	ELSE IF mark ≥ 71 AND ≤ 80	75	75 ≥ 71 AND 75 ≤ 80 (True)	
22	Display "Grade: B"	75	True	"Grade: B"

consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. Display "Invalid mark"
15. **END IF**

23	Display "Enter a mark:"			"Enter a mark:"
24	Input mark	90		
25	IF mark ≥ 0 AND mark ≤ 40	90	90 ≥ 0 AND 90 ≤ 40 (False)	
26	ELSE IF mark ≥ 41 AND ≤ 60	90	90 ≥ 41 AND 90 ≤ 60 (False)	
27	ELSE IF mark ≥ 61 AND ≤ 70	90	90 ≥ 61 AND 90 ≤ 70 (False)	
28	ELSE IF mark ≥ 71 AND ≤ 80	90	90 ≥ 71 AND 90 ≤ 80 (False)	
29	ELSE IF mark ≥ 81 AND ≤ 100	90	90 ≥ 81 AND 90 ≤ 100 (True)	
30	Display "Grade: A"	90	True	"Grade: A"

consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. **IF** (mark ≥ 0 and mark ≤ 40)
4. Display "F"
5. **ELSE IF** (mark ≥ 41 and mark ≤ 60) **THEN**
6. Display "D"
7. **ELSE IF** (mark ≥ 61 and mark ≤ 70) **THEN**
8. Display "C"
9. **ELSE IF** (mark ≥ 71 and mark ≤ 80) **THEN**
10. Display "B"
11. **ELSE IF** (mark ≥ 81 and mark ≤ 100) **THEN**
12. Display "A"
13. **ELSE**
14. Display "Invalid mark"
15. **END IF**

32	Input mark	105		
33	IF mark ≥ 0 AND mark ≤ 40	105	105 ≥ 0 AND 105 ≤ 40 (False)	
34	ELSE IF mark ≥ 41 AND ≤ 60	105	105 ≥ 41 AND 105 ≤ 60 (False)	
35	ELSE IF mark ≥ 61 AND ≤ 70	105	105 ≥ 61 AND 105 ≤ 70 (False)	
36	ELSE IF mark ≥ 71 AND ≤ 80	105	105 ≥ 71 AND 105 ≤ 80 (False)	
37	ELSE IF mark ≥ 81 AND ≤ 100	105	105 ≥ 81 AND 105 ≤ 100 (False)	
38	ELSE	105		
39	Display "Invalid mark"	105		"Invalid mark"

consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

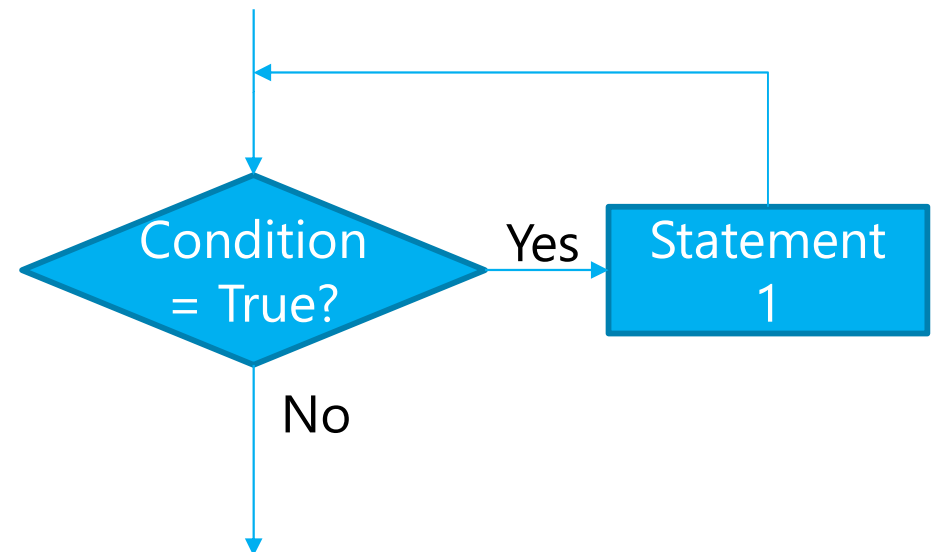
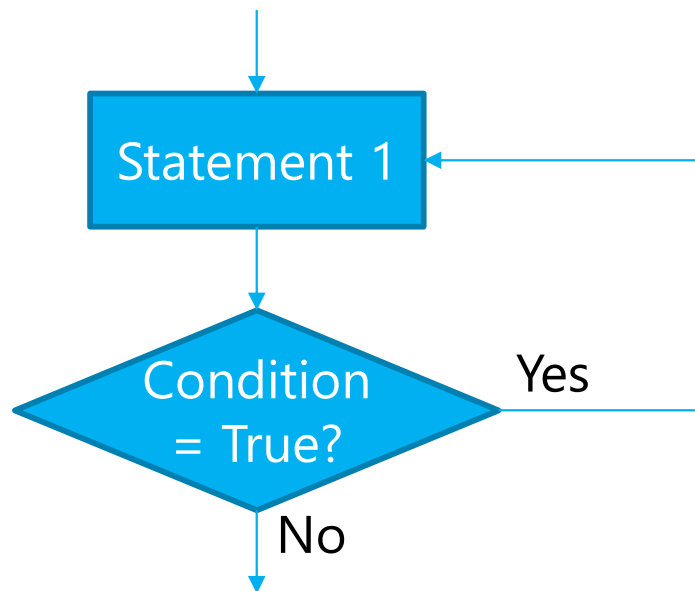
Possible Answer

1. Display "Enter a mark ?"
2. Input mark
3. IF mark < 0 OR mark > 100 THEN
4. Display "Invalid mark"
5. **ELSE IF** (mark >= 0 and mark <=40)
6. Display "F"
7. **ELSE IF** (mark >= 41 and mark <=60) **THEN**
8. Display "D"
9. **ELSE IF** (mark >= 61 and mark <=70) **THEN**
10. Display "C"
11. **ELSE IF** (mark >= 71 and mark <=80) **THEN**
12. Display "B"
13. **ELSE IF** (mark >= 81 and mark <=100) **THEN**
14. Display "A"
15. **END IF**

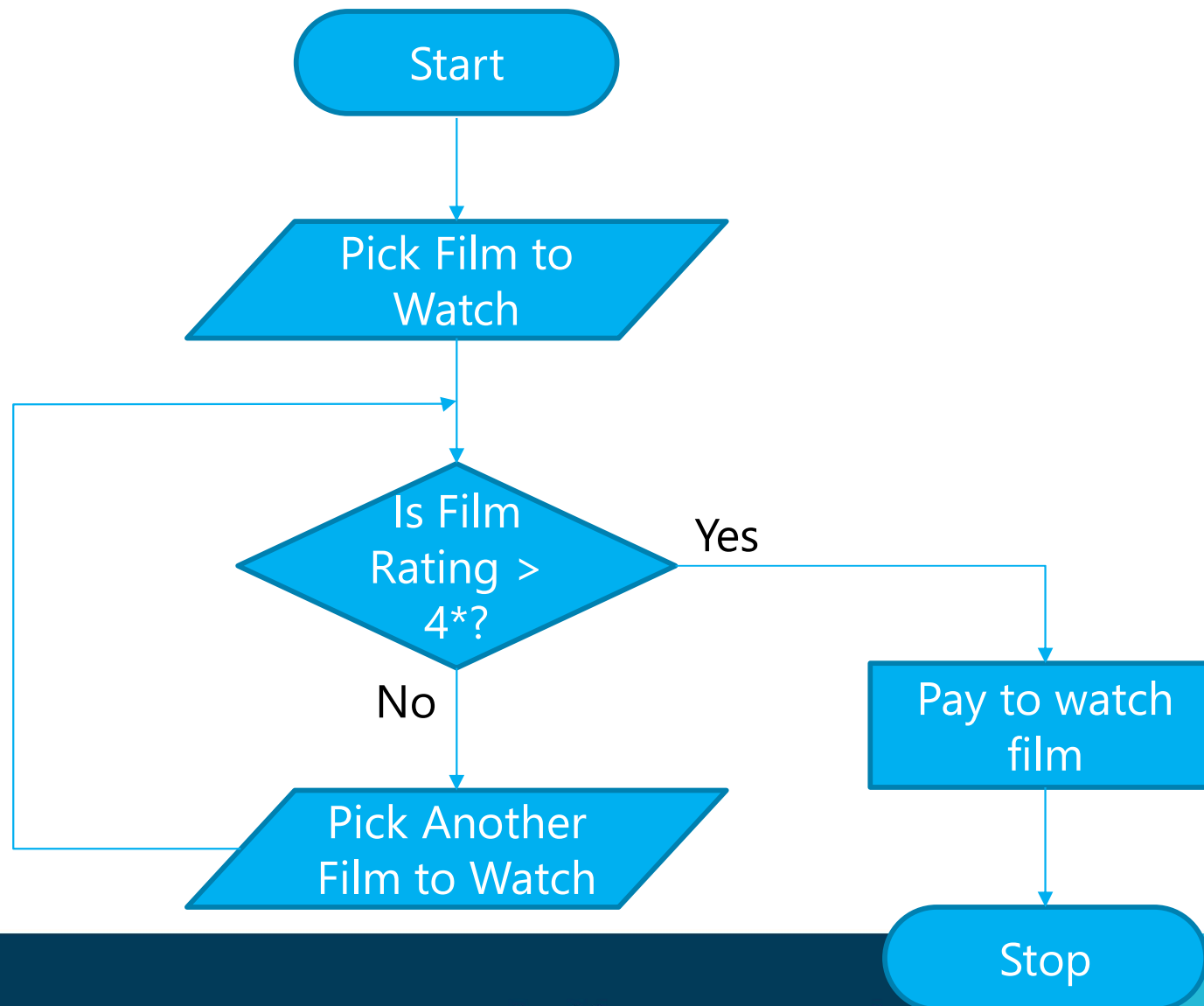
consider various inputs to cover all cases: 35, 50, 65, 75, 90, and an invalid mark 105 and complete the trace table

Repetition

- Repeat statements one or more times
- Also called a **Loop**
- Needs a stop condition i.e. when to stop repeating the loop
- Two types:



Repetition A Simple Example



Guess the Output using trace table

1. Display("Enter a text you like to repeat")
2. Input text
3. Set counter = 0
4. While counter < 5
5. Display text
6. counter = counter + 1
7. END While

Guess the Output using trace table

1. Display("Enter a text you like to repeat")
2. Input text
3. Set counter = 0
4. While counter < 5
5. Display text
6. counter = counter + 1
7. END While

Line	Text	counter	Action
1	Enter a text you like to repeat	-	Display message to user
2	Hello (input)	-	User inputs "Hello"
3	-	0	Initialize counter to 0
4	-	0	Check counter < 5 (True)
5	Hello	0	Display "Hello"
6	-	1	Increment counter (counter = 1)

Guess the Output using trace table

1. Display("Enter a text you like to repeat")
2. Input text
3. Set counter = 0
4. While counter < 5
5. Display text
6. counter = counter + 1
7. END While

Line	Text	counter	Action
1	Enter a text you like to repeat	-	Display message to user
2	Hello (input)	-	User inputs "Hello"
3	-	0	Initialize counter to 0
4	-	0	Check counter < 5 (True)
5	Hello	0	Display "Hello"
6	-	1	Increment counter (counter = 1)
4	-	1	Check counter < 5 (True)
5	Hello	1	Display "Hello"
6	-	2	Increment counter (counter = 2)
4	-	2	Check counter < 5 (True)
5	Hello	2	Display "Hello"
6	-	3	Increment counter (counter = 3)
4	-	3	Check counter < 5 (True)
5	Hello	3	Display "Hello"
6	-	4	Increment counter (counter = 4)
4	-	4	Check counter < 5 (True)
5	Hello	4	Display "Hello"
6	-	5	Increment counter (counter = 5)
4	-	5	Check counter < 5 (False)
7	-	5	Exit While loop

Pseudo Code - Repetition

- Ask use to enter 5 numbers and system print the average
- Discuss the approach here

Pseudo Code - Repetition

- Ask use to enter 5 numbers and system print the average

```
Display "Enter 5 numbers:"

Set total = 0
Set count = 5
Set i = 0

While i < count
    Display "Enter number " + (i + 1) + ":"
    Input num
    Add num to total
    Set i = i + 1
End While

Set average = total / count
Display "The average of the 5 numbers is: " + average
```



Trace Table

Line	Text	total	count	i	Action
1	Enter 5 numbers:	-	-	-	Display message to user
2	-	0	5	0	Initialize total to 0, count to 5, and i to 0
3	-	0	5	0	Check if i < count (True)
4	Enter number 1:	0	5	0	Display prompt for number input
5	10 (input)	10	5	1	Input number 10, add to total, increment i to 1
3	-	10	5	1	Check if i < count (True)
4	Enter number 2:	10	5	1	Display prompt for number input
5	20 (input)	30	5	2	Input number 20, add to total, increment i to 2
3	-	30	5	2	Check if i < count (True)
4	Enter number 3:	30	5	2	Display prompt for number input
5	15 (input)	45	5	3	Input number 15, add to total, increment i to 3
3	-	45	5	3	Check if i < count (True)
4	Enter number 4:	45	5	3	Display prompt for number input
5	25 (input)	70	5	4	Input number 25, add to total, increment i to 4
3	-	70	5	4	Check if i < count (True)
4	Enter number 5:	70	5	4	Display prompt for number input
5	30 (input)	100	5	5	Input number 30, add to total, increment i to 5
3	-	100	5	5	Check if i < count (False)
7	-	100	5	5	Exit While loop
8	-	100	5	5	Calculate average = total / count
9	-	100	5	5	Display "The average of the 5 numbers is: 20.0"

Submit the solutions for activity

<https://forms.office.com/e/e6b82cAkH7>



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Trawsnewid Addysg; Trawsnewid Bywydau
Transforming Education; Transforming Lives