Assignment Week 3 - Questions and Solutions

Course: Building Blocks of Programming

Topic: Flowcharts - Loops

Q 1. Draw a flowchart that takes a positive integer "n" as input and displays the sum of all the positive integers which are less than or equal to n and divisible by 6 but not by 5.

Ans. We can simply iterate over all numbers and print if the conditions are satisfied. Sample flowchart is in Fig 1.

Grading. If the output of flowchart is correct then 2, if there are errors but the overall intent/logic is correct then 1 otherwise 0.

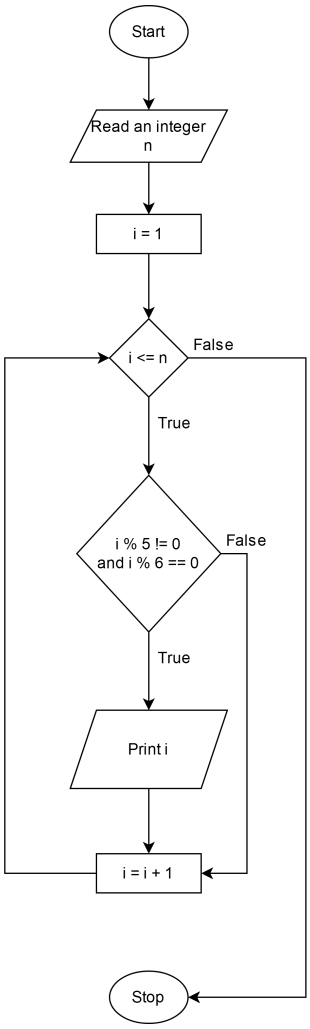

Figure 1: Sample flowchart for Q1

Q 2. Draw a flowchart that takes a positive integer as input and print “Yes” if the number is prime otherwise print “No”.

Ans. We iterate over all the numbers from 2 upto n-1 and print ”No” if we are able to find a factor, otherwise print ”Yes”. Sample flowchart is given in Fig 2. We use the ”%” operator to check divisibility, i.e. i is factor of n only if $n\%i == 0$ We can run it for numbers upto $\frac{n}{2}$ or $\sqrt{n}$ instead of $n-1$ but such optimisations are not required.

Grading. If the output is correct then 2, if there are errors in the logic but the overall intent is correct then 1, otherwise 0.

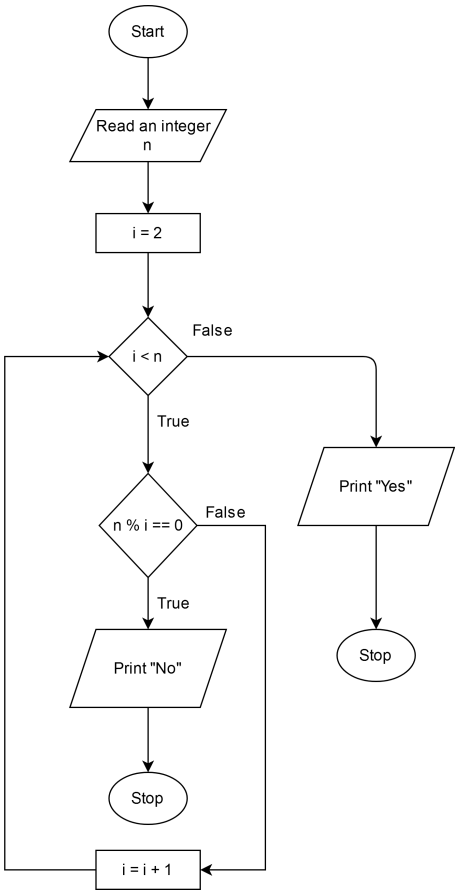

Figure 2: Sample flowchart for Q2

Q 3. Draw a flowchart that takes a positive integer as input and displays the number of divisors of the given number.

Ans. We can modify the solution to the previous question by starting from 1 and maintaining the count of divisors in a separate variable and updating it everytime a new divisor is found, instead of halting when the first divisor is found. This is shown in Fig 3.
We can optimise this by iterating only until $\sqrt{n}$ and adding 2 whenever the number is strictly less than $\sqrt{n}$. If the number is exactly $\sqrt{n}$ then we should add 1. This optimisation is not required.

Grading. If the output of the flowchart is correct then 2, if there are any errors, but the overall intent is correct then 1, otherwise 0.

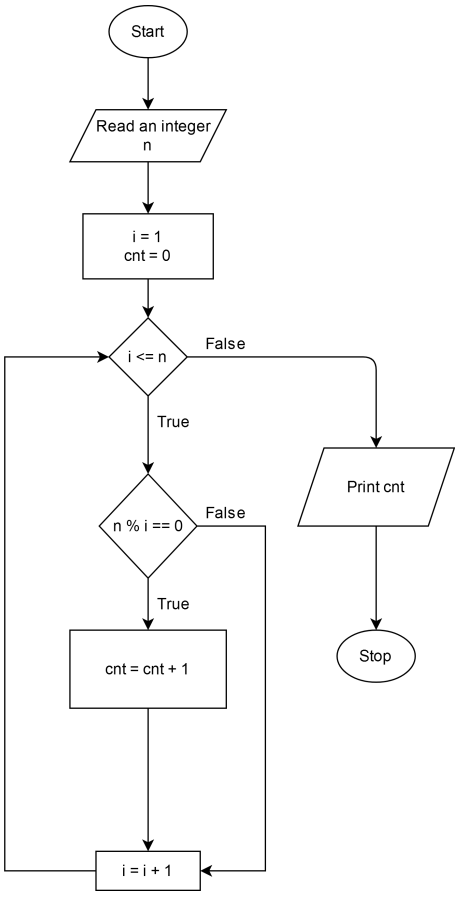

Figure 3: Sample flowchart for Q3

Q 4. Draw a flowchart that takes as input the following

- A positive integer "n", the number of students in the class
- A positive integer "m", the number of the subjects taught

and for **each** student

- "m" integers, the marks of the student in each subject

and displays the average marks of **each** student. (Assume that marks are given out of 100).

Ans. While taking input marks of a student, we maintain the sum of the marks obtained from input so far, and finally print the sum / m at the end, before obtaining input for the next student. This is shown in Fig 4.

Grading. If the output of the flowchart is correct then 2, if there are errors but the overall intent is correct then 1, otherwise 0.

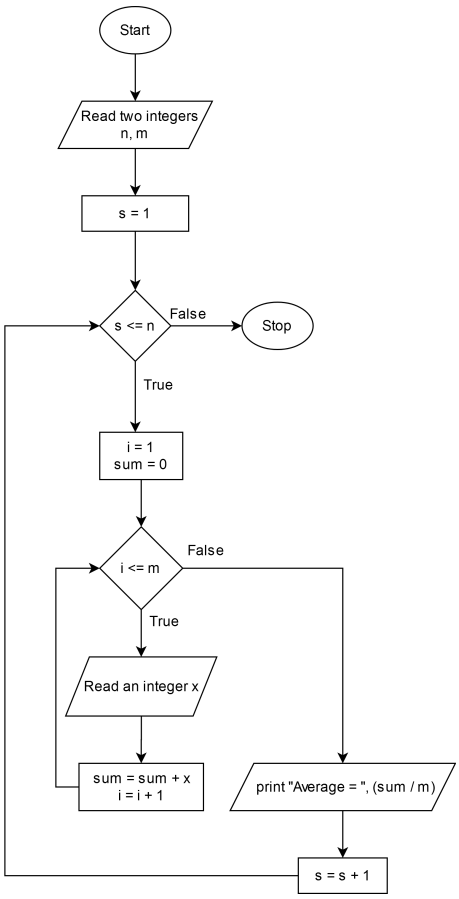

Figure 4: Sample flowchart for Q4

Q 5. Draw a flowchart that takes as input a positive integer "N" and prints all the elements of the sequence 1, 2, 4, 8,... which are less than or equal to N. How many numbers are printed if N = 1048575?

Ans. We can generate all powers of two and stop whenever the result is greater than N. Suppose the number of elements is x, then $2^x \leq N$, therefore $x \leq \log_2 N$, for N = 1048575, $x \leq 19$, so a total of 20 numbers are printed (from $x = 0$ to $x = 19$).
The sample flowchart is given in Fig 5.

Grading. If the correct answer (20) is mentioned and flowchart is correct then 2. If either answer (20) is wrong or there are errors in the flowchart then 1, otherwise 0. Not printing spaces, is not considered as an error.

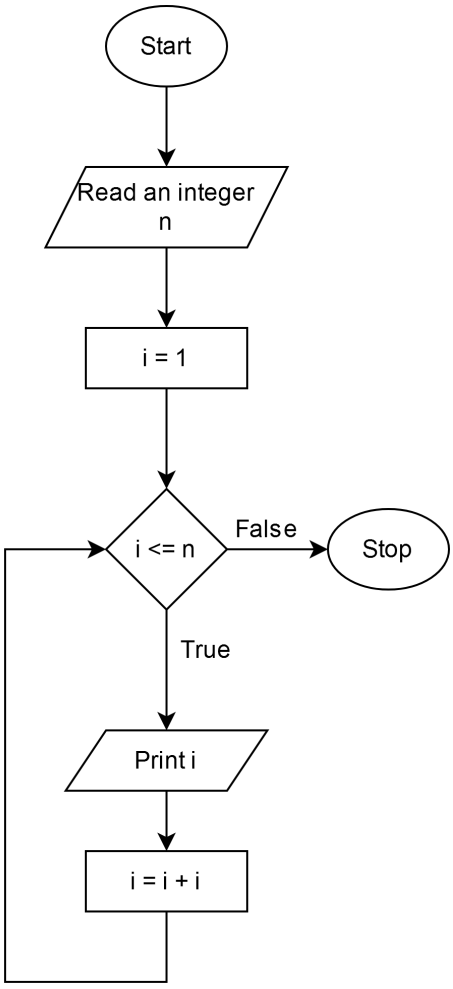

Figure 5: Sample flowchart for Q5

Q 6. Draw a flowchart that takes a positive integer n as input and displays the largest integer x such that n is divisible by 2^x.

Ans. If an integer is divisible by 2^x then it is also divisible by 2^{x-1}. So we can iterate from $x = 0$ and check for the first occurrence of a power of 2, which does not divide n. Sample flowchart is shown in Fig 6.

Grading. If the flowchart gives the correct output then 2, if there are errors but the overall intent is correct then 1, otherwise 0.

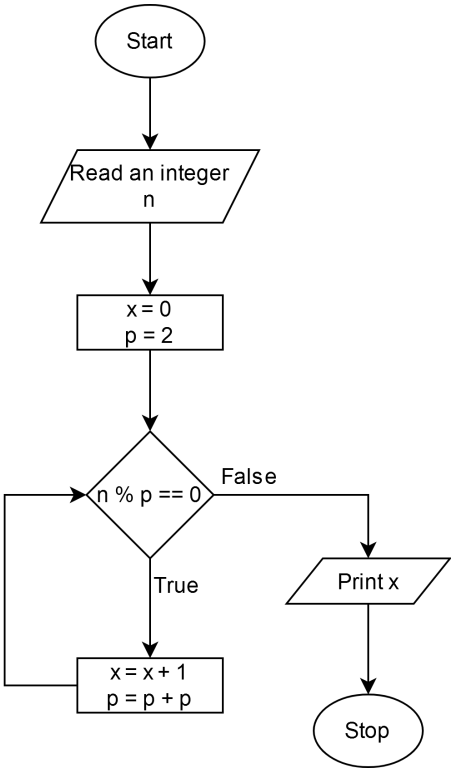

Figure 6: Sample flowchart for Q6

Q 7. Draw a flowchart that takes a positive integer n as input and displays n in binary. For example, if $n = 9$ then display "1001".

Ans. We first find the number of digits that we need to display. If the length is x then 2^x is the smallest integer greater than n. We can find x in a similar manner to the previous question.
We then need to find the digits of n from the most significant digit, so that we can print them in that order.
We know that by definition the $(x-1)^{th}$ position will be "1" (otherwise length will not be x). To find the next set bit, lets remove this "1" from the number n (by subtracting 2^{x-1}), and find the next power of 2 which is less than or equal to the remaining number. That will be the next position where the binary representation has "1", and until then the digits will be "0". This is shown in Fig 7.

Grading. If the output of the flowchart is correct then 2, if there are minor errors then 1, otherwise 0.

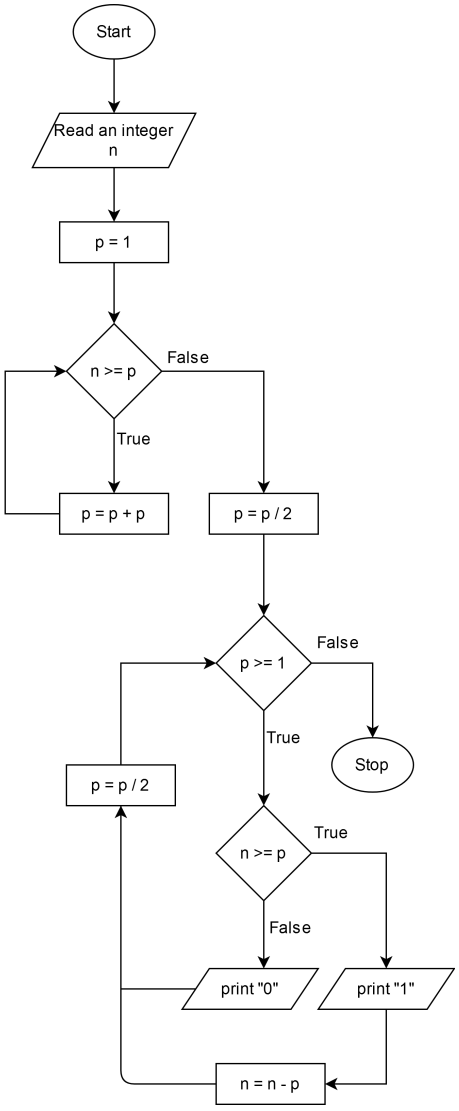

Figure 7: Sample flowchart for Q7

Q 8. Draw a flowchart that takes a positive odd integer, height of the pattern (height of the given example is 11) as input, and displays the pattern (Fig 8).

Figure 8: Pattern for flowchart

Ans. As discussed in class, we can find out the number of spaces and "*"'s in each line and find a pattern for them.
We print the top triangle part first and then the bottom part separately. Firstly we observe that there will be $\frac{h+1}{2}$ stars printed in the middle row, and in row y, $\frac{h+1}{2} - y$ spaces should be printed before starting the "*"'s and y stars should be printed with spaces between them.
For the last part, we repeat the same procedure for the top part, but iterate from $y = h - 1$ to $y = 1$. The flowchart is described in Fig 9.

Grading. Any correct flowchart that print a similar pattern is considered correct. Even if spaces are not printed, but a nested loop with correct number of *'s in each row is printed, give 2. Statement's like "*" * 5 for printing 5 consecutive "*"'s are also correct (although not covered in class). If there are errors in the flowchart but method seems correct then 1, otherwise 0.

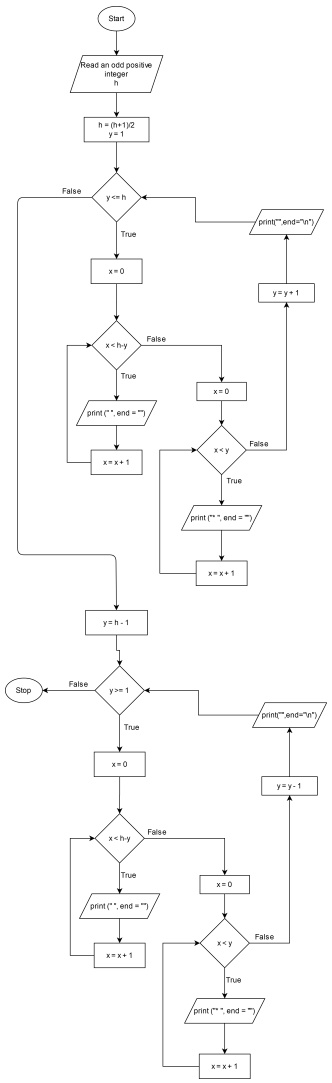

Figure 9: Sample flowchart for Q8

Q 9. Draw a flowchart that takes as input a positive number n and n positive numbers, and displays the greatest common divisor of all the numbers.
For example:- let n = 5 and numbers are - 3, 6, 12, 27, 33 so the number that should be displayed is 3.

Ans. Let's maintain a variable g to be the gcd of all the numbers taken as input so far. Note that g can only decrease when more numbers are added.
The second observation is that all common divisors will be divisors of g.
For the first number, g will be equal to the number taken as input. For the subsequent numbers if there's a change in the gcd, it will be a factor of the number already obtained so far.
So we can iterate from g to 1 and find the first number which is both a factor a g and the number read from input.
In this way we can get the gcd of all the numbers. Flowchart is shown in Fig 10.
A more efficient way is to use Euclid's algorithm for gcd, which will require less operations, however it was not required.

Grading. Any valid method for obtaining the gcd correctly for n numbers is given 2. If there are errors in the flowchart then 1. If there are any logical errors then 0.

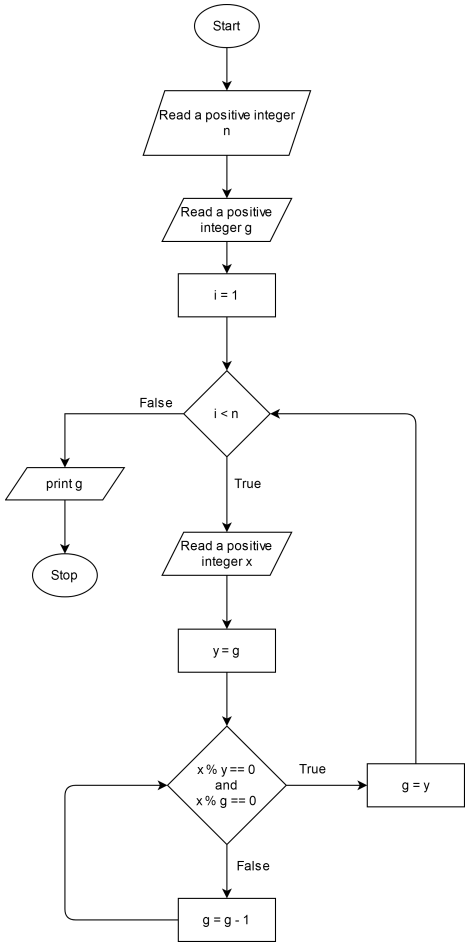

Figure 10: Sample flowchart for Q9

Q 10. Draw a flowchart that takes a positive number h, the height (height of the given example (Fig 11) is 5 (starting from 0)), as input and displays Pascal's triangle up to height h. Note: Print two spaces between two consecutive numbers.

```
          1
        1  1
      1  2  1
    1  3  3  1
  1  4  6  4  1
1  5  10  10  5  1
```

Figure 11: Example for Q10

Ans. Similar to Q8, we have two nested loops, one for printing each line and one to go to subsequent lines.
We can make use of the fact that the r^{th} (starting from 0) number on the n^{th} line will be $\binom{n}{r}$ and the formula $\binom{n}{r+1} = \frac{\binom{n}{r} * (n-r)}{r+1}$ to get the answer. The flowchart is given in Fig 12.

Grading. If the output of the flowchart is correct then 2. If there are functions used for factorial, or binomial coefficient, and flowcharts for those functions are written separately, the answer is considered correct (2). However if functions are used and flowcharts for them are not given then give 1. If output is not correct then 0.

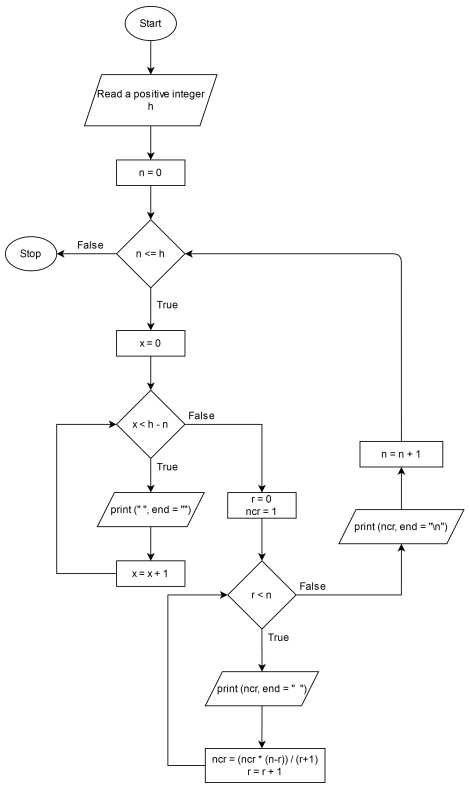

Figure 12: Sample flowchart for Q10