Computer Programming Olympiad

A project of the Institute of IT Professionals South Africa
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COMPUTER PROGRAMMING OLYMPIAD

2016

ROUND 1

POSSIBLE SOLUTIONS

Supported by Oracle and the University of Cape Town.

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NOTE:

Solutions to the problems have been tested using the programming languages and IDEs listed below. Those languages and IDE's identified with an asterisk are those that are used during the International Olympiad in Informatics (IOI).

	IDE	Language Version
C++ solutions	jGrasp 2.0.2_02	GCC 4.6.3*
Java solutions	jGrasp 2.0.2_02	Java 1.8.0*
Pascal solutions	Delphi 2010 Lazarus 1.4.2*	FPC 2.6.4*
Python solutions	Idle	Python 3.4.3*
Scratch solutions	Scratch 2	

CONTRIBUTORS:

Max Brock	IT Curriculum Adviser: Western Cape Education Department
OER Foss	Educator and open-source advocate
Robert Spencer	Programming Olympiad medal winner: Bronze (2010, 2011) and Gold (2012) International Olympiad in Informatics (IOI): Bronze medal winner (2013), deputy leader (2014, 2015) and delegation leader (2016)
Robin Visser	Programming Olympiad medal winner: Bronze (2013) and Silver (2014) International Olympiad in Informatics (IOI): Bronze medal winner (2015), deputy leader (2016)

CODED SOLUTIONS:

Coded solutions to each of the questions using each of the above programming languages can be found by navigating to the following Dropbox folder:

https://www.dropbox.com/sh/0ns8ol67r9sxc9y/AAAH3EaCwuZEjzL-ki7ELFyNa?dl=0

The solutions can be downloaded to your computer by clicking on the "Download" button top right of the screen.

QUESTION 1: SPEEDING

Gauteng has introduced a system of measuring the speed of cars over distance. Write a program that will ask for a time in seconds and a distance in meters as input and will give the speed in km/h as output. Your program must discard fractions of a km (if any). If the speed is 75.9 km/h your program must give 75 as the answer.

The speed for test case (d) was clocked by a special vehicle at Hakskeen Pan.

Examples:
Input: Time? 30 Distance? 1000
Output: 120

Input: Time? 4 Distance? 75
Output: 67

Test your program with the following and type or paste each answer in the correct block on your Answer Sheet (or in the correct block on your screen if you are taking part online).

a) 20 seconds, 800 meters
b) 90 seconds, 1800 meters
c) 5100 seconds, 168 000 meters
d) 22 seconds, 7900 meters

Answers:

a) 144
b) 72
c) 118
d) 1 292

How to get to the answer:

Speed is determined by dividing distance by the time required to travel the distance. In this question the speed is required in km/hr. As time is given in seconds and distance is given in metres these will first need to be converted into hours and kilometres respectively. This is done by dividing the number of seconds by 3 600 (as there are 3 600 second in an hour) and dividing the distance by 1 000 (as there are 1 000 metres in a kilometre). Once you have the distance in kilometres and the time in hours you can then divide the distance by the time to get the answer.

An alternative approach is to divide the distance (in metres) by the time (in seconds) and the multiply the result by 3.6 (3 600/1 000).

Algorithm (Version 1):

1. Ask user for time taken
2. Convert time to hours by dividing by 3 600
3. Ask user for distance travelled
4. Convert distance to kilometres by dividing by 1 000

Algorithm (Version 2):

1. Ask user for time taken
2. Ask user for distance travelled
3. Divide distance travelled (in metres) by time taken (in seconds)
4. Multiply result by 3.6

5. Divide distance (in kilometres) by time (in hours) 6. Output the result rounded down to 0 decimals	5. Output the result rounded down to 0 decimals

SAMPLE C++ SOLUTION

```
#include <iostream>
using namespace std;

int main()
{
  int time, distance;
  cout<<"Time? ";
  cin>>time;
  cout<<"Distance? ";
  cin>>distance;
  cout<<"Output: ";
  cout<<(distance*60*60)/(time*1000);
  cout<<" km/h"<<endl;
}
```

[Solution produced by Robert Spencer]

SAMPLE JAVA SOLUTION

```
import java.util.Scanner;

public class Speeding {
   public static void main(String[] args) {
      Scanner keybd = new Scanner(System.in);
      System.out.print("Enter time: ");
      int time = keybd.nextInt(); // seconds
      System.out.print("Enter distance: ");
      int distance = keybd.nextInt(); // metres
      double t = (double) time / (60 * 60); // hours
      double d = distance / 1000.0; // km
      int speed = (int) (d / t); // km/h
      System.out.println("Output = " + speed + " km/h");
    }
}
```

[Adapted by OER Foss from original solution produced by Max Brock]

SAMPLE PASCAL SOLUTION (USING CONSOLE MODE)

```
program Speeding;   {$APPTYPE CONSOLE}

uses
  SysUtils;

var
  time, distance: integer;
  t, d, output: real;

begin
  try
    write('Enter time: ');
    readln(time); // seconds
    write('Enter distance: ');
    readln(distance); // meters
    t := time / 3600; // hours
    d := distance / 1000; // km
    output := d / t; // km/h
    write('Output: ');
    writeln(trunc(output));
    readln;
  except
    on E: Exception do
      writeln(E.ClassName, ': ', E.Message);
  end;
end.
```

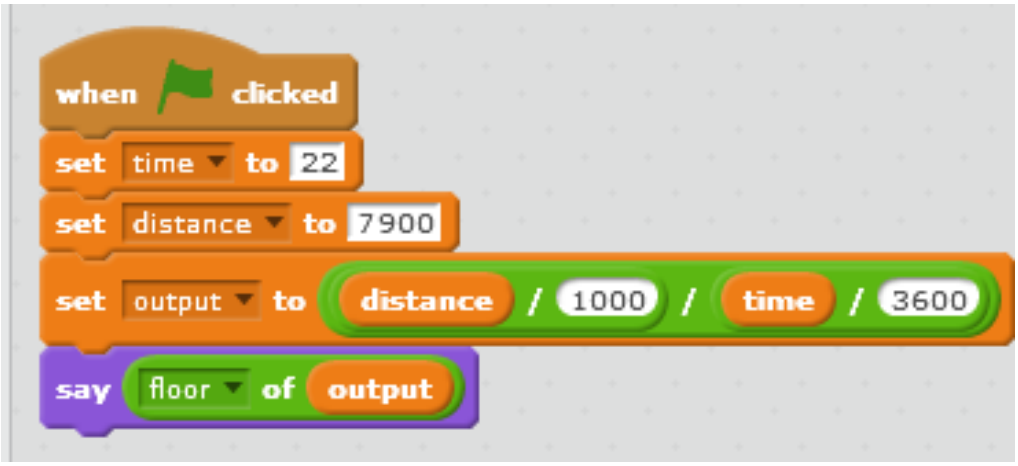
[Adapted by OER Foss from original solution produced by Max Brock]

SAMPLE PYTHON SOLUTION

```
#!/usr/bin/env python3

time = int(input("Enter time in seconds: "))
distance = int(input("Enter distance in metres: "))

print("Output:", int(3.6*(distance/time)), "km/h")
```

[Solution produced by Robin Visser]

SAMPLE SCRATCH SOLUTION



[Solution produced by Max Brock]

QUESTION 2: MATHS

Write a program that asks for an integer value N, then calculates all the factors of N (other than N itself) and adds them together to give the answer. A factor is a positive, whole number that divides N exactly. For example, the factors of 8 are 1, 2, and 4. The sum: 1 + 2 + 4 = 7

Examples:
Input: N? 8
Output: 7

Input: N? 12
Output: 16

Test your program with the following and type or paste each answer in the correct block on your Answer Sheet (or in the correct block on your screen if you are taking part online).

a) N= 6
b) N = 100
c) N = 30 030
d) N = 119 451

Answers:

a) 6
b) 117
c) 66 738
d) 45 429

How to get to the answer:

1. Ask user for positive integer (say N)
2. Create and initialize a variable for the running total (say sum)
3. Loop through all positive integers between 1 and N/2
   - If the integer is a factor of N then add it to the running total
   - If the integer is not a factor of N then ignore it
4. Output the running total

NB: it is only necessary to go up to N/2 as any integers larger than N/2 will not be factors of N, and N itself is specifically excluded in this problem.

SAMPLE C++ SOLUTION

```
#include <iostream>
using namespace std;

int main()
{
  int N;
  cout<<"N? ";
  cin>>N;
  int answer = 0;
  for (int i = 1; i<=N/2; ++i)
    if (N%i==0) answer+=i;
  cout<<"Output: ";
  cout<<answer<<endl;
}
```

[Solution produced by Robert Spencer]

SAMPLE JAVA SOLUTION

```
import java.util.Scanner;

public class SumOfFactors {
   public static void main(String[] args) {
   Scanner keybd = new Scanner(System.in);
   System.out.print("N? ");
   int n = keybd.nextInt();
   int sum = 0;
      for (int i = 1; i <= n/2; i++) {
         if (n % i == 0) {
            sum = sum + i;
            }
         }
         System.out.println("Output: " + sum);
      }
}
```

[Adapted by OER Foss from original solution produced by Max Brock]

SAMPLE PASCAL SOLUTION (USING CONSOLE MODE)

```
program SumOfFactors;   {$APPTYPE CONSOLE}

uses
  SysUtils;

var
  n, sum, i: integer;

begin
  try
    write('Enter value of N: ');
    readln(n);
    sum := 0;
    for i := 1 to (n div 2 + 1) do
    begin
      if n mod i = 0 then
        sum := sum + i;
    end;
    write('Output: ');
    writeln(sum);
    readln;
  except
    on E: Exception do
      writeln(E.ClassName, ': ', E.Message);
  end;
end.
```

[Adapted by OER Foss from original solution produced by Max Brock]

SAMPLE PYTHON SOLUTION

```
#!/usr/bin/env python3

n = int(input("N? "))

factor_sum = 0
for i in range(1, (n//2+1)):
    if (n%i == 0):
        factor_sum += i

print("Output:", factor_sum)
```

[Solution produced by Robin Visser]

SAMPLE SCRATCH SOLUTION

[Solution produced by Max Brock]

QUESTION 3: ENCRYPTION

The ACME Code Company has released their new encryption algorithm: Urgh™. To encrypt a message using the Urgh™ algorithm is simple.

Each letter ends up *N* letters to the right of its original position, and the last *N* letters wrap around to the beginning. In addition the letters are replaced by letters *N* places further in the alphabet.

For example:
If you shift the word APPLE by *N=2* then it becomes LEAPP
If you then replace the letters by letters 2 places further in the alphabet, LEAPP becomes NGCRR

If you shift the word ENCRYPTION by *N=4* you get TIONENCRYP. If you then replace the letters by letters 4 places further in the alphabet, you get XMSRIRGVCT

Write a program that, given a word and the integer number *N*, will output the encrypted word

Examples:
Input: Word? APPLE N? 2
Output: NGCRR

Input: Word? ENCRYPTION N? 4
Output: XMSRIRGVCT

Test your program with the following and type or paste each answer in the correct block on your Answer Sheet (or in the correct block on your screen if you are taking part online).

a) CAT N = 1
b) ACT N = 2
c) NEOAOQNL N = 4
d) EMDVENZKCFUTJXUGKYSARH N = 10

Answers:

(a) UDB or udb
(b) EVC or evc
(c) SURPRISE or surprise
(d) THEQUICKBROWNFOXJUMPED or thequickbrownfoxjumped

How to get to the answer:

1. Ask the user for a word to be encrypted. For example, APPLE
2. Ask the user for the encryption key, the positive number N. For example, 2
3. Remove the N right-most letters of the word that was input and add them to the front of the shortened word. In other words take the last 2 letters (because N=2) of the word APPLE, i.e. LE, and add them to the front of the shortened word. You now have a new word, LEAPP.
4. For each letter in the new word replace it by the letter in the alphabet N places to its right. In this case because N=2 the L is replaced by N (2 places to the right), the E by G, the A by C and the P by R. So the encrypted word is now NGCRR.
5. If the letter is close to the end of the alphabet it may well happen that the letter to the right does not exist as you have to go beyond the letter Z. In this case counting should run to the end of the

alphabet and then begin again at the beginning of the alphabet. For example, if the word to be encrypted is YACHT and the encryption key is 3 then the following should take place:

- YACHT is first transformed into CHTYA, i.e. the last 3 letters are moved to the front of the word.
- The C is then replaced by F, the H by K, the T by W, the Y by B and the A by D. The last part of the alphabet would be Y Z which is then followed by A B C etc. So the letter 3 places to the right of Y would be B. The encrypted word becomes FKWBD

SAMPLE C++ SOLUTION

```
#include <iostream>
#include <string>
using namespace std;

int main()
{
  string input;
  int N;
  cout<<"Word? ";
  cin>>input;
  cout<<"N? ";
  cin>>N;
  cout<<"Output: ";
  for (int i = 0;i<input.length();++i)
  {
    char let = input[(i-N+input.length())%input.length()];
    cout<<char('A'+((let-'A'+N)%26));
  }
  cout<<endl;
}
```

[Solution produced by Robert Spencer]

SAMPLE JAVA SOLUTION

```
import java.util.Scanner;

public class Encryption {
   public static void main(String[] args) {
   Scanner keybd = new Scanner(System.in);
   System.out.print("word? ");
   String word = "";
   word = keybd.next();
   System.out.print("N? ");
   int n1 = keybd.nextInt();
   int cut = word.length() - n1;
   String first = word.substring(cut) .toUpperCase();
   String last = word.substring(0, cut) .toUpperCase();
   String newWord = first + last;
```

```
  String output = "";
  for (int i = 0; i < newWord.length(); i++) {
     int n2 = n1;
     if (newWord.charAt(i) + n2 > 90) {
        n2 = n2 - 26;
       }
     output = output + (char) (newWord.charAt(i) + n2);
    }
  System.out.println("Output: " + output);
  }
}
```

[Adapted by OER Foss from original solution produced by Max Brock]

SAMPLE PASCAL SOLUTION (USING CONSOLE MODE)

```
program Encryption; {$APPTYPE CONSOLE}

uses
  SysUtils;

var
  word, new, output: string;
  m, n, cut, i: integer;
  c: char;

begin
  try
    write('Word? ');
    readln(word);
    write('N? ');
    readln(n);
    cut := length(word) - n;
    new := uppercase(copy(word, cut + 1, n)) + copy(word, 0, cut);
            output := '';
    for i := 1 to length(new) do
    begin
      m := n;
      c := copy(new, i, 1)[1];
      if ord(c) + n > 90 then
        m := n - 26;
      output := output + chr(ord(c) + m);
    end;
    writeln('Output: ' + output);
    readln;
  except
    on E: Exception do
      writeln(E.ClassName, ': ', E.Message);
  end;
end.
```

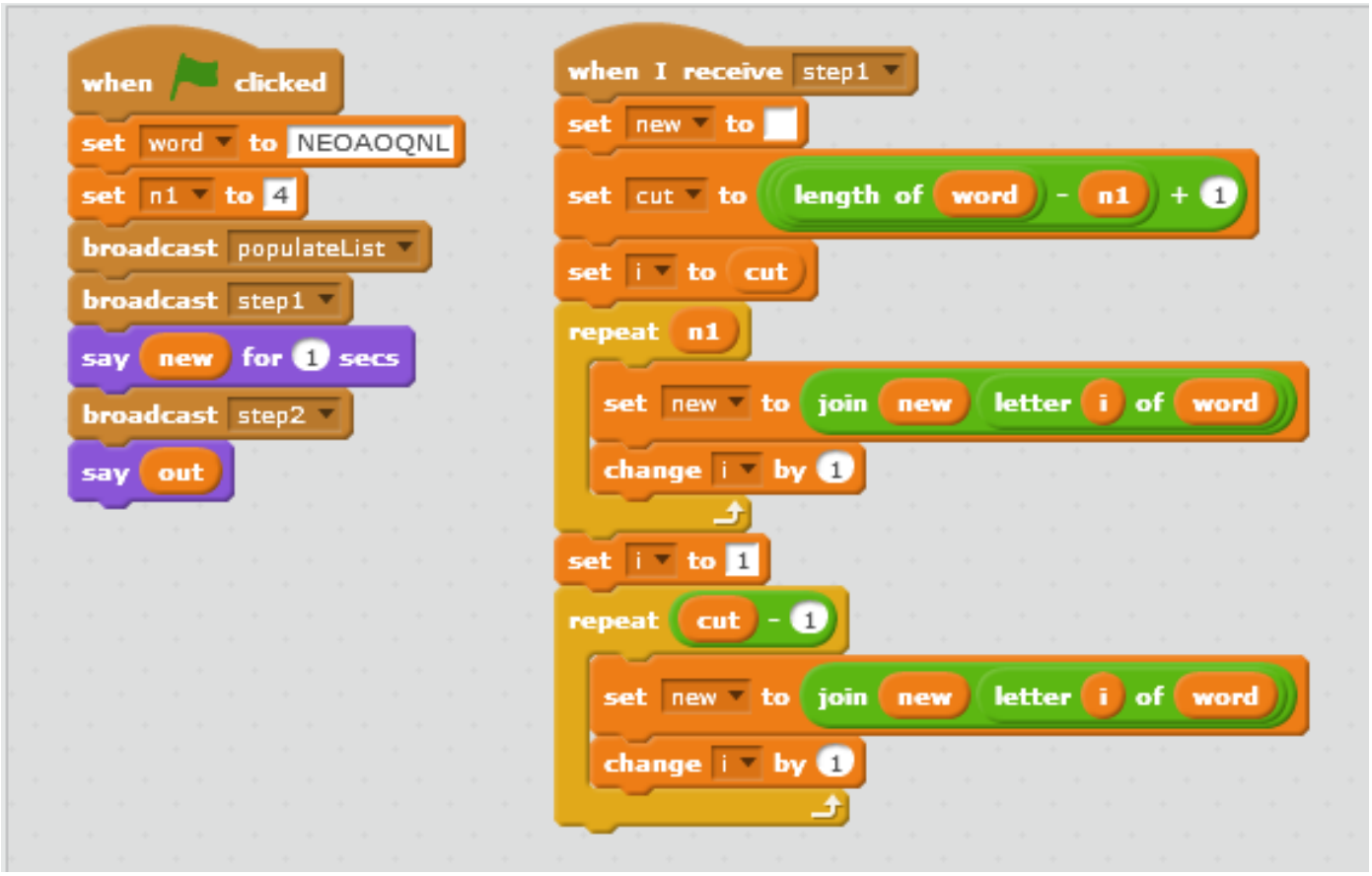
[Adapted by OER Foss from original solution produced by Max Brock]

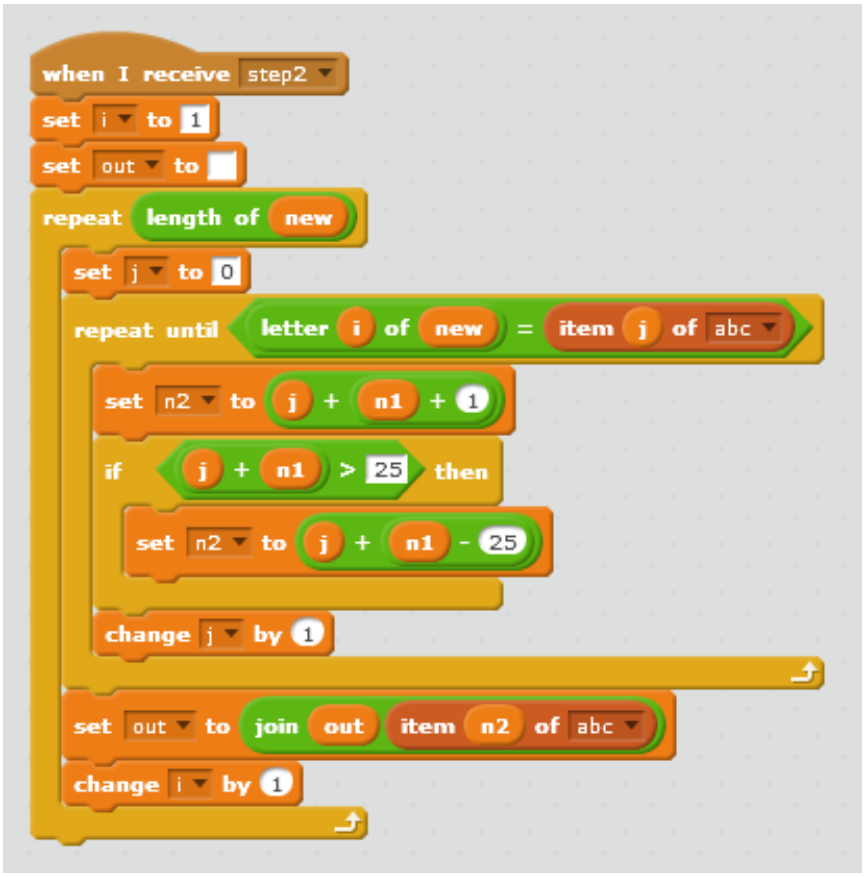
SAMPLE PYTHON 3 SOLUTION

```
#!/usr/bin/env python3

word = input("Word? ")    # Must be in uppercase
n = int(input("N? "))

# Shift word
new_word = ""
for i in range(len(word)):
    new_word = new_word + word[(i+len(word)-n)%len(word)]

# Shift characters
word, new_word = new_word, ""
for i in range(len(word)):
    new_word = new_word + chr((ord(word[i]) - ord('A') + n)%26 + ord('A'))

print("Output:", new_word)
```

[Solution produced by Robin Visser]

SAMPLE SCRATCH SOLUTION





[Solution produced by Max Brock]