IST-ASM Retake Exam — 1st December 2022

Name:

- First, write your name in the box above. Then, have a quick read through all 5 exercises.
- In the end, you will write up your answers on this paper.
  - But please make a draft elsewhere first. Only hand in something readable.
- This is an open-book open-laptop exam: you may work on scrap paper or on your screen.
- Each question is independent from others.

Question 1 Perform the binary addition $-43+50$ in two's complement on 7 bits: convert both numbers to (signed) binary, then compute the sum on 7 bits. Show the details of your work, especially carry bits.

Question 2 The code below implements a certain mathematical function f: from two integers A and B, it computes $C = f(A, B)$. Give a simple expression for f.

$f(A, B) =$

```
A: .word ...
B: .word ...
C: .word ...
main:
    load R1, [A]
    load R2, [B]
    mul R3, R1, R1
    mul R4, R2, R2
    add R3, R3, R4
    mul R4, R1, R2
    add R4, R4, R4
    add R1, R3, R4
    store [C], R1

    bra +0
```

Question 3 Write a program which computes the sum of the squares of the first N positive integers. For instance, with $N = 7$ you should find $1\times1 + 2\times2 + 3\times3 + 4\times4 + 5\times5 + 6\times6 + 7\times7 = 140$. Initially N is stored in R1, and at the end the result should be stored in R2.

Question 4 Write a program that loops over an array of numbers and finds both the maximum and minimum values. The length of the array is a (known) constant, as illustrated below.

```
T:   .word 13, 18, 5, 3, 10, 8, 20, 1, 14, 6
len: .word 10

main:
```

Question 5 Definition: Given a pair of positive integers n and k such that $n \geqslant k \geqslant 0$, we define their *binomial coefficient* as the number of different k-element subsets of a fixed n-element set. This number is usually written $\binom{n}{k}$ and is read as "n choose k". For example, $\binom{4}{2} = 6$ because there are 6 ways to choose 2 elements from a 4-element set $\{a, b, c, d\}$: the different subsets are $\{a, b\}$, $\{a, c\}$, $\{a, d\}$, $\{b, c\}$, $\{b, d\}$, and $\{c, d\}$.

In this exercise, we are interested in the fact that there exists a recursive formula to compute these coefficients:

$$\binom{n}{k} = \binom{n-1}{k-1} + \binom{n-1}{k}$$

The base case of the recursion is the fact that for any integer $n \geqslant 0$, we have $\binom{n}{n} = \binom{n}{0} = 1$.

Your task is to write a recursive `binomial` function which receives n and k in R1 and R2, respectively and returns $\binom{n}{k}$ in R1.

```
leti SP, 0x10000000
main:
    leti R1, 4
    leti R2, 2
    call binomial
    bra +0

binomial:
```