Exercises marked with a ⋆ involve writing programs. These exercises do not have accompanying solutions. You are encouraged to work them out on your own. If you need help with any of them, please reach out to the course staff.

Exercise 1. Consider the following program `mystery.marv`:

```
0     read     r0
1     read     r1
2     setn     r2 2
3     mul      r3 r0 r0
4     mul      r4 r1 r1
5     mul      r5 r0 r1
6     mul      r5 r2 r5
7     add      r6 r3 r4
8     add      r6 r6 r5
9     write    r6
10    halt
```

a. What does the program write when run with inputs -1 and 6?

b. What does the program write when run with inputs 3 and 4?

c. What does the program write in general?

Exercise 2. Consider the following program `mystery.marv`:

```
0    read     r0
1    setn     r1 3
2    mod      r2 r0 r1
3    jnezn    r2 6
4    set1     r3
5    jumpn    7
6    set0     r3
7    write    r3
8    halt
```

a. What does the program write when run with input 5?

b. What does the program write when run with input 9?

c. What does the program write in general?

Exercise 3. Consider the following program `mystery.marv`:

```
0    read     r0
1    setn     r1 2
2    setn     r2 0
3    setn     r3 1
4    jgtn     r2 r0 9
5    write    r3
6    mul      r3 r3 r1
7    addn     r2 1
8    jumpn    4
9    halt
```

a. What does the program write when run with input 3?

b. What does the program write when run with input 8?

c. What does the program write in general?

Exercise 4 ($\star$)**.** Write a program called `sum_of_cubes.marv` that receives two inputs `x` and `y` and writes the sum of their cubes (ie, $\texttt{x}^3 + \texttt{y}^3$) as output.

```
$ python3 marvin.py sum_of_cubes.marv
2<enter>
3<enter>
35
$ python3 marvin.py sum_of_cubes.marv
3<enter>
4<enter>
91
```

Exercise 5 ($\star$)**.** Write a program called `hms.marv` that receives the time `t` in seconds (since some epoch) as input, computes the number of hours `h`, minutes `m`, and seconds `s` that `t` denotes, and writes the `h`, `m`, and `s` values as output.

```
$ python3 marvin.py hms.marv
676<enter>
0
11
16
$ python3 marvin.py hms.marv
86789<enter>
24
6
29
```

Exercise 6 ($\star$)**.** Write a program called `even.marv` that receives `x` as input, and writes 1 as output if `x` is even (ie, divisible by 2) and 0 othersise.

```
$ python3 marvin.py even.marv
42<enter>
1
$ python3 marvin.py even.marv
1729<enter>
0
```

Exercise 7 ($\star$)**.** Write a program called `max.marv` that receives `x` and `y` as inputs, and writes the larger of the two as output.

```
$ python3 marvin.py max.marv
5<enter>
4<enter>
5
$ python3 marvin.py max.marv
-4<enter>
```

```
5<enter>
5
$ python3 marvin.py max.marv
3<enter>
3<enter>
3
```

Exercise 8 ($\star$)**.** Write a program called `sum.marv` that receives `x` as input, and writes the sum $1 + 2 + \cdots + (\texttt{x} - 1) + \texttt{x}$ as output.

```
$ python3 marvin.py sum.marv
10<enter>
55
$ python3 marvin.py sum.marv
100<enter>
5050
```

Exercise 9 ($\star$)**.** Write a program called `prime.marv` that receives `x` as input, and writes 1 as output if `x` is prime (ie, is divisible only by 1 and itself) and 0 otherwise.

```
$ python3 marvin.py prime.marv
10<enter>
0
$ python3 marvin.py prime.marv
19<enter>
1
```

Solutions

Solution 1.

a. `25`

b. `49`

c. $(\texttt{r0} + \texttt{r1})^2$

Solution 2.

a. `0`

b. `1`

c. `1` if `r0` is a multiple of 3 and `0` otherwise

Solution 3.

a. The numbers `1 2 4 8`

b. The numbers `1 2 4 8 16 32 64 128 256`

c. The numbers $\texttt{2}^{\texttt{i}}$ for each $\texttt{0} \leq \texttt{i} \leq \texttt{r0}$

Solution 4. Discuss with course staff.

Solution 5. Discuss with course staff.

Solution 6. Discuss with course staff.

Solution 7. Discuss with course staff.

Solution 8. Discuss with course staff.

Solution 9. Discuss with course staff.