

Assignment 3

Policies:

- Zero tolerance for late submission.
- Please pack all your submissions in one zip file. **RAR is not allowed!!**
- For convenience, your executable programs must be named following the rule hw**XXYY**, where the red part is the homework number and the blue part is the problem number. For example, hw0102 is the executable program for homework #1 problem 2.
- I only accept **PDF**. MS Word is not allowed.
- **Do not forget your Makefile. For convenience, each assignment needs only one Makefile.**
- Please provide a README.

3.1 Tornado (20 pts)

Please develop a program to make the user input two integers as the width m and the height n . Your program should list all integers from 1 to $m \times n$ as follows. Start from the top left corner and list these numbers inward in a counterclockwise direction. Note that alignment is an issue in this problem.

```
1 $ ./hw0301
2 Please enter the width : 5
3 Please enter the height: 3
4 1 12 11 10 9
5 2 13 14 15 8
6 3 4 5 6 7
```

You should give an error message and terminate your program when receiving an invalid input.

3.2 Addition (20 pts)

Please write a program for a user to input two **32-bits non-negative integers** and print the calculation process.

```
1 $ ./hw0102
2 Please enter the first number: 1234
3 Please enter the second number: 456
4   1 2 3 4
5 +)   4 5 6
6 -----
7   1 6 9 0
```

Note that if the overflow case happens, you need to print a warning message and terminate your program.

3.3 Finite State Machine (20 pts)

What is Finite State Machine? Well ... there is an important class called **Automata** taught by Professor Hou. I suggest you to take this course. So I will not introduce what it is but simply describe how it works. Figure 3.1 is a finite state machine example. The circle implies the state. Initially you are in the start state. When receiving a number, you will move to the next state according to the red number indication. The word **all** means you will move to this state with all input numbers. The word **others** means you will move to this state with all input numbers except the number listed to other states.

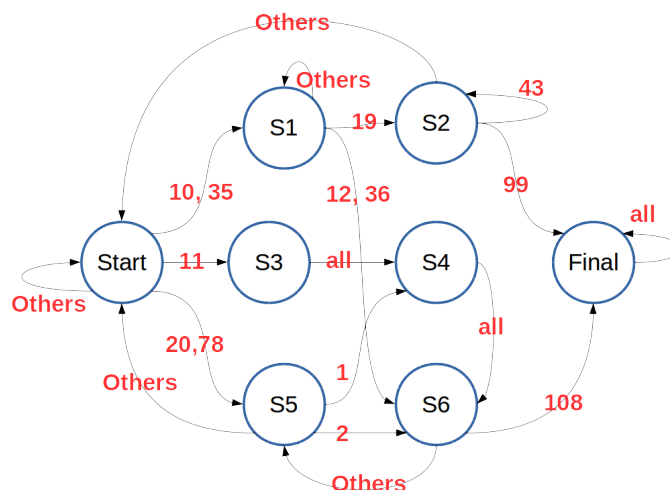


FIGURE 3.1: Deterministic Finite Automata.

Now you need to develop a program for a user to input integers until the final state.

```

1 $ ./hw0303
2 Start
3 Please enter an integer: 35
4 S1
5 Please enter an integer: 19
6 S2
7 Please enter an integer: 43
8 S2
9 Please enter an integer: 99
10 Final

```

3.4 Continued Fraction of e (20 pts)

The number e , also known as Euler's number, is a mathematical constant. There is an interesting representation of e called continued fraction, as shown in figure 3.2. Note that this is an infinite continued fraction and therefore e is irrational. We can use the following pattern to show the continued fraction:

$$[2; 1, 2, 1, 1, 4, 1, 1, 6, \dots, 1, 1, 2n, \dots]$$

$$e = 2 + \frac{1}{1 + \frac{1}{2 + \frac{1}{1 + \frac{1}{1 + \frac{1}{4 + \frac{1}{1 + \ddots}}}}}}$$

FIGURE 3.2: Continued Fraction of e .

Please write a program to calculate the continued fraction of e . The user should input n where $n \geq 2$.

```

1 $ ./hw0304
2 Please enter n: 2
3 Answer: xxx

```

I am a lazy guy so I leave the calculation for yourself, but I write down the calculation as follows:

$$2 + \frac{1}{1 + \frac{1}{2 + \frac{1}{1 + \frac{1}{1 + \frac{1}{4}}}}}$$

Moreover, according to the theory, when $n \rightarrow \infty$, the value will be close to e . Is this true in the programming? Suppose e is 2.7182818284590452354, please find n that is the most close to this value.

3.5 Climate Change (20 pts)

Human-induced climate change includes both global warming driven by emissions of greenhouse gases and the resulting large-scale shifts in weather patterns. Though there have been previous periods of climatic change, since the mid-20th century humans have had an unprecedented impact on Earth's climate system and caused change on a global scale.

In this homework, I want you to implement a program to predict the temperature in the future. The user will input some past temperature data and you need to use **the linear model** to simulate the temperature change. That is, you need to use the following equation to predict the temperature.

$$T(t) = at + b,$$

where t is the year and $T(t)$ is the temperature of the year. Your job is to derive a and b from inputs based on the **least squares approach**. Do not worry, this is not a mathematics class, so you can learn how to get a and b from wikipedia.

The user input ends with -1.

```
1 $ ./hw0305
2 Please enter the year: 2000
3 Temperature: 29.5
4 Please enter the year: 2001
5 Temperature: 29.7
6 Please enter the year: 2002
7 Temperature: 29.6
8 Please enter the year: 2003
9 Temperature: 31.2
10 Please enter the year: 2004
11 Temperature: 30.5
12 Please enter the year: -1
13 Please enter the prediction year: 2022
14 Temperature: XXX
```

I am a lazy guy and I leave the calculation for you.

3.6 Bonus: How Conversion Works? (5 pts)

In this class, I have told you that standard C allows conversion between different numeric types, like **int**, **unsigned int**, **float** **double**. Please describe how conversion works between the following pairs.

- `float` \leftrightarrow `int32_t`
- `int32_t` \leftrightarrow `uint32_t`
- `double` \leftrightarrow `float`

Please look up the specification instead of guess from observation. You should also provide examples to show your description.