Tutorial 4

The goal of this tutorial is to reinforce the following materials:

- Overflow
- Data Types
- Structures

Integer Overflow

- Any variable in C takes up a certain amount of memory (bits).
- This limits the range of values that can be represented.
- Any time you try to go past this limit it is called an “overflow”

- A variable of type `int` allocates 32 bits of memory.
- We want to be able to represent negative numbers as well as positive numbers, so half of this range is negative and half is positive.
- Using this logic, Integers range from $-2^{31}$ to $2^{31} - 1$, or $-2147483648$ to $2147483647$
Overflow

As an INT it is impossible to represent outside of the range of:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INT_MIN</td>
<td>$-2^{31}$</td>
<td>$-2147482648$</td>
</tr>
<tr>
<td>INT_MAX</td>
<td>$2^{31} - 1$</td>
<td>$2147482647$</td>
</tr>
</tbody>
</table>

which is why we have other data-types

Integer Overflow Example

The following function can overflow for large values of $a$ and $b$.

```c
// find_mid(low, high) returns the middle integer between two boundaries, low and high, inclusively [round down to the whole integer]
// requires: 0 <= low <= high
int find_mid(int low, int high){
    return (low + high)/2;
}
```

Even though it can never return a number larger than INT_MAX, the result of computing $(a + b)$ is undetermined.

Practice: On seashell, implement the `find_mid` function that would fix the issue above

Practice Problem: Overflow

The function `not_overflow_add(a, b)` returns true if adding non-negative integers $a$ and $b$ will not cause overflow, otherwise, returns false.

For example,

```
not_overflow_add(1, 0); // => true
not_overflow_add(INT_MAX, 1); // => false
```
## Data Types

<table>
<thead>
<tr>
<th>Variable Type</th>
<th>Description</th>
<th>Printf</th>
</tr>
</thead>
<tbody>
<tr>
<td>int</td>
<td>Integer (numbers)</td>
<td>%d</td>
</tr>
<tr>
<td>char</td>
<td>Characters</td>
<td>%c</td>
</tr>
<tr>
<td>float</td>
<td>Floating Point decimal numbers</td>
<td>%f</td>
</tr>
<tr>
<td>double</td>
<td>Double precision floating value</td>
<td>%f</td>
</tr>
</tbody>
</table>

## What is a Structure?

- Example:
  - Name: Coolio McCool
  - Date of Birth: 01.01.01
  - Student ID: 0101010010

## Structures in Racket vs. C

Structures in C are similar to structures in Racket:

**Racket:**

```
(struct posn (x y)
  #:transparent)
```

```
(define p (posn 1 2))
(define a (posn-x p))
(define b (posn-y p))
```

**C:**

```
struct posn {

  int x;
  int y;

};
```

```
const struct posn p = {1,2};
const int a = p.x;
const int b = p.y;
```

Racket generates selector functions when you define a structure. Instead of selector functions, C has a `structure operator (.)` which selects the value of the requested field.
Structure Coding Example in C

```c
#include "cs136.h"

struct mystruct{
    int number;
    char letter;
};

int main(){
    struct mystruct s = {5,'a'};
    printf("my struct %d, %c \n", s.number, s.letter);
    s.number = 6;
    s.letter = 'b';
    printf("my struct %d, %c \n", s.number, s.letter);
    return 0;
}
```

Practice Problem: Structure – collinear

On Seashell, we have given you the structure `posn`:

```c
struct posn {
    int x;
    int y;
};
```

Implement the function `collinear(a, b, c)` which consumes three `posns` and returns true if a, b and c are collinear, otherwise returns false.