McMaster University
Department of Computing and Software
Dr. W. Kahl

SFWR ENG 2S03
Exercise Sheet 2
Solution Hints

SFWR ENG 2S03 — Principles of Programming

20 September 2006

Please bring your work to the tutorial!

Exercise 2.1 — Treasure Hunt (45% of Midterm 1, 2003)

Design and implement a C program to play the “blind” board game “treasure hunt”.

- The board has 20×20 fields, from $(1, 1)$ to $(20, 20)$.
- On field $(17, 2)$ there is a treasure.
- The player starts on field $(9, 10)$, but is not told this.
- All fields (x, y) with $(x + 2y)$ divisible by 5 are **forbidden**, i.e., the player must not be allowed to move onto such a field.
- The player navigates the board by entering “numeric keypad cursor control commands”:
  - “2” moves **down** one step
  - “8” moves **up** one step
  - “4” moves **left** one step
  - “6” moves **right** one step

  After each successful move, **only** the new distance to the treasure is displayed — for this, the 1-norm is used and whether a field is forbidden or not does not matter, so, e.g., the distance from $(9, 10)$ to $(17, 3)$ is 15 (calculated as $8 + 7$).
- When the player tries to move off the board or onto a forbidden field, a message is displayed noting that the move is impossible, but **not** why it is impossible.
- When the player moves to the field where the treasure is, a congratulatory message is displayed and the program terminates.

Assume that the user will input only numbers! Do not use arrays!

Solution Hints

Design:

- State: integer coordinates.
- Structure: loop until treasure found:

- Input direction
- Calculate hypothetical new position into auxiliary variables
- Check whether new position is legal:

  If yes, move there and output new distance;

  if no, output error message that does not give too much away.

Implementation:

```
#include <stdio.h>
int main()
{
 int target_x=17, target_y=3;

 int x_max=20, y_max=20;
 int x=9, y=10;
 int input, new_x, new_y;
 char * message;            /* superfluous luxury */

 while ( x ≠ target_x  || y ≠ target_y )
 {
   scanf("%d", &input);
   new_x = x; new_y = y;

   switch(input) {
     case 4:   new_x = x–1;
                 message = "cannot move left";
             break;
     case 6:   new_x = x+1;
                 message = "cannot move right";
             break;
     case 2:   new_y = y–1;
                 message = "cannot move down";
             break;
     case 8:   new_y = y+1;
                 message = "cannot move up";
             break;
     default:  printf("???\n");
   }
   if (new_x > 0   &&  new_x ≤ x_max &&
       new_y > 0   &&  new_y ≤ y_max &&  ((new_x + 2 * new_y) % 5 ≠ 0))
   {
     x = new_x;
     y = new_y;
     printf("Your distance to the treasure: %d\n",
            abs(target_x – x) + abs (target_y – y));
   }
   else
   {
    printf("%s\n", message);
  }
 }
 printf("Congratulations! You found the treasure at (%d,%d).\n", x, y);
 return 0;
}
```

Exercise 2.2 (Textbook Exercise Recommendation)

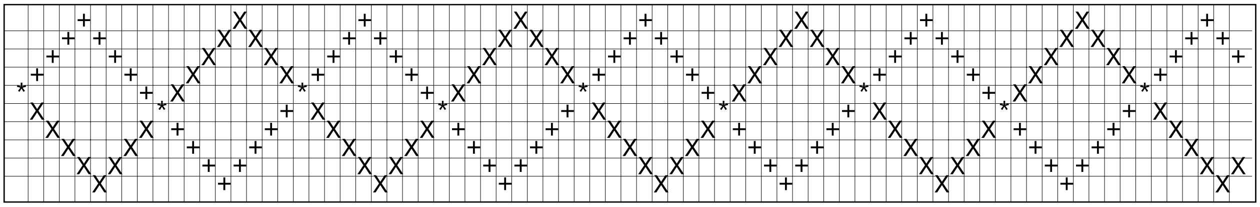
Read chapter 4 of the textbook. Do **at least** the following exercises: 4.5–4.14, 4.24, 4.29

Solution Hints

The last two are about Boolean operations and De Morgan — check the "C-Truth" slides and your logics material if you have any problems.

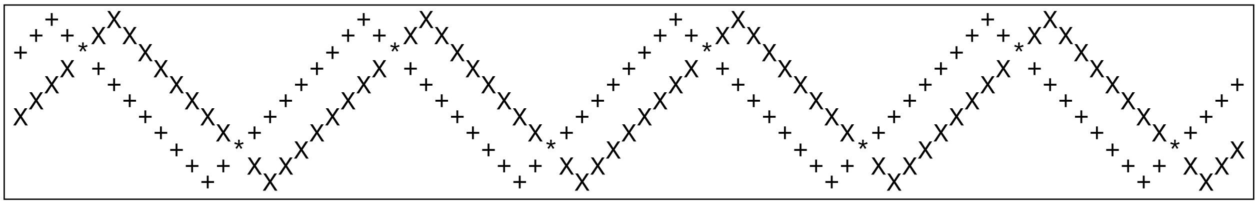
Exercise 2.3 — ASCII Art: Zig-Zag — (50% of Midterm 1, 2004)

Design and implement a C program that asks the user for a height, and for two offset numbers, and uses these three numbers to print a combination of two zig-zag lines of the same height, as in the following example:



Note that one of the zig-zag lines is drawn using the "plus" symbol, the other using the letter "X", and where both zig-zag lines intersect, the asterisk "*" is used.

The grid lines are of course **not** part of the output. Here is another example without those grid lines — any such pattern should be producable:



Assume that the user will input only numbers! Do not use arrays!

Decompose into functions! Design and Document!

Solution Hints

"Only numbers" includes non-positive (or at least negative) numbers, which at least for *height* does not make sense — this has to be caught. If the offset numbers can be negative, this has to be documented.

My Design:

- Decisions:
  - Width is constant 79
  - “Offset” means how far from the left margin is the first entry in the first row. Taken strictly, this implies that offsets lie in the interval $[0, 2 * \mathit{height} - 3]$. For input, I restrict the offsets to non-negative numbers, although the modulo calculation would be unaffected by that.
- Solution Structure:
  - Input three numbers *height*, *offset*1, *offset*2:

    — function *ask* takes as argument the minimal aceptable number and insists on input until the entered number aceptable; that number is then returned.
  - Loop *height* times for the rows, and *width* times for the columns; each time:
    - deciding for each of the two zigzag lines whether they cross the current position (function *onZigZag*), and
    - printing the corresponding character
  - Before the whole loop, and after each row, print a new-line character.

```
#include <stdio.h>
#include <stdbool.h>

int ask(int); /* interactively obtains from user a number bounded from below */

bool onZigZag (int height, int offset, int x, int y);
/* returns true if (x,y) is on the zigzag defined by height and offset */

int main() {
  int height, offset1, offset2;
  const int width = 79;
  int x,y;
  bool hit1, hit2;

  printf ( "For the height of the zig-zag,\n" );        height  = ask(1);
  printf ( "For the offset of the first zig-zag,\n" );  offset1 = ask(0);
  printf ( "For the offset of the second zig-zag,\n" ); offset2 = ask(0);

  printf("\n");
  for ( y = 0; y < height; y++) {
    for ( x = 0; x < width; x++) {
      hit1 = onZigZag( height, offset1, x, y );
      hit2 = onZigZag( height, offset2, x, y );
      if ( hit1 ) {
        if ( hit2 ) printf("*");  /*   hit1 && hit2  */
        else        printf("+");  /*   hit1          */
      }
      else {
        if ( hit2 ) printf("X");  /*           hit2  */
        else        printf(" ");
      }
    } /* end for(x) */
    printf("\n");
  } /* end for(y) */
  return 0;
}

int ask(int min) {
  int n = 0;
  do {
    printf ( "enter a number greater or equal to %d: ", min );
    scanf ( "%d", &n );
  }
  while (n < min);    /* input that is too small leads to re-prompt */
  return n;
}

bool onZigZag (int height, int offset, int x, int y) {
  int period = 2 * (height - 1);                  /* length of zig-zag period */
  int local  = (x + period - offset) % period;    /* position in current period */
  if (local < height)       /* falling flank */
    return  local == y;
  else                      /* rising flank without ends */
    return  (period - local) == y;
}
```

Exercise 2.4

What is the output ot the following C program (which prints not more than ten lines):

```
#include <stdio.h>
int main ( void ) {
    char input[] = "terasse";
    char result[] = "      ";   // six spaces
    int i, j = 0, c = 3, q;
    for ( q = 3; q ≥ 0; q = q - c ) {
       for ( i = 0; i < c; i++ ) {
          printf("j = %d\tc = %d\tq = %d\ti = %d\n", j, c, q, i);
          result[j] = input[q + i];
          j = j + 1;
       }
       c = c - 1;
    }
```

```
   printf("%s!\n", result);
   return 0;
}
```

What is the value of *q* after termination of the outer loop?

Solution Hints

```
j = 0   c = 3   q = 3   i = 0
j = 1   c = 3   q = 3   i = 1
j = 2   c = 3   q = 3   i = 2
j = 3   c = 2   q = 1   i = 0
j = 4   c = 2   q = 1   i = 1
j = 5   c = 1   q = 0   i = 0
assert!
```

The program terminates with the following two states before and after the closing brace of the outer loop:

```
j = 6   c = -65536      q =  2147450880 i = 0
j = 6   c = -65536      q = -2147450880 i = 0
```

Note:

$$\begin{aligned} 2^{16} &= 65536 \\ 2^{31} &= 2147483648 \\ 2^{31} - 2^{15} &= 2147450880 \end{aligned}$$

This program only terminates because of `int` wrap-around!
