CSC 209 Review 5 Solution

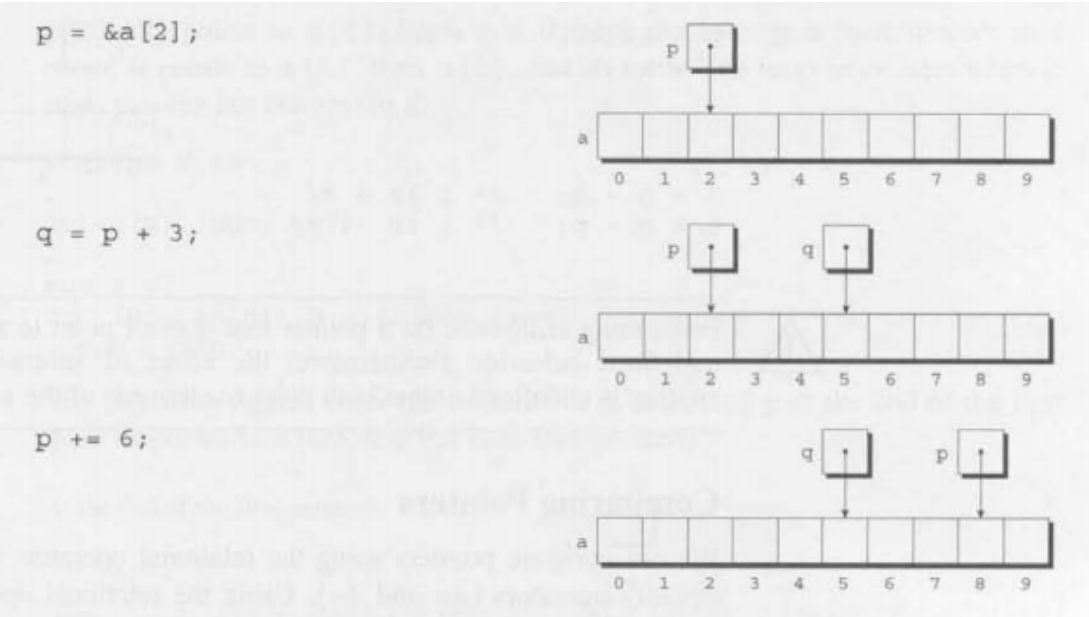
August 22, 2020

1. a) 14
   b) 34
   c) 4
   d) true
   e) false

   Notes

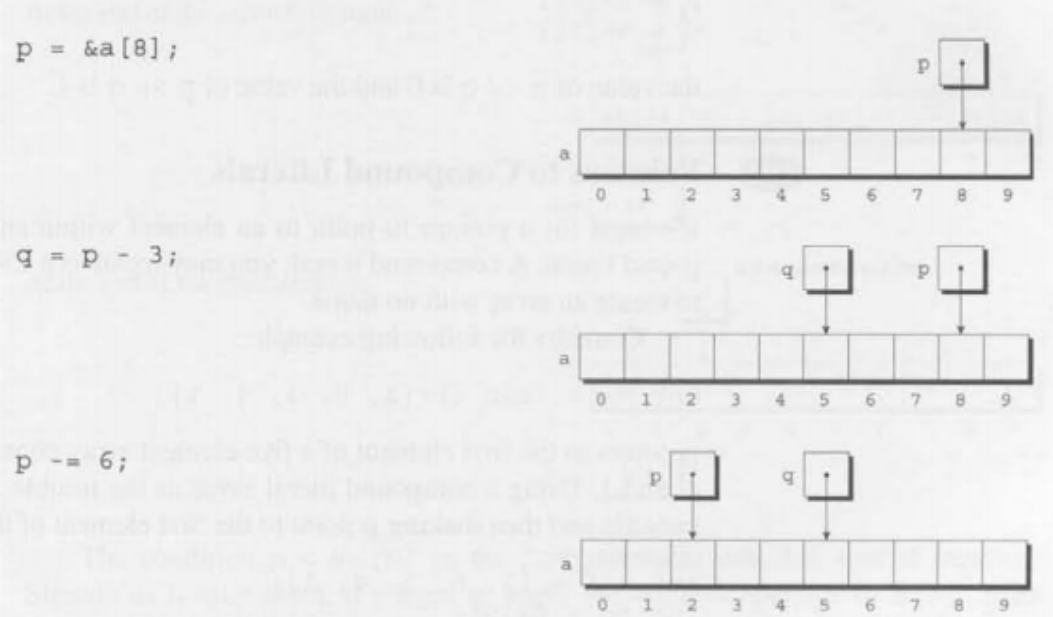
   - **Pointer Arithematic**
     - Adding an integer to a pointer

       Example



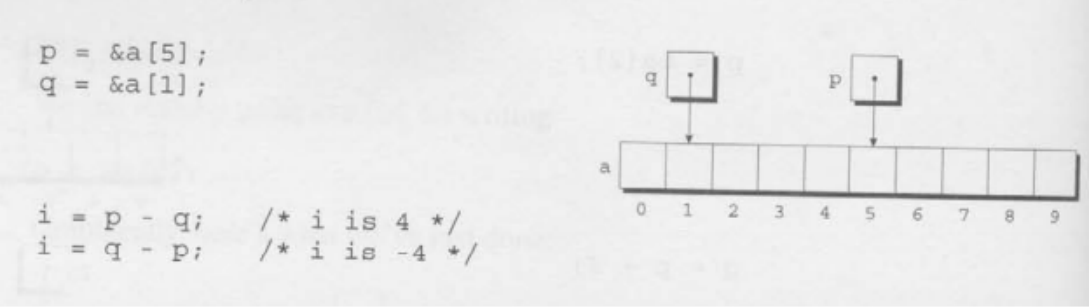
– Subtracting an integer from a pointer

Example



– Subtracting one pointer from another

Example



- **Comparing pointers**
  - Can compare pointers using relational operators (i.e. $<, <=, >, >=$) and the equality operators (i.e. $==, !=$)
  - Returns 1 if `true` and 0 if `false`

Example

```
p = &a[5];
q = &a[1];
```

`p` <= `q` is 0 and `p` >= `q` is 1

2. `low` and `high` are memory addresses.

   So, `low + high` is out of bound, and it could potentially point to an undesirable or wrong value.

   To fix this, we subtract the from high value to the low value:

$$\texttt{middle} = \frac{\texttt{low + high}}{2} \tag{1}$$

3. I need to write the contents of an array `a` after the execution of statements outlined in problem sheet.

   After execution, the array would have contents of $[10, 9, 8, 7, 6, 5, 4, 3, 2, 1]$.

   Notes

   - **Combining the * and ++ Operators**
     - `*p++` or `*p++` → Value of expression is `*p` before increment; increment `p` later
     - `(*p)++` → Value of expression is `*p` before increment; increment `*p` later
     - `*++p` or `*(++p)` → Increment `p` first; value of expression is `*p` after increment
     - `++*p` or `++(*p)` → Increment `*p` first; value of expression is `*p` after increment

   Example

   `a[i++] = j`

   Means assign the value `j` to `a[i]` before increment

   Example 2

```
for (p = &a[0]; p < &a[N]; p++)
  sum += *p;
```

   Is the same as

```
p = &a[0];
while (p < &a[N])
  sum += *p++;
```

4. I need to re-write prototype `make_empty`, `is_empty` and `is_full` of the following code to use the pointer variable `top_ptr` instead of the integer variable `top`.

```
#include <stdbool.h>

#define STACK_SIZE 100

/*external variables*/
int contents[STACK_SIZE]
int top = 0;

void make_empty(void) {
    top = 0;
}

bool is_empty(void) {
    return top == 0;
}

bool is_full(void) {
    return top == STACK_SIZE;
}
```

And after re-write using `top_ptr` instead of `top` have:

```
#include <stdbool.h>

#define STACK_SIZE 100

/*external variables*/
int contents[STACK_SIZE]
int *top_ptr = &contents[0];

void make_empty(void) {
    top_ptr = &contents[0];
}

bool is_empty(void) {
    return top_ptr == &contents[0];
}

bool is_full(void) {
    return top_ptr == &contents[STACK_SIZE-1];
}
```

5. First, I need to identify which of the following expressions are illegal because of mismatched types.

a) `p == a[0]`

b) `p == &a[0]`

c) `*p == a[0]`

d) `p[0] == a[0]`

Here, only `a)` is illegal.

Second, I need to write which of the remaining expressions are true.

Here, the expressions that return true are `b)`, `c)` and `d)`.

Notes

- `*(a+i)` is equal to `a[i]`
- `*p` and `a[]` are the same given `p == a`
- **Using an Array Name as a Pointer**
  - The name of an array can be used as a pointer to the first element in the array.

    Example

    ```
    int a[10];

    *a = 7; /* stores 7 in a[0] */

    *(a+1) = 12; /* stores 7 in a[1] */
    ```

    Example 2

    To simplify the loop, we can replace `&a[0]` by `a` and `&a[N]` by `a + N`:

    ```
    for (p = a; p < a + N; p++)
      sum += *p;
    ```

6. I need to re-write the following to use pointer arithematic instead of array subscripting, and I need to make as few change as possible.

```
1   int sum_array(cost int a[], int n) {
2       int i, sum;
3
4       sum = 0;
5
6       for (i = 0; i < n; i++)
7           sum += a[i];
8       return sum;
9   }
```

After making changes to above code to use pointer arithematic, we have

```
int sum_array(cost int a[], int n) {
    int i, sum;

    sum = 0;

    for (i = 0; i < n; i++)
        sum += *(a+i);
    return sum;
}
```

7. I need to write the following using pointer arithematic so it finds an element in `a` that matches to value `key`. I need to return true if there is a match.

   `bool search(const int a[], int n, int key);`

   And the solution is:

```
bool search(cost int a[], int n, int key) {

    for (int i = 0; i < n; i++) {
        if (*(a+i) == key) {
            return true
        }
    }

    return false;
}
```

8. Here, I need to re-write the following function to use pointer arithmetic instead of array subscripting.

```
void store_zeros(cost int a[], int n) {
    int i;

    for (i = 0; i < n; i++) {
        a[i] = 0;
    }
}
```

   After re-writing above code, we have

```
void store_zeros(cost int a[], int n) {
    int *p;

    for (p = a; p < a + n; p++) {
        *p = 0;
    }
}
```

9. Here, I need to write the function

   `double inner_product(const double *a, const double *b, int n)`

   using pointer arithmetic such that it returns `a[0] * b[0] + a[1] * b[1] + a[2] * b[2] + ... + a[n-1] * b[n-1]`.

   The solution is provided below

```
    double inner_product(const double *a, const double *b, int n) {
        double sum = 0, p*;

        p = a;

        while (p < a + n) {
            sum += *a * *b;

            a++;
            b++;
            p++;
        }

        return sum;
    }
```

Correct Solution

```
double inner_product(const double *a, const double *b, int n) {
    double sum = 0, *p;

    p = a;

    while (p++ < a + n) {
        sum += *a++ * *b++;
    }

    return sum;
}
```

10. Here, I need to rewrite the function `find_middle` so that it uses pointer arithmetic - not subscripting - to visit any element.

    The solution to this exercise is provided below.

```
    int *find_middle(int a[], int n) {
        return a + (n/2)
    }
```

11. Here I need to modify the function `find_largest` function so that it uses pointer arithmetic - not subscripting - to visit array elements

```
int *find_largest(int a[], int n) {
    int *p, *max;

    max = a;

    for (p = a; p < a + n; p++){
        if (*p > *max) {
            max = p;
        }
    }

    return *max;
}
```

12. I need to write the function

    `void find_two_largest(const int *a, int n, int *largest, int *second_largest)`

    using pointer arithmetic.

    The solution to this exercise is:

```
#include <stdbool.h> // bool
#include <limits.h>  // INT_MIN

bool is_largest(int current_max, int val);

void find_two_largest (int a[], int n, int *largest, int*
second_largest) {
    int current_max = INT_MIN;
    int current_second_max = INT_MIN;

    for (int i = 0; i < n; i++) {
        if (is_largest(current_max, a[i])) {
            current_second_max = current_max;
            current_max = *(a + i);
        }
    }

    *largest = current_max;
    *second_largest = current_second_max;
}

bool is_largest(int current_max, int val) {
    if (val > current_max) {
        return true;
    }

```

```
26          return false;
27      }
```

Correct Solution:

```
1       void find_two_largest(const int *a, int n, int *largest, int *
        second_largest) {
2
3           const int *p = a;
4           *largest = *second_largest = *a;
5
6           while (p++ < a + n) {
7               if (*p > *largest) {
8                   *second_largest = *largest;
9                   *largest = *p;
10              } else if (*p > *second_largest)
11                  *second_largest = *p;
12          }
13      }
```

13. I need to rewrite the following program such that it uses a single pointer through the array one element at a time.

```
1       #define N 10
2
3       double ident[N][N];
4       int row, col;
5
6       for (row = 0; row < N; row++) {
7           for (col = 0; col < N; col++) {
8               if (row == col) {
9                   ident[row][col] = 1.0;
10              } else {
11                  ident[row][col] = 0.0;
12              }
13          }
14      }
```

The solution to this exercise is:

```
1       #include <stdio.h>
2       #include <stdbool.h>
3
4       #define N 10
5
6       bool is_row_eq_col(int i, int n);
7
8       int main() {
```

```
9
10      int i = 0;
11
12      double ident[N][N], *p;
13
14
15      for (p = &ident[0][0]; p < &ident[N-1][N-1]; p++) {
16          if (is_row_eq_col(i, N)) {
17              *p = 1.0;
18          } else {
19              *p = 0.0;
20          }
21          i++;
22      }
23
24
25      return 0;
26  }
27
28  bool is_row_eq_col(int i, int n) {
29      if (i % (n+1) != 0) {
30          return false;
31      }
32
33      return true;
34  }
```

Notes

- Learned that the memory address of each row in two dimensional array are placed right next to each other

14. I need to write a statement that uses the `search` function from Exercise 7 to search the entire `temperatures` array for thevalue 32.

    The solution to this problem is:

```
1   int row = 0;
2
3   for (int row = 0; row < 7; row++) {
4       if (search(temperatures[row], 24, 32)) {
5           return true
6       }
7   }
8
9   return false;
```

15. Create a loop that prints all temperature readings in row `i` of the following array using a pointer to visit each element of the row.

`inte temperatures[7][24]`

The solution to this problem is:

```
    int *p;

    for (p = &a[i]; p < &a[i] + 24; p++) {
        printf("%d", *p);
    }
```

Correct Solution:

```
    int *p;

    for (p = &temperatures[i]; p < &temperatures[i] + 24; p++) {
        printf("%d", *p);
    }
```

16. I need to write a loop that prints the highest temperature in the `temperatures` array for each day of the week using `find_largest` function.

    The solution to this problem is:

```
    int *p, *val;

    for (p = &temperatures[i]; p < &temperatures[i] + 24; p++) {
        val = find_largest(p, 24);
        printf("%d\n", *val);
    }
```

17. I need to rewrite the following function to use pointer arithmetic and single loop, instead of array subscripting.

```
    int sum_two_dimensional_array(const int a[][LEN], int n) {
        int i, j, sum = 0;

        for (i = 0; i < n; i++) {
            for (j = 0; j < LEN; j++) {
                sum += a[i][j];
            }
        }

        return sum;
    }
```

    The solution to this problem is:

```c
int sum_two_dimensional_array(const int a[][LEN], int n) {
    int *p, sum = 0;

    for (p = &a[0][0]; p < &a[n-1][LEN-1]; p++) {
        sum += *p;
    }

    return sum;
}
```

18. I need to rewrite the `evaluation_position` function described in exercise 13 of chapter 9 using pointer arithmatic and single loop.

    The solution to this problem is:

```c
int evaluate_position(char board[8][8]) {

    int white = 0, black = 0;
    char *p;

    for (p = &board[0][0]; p < &board[7][7]; p++) {
        switch(*p) {
            case 'Q':
                white += 9;
                break;
            case 'q':
                black += 9;
                break;
            case 'R':
                white += 5;
                break;
            case 'r':
                black += 5;
                break;
            case 'B':
                white += 3;
                break;
            case 'b':
                black += 3;
                break;
            case 'N':
                white += 3;
                break;
            case 'n':
                black += 3;
                break;
            case 'P':
                white++;
                break;
            case 'p':
                black++;
                break;
```

```
38                  default:
39                      break;
40              }
41          }
42
43          return white - black;
44      }
```