CSC 209 Review 7 Solution

August 27, 2020

1 Exercises

1. First, I need to justify if the folllowing declarations legal on an individual basis:

   `struct {int x, y;} x;`

   `struct {int x, y;} y;`

   The struct `struct {int x, y;} x;` is legal. `struct {int x, y;} x;` is equivalent to

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

   and 'x' beside struct represents variable of that type. It is used to declare struct and access members of the struct (e.g. `x.x`,, `x.y`).

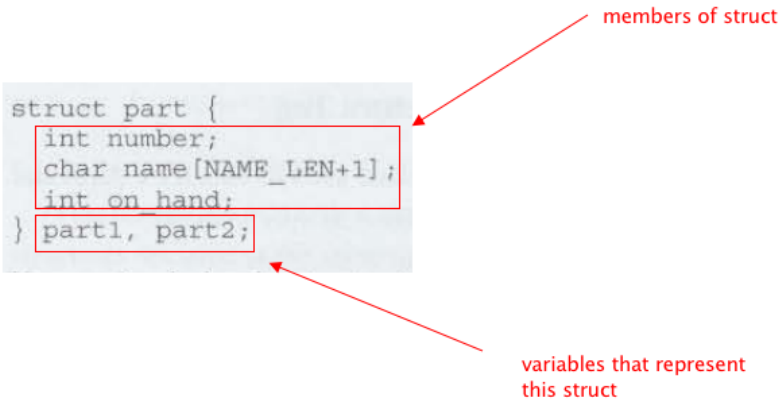
   The same is true for `struct {int x, y;} y;`.

   Second, I need to answer if both declarations of struct can appear in a program.

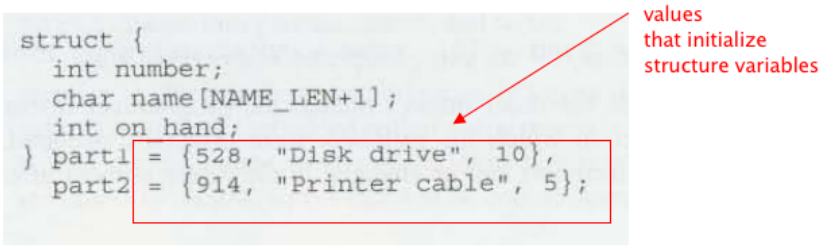
   The answer is yes. Each structure has a separate name space for it's members.

   Notes

   - **Declaring Structure Variables**
     - Struct can have many variables that represent the same struct



- **Initializing Structure Variables**
  - Struct can be initialized with preset values (like python class under __init__)



2. a) I need to declare structure variables named `c1`, `c2` and `c3`, each having members `real` and `imaginary` of type `double`.

   The solution to this problem is:

```
1    struct {
2        double real, imaginary;
3    } c1, c2, c3;
```

   b) I need to modify the declaration in part a) so that

   - `c1`'s members initially have the values 0.0 and 1.0
   - `c2`'s members initially have the values 1.0 and 0.0
   - `c3` is not initialized

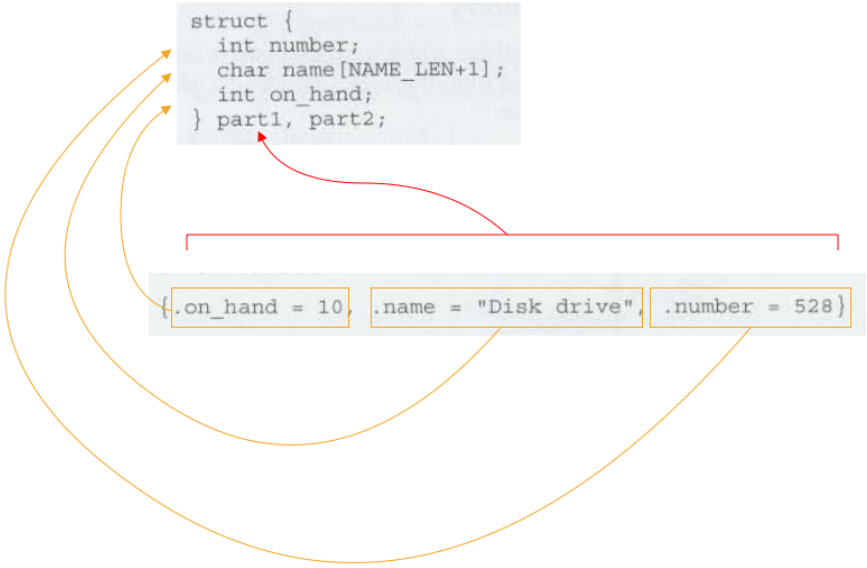
   The solution to this problem is:

```
struct {
    double real, imaginary;
} c1 = {0.0, 1.0},
  c2 = {1.0, 0.0},
  c3;
```

Notes

- **Designated Initializer**
  - Allows specific member variable to be initialized
  - Allows member variables to be initialized in any order

Example



c) I need to write statements that copy the members of `c2` to `c1`.

Copying the members of `c2` and c1 can be done in one statement.

Below is the solution to this problem:

```
c2 = c1
```

d) I need to write statements that add the corresponding members of `c1` and `c2` and store the result in `c3`.

The solution to this problem is:

```
struct {
    double real, imaginary;
} c1 = {0.0, 1.0},
```

```
        c2 = {1.0, 0.0},
        c3;

    ...

    c3 = c1 + c2;
```

Notes

- member variables of struct contains two operators & and . (e.g &`part1.number` and `part1.number`)
- & accesses memory address of the member variable, where as . accesses value
- `part1 = part2` copies contents in `part2` to corresponding member variable in `part1`

```
struct {
  int number;
  char name[NAME_LEN+1];
  int on_hand;
} part1, part2;
```

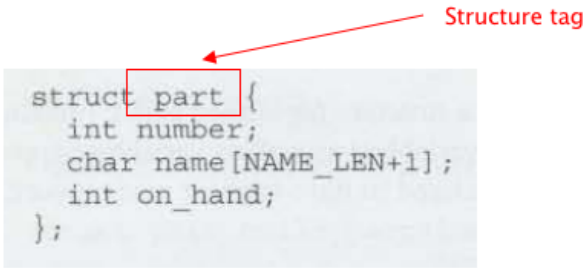
3. a) I need to declare a tag named `complex` for a structure with two members `real` and `imaginary`, of type `double`

The solution to this problem is:

```
    struct complex {
        double real, imaginary;
    };
```

Notes

- **Declaring a Structure Tag**
  - allows to use struct in function calls
  - allows to use the same struct in multiple files of a program



b) I need to use the `complex` tag to declare variables named `c1`, `c2`, `c3`.

The solution to this problem is:

```
struct complex {
    double real, imaginary;
} c1, c2, c3;
```

c) I need to write a function named `make_complex` that satisfies the following:

- The function `make_complex` should have two parameters (`real`, `imaginary`) of type `double`
- The function `make_complex` should store the two arguments in `complex` struct
- The function `make_complex` should return the struct

The solution to this problem is:

```
struct complex {
    double real, imaginary;
};

struct complex (double real, double imaginary) {
    struct complex c1;

    c1.real = real;
    c1.imaginary = imaginary;

    return c1;
}
```

Notes

- **Declaring Variables Cont.**
  - Once the struct tag is formed, it can be used to declare variables

    Example

    `struct part part1, part2`

  - Structure tag can be combined with the declaration of structure variables.
    - it's like creating a global variable (if it's outside of main), or local variable (if it's created inside a function) at the instant the struct is formed

```
struct part {
  int number;
  char name[NAME_LEN+1];
  int on_hand;
} part1, part2;
```

– Declared variables can set values the moment it's declared

Example

`struct part part1 = {528, "Disk Drive", 10}`

d) I need to write a function named `add_complex` that satisfies the following:

- The function `add_complex` should have 2 parameters of type `struct complex`
- The function `add_complex` should add the corresponding members of its arguments
- The function `add_complex` should return the result of type `struct complex`

The solution to this problem is:

```
struct complex {
    double real, imaginary;
};

struct complex add_complex (struct complex c1, struct complex c2)
{
    struct complex c3;

    c3.real = c1.real + c2.real;
    c3.imaginary = c1.imaginary + c2.imaginary;

    return c3;
}
```

4. I need to repeat exercise 3 but using a `type` named `complex`.

a)
```
typedef struct {
    double real, imaginary;
} Complex;
```

b)
```
typedef struct {
    double real, imaginary;
} Complex;

...

Complex c1, c2, c3;
```

c)
```
typedef struct {
    double real, imaginary;
} Complex;

Complex make_complex(double real, double imaginary) {
    Complex c;

    c.real = real;
```

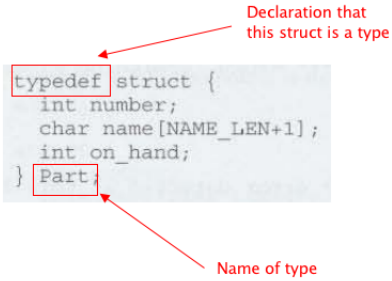
```
        c.imaginary = imaginary;

        return c;
    }
```

d)

```
    typedef struct {
        double real, imaginary;
    } Complex;

    Complex add_complex(Complex c1, Complex c2) {
        Complex c3;

        c3.real = c1.real + c2.real;
        c3.imaginary = c1.imaginary + c2.imaginary;

        return c3;
    }
```

Notes

- **Structure Type**
  - Is an alternative to declaring a structure tag



  - Allows us to define a genuine type name

    Example

    `Part part1, part2;`
  - Once declared, cannot define a structure tag with the same name

5. a) I need to write the following function

   `int day_of_year (struct date d);`

   satisfying the following requirements:

   - The `date` structure should contain three members: `month`, `day`, and `year` all of type `int`
   - The function `day_of_year` should return the day of the year (an integer between 1 and 366) that corresponds to the date `d`

The solution to this problem is:

```
1
2     struct date {
3         int month, day, year;
4     };
5
6     int day_of_year (struct date d);
7
8     ...
9
10    int day_of_year (struct date d) {
11        bool leap_year = false;
12        int days = 0, days_in_month[] = {
13            31, 28, 31, 30,
14            31, 30, 31, 31,
15            30, 31, 30, 31};
16
17        // check if it's the leap year
18        if (((d.year % 4 == 0) &&
19            (d.year % 100 != 0)) ||
20            (d.year % 400 == 0)) {
21
22                leap_year = true;
23            }
24
25
26        // add days from months
27        for (int i = 0; i < d.month; i++) {
28            if (i == d.month-1) {
29                days += d.day;
30                continue;
31            }
32
33            days += days_in_month[i];
34        }
35
36
37        // add 1 more day if month > 2 and it's leap year
38        if (leap_year && d.month > 2) {
39            days += 1;
40        }
41
42
43        // return days
44        return days;
45    }
```

b) I need to write the following function

```
int compare_dates (struct date d1, struct date d2);
```

satisfying the following requirements:

- The function `compare_dates` should return
  - -1 if `d1` is an earlier date than `d2`
  - +1 if `d1` is a later date than `d2`
  - 0 if `d1` and `d2` are the same

The solution to this problem is:

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

struct date {
    int month, day, year;
};

...

int compare_dates (struct date d1, struct date d2) {
    char s1[9], s2[9];

    sprintf(s1,"%4d%2d%2d", d1.year, d1.month, d1.day);
    sprintf(s2,"%4d%2d%2d", d2.year, d2.month, d2.day);

    // return days
    return strcmp(s1,s2);
}
```

6. I need to write the following function

   `struct time split_time(long total_seconds)`

   satisfying the following requirements:

   - The `time` structure has three members `hours`, `minutes`, `seconds`
   - The function `split_time` should return `time` struct containing equivalent time in `hours` (0-23), `minutes` (0-59), `seconds` (0-59)

   The solution to this problem is:

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

struct time {
    int hours, minutes, seconds;
};

struct time split_time (long total_seconds);

```

```
...

struct time split_time (long total_seconds) {
    struct time t;
    int s = (int)total_seconds;

    printf("%d\n", s);

    t.hours = s / 3600;
    s = s - (t.hours * 3600);

    t.minutes = s / 60;
    s = s - (t.minutes * 60);

    t.seconds = s;

    return t;
}
```

7. a) I need to write a function that satisfies the following requirements:

   - The function should reduce the fraction `f` to lowest terms
   - The struct `fraction` contains two members: `numberator` and `denominator`, and both are type `int`

   The solution to this problem is:

```
struct fraction {
    int numerator, denominator;
};

...

struct fraction reduce (struct fraction f) {

    int gcd;

    struct fraction f2;

    if (f.numerator >= f.denominator) {
        gcd = f.denominator;
    } else {
        gcd = f.numerator;
    }

    while (gcd > 0) {
        if ((f.numerator % gcd == 0) &&
            (f.denominator % gcd == 0)) {
            break;
        }

        gcd--;
```

```
        }

        f2.denominator = f.denominator/gcd;
        f2.numerator = f.numerator/gcd;

        return f2;
    }
```

b) I need to write a function that adds two fractions `f1` and `f2`.

The solution to this problem is:

```
    struct fraction {
        int numerator, denominator;
    };

    ...

    struct fraction add (struct fraction *f1, struct fraction *f2) {

        struct fraction f3;

        if (f1->denominator != f2->denominator) {
            f3.numerator = (f1->numerator * f2->denominator) + (f2->
numerator * f1->denominator);
            f3.denominator = f1->denominator * f2->denominator;
        } else {
            f3.numerator = f2->numerator + f1->numerator;
        }

        f3 = reduce(f3);

        return f3;
    }
```

c) I need to create a function that subtracts two fractions `f1` and `f2`.

The solution to this problem is:

```
    struct fraction {
        int numerator, denominator;
    };

    ...

    struct fraction subtract (struct fraction *f1, struct fraction *
f2) {

        struct fraction f3;

        if (f1->denominator != f2->denominator) {
            f3.numerator = (f2->numerator * f1->denominator) - (f1->
numerator * f2->denominator);
            f3.denominator = f1->denominator * f2->denominator;
```

```
14          } else {
15              f3.numerator = f2->numerator - f1->denominator;
16          }
17
18          f3 = reduce(f3);
19
20          return f3;
21      }
```

d) I need to create a function that divides fractions `f1` by fraction `f2`.

The solution to this problem is:

```
1       struct fraction {
2           int numerator, denominator;
3       };
4
5       ...
6
7       struct fraction divide (struct fraction *f1, struct fraction *f2)
        {
8
9           struct fraction f3;
10
11          f3.denominator = f1->denominator * f2->numerator;
12          f3.numerator = f1->numerator * f2->denominator;
13
14          f3 = reduce(f3);
15
16          return f3;
17      }
```

8. a) I need to write a declaration for a `const` variable named `MAGNETA` of type `struct color` that satisfies the following

- `red` has value 255
- `green` has value 0
- `blue` has value 255

The solution to this problem is:

```
1       struct color {
2           int red;
3           int green;
4           int blue;
5       };
6
7       const struct color MAGNETA = {255, 0, 255}
```

I need to rewrite above to use a designated initializer that doesn't specify the value of `green`.

The solution to this problem is:

```c
struct color {
    int red;
    int green;
    int blue;
};

const struct color MAGNETA = {.red = 255, .blue = 255};
```

Notes

b)
- `int` variable prints 0, if nothing is in it

9. a) I need to write the function

`struct color make_color(int red, int green, int blue)`

that satisfies the following requirements:

- The function `make_color` should return `color` structure
- The function `make_color` should return 0 for a member variable if the corresponding argument has value less than 0
- The function `make_color` should return 255 for a member variable if the corresponding argument has value greater than 255

The solution to this problem is:

```c
struct color make_color(int red, int green, int blue) {
    struct color c;

    red = red < 0 ? 0 : red;
    green = green < 0 ? 0 : green;
    blue = blue < 0 ? 0 : blue;

    red = red > 255 ? 255 : red;
    blue = blue > 255 ? 255 : blue;
    green = green > 255 ? 255 : green;

    c.red = red;
    c.green = green;
    c.blue = blue;

    return c;
}
```

b) I need to write the function

`int getRed(struct color c)`

that returns the value of `c`'s red member.

The solution to this problem is

```
int getRed(struct color c) {
    return c.red;
}
```

c) I need to write the function

`bool equal_color(struct color color1, struct color color2)`

satisfying the following requirement

- The function `equal_color` returns true if the corresponding members of `color1` and `color2` are equal

The solution to this problem is:

```
bool equal_color(struct color color1, struct color color2) {
    if ((color1.red == color2.red) &&
        (color1.green == color2.green) &&
        (color1.blue == color2.blue)) {
        return true;
    }

    return false;
}
```

d) I need to write the function

`struct color brighter(struct color c)`

satisfying the following requirement

- if all members of `c` are zero, then return color whose all members have value 3
- If any member of `c` is greater than 0 but less than 3, it is replaced by 3 before the division by 0.7
- if any member of `c` is greater than equal to 3, than, divide by 0.7
- if diving by 0.7 exceeds 255, then replace it with 255

The solution to this problem is:

```
struct color brighter(struct color c) {

    if((c.red == 0 ) &&
        (c.green == 0) &&
        (c.blue == 0)) {

        c.red = 3;
        c.green = 3;
        c.blue = 3;

```

```
            return c;
        }

        c.red = c.red < 3 && c.red > 0 ? 3 : c.red;
        c.green = c.green < 3 && c.green > 0 ? 3 : c.green;
        c.blue = c.blue < 3 && c.blue > 0 ? 3 : c.blue;

        c.red = (int)(c.red/0.7);
        c.green = (int)(c.green/0.7);
        c.blue = (int)(c.blue/0.7);

        c.red = c.red > 255 ? 255 : c.red;
        c.green = c.green > 255 ? 255 : c.green;
        c.blue = c.blue > 255 ? 255 : c.blue;

        return c;
    }
```

e)

```
struct color darker(struct color c) {

    if((c.red == 0 ) &&
        (c.green == 0) &&
        (c.blue == 0)) {

        c.red = 3;
        c.green = 3;
        c.blue = 3;

        return c;
    }

    c.red = c.red < 3 && c.red > 0 ? 3 : c.red;
    c.green = c.green < 3 && c.green > 0 ? 3 : c.green;
    c.blue = c.blue < 3 && c.blue > 0 ? 3 : c.blue;

    c.red = (int)(c.red*0.7);
    c.green = (int)(c.green*0.7);
    c.blue = (int)(c.blue*0.7);

    c.red = c.red > 255 ? 255 : c.red;
    c.green = c.green > 255 ? 255 : c.green;
    c.blue = c.blue > 255 ? 255 : c.blue;

    return c;
}
```

10. a)

```
int area(struct rectangle r) {
    return ((r.upper_left.y - r.lower_right.y) *
            (r.lower_right.x - r.upper_left.x));
}
```

Notes

- **Nested Structure**
  - Works just like a nested class

```
struct person_name {
  char first[FIRST_NAME_LEN+1];
  char middle_initial;
  char last[LAST_NAME_LEN+1];
};
```

```
struct student {
  struct person_name name;
  int id, age;
  char sex;
} student1, student2;
```

```
strcpy(student1.name.first, "Fred");
```

b)

```
struct point center(struct rectangle r) {
    struct point pt;

    pt.x = (int)((r.upper_left.y - r.lower_right.y)/2);
    pt.y = (int)((r.lower_right.x - r.upper_left.x)/2);

    return pt;
}
```

c)

```
struct rectangle translate(struct rectangle r, int x, int y) {

    r.upper_left.x += x;
    r.upper_left.y += y;

    r.lower_right.x += x;
    r.lower_right.y += y;

    return r;
}
```

d)

```
bool inside_rectangle(struct rectangle r, struct point p) {
    if ((p.x > r.upper_left.x && p.x < r.lower_right.x) &&
        (p.y > r.lower_right.y && p.y < r.upper_left.y)) {
            return true;
        }

    return false;
}
```

11. Total of 20 bytes are allocated for `s`.

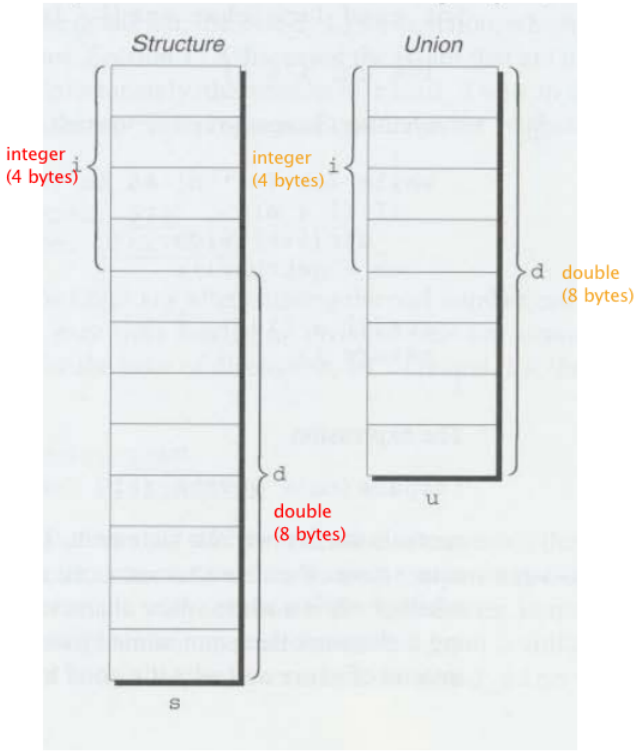
- `a` - 8 bytes
- `e` - 8 bytes
- `f` - 4 bytes

Notes

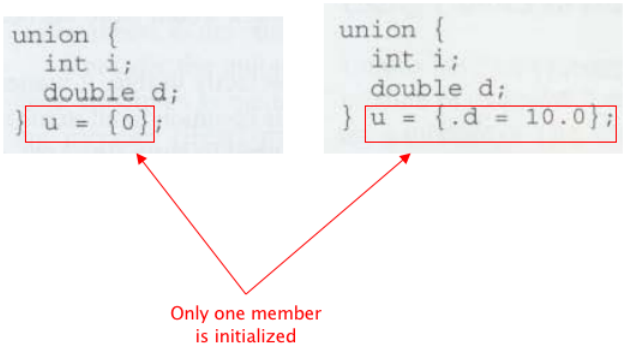
- **Union**
  - is very similar to structure (with one difference)
  - is accessed the same way as structure

    Example

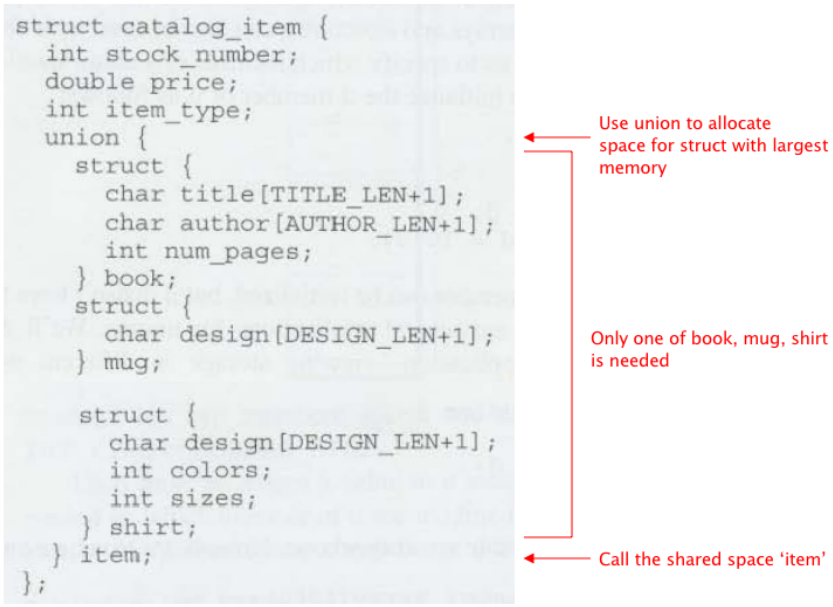
  - shares memory among all members
    - Memory is allocated for the largest of members



  - Is used to save space in structures
  - Only one member can be given an initial value



Example



– feels as if union is used as an efficient version of switch
(could python's type-independent variable also use union?)

12. Total of 16 bytes are allocated for `u`.

- `a` - 8 bytes
- `e` - 16 bytes [is largest]
- `f` - 4 bytes

13.
- `a)` legal
- `b)` legal
- `c)` correction: `s.u.rectangle.height = 25;`
- `d)` legal

- e) correction: `s.u.circle.radius = 5;`
- f) correction: `s.u.circle.radius = 5;`

14. a)
```c
#include <math.h>
#define M_PI 3.14159265358979323846

double area (struct shape s) {
    if (s.shape_kind == RECTANGLE) {
        return s.u.rectangle.height * s.u.rectangle.width;
    } else {
        return M_PI * pow(s.u.circle.radius, 2);
    }
}
```

b)
```c
#include <math.h>
#define M_PI 3.14159265358979323846

double area (struct shape s) {
    if (s.shape_kind == RECTANGLE) {
        return s.u.rectangle.height * s.u.rectangle.width;
    } else {
        return M_PI * pow(s.u.circle.radius, 2);
    }
}
```

c)
```c
struct shape translate (struct shape s, int x, int y) {
    s.center.x += x;
    s.center.y += y;

    return s;
}
```

d)
```c
struct shape translate (struct shape s, int x, int y) {
    s.center.x += x;
    s.center.y += y;

    return s;
}
```

e)
```c
struct shape scale (struct shape s, double c) {
    if (s.shape_kind == RECTANGLE) {
        s.u.rectangle.height *=  c;
        s.u.rectangle.width *= c;
    } else {
        s.u.circle.radius *= c;
    }

    return s;
}
```

15. a) **Notes**

- **Enumeration**
  - Is a set of a small number of possible values
  - Is declared the similar way as union and structure

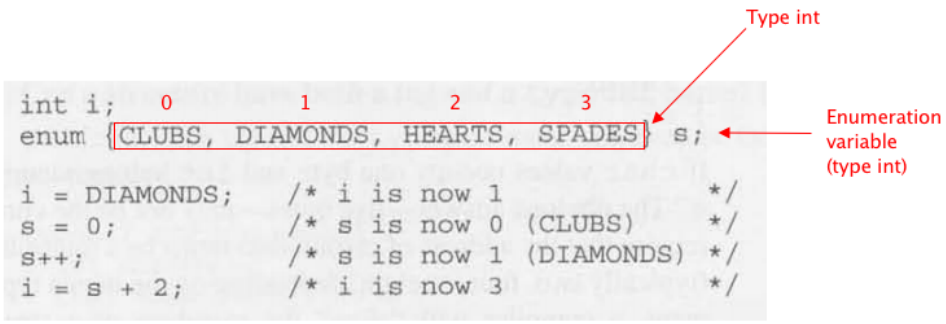
    Example:

    `enum suit { CLUBS = 0, DIAMONDS = 1, HEARTS = 2, SPADES = 3 }`

    `enum` declared by

    `enum suit s1, s2;`
  - C treats enumeration variables and constants as integers
  - Has value 0 for the first constant by default (similar to how array is structured)

    Example



  - Is perfect for struct with unions

```
typedef struct {
  enum {INT_KIND, DOUBLE_KIND} kind;
  union {
    int i;
    double d;
  } u;
} Number;
```

```
void print_number(Number n)
{
  if (n.kind == INT_KIND)
    printf("%d", n.u.i);
  else
    printf("%g", n.u.d);
}
```