CS1100 – Introduction to Programming

Instructor:

Shweta Agrawal (shweta.a@cse.iitm.ac.in)
Lecture 29

How to store multiple related items?

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- Instead it would be good to have a way to store a collection of different types of data – related to one particular object (in this case student).

- Structures in C allow us to do the same.

What is a structure?

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- Structures allow us to store variables of different data types together.
- Useful for logical organization even if all variables are of the same type.
    - Consider storing integer co-ordinates of n points in 2D.
    - Can be stored using an array of size $2n$.
    - But more logical to have x-coordinate separated from y-coordinate.

Defining a structure : Syntax

```
struct [structure tag]
   {
       member definition;
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       ...
       member definition;
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       int age;
       int program;
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```

- struct student is a new data-type.
- We can use struct student in the program just like a basic data type like int.
- struct student s; - defines a new variable s which is "type" struct student.
- Note the semicolon after the definition of the structure.

Using structures

Using structures

```
#include<stdio.h>
#include<string.h>
struct student {
     char rollNumber[6];
     char name[20];
     int age;
     int program;
};

struct student s;
```

Accessing values in a structure :
name.member gives you the value
stored in the member.
Eg : s.name

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```c
int main() {
    struct student S1;
    strcpy(S1.rollNumber, "CH17B005");
    strcpy(S1.name, "Mahendar");
    S1.age = 18;
    S1.program = 1;
    printf("Name: %s\n", S1.name);
    printf("Program: %d\n", S1.program)
}
```

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    S1.age = 18;
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    printf("Name: %s\n", S1.name);
    printf("Program: %d\n", S1.program)
}
```

We can also initialize a structure
by :
```c
struct student S1 =
{"AE18B002","BAKUL",18,1};
```

Assigning a structure to another

```
#include<stdio.h>
#include<string.h>
struct student {
    char rollNumber[6];
    char name[20];
    int age;
    int program;
};
```

```
int main()
{
    struct student S1,S2;
    strcpy(S1.rollNumber, "CS15B1");
    strcpy(S1.name, "Ameet Deshpande");
    S1.age = 18;
    S1.program = 1;
    S2 = S1;
}
```

Assigning a structure to another

```c
#include<stdio.h>
#include<string.h>
struct student {
    char rollNumber[6];
    char name[20];
    int age;
    int program;
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    S1.age = 18;
    S1.program = 1;
    S2 = S1;
}
```

- Assigning one structure to another is supported.
- However checking for equality or not equal of two structures is not supported by the language. S1 == S2 is syntax error.

Given a rectangle and a point
in 2D, determine if the point is
inside the rectangle.

Using structures again

Given a rectangle and a point in 2D, determine if the point is inside the rectangle.
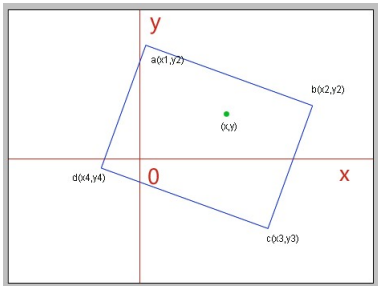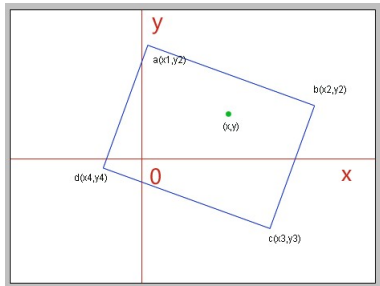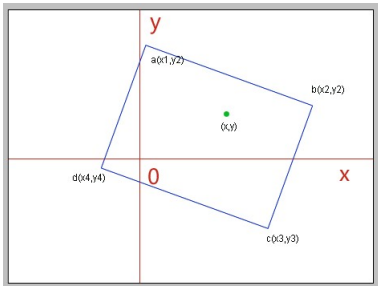
Using structures again

Given a rectangle and a point in 2D, determine if the point is inside the rectangle.
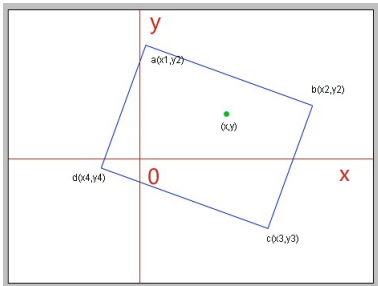
- Simplifying assumption : Assume rectangle is axis-parallel.

Using structures again

Given a rectangle and a point in 2D, determine if the point is inside the rectangle.

- Simplifying assumption : Assume rectangle is axis-parallel.
- How do we represent a point?

Using structures again
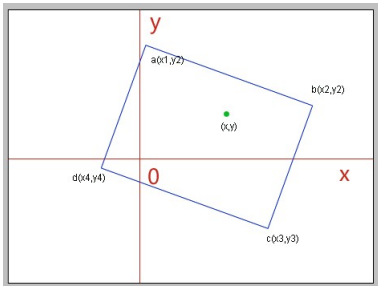

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- Simplifying assumption : Assume rectangle is axis-parallel.
- How do we represent a point?
- How do we represent a rectangle?

Given a rectangle and a point
in 2D, determine if the point is
inside the rectangle.

- Simplifying assumption : Assume rectangle is axis-parallel.
- How do we represent a point?
- How do we represent a rectangle?
- Given a rectangle specified by the endpoints of a diagonal,
  how do we determine if a point lies inside the rectangle?

Define Appropriate Structures

```
#include<stdio.h>
struct point {
     int xCoord;
     int yCoord;
};

struct rectangle {
     struct point lowerLeft;
     struct point upperRight;
};

int IsInside(struct rectangle, struct point);
```
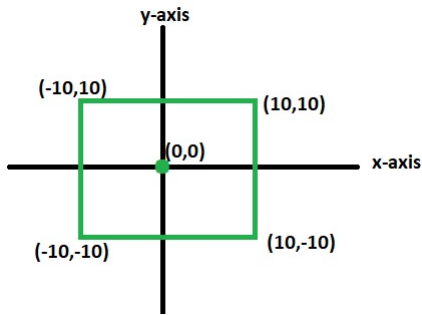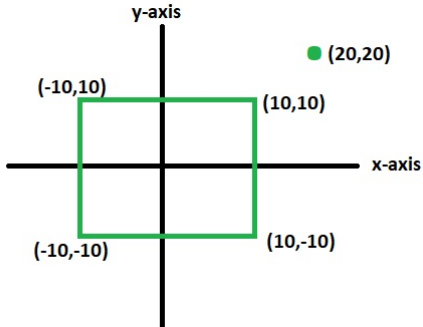
Check whether point is inside

```
int IsInside(struct rectangle R, struct point P)
{
    // to be filled.
}
```
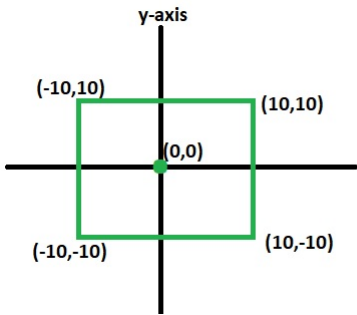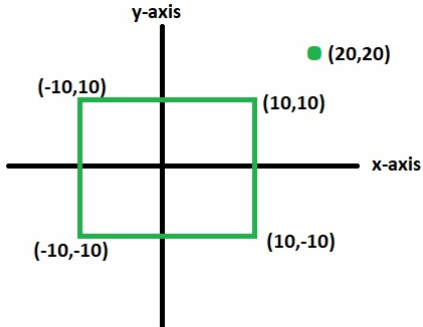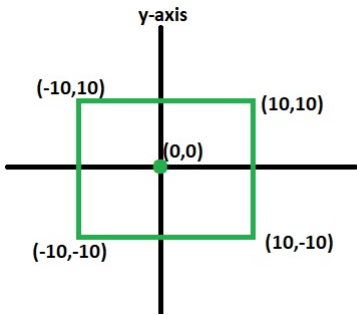
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Check whether point is inside

```c
int IsInside(struct rectangle R, struct point P)
{
    // to be filled.
}
```


Exercise : Complete the function is_inside.

Main Program : Scan the inputs & Invoke fn.

```
main() {
    struct rectangle R;
    struct point P;

    scanf("%d", &R.lowerLeft.xCoord);
    scanf("%d", &R.lowerLeft.yCoord);
    scanf("%d", &R.upperRight.xCoord);
    scanf("%d", &R.upperRight.yCoord);
    scanf("%d", &P.xCoord);
    scanf("%d", &P.yCoord);
    printf("%d\n", IsInside(R, P));
}
```

- Write a function to get a point.
- Write a function to print a point.

modularize the code further

- Write a function to get a point.
- Write a function to print a point.

```
void get_point (struct point pt) {
    scanf("%d", &pt.xCoord);
    scanf("%d", &pt.yCoord);
}

void print_point (struct point pt) {
    printf("%d\t", pt.xCoord);
    printf("%d\n", pt.yCoord);
}
```

Corresponding main file

```c
int main() {
    struct rectangle R;
    struct point P;

    GetPoint(R.lowerLeft);
    GetPoint(R.upperRight);
    GetPoint(P);

    printf("%d\n", IsInside(R, P));
    return 0;
}
```

Corresponding main file

```
int main() {
    struct rectangle R;
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    GetPoint(R.lowerLeft);
    GetPoint(R.upperRight);
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```

- Structures are passed by value.

Corresponding main file

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int main() {
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- Structures are passed by value. When the function is invoked
  - the structure R.lowerLeft is copied to the structure pt.

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    GetPoint(P);

    printf("%d\n", IsInside(R, P));
    return 0;
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  - the structure R.lowerLeft is copied to the structure pt.
- Changes made to contents of the structure are not visible
  outside the function.

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```

- Structures are passed by value. When the function is invoked
  - the structure R.lowerLeft is copied to the structure pt.
- Changes made to contents of the structure are not visible
  outside the function. For that we need to pass by reference.

How are structures stored?

- When the structure is defined - no memory is allocated.
- Only when it is used to declare a structure variable - memory is allocated.
- Contiguous memory allocations are assigned but with some gap filler bytes to fix the memory alignment.

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- When the structure is defined - no memory is allocated.
- Only when it is used to declare a structure variable - memory is allocated.
- Contiguous memory allocations are assigned but with some gap filler bytes to fix the memory alignment.
- The total size required to store a structure will depend on these alignments.

size of a structure

```
#include<stdio.h>
struct student {
    char rollNumber[6];
    char name[20];
    int age;
    int program;
};
int main() {
    printf("size of integer = %ld \n size = %ld\n",
    sizeof(int),sizeof(struct student));
}
```