CS1100 – Introduction to Programming

Instructor:

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Lecture 29

How to store multiple related items?

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- A possible way is to define 4 arrays – each of the appropriate type.
- Arrays allow us to store multiple items but all of them need to be of the same type.
- 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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- 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 in a separated from y-coordinate.

Defining a structure : Syntax

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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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```
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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    printf("Name: %s\n", S1.name);
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}
```

We can also initialize a structure by :

```
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

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#include<stdio.h>
#include<string.h>
struct student {
    char rollNumber[6];
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    S1.age = 18;
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}
```

- 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.

Using structures again

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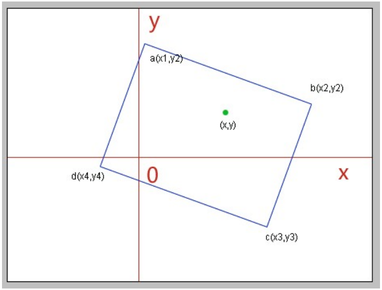

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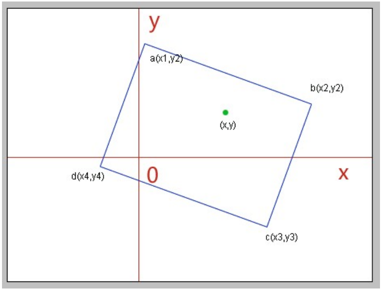

- Simplifying assumption : Assume rectangle is axis-parallel.

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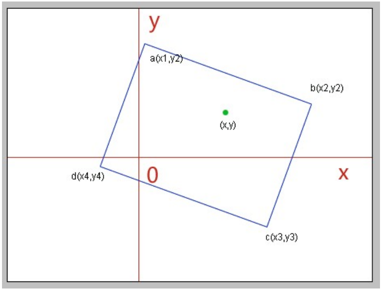

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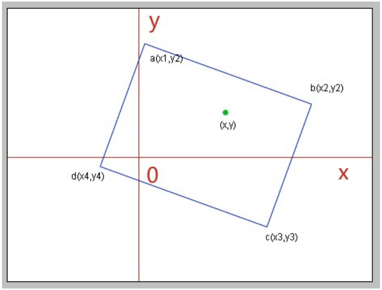

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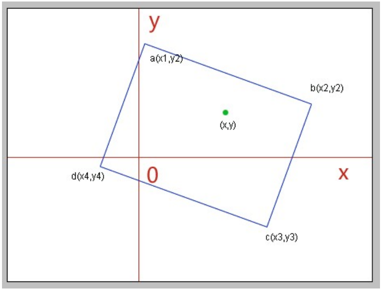

- Simplifying assumption : Assume rectangle is axis-parallel.
- How do we represent a point?
- How do we represent a rectangle?
- Given a rectangle specified by the endpoints of a diagonal, how do we determine if a point lies inside the rectangle?

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)
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    // to be filled.
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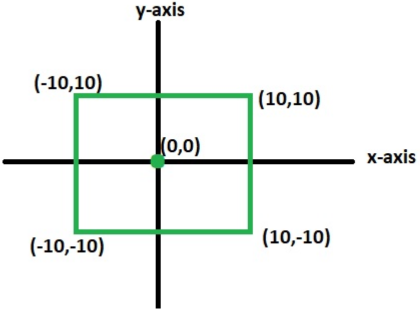

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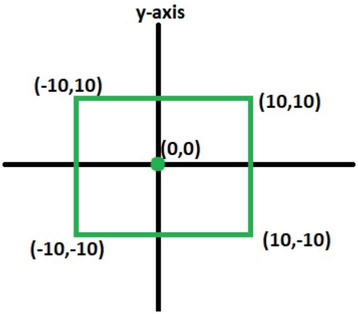

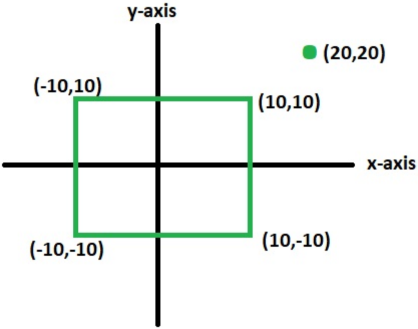

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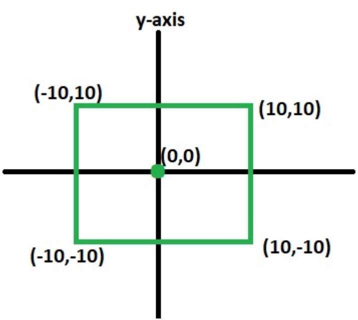

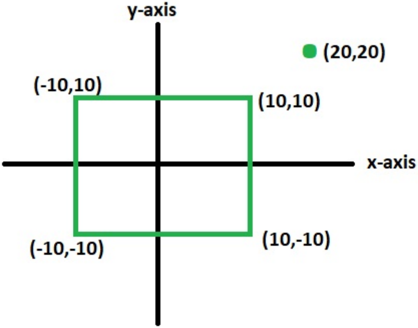

Exercise : Complete the function `is_inside`.

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));
}
```

modularize the code further

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

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

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

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

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

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int main() {
    struct rectangle R;
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    GetPoint(R.lowerLeft);
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- Structures are passed by value.

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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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- Changes made to contents of the structure are not visible outside the function.

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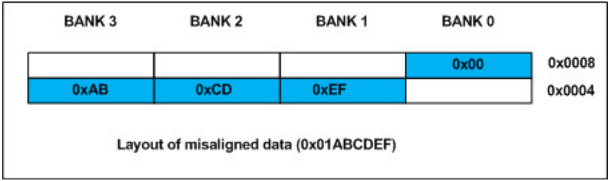
- Structures are passed by value. When the function is invoked - the structure `R.lowerLeft` is copied to the structure `pt`.
- Changes made to contents of the structure are not visible outside the function. For that we need to pass by reference.

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.



BANK 3	BANK 2	BANK 1	BANK 0	
			0x00	0x0008
0xAB	0xCD	0xEF		0x0004

Layout of misaligned data (0x01ABCDEF)

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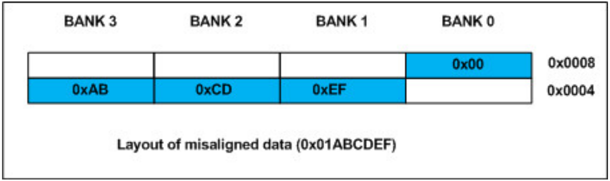

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- The total size required to store a structure will depend on these alignments.

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));
}
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}
```

- What is the output of the program?
- Assume size of int is 4 bytes.
- Why does it print 36 instead of 34?