Introduction to Programming

Week – *8*, Lecture – *2*

Structures in C – Part 1

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We will now discuss a solution to that problem – structures !!

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        int i;
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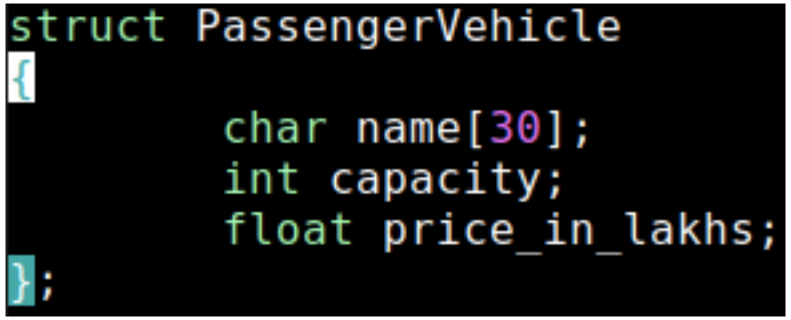
- The above structure is called `sample_structure`, and it contains *three member variables*

We can then create instances of `sample_structure`, just like we do it for any other types, e.g.

```
struct sample_structure s1, s2;
```

Example – The PassengerVehicle



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struct PassengerVehicle
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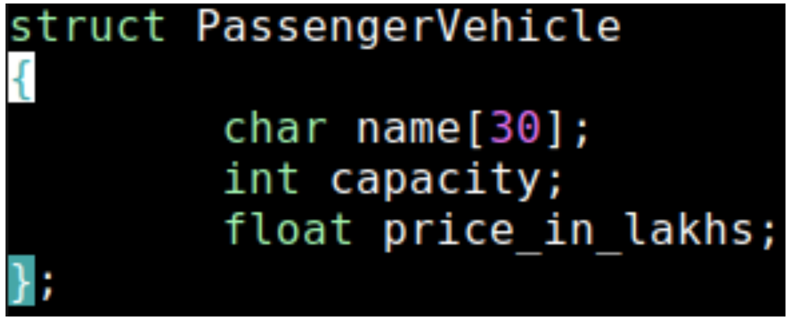
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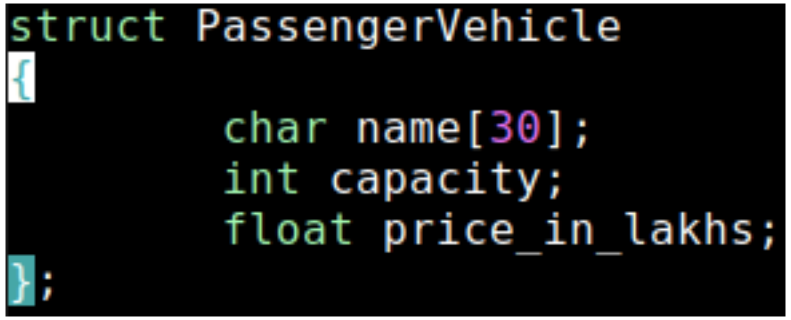

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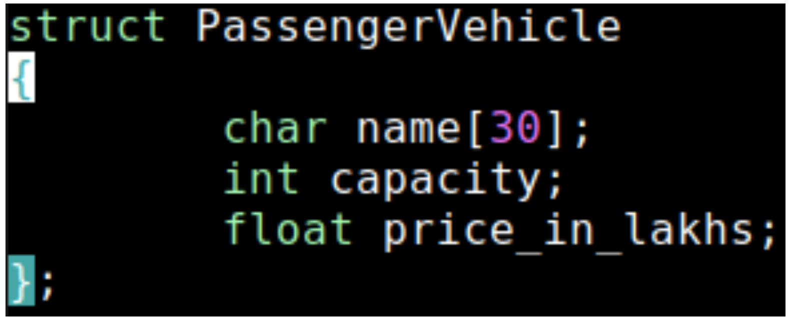

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We keep this declaration in a header file called `Car.h`, so that we can use this structure in multiple programs

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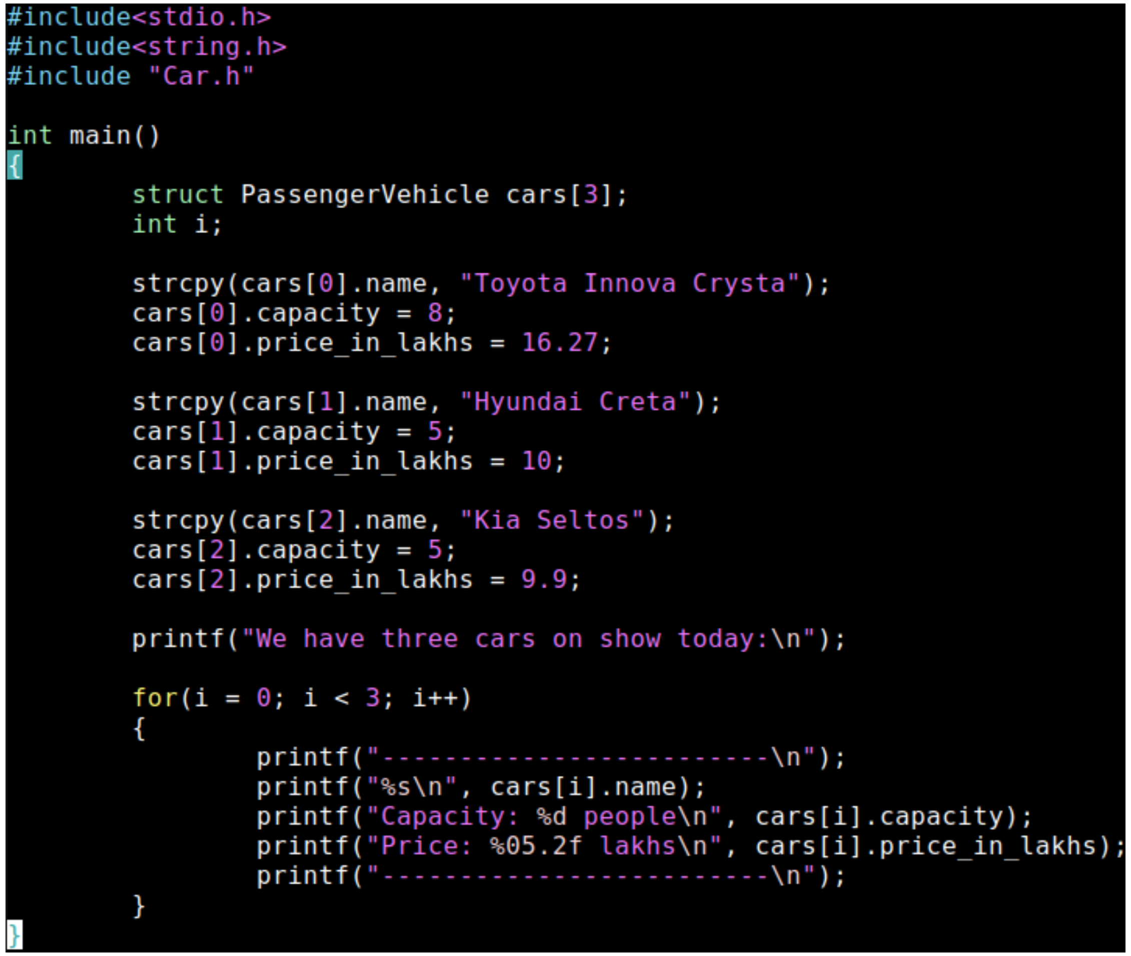
- For example, `s1.i` can be used in every context where an `int` variable may appear

Example – Creating some simple instances



```c
#include<stdio.h>
#include<string.h>
#include "Car.h"

int main()
{
        struct PassengerVehicle cars[3];
        int i;

        strcpy(cars[0].name, "Toyota Innova Crysta");
        cars[0].capacity = 8;
        cars[0].price_in_lakhs = 16.27;

        strcpy(cars[1].name, "Hyundai Creta");
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        printf("We have three cars on show today:\n");

        for(i = 0; i < 3; i++)
        {
                printf("-------------------------\n");
                printf("%s\n", cars[i].name);
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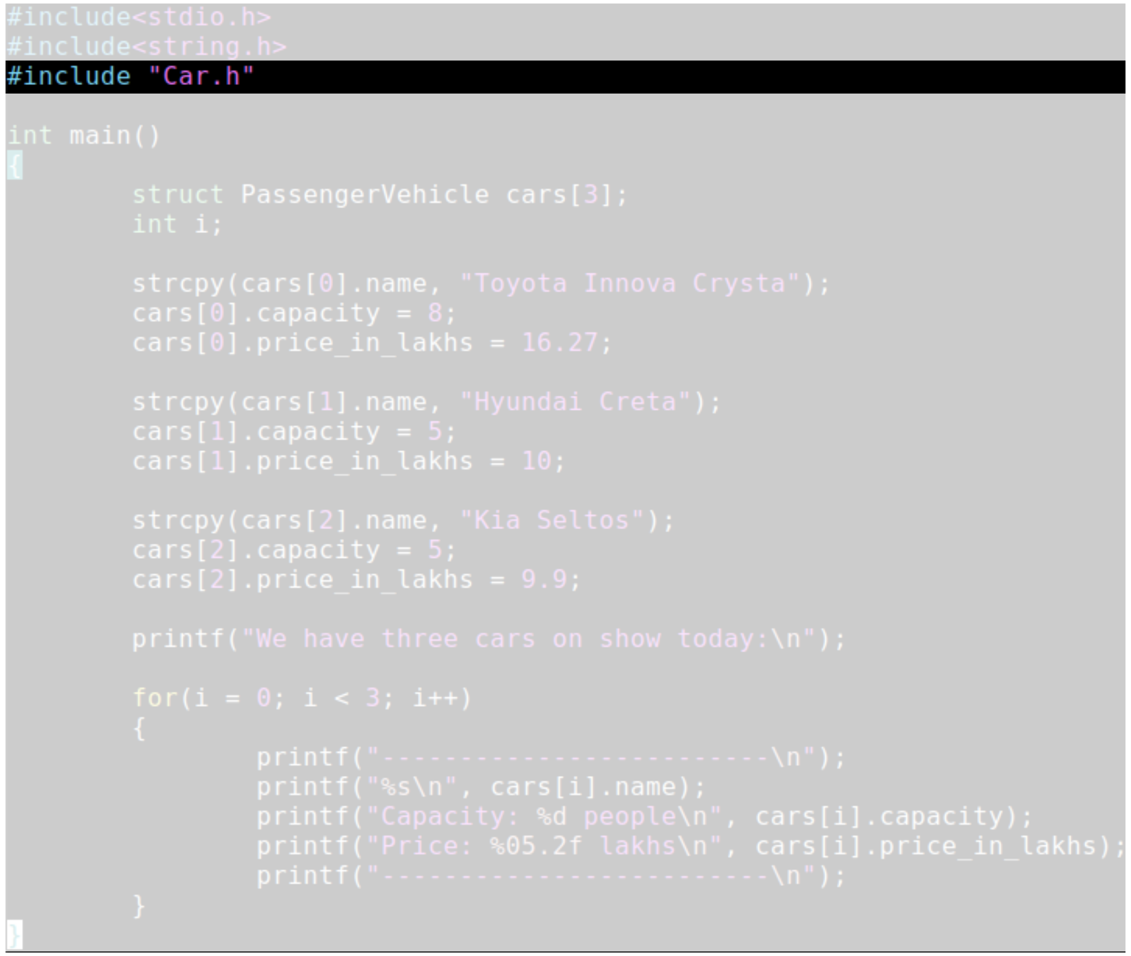

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Including the header file, allows us to create instances of the `PassengerVehicle`

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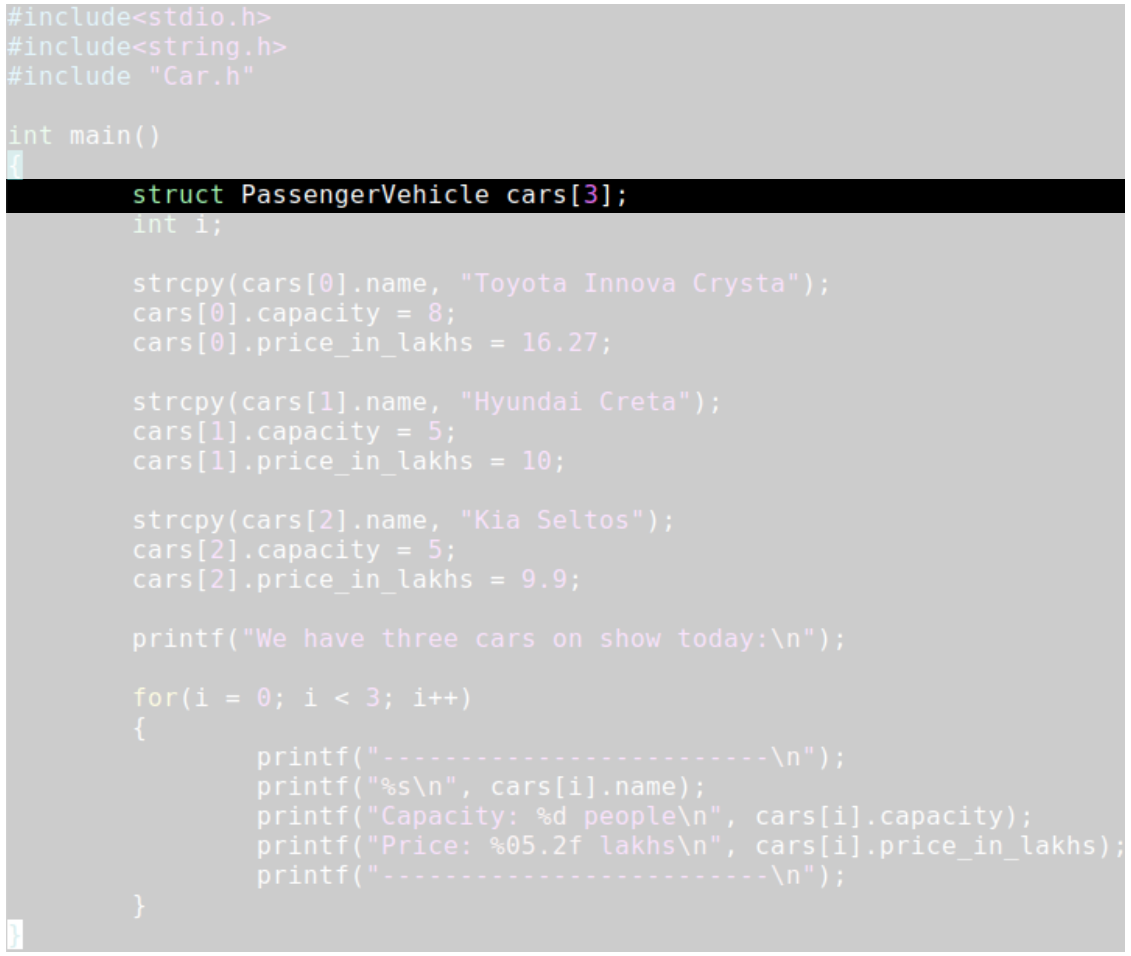

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Here, we are creating an array of structure variables

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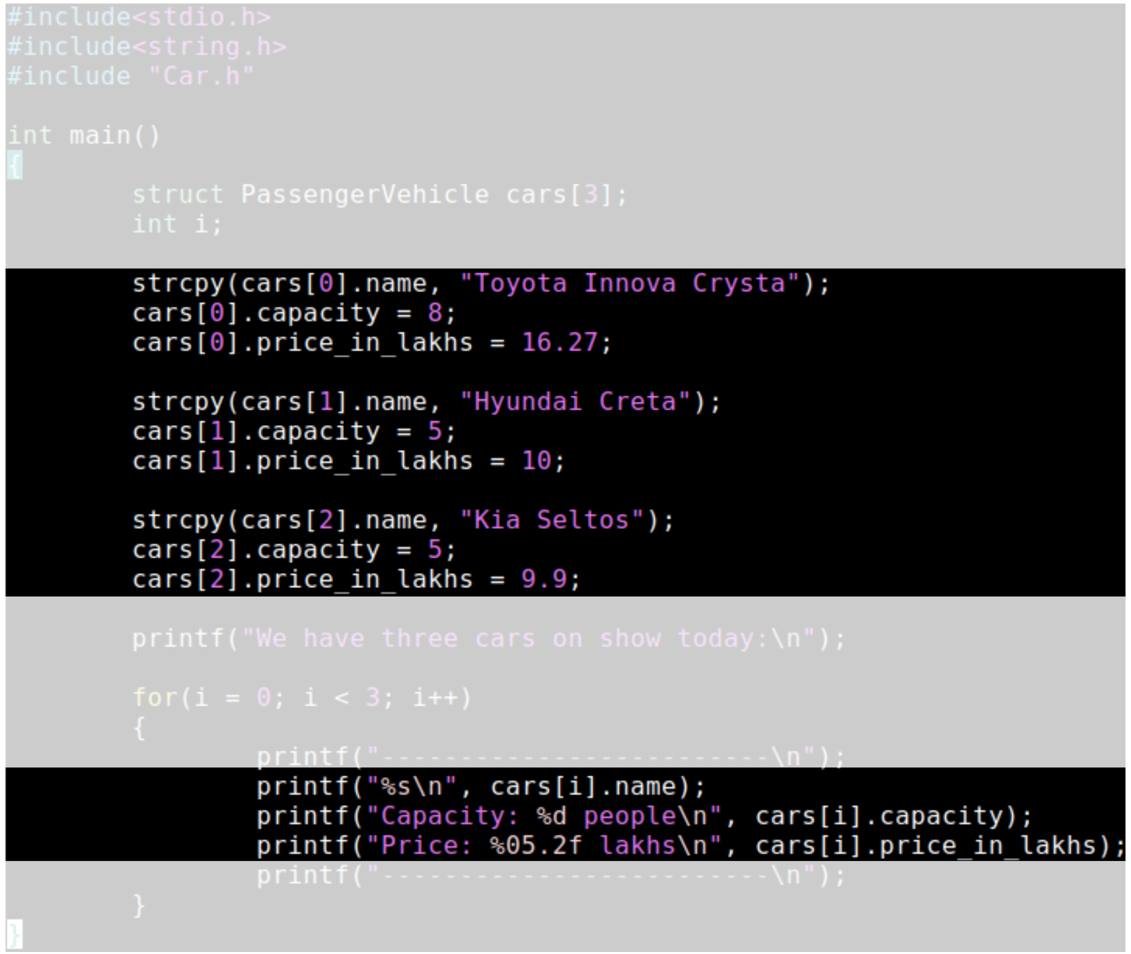

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This is how we can access the individual member variables of the structure variables

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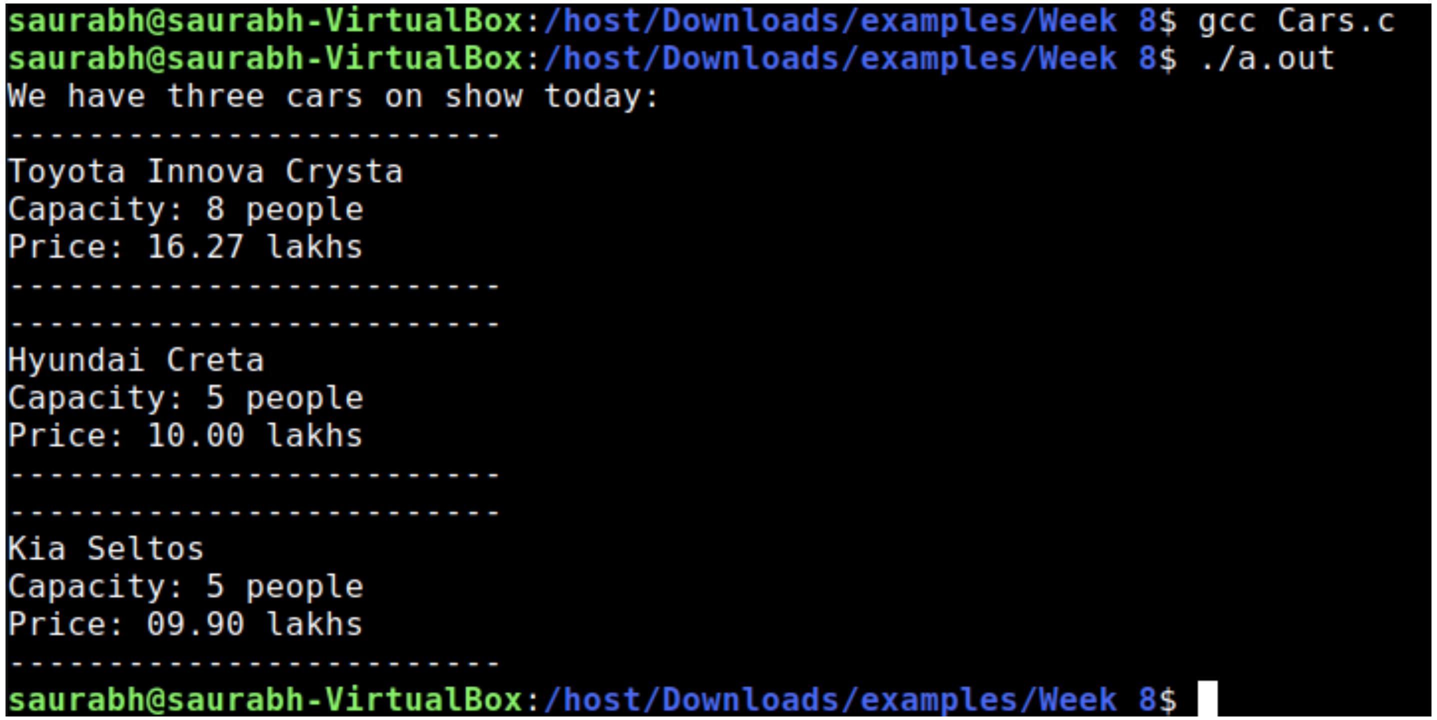

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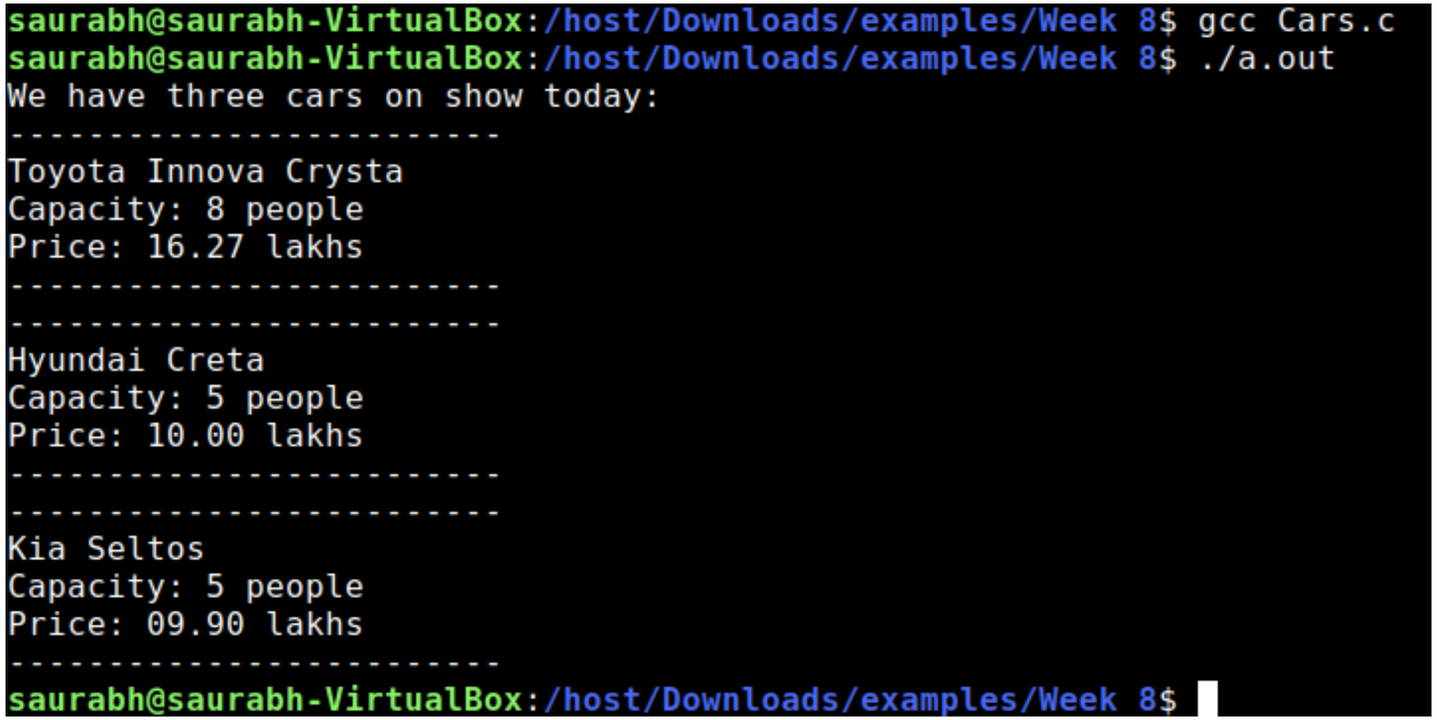

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The value of member variables can be printed in the same fashion as any other variable of the same type

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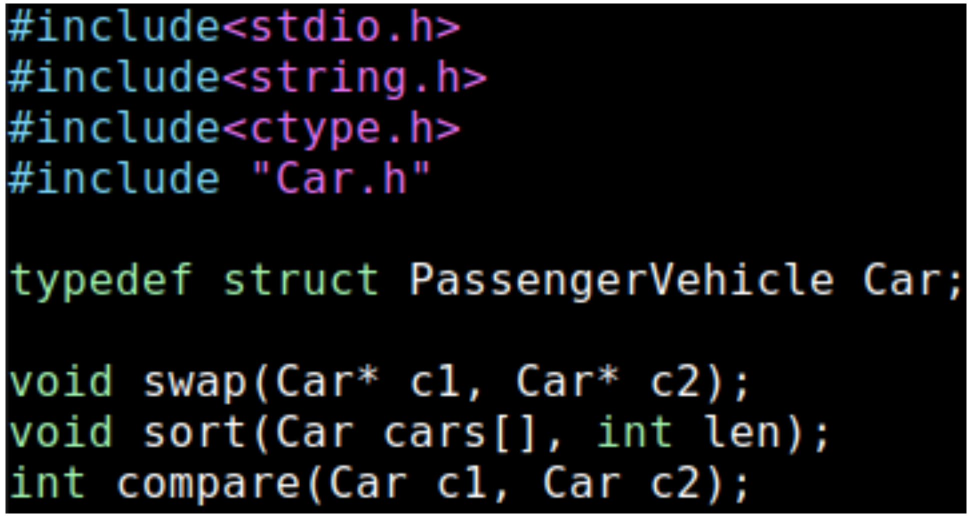
- For example,
  ```
  typedef struct sample_structure new_type;
  ```
- Then, we can simply use this short-cut to create instances of `sample_structure`
  ```
  new_type s3; // equivalent to writing struct sample_structure s3;
  ```

Example – Using `typedef` for short-cuts



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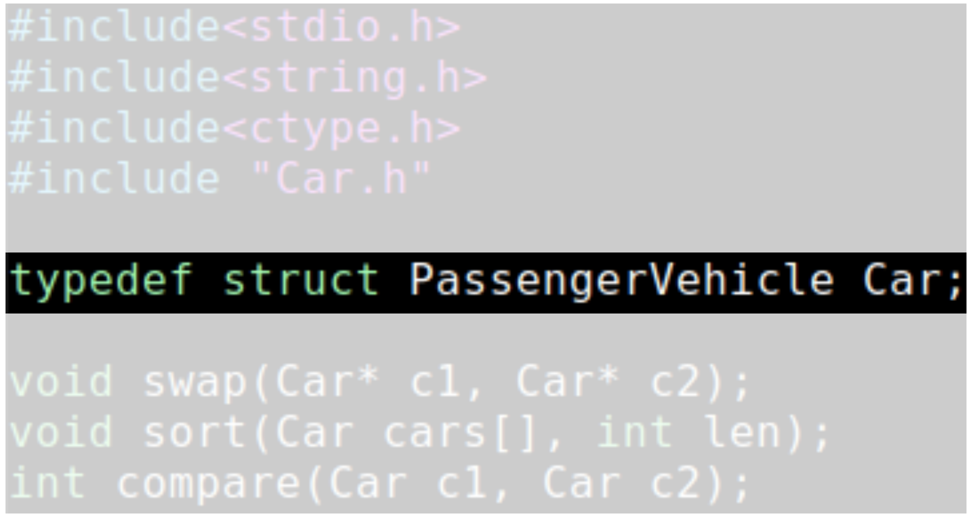

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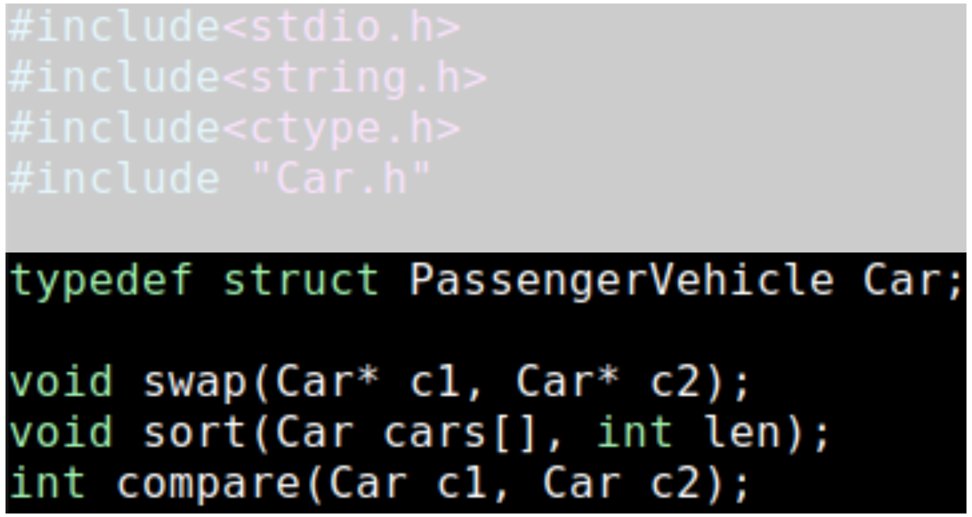

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After that, we can use `Car` as a short-cut to writing: `struct PassengerVehicle`

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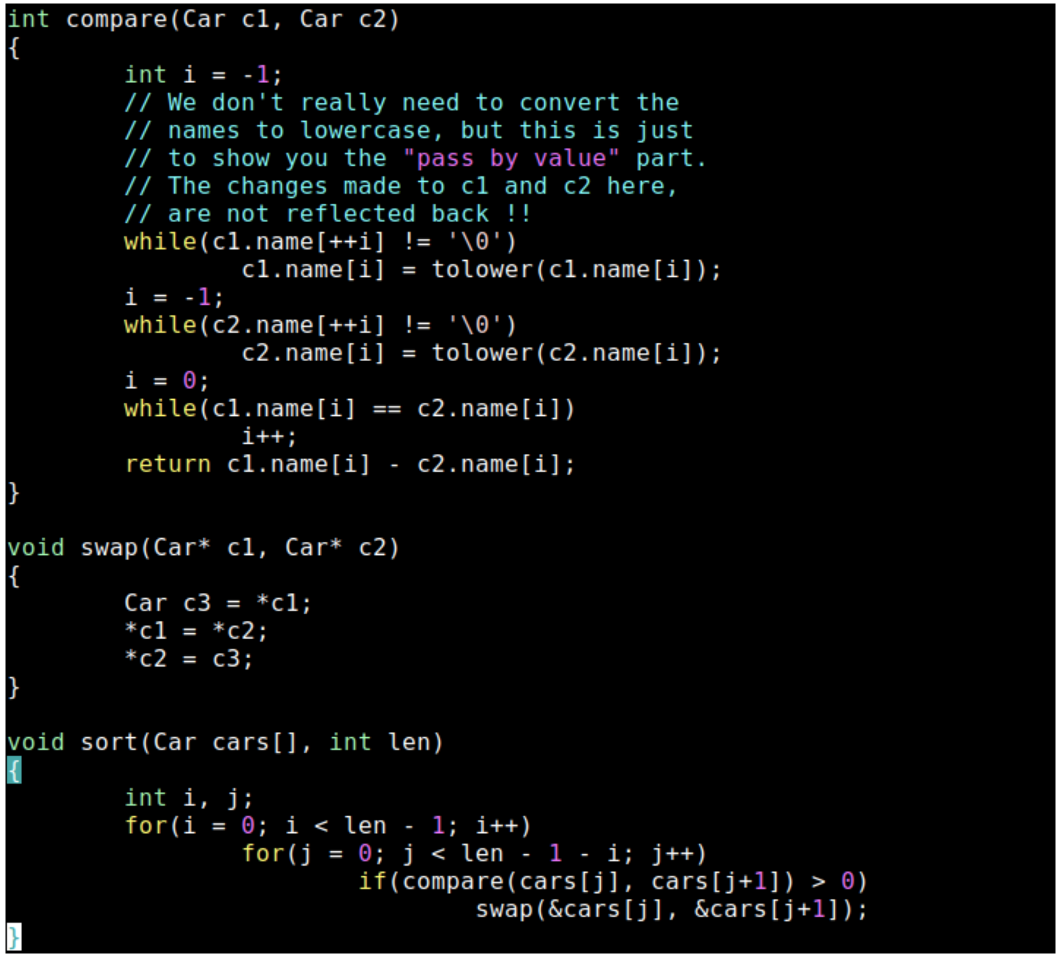
The rules related to passing and returning arguments with function calls, also apply to structures

- So, structure variables can be passed by value as well as reference, in a similar fashion

Example – Sorting Structure Variables



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{
        int i = -1;
        // We don't really need to convert the
        // names to lowercase, but this is just
        // to show you the "pass by value" part.
        // The changes made to c1 and c2 here,
        // are not reflected back !!
        while(c1.name[++i] != '\0')
                c1.name[i] = tolower(c1.name[i]);
        i = -1;
        while(c2.name[++i] != '\0')
                c2.name[i] = tolower(c2.name[i]);
        i = 0;
        while(c1.name[i] == c2.name[i])
                i++;
        return c1.name[i] - c2.name[i];
}

void swap(Car* c1, Car* c2)
{
        Car c3 = *c1;
        *c1 = *c2;
        *c2 = c3;
}

void sort(Car cars[], int len)
{
        int i, j;
        for(i = 0; i < len - 1; i++)
                for(j = 0; j < len - 1 - i; j++)
                        if(compare(cars[j], cars[j+1]) > 0)
                                swap(&cars[j], &cars[j+1]);
}
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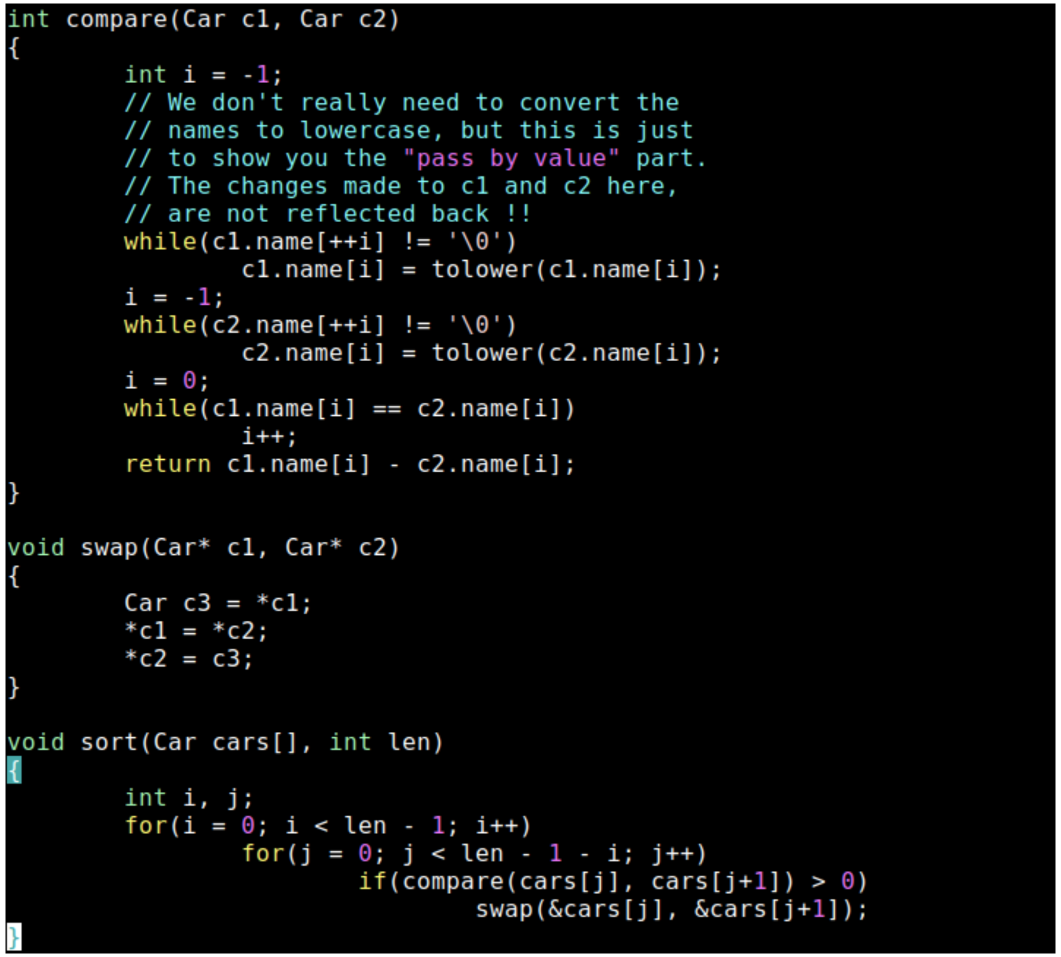

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                c2.name[i] = tolower(c2.name[i]);
        i = 0;
        while(c1.name[i] == c2.name[i])
                i++;
        return c1.name[i] - c2.name[i];
}

void swap(Car* c1, Car* c2)
{
        Car c3 = *c1;
        *c1 = *c2;
        *c2 = c3;
}

void sort(Car cars[], int len)
{
        int i, j;
        for(i = 0; i < len - 1; i++)
                for(j = 0; j < len - 1 - i; j++)
                        if(compare(cars[j], cars[j+1]) > 0)
                                swap(&cars[j], &cars[j+1]);
}
```
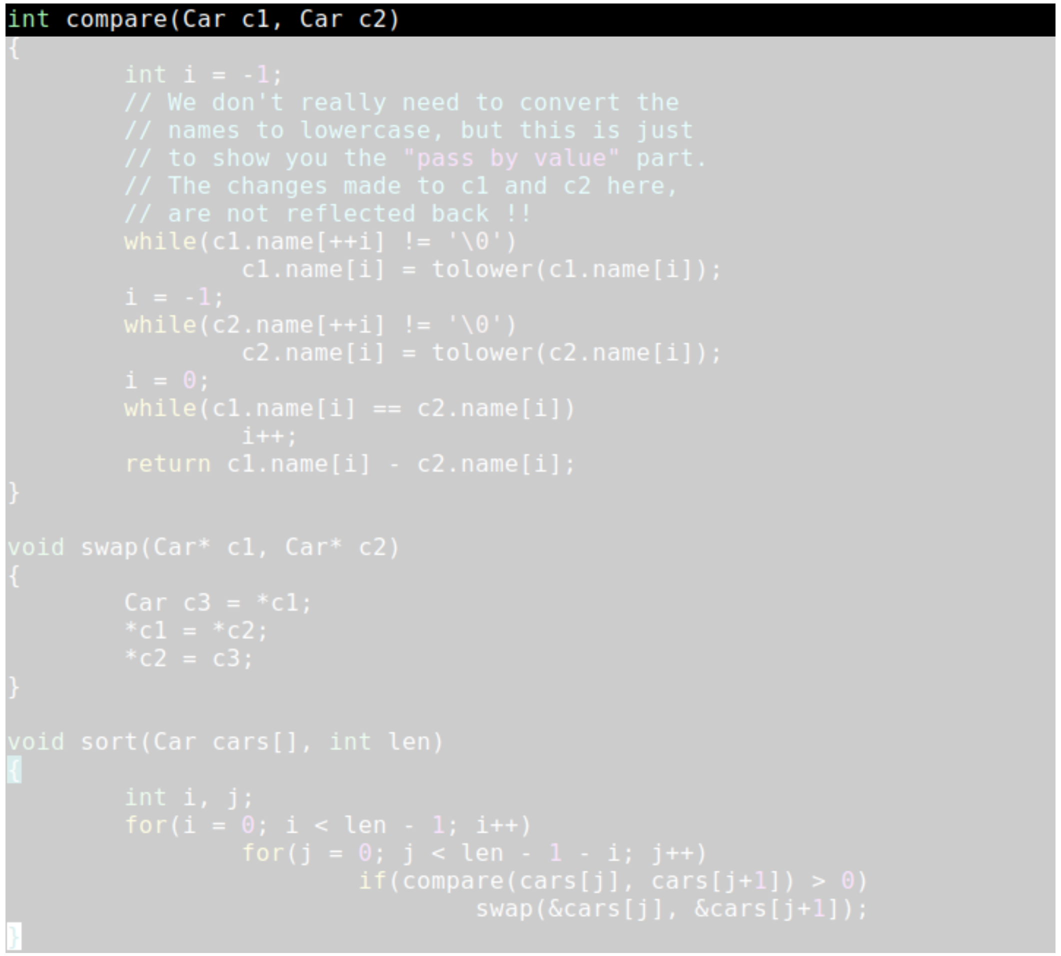

These are some examples of passing structure variables to functions

Example – Sorting Structure Variables

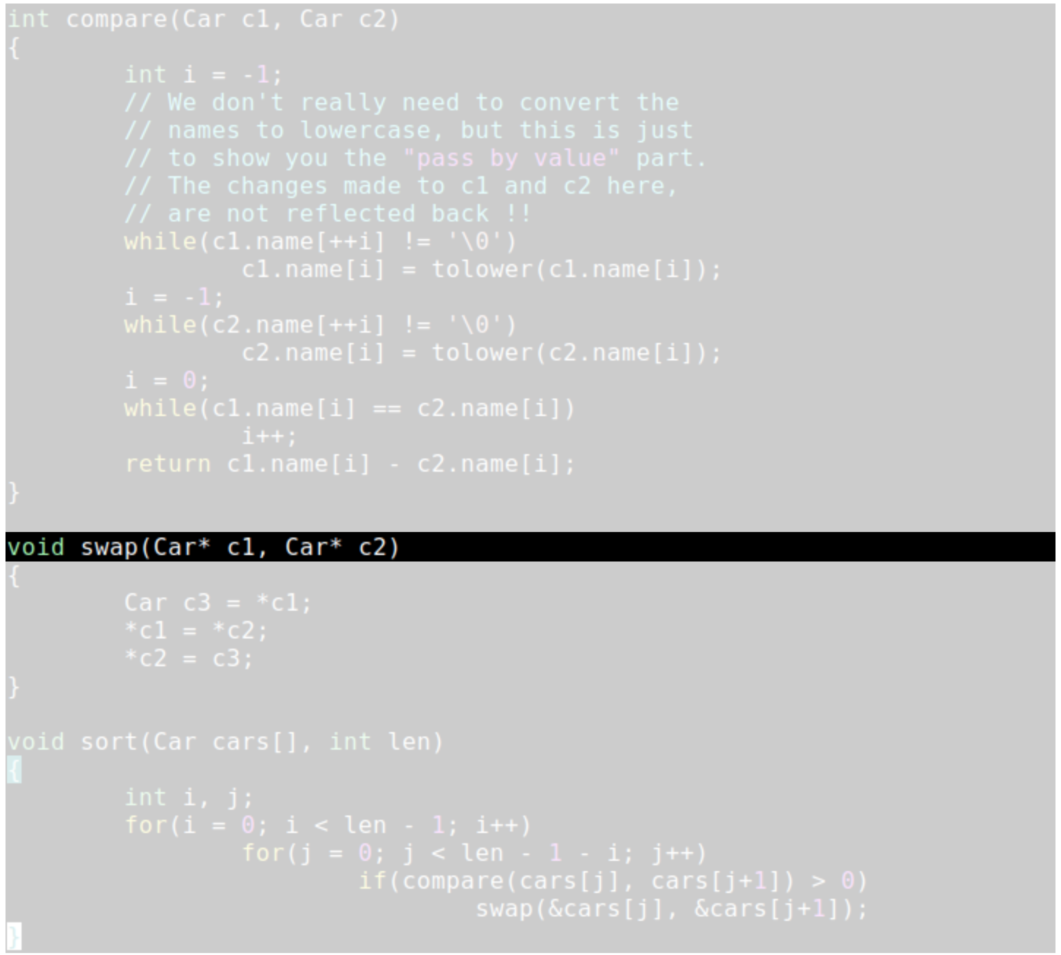


```c
int compare(Car c1, Car c2)
{
        int i = -1;
        // We don't really need to convert the
        // names to lowercase, but this is just
        // to show you the "pass by value" part.
        // The changes made to c1 and c2 here,
        // are not reflected back !!
        while(c1.name[++i] != '\0')
                c1.name[i] = tolower(c1.name[i]);
        i = -1;
        while(c2.name[++i] != '\0')
                c2.name[i] = tolower(c2.name[i]);
        i = 0;
        while(c1.name[i] == c2.name[i])
                i++;
        return c1.name[i] - c2.name[i];
}

void swap(Car* c1, Car* c2)
{
        Car c3 = *c1;
        *c1 = *c2;
        *c2 = c3;
}

void sort(Car cars[], int len)
{
        int i, j;
        for(i = 0; i < len - 1; i++)
                for(j = 0; j < len - 1 - i; j++)
                        if(compare(cars[j], cars[j+1]) > 0)
                                swap(&cars[j], &cars[j+1]);
}
```

These are some examples of passing structure variables to functions

This is an example of Passing structures by value…

Example – Sorting Structure Variables

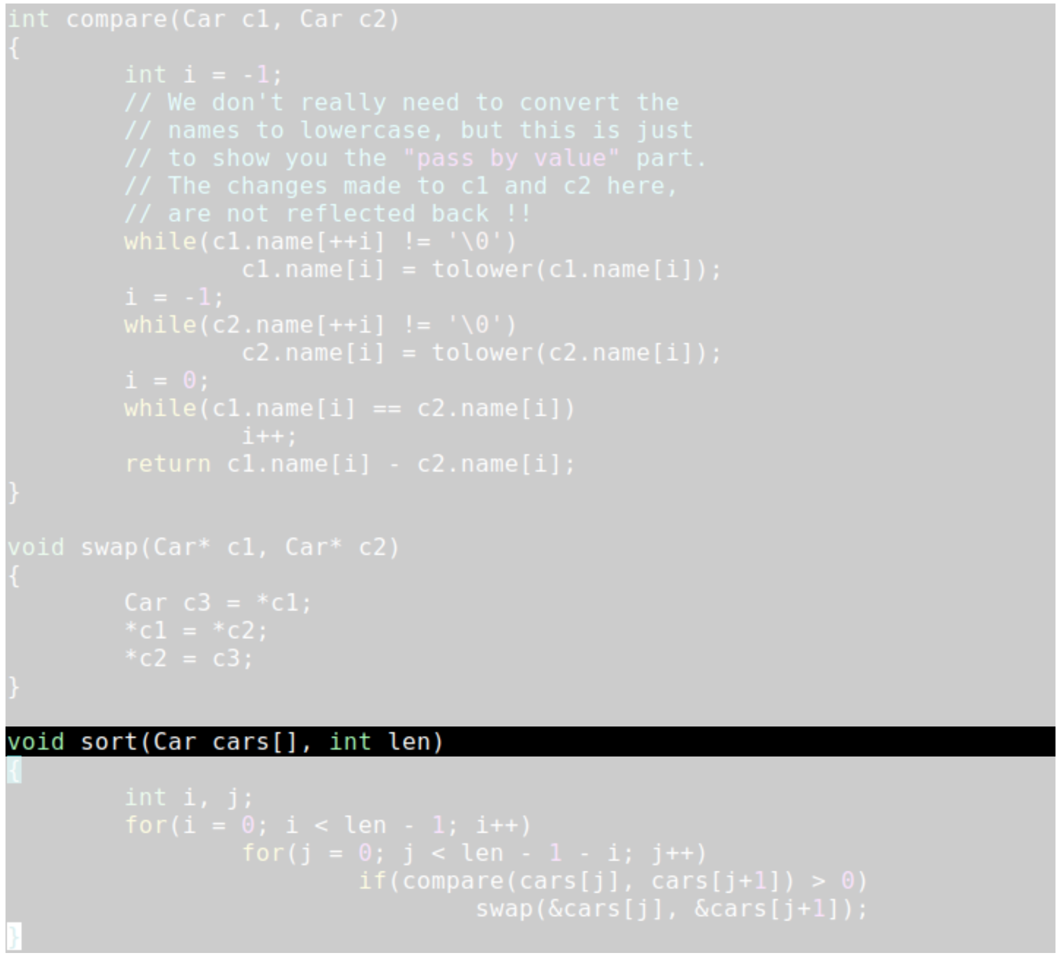


```
int compare(Car c1, Car c2)
{
        int i = -1;
        // We don't really need to convert the
        // names to lowercase, but this is just
        // to show you the "pass by value" part.
        // The changes made to c1 and c2 here,
        // are not reflected back !!
        while(c1.name[++i] != '\0')
                c1.name[i] = tolower(c1.name[i]);
        i = -1;
        while(c2.name[++i] != '\0')
                c2.name[i] = tolower(c2.name[i]);
        i = 0;
        while(c1.name[i] == c2.name[i])
                i++;
        return c1.name[i] - c2.name[i];
}

void swap(Car* c1, Car* c2)
{
        Car c3 = *c1;
        *c1 = *c2;
        *c2 = c3;
}

void sort(Car cars[], int len)
{
        int i, j;
        for(i = 0; i < len - 1; i++)
                for(j = 0; j < len - 1 - i; j++)
                        if(compare(cars[j], cars[j+1]) > 0)
                                swap(&cars[j], &cars[j+1]);
}
```

These are some examples of passing structure variables to functions

… and this is an example of passing structures by reference

Example – Sorting Structure Variables

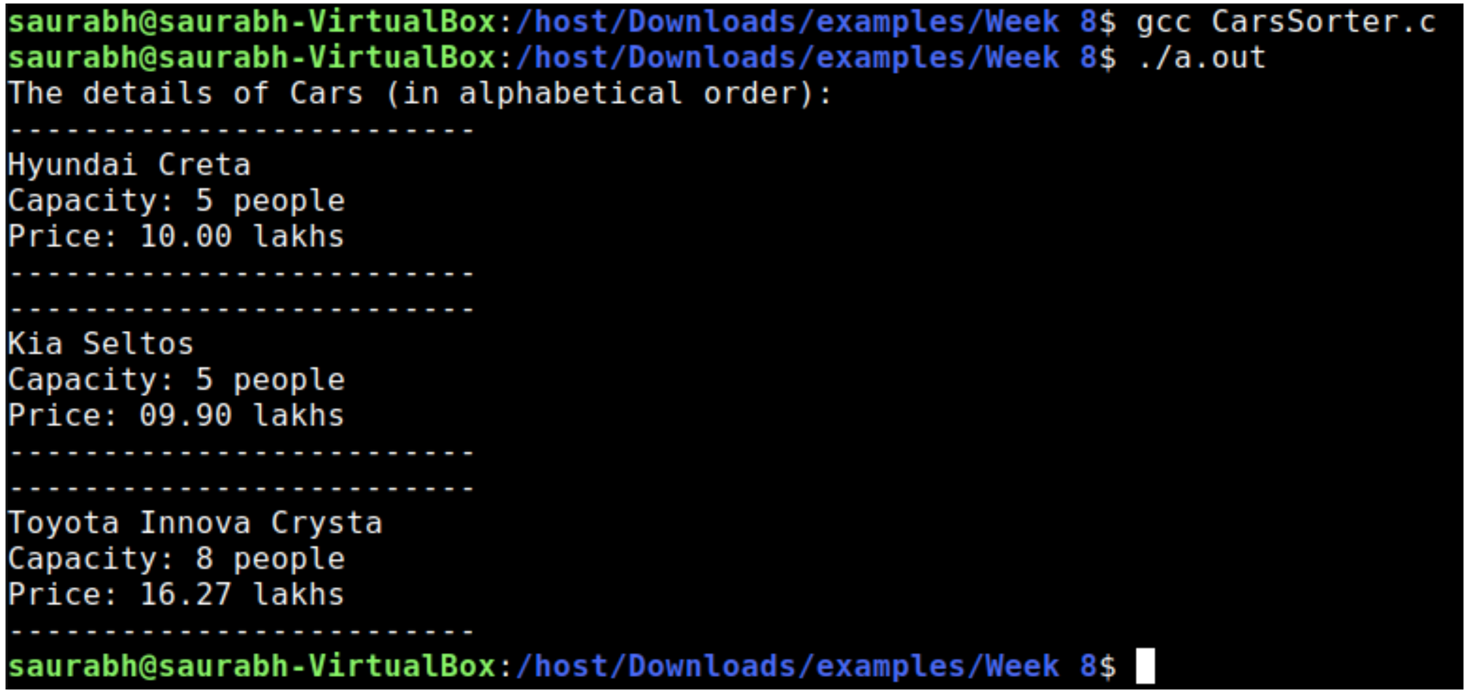


```
int compare(Car c1, Car c2)
{
        int i = -1;
        // We don't really need to convert the
        // names to lowercase, but this is just
        // to show you the "pass by value" part.
        // The changes made to c1 and c2 here,
        // are not reflected back !!
        while(c1.name[++i] != '\0')
                c1.name[i] = tolower(c1.name[i]);
        i = -1;
        while(c2.name[++i] != '\0')
                c2.name[i] = tolower(c2.name[i]);
        i = 0;
        while(c1.name[i] == c2.name[i])
                i++;
        return c1.name[i] - c2.name[i];
}

void swap(Car* c1, Car* c2)
{
        Car c3 = *c1;
        *c1 = *c2;
        *c2 = c3;
}

void sort(Car cars[], int len)
{
        int i, j;
        for(i = 0; i < len - 1; i++)
                for(j = 0; j < len - 1 - i; j++)
                        if(compare(cars[j], cars[j+1]) > 0)
                                swap(&cars[j], &cars[j+1]);
}
```

These are some examples of passing structure variables to functions

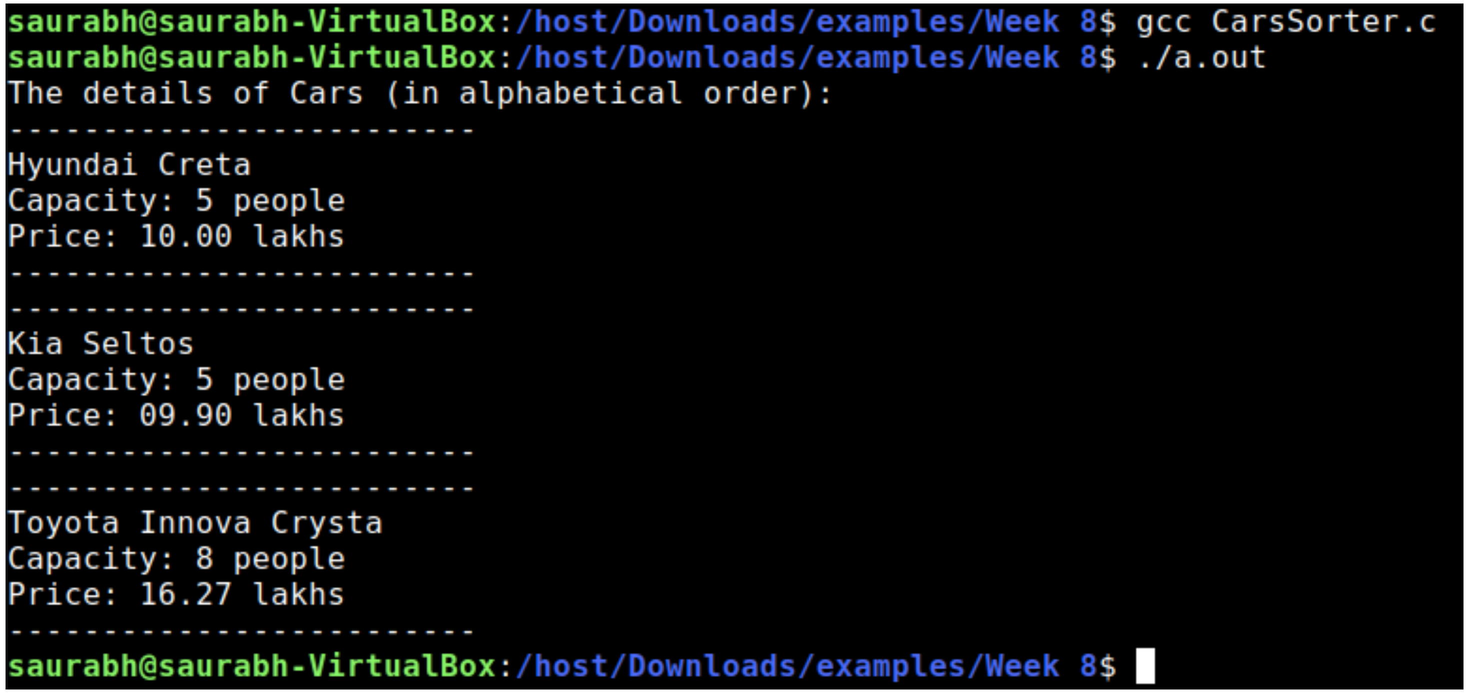
This is an example of passing arrays of structures to functions, which, as usual, are passed by reference

Example – Sorting Structure Variables



```
saurabh@saurabh-VirtualBox:/host/Downloads/examples/Week 8$ gcc CarsSorter.c
saurabh@saurabh-VirtualBox:/host/Downloads/examples/Week 8$ ./a.out
The details of Cars (in alphabetical order):
-------------------------
Hyundai Creta
Capacity: 5 people
Price: 10.00 lakhs
-------------------------
-------------------------
Kia Seltos
Capacity: 5 people
Price: 09.90 lakhs
-------------------------
-------------------------
Toyota Innova Crysta
Capacity: 8 people
Price: 16.27 lakhs
-------------------------
saurabh@saurabh-VirtualBox:/host/Downloads/examples/Week 8$
```

Example – Sorting Structure Variables



```
saurabh@saurabh-VirtualBox:/host/Downloads/examples/Week 8$ gcc CarsSorter.c
saurabh@saurabh-VirtualBox:/host/Downloads/examples/Week 8$ ./a.out
The details of Cars (in alphabetical order):
-------------------------
Hyundai Creta
Capacity: 5 people
Price: 10.00 lakhs
-------------------------
-------------------------
Kia Seltos
Capacity: 5 people
Price: 09.90 lakhs
-------------------------
-------------------------
Toyota Innova Crysta
Capacity: 8 people
Price: 16.27 lakhs
-------------------------
saurabh@saurabh-VirtualBox:/host/Downloads/examples/Week 8$ 
```

You can see the affects of sorting in the `main()` function

Homework !!

We have created a header file in the Vehicle example

- Read more about header files in C, and when is it a good idea to use them
- You may start from here: https://www.geeksforgeeks.org/header-files-in-c-cpp-and-its-uses/

Also figure out why `Car.h` was put inside quotes, and not `<>`

Additional Reading

Though the amount of space taken by a structure should be the sum of spaces of all its variables…

- … there is a chance that it takes a bit more space in the memory than that

You can use the sizeof() operator to figure it out

The additional space is used as a *padding* for proper alignment of data in the memory

These two links may be worth checking out, if you wish to know more:
https://www.geeksforgeeks.org/structure-member-alignment-padding-and-data-packing/
https://stackoverflow.com/questions/11906486/size-of-struct-containing-double-field