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UNITED INTERNATIONAL UNIVERSITY
HAS BEEN RANKED ITS POSITION AMONG TOP 350 UNIVERSITIES IN ASIA.

Structured Programming Language CSI 121/CSE 1111 -Pointer-

Computer Science & Engineering (CSE)

United International University (UIU)

Introduction to Pointer

- Pointers are symbolic representation of addresses.

- Every variable is a memory location and every memory location has its address defined which can be accessed using ampersand (&) operator, which denotes an address in memory.

Syntax: datatype *var_name;

```
int *ptr; //ptr can point to an address
               which holds int data
```

Pointer

- A variable that contains the memory address of another variable
- Pointer type MUST match variable type
  - `int` pointer cannot point to a `float` variable

valid pointer declarations

- `int *ip; // pointer to an integer`
- `double *dp; // pointer to a double`
- `float *fp; // pointer to a float`
- `char *ch // pointer to a character`

Prints the address of the variables defined

```
#include <stdio.h>
int main () {
   int var1;
   char var2[10];
   printf("Address of var1 variable: %x
             \n", &var1 );
   printf("Address of var2 variable: %x
             \n", &var2 );
   return 0;
}
```

Output:

```
Address of var1 variable: bff5a400
Address of var2 variable: bff5a3f6
```

Pointer: Initialization or assignment

```
int a = 5;   // a contains value 5
int *p = &a; // p contains the address
of a

OR
int a = 5; // a contains value 5
int *p;    // pointer p is declared
p = &a;    // p contains the address
of a
```

Pointer: Initialization or assignment

```
int a = 5, b = 8;

int *p = &a;
int *q = &b;
```

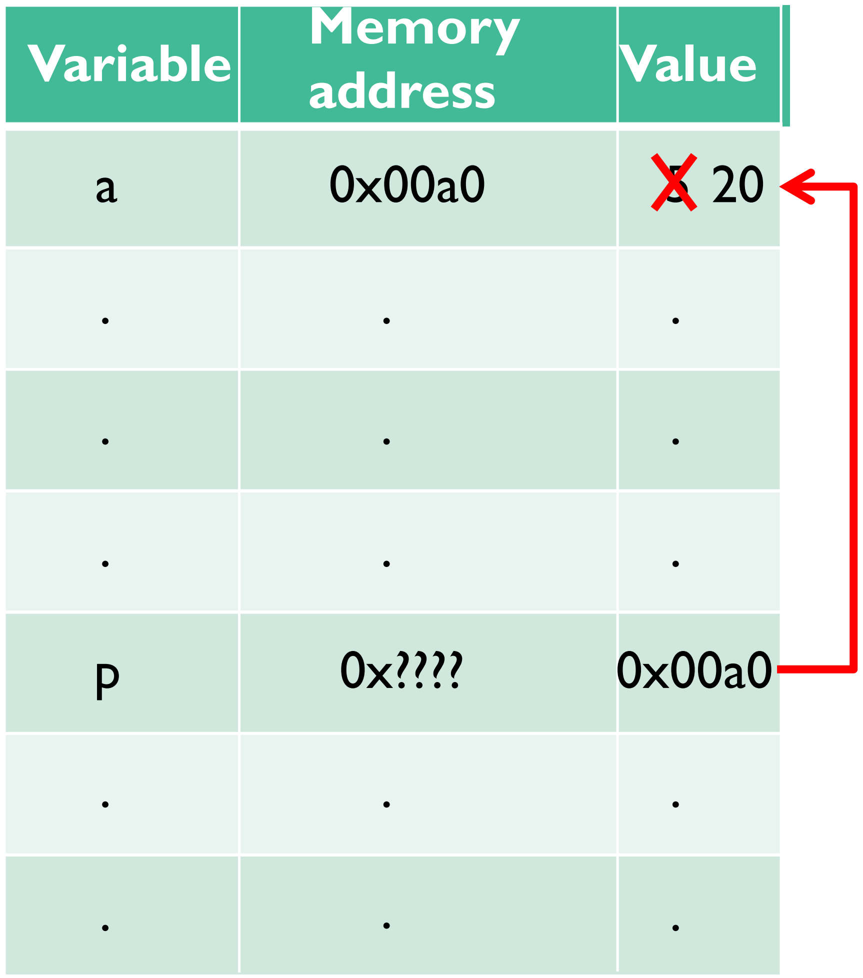
Variable	Memory address	Value
a	0x00a0	5
.	.	.
b	0x00b0	8
.	.	.
p	0x????	0x00a0
q	0x????	0x00b0
.		.

Pointer: Getting or manipulating value

```
int a = 5;
int *p = &a;

*p = 20;

// The following
line will
// print 20
printf("%d\n", a);
```



Variable	Memory address	Value
a	0x00a0	~~5~~ 20
.	.	.
.	.	.
.	.	.
p	0x????	0x00a0
.	.	.
.	.	.

How to Use Pointers?

There are a few important operations:

(a) Define a pointer variable,

(b) Assign the address of a variable to a pointer

(c) Access the value at the address available in the pointer variable.

This is done by using **unary operator * that returns the value of the variable** located at the address specified by its operand.

Example

```
#include <stdio.h>
int main () {
    int var = 20; /* variable declaration */
    int *ip; /* pointer variable */
    ip = &var; /* store address of var*/
    printf("Address of var variable: %x\n", &var );
          /* address stored in pointer variable */
    printf("Address stored in ip variable: %x\n", ip );
         /* access the value using the pointer */
    printf("Value of *ip variable: %d\n", *ip )
    return 0;
}
```

```
Address of var variable: bffd8b3c
Address stored in ip variable: bffd8b3c
Value of *ip variable: 20
```

Pointer of pointer/double pointer

```
int a = 5;      //a contains value 5
int *p = &a;    // p contains the
                     address of a
int **pp = &p; // pp contains the
                     address of p


printf("%d\n", **pp); // what will
                     be the output?
```

POINTER ARITHMETIC

Array, revisited

```
int array[10] = {5, 2, 3, 9, 10, 1,
7, 5, 4, 6};
int *p = &array[0];

printf("%d\n", array);
// what will be the output?
printf("%d\n", p);
// what will be the output?
```

Array as a pointer

```
int a[5] = {3, 2, 5,
1, 4};
```

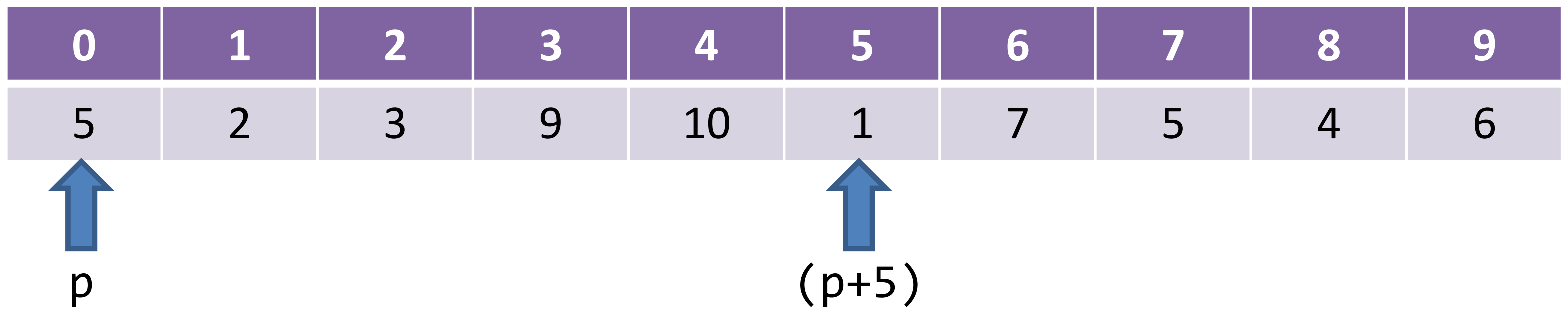
- The variable a contains the memory address of the first element of the array
- We can access the members of an array using pointer as well
- BEWARE: If you are not careful, you might end up in unauthorized memory addresses

Variable	Memory address	Value
a	0x00aa	0x0100
.	.	.
.	.	.
a[0]	0x0100	3
a[1]	0x0104	2
a[2]	0x0108	5
a[3]	0x010c	1
a[4]	0x0110	4
i	0x0114	234198
--	0x0118	21454
.	.	.
.	.	.

Pointer arithmetic

- To access array elements faster
  - Using pointers is faster than array indexing
- Four operators
  - + operator
  - - operator
  - ++ operator
  - -- operator

Pointer addition


0	1	2	3	4	5	6	7	8	9
5	2	3	9	10	1	7	5	4	6

```
int array[10] = {5, 2, 3, 9, 10, 1, 7,5,
4, 6};
int *p = array; // array points to 5

printf("%d", *(p+5));
// what does it print?
```

Pointer addition

```
int array[10] = {5, 2,
3, 9,10, 1, 7, 5,4,6};
int *p = array;
printf("%d",*(p+5));
```

Pointer	Index	Memory address	Value
p	0	0x0100 Base	5
p+1	1	0x0104 address	2
	2	0x0108	3
p+3	3	0x010c	9
	4	0x0110	10
p+5	5	0x0114 How to compute?	1
	6	0x0118	7
	7	0x011c	5
	8	0x0120	4
p+9	9	0x0124	6
	10	0x0128	?
	11	0x012c	?

Pointer addition

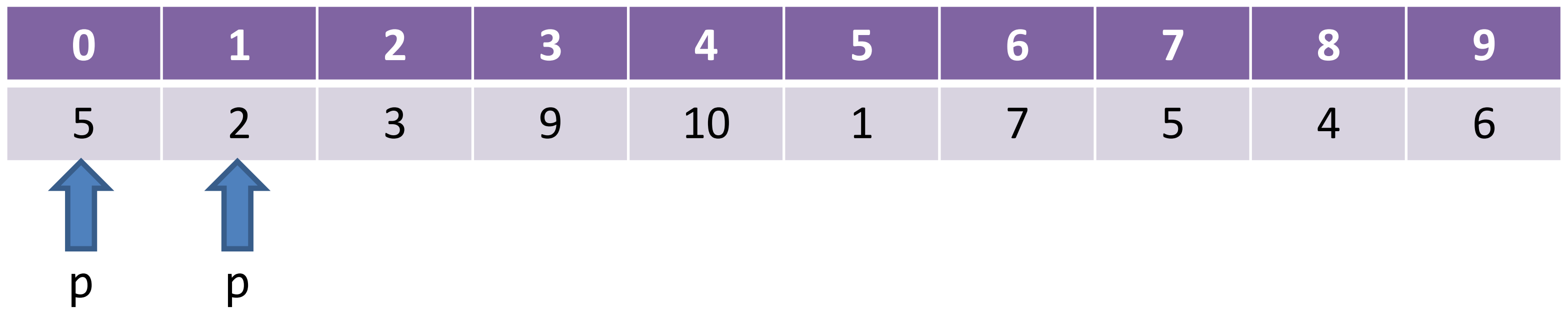
- If we add 1 to a pointer, we are actually adding the space of one variable
- If we have 4-byte integer variable, adding 1 adds 4 to the memory address
- New address = Base address + Variable size * i
- Example: Let the base address of p be 0x0100
  - p+1: 0x0100+4*1 = 0x0104
  - p+3: 0x0100+4*3 = ~~0x0112~~ 0x010c
    - Given address is in hexadecimal!!!
    - Use a calculator to be safe
  - p+5: Try yourself!!!

Problem

Write a C program that prints the content of a given array.

Use pointer addition instead of array indexing.

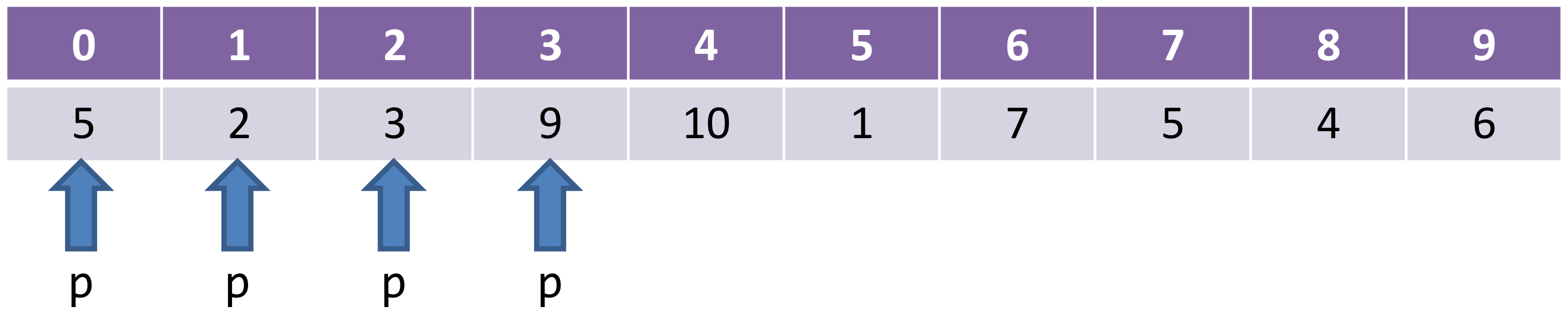
Pointer increment



0	1	2	3	4	5	6	7	8	9
5	2	3	9	10	1	7	5	4	6

```
int array[10] = {5, 2, 3, 9, 10, 1, 7, 5,
4, 6};
int *p = array;   // array points to 5
p++;              // where does p point
to?
printf("%d", *p); // what does it print?
```

Pointer increment



0	1	2	3	4	5	6	7	8	9
5	2	3	9	10	1	7	5	4	6

```
int array[10] = {5, 2, 3, 9, 10, 1, 7, 5, 4,
6};
int *p = array;    // array points to 5
p++;               // where does p point to?
p++;               // where now?
p++;               // where now?
```

Pointer increment

```
int array[10] = {5, 2, 3,
9,10, 1, 7, 5, 4, 6};
int *p = array;
p++;
p++;
p++;
```

p initially

p after line 3

p after line 4

p after line 5

CAUTION: Do NOT access from here

Index	Memory address	Value
0	0x0100	5
1	0x0104	2
2	0x0108	3
3	0x010c	9
4	0x0110	10
5	0x0114	1
6	0x0118	7
7	0x011c	5
8	0x0120	4
9	0x0124	6
10	0x0128	?
11	0x012c	?

Cons of using C pointer

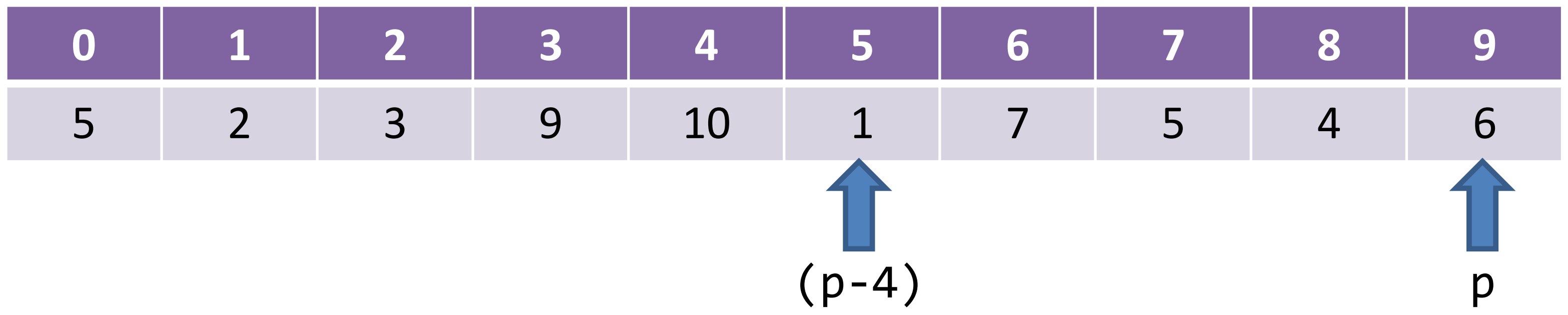
- C pointers are not secure
- They can reach virtually ANY memory address
  - Both in the programs own memory space and outside
  - May cause replacement of important data
  - May cause program to crash
- We manually make sure that the pointer does not try to access unauthorized memory spaces

Problem

Write a C program that prints the content of a given array.

Use pointer increment instead of array indexing.

Pointer subtraction



0	1	2	3	4	5	6	7	8	9
5	2	3	9	10	1	7	5	4	6

```
int array[10] = {5, 2, 3, 9, 10, 1, 7, 5, 4,
6};
int *p = &array[9]; // array points to 6

printf("%d", *(p-4)); // what does it print?
```

Pointer subtraction

```
int array[10] = {5, 2,
9, 10, 1, 7, 5, 4, 6};
int *p = &array[9];
printf("%d", *(p-4));
```

Pointer	Index	Memory address	Value
p-9	0	0x0100	5
	1	0x0104	2
	2	0x0108	3
p-6	3	0x010c	9
	4	0x0110	10
p-4	5	0x0114	1
	6	0x0118	7
	7	0x011c	5
p-1	8	0x0120	4
p	9	0x0124	6
	10	0x0128	?
	11	0x012c	?

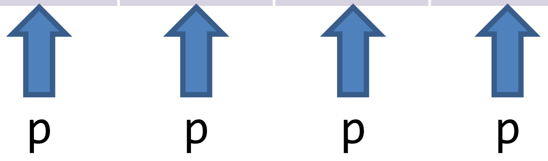
Problem

Write a C program that prints the content of a given array in reverse order.

Use pointer subtraction instead of array indexing.

Pointer decrement

0	1	2	3	4	5	6	7	8	9
5	2	3	9	10	1	7	5	4	6



```
int array[10] = {5, 2, 3, 9, 10, 1, 7, 5, 4,
6};
int *p = &array[9];   // array points to 5
p--;                 // where does p point to?
p--;                 // where now?
p--;                 // where now?
```

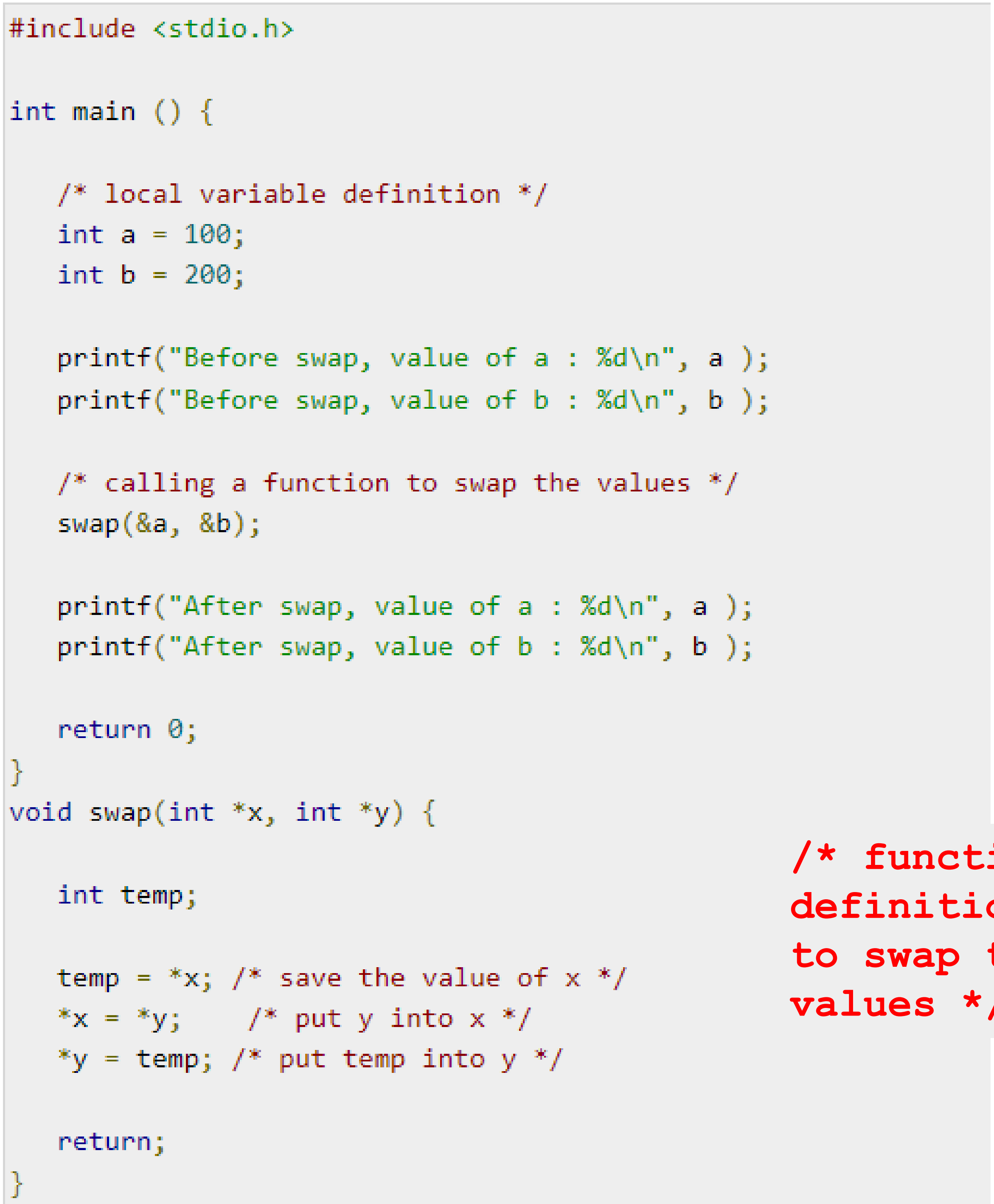
Pointer increment

```
int array[10] = {5, 2,
3, 9,10, 1, 7, 5, 4, 6};
int *p = &array[9];
p--;
p--;
p--;
```

	Index	Memory address	Value
	0	0x0100	5
	1	0x0104	2
	2	0x0108	3
	3	0x010c	9
	4	0x0110	10
p after line 5 ⇨	5	0x0114	1
p after line 4 ⇨	6	0x0118	7
p after line 3 ⇨	7	0x011c	5
p initially ⇨	8	0x0120	4
	9	0x0124	6
	10	0x0128	?
	11	0x012c	?

Passing Pointer to a Function

- When we pass a pointer as an argument instead of a variable then the address of the variable is passed instead of the value.
- So any change made by the function using the pointer is permanently made at the address of passed variable.
- This technique is known as **call by reference**.



```c
#include <stdio.h>

int main () {

   /* local variable definition */
   int a = 100;
   int b = 200;

   printf("Before swap, value of a : %d\n", a );
   printf("Before swap, value of b : %d\n", b );

   /* calling a function to swap the values */
   swap(&a, &b);

   printf("After swap, value of a : %d\n", a );
   printf("After swap, value of b : %d\n", b );

   return 0;
}
void swap(int *x, int *y) {

   int temp;

   temp = *x; /* save the value of x */
   *x = *y;    /* put y into x */
   *y = temp; /* put temp into y */

   return;
}
```

/* function definition to swap the values */

?

Thank You

Example

```
#include <stdio.h>
void salaryhike(int *var, int b){
      *var = *var + b;
}
int main() {
      int salary=0, bonus=0;
      printf("Enter the employee current salary:");
      scanf("%d", &salary);
      printf("Enter bonus:");
      scanf("%d", &bonus);
      salaryhike(&salary, bonus);
      printf("Final salary: %d", salary);
      return 0;
}
```