Computer Programming II

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C Revisited

`switch` and `break`

- Example: calculator.c

```
23          switch (operator) {
24              case '+':
25                  result += value;
26                  break;
27              case '-':
28                  result -= value;
29                  break;
30              case '*':
31                  result *= value;
32                  break;
33              case '/':
34                  if (value == 0) {
35                      printf("Error:Divide by zero\n");
36                      printf("   operation ignored\n");
37                  } else
38                      result /= value;
39                  break;
40              default:
41                  printf("Unknown operator %c\n", operator);
42                  break;
43          }
```

`switch` and `break`

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23          switch (operator) {
24              case '+':
25                  result += value;
26                  break;
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28                  result -= value;
29                  break;
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31                  result *= value;
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33              case '/':
34                  if (value == 0) {
35                      printf("Error:Divide by zero\n");
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38                      result /= value;
39                  break;
40              default:
41                  printf("Unknown operator %c\n", operator);
42                  break;
43          }
```

switch, **break**, and **continue**

```
#include <stdio.h>

int   number;       /* Number we are converting */
char  type;         /* Type of conversion to do */
char  line[80];     /* input line */

int main(void)
{
    while (1) {

        printf("Enter conversion and number: ");

        fgets(line, sizeof(line), stdin);
        sscanf(line, "%c", &type);

        if ((type == 'q') || (type == 'Q'))
            break;

        switch (type) {
            case 'o':
            case 'O':           /* Octal conversion */
                sscanf(line, "%c %o", &type, &number);
                break;
            case 'x':
            case 'X':           /* Hexadecimal conversion */
                sscanf(line, "%c %x", &type, &number);
                break;
            case 'd':
            case 'D':           /* Decimal (For completeness) */
                sscanf(line, "%c %d", &type, &number);
                break;
            case '?':
            case 'h':           /* Help */
                printf("Letter  Conversion\n");
                printf("  o     Octal\n");
                printf("  x     Hexadecimal\n");
                printf("  d     Decimal\n");
                printf("  q     Quit program\n");

                /* Don't print the number */
                continue;
            default:
                printf("Type ? for help\n");
                /* Don't print the number */
                continue;
        }
        printf("Result is %d\n", number);
    }
    return (0);
}
```

break (leave the switch)

continue (within the while loop)

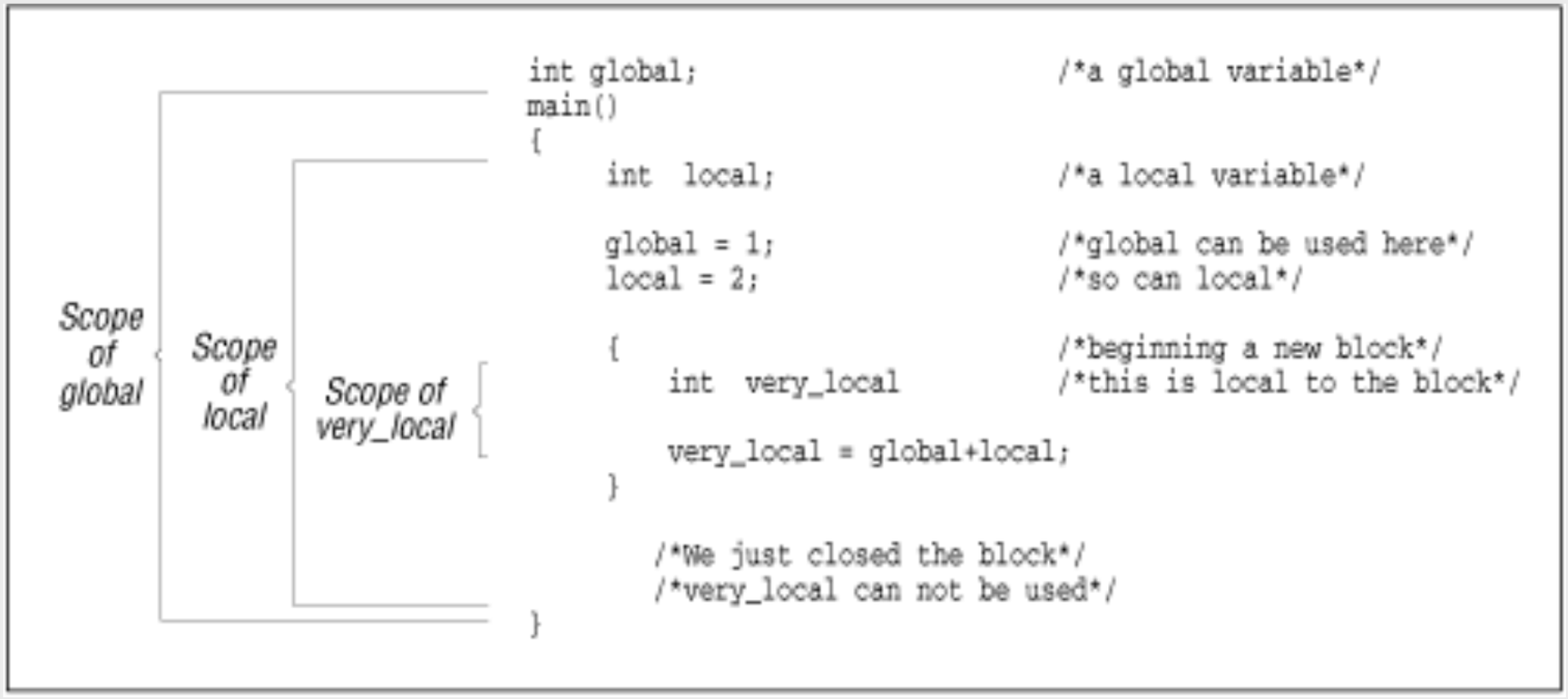
break (leave the while loop)

More about Variables and Functions

Scope and Class

- All variables have two attributes
  - scope
    - global vs. local variables
  - class
    - permanent vs. temporary

Local and Global Variables




```
int global;                     /*a global variable*/
main()
{
     int  local;                /*a local variable*/

     global = 1;                /*global can be used here*/
     local = 2;                 /*so can local*/

     {                          /*beginning a new block*/
         int  very_local        /*this is local to the block*/

         very_local = global+local;
     }

        /*We just closed the block*/
        /*very_local can not be used*/
}
```

Hidden Variables

Scope of global variable count.

Local variable count *hides global variable* count *in this area.*

```
int total;                          /*total number of entries*/
int count;                          /*count of total entries*/

main()
{

     total = 0;
     count = 0;                       /*set global counter*/


     {
          int  count;                 /*a local counter*/

          count=0;

          while (1) {
             if (count > 10)
                 break;

             total += count;
             ++count;
          }
     {

     ++count;
     return (0);
}
```

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Scope of global variable count.

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int total;                          /*total number of entries*/
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     ++count;
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int total;                          /*total number of entries*/
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        count=0;

        while (1) {
           if (count > 10)
               break;

           total += count;
           ++count;
        }
     {

     ++count;
     return (0);
}
```
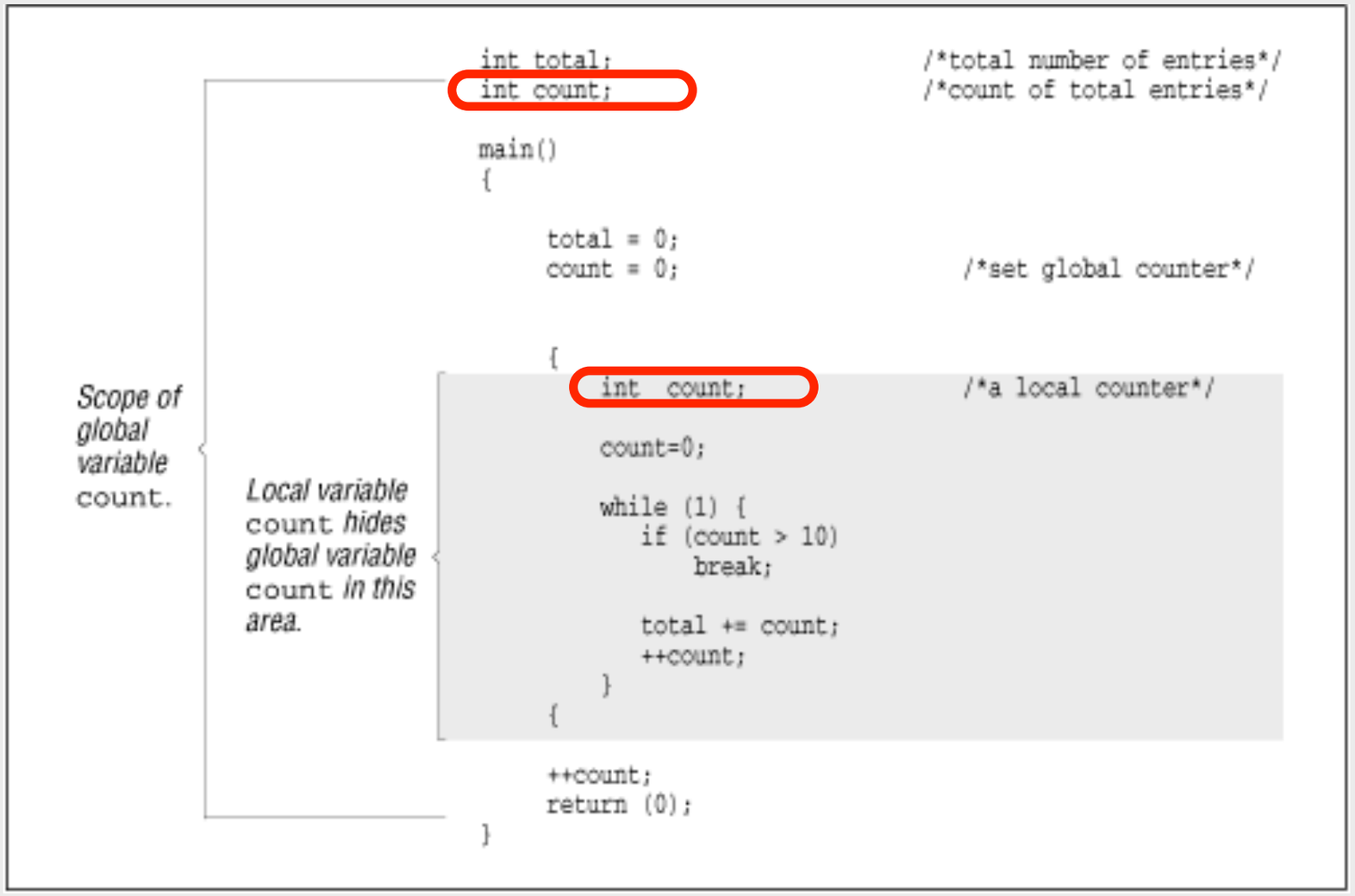

Hidden Variables



The global count has bee hidden by the local count for the scope of the block

The Class of Variables

- The class of variable
  - **permanent**: created and initialized before the program starts and remain in until it terminates
    - **temporary**: allocated from stack; may cause “Stack overflow” error if try to allocate too many temporary variables
      - The size of the stack depends on the system and compiler you are using

static

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- Local variables are temporary unless they are declared **static**

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- When using with global variables, **static** indicates that a variable is local to the current file

permanent vs. temporary

- Example: vars.c

```
4     int counter;     /* loop counter */
5     for (counter = 0; counter < 3; ++counter) {
6         int temporary = 1; /* A temporary variable */
7         static int permanent = 1; /* A permanent variable */
8
9         printf("Temporary %d Permanent %d\n",
10            temporary, permanent);
11        ++temporary;
12        ++permanent;
13    }
14    return (0);
```

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12        ++permanent;
13    }
14    return (0);
```

```
Temporary 1 Permanent 1
Temporary 1 Permanent 2
Temporary 1 Permanent 3
```

Declaration Modifiers

Declared	Scope	Class	Initialized
Outside all blocks	Global	Permanent	Once
static outside all blocks	Global[1]	Permanent	Once
Inside a block	Local	Temporary	Each time block is entered
static inside a block	Local	Permanent	Once

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A static declaration made outside blocks indicates the variable is local to the file in which it is declared

Functions

- Each function contains the following
  - Name
  - Description
  - Parameters
  - Returns

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- In the chapter of pointers, “call by reference” will be discussed

C and the Stack

- C uses a stack to store local variables (i.e. those declared in functions), it is also used when passing parameters to functions
  - The calling function pushes the parameters
  - The function is called
  - The called function picks up the parameters
  - The called function pushes its local variables
  - When finished, the called function pops its local variables and jumps back to the calling function
  - The calling function pops the parameters
  - The return value is handled

Stack Example

```
#include <stdio.h>

double power(int, int);

int  main(void)
{
     int      x = 2;
     double   d;

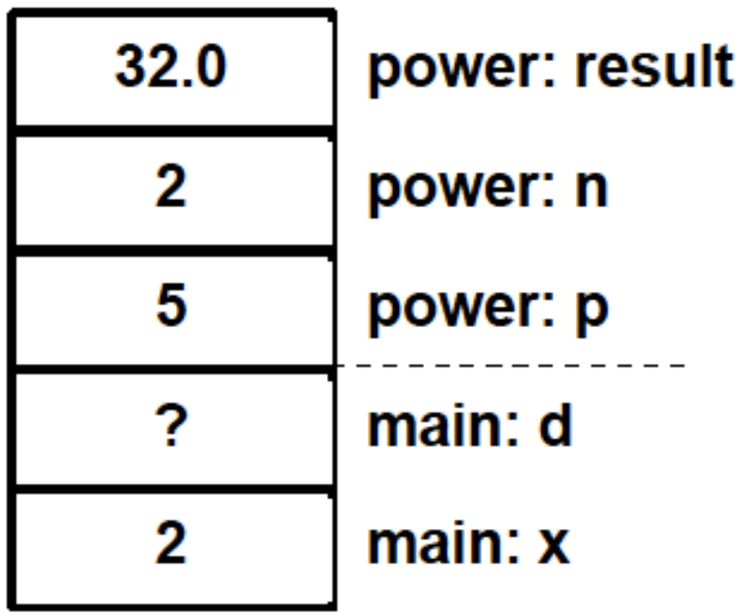
     d = power(x, 5);
     printf("%lf\n", d);

     return 0;
}

double power(int n, int p)
{
     double   result = n;

     while(--p > 0)
              result *= n;

     return result;
}
```



Storage

- C stores local variables on the stack
- Global variables may be declared. These are not stack based, but are placed in the data segment
- Special keywords exist to specify where local variables are stored:
  - **auto** - place on the stack (default)
  - **static** - place in the data segment (heap)
  - **register** - place in a CPU register
- Data may also be placed on the heap, this will be discussed in a later chapter

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- Local variables are automatically allocated on entry into, and automatically deallocated on exit from, a function
- These variables are therefore called “automatic”
  - Initial value: random
  - Initialization: recommended

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```
int  table(void)
{
     int        lines = 13;
     auto int   columns;
```

auto keyword redundant

`static`

- The static keyword instructs the compiler to place a variable into the data segment
- The data segment is permanent (static)
- A value left in a static in one call to a function will still be there at the next call
  - Initial value: 0
  - Initialization: unnecessary if you like zeros

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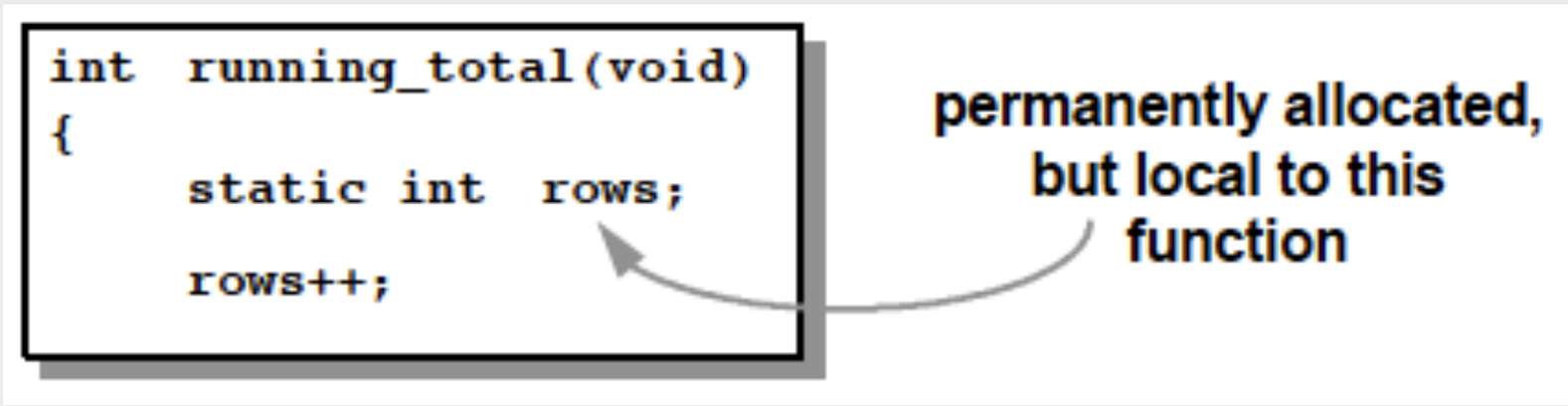

static

- Example: static.c

```
5  void f1() {
6      static int k = 0; /*static variable has its local scope*/
7      int j = 10; /*local variable*/
8      printf("value of k = %d, j = %d", k, j);
9      k += 10;
10     j += 10;
11 }
```

```
13 void f2() {
14     static int k = 0; /*static variable has its local scope*/
15     int j = 10; /*local variable*/
16     printf("value of k = %d, j = %d", k, j);
17     k += 10;
18     j += 10;
19 }
```

```
value of k = 0, j = 10 after first call of f1
value of k = 10, j = 10 after second call of f1
value of k = 20, j = 10 after third call of f1
value of k = 0, j = 10 after first call of f2
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```

static variables have local scope!!

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`register`

- The register keyword tells the compiler to place a variable into a CPU register for optimization purpose
- If a register is unavailable the request will be ignored
- Largely redundant with optimizing compilers
  - Initial value: random
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```
void  speedy_function(void)
{
      register int i;

      for(i = 0; i < 10000; i++)
```

Global Variables

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```
#include <stdio.h>

double    d;

int main(void)
{
     int   i;

     return 0;
}
```

variable “d” is global and available to all functions defined below it

Local Variable

- Example: length.c

```
3  int length(char string[]) {
4      int index; /* index into the string */
5
6      /*
7       * Loop until we reach the end of string character
8       */
9      for (index = 0; string[index] != '\0'; ++index)
10         /* do nothing */
11     return (index);
12 }
```

```
14 int main() {
15     char line[100];»/* Input line from user */
16
17     while (1) {
18         printf("Enter line:");
19         fgets(line, sizeof(line), stdin);
20
21         printf("Length (including newline) is: %d\n", length(line)-1);
22     }
23 }
```

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```
Enter line:Hello
Length (including newline) is: -1
Enter line:World!!
Length (including newline) is: -1
Enter line:Hello
Length (including newline) is: -1
Enter line:^C
```

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int main() {
    char line[100];»/* Input line from user */

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?

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Structured Programming

- Top-down programming
  - start at the top (main) and work your way down
- Bottom-up programming
  - write the lowest-level function first, testing it, and then building on that working set
- Both techniques are useful

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```
int main()
{
    init();
    solve_problems();
    finish_up();
    return (0);
}
```

Recursion

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- A recursive function must follow two basic rules
  - It must have an ending point
  - It must make the problem simpler

Recursion

```
int fact(int number)
{
    if (number == 0)
        return (1);
    /* else */
    return (number * fact(number-1));
}
```

Recursion

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= 5 * fact(4)
= 4 * fact(3)
= 3 * fact(2)
= 2 * fact(1)
= 1 * fact(0)

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= 3 * fact(2)
= 2 * fact(1)
= 1 * fact(0)

Recursion

```
int sum(int first, int last, int array[])
{
    if (first == last)
        return (array[first]);
    /* else */
    return (array[first] + sum(first+1, last, array));
}
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sum(1 8 3 2)
= 1 + sum(8 3 2)
= 8 + sum(3 2)
= 3 + sum(2)
= 2

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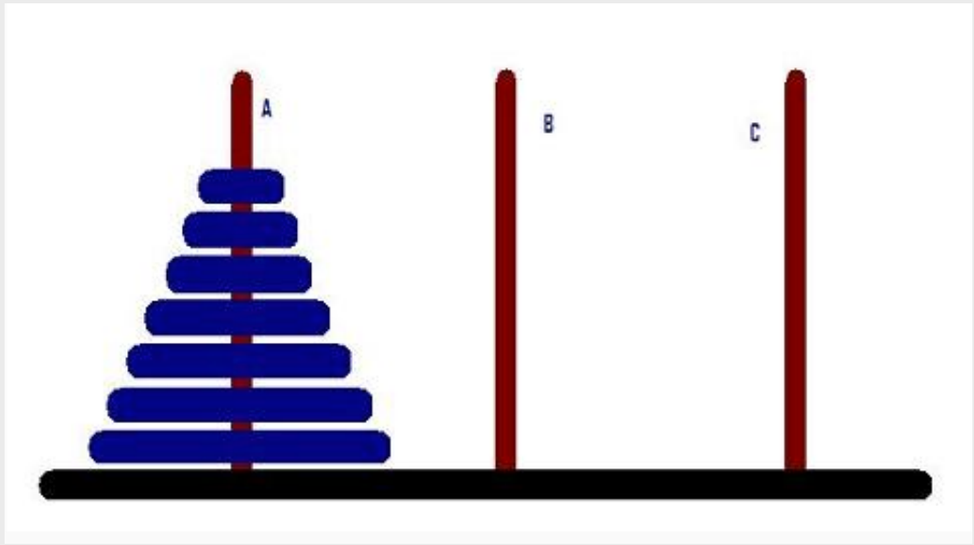

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$$\text{let } S_n = T_n + 1$$

Towers of Hanoi

- Number of Switches

$$T_n = \begin{cases} 0 & \text{if} \quad n = 0 \\ 2T_{n-1} + 1 & \text{if} \quad n > 0 \end{cases}$$

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$$S_n = 2^n$$

$$\Longrightarrow T_n = S_n - 1 = 2^n - 1$$

Towers of Hanoi

- Example: tower.c
  - Animation1, Animation2

```c
void hanoi(int num_towers, char from, char tmp, char to) {
    if(num_towers == 1) {
        printf("Move sheet from %c to %c\n", from, to);
        num_switch++;
    }
    else {
        hanoi(num_towers-1, from, to, tmp);
        hanoi(1, from, tmp, to);
        hanoi(num_towers-1, tmp, from, to);
    }
}
```

Towers of Hanoi

- Example: tower.c
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```
5  void hanoi(int num_towers, char from, char tmp, char to) {
6      if(num_towers == 1) {
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C Preprocessors

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- It is common programming practice to use all uppercase letters for macro names

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#define SIZE 20
```

`#define` Example

- Example: init2b.c

```c
#define SIZE 20     /* work on 20 elements */

int data[SIZE];     /* some data */
int twice[SIZE];    /* twice some data */

int main()
{
    int index;   /* index into the data */

    for (index = 0; index < SIZE; ++index) {
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    }
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#define BIG_NUMBER 10 ** 10

main()
{
    /* index for our calculations */
    int   index;

    index = 0;

    /* syntax error on next line */
    while (index < BIG_NUMBER) {
        index = index * 8;
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- The example cannot be compiled!! Why??

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** is an illegal operator, cause syntax error!!

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```c
#include <stdio.h>

#define FIRST_PART      7
#define LAST_PART       5
#define ALL_PARTS       FIRST_PART + LAST_PART

int main() {
    printf("The square of all the parts is %d\n",
            ALL_PARTS * ALL_PARTS);
    return (0);
}
```

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`#define` Statement

- Example: max.c
  - An expected error!! Why??

```c
#include <stdio.h>

#define MAX =10

int main()
{
    int  counter;

    for (counter = MAX; counter > 0; --counter)
        printf("Hi there\n");

    return (0);
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```

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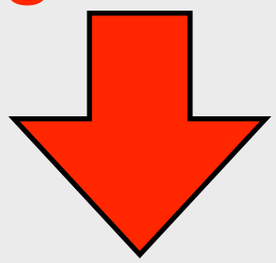

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- Example: size.c
  - Why does 10 - 2 = 10??

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#define FUDGE   SIZE -2;
int main()
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    int size;/* size to really use */

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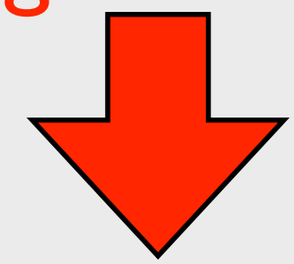

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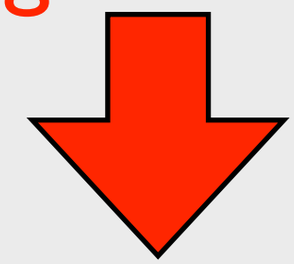

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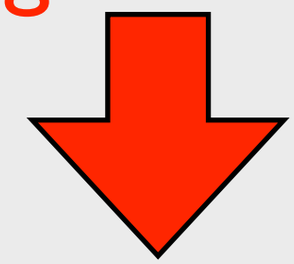

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  - **`const`** follows normal C scope rules, while constants defined by a **`#define`** continue on forever

`#define` vs. `const`

- Two different usages

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               /* (This definition can easily cause problems) */
```

```
const int MAX = 10; /* Define a C constant integer */
                    /* (safer) */
```

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  - `#define` can only define simple constants, but `const` can define any type of C constant, including things like structured classes

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const struct box pink_box = {1.0, 4.5};
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```
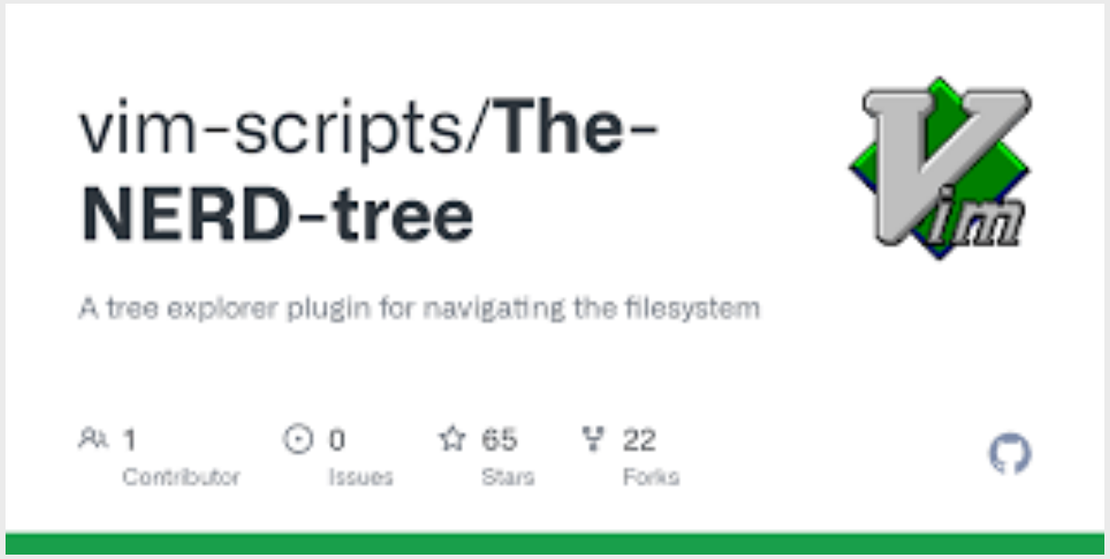
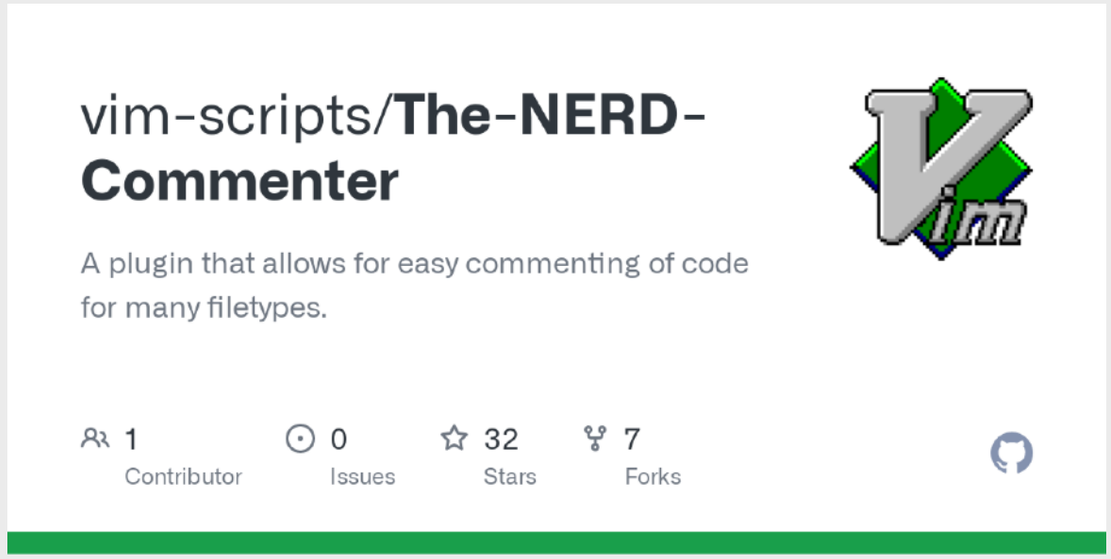

- **`#define`** is essential for things like conditional compilation and other specialized uses

Vim Tips





- Useful Plugins
  - The NERD Tree
  - The NERD Commenter