CSE 374 Lecture 10

(C continued - I/O stuff)

Demo: fopen, fgets

I/O : Printf, scanf

Printf and scanf are two I/O functions, prototyped in stdio.h

- ➔ Printf (print-format)
- ➔ int printf(const char *format, ...)
- ➔ 'Format' is a string that can contain format tags
- ➔ + additional arguments to match tags
- ➔ Number of arguments better match number of %
- ➔ Corresponding arguments better have the right types (%d, int; %f, float; %e, float (prints scientific); %s, \0- terminated char*; … Compiler might check, but not guaranteed
  - ◆ best case scenario: you crash
- ➔ `printf("%s: %d %g\n", p, y+9, 3.0)`

- ➔ scanf (gets input, formatted)
- ➔ int scanf(const char *format, ...)
- ➔ 'Format' is a string that can contain format tags
- ➔ + additional arguments to match tags - should be pointers to the right data type so input can be stored in them
- ➔ `scanf("%d %s", &n, str);`
- ➔ `scanf("%*s %d", &a);`
  - ◆ %*s ignores string until space, then reads in an integer

Formatting Tricks

```
%[flags][width][.precision][length]specifier
```

Where the *specifier character* at the end is the most significant component, since it defines the type and the interpretation of its corresponding argument:

specifier	Output	Example
d *or* i	Signed decimal integer	392
u	Unsigned decimal integer	7235
o	Unsigned octal	610
x	Unsigned hexadecimal integer	7fa
X	Unsigned hexadecimal integer (uppercase)	7FA
f	Decimal floating point, lowercase	392.65
F	Decimal floating point, uppercase	392.65
e	Scientific notation (mantissa/exponent), lowercase	3.9265e+2
E	Scientific notation (mantissa/exponent), uppercase	3.9265E+2
g	Use the shortest representation: %e or %f	392.65
G	Use the shortest representation: %E or %F	392.65
a	Hexadecimal floating point, lowercase	-0xc.90fep-2
A	Hexadecimal floating point, uppercase	-0XC.90FEP-2
c	Character	a
s	String of characters	sample
p	Pointer address	b8000000
n	Nothing printed. The corresponding argument must be a pointer to a signed int. The number of characters written so far is stored in the pointed location.	
%	A % followed by another % character will write a single % to the stream.	%

```c
/* printf example */
#include <stdio.h>

int main()
{
   printf ("Characters: %c %c \n", 'a', 65);
   printf ("Decimals: %d %ld\n", 1977, 650000L);
   printf ("Preceding with blanks: %10d \n", 1977);
   printf ("Preceding with zeros: %010d \n", 1977);
   printf ("Some different radices: %d %x %o %#x %#o \n", 100, 100, 100, 100, 100);
   printf ("floats: %4.2f %+.0e %E \n", 3.1416, 3.1416, 3.1416);
   printf ("Width trick: %*d \n", 5, 10);
   printf ("%s \n", "A string");
   return 0;
}
```

flags	description
-	Left-justify within the given field width; Right justification is the default (see *width* sub-specifier).
+	Forces to preceed the result with a plus or minus sign (+ or -) even for positive numbers. By default, only negative numbers are preceded with a - sign.
(space)	If no sign is going to be written, a blank space is inserted before the value.
#	Used with o, x or X specifiers the value is preceeded with 0, 0x or 0X respectively for values different than zero. Used with a, A, e, E, f, F, g or G it forces the written output to contain a decimal point even if no more digits follow. By default, if no digits follow, no decimal point is written.
0	Left-pads the number with zeroes (0) instead of spaces when padding is specified (see *width* sub-specifier).

width	description
(number)	Minimum number of characters to be printed. If the value to be printed is shorter than this number, the result is padded with blank spaces. The value is not truncated even if the result is larger.
*	The *width* is not specified in the *format* string, but as an additional integer value argument preceding the argument that has to be formatted.

.precision	description
.number	For integer specifiers (d, i, o, u, x, X): *precision* specifies the minimum number of digits to be written. If the value to be written is shorter than this number, the result is padded with leading zeros. The value is not truncated even if the result is longer. A *precision* of 0 means that no character is written for the value 0. For a, A, e, E, f and F specifiers: this is the number of digits to be printed **after** the decimal point (by default, this is 6). For g and G specifiers: This is the maximum number of significant digits to be printed. For s: this is the maximum number of characters to be printed. By default all characters are printed until the ending null character is encountered. If the period is specified without an explicit value for *precision*, 0 is assumed.
.*	The *precision* is not specified in the *format* string, but as an additional integer value argument preceding the argument that has to be formatted.

From cplusplus.com

Learning about iostreams

https://cplusplus.com/reference/cstdio/

fprintf

<cstdio>

```
int fprintf ( FILE * stream, const char * format, ... );
```

Write formatted data to stream

type

FILE

<cstdi

Object containing information to control a stream

Object type that identifies a stream and contains the information needed to control it, including a pointer to its buffer, its position indicator and all its state indicators.

FILE objects are usually created by a call to either fopen or tmpfile, which both return a pointer to one of these objects.

(f)scanf:

- **Whitespace character:** the function will read and ignore any whitespace characters encountered before the next non-whitespace character (whitespace characters include spaces, newline and tab c see isspace). A single whitespace in the *format* string validates any quantity of whitespace c extracted from the *stream* (including none).
- **Non-whitespace character, except format specifier (%):** Any character that is not eith whitespace character (blank, newline or tab) or part of a *format specifier* (which begin with a causes the function to read the next character from the stream, compare it to this non-white character and if it matches, it is discarded and the function continues with the next characte the character does not match, the function fails, returning and leaving subsequent character stream unread.
- **Format specifiers:** A sequence formed by an initial percentage sign (%) indicates a format s which is used to specify the type and format of the data to be retrieved from the *stream* and the locations pointed by the additional arguments.

```
int main() {
    FILE* ptr = fopen("abc.txt", "r");
    if (ptr == NULL) {
        printf("no such file.");
        return 0;
    }

    /* Assuming that abc.txt has content in below
    format
    NAME AGE CITY
    abc  12 hyderabad
    bef  25 delhi
    cce  65 bangalore */
    char buf[100];
    while (fscanf(ptr, "%*s %*s %s ", buf) == 1) {
        printf("%s\n", buf);
    }
    return 0;
}
```

From geeksforgeeks.org

Pointer Review

```
int var = 349;
int *varptr = &var;
```

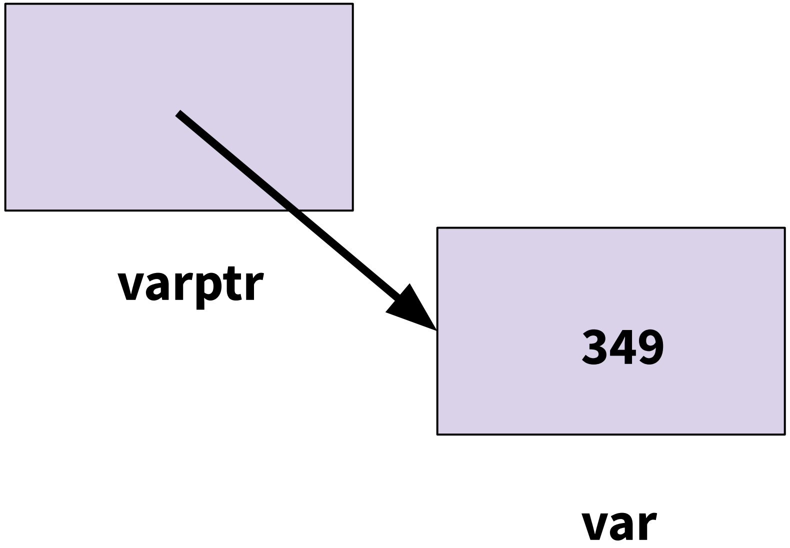
Pointers point to an address in memory
`&x` returns the address

Declare a pointer to a pointer type and it has a specific type/size of memory:

`T *x;` or `T* x`; or `T * x`; or T*x
(T is a type, x is a variable)

An expression to dereference a pointer
`*x` (more generally *expression)
    Dereference - get the value at the address

Arrays have an implicit pointer type
`T = x[n]` implies x is of type T*



Pointers to pointers

Levels of pointers make sense:

I.e.: `argv, *argv, **argv`

Or: `argv, argv[0], argv[0][0]`

But

`&(&p)` doesn't make sense

```
void f(int x) {
    int*p = &x;
    int**q = &p;
    // x, p, *p, q, *q, **q
}
```

Integer, pointer to integer, pointer to pointer to integer

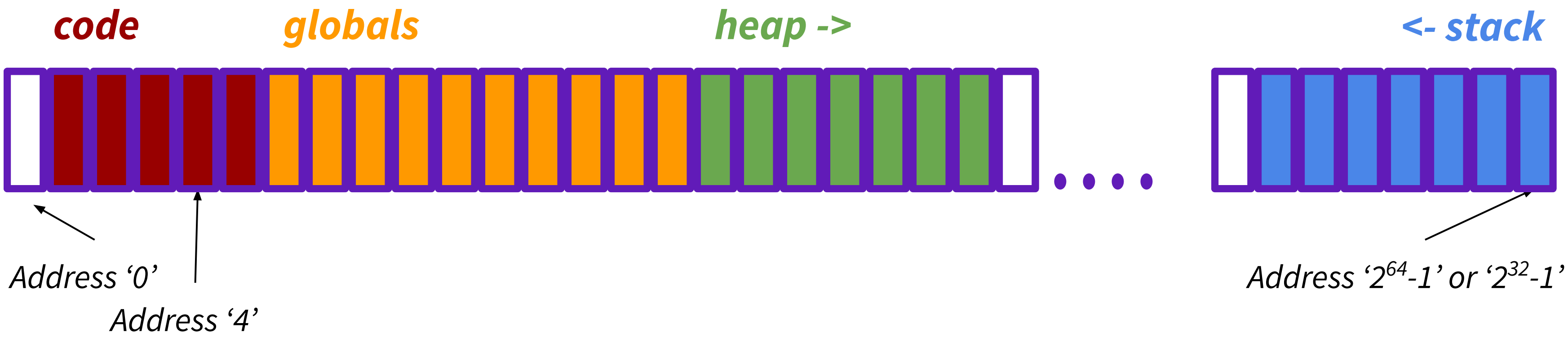
`&p` is the address of '`p`',

`&(&p)` would be the address of the address of `p`, but that value isn't stored separately anywhere and doesn't have an address

Try using `printf ("The address of x is %p\n", &x);`

Storage

- Variables need a place to live in memory
- Get ‘allocated’ a physical space in memory (with an address)
- Size of memory allocation depends on datatype
- Get ‘deallocated’ to release the space in memory



Scope

Variables may be accessed by the caller only at certain times - this is scope

Scope and storage are related, but not the same thing

- Global variables
  - Scope: entire program
  - Not desirable (violate encapsulation) But can be OK for truly global data like conversion tables, physical constants, etc.
- Static global variables
  - Scope: containing file
  - Static functions cannot be called from other files
- Static local variables
  - Scope: that function, rarely used
- Local variables (automatic)
  - Scope: that block – With recursion, multiple copies of same variable (one per stack frame/function activation)

allocated before main, deallocated after main - memory in ‘global’ block

allocated “when reached” deallocated “after block” - memory in frame on stack

```
// includes for functions & types defined elsewhere
#include <stdio.h>
#include "localstuff.h"
// symbolic constants
#define MAGIC 42
// global variables (if any)
static int days_per_month[ ] = { 31, 28, 31, 30, …};
// function prototypes
// (to handle "declare before use")
 void some_later_function(char, int);
// function definitions
void do_this( ) { … }
char *return_that(char s[ ], int n) { … }
int main(int argc, char ** argv) { … }
```

Includes declarations & prototypes you might want to share.

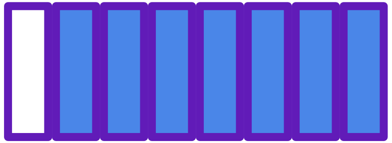
Global variables & forward declarations go first.

Source File Structures

Stuff in function definitions is local to those functions

The stack

<- stack



Stack stores active functions & <u>local</u> variables

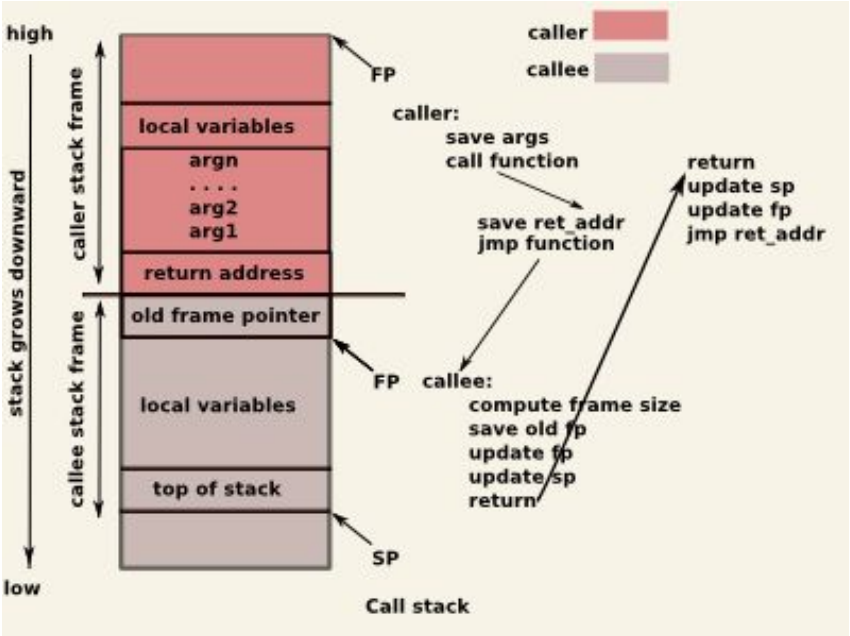
Frames deleted when function returns

Local variables do not persist

Local variables must have defined size

Can not make run-time adjustments

(Arrays must have length)



Local variable initialization

Memory allocation and initialization are not the same thing

Unlike Java, you MUST provide a value to initialize a bit of memory

It is possible to access un-initialized bits
unlike Java with sets defaults and checks for initialization
best case scenario: you crash

Arguments

Demo

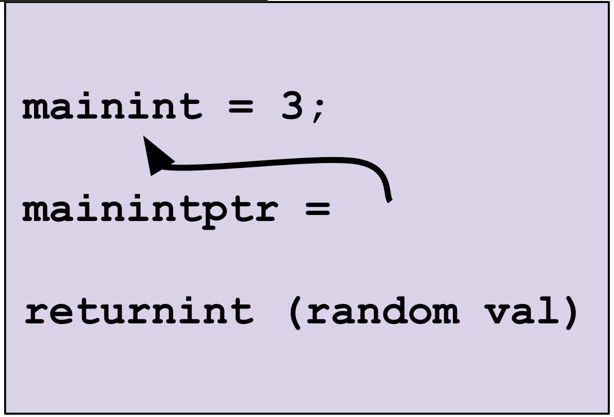
Storage allocation and variable scope is like local variables (i.e. space is part of the function frame added to the stack, and the variable may be used in the function).

All arguments passed by value. (i.e. a copy of the value is made and assigned to the variable.)

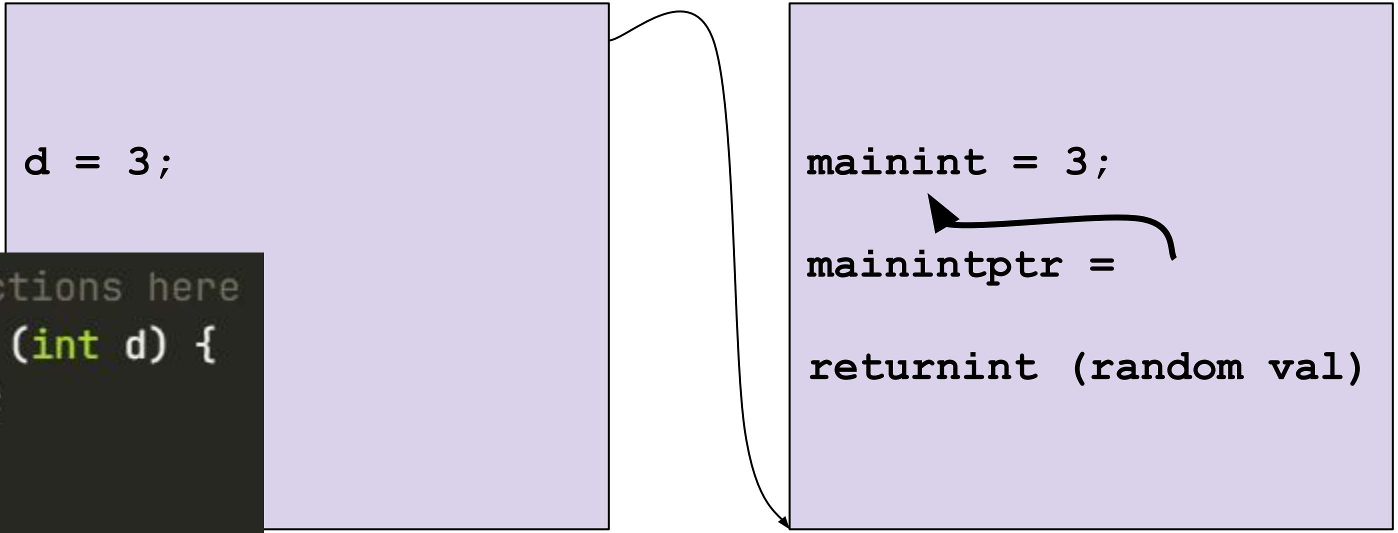
Stack (main)

```c
int main (int argc, char **argv) {
  int mainint = 3;
  int *mainintptr = &mainint;  // hold address of mainint
  int returnint;

```



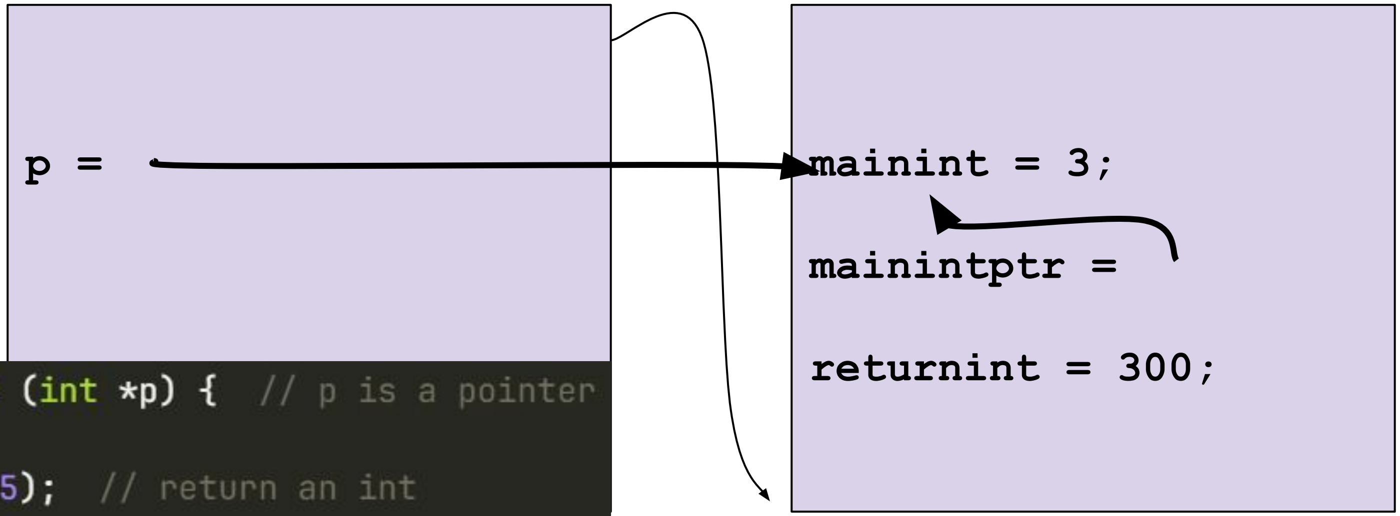
Stack (demoint)




```c
// demo functions here
int demoint (int d) {
  d = d*100;
  return d;
}
```

```c
  // test passing just the integer
  returnint = demoint(mainint);
```

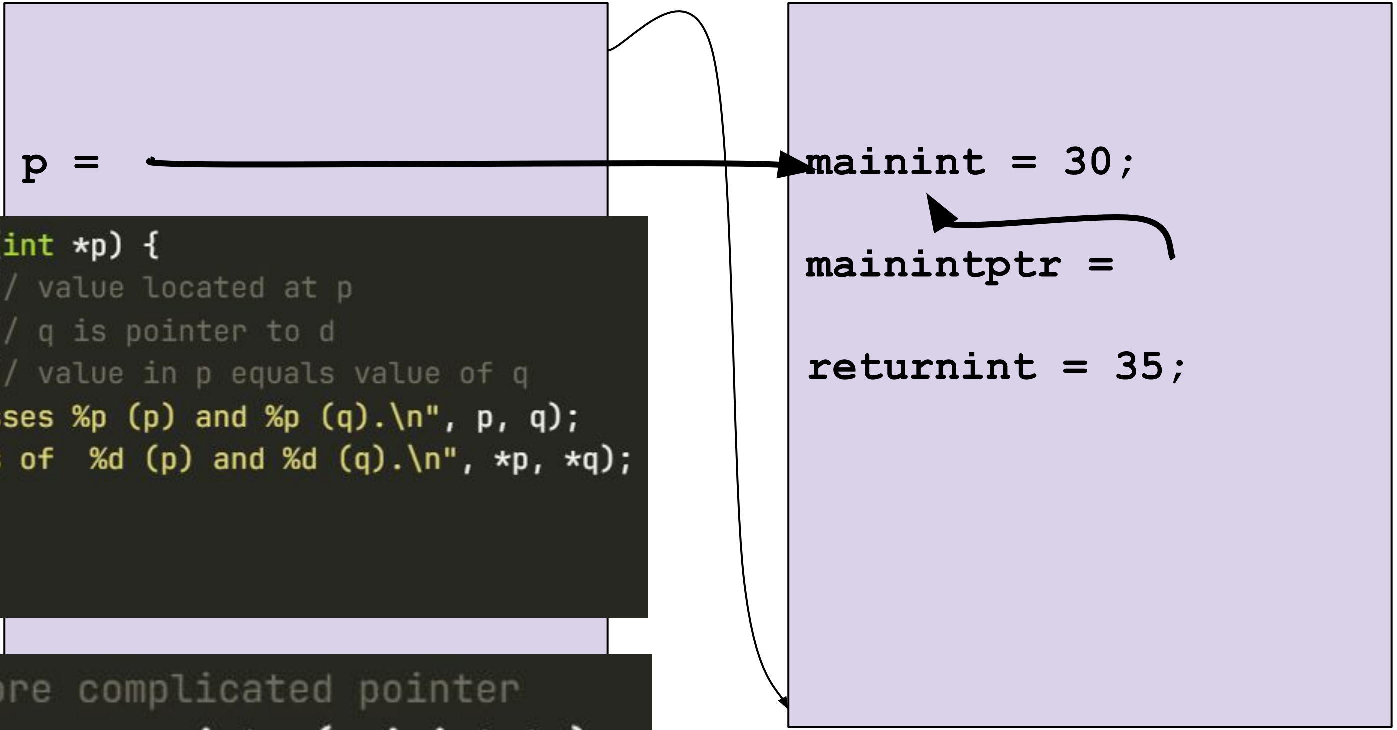
Stack (dempointer)




```
int demopointer (int *p) {  // p is a pointer
  *p = *p *10;
  return (*p + 5);  // return an int
}
```

```
    // test passing a pointer
    returnint = demopointer(mainintptr);
```

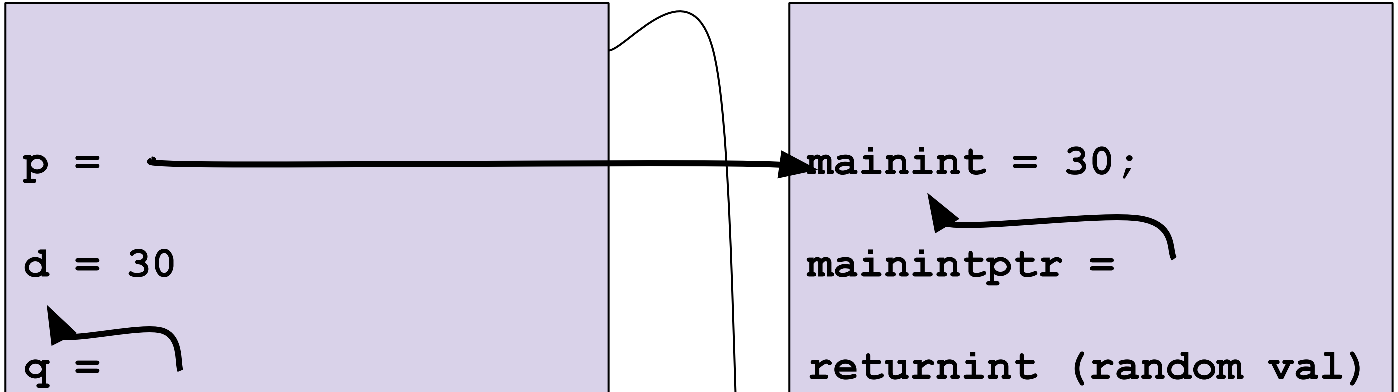
Stack (morepointer)




```c
int morepointer (int *p) {
  int d = *p;   // value located at p
  int *q = &d;  // q is pointer to d
  *p = *q;      // value in p equals value of q
  printf ("Addresses %p (p) and %p (q).\n", p, q);
  printf ("Values of  %d (p) and %d (q).\n", *p, *q);
  *p = *q + 1;
  return *q + 2;
}
```

```c
    // test more complicated pointer
    returnint = morepointer(mainintptr);
```

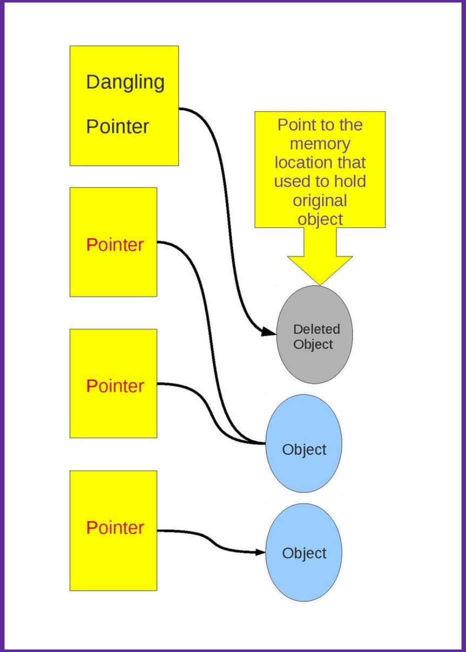
Stack (morepointer)




```c
int morepointer (int *p) {
  int d = *p;    // value located at p
  int *q = &d;   // q is pointer to d
  *p = *q;       // value in p equals value of q
  printf ("Addresses %p (p) and %p (q).\n", p, q);
  printf ("Values of  %d (p) and %d (q).\n", *p, *q);
  *p = *q + 1;
  return *q + 2;
}
```

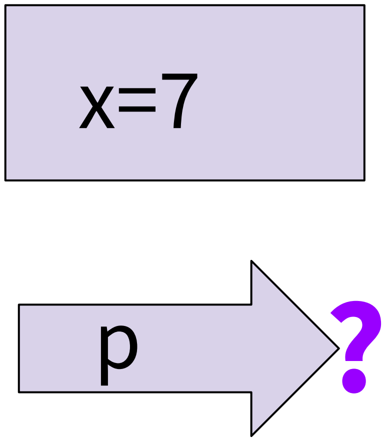
Dangling pointers

Pointers referring to memory that has been released *(Demo)*



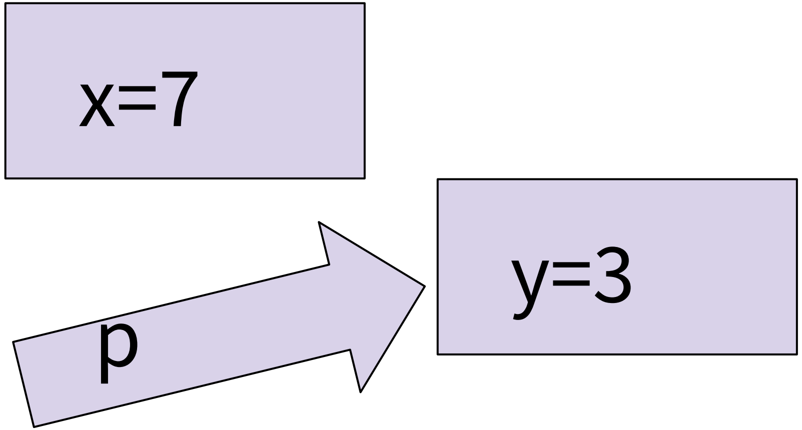
Garbage collecting languages (like Java) only delete memory that is unreachable to avoid this problem.

Dangling Pointers (line 4)



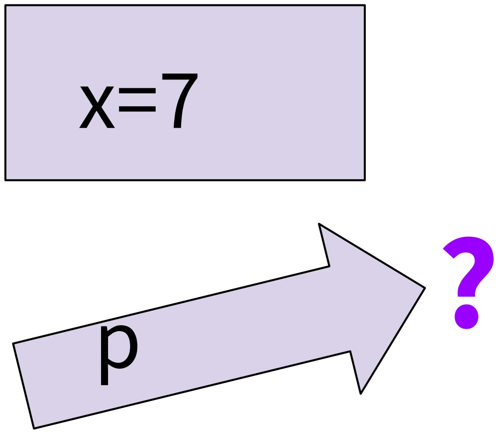

```
3  int* f(int x) {
4    int *p;
5    if (x) {
6      int y = 3;
7      p = &y; /* ok */
8      printf ("y=%d and *p=%d\n", y, *p);
9    } /* ok, but p now dangling */
10   printf ("*p=%d\n", *p);
11   /* y = 4 does not compile */
12
13   *p = 7; /* could CRASH but probably not */
14   printf ("*p=%d\n", *p);
15   return p; /* uh-oh, but no crash yet */
16 }
17
18 void g(int *p) {
19   *p = 123;
20   f(123);  // now just to demonstrate the stack
21   printf ("in g: *p=%d\n", *p);
22 }
23
24 int main(int argc, char **argv) {
25   g(f(7)); /* HOPEFULLY YOU CRASH (but maybe not) */
26 }
```

Dangling Pointers (line 7)




```
3  int* f(int x) {
4    int *p;
5    if (x) {
6      int y = 3;
7      p = &y; /* ok */
8      printf ("y=%d and *p=%d\n", y, *p);
9    } /* ok, but p now dangling */
10   printf ("*p=%d\n", *p);
11   /* y = 4 does not compile */
12
13   *p = 7; /* could CRASH but probably not */
14   printf ("*p=%d\n", *p);
15   return p; /* uh-oh, but no crash yet */
16 }
17
18 void g(int *p) {
19   *p = 123;
20   f(123);  // now just to demonstrate the stack
21   printf ("in g: *p=%d\n", *p);
22 }
23
24 int main(int argc, char **argv) {
25   g(f(7)); /* HOPEFULLY YOU CRASH (but maybe not) */
26 }
```

Dangling Pointers (line 13)




```c
3  int* f(int x) {
4    int *p;
5    if (x) {
6      int y = 3;
7      p = &y; /* ok */
8      printf ("y=%d and *p=%d\n", y, *p);
9    } /* ok, but p now dangling */
10   printf ("*p=%d\n", *p);
11   /* y = 4 does not compile */
12
13   *p = 7; /* could CRASH but probably not */
14   printf ("*p=%d\n", *p);
15   return p; /* uh-oh, but no crash yet */
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18 void g(int *p) {
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20   f(123);  // now just to demonstrate the stack
21   printf ("in g: *p=%d\n", *p);
22 }
23
24 int main(int argc, char **argv) {
25   g(f(7)); /* HOPEFULLY YOU CRASH (but maybe not) */
26 }
```

Arrays again

"A reference to an object of type array-of-T which appears in an expression decays (with three exceptions) into a pointer to its first element; the type of the resultant pointer is pointer-to-T."

http://c-faq.com/aryptr/aryptrequiv.html

Right: x is the array, which decays to a pointer to an int and &x returns a pointer to the entire array.

```
void f1(int* p) {  // takes a pointer
  *p = 5;
}
int* f2() {
     int x[3];     // x on stack, is pointer
     x[0] = 5;
     (&x)[0] = 5; // address of x, points to
                  // same place but different T
     *x = 5;      // put value at location x
     *(x+0) = 5;  // Also put value at x
     f1(x);
     f1(&x);    // wrong – watch types!
     x = &x[2]; // No!  X isn't really a pointer
     int *p = &x[2];
     return x; // correct type, but is a
               // dangling pointer
}
```

Pointer arithmetic

- If p has type T* or T[] and *p has type T
- If p points to one item of type T, p+1 points to a place in memory for the next item of type T
  - So, p[0] is one item of type T, p+i = p[i]
- T[] always has type T*, even if it is declared as T[]
  - Implicit array promotion

    Result: Arrays are always passed by reference, not by value. (The information passed is the address of where the values are stored.)

https://chortle.ccsu.edu/CPuzzles/CPuzzlesMain.html