# The C Programming Language

- C is a high-level language — structured
- C is a low-level language — machine access
- C is a small language, extendable with libraries
- C is permissive: assumes you know what you’re doing
- Good: efficient, powerful, portable, flexible
- Bad: easy to make errors, obfuscation, little support for modularization

# Intro to C

```
#include <stdio.h>

int main() {
   int i;
   extern int gcd(int x, int y);
   for (i = 0; i < 20; i++)
        printf("gcd of 12 and %d is %d\n", i, gcd(12,i));
   return (0);
}

int gcd(int x, int y) {
   int t;
   while (y) {
        t = x; x = y; y = t % y;
   }
   return (x);
}
```

# About C

- Similar to Java - Java took best of C
- `#include` - use declarations of functions
- `main()` returns int, the exit status
- Functions must be
  - declared - tells compiler how to use function
  - defined - creates the item
- Declarations must appear before code

# Basic Control Structures

- Functions - can omit `extern` declaration
- `for` loop - like Java
  - body is one statement
  - braces `{ }` enclose blocks
  - blocks introduce scope level
  - can't mix declarations and non-declarations
    - `for (int i` … - illegal in ANSI C

# More about C

- Uninitialized variables have no default value!
- No run-time checking!
- No polymorphism (`printf` format strings)
- No objects (C predates object-oriented)

Compile: `gcc -Wall -g -o gcd gcd.c`

# C data types

- basic types and literals (King: Ch 7)

```
int i = 38;         long el = 38L;
int hex = 0x2a;     int oct = 033;
printf("i = %d, el = %ld, hex = %d, oct = %d\n",
       i, el, hex, oct);
```

```
i = 38, el = 38, hex = 42, oct = 27
```

```
double d1 = 0.3;   double d2 = 3.0;
double d3 = 6.02e23;
printf("d1 = %f, d2 = %f, d3 = %e\n", d1, d2, d3)
```

```
d1 = 0.300000, d2 = 3.000000, d3 = 6.020000e+23
```

# Data Type Conversion

- The expression on the right side is converted to the type of the variable on the left.

```
char c;
int i = c;    /* c is converted to int */
double d = i; /* i is converted to double */
```

- This is no problem as long as the variable's type is at least as "wide" as the expression.

```
char c = 500; /* compiler warning */
int k = d1;
printf("c = %c, k = %d\n", c, k);
```

```
c =  , k = 0
```

# Data Type Capacity

- What happens when the following code is executed?

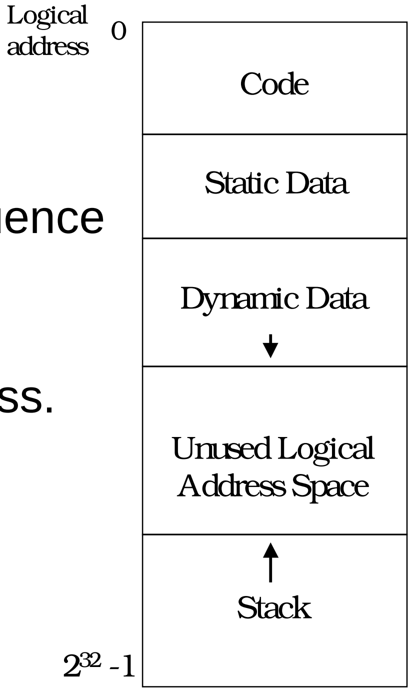
```
char c = 127;
int d;

printf("c = %d\n", c);
c++;

d = 512 / c;
printf("c = %d, d = %d\n", c, d);
```

# Mixed Mode Arithmetic

```
double m = 5/6; /* int / int = int */
printf("Result of 5/6 is %f\n", m);
Result of 5/6 is 0.000000

double n = (double)5/6; /* double / int = double */
printf("Result of (double)5/6 is %f\n", n);
Result of (double)5/6 is 0.833333

double o = 5.0/6; /* double / int = double */
printf("Result of 5.0/6 is %f\n", o);
Result of 5.0/6 is 0.833333

int p = 5.0/6; /* double / int = double but then
                  converted to int */
printf("Result of 5.0/6 is %d\n", p);
 Result of 5.0/6 is 0
```

# Memory model

- Memory is just a sequence of bytes
- A memory location is identified by an address.



Logical address

0

Code

Static Data

Dynamic Data

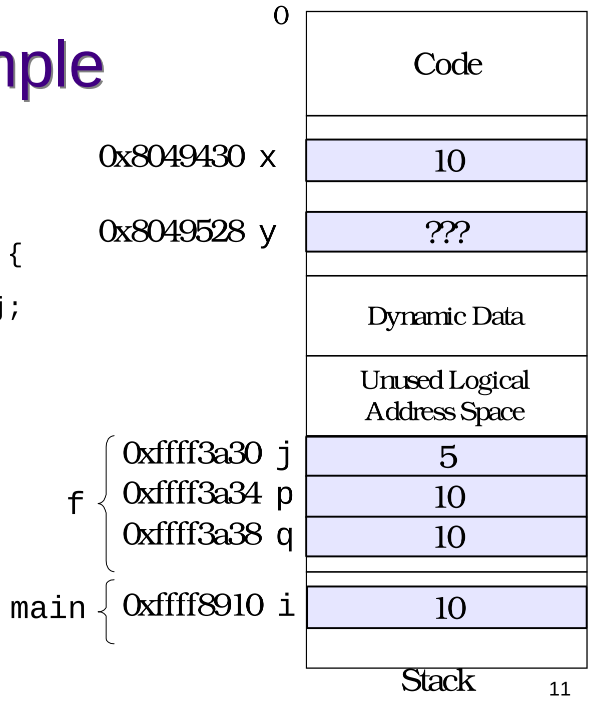
Unused Logical Address Space

Stack

$2^{32}$ -1

# Example

```
int x = 10;
int y;

int f(int p, int q) {
    int j = 5;
    return p * q + j;
}

int main() {

    int i = x;
    y = f(i, i);
    return 0;
}
```



0

Code

0x8049430 x 10

0x8049528 y ???

Dynamic Data

Unused Logical Address Space

f

0xffff3a30 j 5

0xffff3a34 p 10

0xffff3a38 q 10

main

0xffff8910 i 10

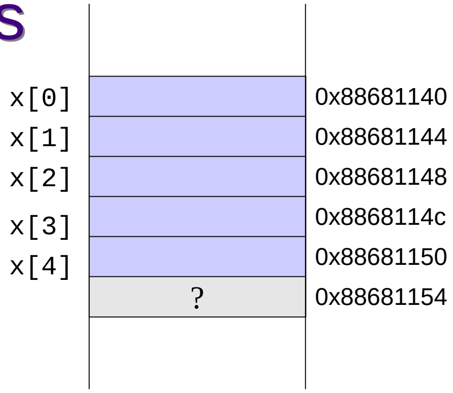
Stack

# Arrays

- Arrays in C are a contiguous chunk of memory that contain a list of items of the same type.
- If an array of ints contains 10 ints, then the array is 40 bytes. There is nothing extra.
- In particular, the size of the array is not stored with the array. There is *no* runtime checking.

# Arrays

```
int x[5];
for (i = 0; i <= 5; i++) {
    x[i] = i*i;
}
```



- No runtime checking of array bounds
- Behaviour of exceeding array bounds is “undefined”
    - program might appear to work
    - program might crash
    - program might do something apparently random

# Initializing arrays

The `sizeof` operator is evaluated by the compiler

Declaration/Definition

```
int a[10]; /*declare 'a' as an
             array of 10 ints*/
sizeof(a) == 10 * sizeof(int) == 40;
```

Static initialization:

```
char letters[4] = {'a', 'q', 'e', 'r'};
```

Initialization loop:

```
for(i = 0; i < N; i++) {
   a[i] = 0;
}
```

# Arrays

- Warning: It is the programmer's responsibility to keep track of the size of an array!
- Often define a maximum size.
- Pre-processor directives are used for constants:
    - E. g., `#define MAXSIZE 30`

# Pointers

- A pointer is a higher-level version of an address.
- A pointer has type information.

```
int i;
int *p;  /* declare p to point to type int */
*p = i;  /* dereference p – set what p points to*/
p = &i   /* Give p the value of the address of i*/
char *c = p; /* Warning: initialization from
                incompatible pointer type */
```

# Important!

- `int *p;`
- Memory is allocated to store the **pointer**
- No memory is allocated to store what the pointer points to!
- Also, p is **not** initialized to a valid address or null.
- I.e., `*p = 10;` is wrong unless memory has been allocated and p set to point to it.

# A picture

```
int i = 19;
int *p;
int *q;
*p = i; /*error*/
q = &i
```

| | |
|---|---|
| 0x80493e0 | 19 |
| | |
| | |
| | |
| 0x80494dc | ? |
| | |
| 0x80494e0 | 0x80493e0 |

Symbol Table

| | |
|---|---|
| i | 0x80493e0 |
| p | 0x80494dc |
| q | 0x80494e0 |

# A picture

```
int i = 19;
int *p;
int *q;

q = &i
p = (int *)malloc(sizeof(int));
*p = i;
```

| | |
|---|---|
| 0x80493e0 | 19 |
| | |
| | |
| | |
| 0x80494dc | 0x8049530 |
| | |
| 0x80494e0 | 0x80493e0 |
| | |
| | |
| 0x8049530 | 19 |

Symbol Table

| | |
|---|---|
| i | 0x80493e0 |
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