Several New Things

- 2's complement representation of negative integers
- The data size flag in the conversion specification of printf
- Recast of &n to *unsigned long* to get the address

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Casts

- **`(T) x`**
  - A cast converts the value held in variable **`x`** to type **`T`**
  - With pointers, casts do not affect the content of the variable pointed (merely an indication to the compiler):
  - `char* c; int* i;`
  - `i = (int *) c;`

Flags (in any order), which modify the specification:

- `-`, which specifies left adjustment of the converted argument in its field.
- `+`, which specifies that the number will always be printed with a sign.
- `0`: for numeric conversions, specifies padding to the field width with leading zeros.
- `#`, which specifies an alternate output form. For `o`, the first digit will become zero. For `x` or `X`, `0x` or `0X` will be prefixed to a non-zero result.

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2's complement

- We won't get into lots of examples of computer arithmetics
- But suffices to say that, under 2's complement
  - The binary representation of negation of an integer n is obtained by
    - First negate n bit-wise
    - Add 1 to the least significant bit
- Example (8-bit data representation)
  - 1's bit pattern is 0000 0001
  - Negation result: 11111110
  - Add binary 1, we get: 11111111
- Example
  - What is -1's negation under 2's complement?
  - What is 0's negation under 2's complement?

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Arrays & pointers

Main9.c

```
#include <stdio.h>

main() {

        int c = 0, in = 0;
        char buf[2048]; char *p = buf;

        while((c = getchar()) != EOF)
                *p++=c;
        *p++ = '\0';
        printf("buffer is \t %s\n", buf);
}
```

- You can increment a pointer
- But you cannot increment an array name

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Pointer increment

- Earlier we used p++ to step through an array
- In C, a pointer is simply a memory address
  - How much does p++ increment the address?
  - We now use printf to investigate

Stepping through an integer array

```
#include <stdio.h>

main() {

        int i, ndigit[10], *p, *end;
        for (i = 0; i < 10; ++i)
                ndigit[i] = i;
        end = &ndigit[10];
        p =  ndigit;
        while (p != end) {
                printf("ndigit is at \t %lX\n", (unsigned long) p);
                printf("ndigit is at \t %p\n",  p);
                p++;
        }
}
/* %p display is “implementation-dependent” */
```

Stepping through an array of char

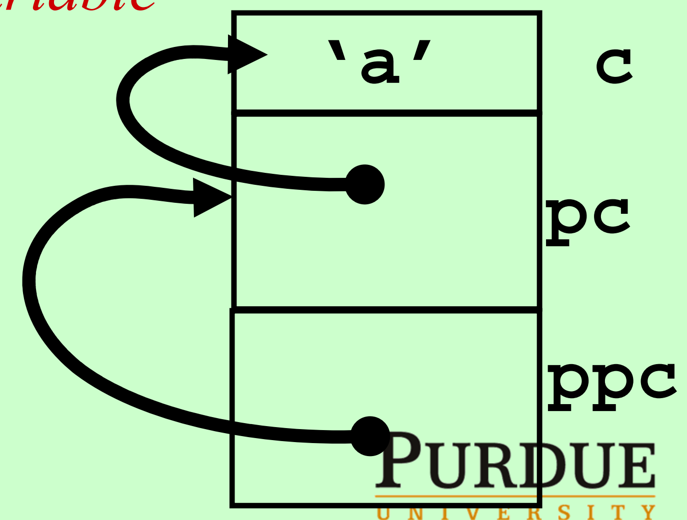
```
#include <stdio.h>

main() {
        int i;
        char ndigit[10], *p, *end;
        for (i = 0; i < 10; ++i)
                ndigit[i] = i;
        end = &ndigit[10];
        p =  ndigit;
        while (p != end) {
                printf("ndigit is at \t %lX\n", (unsigned long) p);
                p++;
        }
}
```

Pointer to Pointer

- **`char c;`** *declares a variable of type character*
- **`char* pc;`** *declares a variable of type pointer to character*
- **`char** ppc;`** *declares a variable of type pointer to pointer to character*
- **`c = 'a';`** *initialize a character variable*
- **`pc = &c;`** *get the address of a variable*
- **`ppc = &pc;`** *get the address of a variable*

- **`c == *pc == **ppc`**



Pointer to pointer

```
#include <stdio.h>
main() {

        int i, ndigit[10], **q, *p, *end;
        for (i = 0; i < 10; ++i)
                ndigit[i] = i;
        end = &ndigit[10];
        p =  ndigit;
        q = &p;
        while (*q != end) {
                printf("ndigit is at \t %lX\n", (unsigned long) * p);
                (*q)++;
        }
}
```

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Aliases

- In the previous example, **q* and *p* are stored at the identical address
- Modifying **q* will therefore also modify the value of *p*
- Two memory references that access the same memory location are called *aliases*
  - We can also say the two memory reference expressions are aliases
  - The simplest case is when two variable names are aliases
    - For example function parameter p and q may be pointers to the same location
- More examples of aliases
  - int ndigit[10], *p;   *p and ndigit[0] are aliases, *(p++) and ndigit[1] are aliases

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- Aliases make it difficult to keep track of variable values
- Aliases make it difficult for the compiler to generate efficient machine code
- In the old days, it is more efficient to use pointers to step through an array than using array indices
  - This is not necessarily the case anymore
  - It is better to use array indexing if possible
    - Compilers are better at analyzing array indexing if there are no potential aliases

Quiz #1 (will be graded)

- Warm up your clickers...

Quiz #1 - 1

- Consider the scope of variable i. What will this program print?

```
int main(){ int i = 42;
  if (1) {
  int i = 0; }
  printf ("%d", i);
}
```

- (a) 42
- (b) 0
- (c) architecture dependent

Quiz #1 - 2

- If there are no syntax errors, the command *gcc –c *.c* will produce

- (a) One executable program, a.out
- (b) One or more *.o files
- (c) Beautified *.c files

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Quiz #1 - 3

- In the C macro #include “abc.h”, abc.h is

- (a) A C standard library function
- (b) An ordinary header file
- (c) A string to be inserted in the program source code

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