Enumerations

Review

- two dimensional array
  - char *p[2] = {“MB”, “Mercedes Bentz”};

```
int main(int argc, char *argv[])
{
    int   i;

    printf("argc = %d\n", argc);
    for (i = 0; i < argc; ++i)
       printf("argv[%d] = %s\n", i, argv[i]);
    return 0;
}
```

Review – function pointer

```
double sum_square(double f(double), int m, int n)
{
    int       k;
    double    sum = 0.0;

    for (k = m; k <= n; ++k)
        sum += f(k) * f(k);
    return sum;
}
```

Bit Operations

- most CPU processes data in word unit
  - 32 bits are processed in parallel

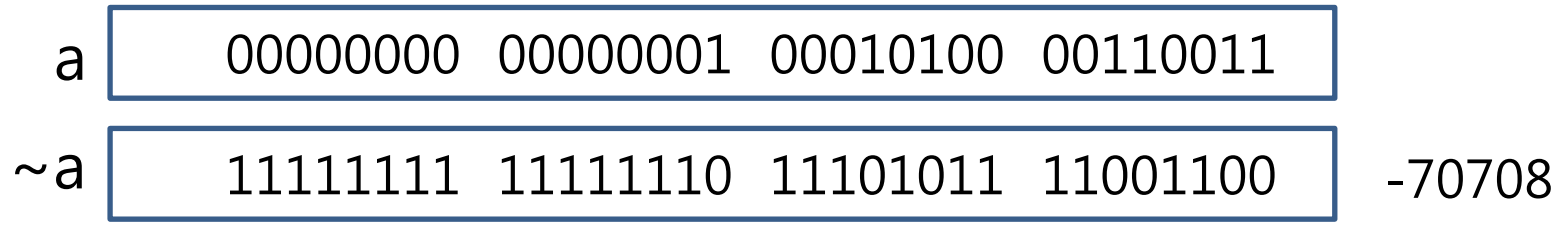
- if you need just one bit of information, the remaining space for 31bits is wasted

C Bitwise Operators

logical operators	(unary) bitwise complement	~
	bitwise and	&
	bitwise exclusive or	^
	bitwise (inclusive) or	|
shift operators	left shift	<<
	right shift	>>

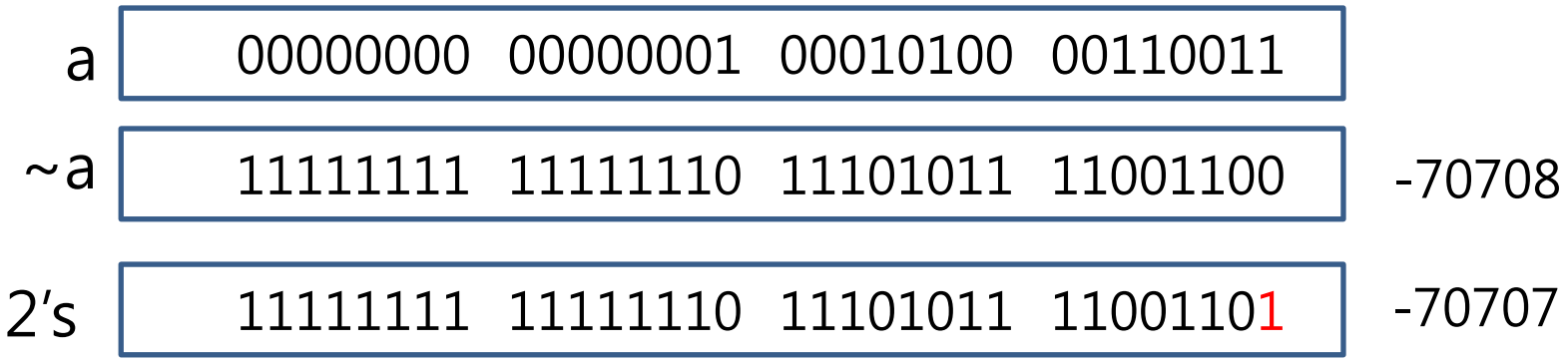
Bitwise Complement

```
int a = 70707;
```



2's Complement

```
int a = 70707;
```



Bitwise Logical Operators

Declarations and initializations		
int a = 33333, b = -77777;		
Expression	**Representation**	**Value**
a	00000000 00000000 10000010 00110101	333333
b	11111111 11111110 11010000 00101111	-77777
a & b	00000000 00000000 10000000 00100101	32805
a ^ b	11111111 11111110 01010010 00011010	-110054
a | b	11111111 11111110 11010010 00111111	-77249
~(a | b)	00000000 00000001 00101101 11000000	77248
(~a & ~b)	00000000 00000001 00101101 11000000	77248

Shift Operators

Declarations and initializations		
char c = 'Z';		
Expression	Representation	Action
c	00000000 00000000 00000000 01011010	unshifted
c << 1	00000000 00000000 00000000 10110100	left-shifted 1
c << 4	00000000 00000000 00000101 10100000	left-shifted 4
c << 31	00000000 00000000 00000000 00000000	left-shifted 31

Declarations and initializations		
int a = 1 << 31; /* shift 1 to the high bit */ unsigned b = 1 << 31;		
Expression	Representation	Action
a	10000000 00000000 00000000 00000000	unshifted
a >> 3	11110000 00000000 00000000 00000000	right-shifted 3
b	10000000 00000000 00000000 00000000	unshifted
b >> 3	00010000 00000000 00000000 00000000	right-shifted 3

Masks

```
void bit_print(int a)
{
  int  i;
  int  n = sizeof(int) * CHAR_BIT;      /* in limits.h */
  int  mask = 1 << (n - 1);             /* mask = 100...0 */

  for (i = 1; i <= n; ++i) {
    putchar(((a & mask) == 0) ? '0' : '1');
    a <<= 1;
    if (i % CHAR_BIT == 0 && i < n)
      putchar(' ');
  }
}
```

bit_print(33333);

00000000 00000000 10000010 00110101

Packing

```
/* Pack 4 characters into an int. */

#include <limits.h>

int pack(char a, char b, char c, char d)
{
   int   p = a;                  /* p will be packed with a, b, c, d */

   p = (p << CHAR_BIT) | b;
   p = (p << CHAR_BIT) | c;
   p = (p << CHAR_BIT) | d;
   return p;
}
```

Unpacking

```
/* Unpack a byte from an int. */

#include <limits.h>

char unpack(int p, int k)              /* k = 0, 1, 2, or 3 */
{
  int      n = k * CHAR_BIT;          /* n = 0, 8, 16, or 24 */
  unsigned mask = 255;                /* low-order byte */

  mask <<= n;
  return ((p & mask) >> n);
}
```

```
k = 1, n = 8
p        = 01100001 01100010 01100011 01100100
mask     = 00000000 00000000 11111111 00000000
p & mask = 00000000 00000000 01100011 00000000
return     00000000 00000000 00000000 01100011
```

Enumeration Types

enum day {sun, mon., tue, wed, thu, fri, sat);
enum day d1, d2, holidays;

- enumerators are of int type
- the first one is zero, ..

enum suit {club = 3, diamonds, hearts = 0; spades} a, b;

```
enum day find_next_day(enum day d)
   {
    enum day next_day;
    switch (d) {
    case su:
      next_day = mo;
      break;
    case mo:
      next_day = tu;
      break;
    ...
    case sa:
      next_day = su;
      break;
    }
    return next_day;
   }
```

Enumerators are constants of type `int`. Thus, they can be used in case labels in a switch statement.

Example of using enumerators with switch

```
enum day {su, mo, tu, we, th, fr, sa};
```

Enumeration Types

- type casting applies

```
enum day {su, mo, tu, we, th, fr, sa};

enum day find_next_day(enum day d)
{
 assert((int) d >= 0 && (int) d < 7)
 return ((enum day)(((int) d + 1) % 7));
}
```

Preprocessor

- works before compilation

  #include

  – includes “file name” or

  – search <file name> in other directories

- macros

  #define SEC_PER_DAY (60 * 60 * 24)

  #define SQ(x) ((x) * (x))

  #define max(x, y) (((x) > (y)) ? (x) : (y))

Conditional Compilation

```
#if win
   #define WIN32
   #include <windows.h>
   #include <winsock.h>
#else
   #define closesocket close
   #include <sys/types.h>
   #include <sys/socket.h>
   #include <netinet/in.h>
   #include <arpa/inet.h>
   #include <netdb.h>
#endif

#include <stdio.h>
#include <string.h>
.....
```

set the value of win using #define

Other directives

- defined operator

```
# if (defined(HP) || defined(SUN)) && !defined(SUN3)
        ......
#endif
```

- debugging code

```
# if DEBUG
        ......
#endif
```

```
#if HEAP_SIZE < 24000
        # error “not enough space for malloc”
#endif
```

Stringization

```
#define message(a, b) printf (#a  “and “  #b);
```

message(Hail, SKKU) is replaced by

```
    printf(“Hail”  “and”  “SKKU”)
```

```
#define X(i)   X ## i
```

X(2) is replaced by X2