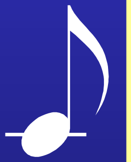
Conversions

- 6.5.16 Assignment operators
  - para 3 – The type of an assignment expression is the type of the left operand...
- 6.5.16.1 Simple assignment
  - para 2 – The value of the right operand is converted to the type of the assignment expression

```
unsigned short x = 0;
x = UINT_MAX;
```



Assignment is the only binary operator that can cause the type of one of its operands to be implicitly converted to a "narrower" type.
So x = y; → x == y;   is not true

- 6.3.1.1 Booleans, characters, and integers
  - para 2 – If an int can represent all the values of the original type, the value is converted to an int; otherwise, it is converted to an unsigned int. These are called the ***integer promotions***.

```
char c1, c2;
```

```
c1 + c2
```

```
(int)c1 + (int)c2
```

Why does the compiler prefer ints?

- **6.5.2.2 Function calls**
  - **para 6 – if the expression that denotes the called function does not include a prototype, the *integer promotions* are performed on each argument, and arguments that have type float are promoted to double. These are called the *default argument promotions*.**

```
#include <stdio.h>

int main(void)
{
    return call(4, 2);
}

int call(double a, double b)
{
    return printf("%f, %f\n", a, b);
}
```

$\longrightarrow$ ✗

6.5.2.2 Function calls

- para 7 – if the expression that denotes the called function has a type that does include a prototype, the arguments are implicitly converted, as if by assignment, to the types of the corresponding parameters...

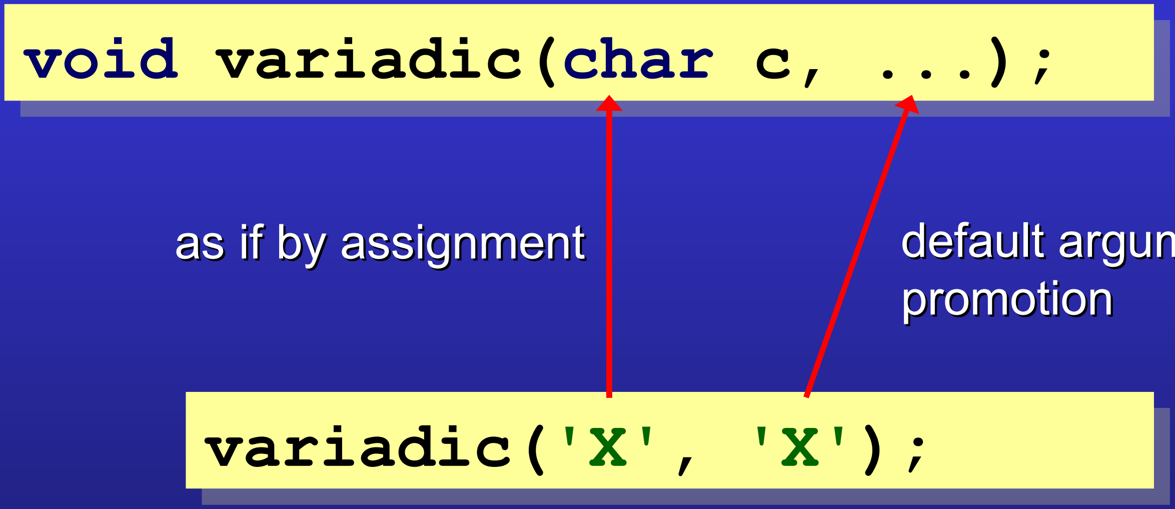
```c
#include <stdio.h>

int call(double, double);

int main(void)
{
    return call(4, 2);
}

int call(double a, double b)
{
    return printf("%f, %f\n", a, b);
}
```

✓

argument promotion

6.5.2.2 Function calls

- para 7 – The ellipsis notation in a function prototype declarator causes argument type conversions to stop after the last declared parameter. The *default argument promotions* are performed on the trailing arguments.

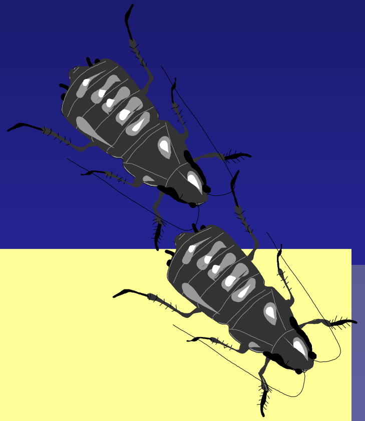


```
void variadic(char c, ...);
```

```
variadic('X', 'X');
```

spot the bugs

```
#include <stdio.h>

int main(void)
{
    printf("%p", NULL);

    printf("%p", 0);

    printf("%p", (void*)0);

}
```



exercise

answer

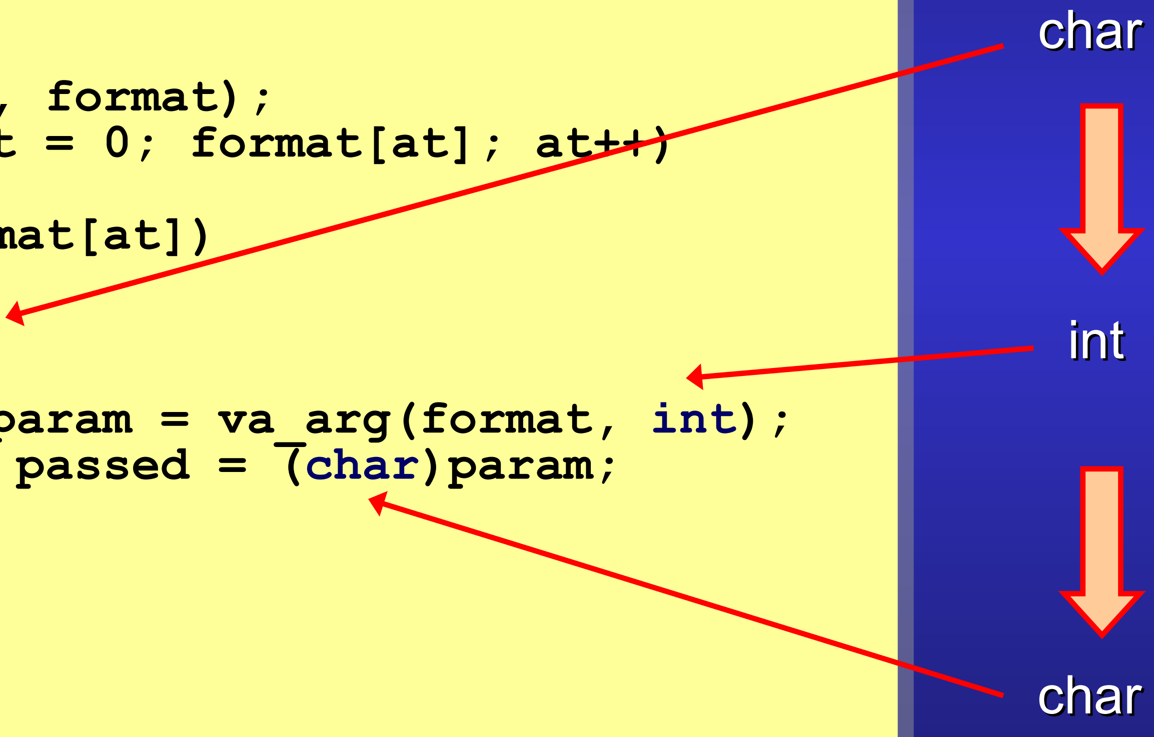
- only (void*)0 is guaranteed to be a pointer
    - 0 is an int
    - NULL could be 0 too

```
#include <stdio.h>

int main(void)
{
    printf("%p", NULL);        ←  ✗

    printf("%p", 0);           ←  ✗

    printf("%p", (void*)0);    ←  ✓

}
```

<stdarg.h> provide type-unsafe access

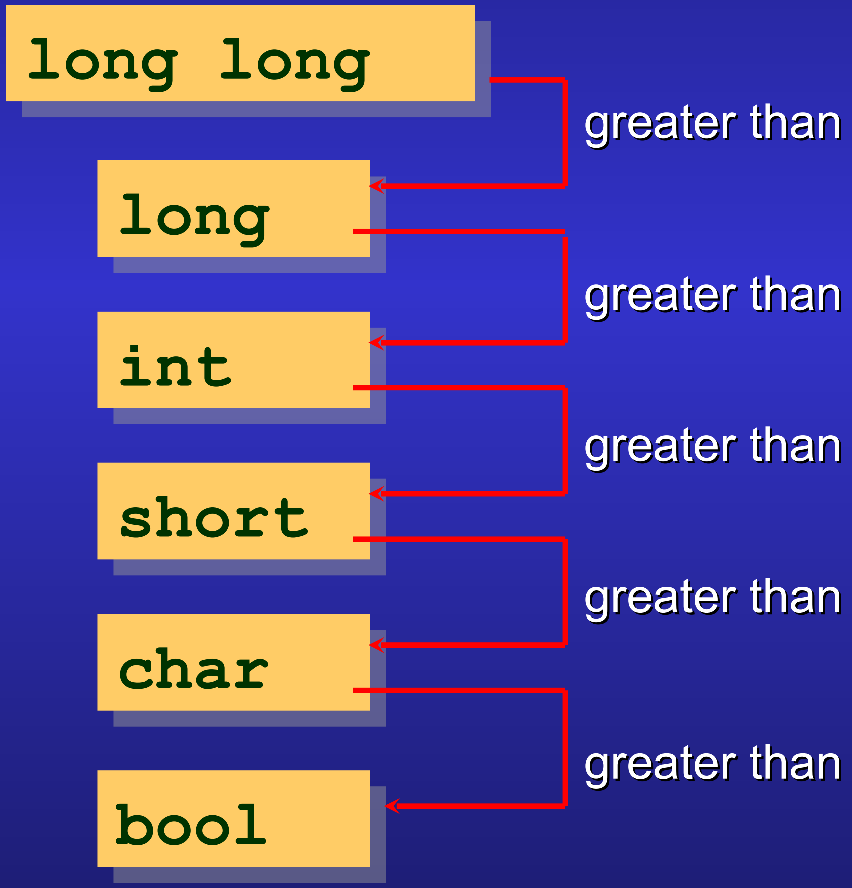
- restrictions on all the va_ macros

```
#include <stdarg.h>

int printf(const char * format, ...)
{
  va_list args;
  va_start(args, format);
  for (size_t at = 0; format[at]; at++)
  {
    switch (format[at])
    {
      case 'c':
      {
          int param = va_arg(format, int);
          char passed = (char)param;
          ...
      }
      ...
    }
  }
  va_end(args);
}
```



6.3.1.1 Booleans, characters, and integers

…
Every integer type has an *integer conversion rank*…
…



rank

6.3.1.8 Usual arithmetic conversions

part 1: the obvious conversion rule (safe)

…
[both operands have integer type]
…

• the *integer promotions* are performed on both operands

```
int + char
int + int
```
✓

• If both operands have the same type, then no further conversion is needed.

```
long + long
```
✓

• Otherwise, if both operands have signed integer types or both have unsigned integer types, the operand with the type of lesser integer conversion rank is converted to the type of the operand with greater rank.

```
long + int
long + long
```
✓

…

6.3.1.8 Usual arithmetic conversions

part 2: the signed → unsigned rule (lossy)

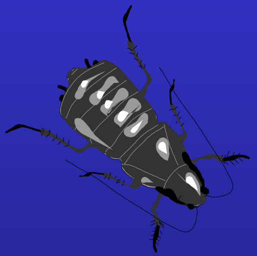
…
[one signed and one unsigned operand]
…

• Otherwise, if the operand that has unsigned integer type has rank greater or equal to the rank of the type of the other [signed] operand, then the operand with the signed integer type is converted to the type of the operand with the unsigned integer type.

```
unsigned long + int
```

$\downarrow$

```
unsigned long + unsigned long
```



a negative signed integer value can be converted into a large positive unsigned integer value!!

6.3.1.8 Usual arithmetic conversions

- part 3: the unsigned → signed rule (safe)

…
[one signed and one unsigned operand]
[rank(signed operand) > rank(unsigned operand)]
…

•Otherwise, if the type of the operand with signed integer type can represent all of the values of the type of the operand with unsigned integer type, then the operand with unsigned integer type is converted to the type of the operand with signed integer type.

```
long + unsigned int
```

? ✓

```
long + long
```

this depends on their value representations, as specified in <limits.h>

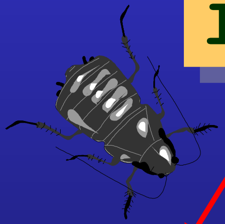
6.3.1.8 Usual arithmetic conversions

part 4 – the last resort rule (lossy)

…

•Otherwise, both operands are converted to the unsigned integer type corresponding to the type of the operand with signed integer type.

$$\begin{tikzcd}
 & \texttt{long + long} \\
 & \texttt{long + unsigned int} \arrow[u, "? \text{ (part 3) NO}"'] \arrow[d, "\checkmark"'] \arrow[dl] \\
\texttt{unsigned long + unsigned long} &
\end{tikzcd}$$



- is this program's behaviour
  - undefined?
  - unspecified?
  - implementation-defined?
  - conforming?
  - strictly conforming?

```
#include <stdio.h>

int main(void)
{
    unsigned long a = 0;
    signed int b = -42;
    unsigned long long c = a + b;
    printf("%llu\n", c);
}
```

- is this program's behaviour
  - undefined? NO
  - unspecified? NO
  - implementation-defined? YES
  - conforming? YES
  - strictly conforming? NO

```
#include <stdio.h>

int main(void)
{
    unsigned long a = 0;
    signed int b = -42;
    unsigned long long c = a + b;
    printf("%llu\n", c);
}
```

```
18446744073709551574
```

answer

signed ↔ unsigned

- 6.3.1.3 Signed and unsigned integers
  - para 1 – When a value with integer type is converted to another integer type, other than _Bool, if the value can be represented by the new type, it is unchanged.
  - para 2 – Otherwise, if the new type is unsigned, the value is converted by repeatedly adding or subtracting one more than the maximum value that can be represented in the new type until the value is in the range of the new type.
  - para 3 – Otherwise, the new type is signed and the value cannot be represented in it; either the result is implementation-defined or an implementation-defined signal is raised.

- these operators perform *no* conversions

unary	`!`
boolean	`&& ||`

$\Big\} \rightarrow$ int 0/1

unary	`++ --`
assignment	`= *= /= %= += -= ...`
comma	`,`

- these operators perform *integer promotion*

unary	`~ + -`
shift	`<< >>`

conversions

- these operators perform the ***usual arithmetic conversions***

arithmetic	`* / % + -`
relational	`< > <= >= == !=`
bitwise	`& ^ |`
ternary	`?:`

- what does this program print?
  - assume sizeof(short) == 2
  - assume sizeof(int) == 4

```
void exercise(void)
{
    short s = 42;

    printf("%zd\n", sizeof(s));

    printf("%zd\n", sizeof(s && s);

    printf("%zd\n", sizeof(+s));

    printf("%zd\n", sizeof(s = s));
}
```

answer

```
void exercise(void)
{
    short s = 42;

    printf("%zd\n", sizeof(s));

    printf("%zd\n", sizeof(s && s));

    printf("%zd\n", sizeof(+s));

    printf("%zd\n", sizeof(s = s));
}
```

$\longrightarrow$ **2 4 4 2**