CS10003:
Programming & Data Structures

Dept. of Computer Science & Engineering
Indian Institute of Technology Kharagpur

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Pointer Basics

What is a pointer?

First of all, it is a variable, just like other variables you studied

- So it has type, storage etc.

Difference: it can only store the address (rather than the value) of a data item

Type of a pointer variable – pointer to the type of the data whose address it will store

- Example: int pointer, float pointer,…
- Can be pointer to any user-defined types also like structure types

What is a pointer?

They have a number of useful applications

- Enables us to access a variable that is defined outside the function
- Can be used to pass information back and forth between a function and its reference point
- More efficient in handling data tables
- Reduces the length and complexity of a program
- Sometimes also increases the execution speed

Basic Concept

As seen before, in memory, every stored data item occupies one or more contiguous memory cells

The number of memory cells required to store a data item depends on its type (char, int, double, etc.).

Whenever we declare a variable, the system allocates memory location(s) to hold the value of the variable.

Since every byte in memory has a unique address, this location will also have its own (unique) address.

Basic Concept

Consider the statement

```
int  xyz = 50;
```

This statement instructs the compiler to allocate a location for the integer variable xyz, and put the value 50 in that location

Suppose that the address location chosen is 1380

xyz	**➔**	**variable**
50	**➔**	**value**
1380	**➔**	**address**

Basic Concept

During execution of the program, the system always associates the name xyz with the address 1380

The value 50 can be accessed by using either the name xyz or the address 1380

Since memory addresses are simply numbers, they can be assigned to some variables which can be stored in memory

Such variables that hold memory addresses are called pointers

Since a pointer is a variable, its value is also stored in some memory location

Basic Concept

Suppose we assign the address of xyz to a variable p

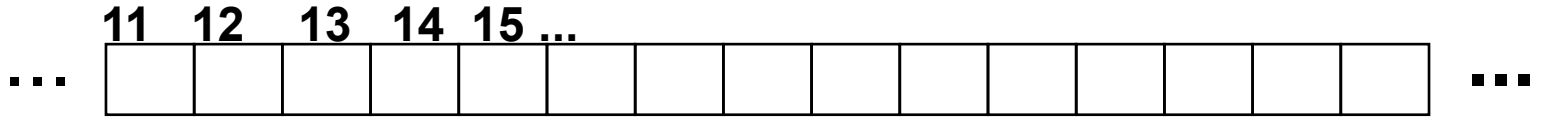
p is said to point to the variable xyz

Variable	Value	Address
xyz	50	1380
p	1380	2545

p = &xyz;

Address vs. Value

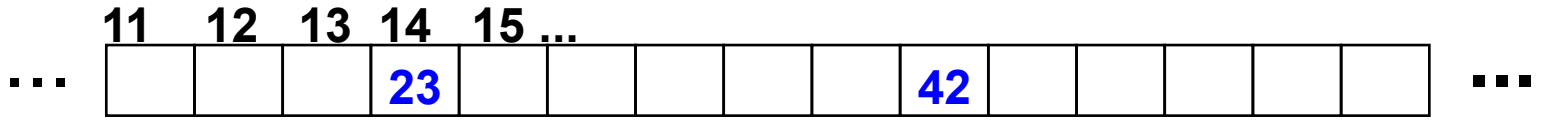
Each memory cell has an address associated with it



Address vs. Value

Each memory cell has an address associated with it

Each cell also stores some value

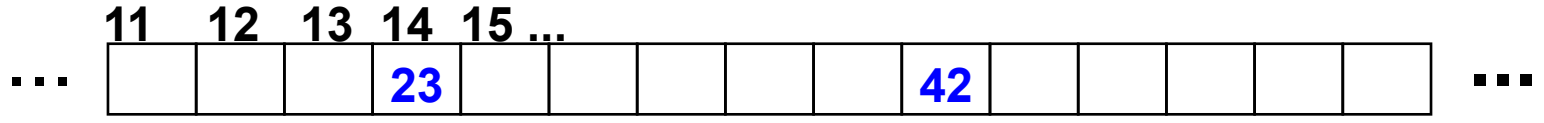


Address vs. Value

Each memory cell has an address associated with it

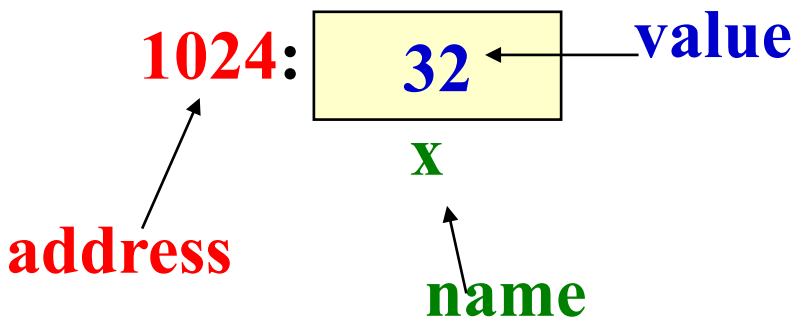
Each cell also stores some value

Don’t confuse the address referring to a memory location with the value stored in that location



Values vs Locations

Variables name memory locations, which hold values



Pointers

A pointer is just a C variable whose value can contain the address of another variable

Needs to be declared before use just like any other variable

General form:

```
data_type *pointer_name;
```

Three things are specified in the above declaration:

- The asterisk (*) tells that the variable pointer_name is a pointer variable
- pointer_name needs a memory location
- pointer_name points to a variable of type data_type

Example

```
int *count;
float   *speed;
char *c;
```

Once a pointer variable has been declared, it can be made to point to a variable using an assignment statement like

```
int *p, xyz;
    :
p = &xyz;
```

This is called pointer initialization

Accessing the Address of a Variable

The address of a variable is given by the & operator

The operator & immediately preceding a variable returns the address of the variable

Example:

```
p = &xyz;
```

The address of xyz (1380) is assigned to p

The & operator can be used only with a simple variable (of any type, including user-defined types) or an array element

```
&distance
&x[0]
&x[i-2]
```

Illegal Use of &

```
 &235
        Pointing at constant

int   arr[20];
        :
      &arr;
        Pointing at array name

&(a+b)
        Pointing at expression
```

In all these cases, there is no storage,
so no address either

Example

Output

```
10 is stored in location 3221224908
2.500000 is stored in location 3221224904
12.360000 is stored in location 3221224900
12345.660000 is stored in location 3221224892
A is stored in location 3221224891
```

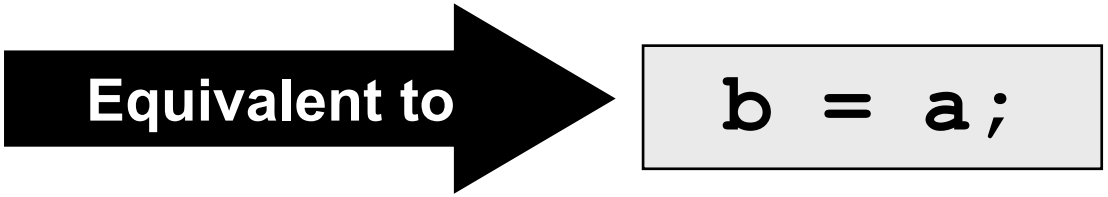
```
#include  <stdio.h>
int main()
{
    int   a;
    float  b, c;
    double  d;
    char  ch;

    a = 10;   b = 2.5;  c = 12.36;  d = 12345.66;  ch = 'A';
    printf  ("%d is stored in location %u \n",  a,  &a) ;
    printf  ("%f is stored in location %u \n",  b,  &b) ;
    printf  ("%f is stored in location %u \n",  c,  &c) ;
    printf  ("%lf is stored in location %u \n", d,  &d) ;
    printf  ("%c is stored in location %u \n",  ch, &ch) ;
    return 0;
}
```

Accessing a variable through its Pointer

Once a pointer has been assigned the address of a variable, the value of the variable can be accessed using the indirection operator (*).

```
int   a, b;
int   *p;
p = &a;
b = *p;
```



Example

```
#include  <stdio.h>
int main()
{
     int    a, b;
     int    c = 5;
     int    *p;

     a  =  4  *  (c  +  5) ;

     p  =  &c;
     b  =  4  *  (*p  +  5) ;
     printf  ("a=%d  b=%d \n",  a, b);
     return 0;
}
```

Equivalent

```
a=40 b=40
```

Example

```
int main()
{
    int  x, y;
    int  *ptr;

    x = 10 ;
    ptr = &x ;
    y = *ptr ;
    printf ("%d is stored in location %u \n",x,&x);
    printf ("%d is stored in location %u \n",*&x,&x);
    printf ("%d is stored in location %u \n",*ptr,ptr);
    printf ("%d is stored in location %u \n",y,&*ptr);
    printf ("%u is stored in location %u \n",ptr,&ptr);
    printf ("%d is stored in location %u \n",y,&y);

    *ptr = 25;
    printf ("\nNow x = %d \n", x);
    return 0;
}
```

Then output is

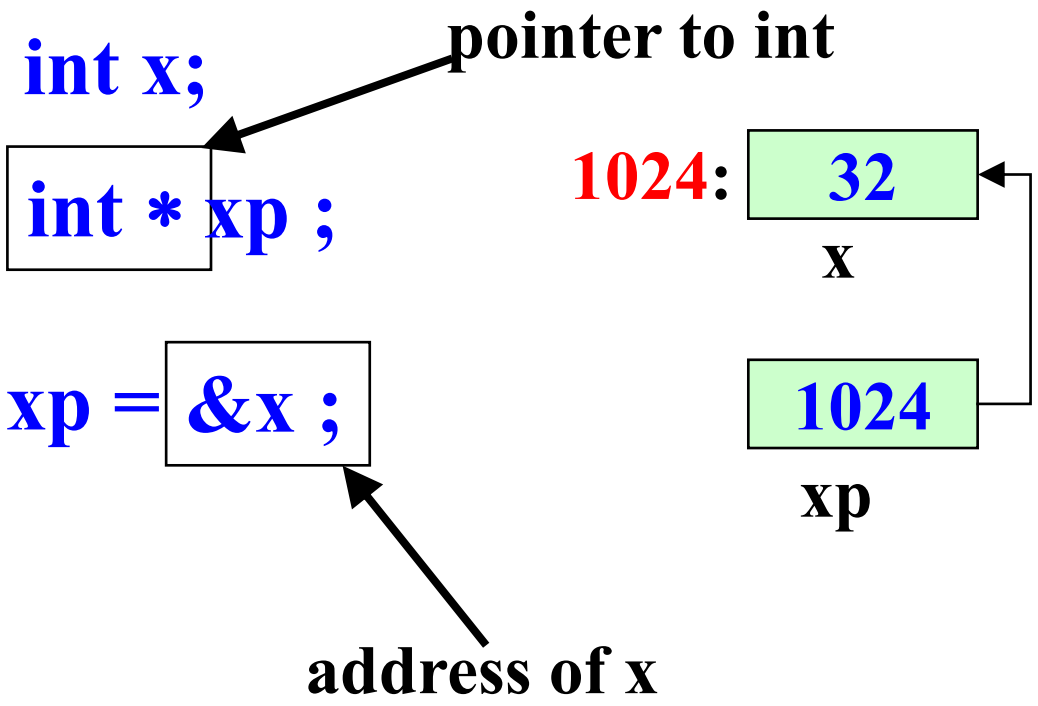
```
10 is stored in location 3221224908
10 is stored in location 3221224908
10 is stored in location 3221224908
10 is stored in location 3221224908
3221224908 is stored in location 3221224900
10 is stored in location 3221224904

Now x = 25
```

Suppose that

```
Address of x:     3221224908
Address of y:     3221224904
Address of ptr:   3221224900
```

Example




```
*xp = 0;          /* Assign 0 to x */
*xp = *xp + 1;    /* Add 1 to x */
```

Value of the pointer

Declaring a pointer just allocates space to hold the pointer – it does not allocate something to be pointed to!

Local variables in C are not initialized, they may contain anything

After declaring a pointer:

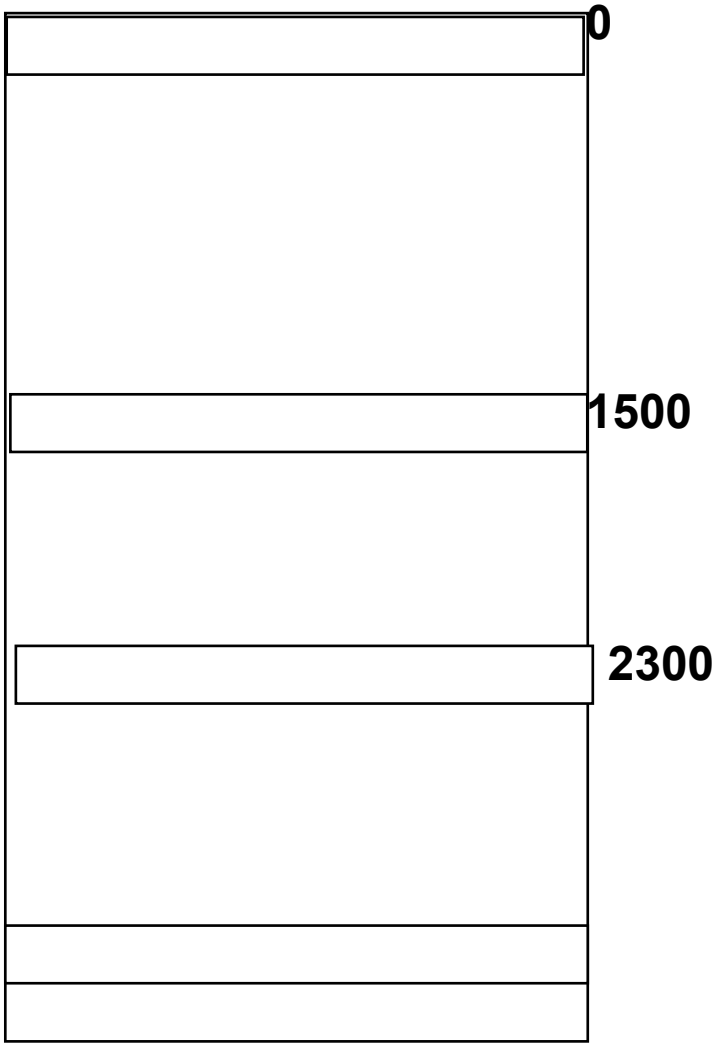
```
int *ptr;
```

ptr doesn't actually point to anything yet. We can either:

make it point to something that already exists, or

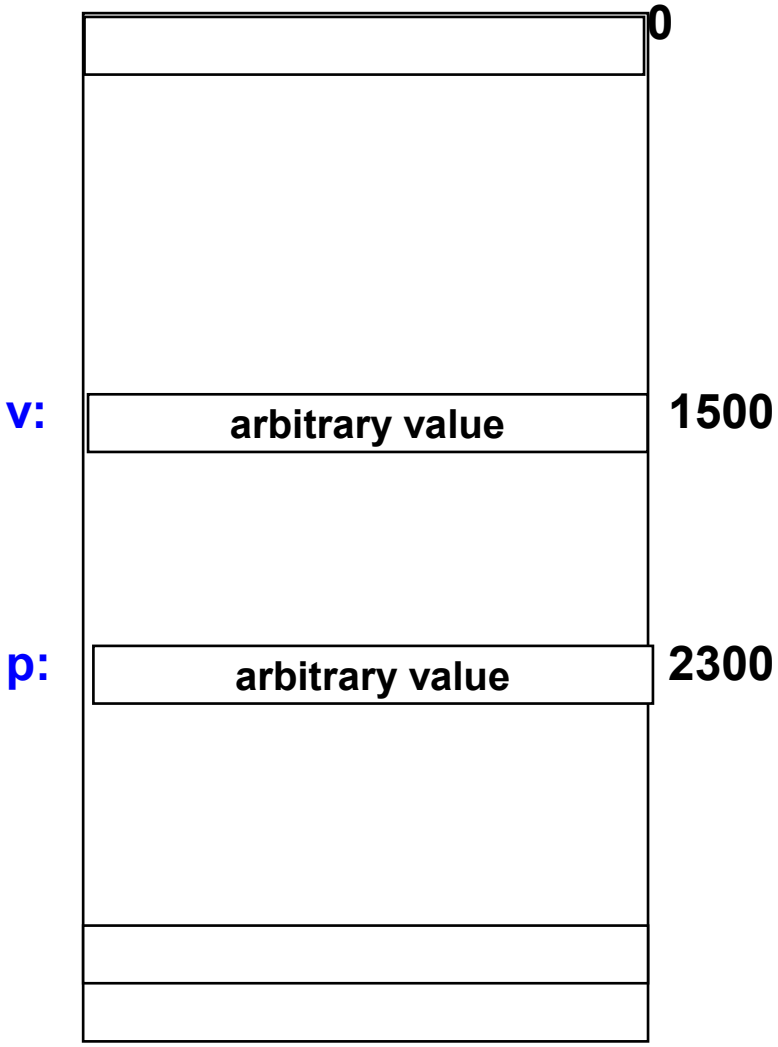
allocate room in memory for something new that it will point to… (dynamic allocation, to be done later)

Example



Memory and Pointers:

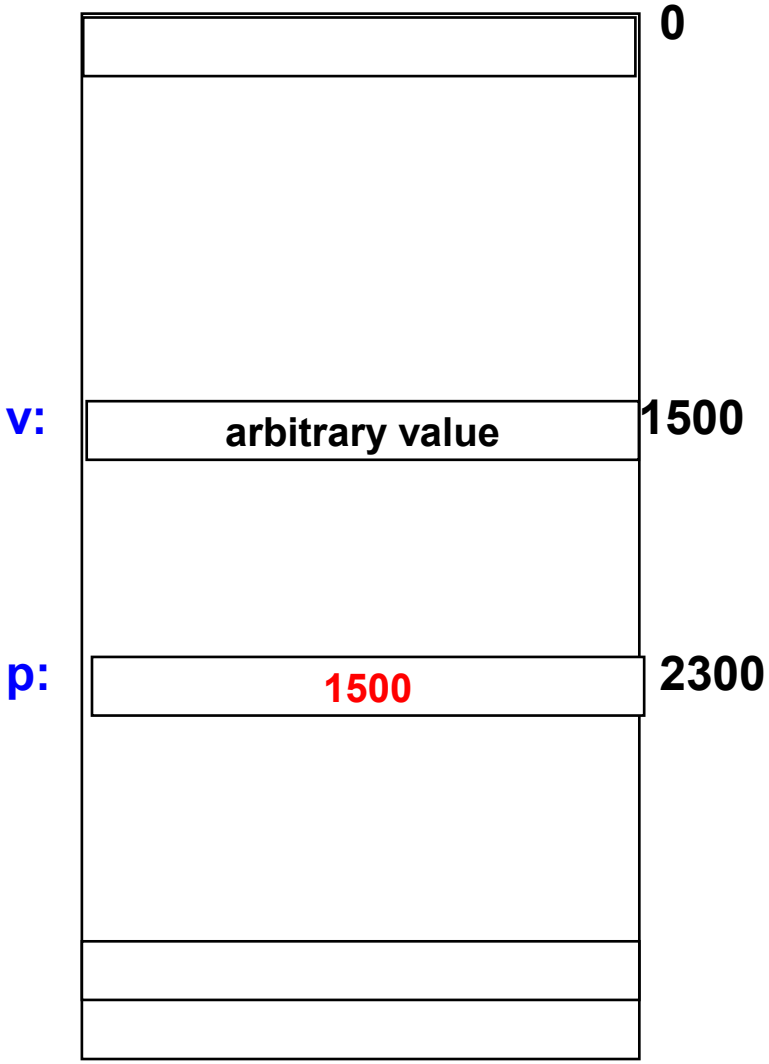
Example



Memory and Pointers:

int *p, v;

Example

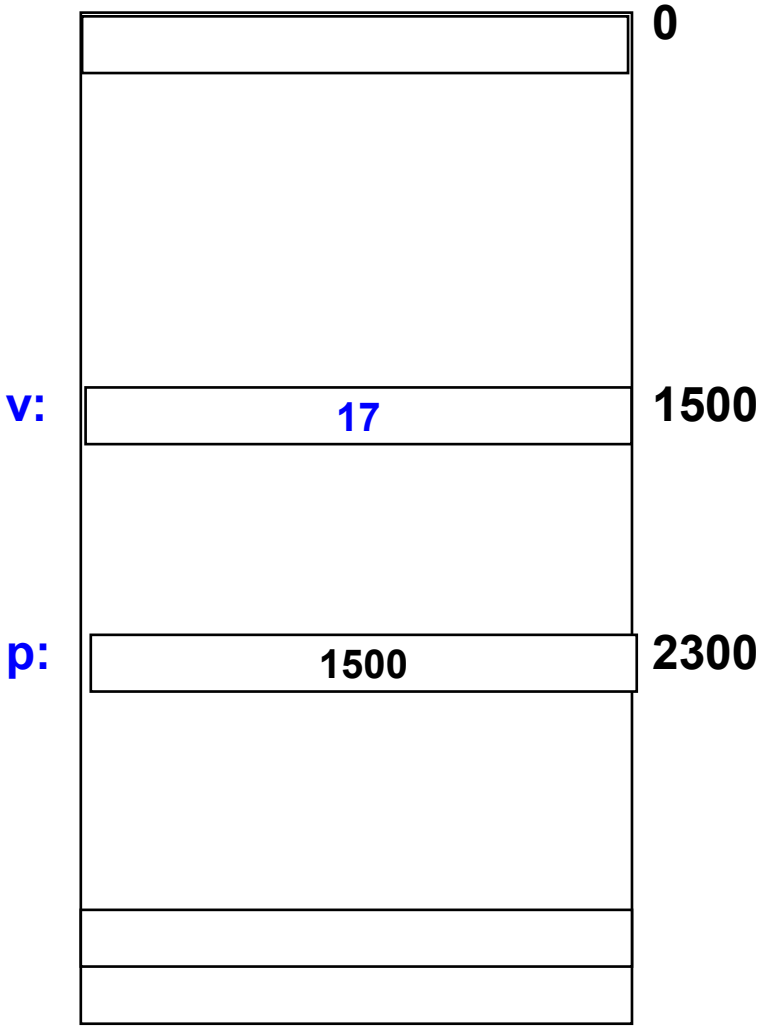


Memory and Pointers:

int v, *p;

p = &v;

Example



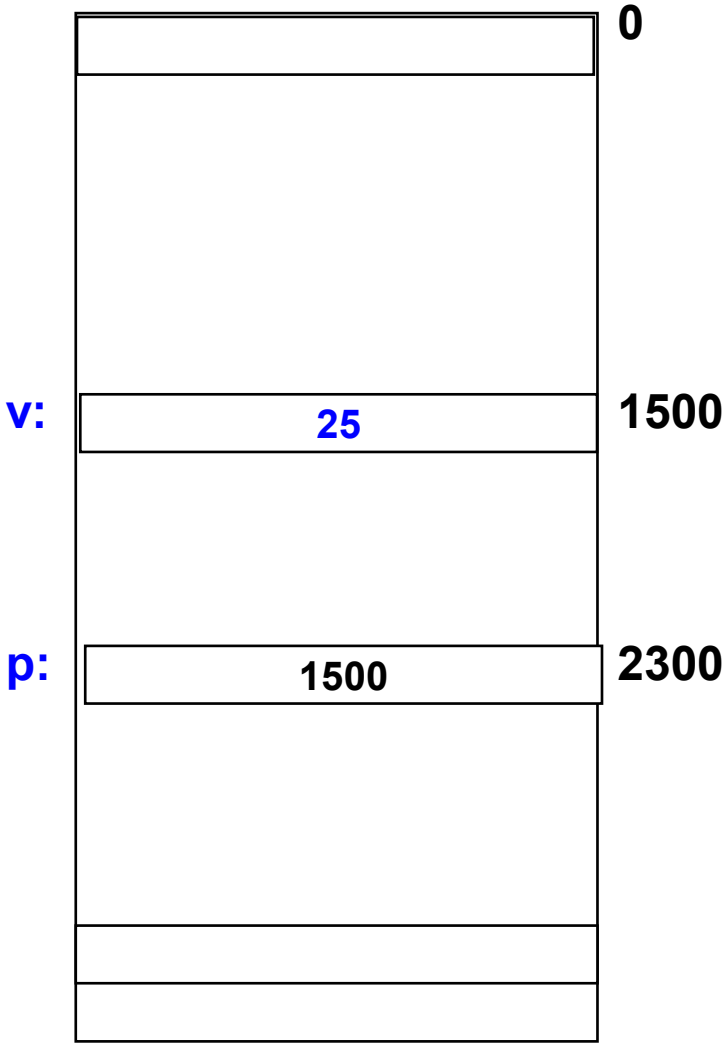
Memory and Pointers:

int v, *p;

p = &v;

v = 17;

Example



Memory and Pointers:

```
int v, *p;
p = &v;
v = 17;
*p = *p + 4;
v = *p + 4;
```

More examples of using Pointers in Expressions

If p1 and p2 are two pointers, the following statements are valid:

```
sum = *p1 + *p2;
prod = *p1 * *p2;
prod = (*p1) * (*p2);
*p1 = *p1 + 2;
x = *p1 / *p2 + 5;
```

`*p1` can appear on the left hand side

Note that this unary * has higher precedence than all arithmetic/relational/logical operators

Things to Remember

Pointer variables must always point to a data item of the same type

```
float   x;
int    *p;
    :
p = &x;
```

will result in wrong output

Never assign an absolute address to a pointer variable

```
int   *count;
count = 1268;
```

Thank You!