Class

Review: Array

Students in a class:

Mary	John	Eric	Katy	Tim

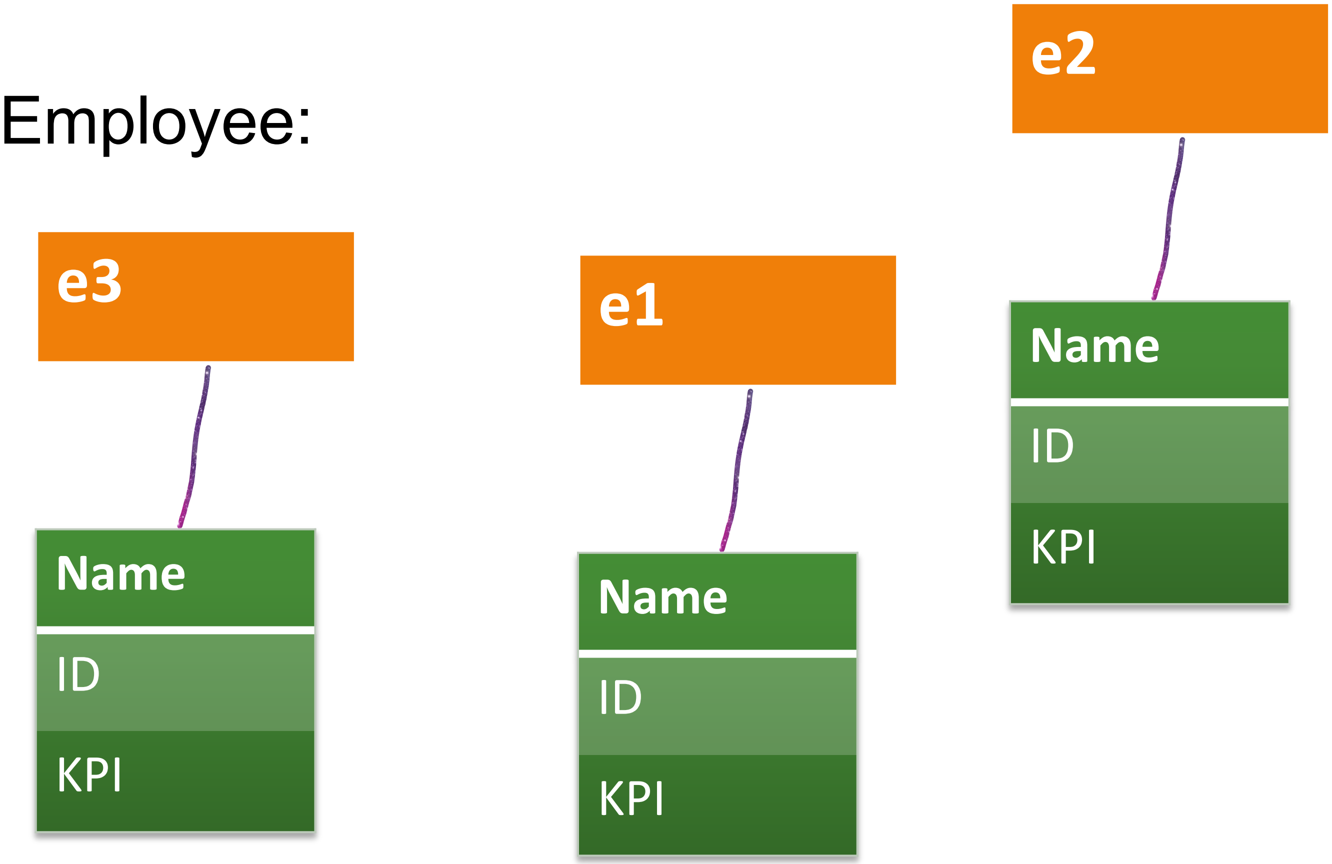
Review: Parallel Array

Students in a class:

	0	1	2	3	4
names	Mary	John	Eric	Katy	Tim
IDs	1111	1121	1234	3214	1232
KPI	9	8	7	6	5

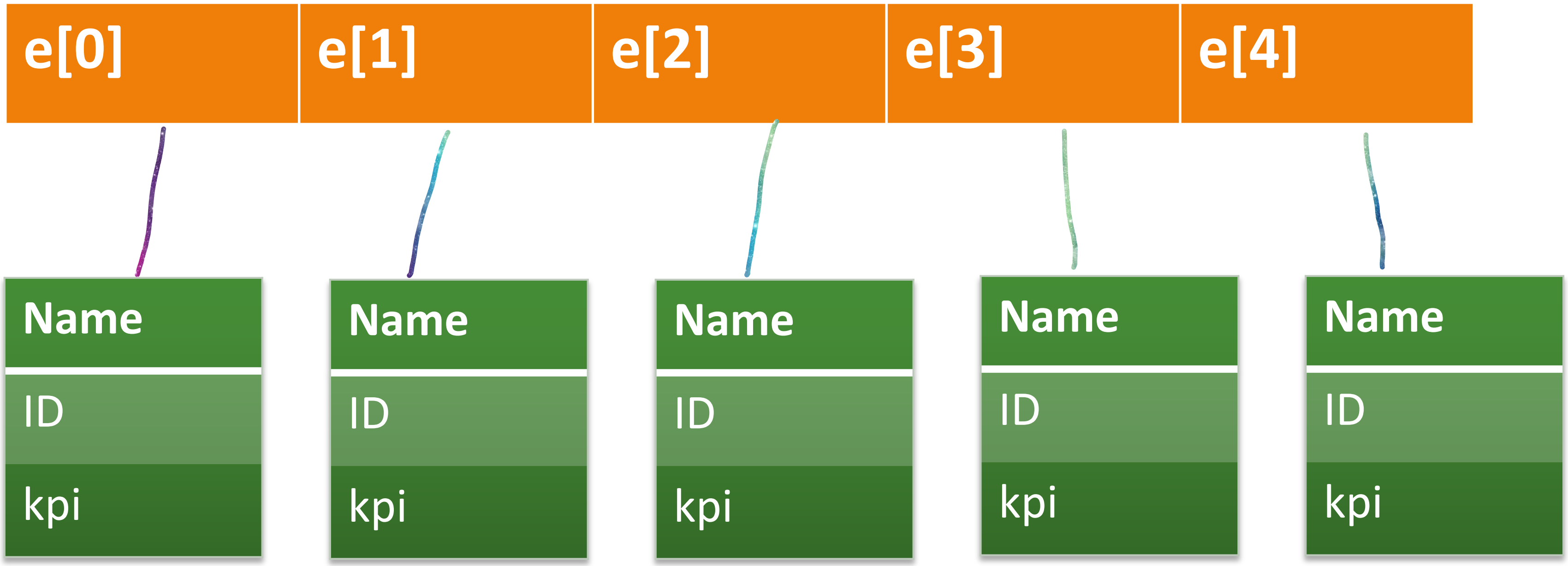
Class

Employee:



Class

Employee in a class:



e[0] e[1] e[2] e[3] e[4]

Name
ID
kpi

Name
ID
kpi

Name
ID
kpi

Name
ID
kpi

Name
ID
kpi

Structured data

- Parallel arrays aren’t a natural fit for *heterogeneous* rows of data
  - One set of names, one set of ID, one set of GPAs
- What we have is structured data
  - Name, ID, GPA for each employee
  - One set of employees
- For a single employee we could do:

```
string name;
double id;
double kpi;
```

  - Allocates memory space for 1 strings and 2 double

Using classes

- C++ provides *classes* to group structured data together

```
class Employee
{
 public:
    string name;
    int id;
    int kpi;
};
```

- This is a *class definition*
  - Give the class a name - Employee
  - Tell the compiler what the parts of the class are
    - Each part has a type and a name (looks just like a variable)
    - The parts of a class are called *members*

Using classes

- C++ provides *classes* to group structured data together

```
class Employee
{
    public:
       string name;
       int id;
       int kpi;
};
```

Using classes

- Defining the class creates a blueprint
  - No memory is allocated yet
  - The class is used as a data type in a variable declaration:
    - Variable declaration is always:

    ```
    type name;
    ```

    - So in this example:

    ```
    int num;
    num = 10;
    Employee e1;
    e1.name = “peter”;
    ```

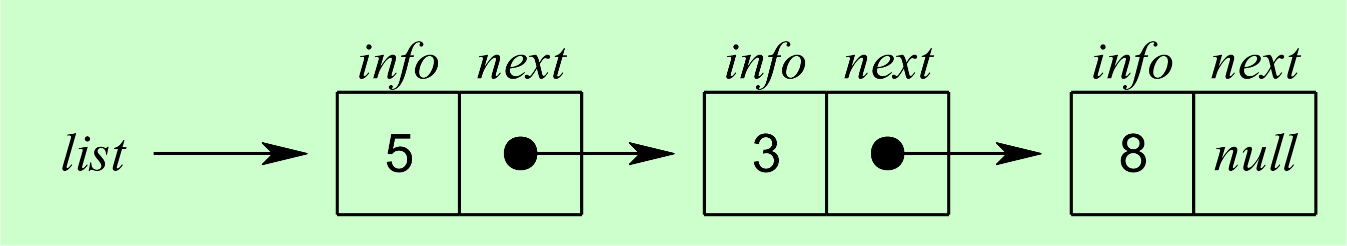
- This variable declaration:
  - Allocates memory space for an *instance* of the class
    - 2 strings, 1 int
  - Names that memory space
  - A class instance is also called an ***object***

Using class objects

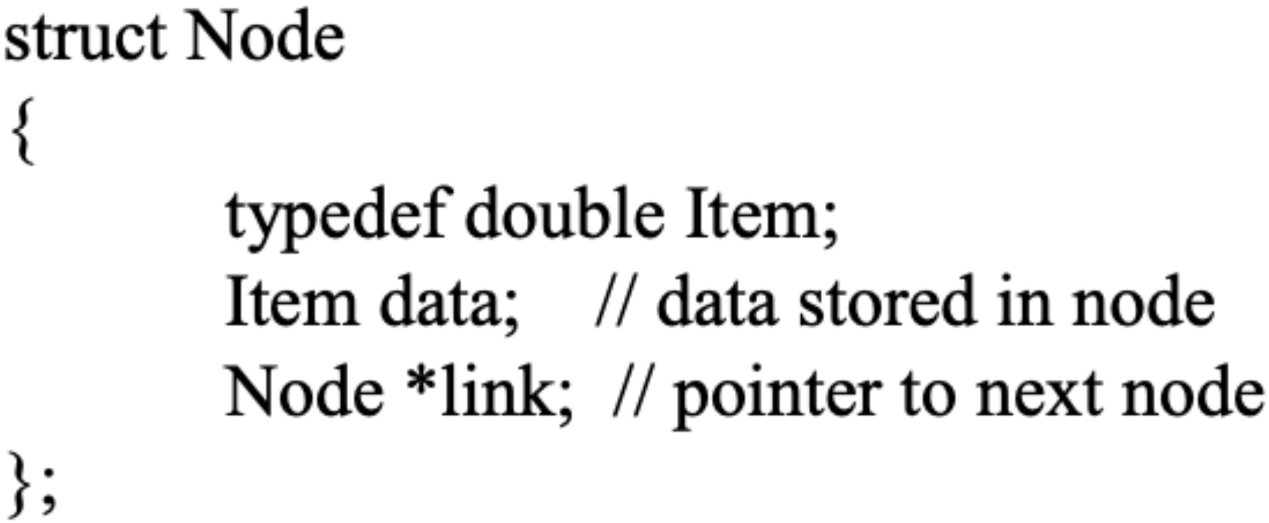
- With arrays, you always have to indicate which element in the array you want to use
  - Using the array subscript operator []
  - E.g. `this_array[15]`
- With class objects, you have to indicate which part of the class you want to use
  - The *member access operator* (.) indicates part of an object
  - The parts are used like any other variable:

```
e1.name = “peter”;
cin >> emp.id;
e1.kpi= e1.kpi + 1;
```

Linked List

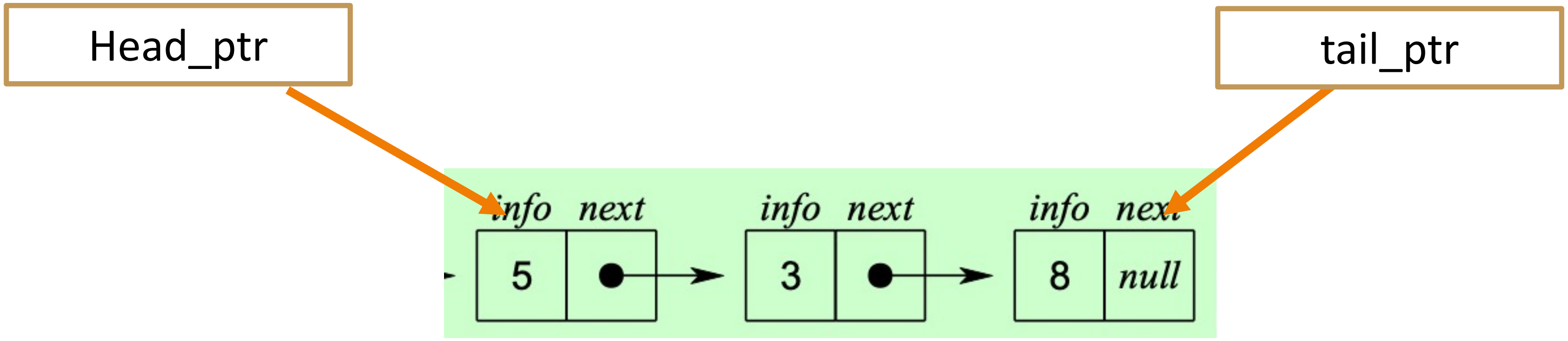


Declare a Call for Node



```
struct Node
{
        typedef double Item;
        Item data;    // data stored in node
        Node *link;  // pointer to next node
};
```

Linked List



```
Struct Node
{
    typedef double Item;
    Item data;
    Node *link;
};

Node *head_ptr;
Node *tail_ptr;
```

Variables, Memory and Pointers

- A variable is a named piece of memory
  - The name stands in for the *memory address*

```
int num;//allocate memory to it first
num = 10;
```

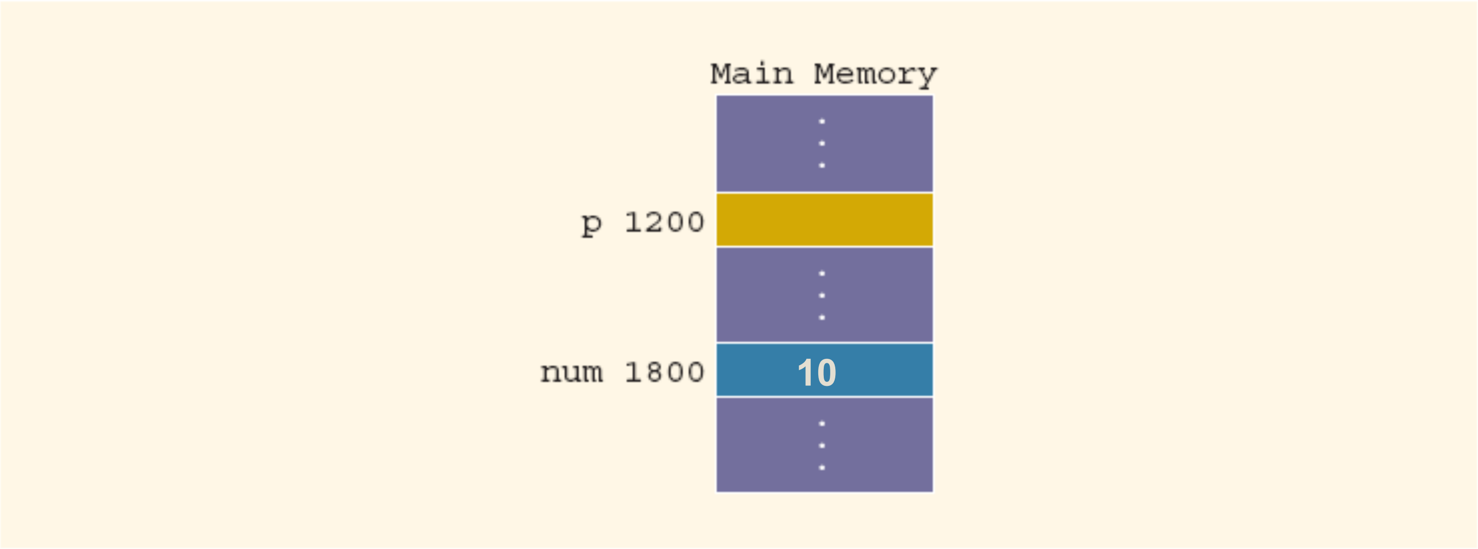


FIGURE 13-1 Main memory, p, and num

Variables, Memory and Pointers

- When a value is assigned to a variable, it is stored at that address in memory

```
num = 78;
```

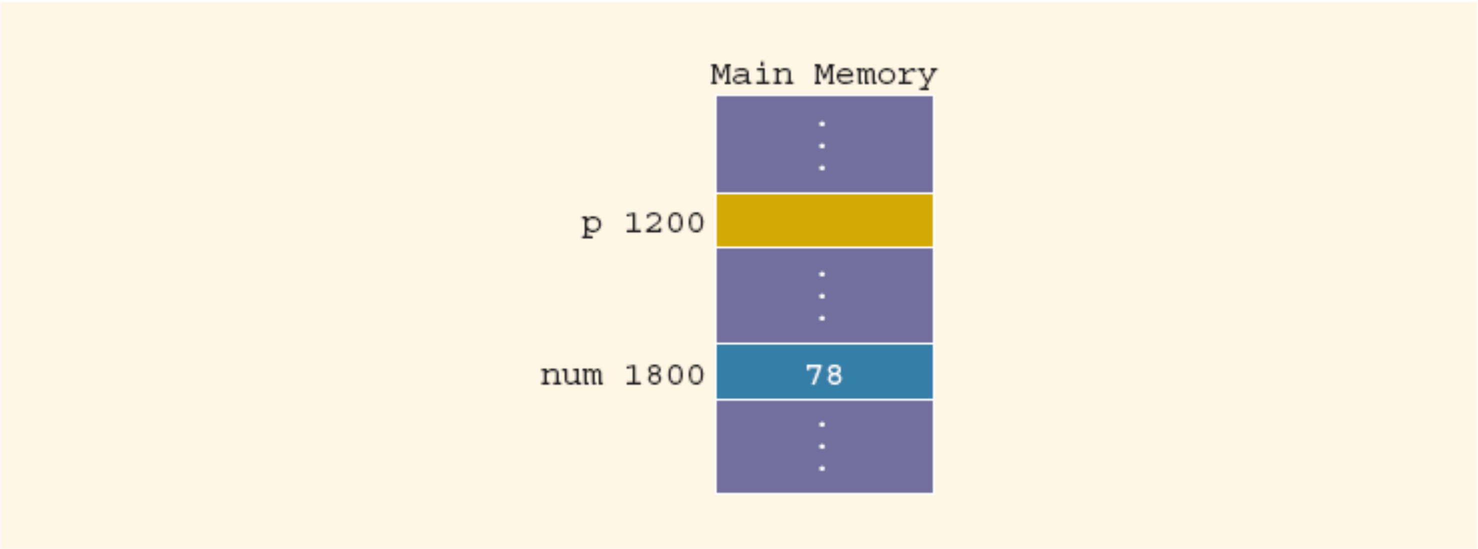


FIGURE 13-2 num after the statement num = 78; executes

Variables, Memory and Pointers

- A *pointer* is a variable that holds the address of another variable
  - It is declared in terms of the type of variable it points at:

```
int *p; // given a * in front of a variable, it means
  that this variable is a pointer.
```

- int num; num = 78;

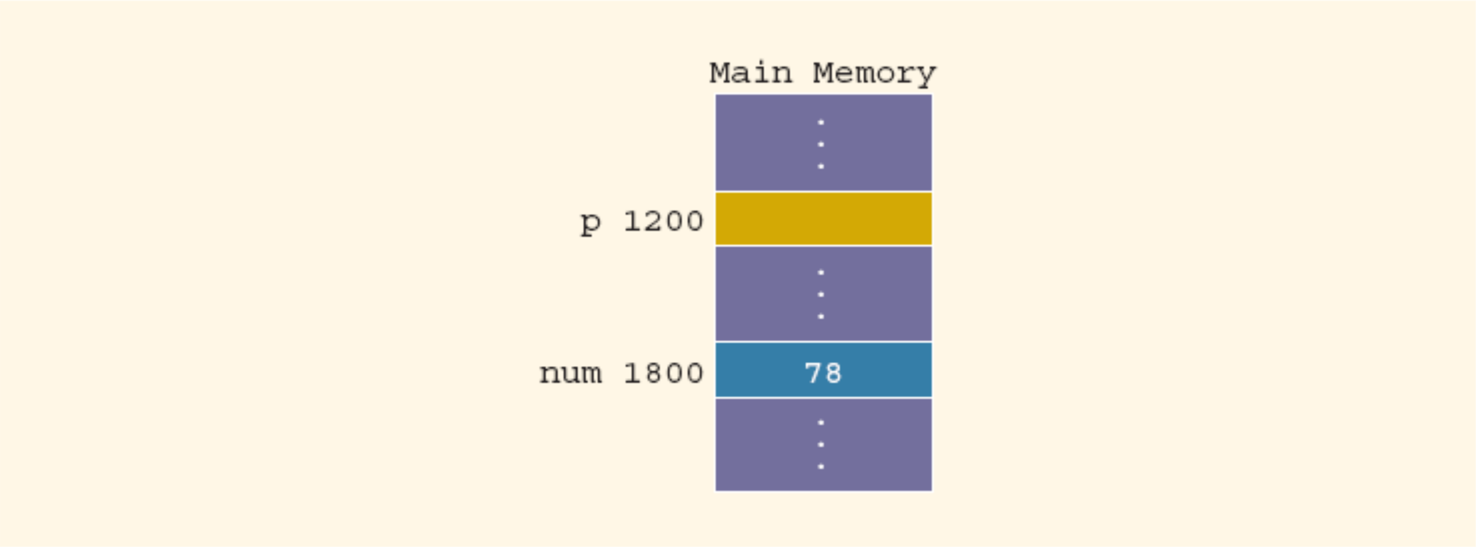


FIGURE 13-2 num after the statement num = 78; executes

Variables, Memory and Pointers

- The operator & returns the address of a variable
  - It can then be assigned to a pointer

```
p = &num;
// &num => the address of the variable num ⇔ 1800
// assign the address of num to the value of p.
```

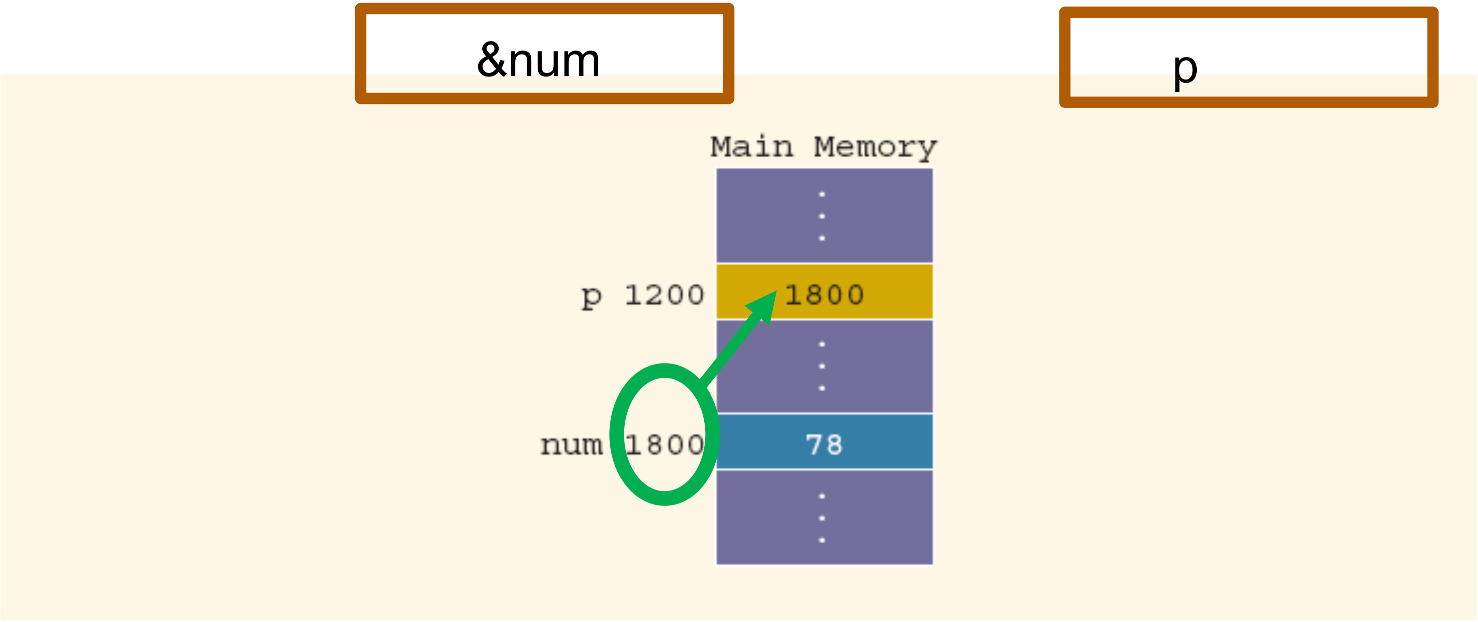


FIGURE 13-3 p after the statement p = &num; executes

Variables, Memory and Pointers

- The operator * takes an address (a pointer) and returns the location in memory being pointed to
  - Can only be applied to a pointer

```
*p = 24;
int *q; // define a pointer;
*q = 30; // assign 30 to the variable that the pointer
  pointed to.
```

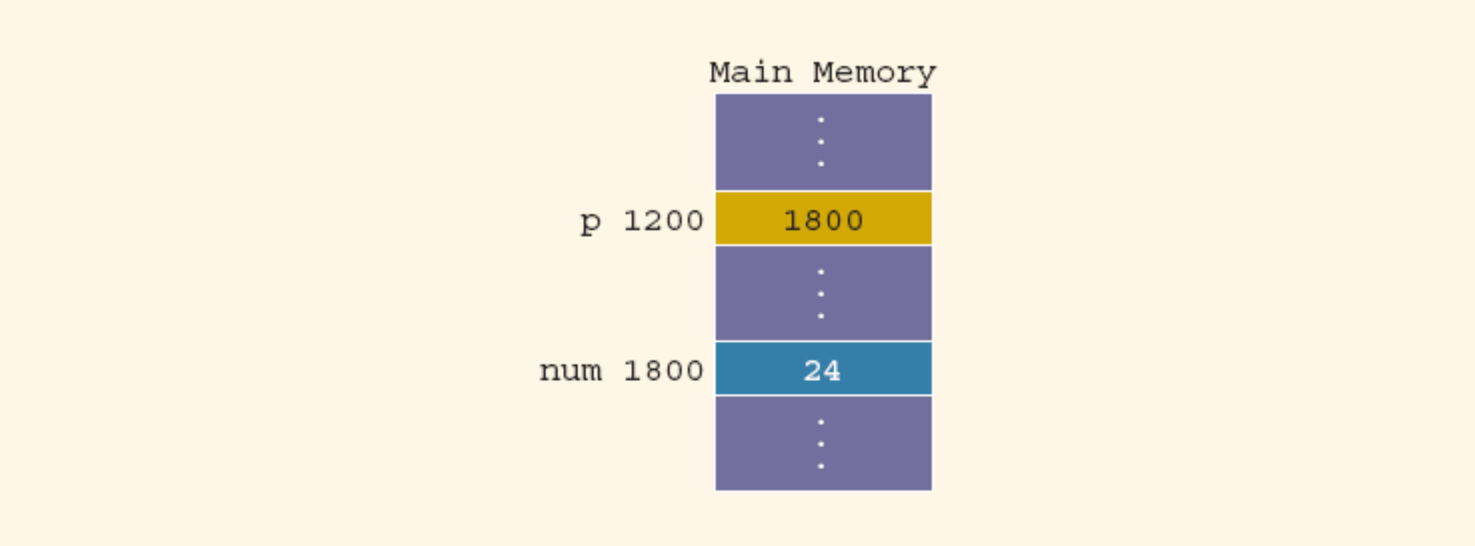
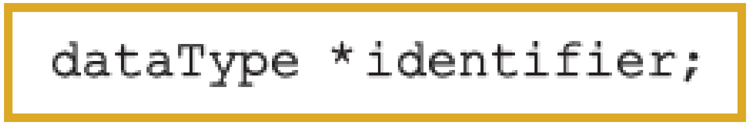


FIGURE 13-4 *p and num after the statement *p = 24; executes

Declaring Pointer Variables

- Syntax:



```
dataType *identifier;
```

- Examples:

```
int *p;
char *ch;
```

- These statements are equivalent:

```
int  *p;
int*  p;
int * p;
```

Declaring Pointer Variables (continued)

- In the statement:

  ```
  int* p, q; // p is a pointer; q is variable
  int num1, num2; ⇔ int num1; int num2;
  ```

  only `p` is the pointer variable, not `q`; here `q` is an `int` variable

- To avoid confusion, attach the character `*` to the variable name:

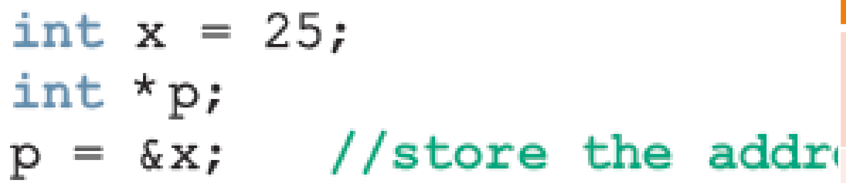
  ```
  int    *p, q;
  int    *p, *q;
  int array1[100], array2[20];
  ```

Address of Operator (&)

- The ampersand, &, is called the ***address of operator***
- The address of operator is a unary operator that returns the ***address of its operand***

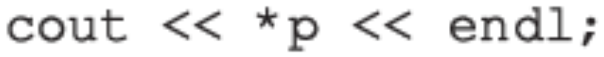
Dereferencing Operator (*)

- When used as a unary operator, * is the dereferencing operator or indirection operator
  - Refers to object to which its operand points
- Example:



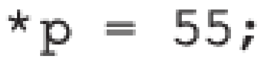
```
int x = 25;
int *p;
p = &x;    //store the addr
```

  - To print the value of x, using p:



```
cout << *p << endl;
```

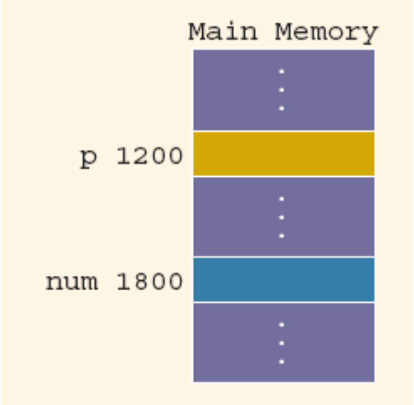
  - To store a value in x, using p:



```
*p = 55;
```

Variable name	address	value
x	153	55
p (pointer)	1008	***153***

Exercise



- Assuming the memory layout provided, after this code executes:

```
int num; // declare an integer variable
int *p; // declare a pointer named: p
num = 50; // assign 50 to variable num
p = &num;
//1. assign a pointer p to the variable num;
//2. assign the address of num (1800) to the value of
   the pointer p
*p = 38;
//assign 38 to *p (the value of the pointer pointed to)
// the value of num = 38
```

- What are the values of these expressions?

```
&num = 1800; // &num: the address of the variable num
num = ? // value of num = 38
&p = ? // &: address of something; &p: the address of the pointer p 1200
p = ? // the value of p ⇔ the address that the pointer pointed to, 1800.
*p = ? // *p: the value of the pointer pointed to, 38.
```

Assigning Pointers

- Pointers can be assigned to pointers of the same type

```
int x, *p, *q; //declare one variable x, and 2 pointers p, q
x = 50; // the value of x = 50
p = &x;
//1. a pointer p points to the variable x
//2. assign the address of x to the value of the pointer p
q = p; // q is a pointer; assign the value of p to the value
  of q ⇔ both pointers p and q are assigned to variable x.
```

- The value of *q is?

*q: the value that the pointer q pointed to

So *q is 50

Variable name	address	value
x	153	50
p (pointer)	1008	***153***
q (pointer)	17	***153***

Assigning Pointers

- Pointers can be assigned to pointers of the same type

```
int x, *p, *q;
x = 50;
p = &x;
q = p;
```

- The value of *q is 50

The Null Pointer

- In addition to variable addresses and other pointers, a pointer can be assigned to the *null pointer*
  - Either the number `0` or the constant `NULL`
  - Used to indicate an invalid pointer (pointing to nothing)
  - Dereferencing a null pointer causes ***a hard error***

```
int *p = 0;
p = NULL;
*p //dereferencing
```

Comparing Pointers

- Be careful of the difference between comparing two pointers and comparing their values:

```
int x = 50, y = 50, *p, *q;
p = &x;
q = &y;
```

- `*q == *p` evaluates to?
- `q == p` evaluates to?

Comparing Pointers

- Be careful of the difference between comparing two pointers and comparing their values:

```
int x = 50, y = 50, *p, *q;
p = &x;
q = &y;
```

- `*q == *p` evaluates to `true`
- `q == p` evaluates to `false`

Pointers and Class

```
class A
{
public:
	char a, b, c;
	int r[7];
};
```

Class	A		
	Public variables:		
		char	a = ‘7’
		char	b = ‘a’
		char	c = ‘a’
		int	r[7]

value						5
index	0	1	..	…	..	6

Pointers and Class

```
A x; // declare an object named x with the type of the class A.

x.a = '7';
x.b = 'b';
x.c = 'a’;

A *p; // declare a pointer named p with the type A.
p = &x;

(*p).a = '8';
(*p).b = 'b';
p->b = 'a’; // 1. p is a pointer;
            // 2. p points to an object;
            // 3. one element of this object is b;
            // 4. we are updated the value of the element b for
this object ( the object that the pointer p points to).

p->r[6] = 5;
cout << x.r[6] << endl;
```

```
int num;

num = 78;

p = &num;

y.a = ‘9’;
y.b = ‘b’;
```

Pointers and Classes

- A pointer to a class object is no different than a pointer to any other type of variable
- Given:

```
class album
{
public:
  string title;
  string artist;
  int tracks;
  double price;
};
album stock[100];
album *pick;
```

Pointers and Classes

- A particular album can be selected by assignment:

```
pick = album;
pick = pick + 49;
or
pick = &(album[49]);
```

- The members of that album are accessed by a combination of dereference (`*`) and membership (`.`):

```
(*pick).title = “Listener Supported”;
```

- There is also a syntactic shortcut:

```
pick->title = “Listener Supported”;
```