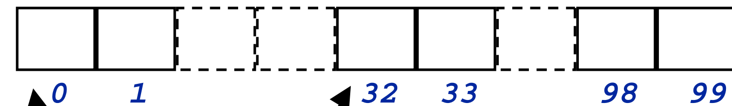
arrays and strings: pointers and memory allocation

- **Why not rely solely on string and Vector classes?**
  - how are string and Vector implemented?
  - lower level access can be more efficient (but be leery of claims that C-style arrays/strings *required* for efficiency)
  - real understanding comes when more levels of abstraction are understood

- **string and vector classes insulate programmers from inadvertent attempts to access memory that's not accessible**
  - what is the value of a pointer?
  - what is a segmentation violation?

Contiguous chunks of memory

```
int * a = new int[100];
```



- In C++ allocate using array form of new

```
int * a = new int[100];
double * b = new double[300];
```

- new [] returns a pointer to a block of memory
  - how big? where?
- size of chunk can be set at runtime, not the case with

```
int a[100];
cin >> howBig;
int a[howBig];
```

- delete [] a; // storage returned

```
a is a pointer
*a is an int
a[0] is an int (same as *a)
a[1] is an int
a+1 is a pointer
a+32 is a pointer
*(a+1) is an int (same as a[1])
*(a+99) is an int
*(a+100) is trouble
a+100 is valid for comparison
```

C-style contiguous chunks of memory

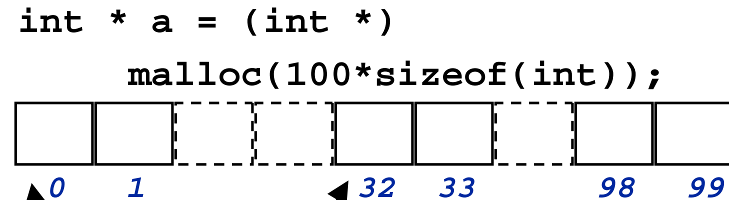
- In C, malloc is used to allocate memory

```
int * a = (int *)
   malloc(100 * sizeof(int));
double * d = (double *)
   malloc(200 * sizeof(double));
```

- malloc must be cast, is NOT type-safe (returns void *)
  - void * is 'generic' type, can be cast to any pointer type

- free(d); // return storage

```
int * a = (int *)
        malloc(100*sizeof(int));
```




```
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a+100 is valid for comparison
```
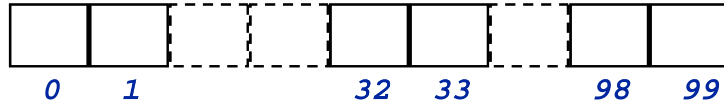
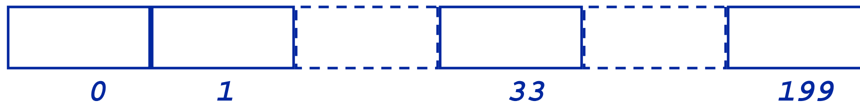

Address calculations, what is sizeof(...)?

```
int * a = new int[100];
```




```
a[33] is the same as *(a+33)
if a is 0x00a0, then a+1 is
0x00a4, a+2 is 0x00a8
(think 160, 164, 168)
```

```
double * d = new double[200];
```




```
*(d+33) is the same as d[33]
if d is 0x00b0, then d+1 is
0x00b8, d+2 is 0x00c0
(think 176, 184, 192)
```

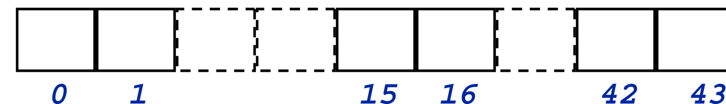
- x is a pointer, what is x+33?
  - a pointer, but where?
  - what does calculation depend on?
- result of adding an int to a pointer depends on size of object pointed to
- result of subtracting two pointers is an int:

```
(d + 3) - d == ________
```

More pointer arithmetic

- address one past the end of an array is ok for *pointer comparison only*

```
char * a = new int[44];
char * begin = a;
char * end = a + 44;
```



- what about *(begin+44)?
- what does begin++ mean?

```
while (begin < end)
{
   *begin = 'z';
   begin++;  // *begin++ = 'z'
}
```

- how are pointers compared using < and using == ?
- what is value of end - begin?

What is a C-style string?

- array of char terminated by sentinel '\0' char
  - sentinel char facilitates string functions
  - '\0' is nul char, unfortunate terminology
  - how big an array is needed for string "hello"?
- a string is a pointer to the first character just as an array is a pointer to the first element
  - `char * s = new char[6];`
  - what is the value of s? of s[0]?
- char * string functions in <string.h>

C style strings/string functions

- strlen is the # of characters in a string
  - same as # elements in char array?

```
int strlen(char * s)
// pre: '\0' terminated
// post: returns # chars
{
    int count=0;
    while (*s++) count++;
    return count;
}
```

- Are these less cryptic?

```
while (s[count]) count++;
// OR, is this right?
char * t = s;
while (*t++);
return t-s;
```

- what's "wrong" with this code?

```
int countQs(char * s)
// pre: '\0' terminated
// post: returns # q's
{
  int count=0;
  for(k=0;k < strlen(s);k++)
    if (s[k]=='q') count++;
  return count;
}
```

- how many chars examined for 10 character string?
- solution?

More string functions (from < string.h>)

- strcpy copies strings
  - who supplies storage?
  - what's wrong with s = t?

```
char s[5];
char t[6];
char * h = "hello";
strcpy(s,h); // trouble!
strcpy(t,h); // ok

char * strcpy(char* t,char* s)
//pre: t, target, has space
//post: copies s to t,returns t
{
   int k=0;
   while (t[k] = s[k]) k++;
   return t;
}
```

- strncpy copies n chars (safer?)

- what about relational operators <, ==, etc.?
- can't overload operators for pointers, no overloaded operators in C
- strcmp (also strncmp)
  - return 0 if equal
  - return neg if lhs < rhs
  - return pos if lhs > rhs

```
if (strcmp(s,t)==0) // equal
if (strcmp(s,t) < 0)// less
if (strcmp(s,t) > 0)// ????
```

Arrays and pointers

- These definitions are related, but not the same

```
int a[100];
int * ap = new int[10];
```

- both a and ap represent ‘arrays’, but ap is an lvalue

- arrays converted to pointers for function calls:

```
char s[] = "hello";
// prototype: int strlen(char * sp);
cout << strlen(s) << endl;
```

- multidimensional arrays and arrays of arrays

```
int a[20][5];
int * b[10]; for(k=0; k < 10; k++) b[k] = new int[30];
```

Microsoft question

- Write atoi, write itoa, which is harder?

- Questions? Issues? Problems?

```
int atoi(const char * sp);
char * itoa(int num);
```

- Difference between `const char * p` and `char * const p`
  - one is a pointer to a constant character
  - one is a constant pointer to a character