Pointers and Memory Allocation

```
#include <iostream>
using namespace std;

int main()
{
  int x, *p, **q;

  x = 10;

  p = &x;

  q = &p;

  cout << **q; // prints the value of x

  return 0;
}
10
```

Dynamic memory allocation for 2D arrays

In the following examples, we have considered ‘**r**‘ as number of rows, ‘**c**‘ as number of columns and we created a 2D array with r = 3, c = 4 and following values

```
  1  2  3  4
  5  6  7  8
  9  10 11 12
```

Using a single pointer:

A simple way is to allocate memory block of size r*c and access elements using simple pointer arithmetic.

```
int main()
{
    int r = 3, c = 4;
    int *arr = new int[r * c];

    int i, j, count = 0;
    for (i = 0; i <  r; i++)
      for (j = 0; j < c; j++)
         *(arr + i*c + j) = ++count;

    for (i = 0; i <  r; i++)
      for (j = 0; j < c; j++)
         printf("%d ", *(arr + i*c + j));

   /* Code for further processing and free the
      dynamically allocated memory */
   return 0;
}
```

Using an array of pointers

We can create an array of pointers of size r. Note that from C99, C language allows variable sized arrays. After creating an array of pointers, we can dynamically allocate memory for every row.

```
int main()
{
    int r = 3, c = 4, i, j, count;

    int *arr[r];
    for (i=0; i<r; i++)
         arr[i] = new int[c];

    // Note that arr[i][j] is same as *(*(arr+i)+j)
    count = 0;
    for (i = 0; i <  r; i++)
      for (j = 0; j < c; j++)
         arr[i][j] = ++count; // Or *(*(arr+i)+j) = ++count

    for (i = 0; i <  r; i++)
      for (j = 0; j < c; j++)
         cout<< arr[i][j];

    /* Code for further processing and free the
      dynamically allocated memory */

   return 0;
}
```

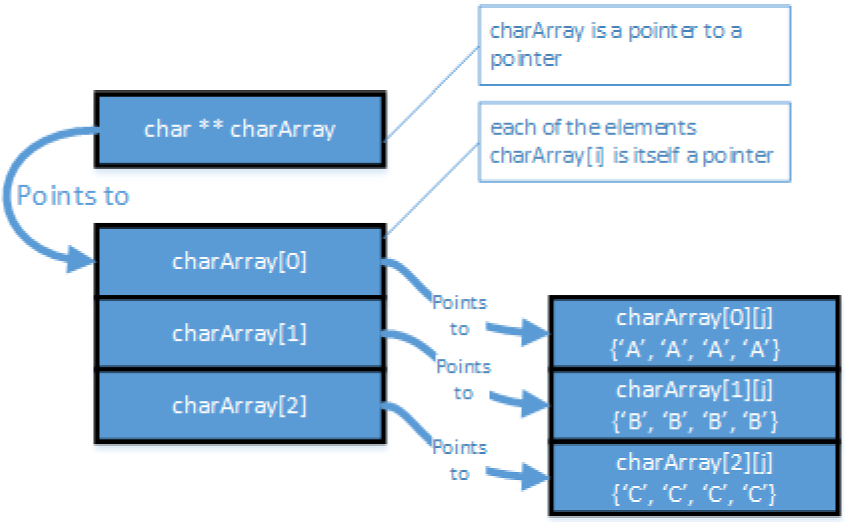
Using pointer to pointer

```
/* 2-D Dynamically allocated array of chars */

#include

using namespace std;

int main() {

int cols = 4;
int rows = 3;

// Allocate a 2-d array of ints 3 x 2
char** charArray = new char*[rows];
for(int i = 0; i < rows; ++i) {
charArray[i] = new char[cols];
}

// Fill the array
for(int i = 0; i < rows; ++i) {
for(int j = 0; j < cols; ++j) {
charArray[i][j] = char(i + 65);
}
}

// Output the array
for(int i = 0; i < rows; ++i) {
for(int j = 0; j < cols; ++j) {
cout << charArray[i][j];
}
cout << endl;
}

// Deallocate memory by deleting
for(int i = 0; i < rows; ++i) {
delete [] charArray[i];
}
delete [] charArray;
```

Output

```
1 AAAA
2 BBBB
3 CCCC
```

To understand this better, consider what is happening with the memory addresses:



Sort objects by using array of pointers

```
#include <iostream>
 #include <string>
 using namespace std;

 class person{
    protected:
       string name;
    public:
       void setName()
       { cout << "Enter name: "; cin >> name; }
       void printName()
       { cout << endl << name; }
       string getName()
       { return name; }
 };
 int main(){
    void bsort(person**, int);
    person* persPtr[100];
    int n = 0;
    char choice;

    do {
       persPtr[n] = new person;
       persPtr[n]->setName();
       n++;
       cout << "Enter another (y/n)? ";
       cin >> choice;
    }while( choice=='y' );

    cout << "\nUnsorted list:";
    for(int j=0; j<n; j++)
    {
       persPtr[j]->printName();
    }

    bsort(persPtr, n);

    cout << "\nSorted list:";
    for(int j=0; j<n; j++)
    {
      persPtr[j]->printName();
    }
    cout << endl;
    return 0;
 }
 void bsort(person** pp, int n){
    void order(person**, person**);
    int j, k;

    for(j=0; j<n-1; j++)
       for(k=j+1; k<n; k++)
        order(pp+j, pp+k);
```

```
  }
void order(person** pp1, person** pp2){
   if( (*pp1)->getName() > (*pp2)->getName() )  {
      person* tempptr = *pp1;
      *pp1 = *pp2;
      *pp2 = tempptr;
   }
}
```

Dynamic linked list

```
// linklist.cpp
// linked list
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
struct link                           //one element of list
   {
   int data;                          //data item
   link* next;                        //pointer to next link
   };
////////////////////////////////////////////////////////////////
class linklist                        //a list of links
   {
   private:
      link* first;                    //pointer to first link
   public:
      linklist()                      //no-argument constructor
         { first = NULL; }            //no first link
      void additem(int d);            //add data item (one link)
      void display();                 //display all links
   };
//--------------------------------------------------------------
void linklist::additem(int d)         //add data item
   {
   link* newlink = new link;          //make a new link
   newlink->data = d;                 //give it data
   newlink->next = first;             //it points to next link
   first = newlink;                   //now first points to this
   }
//--------------------------------------------------------------
void linklist::display()              //display all links
   {
   link* current = first;             //set ptr to first link
   while( current != NULL )           //quit on last link
      {
      cout << current->data << endl;  //print data
      current = current->next;        //move to next link
      }
   }
////////////////////////////////////////////////////////////////
int main()
   {
   linklist li;       //make linked list

   li.additem(25);    //add four items to list
   li.additem(36);
   li.additem(49);
   li.additem(64);
   li.display();      //display entire list
   return 0;
   }
```

Pointer to function

A function pointer, or a pointer to a function, can be best thought as the address of the code executed when the function is called.

int ((*fp) (int i, int j)

declares fp to be variable of type “pointer to a function that take two integers arguments and returns an integer as its value. “

Example

```
double (*fp)(double);
int main()
{
 table(sin, 0,180,10);
}
void table( double(*fp) (double), int init, int end, int incr)
{ int theta;

for(theta = int; theta<=end; theta += incr)
  cout<<theta<<”   “<<(*fp)(theta/180.0*3.1416));

}//end table
```

Inheritance

Single Inheritance

```
// inheritance using English Distances
#include <iostream>
using namespace std;
enum posneg { pos, neg };         //for sign in DistSign
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   protected:                     //NOTE: can't be private
      int feet;
      float inches;
   public:                        //no-arg constructor
      Distance() : feet(0), inches(0.0)
         {  }                     //2-arg constructor)
      Distance(int ft, float in) : feet(ft), inches(in)
         {  }
      void getdist()              //get length from user
         {
         cout << "\nEnter feet: ";  cin >> feet;
         cout << "Enter inches: ";  cin >> inches;
         }
      void showdist() const       //display distance
         { cout << feet << "\'-" << inches << '\"'; }
   };
////////////////////////////////////////////////////////////////
class DistSign : public Distance  //adds sign to Distance
   {
   private:
      posneg sign;                //sign is pos or neg
   public:
                                  //no-arg constructor
      DistSign() : Distance()     //call base constructor
         { sign = pos; }          //set the sign to +

                                  //2- or 3-arg constructor
      DistSign(int ft, float in, posneg sg=pos) :
              Distance(ft, in)    //call base constructor
         { sign = sg; }           //set the sign

      void getdist()              //get length from user
              {
              Distance::getdist();     //call base getdist()
              char ch;                 //get sign from user
              cout << "Enter sign (+ or -): ";  cin >> ch;
              sign = (ch=='+') ? pos : neg;
              }
      void showdist() const        //display distance
              {
              cout << ( (sign==pos) ? "(+)" : "(-)" );  //show sign
              Distance::showdist();                     //ft and in
              }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   DistSign alpha;                    //no-arg constructor
   alpha.getdist();                   //get alpha from user

   DistSign beta(11, 6.25);           //2-arg constructor

   DistSign gamma(100, 5.5, neg);     //3-arg constructor

                                 //display all distances
   cout << "\nalpha = ";  alpha.showdist();
   cout << "\nbeta = ";  beta.showdist();
   cout << "\ngamma = ";  gamma.showdist();
   cout << endl;
   return 0;
   }
```

Overriding functions in the subclasses

```
// models employee database using inheritance
#include <iostream>
using namespace std;
const int LEN = 80;                //maximum length of names
```

```
////////////////////////////////////////////////////////////////
class employee                     //employee class
   {
   private:
      char name[LEN];              //employee name
      unsigned long number;        //employee number
   public:
      void getdata()
         {
         cout << "\n   Enter last name: "; cin >> name;
         cout << "   Enter number: ";      cin >> number;
         }
      void putdata() const
         {
         cout << "\n   Name: " << name;
         cout << "\n   Number: " << number;
         }
   };
////////////////////////////////////////////////////////////////
class manager : public employee    //management class
   {
   private:
      char title[LEN];             //"vice-president" etc.
      double dues;                 //golf club dues
   public:
      void getdata()
         {
         employee::getdata();
         cout << "   Enter title: ";          cin >> title;
         cout << "   Enter golf club dues: "; cin >> dues;
         }
      void putdata() const
         {
         employee::putdata();
         cout << "\n   Title: " << title;
         cout << "\n   Golf club dues: " << dues;
         }
   };
////////////////////////////////////////////////////////////////
class scientist : public employee  //scientist class
   {
   private:
      int pubs;                    //number of publications
   public:
      void getdata()
         {
         employee::getdata();
         cout << "   Enter number of pubs: "; cin >> pubs;
         }
      void putdata() const
         {
         employee::putdata();
         cout << "\n   Number of publications: " << pubs;
         }
   };
////////////////////////////////////////////////////////////////
class laborer : public employee    //laborer class
   {
   };
////////////////////////////////////////////////////////////////
int main()
   {
   manager m1, m2;
   scientist s1;
   laborer l1;

   cout << endl;           //get data for several employees
   cout << "\nEnter data for manager 1";
   m1.getdata();

   cout << "\nEnter data for manager 2";
   m2.getdata();

   cout << "\nEnter data for scientist 1";
   s1.getdata();

   cout << "\nEnter data for laborer 1";
   l1.getdata();
                           //display data for several employees
   cout << "\nData on manager 1";
   m1.putdata();

   cout << "\nData on manager 2";
   m2.putdata();

   cout << "\nData on scientist 1";
   s1.putdata();

   cout << "\nData on laborer 1";
   l1.putdata();
   cout << endl;
   return 0;
   }
```

Public and private inheritance

```
// tests publicly- and privately-derived classes

#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class A                  //base class
   {
   private:
      int privdataA;     //(functions have the same access
   protected:            //rules as the data shown here)
      int protdataA;
   public:
      int pubdataA;
   };
////////////////////////////////////////////////////////////////
class B : public A       //publicly-derived class
   {
   public:
      void funct()
         {
         int a;
         a = privdataA;  //error: not accessible
         a = protdataA;  //OK
         a = pubdataA;   //OK
         }
   };
////////////////////////////////////////////////////////////////
class C : private A      //privately-derived class
   {
   public:
      void funct()
         {
         int a;
         a = privdataA;  //error: not accessible
         a = protdataA;  //OK
         a = pubdataA;   //OK
         }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   int a;

   B objB;
   a = objB.privdataA;   //error: not accessible
   a = objB.protdataA;   //error: not accessible
   a = objB.pubdataA;    //OK (A public to B)

   C objC;
   a = objC.privdataA;   //error: not accessible
   a = objC.protdataA;   //error: not accessible
   a = objC.pubdataA;    //error: not accessible (A private to C)
   return 0;
   }
```

Levels of inheritance

```
// multiple levels of inheritance
#include <iostream>
using namespace std;
const int LEN = 80;                //maximum length of names
////////////////////////////////////////////////////////////////
class employee
   {
   private:
      char name[LEN];              //employee name
      unsigned long number;        //employee number
   public:
      void getdata()
         {
         cout << "\n   Enter last name: "; cin >> name;
         cout << "   Enter number: ";      cin >> number;
         }
      void putdata() const
         {
         cout << "\n   Name: " << name;
         cout << "\n   Number: " << number;
         }
   };
////////////////////////////////////////////////////////////////
class manager : public employee    //manager class
   {
   private:
      char title[LEN];               //"vice-president" etc.
      double dues;                   //golf club dues
   public:
      void getdata()
         {
         employee::getdata();
         cout << "   Enter title: ";          cin >> title;
         cout << "   Enter golf club dues: "; cin >> dues;
         }
      void putdata() const
         {
         employee::putdata();
         cout << "\n   Title: " << title;
         cout << "\n   Golf club dues: " << dues;
         }
   };
////////////////////////////////////////////////////////////////
class scientist : public employee  //scientist class
   {
   private:
      int pubs;                      //number of publications
   public:
      void getdata()
         {
         employee::getdata();
         cout << "   Enter number of pubs: "; cin >> pubs;
         }
      void putdata() const
         {
         employee::putdata();
         cout << "\n   Number of publications: " << pubs;
         }
   };
////////////////////////////////////////////////////////////////
class laborer : public employee    //laborer class
   {
   };
////////////////////////////////////////////////////////////////
class foreman : public laborer     //foreman class
   {
   private:
      float quotas;  //percent of quotas met successfully
   public:
      void getdata()
         {
         laborer::getdata();
         cout << "   Enter quotas: "; cin >> quotas;
         }
      void putdata() const
         {
         laborer::putdata();
         cout << "\n   Quotas: " << quotas;
         }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   laborer l1;
   foreman f1;

   cout << endl;
   cout << "\nEnter data for laborer 1";
   l1.getdata();
   cout << "\nEnter data for foreman 1";
   f1.getdata();

   cout << endl;
   cout << "\nData on laborer 1";
   l1.putdata();
   cout << "\nData on foreman 1";
   f1.putdata();
   cout << endl;
   }
```

Member functions in multiple inheritance

```
// englmult.cpp
// multiple inheritance with English Distances
#include <iostream>
#include <string>
using namespace std;
////////////////////////////////////////////////////////////////
class Type                        //type of lumber
   {
   private:
      string dimensions;
      string grade;
   public:                        //no-arg constructor
      Type() : dimensions("N/A"), grade("N/A")
         {  }
                                  //2-arg constructor
      Type(string di, string gr) : dimensions(di), grade(gr)
         {  }
      void gettype()              //get type from user
         {
         cout << "   Enter nominal dimensions (2x4 etc.): ";
         cin >> dimensions;
         cout << "   Enter grade (rough, const, etc.): ";
         cin >> grade;
         }
      void showtype() const       //display type
         {
         cout << "\n   Dimensions: " << dimensions;
         cout << "\n   Grade: " << grade;
         }
   };
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   private:
      int feet;
      float inches;
   public:                         //no-arg constructor
      Distance() : feet(0), inches(0.0)
         {  }                      //constructor (two args)
      Distance(int ft, float in) : feet(ft), inches(in)
         {  }
      void getdist()               //get length from user
         {
         cout << "   Enter feet: ";  cin >> feet;
         cout << "   Enter inches: ";  cin >> inches;
         }
      void showdist() const        //display distance
         { cout  << feet << "\'-" << inches << '\"'; }
   };
////////////////////////////////////////////////////////////////
class Lumber : public Type, public Distance
   {
   private:
      int quantity;                       //number of pieces
      double price;                       //price of each piece
   public:                                //constructor (no args)
      Lumber() : Type(), Distance(), quantity(0), price(0.0)
         {  }
                                    //constructor (6 args)
      Lumber( string di, string gr,       //args for Type
              int ft, float in,           //args for Distance
              int qu, float prc ) :       //args for our data
              Type(di, gr),               //call Type ctor
              Distance(ft, in),           //call Distance ctor
              quantity(qu), price(prc)    //initialize our data
          {  }
      void getlumber()
         {
         Type::gettype();
         Distance::getdist();
         cout << "   Enter quantity: "; cin >> quantity;
         cout << "   Enter price per piece: "; cin >> price;
         }
      void showlumber() const
         {
         Type::showtype();
         cout << "\n   Length: ";
         Distance::showdist();
         cout << "\n   Price for " << quantity
                << " pieces: $" << price * quantity;
         }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Lumber siding;                   //constructor (no args)

   cout << "\nSiding data:\n";
   siding.getlumber();              //get siding from user

                                    //constructor (6 args)
   Lumber studs( "2x4", "const", 8, 0.0, 200, 4.45F );
```

```
                                    //display lumber data
   cout << "\nSiding";  siding.showlumber();
   cout << "\nStuds";     studs.showlumber();
   cout << endl;
   return 0;
   }
```

Constructors in multiple inheritance

```
// multiple inheritance with English Distances
#include <iostream>
#include <string>
using namespace std;
////////////////////////////////////////////////////////////////
class Type                        //type of lumber
   {
   private:
      string dimensions;
      string grade;
   public:                        //no-arg constructor
      Type() : dimensions("N/A"), grade("N/A")
         {  }
                                  //2-arg constructor
      Type(string di, string gr) : dimensions(di), grade(gr)
         {  }
      void gettype()              //get type from user
         {
         cout << "   Enter nominal dimensions (2x4 etc.): ";
         cin >> dimensions;
         cout << "   Enter grade (rough, const, etc.): ";
         cin >> grade;
         }
      void showtype() const       //display type
         {
         cout << "\n   Dimensions: " << dimensions;
         cout << "\n   Grade: " << grade;
         }
   };
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   private:
      int feet;
      float inches;
   public:                        //no-arg constructor
      Distance() : feet(0), inches(0.0)
         {  }                     //constructor (two args)
      Distance(int ft, float in) : feet(ft), inches(in)
         {  }
      void getdist()              //get length from user
         {
         cout << "   Enter feet: ";  cin >> feet;
         cout << "   Enter inches: ";  cin >> inches;
         }
      void showdist() const       //display distance
         { cout  << feet << "\'-" << inches << '\"'; }
   };
```

```
////////////////////////////////////////////////////////////////
class Lumber : public Type, public Distance
   {
   private:
      int quantity;                        //number of pieces
      double price;                        //price of each piece
   public:                                 //constructor (no args)
      Lumber() : Type(), Distance(), quantity(0), price(0.0)
         {  }
                                   //constructor (6 args)
      Lumber( string di, string gr,        //args for Type
              int ft, float in,            //args for Distance
              int qu, float prc ) :        //args for our data
              Type(di, gr),                //call Type ctor
              Distance(ft, in),            //call Distance ctor
              quantity(qu), price(prc)     //initialize our data
          {  }
      void getlumber()
         {
         Type::gettype();
         Distance::getdist();
         cout << "   Enter quantity: "; cin >> quantity;
         cout << "   Enter price per piece: "; cin >> price;
         }
      void showlumber() const
         {
         Type::showtype();
         cout << "\n   Length: ";
         Distance::showdist();
         cout << "\n   Price for " << quantity
                << " pieces: $" << price * quantity;
         }
   };
////////////////////////////////////////////////////////////////

int main()
   {
   Lumber siding;                   //constructor (no args)

   cout << "\nSiding data:\n";
   siding.getlumber();              //get siding from user

                                    //constructor (6 args)
   Lumber studs( "2x4", "const", 8, 0.0, 200, 4.45F );

                                    //display lumber data
   cout << "\nSiding";  siding.showlumber();
   cout << "\nStuds";     studs.showlumber();
   cout << endl;
   return 0;
   }
```

Ambiguity in multiple inheritance

```
// ambigu.cpp
// demonstrates ambiguity in multiple inheritance
#include <iostream>
```

```
using namespace std;
////////////////////////////////////////////////////////////////
class A
   {
   public:
      void show()  { cout << "Class A\n"; }
   };
class B
   {
   public:
      void show()  { cout << "Class B\n"; }
   };
class C : public A, public B
   {
   };
////////////////////////////////////////////////////////////////
int main()
   {
   C objC;            //object of class C
// objC.show();       //ambiguous--will not compile
   objC.A::show();    //OK
   objC.B::show();    //OK
   return 0;
   }
```

Aggregation: Classes within classes

```
// containership with employees and degrees
#include <iostream>
#include <string>
using namespace std;
////////////////////////////////////////////////////////////////
class student                 //educational background
   {
   private:
      string school;          //name of school or university
      string degree;          //highest degree earned
   public:
      void getedu()
         {
         cout << "   Enter name of school or university: ";
         cin >> school;
         cout << "   Enter highest degree earned \n";
         cout << "   (Highschool, Bachelor's, Master's, PhD): ";
         cin >> degree;
         }
      void putedu() const
         {
         cout << "\n   School or university: " << school;
         cout << "\n   Highest degree earned: " << degree;
         }
   };
////////////////////////////////////////////////////////////////
class employee
   {
   private:
      string name;            //employee name
      unsigned long number;   //employee number
   public:
      void getdata()
         {
         cout << "\n   Enter last name: "; cin >> name;
         cout << "   Enter number: ";      cin >> number;
         }
      void putdata() const
         {
         cout << "\n   Name: " << name;
         cout << "\n   Number: " << number;
         }
   };
////////////////////////////////////////////////////////////////
class manager                 //management
   {
   private:
      string title;           //"vice-president" etc.
      double dues;            //golf club dues
      employee emp;           //object of class employee
      student stu;            //object of class student
   public:
      void getdata()
         {
         emp.getdata();
         cout << "   Enter title: ";          cin >> title;
         cout << "   Enter golf club dues: "; cin >> dues;
         stu.getedu();
         }
      void putdata() const
         {
         emp.putdata();
         cout << "\n   Title: " << title;
         cout << "\n   Golf club dues: " << dues;
         stu.putedu();
         }
   };
////////////////////////////////////////////////////////////////
class scientist               //scientist
   {
   private:
      int pubs;               //number of publications
      employee emp;           //object of class employee
      student stu;            //object of class student
   public:
      void getdata()
         {
         emp.getdata();
         cout << "   Enter number of pubs: "; cin >> pubs;
         stu.getedu();
         }
      void putdata() const
         {
         emp.putdata();
         cout << "\n   Number of publications: " << pubs;
         stu.putedu();
         }
   };
////////////////////////////////////////////////////////////////
```

```
class laborer                     //laborer
   {
   private:
      employee emp;           //object of class employee
   public:
      void getdata()
         { emp.getdata(); }
      void putdata() const
         { emp.putdata(); }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   manager m1;
   scientist s1, s2;
   laborer l1;

   cout << endl;
   cout << "\nEnter data for manager 1";    //get data for
   m1.getdata();                            //several employees

   cout << "\nEnter data for scientist 1";
   s1.getdata();

   cout << "\nEnter data for scientist 2";
   s2.getdata();

   cout << "\nEnter data for laborer 1";
   l1.getdata();

   cout << "\nData on manager 1";           //display data for
   m1.putdata();                            //several employees

   cout << "\nData on scientist 1";
   s1.putdata();

   cout << "\nData on scientist 2";
   s2.putdata();

   cout << "\nData on laborer 1";
   l1.putdata();
   cout << endl;
   return 0;
   }
```

Virtual functions

<u>Normal functions access with pointers (early binding)</u>

```
// notvirt.cpp
// normal functions accessed from pointer
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Base                       //base class
   {
   public:
      void show()                //normal function
```

```
         { cout << "Base\n"; }
   };
////////////////////////////////////////////////////////////////
class Derv1 : public Base        //derived class 1
   {
   public:
      void show()
         { cout << "Derv1\n"; }
   };
////////////////////////////////////////////////////////////////
class Derv2 : public Base        //derived class 2
   {
   public:
      void show()
         { cout << "Derv2\n"; }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Derv1 dv1;           //object of derived class 1
   Derv2 dv2;           //object of derived class 2
   Base* ptr;           //pointer to base class

   ptr = &dv1;          //put address of dv1 in pointer
   ptr->show();         //execute show()

   ptr = &dv2;          //put address of dv2 in pointer
   ptr->show();         //execute show()
   return 0;
   }
```

Output

```
Base
Base
```

Virtual functions accessed with pointers (late binding)

```
// virt.cpp
// virtual functions accessed from pointer
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Base                        //base class
   {
   public:
      virtual void show()         //virtual function
         { cout << "Base\n"; }
   };
////////////////////////////////////////////////////////////////
class Derv1 : public Base         //derived class 1
   {
   public:
      void show()
         { cout << "Derv1\n"; }
   };
////////////////////////////////////////////////////////////////
```

```
class Derv2 : public Base         //derived class 2
   {
   public:
      void show()
         { cout << "Derv2\n"; }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Derv1 dv1;           //object of derived class 1
   Derv2 dv2;           //object of derived class 2
   Base* ptr;           //pointer to base class

   ptr = &dv1;          //put address of dv1 in pointer
   ptr->show();         //execute show()

   ptr = &dv2;          //put address of dv2 in pointer
   ptr->show();         //execute show()
   return 0;
   }
```

Output

```
Derv1
Derv2
```

Abstract class and pure virtual functions

```
// virtpure.cpp
// pure virtual function
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Base                        //base class
   {
   public:
      virtual void show() = 0;    //pure virtual function
   };
////////////////////////////////////////////////////////////////
class Derv1 : public Base         //derived class 1
   {
   public:
      void show()
         { cout << "Derv1\n"; }
   };
////////////////////////////////////////////////////////////////
```

```
class Derv2 : public Base         //derived class 2
   {
   public:
      void show()
         { cout << "Derv2\n"; }
   };
////////////////////////////////////////////////////////////////
int main()
   {
// Base bad;              //can't make object from abstract class
   Base* arr[2];          //array of pointers to base class
   Derv1 dv1;             //object of derived class 1
   Derv2 dv2;             //object of derived class 2

   arr[0] = &dv1;         //put address of dv1 in array
   arr[1] = &dv2;         //put address of dv2 in array

   arr[0]->show();        //execute show() in both objects
   arr[1]->show();
   return 0;
   }
```

Virtual functions and Polymorphism

```
// virtpers.cpp
// virtual functions with person class
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class person                         //person class
   {
   protected:
      char name[40];
   public:
      void getName()
         { cout << "   Enter name: "; cin >> name; }
      void putName()
         { cout << "Name is: " << name << endl; }
      virtual void getData() = 0;        //pure virtual func
      virtual bool isOutstanding() = 0;  //pure virtual func
   };
////////////////////////////////////////////////////////////////
class student : public person        //student class
   {
   private:
      float gpa;              //grade point average
   public:
      void getData()          //get student data from user
         {
         person::getName();
         cout << "   Enter student's GPA: "; cin >> gpa;
         }
      bool isOutstanding()
         { return (gpa > 3.5) ? true : false; }
   };
////////////////////////////////////////////////////////////////
class professor : public person      //professor class
   {
```

```
   private:
      int numPubs;             //number of papers published
   public:
      void getData()           //get professor data from user
         {
         person::getName();
         cout << "   Enter number of professor's publications: ";
         cin >> numPubs;
         }
      bool isOutstanding()
         { return (numPubs > 100) ? true : false; }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   person* persPtr[100];     //array of pointers to persons
   int n = 0;                //number of persons on list
   char choice;

   do {
      cout << "Enter student or professor (s/p): ";
      cin >> choice;
      if(choice=='s')                  //put new student
         persPtr[n] = new student;     //   in array
      else                             //put new professor
         persPtr[n] = new professor;   //   in array
      persPtr[n++]->getData();         //get data for person
      cout << "   Enter another (y/n)? ";  //do another person?
      cin >> choice;
      } while( choice=='y' );          //cycle until not 'y'

   for(int j=0; j<n; j++)              //print names of all
      {                                //persons, and
      persPtr[j]->putName();           //say if outstanding
      if( persPtr[j]->isOutstanding() )
         cout << "   This person is outstanding\n";
      }
   return 0;
   }  //end main()
```

Virtual base class

```
// normbase.cpp
// ambiguous reference to base class

class Parent
   {
   protected:
      int basedata;
   };
class Child1 : public Parent
   { };
class Child2 : public Parent
   { };
class Grandchild : public Child1, public Child2
   {
   public:
      int getdata()
         { return basedata; }   // ERROR: ambiguous
   };

// virtbase.cpp
// virtual base classes

class Parent
   {
   protected:
      int basedata;
   };
class Child1 : virtual public Parent   // shares copy of Parent
   { };
class Child2 : virtual public Parent   // shares copy of Parent
   { };
class Grandchild : public Child1, public Child2
   {
   public:
      int getdata()
         { return basedata; }    // OK: only one copy of Parent
   };
```

Virtual destructors

```
//vertdest.cpp
//tests non-virtual and virtual destructors
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Base
   {
   public:
      ~Base()                          //non-virtual destructor
//    virtual ~Base()                  //virtual destructor
         { cout << "Base destroyed\n"; }
   };
////////////////////////////////////////////////////////////////
class Derv : public Base
  {
   public:
      ~Derv()
         { cout << "Derv destroyed\n"; }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Base* pBase = new Derv;
   delete pBase;
   return 0;
   }
```

typeid operator

```
// typeid.cpp
// demonstrates typeid() function
// RTTI must be enabled in compiler
```

```
#include <iostream>
#include <typeinfo>           //for typeid()
using namespace std;
////////////////////////////////////////////////////////////////
class Base
   {
   virtual void virtFunc()    //needed for typeid
      {  }
   };
class Derv1 : public Base
   { };
class Derv2 : public Base
   { };
////////////////////////////////////////////////////////////////
void displayName(Base* pB)
   {
   cout << "pointer to an object of: ";  //display name of class
   cout << typeid(*pB).name() << endl;  //pointed to by pB
   }
//--------------------------------------------------------------
int main()
   {
   Base* pBase = new Derv1;
   displayName(pBase);   //"pointer to an object of class Derv1"

   pBase = new Derv2;
   displayName(pBase);   //"pointer to an object of class Derv2"
   return 0;
   }
```

Checking the type of a class with dynamic_cast

```
//dyncast1.cpp
//dynamic cast used to test type of object
//RTTI must be enabled in compiler
#include <iostream>
#include <typeinfo>           //for dynamic_cast
using namespace std;
////////////////////////////////////////////////////////////////
class Base
   {
   virtual void vertFunc()    //needed for dynamic cast
      {  }
   };
class Derv1 : public Base
   {  };
class Derv2 : public Base
   {  };
////////////////////////////////////////////////////////////////
//checks if pUnknown points to a Derv1
bool isDerv1(Base* pUnknown)  //unknown subclass of Base
   {
   Derv1* pDerv1;
   if( pDerv1 = dynamic_cast<Derv1*>(pUnknown) )
      return true;
   else
      return false;
   }
```

```
//--------------------------------------------------------------
int main()
   {
   Derv1* d1 = new Derv1;
   Derv2* d2 = new Derv2;

   if( isDerv1(d1) )
      cout << "d1 is a member of the Derv1 class\n";
   else
      cout << "d1 is not a member of the Derv1 class\n";

   if( isDerv1(d2) )
      cout << "d2 is a member of the Derv1 class\n";
   else
      cout << "d2 is not a member of the Derv1 class\n";
   return 0;
   }
```

Changing pointer type with dynamic_cast

```
//dyncast2.cpp
//tests dynamic casts
//RTTI must be enabled in compiler
#include <iostream>
#include <typeinfo>            //for dynamic_cast
using namespace std;
////////////////////////////////////////////////////////////////
class Base
   {
   protected:
      int ba;
   public:
      Base() : ba(0)
         {  }
      Base(int b) : ba(b)
         {  }
      virtual void vertFunc()  //needed for dynamic_cast
         {  }
      void show()
         { cout << "Base: ba=" << ba << endl; }
   };
////////////////////////////////////////////////////////////////
class Derv : public Base
   {
   private:
      int da;
   public:
      Derv(int b, int d) : da(d)
         { ba = b; }
      void show()
         { cout << "Derv: ba=" << ba << ", da=" << da << endl; }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Base* pBase = new Base(10);          //pointer to Base
   Derv* pDerv = new Derv(21, 22);      //pointer to Derv
   //derived-to-base: upcast -- points to Base subobject of Derv
   pBase = dynamic_cast<Base*>(pDerv);
   pBase->show();                       //"Base: ba=21"

   pBase = new Derv(31, 32);            //normal
   //base-to-derived: downcast -- (pBase must point to a Derv)
   pDerv = dynamic_cast<Derv*>(pBase);
   pDerv->show();                       //"Derv: ba=31, da=32"
   return 0;
   }
```

friend Functions and friend Classes

friend Function

```
// friend.cpp
// friend functions
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class beta;              //needed for frifunc declaration

class alpha
   {
   private:
      int data;
   public:
      alpha() : data(3) {  }            //no-arg constructor
      friend int frifunc(alpha, beta);  //friend function
   };
////////////////////////////////////////////////////////////////
class beta
   {
   private:
      int data;
   public:
      beta() : data(7) {  }             //no-arg constructor
      friend int frifunc(alpha, beta);  //friend function
   };
////////////////////////////////////////////////////////////////
int frifunc(alpha a, beta b)            //function definition
   {
   return( a.data + b.data );
   }
//--------------------------------------------------------------
int main()
   {
   alpha aa;
   beta bb;

   cout << frifunc(aa, bb) << endl;     //call the function
   return 0;
   }
```

```cpp
// nofri.cpp
// limitation to overloaded + operator
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   private:
      int feet;
      float inches;
   public:
      Distance() : feet(0), inches(0.0)  //constructor (no args)
         {  }                            //constructor (one arg)
      Distance(float fltfeet)     //convert float to Distance
         {                        //feet is integer part
         feet = static_cast<int>(fltfeet);
             inches = 12*(fltfeet-feet); //inches is what's left
         }
      Distance(int ft, float in)  //constructor (two args)
         { feet = ft; inches = in; }
      void showdist()             //display distance
         { cout << feet << "\'-" << inches << '\"'; }
      Distance operator + (Distance);
   };
//--------------------------------------------------------------
                                  //add this distance to d2
Distance Distance::operator + (Distance d2)   //return the sum
   {
   int f = feet + d2.feet;        //add the feet
   float i = inches + d2.inches;  //add the inches
   if(i >= 12.0)                  //if total exceeds 12.0,
      { i -= 12.0; f++;  }        //less 12 inches, plus 1 foot
   return Distance(f,i);          //return new Distance with sum
   }
////////////////////////////////////////////////////////////////
int main()
   {
   Distance d1 = 2.5;             //constructor converts
   Distance d2 = 1.25;            //float feet to Distance
   Distance d3;
   cout << "\nd1 = "; d1.showdist();
   cout << "\nd2 = "; d2.showdist();

   d3 = d1 + 10.0;                //distance + float: OK
   cout << "\nd3 = "; d3.showdist();
// d3 = 10.0 + d1;                //float + Distance: ERROR
// cout << "\nd3 = "; d3.showdist();
   cout << endl;
   return 0;
   }
```

```cpp
// frengl.cpp
// friend overloaded + operator
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
```

```
class Distance                    //English Distance class
   {
   private:
      int feet;
      float inches;
   public:
      Distance()                  //constructor (no args)
         { feet = 0; inches = 0.0; }
      Distance( float fltfeet )   //constructor (one arg)
         {                        //convert float to Distance
         feet = int(fltfeet);           //feet is integer part
         inches = 12*(fltfeet-feet);    //inches is what's left
         }
      Distance(int ft, float in)  //constructor (two args)
         { feet = ft; inches = in; }
      void showdist()             //display distance
         { cout << feet << "\'-" << inches << '\"'; }
      friend Distance operator + (Distance, Distance); //friend
   };
//--------------------------------------------------------------
Distance operator + (Distance d1, Distance d2) //add D1 to d2
   {
   int f = d1.feet + d2.feet;        //add the feet
   float i = d1.inches + d2.inches;  //add the inches
   if(i >= 12.0)                  //if inches exceeds 12.0,
      { i -= 12.0; f++;  }        //less 12 inches, plus 1 foot
   return Distance(f,i);          //return new Distance with sum
   }
//--------------------------------------------------------------
int main()
   {
   Distance d1 = 2.5;                //constructor converts
   Distance d2 = 1.25;               //float-feet to Distance
   Distance d3;
   cout << "\nd1 = "; d1.showdist();
   cout << "\nd2 = "; d2.showdist();

   d3 = d1 + 10.0;                   //distance + float: OK
   cout << "\nd3 = "; d3.showdist();
   d3 = 10.0 + d1;                   //float + Distance: OK
   cout << "\nd3 = "; d3.showdist();
   cout << endl;
   return 0;
   }
```

friends for functional notation

```
// misq.cpp
// member square() function for Distance
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   private:
      int feet;
      float inches;
   public:                        //constructor (no args)
```

```
      Distance() : feet(0), inches(0.0)
         {  }                     //constructor (two args)
      Distance(int ft, float in) : feet(ft), inches(in)
         {  }
      void showdist()             //display distance
         { cout << feet << "\'-" << inches << '\"'; }
      float square();             //member function
   };
//--------------------------------------------------------------
float Distance::square()          //return square of
   {                              //this Distance
   float fltfeet = feet + inches/12;    //convert to float
   float feetsqrd = fltfeet * fltfeet;  //find the square
   return feetsqrd;               //return square feet
   }
////////////////////////////////////////////////////////////////
int main()
   {
   Distance dist(3, 6.0);         //two-arg constructor (3'-6")
   float sqft;

   sqft = dist.square();          //return square of dist
                                  //display distance and square
   cout << "\nDistance = "; dist.showdist();
   cout << "\nSquare = " << sqft << " square feet\n";
   return 0;
   }
```

friend class

```
// friclass.cpp
// friend classes
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class alpha
   {
   private:
      int data1;
   public:
      alpha() : data1(99) {  }   //constructor
      friend class beta;         //beta is a friend class
   };
////////////////////////////////////////////////////////////////
class beta
   {                             //all member functions can
   public:                       //access private alpha data
      void func1(alpha a)  { cout << "\ndata1=" << a.data1; }
      void func2(alpha a)  { cout << "\ndata1=" << a.data1; }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   alpha a;
   beta b;

   b.func1(a);
   b.func2(a);
   cout << endl;
   return 0;

   }
```

Overloading operators

Overloading Binary Operators
Arithmetic operators

```
// englplus.cpp
// overloaded '+' operator adds two Distances
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   private:
      int feet;
      float inches;
   public:                        //constructor (no args)
      Distance() : feet(0), inches(0.0)
         {  }                     //constructor (two args)
      Distance(int ft, float in) : feet(ft), inches(in)
         {  }
      void getdist()              //get length from user
         {
         cout << "\nEnter feet: ";  cin >> feet;
         cout << "Enter inches: ";  cin >> inches;
         }
      void showdist() const       //display distance
         { cout << feet << "\'-" << inches << '\"'; }

      Distance operator + ( Distance ) const;  //add 2 distances
   };
//--------------------------------------------------------------
                                  //add this distance to d2
Distance Distance::operator + (Distance d2) const  //return sum
   {
   int f = feet + d2.feet;        //add the feet
   float i = inches + d2.inches;  //add the inches
   if(i >= 12.0)                  //if total exceeds 12.0,
      {                           //then decrease inches
      i -= 12.0;                  //by 12.0 and
      f++;                        //increase feet by 1
      }                           //return a temporary Distance
   return Distance(f,i);          //initialized to sum
   }
////////////////////////////////////////////////////////////////
int main()
   {
   Distance dist1, dist3, dist4;   //define distances
   dist1.getdist();                //get dist1 from user

   Distance dist2(11, 6.25);       //define, initialize dist2
   dist3 = dist1 + dist2;          //single '+' operator

   dist4 = dist1 + dist2 + dist3;  //multiple '+' operators
                                   //display all lengths
   cout << "dist1 = ";  dist1.showdist(); cout << endl;
   cout << "dist2 = ";  dist2.showdist(); cout << endl;
   cout << "dist3 = ";  dist3.showdist(); cout << endl;
   cout << "dist4 = ";  dist4.showdist(); cout << endl;
   return 0;
   }
```

Unary operators

```
// countpp1.cpp
// increment counter variable with ++ operator
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Counter
   {
   private:
      unsigned int count;              //count
   public:
      Counter() : count(0)             //constructor
         {  }
      unsigned int get_count()         //return count
         { return count; }
      void operator ++ ()            //increment (prefix)
         {
         ++count;
         }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Counter c1, c2;                     //define and initialize

   cout << "\nc1=" << c1.get_count();  //display
   cout << "\nc2=" << c2.get_count();

   ++c1;                           //increment c1
   ++c2;                           //increment c2
   ++c2;                           //increment c2

   cout << "\nc1=" << c1.get_count();  //display again
   cout << "\nc2=" << c2.get_count() << endl;
   return 0;

   }
```

```
// countpp2.cpp
// increment counter variable with ++ operator, return value
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Counter
```

```
   {
   private:
      unsigned int count;      //count
   public:
      Counter() : count(0)     //constructor
         {  }
      unsigned int get_count() //return count
         { return count; }
      Counter operator ++ ()   //increment count
         {
         ++count;              //increment count
         Counter temp;         //make a temporary Counter
         temp.count = count;   //give it same value as this obj
         return temp;          //return the copy
         }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Counter c1, c2;                         //c1=0, c2=0

   cout << "\nc1=" << c1.get_count();    //display
   cout << "\nc2=" << c2.get_count();

   ++c1;                                   //c1=1
   c2 = ++c1;                              //c1=2, c2=2

   cout << "\nc1=" << c1.get_count();    //display again
   cout << "\nc2=" << c2.get_count() << endl;
   return 0;
   }
// countpp3.cpp
// increment counter variable with ++ operator
// uses unnamed temporary object
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Counter
   {
   private:
      unsigned int count;        //count
   public:
      Counter() : count(0)       //constructor  no args
         {  }
      Counter(int c) : count(c)  //constructor, one arg
         {  }
      int get_count()            //return count
         { return count; }
      Counter operator ++ ()     //increment count
         {
         ++count;                //increment count, then return
         return Counter(count);    //   an unnamed temporary object
         }                       //   initialized to this count
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Counter c1, c2;                         //c1=0, c2=0
   cout << "\nc1=" << c1.get_count();    //display
   cout << "\nc2=" << c2.get_count();

   ++c1;                                 //c1=1
   c2 = ++c1;                            //c1=2, c2=2

   cout << "\nc1=" << c1.get_count();    //display again
   cout << "\nc2=" << c2.get_count() << endl;
   return 0;
   }
```

Posfix Notation

```
// postfix.cpp
// overloaded ++ operator in both prefix and postfix
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Counter
   {
   private:
      unsigned int count;          //count
   public:
      Counter() : count(0)         //constructor  no args
         {  }
      Counter(int c) : count(c)    //constructor, one arg
         {  }
      unsigned int get_count() const //return count
         { return count; }

      Counter operator ++ ()       //increment count (prefix)
         {                         //increment count, then return
         return Counter(++count);  //an unnamed temporary object
         }                         //initialized to this count

      Counter operator ++ (int)    //increment count (postfix)
         {                         //return an unnamed temporary
         return Counter(count++);  //object initialized to this
         }                         //count, then increment count
   };
////////////////////////////////////////////////////////////////
int main()
   {
   Counter c1, c2;                       //c1=0, c2=0

   cout << "\nc1=" << c1.get_count();    //display
   cout << "\nc2=" << c2.get_count();

   ++c1;                                 //c1=1
   c2 = ++c1;                            //c1=2, c2=2 (prefix)

   cout << "\nc1=" << c1.get_count();    //display
   cout << "\nc2=" << c2.get_count();

   c2 = c1++;                            //c1=3, c2=2 (postfix)
   cout << "\nc1=" << c1.get_count();    //display again
   cout << "\nc2=" << c2.get_count() << endl;
   return 0;
   }
```

Comparison Operators

```
// engless.cpp
// overloaded '<' operator compares two Distances
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   private:
      int feet;
      float inches;
   public:                        //constructor (no args)
      Distance() : feet(0), inches(0.0)
         {  }                     //constructor (two args)
      Distance(int ft, float in) : feet(ft), inches(in)
         {  }
      void getdist()              //get length from user
         {
         cout << "\nEnter feet: ";  cin >> feet;
         cout << "Enter inches: ";   cin >> inches;
         }
      void showdist() const       //display distance
         { cout << feet << "\'-" << inches << '\"'; }
      bool operator < (Distance) const; //compare distances
   };
//--------------------------------------------------------------
                                 //compare this distance with d2
bool Distance::operator < (Distance d2) const  //return the sum
   {
   float bf1 = feet + inches/12;
   float bf2 = d2.feet + d2.inches/12;
   return (bf1 < bf2) ? true : false;
   }
////////////////////////////////////////////////////////////////
int main()
   {
   Distance dist1;                 //define Distance dist1
   dist1.getdist();                //get dist1 from user

   Distance dist2(6, 2.5);         //define and initialize dist2
                                   //display distances
   cout << "\ndist1 = ";  dist1.showdist();
   cout << "\ndist2 = ";  dist2.showdist();

   if( dist1 < dist2 )             //overloaded '<' operator
      cout << "\ndist1 is less than dist2";
   else
      cout << "\ndist1 is greater than (or equal to) dist2";
   cout << endl;
   return 0;
   }
```

Arithmetic Assignment operators

```
// englpleq.cpp
// overloaded '+=' assignment operator
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Distance                     //English Distance class
   {
   private:
      int feet;
      float inches;
   public:                         //constructor (no args)
      Distance() : feet(0), inches(0.0)
         {  }                      //constructor (two args)
      Distance(int ft, float in) : feet(ft), inches(in)
         {  }
      void getdist()               //get length from user
         {
         cout << "\nEnter feet: ";  cin >> feet;
         cout << "Enter inches: ";  cin >> inches;
         }
      void showdist() const        //display distance
         { cout << feet << "\'-" << inches << '\"'; }
      void operator += ( Distance );
   };
//--------------------------------------------------------------
                                   //add distance to this one
void Distance::operator += (Distance d2)
   {
   feet += d2.feet;                //add the feet
   inches += d2.inches;            //add the inches
   if(inches >= 12.0)              //if total exceeds 12.0,
      {                            //then decrease inches
      inches -= 12.0;              //by 12.0 and
      feet++;                      //increase feet
      }                            //by 1
   }
////////////////////////////////////////////////////////////////
int main()
   {
   Distance dist1;                 //define dist1
   dist1.getdist();                //get dist1 from user
   cout << "\ndist1 = ";  dist1.showdist();

   Distance dist2(11, 6.25);       //define, initialize dist2
   cout << "\ndist2 = ";  dist2.showdist();

   dist1 += dist2;                 //dist1 = dist1 + dist2
   cout << "\nAfter addition,";
   cout << "\ndist1 = ";  dist1.showdist();
   cout << endl;
   return 0;
   }
```

Data Conversion

Type conversion

Conversion	Routine in Destination	Routine in source
Basic to basic (float to int)	Built in	Built in
Basic to class (int to obj)	Constructor	
Class to Basic (obj to int)		Operator function
Class to class (obj to otherObj	Constructor	Operator function

Conversion between Class and Basic Types

```
// englconv.cpp
// conversions: Distance to meters, meters to Distance
#include <iostream>
using namespace std;
////////////////////////////////////////////////////////////////
class Distance                    //English Distance class
   {
   private:
      const float MTF;            //meters to feet
      int feet;
      float inches;
   public:                        //constructor (no args)
      Distance() : feet(0), inches(0.0), MTF(3.280833F)
         {  }                     //constructor (one arg)
      Distance(float meters) : MTF(3.280833F)
         {                        //convert meters to Distance
         float fltfeet = MTF * meters;  //convert to float feet
         feet = int(fltfeet);           //feet is integer part
         inches = 12*(fltfeet-feet);    //inches is what's left
         }                        //constructor (two args)
      Distance(int ft, float in) : feet(ft),
                                      inches(in), MTF(3.280833F)
         {  }
      void getdist()              //get length from user
         {
         cout << "\nEnter feet: ";  cin >> feet;
         cout << "Enter inches: ";  cin >> inches;
         }
      void showdist() const       //display distance
```

```
         { cout << feet << "\'-" << inches << '\"'; }

      operator float() const      //conversion operator
         {                        //converts Distance to meters
         float fracfeet = inches/12;     //convert the inches
         fracfeet += static_cast<float>(feet); //add the feet
         return fracfeet/MTF;            //convert to meters
         }
   };
////////////////////////////////////////////////////////////////
int main()
   {
   float mtrs;
   Distance dist1 = 2.35F;        //uses 1-arg constructor to
                                  //convert meters to Distance
   cout << "\ndist1 = "; dist1.showdist();

   mtrs = static_cast<float>(dist1); //uses conversion operator
                                     //for Distance to meters
   cout << "\ndist1 = " << mtrs << " meters\n";

   Distance dist2(5, 10.25);      //uses 2-arg constructor

   mtrs = dist2;                  //also uses conversion op
   cout << "\ndist2 = " << mtrs << " meters\n";

// dist2 = mtrs;                  //error, = won't convert
   return 0;
   }
```

Conversion between Objects of Different Classes

```
class Cartesian
{
double x;
double y;
public:
Cartesian()
{x=0,y=0)
Cartesian(doubly x, double y)
{
this.x=x
this.y=y
}
//added constructor
Cartesian(Polar p)
{
double r=P.getRadius();
double a=p.getAngle();
x=r*cos(a)
y=r*cos(a)
}
};
class Polar
{
double radius;
double angle;
public:
Polar()
{
radius=0;
angle=0;
}
Polar (double r, double a)
{
radius=r;
angle=a;
}
operator Cartesian()
{
double x=Radius*cos(angle);
double y=radius*sin(angle);
return cartesian(x,y)
}
};
```

In main

```
Polar P(10,.5)
Cartesian c;
c=p
```