[**Open book, handouts, and notes**] Show all of your work clearly in the space provided or on the additional page at the end of the exam. If the additional page is used, clearly identify to which exam question it is related. Be sure to **read each problem carefully**. You should answer all 5 questions, and you may wish to answer the bonus question if you have time. Note that the exam is double sided.

1. (15 points) Briefly, in your own words, describe three advantages of using abstract data types.

2. (15 points) Briefly, in your own words, describe how *rvalue*s and *lvalue*s differ. Use examples when appropriate.

3. (20 points) Rewrite lines 4 through 10 using iterators instead. The modified function should do exactly the same thing as the original function.

```
int FindIt(const vector<int>& Vec, int number)
{
  bool found=false;

  for(int i=0; i<Vec.size(); ++i) {
    if(Vec[i]==number) {
      found = true;
      break;
    }
  }

  return found;
}
```

4. In this multi-part problem, you will make use of a Widget class. The relevant part of the Widget class definition is:

```
class Widget
{
public:
  Widget();
  Widget(double d1, const string& s1);
  Widget(int i1, double d1, const string& s1);
  bool isLessThan(const Widget& rhs);
  bool isEqual(const Widget& rhs);
  Widget& operator= (const Widget& rhs);
  ...

private:
  ...
};
```

(a) (10 points) Write the function prototype for the overloaded $>$ operator auxiliary function.

(b) (10 points) Write the function for the overloaded $>$ operator auxiliary function.

(c) (15 points) Based on the member functions available in the class definition, label each of the following statements according to whether it:

D calls the Default constructor
CC calls the Copy Constructor
C calls a Constructor (non-default)
A calls the assignment operator function
I is illegal

Full credit for correct answers. . . for partial credit, explain your reasoning.

```
Widget Wid1;

Widget Wid2 = Wid1;

Widget Wid3(34.12);

Widget Wid4(1, 3.2, "Later");

Widget Wid5(4, 2, "Never");

Wid1 = Wid4;

Wid3 = Wid5;
```

5. (15 points) Identify any memory leaks in the following function. It may be helpful to draw a memory diagram.

```
int main()
{
  int* Iptr1 = new int;
  int* Iptr2 = Iptr1;
  int* Iptr3 = new int;
  Iptr3 = Iptr1;
  Iptr2 = new int;
  char* Cptr1 = new char[3];
  char* Cptr2 = Cptr1;

  delete Iptr1;
  delete Iptr2;
  delete Iptr3;
  delete [] Cptr1;

  return 0;
}
```

bonus (5 points) Briefly, in your own words, explain the concept of model/view separation.

Additional work area for any problem. Clearly identify to which problem the work on this page is related.

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