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- Print your name in the space provided below. Code Form **A** on your Opscan. Check your SSN and Form Encoding!
- Choose the single best answer for each question — some answers may be partially correct. If you mark more than one answer, it will be counted wrong.
- Unless a question involves determining whether given C++ code is syntactically correct, assume that it is valid. The given code has been compiled and tested, except where there are deliberate errors. Unless a question specifically deals with compiler `#include` directives, you should assume the necessary header files have been included.
- Be careful to distinguish integer values from floating point (real) values (containing a decimal point). In questions/answers which require a distinction between integer and real values, integers will be represented without a decimal point, whereas real values will have a decimal point, [1704 (integer), 1704.0 (real)].
- The answers you mark on the Opscan form will be considered your official answers.
- When you have completed the test, sign the pledge at the bottom of this page and turn in the test.
- This is a closed-book, closed-notes examination. No calculators or other electronic devices may be used during this examination. You may not discuss (in any form: written, verbal or electronic) the content of this examination with any student who has not taken it. You must return this test form when you complete the examination. Failure to adhere to any of these restrictions is an Honor Code violation.
- There are 25 questions, equally weighted. The maximum score on this test is 100 points.

Do not start the test until instructed to do so!

Print Name (Last, First) Solution

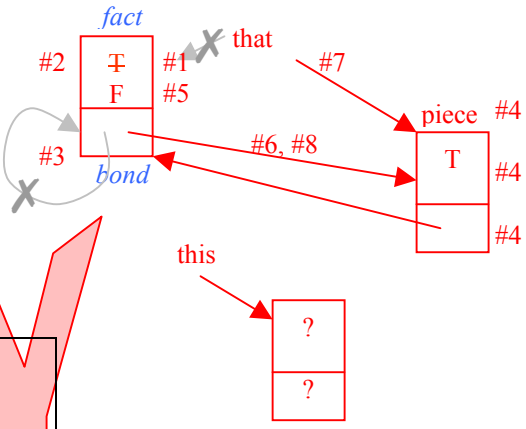
Pledge: On my honor, I have neither given nor received unauthorized aid on this examination.

N. D. Barnette
signature

I. Class Pointers

For the following 4 questions, assume the following declarations:

```
class   Article; //forward declaration
class   Article {
  private:
     Article* bond;
     bool     fact;
  public: //member functions
     void statement();
     ~Article();
};
```




```
//inside the Article member function statement
    Article* that = new Article;        //#1
    that->fact = true;                  //#2
    that->bond = that;                  //#3
    Article piece = *that;              //#4
    piece.bond->fact = false;           //#5
    piece.bond->bond = &piece;          //#6
    that = &piece;                      //#7
    that->bond->bond = that;            //#8
```

1. From inside the same member function as the above code, what is the **type**, (not value), of the expression at the right:

```
that->bond->bond
```

1) NULL
2) Article
3) Article*
4) bond
5) bond*
6) None of the above

2. From inside the same member function as the above code, which of the following statements could be used to change the `Article` object containing a `false fact` to a `true fact` (after the last statement above)?

1) `piece.fact = true;`
2) `that->fact = true;`
3) `that->bond->fact = true;`
4) `piece->fact = true;`
5) `piece->bond->fact = true;`
6) None of the above

3. From inside the same member function as the above code, immediately before the function terminates, how many `Article` objects can be accessed?

1) 1
2) 2
3) 3
4) 4
6) None of the above

Don't forget to count the invoking object pointed to by the *this* pointer, (but never accessed in the code above).

4. Considering just the code above, after the member function, `statement()`, has completed execution, (i.e. went out of scope), how many `Article` objects would the destructor be executed upon?

1) 1
2) 2
3) 3
4) 4
5) 0
6) None of the above

Only the local static object, `piece`, is automatically destructed.

II. Linked List Class Manipulation

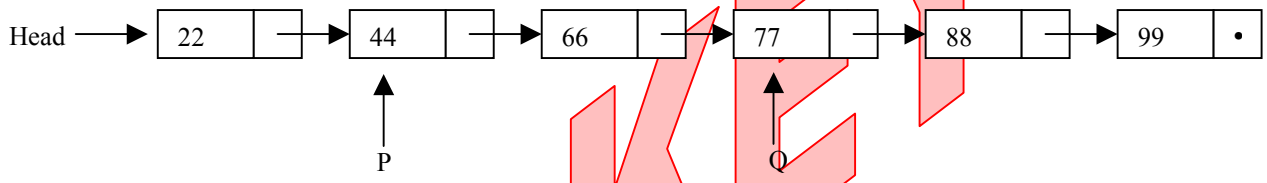
Consider the linked list class and list node declarations given below:

```
class ItemType {
private:
   int Value;
public:
   ItemType();
   ItemType(int newValue);
   void setValue(int newValue);
   int  getValue() const ;
};
```

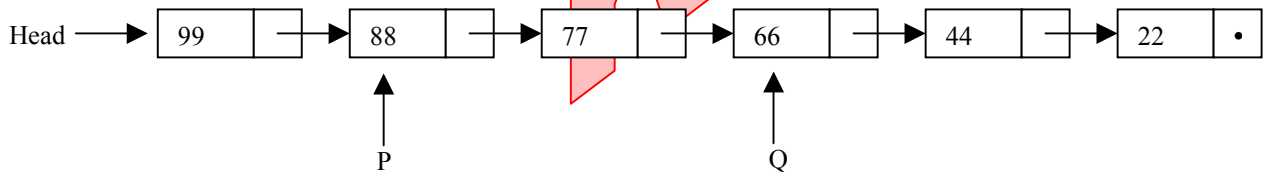
```
class LinkNode {
private:
   ItemType  Data;
   LinkNode* Next;
public:
   LinkNode();
   LinkNode(ItemType newData);
   bool setNext(LinkNode* newNext);
   bool setData(ItemType  newData);
   ItemType  getData() const;
   LinkNode* getNext() const;
};

LinkNode *Head, *P, *Q;
```

Assume that the member functions above have been implemented correctly to carry out their intended task. Also, assume that operations have been executed to create the initial list structure below:



For the next 4 questions, select missing statements for the client, (not class), code segment below to transmogrify the above list into the list shown below:




```
LinkNode* x = Head;                          //initialize x to first node
LinkNode* y = Q->getNext()->getNext(); //5.   //initialize y to last  node
LinkNode*  t;
if (x != NULL && y != NULL && x != y) {      //check trivial cases
  do { for (int i=0; i < 3; i++) { //test correction
    for (t=x; (t!=NULL && t->getNext()!= y); )  //hmmm what is
        t = t->getNext();                       //this for doing?
    //swap *x & *y
    int s = x->getData().getValue(); //6.       //assign  s to *x
    x-> setData(y->getData().getValue()); //7. //assign *x to *y
    y->setData(s);
    x = x->getNext();                           //increment x
    y = __ t _____________________; //8.        //decrement y

  } while ( x->getData().getValue() > y->getData().getValue() );
}//if
```

This question contains an error. The correct answer to 7 should have been: **`setData(y->getData());`** The setData() expects an ItemType parameter not an int, which means the following statement **`y->setData(s);`** is also passing the wrong parameter.

II. Linked List Class Manipulation (continued)

Select from the possible answers for the 4 questions given on the previous page.

1) `Q->Next->Next`	2) `Q->getNext()->getNext()`
3) `*x`	4) `x->getData()`
5) `x->getData().getValue()`	6) `setData(y->getData().getValue())`
7) `setData(y->Data.Value)`	8) `y->getNext()`
9) `t`	10) `t->getNext()`

In looking over the code I compiled to check this question, I see that I mistakenly left in the scope a typedef equating int to ItemType (which I needed to compile the code for section V.).

Discussion for Page 8 Section IV questions 17-20:

Parameterized construction of Miranda allocates a 'F' bool. Initialization (copy) construction of AJ allocates a 'F' bool. Default construction of Cobb allocates a 'T' bool. Parameterized construction of Hillary allocates a 'F' bool. Execution of DustPuppy and pass by value of Miranda results in a deep copy construction of a local Chief object. Changes to Chief affect the copy which is deallocated by the destuctor when DustPuppy terminates. Cobb assigned to Hillary results in a member-wise shallow assignment (& a memory leak) and pointer aliases. Setting and negating Hillary's bool results in Cobb's also being set due to the pointer alias.

III. Separate Compilation

For the next three questions, consider a C++ program composed of three `cpp` files and three corresponding header files, as shown below, (the name of the file is in the first comment line of the file). All function calls are shown, as are all type declarations, function prototypes and *some* `include` directives. In the source and header files, there should be only one physical occurrence of a function prototype, and one physical occurrence of a type declaration. Do not assume that any preprocessor directives are used but not shown.

```
// main.h
class mClass {
   //. . .
};
```

```
// main.cpp
#include "main.h"
_____________________  //Line  9
_____________________  //Line 10
//. . .
void main() {
   Class2 C;
   Exam2(C);
   //. . .
}//end main

//. . .
   // mClass me
```

```
// Exam2.h
//. . .
void Exam2(Clas
```

```
// Exam2.cpp
#include "Exam2.h"
//. . .
void Exam2(Class2& C2obj) {
   //. . .
}
```

```
// Class2.h
_____________________  //Line 11
//. . .
class Class2 {
  private:
     mClass MObj;
  //. . .
};
```

```
// Class2.cpp
#include "Class2.h"
//. . .
   // Class2 member Functions
```

9: When main.cpp is compiled the inclusion of Class2 is necessary for the first declaration in main().

10: The inclusion of Exam2 is required to provide access to Exam2() for invocation.

Note: if answers to 9 & 10 are swapped then compilation of main.cpp causes an undeclared Class2 error since its the parameter type in Exam2.

9. If the organization shown above is used, and no preprocessor directives are added, which of the following `include` directives should replace the underscores at `Line 9` above so that `main.cpp` can be successfully compiled?

   1) Nothing.
   2) `#include "main.h"`
   3) `#include "Exam2.h "`
   4) `#include "Class2.h"`
   5) `#include "Exam2.cpp"`
   6) `#include "Class2.cpp"`
   7) None of these.

10. If the organization shown above is used, and no preprocessor directives are added, which of the following `include` directives should replace the underscores at `Line 10` above so that `main.cpp` can be successfully compiled?

   1) Nothing.
   2) `#include "main.h"`
   3) `#include "Exam2.h "`
   4) `#include "Class2.h"`
   5) `#include "Exam2.cpp"`
   6) `#include "Class2.cpp"`
   7) None of these.

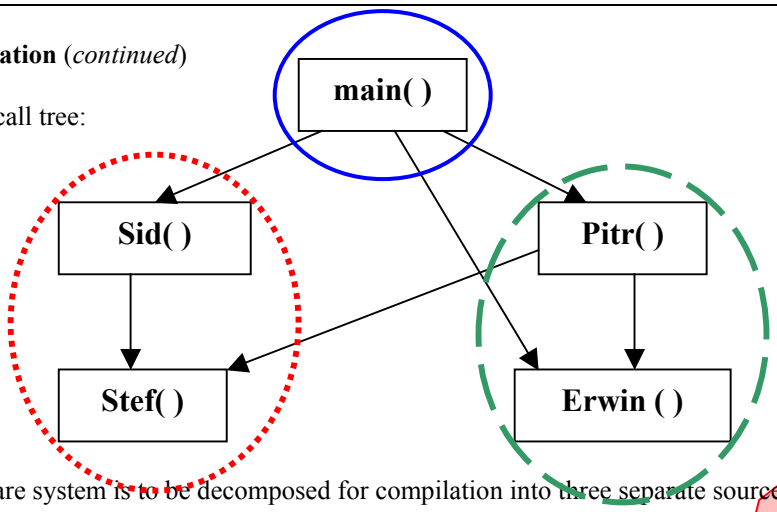
11. If the organization shown above is used, and no preprocessor directives are added, which of the following `include` directives should replace the underscores at `Line 11` above so that `Class2.cpp` can be successfully compiled?

   1) Nothing.
   2) `#include "main.h"`
   3) `#include "Exam2.h`
   4) `#include "Class2.h"`
   5) `#include "Exam2.cpp"`
   6) `#include "Class2.cpp"`

11: Class2 uses the mClass type which is declared in main.h

III. Separate Compilation (*continued*)

Consider the function call tree:



Assume that the software system is to be decomposed for compilation into three separate source files: `main.cpp`, `Sid.cpp`, and `Pitr.cpp`, and accompanying header files of the same names. The function definitions are to be placed in the various cpp files as shown below along with the corresponding code for the files.

`FN definition locations`

Definition for:	Goes in:
`main( )`	`main.cpp`
`Sid( )`	`Sid.cpp`
`Stef( )`	`Sid.cpp`
`Pitr( )`	`Pitr.cpp`
`Erwin( )`	`Pitr.cpp`

`Scott separate compilation unit`

```
//Pitr.h
void Pitr ( /* parameters */ );
```

```
// Pitr.cpp
#include "Pitr.h"
void Erwin( /* parameters */ );

void Pitr ( /* parameters */ ){
// Pitr's code
   Erwin();
   Stef();
}

void Erwin ( /* parameters */ ){
// Erwin's code
   Erwin( /* parameters */ );
}
```

`Sid separate compilation unit`

```
//Sid.h
void Sid ( /* parameters */ );
int greg;
```

```
// Sid.cpp
#include "Sid.h"

void Stef ( /* parameters */ );

void Sid ( /* parameters */ ){
// Sid's code
   Stef( /* parameters */ );
}

void Stef ( /* parameters */ ){
// Stef's code
}
```

`main separate compilation unit`

```
//main.h
/* main declarations */
```

```
//main.cpp
#include "main.h"
#include "Sid.h"

void main() {

   Sid  ( /* parameters */ );
   Pitr ( /* parameters */ );
   Erwin( /* parameters */ );

}
```

III. Separate Compilation (*continued*)

Assume that there are no global type and no global constant declarations, (and also no global variables of course). Answer the following questions with respect to the above compilation organization and the goals of achieving information hiding and restricted scope:

12. Assuming the partial code above was completed and contained no syntax errors, if **only** "`Pitr.cpp`" is **compiled** (not built) within Microsoft Visual C++, which of the following type of errors would occur:

```
1) Compilation error C2065: Erwin : undeclared identifier
2) Compilation error C2065: Stef : undeclared identifier
3) Compilation error C2001: missing main function.
4) No errors would be generated.
```

12: When Pitr.cpp is compiled the call to Stef(), [shown on the call tree], requires that the prototype for Stef be in the same scope.

13. Which of the following prototypes should be moved from its unit source.cpp file to the unit header.h file?

```
1) void Sid ( /* parameters */ );          3) void Erwin ( /* parameters */ );
                Since Erwin() is called by main() which is in another .cpp file.
2) void Pitr( /* parameters */ );          4) void main ( );
```

14. In addition to the include directives listed above, where else **should** "`Pitr.h`" be included?

```
(1) main.h        (3) Sid.h         (5) Pitr.h
(2) main.cpp      (4) Sid.cpp       (6) nowhere else
```

14: main() contains a call to Erwin() so the header for the file containing it needs to be included..

15. In addition to the include directives listed above, where else **should** "`Sid.h`" be included?

```
(1) main.h        (3) Pitr.cpp          (5) nowhere
(2) Pitr.h        (4) Sid.h
```

15: Pitr() contains a call to Stef() so the header for the file containing it needs to be included..

16. Assume all the code above was completed and contains no syntax or compilation errors. Further, assume that all of the header files have appropriate conditional compilation directives surrounding their contents. When the project containing the files is built within Microsoft Visual C++, which of the following linker errors would occur:

```
1) error LNK2015: multiple definitions for identifier 'Stef'
2) error LNK2015: multiple definitions for identifier 'Erwin'
3) Pitr.obj : error LNK2005: "int  greg" already defined in Sid.obj
4) No errors would be generated.
```

16: I decided to omit this question, (which is why I set any response to be treated as correct). I mistakenly left in the line that you were to assume no global variables, when in fact `greg` in `Sid.h` is a global variable which would cause a classic linking error.

IV. Object Manipulations

Assume the following class declaration and implementation:

```
class IlliadUF {
private:
   bool* unix;
public:
   IlliadUF();
   IlliadUF(bool LordCrud);
   IlliadUF(const IlliadUF& Mike);
   bool getTF() const;
   void setTF(bool truth);
   ~IlliadUF();
};

IlliadUF::IlliadUF () {
   unix = new bool(true);
}

IlliadUF::IlliadUF (bool LordCrud) {
   unix = new bool(LordCrud);
}
```

```
bool IlliadUF::getTF() const {
   return(*unix);
}

void IlliadUF::setTF(bool truth) {
   *unix = truth;
}

IlliadUF::IlliadUF
          (const IlliadUF& Mike) {
   unix = new bool(*Mike.unix);
}

IlliadUF::~IlliadUF () {
    delete unix;
}
```

Given the following code:

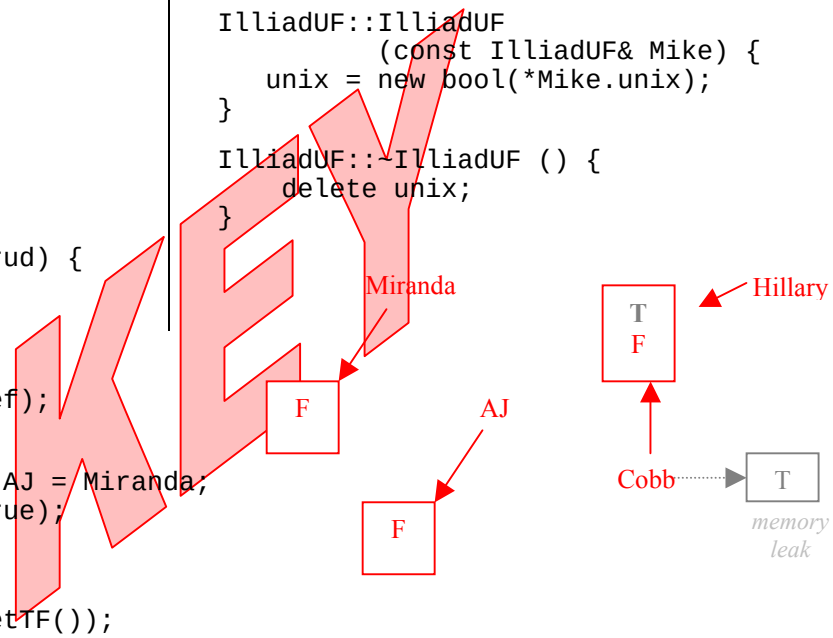
```
void DustPuppy(IlliadUF Chief);

void main() {
   IlliadUF Miranda(false), AJ = Miranda;
   IlliadUF Cobb, Hillary(true);

   DustPuppy(Miranda);
   Cobb = Hillary;
   Hillary.setTF(!Hillary.getTF());

   cout << boolalpha; //stream modifier to output true/false for bools
   cout << "Contents of Miranda is:" << Miranda.getTF() << endl;     //LINE 1
   cout << "Contents of AJ is:"      << AJ.getTF()      << endl;     //LINE 2
   cout << "Contents of Cobb is:"    << Cobb.getTF()    << endl;     //LINE 3
   cout << "Contents of Hillary is:" << Hillary.getTF() << endl;     //LINE 4
}

void DustPuppy(IlliadUF Chief) { Chief.setTF(!Chief.getTF()); }
```



For the next 4 questions, select your answers from the following:

1) `true`
2) `false`
3) `Execution Error`
4) None of these

See page 4 for problem discussion.

17. What bool value is output by the call `Miranda.getTF()` in `LINE 1` above? 2) `false`

18. What bool value is output by the call `AJ.getTF()` in `LINE 2` above? 2) `false`

19. What bool value is output by the call `Cobb.getTF()` in `LINE 3` above? 2) `false`

20. What bool value is output by the call `Hillary.getTF()` in `LINE 4` above? 2) `false`

The 4 objects in main() and the copy of Chief() in

21. In the above code, immediately before `main()` goes out of scope, what is the total number of `IlliadUF` objects that has been dynamically allocated, (include in the count any that have been allocated and destructed).

(1) 1 (3) 3 (5) 5 (7) 7 (9) 0
(2) 2 (4) 4 (6) 6 (8) 8 (10) None of the above

V. Recursion

Assume that the LinkNode and LinkList classes discussed in class have been implemented correctly and are available for use. The LinkList and LinkNode interfaces are given below:

```
#include "LinkNode.h"   // for node declaration
#include "Item.h"
class LinkList {
private:
   LinkNode* Head;    // points to head node in list
   LinkNode* Tail;    // points to tail node in list
   LinkNode* Curr;    // points to "current" node
public:
   LinkList(); //constructor
   LinkList::LinkList(const LinkList& Source);
   LinkList& LinkList::operator=
             (const LinkList& otherList);
   ~LinkList();//destructor
   bool isEmpty() const;
   bool inList() const;
   bool PrefixNode(const Item& newData);
   bool Insert(const Item& newData);
   bool Advance();
   void gotoHead();
   void gotoTail();
   bool DeleteCurrentNode();
   bool DeleteValue(const Item& Target);
   Item getCurrentData() const;
   void setCurrentData(const Item& newData);
};
```

KEY

```
//LinkNode.h
#include "Item.h"
class LinkNode {
private:
   Item      Data; //data "capsule"
   LinkNode* Next; //pointer next
node
public:
   LinkNode();
   LinkNode(const Item& newData);
   void setData(const Item& newData);
   void setNext(LinkNode* const
newNext);
   Item getData() const;
   LinkNode* getNext() const;
};
```

Assume that the Item type has been typedef'd to be equivalent to an `int` and that each node of the list holds one digit of an integer number. If the list stores a date then we might wish to code a recursive function to determine if the date is a palindrome. A palindrome is something that is the same forwards as backwards. For example, the date 10 02 2001 would be a palindromic date, (Europeans list the day first, so for them 20 02 2002 would be a palindromic date).

Given the following, incomplete, palidrome list class member functions:

```
bool LinkList::ListPalindrome() {
   //setup function for Palindrome which does the real work
   if  ( ! isEmpty() ) {
      gotoHead();
      bool palin = Palindrome();
      for (; (Tail->getNext() != NULL); Tail = Tail->getNext()) ;
      return ( palin );
   } else
      return (false);
```

```
} // ListPalindrome

bool LinkList::Palindrome() {
   LinkNode* tmp;
   if (_________________) //22.
      return true;
   if  (_________________) //23.
      return (false);
   Advance();
   for (tmp = Curr; tmp->getNext() != Tail; tmp = tmp->getNext()) ;//null for
   _____________________; //24.
   return( Palindrome() ) ;
} // Palindrome
```

Curr starts at the beginning of the list and tail at the end. Elements are compared and if matched Curr advances forward and tail is moved backward.

22. Select from the missing statements below to correctly fill in the blank for line numbered **//22.** in the above code to correctly satisfy the first base case of the Palindrome function?

1) `Head == NULL`
2) `Head == Tail`
3) `Curr == NULL`
4) `Curr == Head`
5) `Curr == Tail`
6) `None of the above`

If Curr and Tail are ever pointing to the same node then it is the only one remaining and thus list is a palindrome since this single element equals itself.

23. Select from the missing statements below to correctly fill in the blank for line numbered **//23.** in the above code to correctly satisfy the second base case of the Palindrome function?

1) `Head->getData() == Tail->getData()`
2) `Head->getData() != Tail->getData()`
3) `getCurrentData() == Tail->getData()`
4) `getCurrentData() != Tail->getData()`

If the nodes that Curr and Tail are pointing to do not contain equal items then the list cannot be a palindrome.

24. Select from the missing statements below to correctly fill in the blank for line numbered **//24.** in the above code to correctly setup the recursive call to the Palindrome function?

1) `Head = tmp`
2) `Curr = tmp`
3) `Tail = tmp`
4) `Head = Curr`
5) `Tail == Curr`
6) `None of the above`

tmp traverses the list until it points to the node that precedes the tail pointer, which is used to move tail backwards through the list.

25. Which of the recursive problem solution methods is the `Palindrome()` function an example?

1) `Tail (going up) recursion`
2) `Head (going down) recursion`
3) `Middle Decomposition`
4) `Edges & Center Decomposition`
5) `Backtracking`
6) `None of the above`