(Email [mmgeorg@umich.edu](mailto:mmgeorg@umich.edu) if you have questions or if there are typos)

Q4) Answer the following question (focus tree recursion)

// A tree is defined as either being empty with a nullptr or having nodes of // the following type. The tree is also sorted.

struct Tree\_node{

Tree\_node \* left;

Tree\_node \* right;

int datum;

};

// Requires: root points to valid tree described above

// Modifies: nothing

// Effects: returns the number of nodes in the tree

// Ex: 3

// num\_nodes( / \ ) -> 3

// 1 7

int num\_nodes(Tree\_node \* root)

{

// Base case-- no nodes in this tree

if(root == nullptr) { return 0; }

// Recursive case-- one node here + num in left

// subtree + num in right subtree

return num\_nodes(root->right) + num\_nodes(root->left) + 1;

}

// Requires: root points to valid tree described above

// root points to a tree with an odd number of nodes (for simplicity)

// tree is nonempty

// Modifies: nothing

// Effects: returns pointer to the node with the median val found in the tree

// Ex: 3

// median( / \ ) -> 3

// 1 7

// Note -- this one is pretty tricky! It’s a good exercise, but don’t panic

// if you struggled with it. I probably should have said in the directions

// that you could use a helper function and the num\_nodes function you wrote.

int median(Tree\_node \* root)

{

return median\_helper(0, 0, root)->datum;

}

// Helper function for median

Tree\_node \* median\_helper(int nodes\_left, int nodes\_right, Tree\_node \* root)

{

// Base case

if(root == nullptr) { return nullptr; }

// Calculate “balance” of this node-- how many nodes are to its

// left vs. how many nodes are to its right?

int balance = nodes\_left + num\_nodes(root->left)

- nodes\_right - num\_nodes(root->right);

// If this is the middle node, this is the median

if(balance == 0) { return root; }

// If the balance is positive, there are more nodes to the left

// than to the right, so we have to look left for the median

else if(balance > 0) {

return median\_helper(nodes\_left, nodes\_right

+ num\_nodes(root->right) + 1, root->left);

}

// If the balance is negative, there are more nodes to the right

// than to the left, so we have to look right for the median

else {

return median\_helper(nodes\_left + num\_nodes(root->left) + 1,

nodes\_right, root->right);

}

}

Q2) Answer the following questions, focus linked list and templates/iterators

// List is singly linked list

// Having a Node the following members: {Node \* next; int datum}

2.1

// Requires: List is valid list (can be nullptr)

// Modifies: The list pointed to by

// Effects: Returns pointer to head of the list given in reverse

// Ex: HEAD[1] -> [2] -> NULL returns HEAD[2] -> [1] -> NULL

VERIFIED

Node \* reverse\_list(Node \* head){

Node \* last\_visited = nullptr;

Node \* to\_fix = head;

Node \* save;

while(to\_fix) {

save = to\_fix->next;

to\_fix->next = last\_visited;

last\_visited = to\_fix;

to\_fix = save;

}

return last\_visited;

}

2.2

// Requires: List is valid

// Modifies: nothing

// Effects: Returns if this list is circular, empty is not circular

// Ex: HEAD[1] -> [2] -> HEAD[1]... == true, HEAD[1] -> NULL == false

VERIFIED

bool is\_circular(Node \* head){

if(!head) { return false; }

Node \* save = head;

head = head->next;

while(head) {

if(save == head) { return true; }

head = head->next;

}

return false;

}

2.3

template<typename IterType, typename T>

class Internal\_Vec{

vector<T> v1;

public:

Internal\_Vec(){}

bool am\_I\_before(IterType it, IterType end); // IMPLEMENT ON NEXT PAGE

};

// **am\_I\_before**

// Requires: it is valid iterator and points to a container with type “T”

// Modifies : this

// Effects: Returns true if the element’s datum before it is the same as it’s

// : then pushes this datum on v1 if true

// Ex: [1][2], it points to [2], returns false;

// [2][2], it points to second [2], returns true;

// IMPORTANT, this iterator could be pointing at anything, not necessarily v1

// Do everything you must here to make this work, including func signatures:

template <typename IterType, typename T>

bool Internal\_Vec::am\_I\_before(IterType it, IterType end)

{

if(it == end) { return false; }

T val = \*it;

--it;

if(it == end) { return false; }

T prev = \*it;

v1.push\_back(val);

return prev == val;

}

Q5) Give output of code below code (focus on try catch)

VERIFIED

class LolExcept{};

class HahaExcept : public LolExcept {};

void try\_catch(int in)

{

cout << "in: " << in << endl;

try{

if(in == 42) throw HahaExcept();

if(in == 7) throw LolExcept();

}

catch(HahaExcept &){

cout << "Caught at HahaExcept" << endl;

}

cout << (42/in) << endl;

}

int main(int argc, char \* argv[])

{

try{

try\_catch(42);

try\_catch(7);

}

catch(LolExcept &){

cout << "Caught at LolExcept 1" << endl;

}

catch(...){

cout << "Caught by everything 1" << endl;

}

try{

try\_catch(7);

try\_catch(0);

}

catch(LolExcept &){

cout << "Caught at LolExcept 2" << endl;

}

catch(...){

cout << "Caught by everything 2" << endl;

}

return 0;

}

5.1

What is output:

in: 42

Caught at HahaExcept

1

in: 7

Caught at LolExcept 1

in: 7

Caught at LolExcept 2

(Note: after the catch at LolExcept 2, the try\_catch(0) does not execute!)

Q3) Answer the following questions (focus functors and iterators)

3.1

// Write a functor that returns true if earlier in alphabet (< operator)

// Ex. FunFunc f1(“dog”);

// f1(“cat”)); -> True

// f1(“whale”); -> False

class FunFunc{

string word;

public:

FunFunc(const string & word\_in){

word = word\_in;

}

bool operator() (const string & other){

return other < word;

}

};

3.2

// Requires: begin/dest point to the beginning of a data structure, end to

// end duh, data structure pointed to by dest is >= size of data

// structure pointed to by begin and both contain the same data type

// Modifies: data structure pointed to by dest

// Effects: if pred is false, copy the value into the second data structure

// pointed to by dest

// Ex: begin -> [“a”,”b”,”c”] and if pred = FunFunc(“b”)

// then you should end up dest -> [“b”, “c”]

template <typename IterType, typename IterType2, typename Pred>

int grab\_on\_false(IterType begin, IterType end, Itertype2 dest, Pred pred){

int new\_size\_dest = 0;

while(begin != end) {

if(pred(\*begin)) {

\*dest = \*begin;

++new\_size\_dest;

++dest;

}

++begin;

}

return new\_size\_dest;

}

3.3

Do you need all the templates above in grab\_on\_false?

Yes, because we’re not sure if IterType is the same as IterType2.

3.4

What are the benefits to the following, why exist? Why are functors fun?

Iterators:

Encapsulation, allows us to move through ADTs

Functors:

They help reduce code duplication, help us compare custom types (comparators), etc. Functors aren’t fun. -> sorry Melissa but they are

(Dynamic memory on next page)

// CODE:

int where = 4;

int \* am = new int(5);

class LeakMem

{

int \* first;

int second;

int \* arr = new int[where];

int \* arr2 = arr;

public:

LeakMem(int first\_in) : first(new int(first\_in))

{

cout << "LeakMem Norm Ctor Called" << endl;

second = 5;

for(int i = 0; i < 4; i++)

{

arr[i] = i;

}

}

void start\_me()

{

cout << second << endl;

cout << \*am << endl;

delete am;

}

void run\_me()

{

cout << where << endl;

delete first;

cout << first << endl;

}

};

int main(int argc, char \* argv[])

{

LeakMem lm(5);

lm.start\_me();

lm.run\_me();

lm.start\_me();

return 0;

}

Q1) Answer the questions about the code on prev. page [wud rec. the diagram first] (focus Dynamic Memory)

1.1: What memory is leaked [from what variable(s)]?

The memory pointed to by arr (the same memory pointed to by arr2) is leaked because it is never deleted with delete[].

1.2 What double deletes happen or bad access?

When we call start\_me the first time, am gets deleted. When we call it again, we try to access that zombie object (bad access) and then we delete it again (double free).

1.3: Draw a memory diagram of the process running using the table below [make sure to use the following variables: lm (including all members and what they create), where, am, and functions if you feel like having fun

|  |  |  |
| --- | --- | --- |
| Stack | Heap | Global |
| Lm  (in main)  first  Second  (in lm object within main)  arr  Arr2  (local pointers to heap memory)  first\_in, i (local variables in LeakMem constructor) | new int(5)  new int(first\_in)  new int[where] | where  am |