CSE 333 Midterm Exam 7/25/16 Sample Solution

Question 1. (10 points) Preprocessor. Suppose we have the following two files:

defs.h:

```
#define DIV(a,b) a / b
#define INCDIV(c,d) DIV(c + 1, d + 1)
```

main.c:

```
#include <stdio.h>
#include "defs.h"
int main() {
  int n = INCDIV(5, 1);
  printf("%d\n", n);
  return 0;
}
```

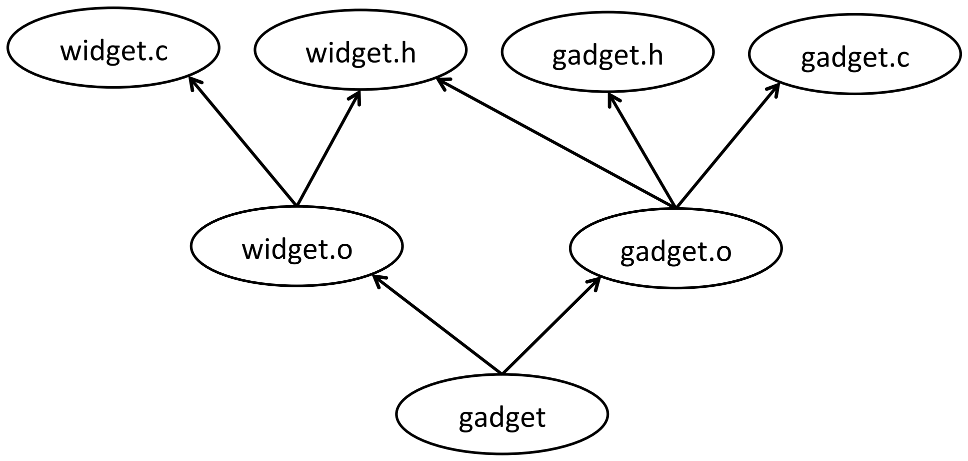
(a) (7 points) Show the result produced by the C preprocessor when it processes file `main.c` (i.e., if we were compiling this file, what output would the preprocessor send to the C compiler that actually translates the program to machine code?). You should ignore the `#include <stdio.h>` directive since that includes library declarations that we do not have access to. Write the rest of the preprocessor output below.

```
int main() {
  int n = 5 + 1 / 1 + 1;
  printf("%d\n", n);
  return 0;
}
```

(b) (3 points) What output does this program print when it is executed?

```
7
```

Make and related things. We have the following diagram that describes the dependencies between the various files that are involved in building an executable program named `gadget`.



Question 2. (9 points, 3 each) What can we conclude from the above diagram? In the statements below, **circle** the number of the *best* choice in each group of possible answers:

(a) The `widget.c` source file:

[✓ (i) **Definitely**] contains a `#include "widget.h"` preprocessor directive.

(ii) **Might** contain a `#include "widget.h"` preprocessor directive, but might not.

(iii) **Does not** contains a `#include "widget.h"` preprocessor directive.

(b) The `gadget.c` source file:

(i) **Definitely** contains a `#include "widget.h"` preprocessor directive.

[✓ (ii) **Might**] contain a `#include "widget.h"` preprocessor directive, but might not. **(`gadget.h` might `#include widget.h` to create the dependency.)**

(iii) **Does not** contains a `#include "widget.h"` preprocessor directive.

(c) The `main` function for this program:

(i) **Definitely** is implemented (defined) in the `gadget.c` source file.

[✓ (ii) **Might**] be implemented (defined) in the `gadget.c` source file, but might not.

(iii) **Is not** implemented (defined) in the `gadget.c` source file.

(more about this diagram on the next page)

Question 3. (17 points) Making stuff. Write an appropriate `Makefile` that will compile and link the files described by the dependency diagram on the previous page to build the executable program named `gadget`. Your `Makefile` should only recompile or relink files if needed to bring targets up to date. The default target in the `Makefile` should be the executable program `gadget`, i.e., if `make` is run with no arguments, the `gadget` program (target) should be built.

You should use `gcc` with appropriate options to compile the program. To save a little time and writing, you may omit `-std=c11`, but you should include `-Wall` and `-g` in appropriate places. In addition, you may find the following options to be useful:

- `-o` *outputfilename* – specify gcc output file
- `-c` – only create a `.o` file and then stop without linking. (If `-c` is given, then the option `-o` *filename*.o is assumed as the default, where *filename*.c is the input file.)

Reminder: the format of a makefile rule is:

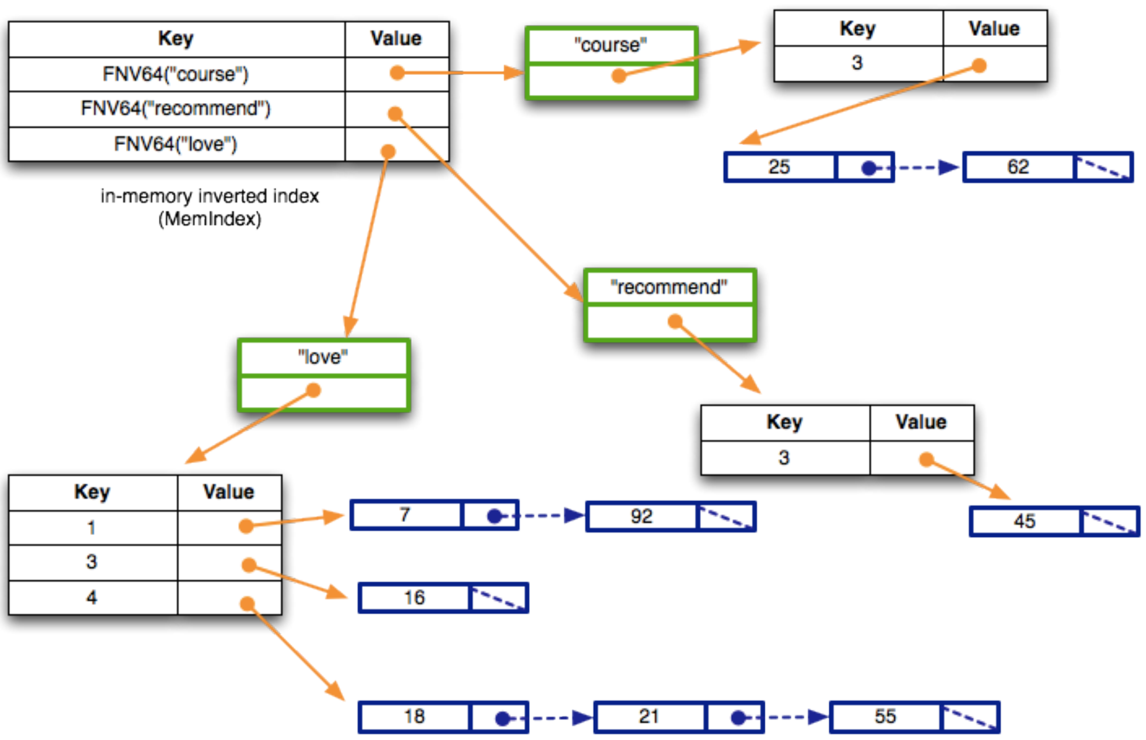
target: sources
    command

```
gadget: widget.o gadget.o
        gcc -Wall -g -o gadget widget.o gadget.o

widget.o: widget.c widget.h
        gcc -Wall -g -c widget.c

gadget.o: gadget.c gadget.h widget.h
        gcc -Wall -g -c gadget.c
```

Note: This solution is about the minimum possible. Solutions that included other features like –o options or Makefile variables did, of course, receive full credit if those features were used properly.

Question 4. (22 points) C programming! This question involves adding a function to the code from HW2. Copies of the `HashTable.h` and `memindex.h` header files, which are the ones needed for this problem, are provided on separate pages. You should assume that those headers, and any other necessary header files and declarations, have already been included in the source files.

After building the inverted index data structures in HW2, we would like to scan the index and, for each word we find, print out the number of different documents where the word appears. For example, here is the inverted index diagram from the HW2 assignment:



The output of the function should list each word in the inverted index and the number of documents where it appears, using a separate line for each word. For the above data the output might be:

```
recommend  1
love  3
course  1
```

The words may appear in any order, and the exact spacing doesn't matter. The output should be written to `stdout` (i.e., feel free to use `printf`). On the next page, implement function `PrintWordDocCounts` to produce this output.

(Hint: Don't panic! The solution isn't particularly long – the sample solution is less than 15 or 20 lines of code. Of course, yours isn't required to be any particular length.)

Question 4. (cont.) Write your implementation of function `PrintWordDocCounts` below.

```
// For each word in MemIndex mi, print on stdout a line
// containing that word and the number of documents where
// it appears.

void PrintWordDocCounts(MemIndex mi) {
  Verify333(mi != NULL);
  // add your code here

  HTIter iter = HashTableMakeIterator(mi);
  while (!HTIteratorPastEnd(iter)) {
    HTKeyValue kv;
    int res = HTIteratorGet(iter, &kv);
    if (res) {
      WordDocSet *wds = (WordDocSet *) kv.value;
      char *word = wds->word;
      int count = NumElementsInHashTable(wds->docIDs);
      printf("%s: %d\n", word, count);
    }
    HTIteratorNext(iter);
  }
  HTIteratorFree(iter);
}
```

Grading note: There were a few solutions that processed the hash table by calling HTIteratorNext repeatedly until the number of calls matched the table size, without actually using HTIteratorPastEnd. We allowed this on the exam without deducting points, but it is poor style since it mixes a counting loop with an iterator. It would be much better to use the iterator interface by itself.

Question 5. (20 points) Bugs 'R Us. One of your friends has been trying to learn C and has been experimenting with a linked list of strings, using dynamically allocated nodes and string values. The list allows duplicates and strings are not stored in any particular order. The problem is that the code is badly broken, and, in fact, doesn't even compile.

Make changes needed in the code below so that function `new_node` allocates a properly initialized new node and `insert` successfully adds it to the front of the list. If you want to rewrite the code instead of modifying it here, you can use the next page.

(Sample solution given below as additions and changes in bold green type. The main bugs are missing dynamic allocation for strings and nodes. Given that this is an exam question we did not require full error checking of malloc results as would be done in production code.)

```
#include <stdlib.h>

#include <string.h>    // needed for strlen, strcpy

struct strnode {          // node in a string linked list:
  char * str;             //   copy of the string (on the heap)
  struct strnode * next; //   next node or NULL if none
};
struct strnode * str_list; // global pointer to list of strings

// return a new node with copy of string s and next == NULL

struct strnode * new_node(char * s) {

  struct strnode * node;

  node = (struct strnode *)malloc(sizeof(strut strnode));

  node->str = (char *)malloc((strlen(s)+1);

  strcpy(node->str, s);

  node->next = NULL;

  return node;

}

// add a new node with a copy of s to the front of str_list

void insert(char * s) {

  struct strnode * p = new_node(s);  // '*' missing in decl.

  p->next = str_list;     // order of these 2 lines reversed

  str_list = p;

}
```

Question 6. (20 points) Not quite the traditional what-does-it-print question. Consider the following C++ program, which, as is usual, compiles and executes with no errors.

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

int f(int &n, int *pa, int &k, int *pb) {
  k = pb[1];
  pb[2] = pa[1];
  n = *pb**pa;
  return k+1;
}

int main() {
  int a = 1;
  int &b = a;
  int ray[4] = { 10, 11, 12, 13 };
  int *p = ray;
  int *q = &ray[1];

  *p = f(ray[2], p, b, q);

  cout<< "a = " << a << ", b = " << b << ", *q = " << *q << endl;
  cout<< "ray = ";
  for (int k = 0; k < 4; k++)
    cout << ray[k] << " ";
  cout << endl;

  return 0;
}
```

What output does this program produce when it runs? (You are not required to draw a boxes-n-arrows diagram, but you might find doing so to be very helpful, and it might help us if we need to assign partial credit to a not-completely-perfect answer.)

```
a = 12, b = 12, *q = 11
ray = 13 11 110 11
```

Question 7. (2 free points) (All reasonable answers receive the points. All answers are reasonable as long as there's something written here. ☺)

(a) (1 point) What question were you expecting to appear on this exam that wasn't here?

Implement a C++ compiler. Be sure to include all library functions and templates plus a complete set of tests for all of your code.

(b) (1 point) Should we include that question on the final exam? (circle or fill in)

Yes

No

Heck No!!

$!@$^*% No !!!!!

None of the above. My answer is **Sure, why not?** .