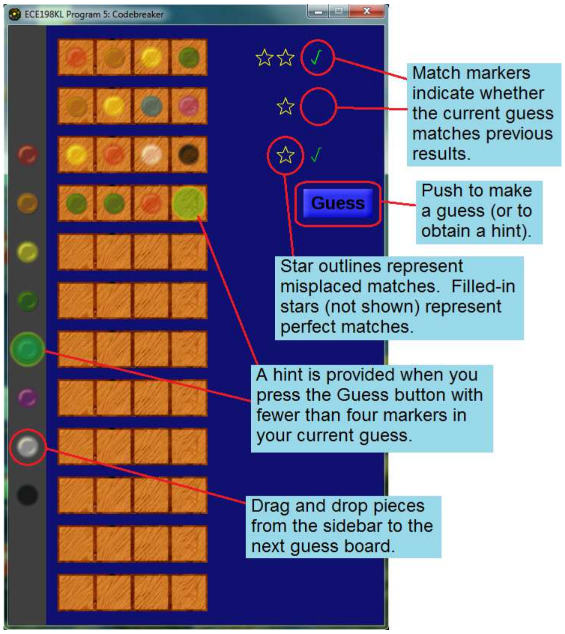
ECE198KL: Introduction to Computer Engineering II **Spring 2013**
Program 5 **due: 10 p.m. on Monday 18 February**

Codebreaker

Your task this week is to implement the logic for a code-breaking game. A code sequence of four numbers from 1 to 8 (colors in the graphical version) is first chosen at random. The player guesses a sequence of four numbers and is given feedback on each guess, including the number of values that appear in the same place in the solution code (these we call *perfect matches*), and the number of values that appear in a different place in the solution code (these we call *misplaced matches*). If the player manages to guess the correct sequence in twelve or fewer guesses, they win the game. Otherwise, they lose.

The objective for this week is for you to gain some experience with basic I/O, to implement code using multiple subroutines, and to solve a problem that requires moderately sophisticated reasoning and control logic. The task here is thus somewhat more difficult than last week's. If you want to read ahead and use arrays, feel free to do so. One of the challenges requires use of arrays. But the code should be fairly manageable without using arrays (we wrote the solution that way, just to check).

As always, routine details such as how to obtain the code and how to hand in your program can be found in the specification for Program 1. Instructions on targeting and making the Linux and Android versions can be found in the specification for Program 4.



Match markers indicate whether the current guess matches previous results.

Push to make a guess (or to obtain a hint).

Star outlines represent misplaced matches. Filled-in stars (not shown) represent perfect matches.

A hint is provided when you press the Guess button with fewer than four markers in your current guess.

Drag and drop pieces from the sidebar to the next guess board.

The Pieces

We are using the same package to allow cross-compilation on different platforms as well as support for the graphical user interface. With a number of image files and more sample tests, this week's distribution is almost 150 files. Again, however, you again need only look at three of those files—the rest serve to incorporate your code into the graphical game and to allow you to build the game as a text version on the lab machines or as a graphical version on Android, Linux, Windows, or WebOS.

The three files that you should examine are a header file, the source file that you must complete, and a standalone file that creates a text version of the game and may help you debug your code before you build it into the graphical version.

Let's discuss each of these in a little more detail:

`jni/prog5.h` This header file provides function declarations and descriptions of the functions that you must write for this assignment, along with a description of the `prog5_printf` function that you must use for printing output from your functions.

`jni/prog5.c` The main source file for your code. Function headers for all regular and challenge functions are provided to help you get started. We will work together on the `set_seed` function in programming studio. The next two, `start_game` and `make_guess`, are left for you to finish independently. The last two, `compare_guesses` and `get_hint`, correspond to challenges.

`text_version.c` This file uses `#include` to pull in the source file that you must edit, but not the rest of the game package, then executes your code as a text-mode game. You may find this version easier to debug, and we have provided some test files as well as a gold (correct, fully operational) version if you want to create more test outputs. The text version does not implement the challenges.

We have also included some additional files for testing, but we leave discussion of those files for the Testing section of this document.

In programming studio, we will discuss pseudo-random number generation and the idea of error-checking user input, then develop the `set_seed` function together to robustly translate user input into a well-defined seed for the pseudo-random number generator.

The rest of the assignment must be completed on your own. If you want to get started before Thursday, you can leave the implementation of `set_seed` provided in the distribution and work on `start_game` and `make_guess`. Together with `set_seed`, these three functions comprise the whole assignment for this week.

Details

You should read the descriptions of the functions in the header file and peruse the function headers in the source file before you begin coding. For the `set_seed` routine that we will develop in programming studio, the function signature appears below:

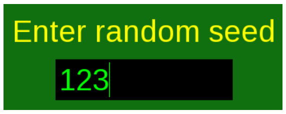
```
int32_t set_seed (const char* seed_str);
```

The function receives a string (a pointer to a character) as its input and produces a 32-bit signed integer as output. The "`const`" qualifier means that the routine is not allowed to change the contents of the string.

We use the following two library calls to produce sequences of pseudo-random numbers:

```
void srand (unsigned int seed);
int rand ();
```

In the graphical version of our game, the value typed into the entry box shown to the right is delivered to the `set_seed` function as a string when the player presses <Enter>. The `set_seed` routine must then check whether the string represents a number, and, if so, use it to seed the pseudo-random number generator via a call to `srand`. Calls to `rand` then produce pseudo-random numbers in the range $[0, 2^{31} - 1]$.



Enter random seed

123

The return value from `set_seed` indicates whether the input string did in fact correspond to a number. When the string represents a number, the function returns 1. Otherwise, the function returns 0.

We use fixed seeds in this assignment because a fixed seed produces a fixed sequence of random numbers, which means that the solution code will always be the same. Determinism makes debugging much easier—imagine trying to find a bug that only appears in one run out of every million. Once you have debugged your code (but **not in the version that you submit for grading**), feel free to change the random seed to be, for example, time-based (`srand (time (NULL));`), so as to provide a more realistic feeling of randomness.

Now let's consider the part that you must do alone. Here are function signatures for the two functions:

```
int32_t start_game (int32_t* one, int32_t* two, int32_t* three, int32_t* four);
int32_t make_guess (const char* guess_str, int32_t* one, int32_t* two, int32_t* three,
                    int32_t* four);
```

The `start_game` routine selects the solution code, a set of four numbers from 1 to 8. To ensure consistency between your program's output and ours, you **must use the algorithm on the next page** for generating the solution code.

Step 1: Starting with the first value in the code sequence, generate a random integer in the range 0 to 7 inclusive using a single call to `rand` and a single modulus (`%`) operator.
Step 2: Add 1 to the resulting number to get a value in the range 1 to 8.
Step 3: Repeat for the other three solution code values (in order).

You must also make your own copy of the solution code using file-scoped variables. This copy will be necessary when you implement `make_guess`.

Be sure not to call `srand` outside of the `set_seed` function and not to call `rand` outside of the `start_game` function. Calling either of these disrupts the sequence of random numbers and will cause your output to differ from ours. Please also be aware that **the pseudo-random number generators on Linux and Android are different**, so the same random seed will produce different solution codes on the lab machine and your Android device.

Finally, you must write the `make_guess` routine that compares a player's guess with the solution. The inputs to this routine include a string (the player's input) and four pointers to integers. Your routine must validate the string in the same way that we did for `set_seed`. A valid string contains exactly four numbers (and no extra garbage at the end). All four numbers in the string must be between 1 and 8. If the string is invalid, your routine must print an error message, "`set_seed: invalid seed\n`", then return 0.

For a valid string, you must store a copy of the guessed code *in order* in the four addresses provided as input parameters. Your routine must then compare the guessed code with the solution code to count the number of perfect and misplaced matches, then print a message informing the player of the results.

Let's consider some examples. Imagine that the solution code is `1 1 2 3`. If the player guesses `1 2 2 4`, the first (leftmost) and third code values match perfectly, so they have two perfect matches. How many misplaced matches does this guess have? Think of the solution and guess code values as being paired with one another. If we pair two values as a perfect match, neither of these values can be paired with another value. So the `1` in the guess does not produce a misplaced match: the `1` in the guess has already been paired with the first `1` in the solution. Neither does the first (left) `2` in the guess produce a misplaced match: the `2` in the solution has already been paired with the other `2` in the guess. Perfect matches are always paired before misplaced matches, so there is never any ambiguity. If you are in doubt, use the test code that we have provided to check your answers on the lab machines.

What happens if (using the same solution code: `1 1 2 3`) the user guesses `4 4 1 1`? Here they have no perfect matches. How many misplaced matches does the guess code have? Keep the pairing idea in mind. We can pair either of the `1`'s in the guess with the `1`'s in the solution, but we have exactly two pairs, and thus we must report exactly two misplaced matches.

Once your routine has calculated the number of perfect and misplaced matches, it must print a message using exactly the format shown here (without the quotes):

"`With guess 1, you got 1 perfect matches and 2 misplaced matches.\n`"

The guess number starts at 1 and goes up as high as 12—your code must also track this value using a file-scoped variable. Note that only valid guesses count as turns. Do not adjust the word "matches" for subject-verb agreement.

The `make_guess` routine should return 1 when the user has provided a valid guess string.

Challenges for Program 5

Here are some challenges for this week. You can find the function signatures in the header or the source file. You can test correct behavior in the Android demo package (see the web page). For the challenges, you must either write your own tests or use the graphical version to test on the lab machines.

(8 points) Implement `compare_guesses`, which checks whether a guess that the user is considering could be the solution, based on a previous guess and the feedback (number of perfect and misplaced matches) given for the previous guess. For this function, all information is provided to you. If you implement it correctly, this challenge should be pretty easy, so make sure that you think about your strategy. Be aware that the guess being considered may not be complete: values can be 0 rather than in the range 1 to 8.

(12 points) (REQUIRES PREVIOUS CHALLENGE) Implement `get_hint`, which provides a sample code (four values) that is consistent with all previous guesses (in other words, `compare_guesses` returns 1 for all previous guesses made during this game). You will need to add code to track those guesses yourself. Note that one easy and accurate hint is to simply provide the solution: **NO CREDIT WILL BE GIVEN** for that approach.

Specifics

- Your code must be written in C and and must be contained in the `prog5.c` file provided to you — we will NOT grade files with any other name.
- You must implement `set_seed`, `start_game`, and `make_guess` correctly.
- Your routine's return values and outputs must match the gold version's exactly for full credit.
- Your code must be well-commented. You may use either C-style (`/* can span multiple lines */`) or C++-style (`// comment to end of line`) comments, as you prefer. Follow the commenting style of the code examples provided in class and in the textbook.

Building and Testing

We suggest that you begin by developing your code using the text version of the game on the Linux machines in the lab. As with Program 4, all operations mentioned here should be performed from your `prog5` directory, not from the `jni` subdirectory that contains the file with your code.

You should test your program thoroughly before handing in your solution. We have provided you a set of tests with the text version, but nothing specifically for the challenges. You should get in the habit of writing your own tests. To compile the `text_version.c` file, type

```
gcc -g -Wall text_version.c
```

If successful, the compiler produces an executable called `a.out`, which you can execute by typing "`./a.out`" (no quotes). You can also run the code with the `gdb` debugger (or a GUI interface that uses it, such as DDD) by typing:

```
gdb a.out
```

The `text-examples` subdirectory contains a gold version of the text-based variant along with some sample input and output files. These are not scripts, but direct input. If you want to produce another copy of `output1`, you can execute the gold version (from within the `text-examples` directory) by typing:

```
./text-version-gold < input1 > output1-copy
```

The `output1-copy` file then matches the `output1` file provided exactly. You can, of course, run your own program in the same way and then use `diff` to compare outputs. You can also run the gold program on different inputs, if you are concerned about a particular test case. If you set your random seed correctly, you should not have difficulty getting the gold version to produce a solution code that you know in advance. You can also run it with twelve identical guesses, since the game prints out the solution if the player loses.

Grading Rubric

Functionality (65%)

- 10% - `set_seed` function works correctly
- 10% - `start_game` function works correctly
- 40% - `make_guess` function works correctly
- 5% - all outputs match exactly

Style (15%)

- 5% - compilation generates no warnings (note: any warning means 0 points here)
- 5% - does not use global variables (file-scoped are necessary)
- 5% - indentation and variable names are appropriate and reasonably meaningful (index variables can be single-letter)

Comments, clarity, and write-up (20%)

- 5% - introductory paragraph explaining what you did (even if it's just the required work)
- 15% - code is clear and well-commented

Note that some point categories in the rubric may depend on other categories. If your code does not compile, you may receive a score close to 0 points.