

2011 BIOSTAT 615/815 Homework #1

Due is Thursday January 20th, 08:30AM (before the class starts)

Problem 0. Introductory Questionnaire

1. What are you hoping to learn from this course? Do you have specific goal to achieve?
2. Have you had any prior programming language experience? If so, in which lanaguages (e.g. C, C++, Java, R, SAS, Matlab...) ?
3. How would you rate your programming skills and experience?
4. Have you ever enroll in 615 or 815 (before 2011)?

Problem 1. Extension of Fisher's Exact Test

Implement a program `fullFastFishersExactTest`, as an extended version from the `fastFisherExactTest` presented in the class. The following two additional features are required for the `fullFastFishersExactTest`.

1. When more than or less than 4 input arguments were specified, report an error message with an adequate guide on how to use the program.
2. In addition to the 2-sided p-values, calculate and output one sided p-values (in both directions). The two-sided and one-sided p-values can be calculated by
 - $p_{2sided}(a, b, c, d) = \sum_x \Pr(x) I[\Pr(x) \leq \Pr(a)]$
 - $p_{greater}(a, b, c, d) = \sum_{x \geq a} \Pr(x)$
 - $p_{less}(a, b, c, d) = \sum_{x \leq a} \Pr(x)$

where $\Pr(x)$ is the hypergeometric probability of $[\#row1, col1] = x$ with row sums of $a + b$ and $c + d$, and column sums of $a + c$ and $b + d$.

Below is an example of expected output of the program.

```
user@host:~/> ./fullFastFishersExactTest 2 7 8 2
Two-sided log10(p) = -1.63801, p-value = 0.0230141
One-sided (less) log10(p) = -1.73232, p-value = 0.0185217
One-sided (greater) log10(p) = -0.000428027, p-value = 0.999015

user@host:~/> ./fullFastFishersExactTest 20 70 80 20
Two-sided log10(p) = -15.2289, p-value = 5.90393e-16
One-sided (less) log10(p) = -15.3764, p-value = 4.20368e-16
One-sided (greater) log10(p) = 8.0232e-14, p-value = 1

user@host:~/> ./fullFastFishersExactTest
Usage: fullFastFishersExactTest [#row1col1] [#row1col2] [#row2col1] [#row2col2]
```

Turn in a hard copy of your full code, and example output. Also, e-mail your source code (.cpp only as an attached file) to hmkang@umich.edu with title 'BIOSTAT 615/815 Homework #1 - [Your Full Name]'

Problem 2 - Revisiting towerOfHanoi

Consider the following version of modified towerOfHanoi program

```
#include <iostream>

void towerOfHanoi(int n, int s, int i, int d, int& ra) {
    ++ra;
    if ( n > 0 ) {
        towerOfHanoi(n-1,s,d,i,ra);
        std::cout << "Disk " << n << " : " << s << " -> " << d << std::endl;
        towerOfHanoi(n-1,i,s,d,ra);
    }
}

int main(int argc, char** argv) {
    int n = atoi(argv[1]);
    int numCalls = 0;
    towerOfHanoi(n, 1, 2, 3, numCalls);
    std::cout << "Total of " << numCalls << " function calls have been made" << std::endl;
}
```

1. What is the total number of function calls reported when $n = 3$?
2. What would be the total number of function calls reported for an arbitrary n ? Explain why.
3. What would happen if the last argument of towerOfHanoi() function was int ra instead of int& ra?

Problem 3 - Pointers and Arrays

Consider the following program ps-1-3.cpp.

```
#include <iostream>

int main(int argc, char** argv) {
    int nv = argc;
    int& nr = argc;
    int* pr = &argc;

    char** ppc = argv;
    char* pc = *argv;
    char c1 = **argv;
    char c2 = argv[1][2];

    std::cout << "argc = " << argc << std::endl;
    std::cout << "nv = " << nv << std::endl;
    std::cout << "nr = " << nr << std::endl;
    std::cout << "pr[0] = " << pr[0] << std::endl << std::endl;

    std::cout << "pc = " << pc << std::endl;
    std::cout << "ppc[0] = " << ppc[0] << std::endl;
    std::cout << "argv[0] = " << argv[0] << std::endl;
    std::cout << "c1 = " << c1 << std::endl;
    std::cout << "c2 = " << c2 << std::endl << std::endl;

    nr = 10;
    ++argv;

    std::cout << "argc = " << argc << std::endl;
    std::cout << "nv = " << nv << std::endl;
    std::cout << "nr = " << nr << std::endl;
    std::cout << "pr[0] = " << pr[0] << std::endl << std::endl;

    std::cout << "pc = " << pc << std::endl;
    std::cout << "ppc[0] = " << ppc[0] << std::endl;
    std::cout << "argv[0] = " << argv[0] << std::endl;
    std::cout << "c1 = " << c1 << std::endl;
    std::cout << "c2 = " << c2 << std::endl << std::endl;

    return 0;
}
```

What is the output of the following program ps-1-3.cpp when you run the following command?

```
user@host:~/> ./ps-1-3 Hello World
```

Briefly explain why each output line changes or does not change between the first and second half of the outputs.