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/////////////////////////////////////////////////////////////////
// coord-iterative.cpp
// Brooklyn College CISC3130 M. Lowenthal - Bonus Assignment
// Robert Wagner
// 2016-02-25
//
// iterative version of the bonus assignment
// takes advantage of the fact that a multivariate function A(a1,a2,a3, ... a_n) is
// bijective with a single dimensional B(b) with b = { 0 ... product(a1,a2,...a_n) }
// using modular arithmetic. this works as long as the product(a1..a_n) does not
// overflow the variable data type used.
//
// to compile: g++ coord-iterative.cpp -o coord-iterative
// to run: ./coord-iterative <# of dims> <size1> <size2> ...
// eg: ./coord-iterative 3 4 5 6
/////////////////////////////////////////////////////////////////
#include <iostream>
#include <stdlib.h>
using namespace std;
int main(int argc, char* argv[]) {
    if (argc < 3) { cout << "must pass at least two integers." << endl; return -1; }
    int mods[argc-2];
    int divs[argc-2];
    int max, mod, div, index;
    // first, initialize what we know we can initialize
    int dim = atoi(argv[1]);
    if (argc - 2 != dim) { cout << "invalid number of parameters." << endl; return -1; }
    mods[0] = atoi(argv[2]);
    divs[0] = dim;
    max = mods[0] * dim;
    for (int n = 0; n < max; n++) { // the only loop
        // if we are still within our parameter list, continue to initialize
        if (n < argc - 3) {
            mods[n + 1] = atoi(argv[n + 3]);
            divs[n + 1] = divs[n] * mods[n];
            max = max * mods[n + 1];
        }
        index = n % dim;
        // if there should be an opening parenthesis, print it
        if (index == 0) cout << "(";
        // print the actual number
        mod = mods[index];
        div = divs[index];
        cout << 1 + (n / div) % mod;
        // print closing parenthesis or just a comma or both
        if (n+1 >= max) cout << ")" << endl;
        else if ((n+1) % dim != 0) cout << ", ";
        else cout << "), ";
    }
}

```

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////////////////////////////////////
// coord-recurse.cpp
// Brooklyn College CISC3130 M. Lowenthal - Bonus Assignment
// Robert Wagner
// 2016-03-08
// recursive version of the bonus assignment
// builds a global variable finalString and recurses through the possible permutations
// of the dimension sizes, and only adds coordinates if it hasn't been added already
//
// to compile: g++ coordinates.cpp -o coordinates
// to run: ./coordinates <# of dims> <size1> <size2> ...
// eg: ./coordinates 3 4 5 6
////////////////////////////////////
#include <iostream>
#include <stdlib.h>
#include <string>
#include <sstream>
using namespace std;

string finalString = "";

void recurse(int N, int values[]) {
    ostringstream SS;
    SS << "(";
    for (int i = 0; i < N; i++) { // the only loop in the recursion
        SS << values[i];
        if (i < N - 1) SS << ", ";
        if (values[i] > 1) {
            values[i] -= 1;
            recurse(N, values);
            values[i] += 1;
        }
    }
    SS << ")", ";";
    string s = SS.str();

    // only add it if its not already added
    if (finalString.find(s) == string::npos)
        finalString.append(s);
}

int main(int argc, char* argv[]) {
    if (argc < 3) { cout << "must pass at least two integers." << endl; return -1; }
    int vals[argc-2];
    // first, initialize what we know we can initialize
    int dim = atoi(argv[1]);
    if (argc - 2 != dim) { cout << "invalid number of parameters." << endl; return -1; }

    // this loop only acts to fill the input array with the passed parameter values
    for (int i = 0; i < dim; i++) vals[i] = atoi(argv[i + 2]);

    // do the work
    recurse(dim, vals);

    // now global string finalString contains the final output with a trailing ',' to
    remove
    finalString = finalString.substr(0, finalString.length() - 2);
    cout << finalString << endl;
}

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robert@C720:~/courses/CISC3130/bonus$ g++ coord-iterative.cpp -o coord-iterative
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 5 4 3 2 1 2
(1, 1, 1, 1, 1), (2, 1, 1, 1, 1), (3, 1, 1, 1, 1), (4, 1, 1, 1, 1), (1, 2, 1, 1, 1), (2, 2, 1, 1, 1), (3, 2, 1, 1, 1), (4, 2, 1, 1, 1), (1, 3, 1, 1, 1), (2, 3, 1, 1, 1), (3, 3, 1, 1, 1), (4, 3, 1, 1, 1), (1, 1, 2, 1, 1), (2, 1, 2, 1, 1), (3, 1, 2, 1, 1), (4, 1, 2, 1, 1), (1, 2, 2, 1, 1), (2, 2, 2, 1, 1), (3, 2, 2, 1, 1), (4, 2, 2, 1, 1), (1, 3, 2, 1, 1), (2, 3, 2, 1, 1), (3, 3, 2, 1, 1), (4, 3, 2, 1, 1), (1, 1, 1, 1, 2), (2, 1, 1, 1, 2), (3, 1, 1, 1, 2), (4, 1, 1, 1, 2), (1, 2, 1, 1, 2), (2, 2, 1, 1, 2), (3, 2, 1, 1, 2), (4, 2, 1, 1, 2), (1, 3, 1, 1, 2), (2, 3, 1, 1, 2), (3, 3, 1, 1, 2), (4, 3, 1, 1, 2), (1, 1, 2, 1, 2), (2, 1, 2, 1, 2), (3, 1, 2, 1, 2), (4, 1, 2, 1, 2), (1, 2, 2, 1, 2), (2, 2, 2, 1, 2), (3, 2, 2, 1, 2), (4, 2, 2, 1, 2), (1, 3, 2, 1, 2), (2, 3, 2, 1, 2), (3, 3, 2, 1, 2), (4, 3, 2, 1, 2)
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 1 1
(1)
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 3 4 5 6
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robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 2 2 2
(1, 1), (2, 1), (1, 2), (2, 2)
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 5 1 1 1 1 5
(1, 1, 1, 1, 1), (1, 1, 1, 1, 2), (1, 1, 1, 1, 3), (1, 1, 1, 1, 4), (1, 1, 1, 1, 5)
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 3 8 4 5
(1, 1, 1), (2, 1, 1), (3, 1, 1), (4, 1, 1), (5, 1, 1), (6, 1, 1), (7, 1, 1), (8, 1, 1), (1, 2, 1), (2, 2, 1), (3, 2, 1), (4, 2, 1), (5, 2, 1), (6, 2, 1), (7, 2, 1), (8, 2, 1), (1, 3, 1), (2, 3, 1), (3, 3, 1), (4, 3, 1), (5, 3, 1), (6, 3, 1), (7, 3, 1), (8, 3, 1), (1, 4, 1), (2, 4, 1), (3, 4, 1), (4, 4, 1), (5, 4, 1), (6, 4, 1), (7, 4, 1), (8, 4, 1), (1, 1, 2), (2, 1, 2), (3, 1, 2), (4, 1, 2), (5, 1, 2), (6, 1, 2), (7, 1, 2), (8, 1, 2), (1, 2, 2), (2, 2, 2), (3, 2, 2), (4, 2, 2), (5, 2, 2), (6, 2, 2), (7, 2, 2), (8, 2, 2), (1, 3, 2), (2, 3, 2), (3, 3, 2), (4, 3, 2), (5, 3, 2), (6, 3, 2), (7, 3, 2), (8, 3, 2), (1, 4, 2), (2, 4, 2), (3, 4, 2), (4, 4, 2), (5, 4, 2), (6, 4, 2), (7, 4, 2), (8, 4, 2), (1, 1, 3), (2, 1, 3), (3, 1, 3), (4, 1, 3), (5, 1, 3), (6, 1, 3), (7, 1, 3), (8, 1, 3), (1, 2, 3), (2, 2, 3), (3, 2, 3), (4, 2, 3), (5, 2, 3), (6, 2, 3), (7, 2, 3), (8, 2, 3), (1, 3, 3), (2, 3, 3), (3, 3, 3), (4, 3, 3), (5, 3, 3), (6, 3, 3), (7, 3, 3), (8, 3, 3), (1, 4, 3), (2, 4, 3), (3, 4, 3), (4, 4, 3), (5, 4, 3), (6, 4, 3), (7, 4, 3), (8, 4, 3), (1, 1, 4), (2, 1, 4), (3, 1, 4), (4, 1, 4), (5, 1, 4), (6, 1, 4), (7, 1, 4), (8, 1, 4), (1, 2, 4), (2, 2, 4), (3, 2, 4), (4, 2, 4), (5, 2, 4), (6, 2, 4), (7, 2, 4), (8, 2, 4), (1, 3, 4), (2, 3, 4), (3, 3, 4), (4, 3, 4), (5, 3, 4), (6, 3, 4), (7, 3, 4), (8, 3, 4), (1, 4, 4), (2, 4, 4), (3, 4, 4), (4, 4, 4), (5, 4, 4), (6, 4, 4), (7, 4, 4), (8, 4, 4), (1, 1, 5), (2, 1, 5), (3, 1, 5), (4, 1, 5), (5, 1, 5), (6, 1, 5), (7, 1, 5), (8, 1, 5), (1, 2, 5), (2, 2, 5), (3, 2, 5), (4, 2, 5), (5, 2, 5), (6, 2, 5), (7, 2, 5), (8, 2, 5), (1, 3, 5), (2, 3, 5), (3, 3, 5), (4, 3, 5), (5, 3, 5), (6, 3, 5), (7, 3, 5), (8, 3, 5), (1, 4, 5), (2, 4, 5), (3, 4, 5), (4, 4, 5), (5, 4, 5), (6, 4, 5), (7, 4, 5), (8, 4, 5)
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 7 1 1 1 2 1 1 4
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robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 2 12 12
(1, 1), (2, 1), (3, 1), (4, 1), (5, 1), (6, 1), (7, 1), (8, 1), (9, 1), (10, 1), (11, 1), (12, 1), (1, 2), (2, 2), (3, 2), (4, 2), (5, 2), (6, 2), (7, 2), (8, 2), (9, 2), (10, 2), (11, 2), (12, 2), (1, 3), (2, 3), (3, 3), (4, 3), (5, 3), (6, 3), (7, 3), (8, 3), (9, 3), (10, 3), (11, 3), (12, 3), (1, 4), (2, 4), (3, 4), (4, 4), (5, 4), (6, 4), (7, 4), (8, 4), (9, 4), (10, 4), (11, 4), (12, 4), (1, 5), (2, 5), (3, 5), (4, 5), (5, 5), (6, 5), (7, 5), (8, 5), (9, 5), (10, 5), (11, 5), (12, 5), (1, 6), (2, 6), (3, 6), (4, 6), (5, 6), (6, 6), (7, 6), (8, 6), (9, 6), (10, 6), (11, 6), (12, 6), (1, 7), (2, 7), (3, 7), (4, 7), (5, 7), (6, 7), (7, 7), (8, 7), (9, 7), (10, 7), (11, 7), (12, 7), (1, 8), (2, 8), (3, 8), (4, 8), (5, 8), (6, 8), (7, 8), (8, 8), (9, 8), (10, 8), (11, 8), (12, 8), (1, 9), (2, 9), (3, 9), (4, 9), (5, 9), (6, 9), (7, 9), (8, 9), (9, 9), (10, 9), (11, 9), (12, 9), (1, 10), (2, 10), (3, 10), (4, 10), (5, 10), (6, 10), (7, 10), (8, 10), (9, 10), (10, 10), (11, 10), (12, 10), (1, 11), (2, 11), (3, 11), (4, 11), (5, 11), (6, 11), (7, 11), (8, 11), (9, 11), (10, 11), (11, 11), (12, 11), (1, 12), (2, 12), (3, 12), (4, 12), (5, 12), (6, 12), (7, 12), (8, 12), (9, 12), (10, 12), (11, 12), (12, 12)

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```

robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 3 5 4 1
(1, 1, 1), (2, 1, 1), (3, 1, 1), (4, 1, 1), (5, 1, 1), (1, 2, 1), (2, 2, 1), (3, 2, 1), (4, 2, 1),
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(4, 4, 1), (5, 4, 1)
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 0
must pass at least two integers.
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 0 1
invalid number of parameters.
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 1 0
robert@C720:~/courses/CISC3130/bonus$ ./coord-iterative 1 7
(1), (2), (3), (4), (5), (6), (7)
robert@C720:~/courses/CISC3130/bonus$ g++ coord-recurse.cpp -o coord-recursive
robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 2 2 2
(1, 1), (1, 2), (2, 1), (2, 2)
robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 1 1
(1)
robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 1 8
(1), (2), (3), (4), (5), (6), (7), (8)
robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 3 5 4 1
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(5, 3, 1), (5, 4, 1)
robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 7 1 1 1 2 1 1 4
(1, 1, 1, 1, 1, 1, 1), (1, 1, 1, 1, 1, 1, 2), (1, 1, 1, 1, 1, 1, 3), (1, 1, 1, 1, 1, 1, 4), (1, 1,
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robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 2 12 12
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(12, 10), (12, 11), (12, 12)
robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 5 4 3 2 1 2
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2, 1, 1), (4, 3, 2, 1, 2)
robert@C720:~/courses/CISC3130/bonus$ ./coord-recursive 3 8 4 5
(1, 1, 1), (1, 1, 2), (1, 1, 3), (1, 1, 4), (1, 1, 5), (1, 2, 1), (1, 2, 2), (1, 2, 3), (1, 2, 4),
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(6, 4, 3), (6, 4, 4), (6, 4, 5), (7, 1, 1), (7, 1, 2), (7, 1, 3), (7, 1, 4), (7, 1, 5), (7, 2, 1),
(7, 2, 2), (7, 2, 3), (7, 2, 4), (7, 2, 5), (7, 3, 1), (7, 3, 2), (7, 3, 3), (7, 3, 4), (7, 3, 5),
(7, 4, 1), (7, 4, 2), (7, 4, 3), (7, 4, 4), (7, 4, 5), (8, 1, 1), (8, 1, 2), (8, 1, 3), (8, 1, 4),
(8, 1, 5), (8, 2, 1), (8, 2, 2), (8, 2, 3), (8, 2, 4), (8, 2, 5), (8, 3, 1), (8, 3, 2), (8, 3, 3),
(8, 3, 4), (8, 3, 5), (8, 4, 1), (8, 4, 2), (8, 4, 3), (8, 4, 4), (8, 4, 5)
robert@C720:~/courses/CISC3130/bonus$

```

```

robert@C720:~/courses/CISC3130/bonus$ g++ coord-iterative.cpp -o coord-iterative
robert@C720:~/courses/CISC3130/bonus$ g++ coord-recurse.cpp -o coord-recursive
robert@C720:~/courses/CISC3130/bonus$ time ./coord-recursive 5 5 5 5 5 5 > /dev/null
^C
real    4m57.059s
user    4m56.940s
sys     0m0.012s

robert@C720:~/courses/CISC3130/bonus$ time ./coord-iterative 5 5 5 5 5 5 > /dev/null

real    0m0.028s
user    0m0.008s
sys     0m0.000s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-recursive 2 50 50 > /dev/null
^C

real    3m12.837s
user    3m12.784s
sys     0m0.000s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-iterative 2 50 50 > /dev/null

real    0m0.021s
user    0m0.004s
sys     0m0.000s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-recursive 2 5 5 > /dev/null

real    0m0.015s
user    0m0.000s
sys     0m0.004s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-iterative 2 5 5 > /dev/null

real    0m0.020s
user    0m0.004s
sys     0m0.000s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-recursive 2 10 10 > /dev/null

real    0m0.322s
user    0m0.308s
sys     0m0.000s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-iterative 2 10 10 > /dev/null

real    0m0.023s
user    0m0.000s
sys     0m0.004s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-recursive 2 20 20 > /dev/null
^C

real    5m0.097s
user    5m0.032s
sys     0m0.004s
robert@C720:~/courses/CISC3130/bonus$ time ./coord-iterative 2 20 20 > /dev/null

real    0m0.021s
user    0m0.000s
sys     0m0.008s
robert@C720:~/courses/CISC3130/bonus$

```