CS302 Final Exam, December 10, 2013 - James S. Plank

Question 1: Sorting Algorithms

Part 1: Below are six outputs of sorting doubles, where we print the unsorted vector first, and then the vector after the first two iteration of the sorting algorithm. For each of these outputs, say whether it could be the result of selection sort, insertion sort, neither or both. You should assume that insertion sort does not sentinelize the first element.

Output A

```
Initial:      9.93 6.18 4.18 3.54 3.72 8.14 2.23 7.79
Iteration 0: 6.18 9.93 4.18 3.54 3.72 8.14 2.23 7.79
Iteration 1: 4.18 6.18 9.93 3.54 3.72 8.14 2.23 7.79
```

Output B

```
Initial:      7.34 0.27 8.95 2.85 3.49 2.46 2.13 0.22
Iteration 0: 0.27 7.34 8.95 2.85 3.49 2.46 2.13 0.22
Iteration 1: 0.27 7.34 8.95 2.85 3.49 2.46 2.13 0.22
```

Output C

```
Initial:      2.51 2.09 9.41 4.23 3.96 3.83 2.32 5.36
Iteration 0: 2.09 2.51 9.41 4.23 3.96 3.83 2.32 5.36
Iteration 1: 2.09 2.32 9.41 4.23 3.96 3.83 2.51 5.36
```

Output D

```
Initial:      8.63 3.23 1.56 8.19 3.60 0.30 7.18 4.01
Iteration 0: 3.23 1.56 8.19 3.60 0.30 7.18 4.01 8.63
Iteration 1: 1.56 3.23 3.60 0.30 7.18 4.01 8.19 8.63
```

Output E

```
Initial:      4.76 4.36 3.72 2.16 3.25 6.78 2.04 2.66
Iteration 0: 4.36 3.72 2.16 3.25 2.04 2.66 4.76 6.78
Iteration 1: 3.72 2.16 3.25 2.04 2.66 3.72 4.76 6.78
```

Output F

```
Initial:      6.05 7.32 6.33 7.50 3.37 4.62 7.09 6.44
Iteration 0: 3.37 7.32 6.33 7.50 6.05 4.62 7.09 6.44
Iteration 1: 3.37 4.62 6.33 7.50 6.05 7.32 7.09 6.44
```

Part 2: Show me the result of partitioning the vector $\{251, 983, 036, 783, 734, 186, 494, 469, 619\}$ using the "median of three" pivot selection.

Question 2: Dynamic Programming

Below is a dynamic program **GetCounts**(), which takes an integer **N**, and returns a vector of ten integers. It is correct, but it only implements "Step 1" of dynamic programming. Your job is to do "Step 2" -- memoize the program. The way I want you to do this is as follows: The answer sheet for Question 2 contains this code in its entirety. You need to modify the code by crossing out lines, and adding lines of code (put them in boxes and put arrows to where they should go).

I want to stress that you don't need to figure out what this code is doing. You do need to understand dynamic programming to the point where you can memoize this code correctly, even if you don't really know what it does.

```cpp
class XXX {
  public:
    long long GetCounts(int N);
    long long gc(string s, int zero);
};

long long XXX::gc(string s, int zero)
{
  int i, f, nz;
  string r, news;
  long long rv, one, rplus1;

  if (s.size() == 0) return 0;

  one = 1;
  rv = 0;
  if (s.size() == 1) {
    for (i = 1; i <= s[0]-'0'; i++) rv ^= (1L << i);
    if (zero) rv ^= 1;
    return rv;
  }

  f = s[0] - '0';
  for (i = 1; i < s.size() && s[i] == '0'; i++) ;

  nz = i-1;
  r = s.substr(nz+1);
  rplus1 = (r == "") ? 0 : atoi(r.c_str());
  rplus1++;
  rv ^= ((1L << f)*rplus1);
  rv ^= rplus1;

  if (r != "") rv ^= gc(r, 1);

  if (s[0] == '0') return rv;

  if (zero || s[0] > '1') news.push_back(s[0]-1);
  for (i = 1; i < s.size(); i++) news.push_back('9');
  return rv ^ gc(news, zero);
}

long long XXX::GetCounts(int N)
{
  string s;
  char buf[20];

  sprintf(buf, "%d", N);
  s = buf;
  return gc(s, 0);
}
```