#### Admin

- ♦ Today's topics
- Sorting, sorting, and more sorting!
- Reading
  - Ch 7
- Midterm next Tuesday evening
  - Terman Aud 7-9pm
- ♦ Boggle and late days

#### Selection sort code

```
void SelectionSort(Vector<int> &v)
{
  for (int i = 0; i < v.size()-1; i++) {
    int minIndex = i; // find index of min in range i to end
    for (int j = i+1; j < v.size(); j++) {
        if (v[j] < v[minIndex])
            minIndex = j;
        }
        Swap(v[i], v[minIndex]); // swap min to front
}</pre>
```

# Selection sort analysis

- Count work inside loops
  - First iteration does N-1 compares, second does N-2, and so on
     one swap per iteration

Lecture #15

```
N-I + N-2 + N-3 + ... + 3 + 2 + I
```

"Gaussian sum"

#### Add sum to self

 $N-1 + N-2 + N-3 + \dots + 3 + 2 + 1$ + 1 + 2 + 3 + \dots + N-2 + N-1 = N + N + N + \dots + N + N = (N-1)N Sum = 1/2 \* (N-1)N = O(N<sup>2</sup>)

# Insertion sort algorithm

- How you might sort hand of just-dealt cards...
  - Each subsequent element inserted into proper place
    - Start with first element (already sorted)
    - Insert next element relative to first
    - Repeat for third, fourth, etc.
    - Slide elements over to make space during insert



#### Insertion sort analysis

- Count work inside loops
  - First time inner loop does I compare/move
  - Second iteration does <= 2 compare/move, third <= 3, and so on</li>
  - Last iteration potentially N-I comparisons
- ♦ Cases
  - What is best case? Worst case?
  - Average (expected) case?

# Insertion vs Selection

- ♦ Big O?
- ♦ Mix of operations?
- Number of comparisons vs moves
- Best/worst inputs?
- ♦ Ease of coding?
- Why do we need multiple algorithms?

# Quadratic growth

- In clock time
  - 10,000 3 sec
  - 20,000 13 sec
  - 50,000 77 sec
  - 100,000 5 min
- Oouble input -> 4X time
  - Feasible for small inputs, quickly unmanagable
- ◇ Halve input -> 1/4 time
  - Hmm... can recursion save the day?
  - If have two sorted halves, how to produce sorted full result?









### Quadratic vs linearithmic

#### Compare SelectionSort to MergeSort

- 10,000 3 sec .05 sec
- 20,000 13 sec .15 sec
- 50,000 78 sec .38 sec
- 100,000 5 min .81 sec
- 200,000 20 min 1.7 sec
- 1,000,000 8 hrs (est) 9 sec

#### O(NlogN) is pretty good, can we do better?

- Theoretical result (beyond scope of 106B) no general sort algorithm better than NlogN
- But a better NlogN in practice?

# Quicksort idea

- ◇ "Divide and conquer" algorithm
  - Divide input into low half and high half
  - Recursively sort each half
  - Join two halves together
- "Hard-split easy-join"
  - Each element examined and placed in correct half
  - Join step is trivial