- Given a set of \( n \) points \( S \), find the smallest convex polygon containing all the points.
- We'll present the convex polygon as the ordered sequence of vertices.
Brute Force #1 \( O(n^4) \)

- Any point inside any triangle is not part of the hull
- Sort by polar angle around a centroid

Brute Force #2 \( O(n^2) \)

- For each line segment (pair of points) if all other points are on the same side of that line, the segment is part of the hull.
Graham's Scan

1. Find a known point on the hull $P$
2. Sort the remaining points by polar angle in counter-clockwise order around $P$
3. Process the points in consecutive triples $P_iP_2P_3$
   - If $\angle P_1P_2P_3 < 180^\circ$ then $P_2$ is in the interior of the triangle $PP_1P_3$ therefore not part of the hull
- If $\angle P_1P_2P_3 < \pi$ discard $P_2$ and try $P_0P_2P_3$

- otherwise advance to $P_2P_3P_4$
GrahamScan(Q)
1. let \( p_0 \) be the point in \( Q \) with the lowest \( y \)-coordinate \( \Theta(n) \)
2. let \( \langle p_1, p_2, \ldots, p_m \rangle \) be the remaining points in \( Q \)
   sorted by polar angle around \( p_0 \) \( \Theta(n \log n) \)
3. if \( m < 2 \)
    4. return "convex hull is empty"
5. else let \( S \) be an empty stack
6. \( \text{Push}(p_0, S) \)
7. \( \text{Push}(p_1, S) \)
8. \( \text{Push}(p_2, S) \)
9. for \( i = 3 \) to \( m \)
10. \( \text{while} \) the angle formed by \( p_i \) and the top 2 elements of \( S \) makes a non-left turn
11. \( \text{Pop}(S) \)
12. \( \text{Push}(p_i, S) \)
13. return \( S \)
PotD: Singleton Finder

- Given a sorted array in which each element appears twice and one element appears only once. Give a divide and conquer algorithm to find that element with complexity $O(\log n)$

- Example

  input: [1, 1, 3, 3, 4, 5, 5, 7, 7, 8, 8]
  output: 4