You may work in pairs for this assignment. If you choose to work with a partner, make sure only one of you submits a solution, and you paste a copy of the Partners Template that contains the names and PIDs of both students at the beginning of the file you submit.

Prepare your answers to the following questions, either in a plain text file or a typed MS Word document. Solutions submitted in other formats will be discarded. Partial credit will only be given if you show relevant work or give a relevant justification for your answer.

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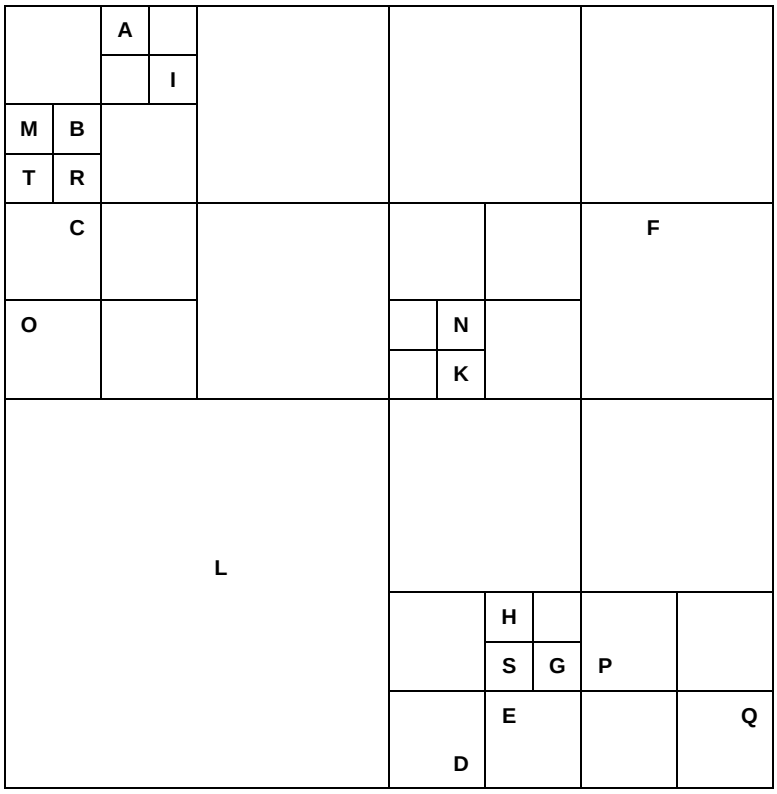
1. **[15 points]** Consider the algorithm for insertion into a PR quadtree, assuming a bucket size of 1. Suppose that a data object was inserted, and its coordinates matched those of a data object already stored in the tree. What would happen if the insertion algorithm did not reject the insertion of such a duplicate object?

2. **[20 points]** Suppose that a PR quadtree, with bucket size 1, represents a region in the *xy*-plane bounded between (0, 0) and (2^10, 2^10). Suppose further that we insert two data objects *A* and *B*, corresponding to locations that are separated by a distance of 5 units. Given only that much information, give the most precise statement you can regarding how many region splits will be required in order to separate *A* and *B*? Justify your answer carefully.

3. The diagram below shows a partitioned world, which can be represented by a PR quadtree, with bucket size 1.



a) **[15 points]** How many leaf nodes (nonempty) would the quadtree have?

b) **[15 points]** How many internal nodes would the quadtree have?

4. Suppose a PR quadtree stores 972 data objects.

a) **[5 points]** If the bucket size is 1, what is the minimum number of levels the tree could have? Why?

b) **[5 points]** If the bucket size is 2, what is the minimum number of levels the tree could have? Why?

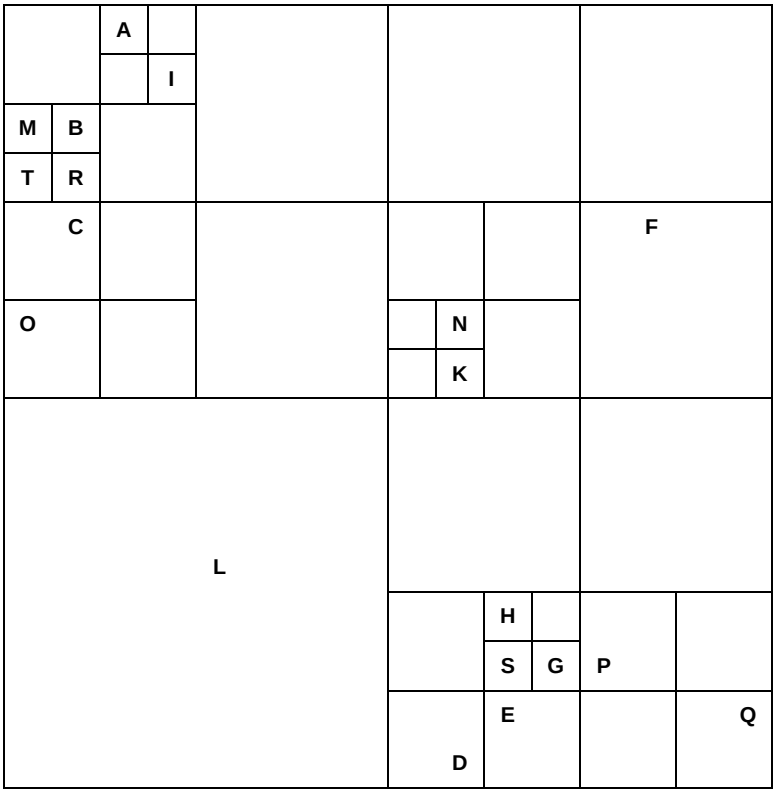
c) **[5 points]** If the bucket size is 4, what is the minimum number of levels the tree could have? Why?

d) **[5 points]** If the bucket size is 8, what is the minimum number of levels the tree could have? Why?

5. **[15 points]** Haskell Hoo IV, a noted blogger, suggests that if you implement buckets in your PR quadtree leaf nodes, then the bucket for a leaf node should itself be a PR quadtree whose world is simply the region that corresponds to that leaf node. He asserts that's more elegant than using some sort of linear structure for the bucket (which is an entirely subjective claim), and he also asserts that his suggestion will improve efficiency in both memory cost and search cost (which is an objective claim).

Simply from a coding perspective, there's nothing difficult about having a PR quadtree whose leaves also contain PR quadtree objects.

Comment on Hoo's suggestion. Be precise.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