In the following problems, $B$ is the block size, and $M$ is the memory capacity. You can assume $M \geq B^2$ if necessary.

**Problem 1.** Let $L = \{\ell_1, \ldots, \ell_l\}$ be a set of $l$ vertical lines in $\mathbb{R}^2$, where $l = B^{O(1)}$. Let $S$ be a set of $N$ horizontal segments such that each segment in $S$ has its endpoints on two different lines in $L$. Given a vertical ray $r$ shooting downwards from a point, a query reports all the segments in $S$ intersecting $r$. Give a structure on $S$ that consumes $O(N/B)$ space, and answers a query in $O(1 + K/B)$ I/Os, where $K$ is the number of segments reported. Your structure also needs to support an insertion and a deletion in $O(\log BN)$ I/Os amortized.

**Problem 2.** Let $S$ be a set of $N$ horizontal segments in $\mathbb{R}^2$. Give a structure on $S$ that consumes $O(N/B)$ space, and answers a query of Problem 1 in $O(\log_B^2 N + K/B)$ I/Os, where $K$ is the number of segments reported. Your structure also needs to support an insertion and a deletion in $O(\log_B^2 N)$ I/Os amortized.

**Problem 3 (three-sided range reporting on rectangles).** Let $S$ be a set of axis-parallel rectangles in $\mathbb{R}^2$. Given a 3-sided rectangle $q = [x_1, x_2] \times [y, \infty)$, a query reports all the rectangles in $S$ that intersect $q$. Describe a fully dynamic structure on $S$ that consumes $O(N/B)$ space, answers a query in $O(\log_B^2 N + K/B)$ I/Os (where $K$ is the number of reported rectangles), and supports an update in $O(\log_B^2 N)$ I/Os amortized.