

$O(n^2)$ solution

Let's look at every pair of cars. Define the cars we are observing as i and j . Assume WLOG that $s_i < s_j$. We can "imagine" that car i doesn't move and that car j moves at a speed of $s_j - s_i$, similar to the idea of frames of reference in physics. Now we have a much simpler problem, we have reduced it to counting how many times car j crosses some point in a circle of circumference d after some time t has passed.

Depending on whether or not $p_i \leq p_j$ we have 2 cases:

Case 1: $p_i \geq p_j$

$$\lfloor \frac{t(s_j - s_i) + d - (p_i - p_j)}{d} \rfloor$$

Case 2: $p_i < p_j$

$$\lfloor \frac{t(s_j - s_i) - (p_i - p_j)}{d} \rfloor$$

$O(n \log n)$ solution

Notice that the formula in case 1 can be made equivalent to the formula in case 2 by just removing the d from the fraction and adding 1 if $p_i \geq p_j$. Now we can try to simplify it.

$$\begin{aligned} \lfloor \frac{t(s_j - s_i) - (p_i - p_j)}{d} \rfloor + [p_i \geq p_j] &\iff \\ \lfloor \frac{ts_j - ts_i - p_i + p_j}{d} \rfloor + [p_i \geq p_j] &\iff \\ \lfloor \frac{ts_j + p_j - ts_i - p_i}{d} \rfloor + [p_i \geq p_j] \end{aligned}$$

Now, notice that this fraction has 2 independent parts, the one related to car j and the one related to car i and if it weren't for the fact that we are dealing with floor division, we could've easily split it into the 2 parts and counted everything separately. But what if we did that anyways?

Turns out we can indeed do that, after a bit of error correction. That's because when we split it into those 2 parts during floor division, we might be off by one. That happens when the difference of $ts_j + p_j \bmod d$ and $ts_i + p_i \bmod d$ is smaller than 0. After accounting for this case the formula

looks like:

$$\lfloor \frac{ts_j + p_j}{d} \rfloor - \lfloor \frac{ts_i + p_i}{d} \rfloor + [p_i \geq p_j] - [(ts_j + p_j) \bmod d < (ts_i + p_i) \bmod d]$$

The 2 conditions can be kept track of using a point add range query data structure, such as Fenwick tree or segment tree.