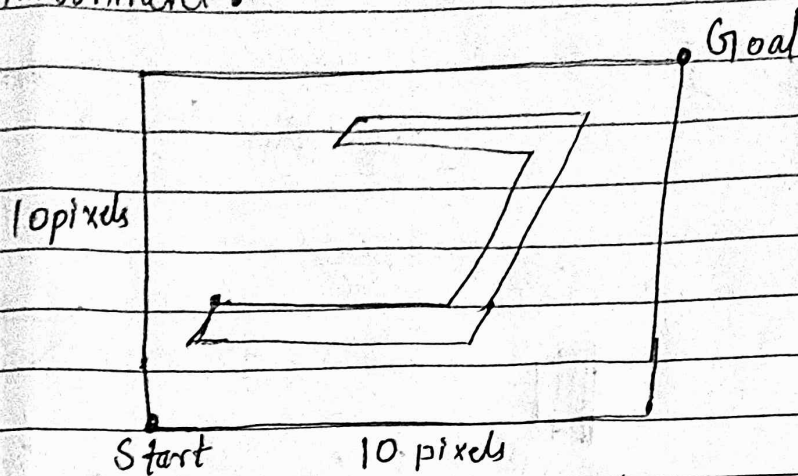


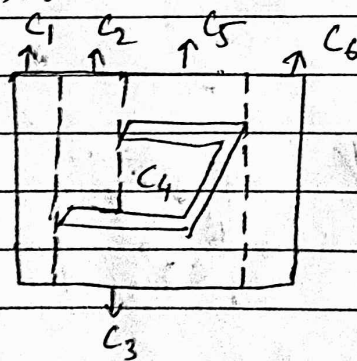
Q.1. → Environment:



Now, we need to find the time taken by a robot with sensing radius of ~~1~~ 1 pixel at a time to cover all the empty space.

• We will be doing this using Moore decomposition.  
 → Connectivity We send a line 'L' through environment and look for critical points, as connectivity of 'L' changes in free space at critical points.

Following are the cells and critical points we get, & as we get the critical points we start covering the environment.

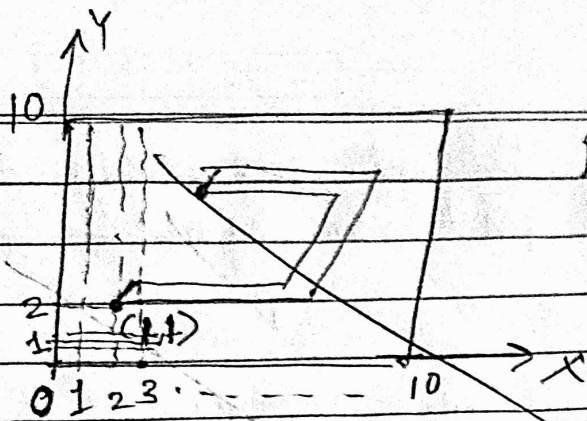


(Assumption:  
 Robot takes  
 one step in 1 sec)  
 i.e. 1 pixel/step

Now, ~~when~~ we pass line L, we cover the cells & detect critical points

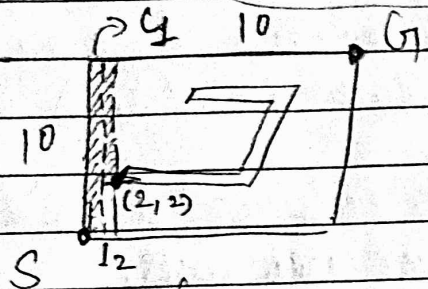
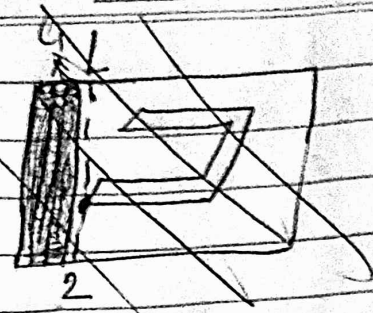
① we ~~cover~~

→ We choose upper cell to cover whenever there is a split in free space due to obstacle.



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1<sup>st</sup> step



Rebb Graph

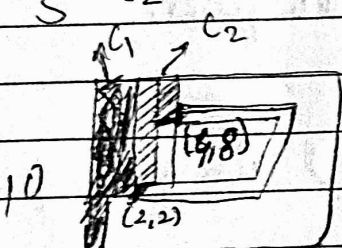
Time taken

To cover  $C_1$

$$\Rightarrow 10 + 8$$

$$\Rightarrow 18 \text{ sec}$$

Rebb Graph



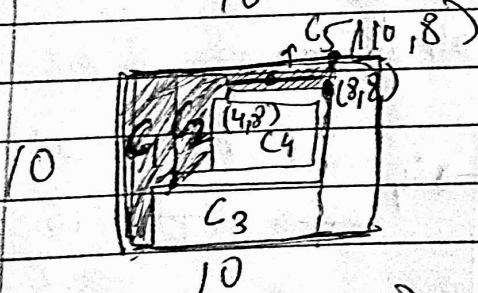
Cover  $C_2$

$$\Rightarrow 8 + 2$$

$$\Rightarrow 10 \text{ sec}$$

$\therefore$  Total  $C_1 + C_2$

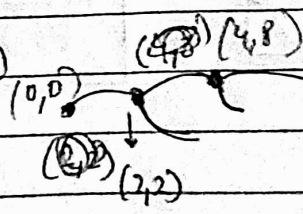
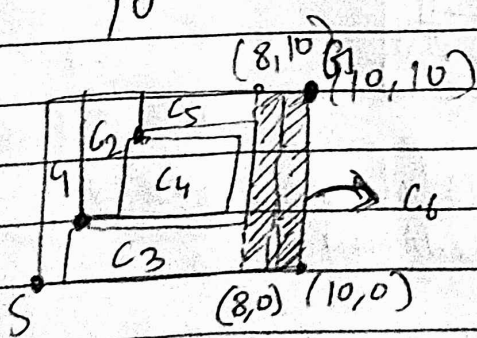
$$\Rightarrow 28 \text{ sec}$$



Cover  $C_3$

$$C_3 = 8$$

$$\text{Total} = 36 \text{ sec}$$



$C_5$

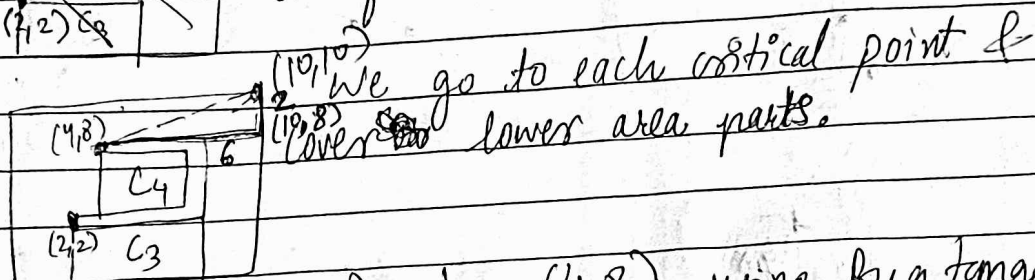
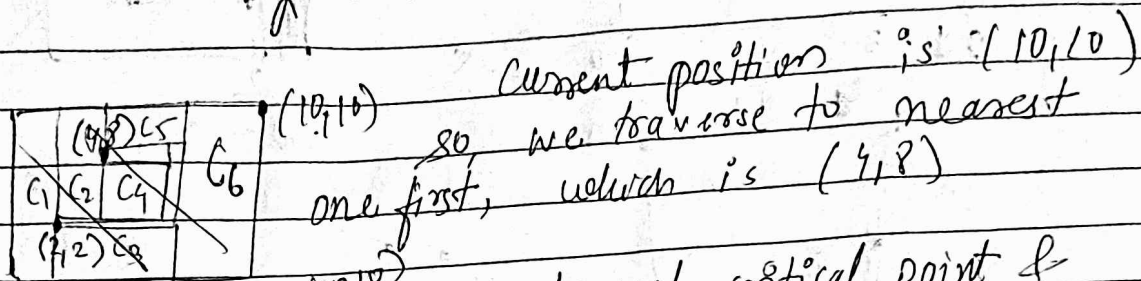
$$\text{Total} = 56 \text{ sec}$$

Now, we search for critical points that have uncovered cells in using Rebb Graph

So, two critical cells are not covered  $C_3$  &  $C_4$  & their critical points are  $(2,2)$  for  $C_3$  &  $(4,8)$  for  $C_4$



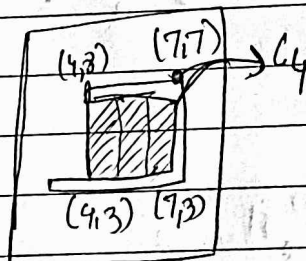
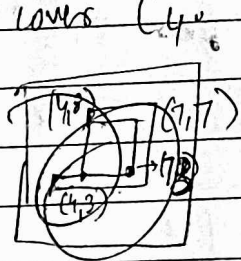
Now, we by using Tangent Bug Algorithm we traverse to critical points one by one & cover the remaining cells.



1<sup>st</sup> case: Now, (10,10) to (4,8) using Bug tangent Algo

$$\Rightarrow 2\sqrt{10} \Rightarrow 6 \text{ steps} - (1)$$

Now, we reached (4,8) critical point & we cover C4.



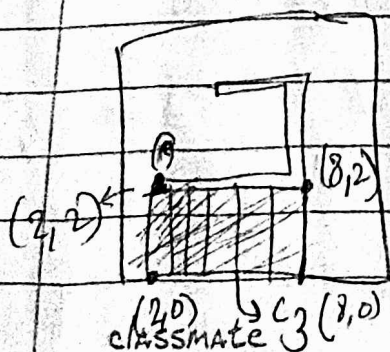
For C4 coverage  
 $\rightarrow 15 \text{ pix} \times 15 \text{ secs}$   
 $+ 6 \text{ secs}$

$$\Rightarrow 21 \text{ secs}$$

$$\therefore \text{Total} = \underline{\underline{77 \text{ secs}}}$$

until Now

Now, going (4,8) to (2,2) using Tangent Bug Algorithm



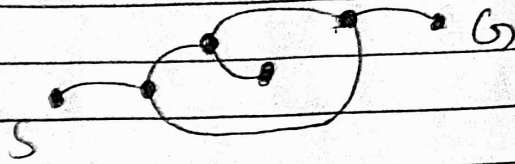
$$\text{Total steps} = 6 \text{ steps} \Rightarrow 6 \text{ secs}$$

$$\text{Total steps to cover } C_3 = 6 \text{ secs} + 12 \text{ secs} \Rightarrow 18 \text{ secs}$$

~~Total Time~~

$\therefore$  Total Time taken =  $77 + 18 \text{ sec}$   
 $\Rightarrow 95 \text{ sec}$

Reb graph in the end:



$\therefore$  Total Time ~~is~~ cover =  $95 \text{ sec}$