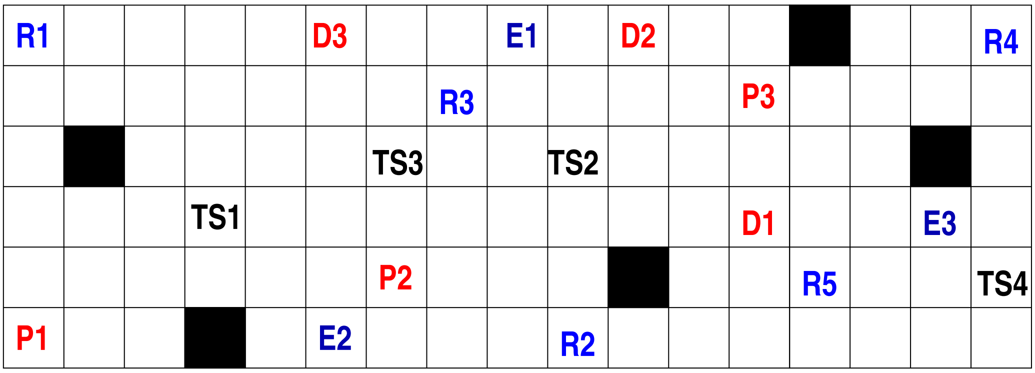
Problems for Assignments:

1. **[Multi Agent Path Finding]** Consider a warehouse and a set of robots which pick up items from designated places, deliver those in desired locations, and finally the robots go to the end location. Assume that the warehouse is represented as a 2-D grid of size $n \times m$. Each location (L_i) on warehouse floor can be denoted by a pair of integers $L_i = (x_i, y_i)$. Each cell on the grid can be categorized in one of the following ways (see diagram below) - source location (P1-P3), destination location (D1-D3), temporary storage location (TS1-TS4), obstacle (black square), normal (rest of the cells). Source & destination denote pick-up and drop locations respectively. Temporary storage location denotes the place where robot can keep some items. Obstacle represents a location where no robot can move. Rest of the cells are considered as normal cell. Let there be k number of robots and r number of tasks. The details of robot location and tasks are provided as per the following table.

Robot	Location		Task	Location	
	Init	Final		pick-up	deliver
Robot-1	R1	E1	Task-1	P1	D1
Robot-2	R2	E2	Task-2	P2	D3
Robot-3	R1	E2	Task-3	P1	D3
...	...	...	...	...	...

Assume that the a robot can move at most one cell (either vertically or horizontally) at a time step, a normal cell can be occupied by at most one robot. Source, destination, temporary storage locations can accommodate multiple robots simultaneously. Our target here is develop a work schedule that minimizes the time to complete all tasks. You need to develop both optimal as well as heuristic algorithms.



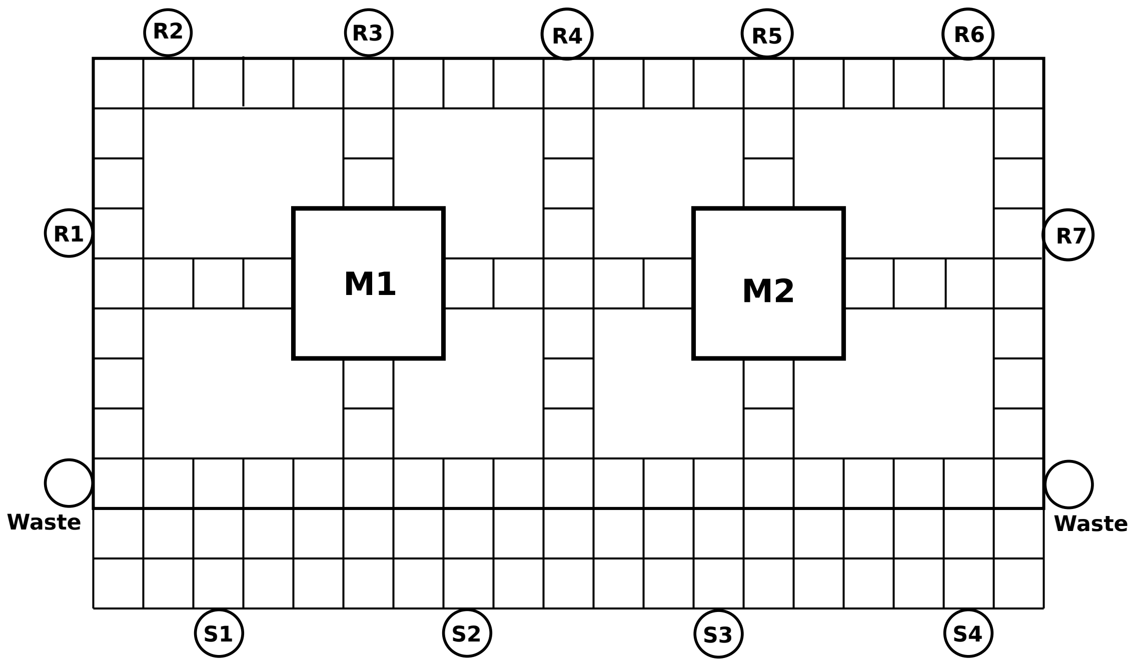
2. **[Microfluidics]** Consider the following layout for microfluidic operations. In the diagram R1-R7 denote the reservoir for chemicals with 100% concentration. Both M1 & M2 are mixer and splitter modules. Such a module can take an unit volume of liquid of two different chemicals each, mix them to produce a less concentrated liquid droplet and split them into two droplets with equal volume. For example, when a 100% concentrated droplet of chemicals C1 and C2 each are mixed, the resultant mixture will have concentration of 50% for each of the chemicals and the concentration is denoted as (1:1). If a droplet with concentration (1:1) (C1:C2) is mixed with a pure droplet of C1, the resultant droplet will have concentration (3:1) [This can be derived from - $(C1 + \frac{C1}{2} : \frac{C2}{2})$]. In the diagram, S1-S4 are location where final solution (single droplet) with desired concentration of the chemicals will be collected. Any unwanted droplet needs to be dumped into waste reservoir. Given the following information and constraints, our target is to minimize the time to complete preparation of all chemical solutions and route it to desired location.

   (a) The layout can be considered as 2D cell structure. Each cell can contain at most one droplet of liquid at a time. A droplet can move either in horizontal/vertical (no diagonal) direction or remain idle at a cell. At a time two consecutive cells (either horizontal or vertical) cannot be occupied by two droplets.

   (b) A reservoir can hold unlimited amount of liquid. Location of reservoirs are fixed and will be provided as input. Such input will indicate the cell number to which the reservoir is connected.

   (c) Location of mixer/splitter modules are fixed. It can accommodate only two droplets at a time. Once the mixing and splitting are done, two droplets may need to be taken out of the module and routed to the appropriate place.

   (d) Target concentration for different chemical solutions. S1 - (C11 : C12 : C13 : C14 : C15 : C16 : C17), C11-C17 are all integers. Similarly for S2, S3, S4.



You need to develop optimal as well as heuristic algorithms.

3. **[Electric vehicles]** Consider a city network where we need to route a set of electric vehicles which may require to be charged during its journey from some source to some destination. Let us assume that we have n cities $(v_1, v_2, \ldots, v_n)$ and the distance between cities v_i and v_j be e_{ij} (if two cities are not connected directly then $e_{ij} = \infty$ and $e_{ij} = e_{ji})$. Assume that each city has a single charging station which can charge one EV at a time. Consider a set of k EVs namely $P_1, P_2, \ldots, P_k$. For each EV the following information is provided -

   (a) S_r - source node

   (b) D_r - destination node

   (c) B_r - battery charge status initially

   (d) c_r - charging rate for battery at a charging station (energy per unit time)

   (e) d_r - discharging rate of battery while traveling (distance travel per unit charge)

   (f) M_r - maximum battery capacity

   (g) s_r - average traveling speed (distance per unit time).

   Assume that all vehicles start their journey at $t = 0$ and P_r reaches it destination at $t = T_r$. We need to route all the vehicles from their respective sources to destinations such that $\max\{T_r\}$ is minimized. You need to develop both optimal as well as heuristic algorithms.