# Instructions

- This is the first part of the competition. There are 4 questions and it is 15 pages long. Please confirm that you have the proper booklet and that no pages are missing.

- You have 2 hours and 15 minutes to write this part of the competition.

- Please first write your group number on each page of this booklet. Note that failure to do so may result in your answers getting lost and your group receiving no marks for the corresponding questions.

- For each question, there is space in this booklet for writing your answer. Please write your final solutions in the indicated places, in the format explained in the questions. Answers stated on any other papers will NOT be marked.

- Please submit only the answer sheets that you want marked.

- Answers that are infeasible will be heavily penalized. Please ensure that all your answers satisfy the constraints given in each of the questions.

1   Winter is HERE!

The Night King has risen and marches south towards the Wall along with his summoned army of white walkers. It is now up to the Night's Watch to save Westeros by preventing the white walkers from passing through the Wall. As Lord Commander of the Night's Watch, you must devise a strategy to defeat the army of the dead. You have your work cut out for you indeed, but luckily you have the support of your valiant army of diverse soldiers. The Night's Watch ranks are currently comprised of the following categories of soldiers: the Rangers, the Wildlings and the Giants. Rangers are known for their formidable sword skills and as the name suggests, are excellent riders. The Giants can bring about substantial damage but are limited by their mobility. The Wildlings, although great fighters, lack in discipline and strategy. In order to catch the White Walkers off guard, a section of the Night's Watch will march out to meet them head on in the battlefield. There must be **at least 2 different types of soldiers** represented (for example, you cannot send out only rangers). The battlefield can be pictured as a simple map, as shown below, where each of the squares can be thought to be occupied by a white walker.


The Wall
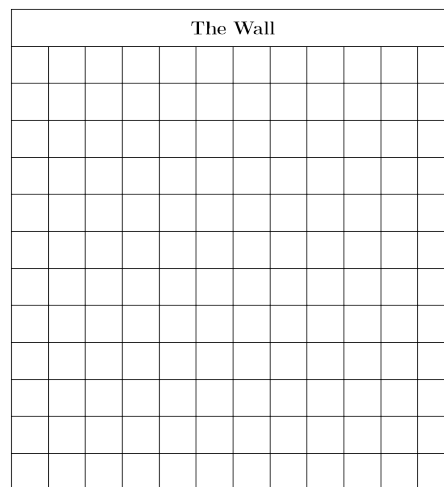
Each of the soldiers of the Night's Watch can only defend specific areas. The Rangers can cover an L-shape, i.e. two blocks horizontally and one vertically or two blocks vertically and one horizontally. The Wildlings can cover any number of blocks but only diagonally and of the two types of Giants one with a horizontal cover and the other with a vertical cover. To provide a better understanding, a pictorial representation of the characters are given:
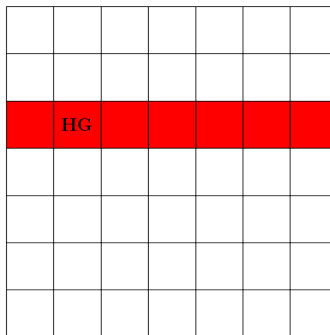
- **Ranger**: Two blocks horizontally and one vertically or two blocks vertically and one horizontally.
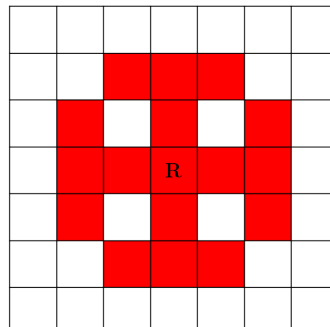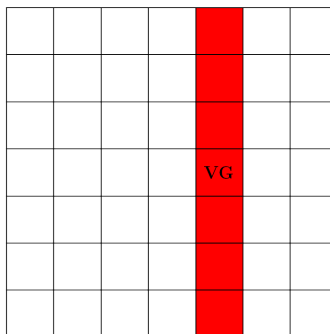
- **Wildling**: Covers any number of blocks diagonally.
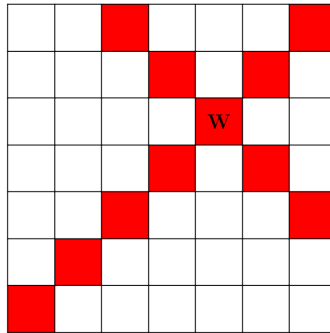
- **Horizontal covering Giant**: Covers any number of blocks horizontally.

- **Vertical covering Giant**: Covers any number of blocks vertically.

Even with a well-trained versatile army the Night's Watch's only chance of victory lies in Dragon Glass. Legend states that the only way to slay a White Walker is with weapons forged of Dragon Glass. Hence, as a Lord Commander, whomever you send out to battle must wield such a weapon. Currently, the Night's Watch has 30 pieces of Dragon Glass. To properly equip a Ranger, a long sword must be fashioned from **6 pieces of Dragon Glass**. In other words, every time you send a Ranger out to the field your Dragon Glass stock goes down by six. A Wildling carries a spear requiring **5 pieces of Dragon Glass** whereas a Giant is equipped with specially crafted gloves with shards of Dragon Glass laced in requiring only **4 pieces**. Given the lack of visibility beyond the wall the soldiers of Night's Watch must be strategically placed to avoid accidentally running

into each other. A character **cannot** be placed within the area that can possibly be traversed by other characters.

Acceptable placement

Not Acceptable placement
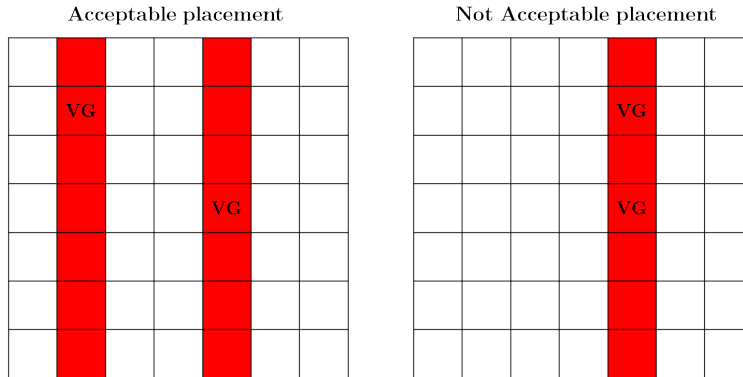
You must place your characters in such a way so as to maximize the area that are covered by all characters placed on the map bearing in mind the above restrictions. Winter has finally arrived.

Note: If any of the restrictions mentioned are violated, a character will be removed from you solution in the order of Ranger, Wildling then Giant until a valid solution is found!

Please draw your solution in the following map.

Please mark the location where you want to place a character using the following letters: R – Ranger; W – Wildling; VG – Vertical moving Giant; HG - Horizontal moving Giant.

The Wall												
	1	2	3	4	5	6	7	8	9	10	11	12
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	1	2	3	4	5	6	7	8	9	10	11	12
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2   Save Gotham City

Once again, the villains of Gotham City have risen up in an attempt to send the citizens into chaos. Dr. Crane, commonly known as 'Scarecrow' has finally perfected his scare toxin into a soluble form which he plans to pour into the city's main water reservoir. Luckily, Batman is able to track down Scarecrow and his goons, but upon arrival he finds them pouring the last of the toxin into the main reservoir. He springs into action taking out the goons but Scarecrow flees the scene.

The **only** option that Batman has is to salvage as much water as possible from the three reservoirs using the faucets (see picture below) by transferring clean water into containers before the toxin spreads from the main reservoir to the three adjacent reservoirs.
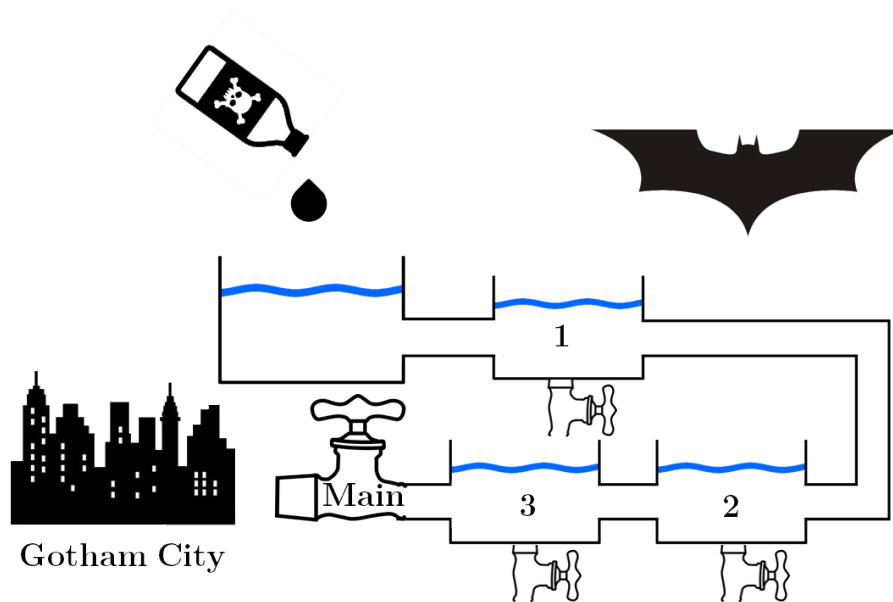
He only has access to a limited number of containers which are next to each faucet. The system is originally full of clean water. The toxin infected water flows through the system corrupting each reservoir along the way. Batman has **15 minutes** to extract water from reservoir 1 before the toxin spreads. He then jumps in the batmobile and drives to the second reservoir, where he has **35 minutes** to extract clean water. He then drives to the final reservoir leaving him **20 minutes** to transfer water before he must close main valve in order to prevent the release of the infected water.

Important Information

- At **each** reservoir there are **five different types of containers**. They are of different capacities, quantities and can be filled at different rates (see tables on the next page).

- Filling up different containers takes specific amounts of time. This varies depending on the shape of the container's opening given some spilling is unavoidable.

- It is not possible to transfer water from one container to another later on given that Batman must travel as quickly as possible from one reservoir to the next and can't bring full containers with him.

- The total time that he has for **reservoirs 1, 2 and 3** are **15, 35, and 20 minutes** respectively.

- Batman can only have **one** valve open at a time and must close it before the toxin arrives to avoid releasing any infected water.

- **Only** the containers beside a particular reservoir can be used to save water from that reservoir. For example, you cannot use a container belonging to reservoir 1 for saving water from reservoir 2.

- Once you start filling up a container you **must fill it to capacity**. This means you will use the full time allocated for filling it.

Reservoir 1(15 mins)

Type of Container	Capacity (Liters)	Time to Fill (min)	Available Number of Containers
Container 1	150	2	10
Container 2	300	3	5
Container 3	450	4	6
Container 4	500	5	6
Container 5	650	6	4

Reservoir 2(35 mins)

Type of Container	Capacity (Liters)	Time to Fill (min)	Available Number of Containers
Container 1	100	1	5
Container 2	350	3	5
Container 3	450	4	3
Container 4	500	6	3
Container 5	700	8	2

Reservoir 3(20 mins)

Type of Container	Capacity (Liters)	Time to Fill (min)	Available Number of Containers
Container 1	100	2	6
Container 2	350	4	5
Container 3	450	5	6
Container 4	500	5	7
Container 5	700	6	2

Question

How much clean water can Batman save?

Answer

The number of containers of each type used for reservoir 1 is:

container 1 _____ container 2 _____ container 3 _____ container 4 _____ and container 5 _____.

This is a total of _____ liters which takes _____ minutes to fill.

The number of containers of each type used for reservoir 2 is: container 1 _____ container 2 _____ container 3 _____ container 4 _____ and container 5 _____.

This is a total of _____ liters which takes _____ minutes to fill.

The number of containers of each type used for reservoir 3 is:

container 1 _____ container 2 _____ container 3 _____ container 4 _____ and container 5 _____.

This is a total of _____ liters which takes _____ minutes to fill.

The total amount of clean of water saved is _____.

Note: Your solution will be penalized if the time spent filling containers at a reservoir exceeds the limit. The volume of your average sized container will be deducted from your total amount of clean water!

3   Survival Problem: the Mighty Maze

A survival maze, as outlined in the diagram below, represents a challenge for the bravest. Once you enter the maze, you have to cross through to the end following the directions of the given paths. Inside, there are 3 different types of zones: safety zones colored in green (total of 5 green circles), danger zones colored in red, and a free zone colored in purple (oval-shaped after entrance).
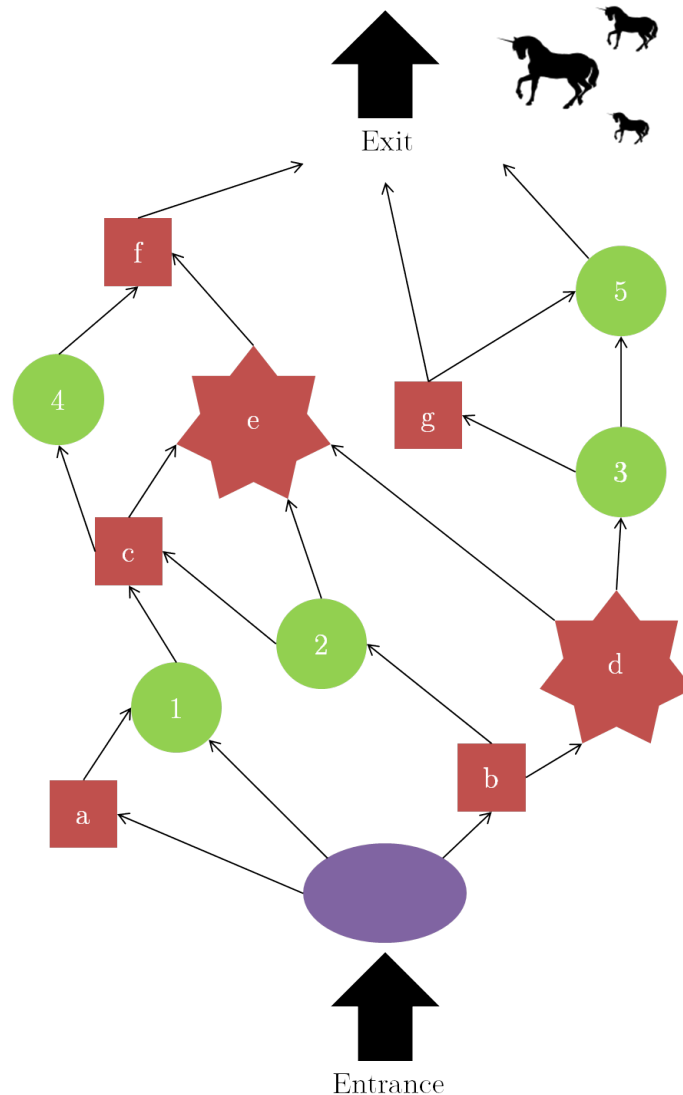
In order to survive going through the game, you are equipped with a backpack to carry water and food. The backpack has a limit of 54 units of food and water together. You have to fill your backpack with units of food and water in the free zone providing that you respect the limitation of the backpack. Inside the maze, you will consume 2 units of water and 1 unit of food every hour. Crossing a safety zone takes 15 hours while crossing a big danger zone takes 10 hours and a small danger zone 7 hours (see table 2). Safety zones have extra supplies to refill your backpack but in limited quantities as shown in table 1. When crossing safety zones you still consume resources at the given rates but, you can restock your backpack at will using the amount of water and food available in that zone respectively.

More importantly, you have no more than 45 hours to get out of the maze. Otherwise the exit will be blocked by angry unicorns.

Danger Zone	Time (hours)
a	7
b	7
c	7
d	10
e	10
f	7
g	7
Safety Zones	15

Table 1: Danger and safety zone crossing times

Safety Zone	Food	Water
1	-	12
2	35	65
3	6	10
4	25	45
5	15	30

Table 2: Limited supplies of the different safety zones

Question

Do you think you stand a chance of making it out alive?
1. What is the fastest path to cross the maze?

Use Table **??** to test different paths and help you determine whether or not you will survive crossing the Maze.

Path	Time	Supply Shortage	Survivability

Table 3: Crossing time of each path and whether or not a supply shortage will take place

Answer

1. After finding the fastest path to cross the Mighty Maze, use the following table to submit your answer.

Path	Units added to backpack		Units remaining after crossing the zone	
	Water	Food	Water	Food
Free Zone				

The fastest path to cross the maze is (e.g. b-d-3-g): _____.

Note: If you can't determine a path that meets all constraints, list a path which allows you to make it through the maze only violating the 45 hour time limit. (By as little as possible)

2. The maximum time you will survive inside is: _____.

4   A Foodie's Adventure

Chloe Williams, an Aussie food blogger based in Amsterdam loves travelling and discovering different cuisines around the world. Next summer, she is heading to Montreal to discover its gastronomic diversity for a whole day and you are the lucky Montrealers accompanying her!

Chloe established a list of restaurants, coffee shops, and eateries she plans to visit during her stay. Her diverse selection of what is thought to be a foodie's hottest summer picks includes:

- Brigade (B)

- Juliette & Chocolat (JC)

- Hoogan & Beaufort (HB)

- Hvor (H)

- Foxy (F)

- Laurea (L)

- Manitoba (M)

- Salmigondis (S)

- Tapas24 (T)

- Victoria Pier (VP)

These different food hangouts as well as the cost of travel between them are shown on the map of Figures 1 and 2. Ideally, she will be able to visit all of these places while minimizing travel expenses and occasionally visiting touristic spots. The different places she is going to visit as well as the cost of travelling between them are shown on the map of Figure 2. In addition, the surrounding touristic spots are included on the map of Figure 3. During her stay she is staying at the St Paul Hotel shown on the map of Figures 1, 2, and 3.
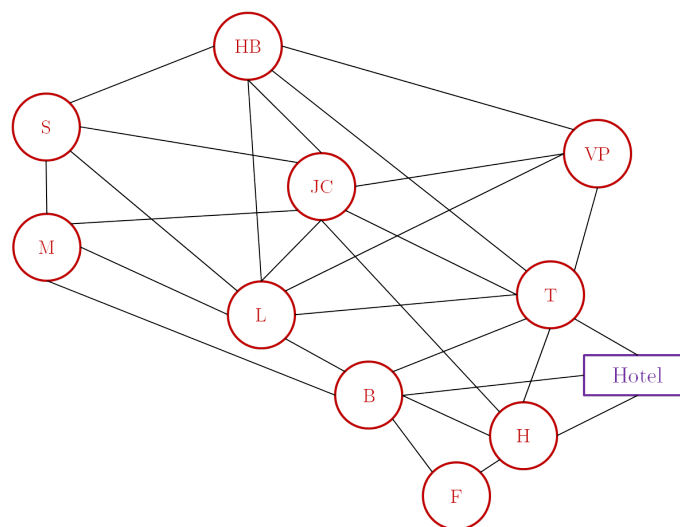

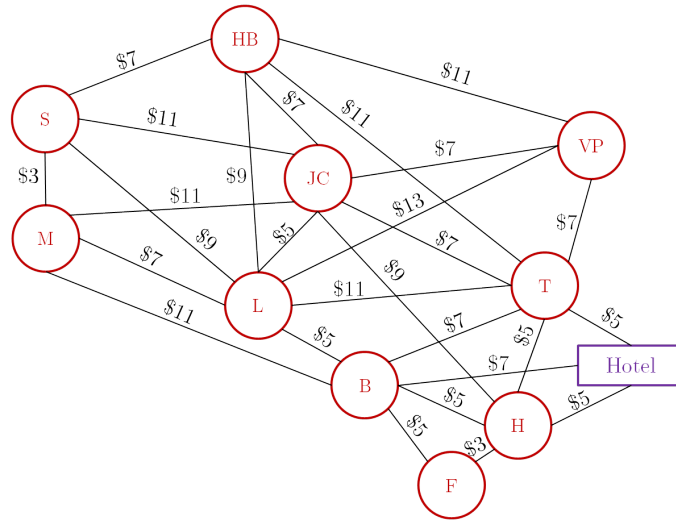Figure 1: Map of the food hangouts Chloe is trying out in Montreal

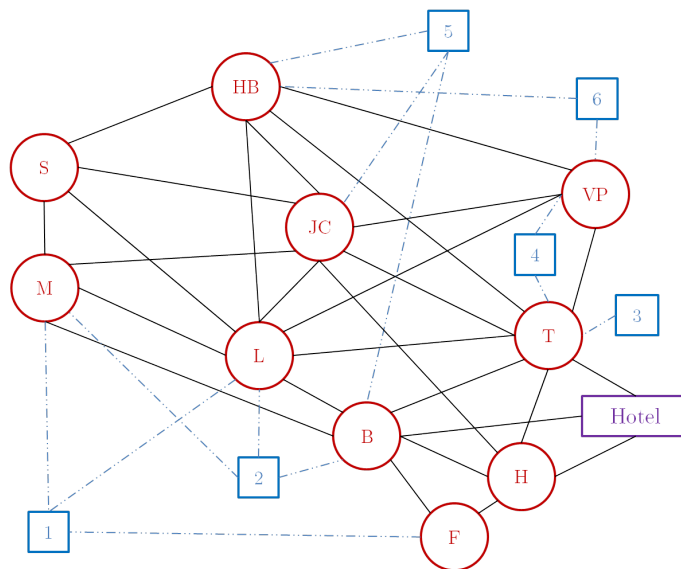Figure 2: Map of the food hangouts and the cost of travel between them

Figure 3: Map of the food hangouts and touristic spots in Montreal

	Food Hangouts										
	Brigade (B)	Juliette& Chocolat (JC)	Foxy (F)	Hoogan& Beaufort (HB)	Hvor (H)	Laurea (L)	Manitoba (M)	Salmigondis (S)	Tapas24 (T)	Victoria Pier (VP)	Hotel
Brigade (B)	-	-	$5	-	$5	$5	$11	-	$7	-	$7
Juliette& chocolat (JC)	-	-	-	$7	$9	$5	$11	$11	$7	$7	-
Foxy (F)	$5	-	-	-	$3	-	-	-	-	-	-
Hoogan& Beaufort (HB)	-	$7	-	-	-	$9	-	$7	$11	$11	-
Hvor (H)	$5	$9	$3	-	-	-	-	-	$5	-	$5
Laurea (L)	$5	$5	-	$9	-	-	$7	$9	$11	$13	-
Manitoba (M)	$11	$11	-	-	-	$7	-	$3	-	-	-
Salmigondis (S)	-	$11	-	$7	-	$9	$3	-	-	-	-
Tapas24 (T)	$7	$7	-	$11	$5	$11	-	-	-	$7	$5
Victoria Pier (VP)	-	$7	-	$11	-	$13	-	-	$7	-	-
Hotel	$7	-	-	-	$5	-	-	-	$5	-	-

Table 1: Cost of travel between the different food hangouts

Questions

1. Can you help Chloe establish and plan the least costing tour of the **food hangouts** starting from her hotel, visiting each place once, and returning to the hotel? (*e.g. Hotel-B-M-VP-...-Hotel*)

The least costing tour is:_____.

Total cost: _____.

2. The food blogger would like to visit a few touristic spots in addition to her tour of food hangouts. Can you determine the shortest path between the places Chloe is visiting (food hangouts) and the surrounding touristic spots using the map in Figure 3? *(e.g. HB-S, S-L, L-VP, VP-4, 4-T, T-3 ...)* This way, when she is at any location on her list she will know the nearest point of interest. The traveling costs between the food hangouts and touristic spots are given in Table 3.

(Hint: Find a network of the least costing paths linking all the locations including food hangouts and touristic spots. Do not worry about how it would interfere with the tour established in the previous question.)

		St Joseph's Oratory (1)	Mount Royal Park (2)	Pointe-à-Callière Museum (3)	Notre Dame Basilica(4)	Olympic Stadium (5)	Old Montreal (6)
				Touristic spots			
Food hangouts	Brigade (B)	-	$3.75	-	-	$15.00	-
	Juliette&chocolat (JC)	-	-	-	-	$9.90	-
	Foxy (F)	$9.75	-	-	-	-	-
	Hoogan&Beaufort (HB)	-	-	-	-	$5.25	$7.80
	Hvor (H)	-	-	-	-	-	-
	Laurea (L)	$9.00	$4.35	-	-	-	-
	Manitoba (M)	$8.40	$7.20	-	-	-	-
	Salmigondis (S)	-	-	-	-	-	-
	Tapas24 (T)	-	-	$0.75	$0.60	-	-
	Victoria Pier (VP)	-	-		$2.70	-	$1.35

Table 2: Cost of travel between the food hangouts and touristic spots

Use the following map to help you determine the network.
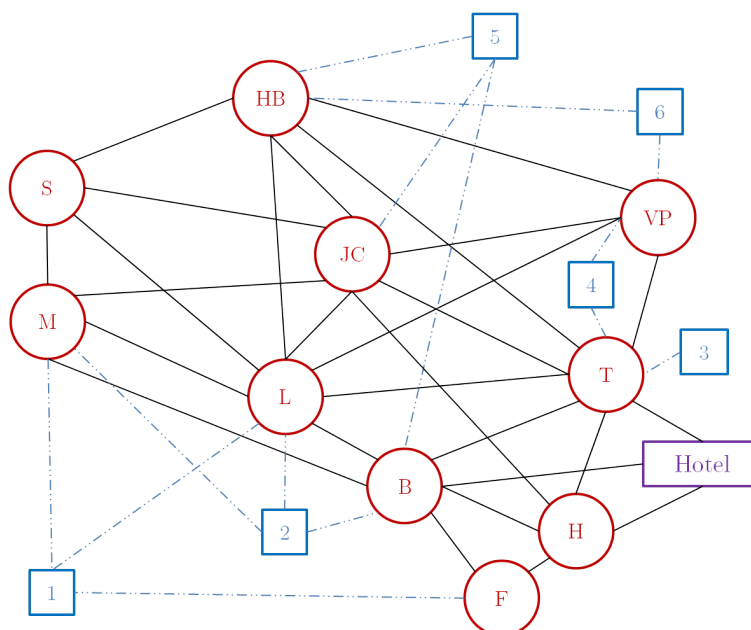
The shortest network of paths between the different places of Montreal, shown in figure 3, is: _____.