

Travelling Salesman Problem: THEME PARK Answer Worksheet

TASK

You are helping to organise a school trip to Hamilton's Adventure Park in October.

Your teacher is arranging the transport. A coach will drop you off at the Park gates at 10am, but they need to know what time you will be leaving. The coach will be staying at the Park until you are ready to leave and will be charging an hourly rate during this time. The school is funding the trip, although they only have a limited budget and they want to make it as cheap as possible.

Therefore, in order to keep the transport costs as low as possible, it is up to you to plan the quickest route around Hamilton's Adventure Park. As you will have standard tickets, you need to allocate time to queue for entry to the Park. You will also need to allow time for you and your friends to visit each main attraction once before returning to the Park gates, and include a 30 minute lunch break.

INFORMATION GATHERING

1. What information do you need to consider for this task?

- Lunch Break length,
- How far apart rides are (distance)
- How long rides taken to queue,
- How long rides take to complete (duration)
- What time you start

2. Complete the table below to complete the network and show the quickest routes between all attractions

	Park Gates	Animal Kingdom	Carnival Land	Corkscrew	Log Flume	Wonder Wheel	The Hole	Roller Coaster
Park Gates	-	8m	12m	11m	14m30s	14m	23m	22m30s
Animal Kingdom	8m	-	20m	3m	6m30s	20m	17m30s	29m30s
Carnival Land	12m	20m	-	23m	20m	6m30s	15m30s	10m30s
Corkscrew	11m	3m	23m	-	6m30s	20m	17m30s	28m
Log Flume	14m30s	6m30s	20m	6m30s	-	13m30s	11m	21m30s
Wonder Wheel	14m	20m	6m30s	20m	13m30s	-	9m	9m30s
The Hole	23m	17m30s	15m30s	17m30s	11m	9m	-	10m30s
Roller Coaster	22m30s	29m30s	10m30s	28m	21m30s	9m30s	10m30s	-

UPPER AND LOWER BOUNDS

Lowest Upper Bound - Nearest Neighbour Algorithm

1. Pick any starting vertex
2. Consider the edges that join the starting vertex to other vertices. Pick the edge with the minimum weight and add this to the cycle
3. Repeat step 2 until all vertices have been chosen
4. Add the edge that joins the last vertex to the first vertex to complete the cycle

Highest Lowest Bound - Minimum Spanning Tree / Prim's Algorithm

1. Pick any vertex. Remove the two connecting edges with least weight
2. Find the minimum spanning tree for the other vertices using Prim's Algorithm:
 - a. From any start vertex, draw the lowest valued edge to start your tree
 - b. From any vertex on your tree, add the edge with the lowest value

- c. If there are $n-1$ edges in your tree, you have finished. If not, repeat step b
3. Add back in the two edges previously removed
4. The weight of the resulting graph (which may not be a cycle) is a lower bound
5. Repeat steps 1-4 for each vertex. The largest result is the overall lower bound

3. Applying the Nearest Neighbour Algorithm, complete the Table below:

Starting vertex	Tour using Nearest Neighbour Algorithm	Weight of tour
Park Gates	PG, AK, C, LF, TH, WW, CL, RC, PG	$8m + 3m + 6m30 + 11m + 9m + 6m30 + 10m30 + 22m30 = 77m$
Animal Kingdom	AK, C, LF, TH, WW, CL, RC, PG, AK	$3m + 6m30 + 11m + 9m + 6m30 + 10m30 + 22m30 + 8m = 77m$
Carnival Land	CL, WW, TH, LF, AK, C, PG, RC, CL	$6m30 + 9m + 11m + 6m30 + 3m + 11m + 22m30 + 10m30 = 80m$
	CL, WW, TH, LF, C, AK, PG, RC, CL	$6m30 + 9m + 11m + 6m30 + 3m + 8m + 22m30 + 10m30 = 77m$
Corkscrew	C, AK, LF, TH, WW, CL, RC, PG, C	$3m + 6m30 + 11m + 9m + 6m30 + 10m30 + 22m30 + 11m = 80m$
Log Flume	LF, AK, C, PG, CL, WW, TH, RC, LF	$6m30 + 3m + 11m + 12m + 6m30 + 9m + 10m30 + 21m30 = 80m$
	LF, C, AK, PG, CL, WW, TH, RC, LF	$6m30 + 3m + 8m + 12m + 6m30 + 9m + 10m30 + 21m30 = 77m$
Wonder Wheel	WW, CL, RC, TH, LF, AK, C, PG, WW	$6m30 + 10m30 + 10m30 + 11m + 6m30 + 3m + 11m + 14m = 73m$
	WW, CL, RC, TH, LF, C, AK, PG, WW	$6m30 + 10m30 + 10m30 + 11m + 6m30 + 3m + 8m + 14m = 70m$
The Hole	TH, WW, CL, RC, LF, AK, C, PG, TH	$9m + 6m30 + 10m30 + 21m30 + 6m30 + 3m + 11m + 23m = 91m$
	TH, WW, CL, RC, LF, C, AK, PG, TH	$9m + 6m30 + 10m30 + 21m30 + 6m30 + 3m + 8m + 23m = 88m$
Roller Coaster	RC, WW, CL, PG, AK, C, LF, TH, RC	$9m30 + 6m30 + 12m + 8m + 3m + 6m30 + 11m + 10m30 = 67m$

5. What is the Lowest Upper Bound?

67 minutes

5. Applying the Minimum Spanning Tree/Prim's Algorithm, complete the Table below:

Vertex deleted	Total weight of Minimum Spanning Tree	Total weight of two shortest edges connected to deleted vertex	Lower Bound
Park Gates	$3m + 6m30 + 6m30 + 9m + 9m30 + 11m = 45m30$	$8m + 12m = 20m$	$65m30$
Animal Kingdom	$6m30 + 6m30 + 9m + 9m30 + 11m + 11m = 53m30$	$3m + 6m30 = 9m30$	$63m$
Carnival Land	$3m + 6m30 + 8m + 9m + 9m30 + 11m = 47m$	$6m30 + 10m30 = 17m$	$64m$
Corkscrew	$6m30 + 6m30 + 8m + 9m + 9m30 + 11m = 50m30$	$3m + 6m30 = 9m30$	$60m$
Log Flume	$3m + 6m30 + 8m + 9m + 9m30 + 11m30 = 47m30$	$6m30 + 6m30 = 13m$	$60m30$
Wonder Wheel	$3m + 6m30 + 8m + 10m30 + 10m30 + 11m = 49m30$	$6m30 + 9m = 15m30$	$65m$
The Hole	$3m + 6m30 + 6m30 + 8m + 9m30 + 12m = 45m30$	$9m + 10m30 = 19m30$	$65m$
Roller Coaster	$3m + 6m30 + 6m30 + 8m + 9m + 11m = 44m$	$9m30 + 10m30 = 21m$	$65m$

6. What is the Highest Lower Bound?

65 minutes and 30 seconds

7. Solution

a. What is the most reasonable tour time and route of Hamilton's Adventure Park?

477 minutes (7 hours 57 minutes) – This

b. Using the tour time from Question 7a. and the information from Question 1, use the space below to outline how long you will be in the Park altogether and what time you will need the coach to collect you from the Park Gates.

The total time at Hamiltons Adventure Park is 477 minutes (7 hours 57 minutes).

This is made up from the total tour time (67 minutes) plus queing / ride time for attractions (350 minutes), plus entry to the park (30 minutes) plus a lunch break (30 minutes).

We now know that 8 hours is the minimum required time to visit Hamilton's Adventure Park in October. **Therefore, as the coach is dropping you off at the Park Gates for 10am, it will need to collect you again at 6pm.**

**This point can be up for discussion – What about toilets?*

**Some of you may have decided to allocate an extra hour in the Park for toilet breaks, snacks, or extra rides. In which case, the coach will need to collect you from the Park Gates at 7pm instead.*

We would have started at the Roller Coaster, then gone to the WonderWheel, then the Carnival Land, then the Park Gates, then the Animnal Kingdwom then the Corkscrew, then the Log Flume then the The Hole and finally the Rollercoaster.