HW 8: Vehicle Routing

ISE 754: Logistics Engineering | Fall 2019

Assigned: Wed, 13 Nov (Groups of 2) | Due: 11:30a, Wed, 20 Nov

Solve questions 1(a), 2(a) and 3(a) by hand (you can submit a scanned copy of your solution, or you can just turn in a paper copy in class) and then, for questions 1(b), 2(b), 3(b)–6, create a script in Matlab that performs the calculations needed to answer each question, one cell for each part of each question. Please submit your script and diary/published output file via Moodle.

1. (a) Given the initial location sequence 1, 5, 2, 6, 4, 3, 1 with a total distance of 22, use the table below to determine the final location sequence determined after applying the *twoopt* improvement procedure by hand to the sequence. The total distance (TD) of each possible of 120 possible sequences is listed in the table. Include the order in which each sequence is considered by the procedure.

Seq								TD	Seq								TD	Seq								TD
1	1	2	3	4	5	6	1	38	41	1	3	5	6	2	4	1	32	81	1	5	3	4	2	6	1	24
2	1	2	3	4	6	5	1	25	42	1	3	5	6	4	2	1	24	82	1	5	3	4	6	2	1	25
3	1	2	3	5	4	6	1	23	43	1	3	6	2	4	5	1	30	83	1	5	3	6	2	4	1	27
4	1	2	3	5	6	4	1	30	44	1	3	6	2	5	4	1	22	84	1	5	3	6	4	2	1	19
5	1	2	3	6	4	5	1	28	45	1	3	6	4	2	5	1	21	85	1	5	4	2	3	6	1	12
6	1	2	3	6	5	4	1	20	46	1	3	6	4	5	2	1	29	86	1	5	4	2	6	3	1	20
7	1	2	4	3	5	6	1	31	47	1	3	6	5	2	4	1	28	87	1	5	4	3	2	6	1	13
8	1	2	4	3	6	5	1	22	48	1	3	6	5	4	2	1	14	88	1	5	4	3	6	2	1	9
9	1	2	4	5	3	6	1	40	49	1	4	2	3	5	6	1	29	89	1	5	4	6	2	3	1	20
10	1	2	4	5	6	3	1	47	50	1	4	2	3	6	5	1	20	90	1	5	4	6	3	2	1	18
11	1	2	4	6	3	5	1	31	51	1	4	2	5	3	6	1	32	91	1	5	6	2	3	4	1	25
12	1	2	4	6	5	3	1	39	52	1	4	2	5	6	3	1	39	92	1	5	6	2	4	3	1	28
13	1	2	5	3	4	6	1	37	53	1	4	2	6	3	5	1	25	93	1	5	6	3	2	4	1	31
14	1	2	5	3	6	4	1	33	54	1	4	2	6	5	3	1	33	94	1	5	6	3	4	2	1	24
15	1	2	5	4	3	6	1	21	55	1	4	3	2	5	6	1	32	95	1	5	6	4	2	3	1	25
16	1	2	5	4	6	3	1	33	56	1	4	3	2	6	5	1	21	96	1	5	6	4	3	2	1	19
17	1	2	5	6	3	4	1	38	57	1	4	3	5	2	6	1	26	97	1	6	2	3	4	5	1	27
18	1	2	5	6	4	3	1	34	58	1	4	3	5	6	2	1	26	98	1	6	2	3	5	4	1	18
19	1	2	6	3	4	5	1	34	59	1	4	3	6	2	5	1	23	99	1	6	2	4	3	5	1	20
20	1	2	6	3	5	4	1	25	60	1	4	3	6	5	2	1	22	100	1	6	2	4	5	3	1	41
21	1	2	6	4	3	5	1	20	61	1	4	5	2	3	6	1	34	101	1	6	2	5	3	4	1	32
22	1	2	6	4	5	3	1	41	62	1	4	5	2	6	3	1	42	102	1	6	2	5	4	3	1	22
23	1	2	6	5	3	4	1	32	63	1	4	5	3	2	6	1	39	103	1	6	3	2	4	5	1	33
24	1	2	6	5	4	3	1	22	64	1	4	5	3	6	2	1	35	104	1	6	3	2	5	4	1	25
25	1	3	2	4	5	6	1	39	65	1	4	5	6	2	3	1	41	105	1	6	3	4	2	5	1	25
26	1	3	2	4	6	5	1	26	66	1	4	5	6	3	2	1	39	106	1	6	3	4	5	2	1	33
27	1	3	2	5	4	6	1	25	67	1	4	6	2	3	5	1	25	107	1	6	3	5	2	4	1	31
28	1	3	2	5	6	4	1	32	68	1	4	6	2	5	3	1	40	108	1	6	3	5	4	2	1	17
29	1	3	2	6	4	5	1	28	69	1	4	6	3	2	5	1	32	109	1	6	4	2	3	5	1	17
30	1	3	2	6	5	4	1	20	70	1	4	6	3	5	2	1	31	110	1	6	4	2	5	3	1	32
31	1	3	4	2	5	6	1	31	71	1	4	6	5	2	3	1	33	111	1	6	4	3	2	5	1	20
32	1	3	4	2	6	5	1	20	72	1	4	6	5	3	2	1	31	112	1	6	4	3	5	2	1	19
33	1	3	4	5	2	6	1	34	73	1	5	2	3	4	6	1	24	113	1	6	4	5	2	3	1	34
34	1	3	4	5	6	2	1	34	74	1	5	2	3	6	4	1	20	114	1	6	4	5	3	2	1	32
35	1	3	4	6	2	5	1	27	75	1	5	2	4	3	6	1	21	115	1	6	5	2	3	4	1	25
36	1	3	4	6	5	2	1	26	76	1	5	2	4	6	3	1	33	116	1	6	5	2	4	3	1	28
37	1	3	5	2	4	6	1	31	77	1	5	2	6	3	4	1	26	117	1	6	5	3	2	4	1	31
38	1	3	5	2	6	4	1	26	78	1	5	2	6	4	3	1	22	118	1	6	5	3	4	2	1	24
39	1	3	5	4	2	6	1	18	79	1	5	3	2	4	6	1	30	119	1	6	5	4	2	3	1	19
40	1	3	5	4	6	2	1	19	80	1	5	3	2	6	4	1	25	120	1	6	5	4	3	2	1	13

(b) Use the distance data in the following table and `tsp2opt` to solve the same problem.

d_{ij}	1	2	3	4	5	6
1	0	8	6	9	1	5
2	3	0	1	5	4	2
3	9	2	0	3	1	1
4	8	2	1	0	10	6
5	6	7	10	1	0	10
6	6	2	5	2	1	0

2. (a) The two tables below list the travel times between six nodes and a time window for each node. Given a delivery vehicle route that starts from the depot located at node 1 and then visits each customer (i.e., node) in the sequence 4, 2, 5, 3, and 6 and then returns to the depot, determine the minimum total time span (in hours) needed to complete all deliveries and return to the depot. Loading/unloading time and vehicle capacity can be ignored. The time window for each node indicates the earliest and latest times at which the delivery can be made; for example, the earliest time at which the vehicle can depart the depot (node 1) is 6:00, and the latest time at which it can return is midnight (24:00).

Travel Time (hrs)

Node	1	2	3	4	5	6
1	0	2	2	2	1	2
2	2	0	3	2	3	3
3	2	3	0	3	2	2
4	2	2	3	0	3	1
5	1	3	2	3	0	3
6	2	3	2	1	3	0

Time Window

Node	Earliest	Latest
1	6:00	24:00
2	9:00	12:00
3	18:00	21:00
4	9:00	18:00
5	15:00	18:00
6	21:00	24:00

(b) Use the same data and `rteTC` to solve the problem.

3. (a) Determine the minimum total logistics cost returned by *minTLC* for three shipments if the following route is used: 2, 3, 2, 1, 3, 1. The two tables below list the distances between each location and data for each shipment. A truck's cubic and weight capacities are 2,750 ft^3 and 25 tons, respectively, and the PPI for TL is 125. The inventory carrying rate for each shipment is 0.3, and each product is batch produced and consumed at a constant rate.

Inter-Location Distances (mi)

Location	1	2	3	4	5	6
1	0	180	320	100	100	40
2	180	0	140	80	240	140
3	320	140	0	220	300	280
4	100	80	220	0	240	60
5	180	240	300	240	0	220
6	40	140	280	60	220	0

Shipment Data

Shipment	1	2	3
Demand (ton/yr)	200	300	100
Density (lb/ft^3)	20	5	10
Begin Location	6	3	2
End Location	5	1	4
Value ($/ton)	20,000	5,000	10,000

(b) Use the same data and `minTLC` to solve the problem.

4. Consolidated Package Systems has hub in Knoxville, TN. The location of the hub is provided in the worksheet *Q4-DC* of spreadsheet *HW8data.xlsx*, while the worksheet *Q4-Customers* contains, for 180 customers that are to be served tomorrow, their location, number of packages, and whether packages are to be delivered in the morning (*M*) between 8–12, the afternoon (*A*) between 12–5, or evening (*E*) between 5–9 pm. The maximum number of packages on board each identical van cannot exceed 30, and each driver can work a maximum of eight hours per day. Each delivery to a customer takes two minutes irrespective of the number of packages delivered. Most of the customers are at residential locations and any differences in the physical weight and cube of the packages can be ignored. Each vehicle travels at 70 mph on rural Interstate highways, 50 mph on urban Interstate highways, 20 mph on non-Interstate urban roads, 45 mph on the remaining rural roads, and 15 mph on the connector links and residential roads. Your routes should use all of the roads that are in a 12% expanded rectangle that encloses the depot and customers. Determine the number of vans needed for tomorrow's deliveries along with the route of each van.

5. A 3PL would like to establish a set of regular routes (or "milk runs") that they can use to supply customers in the Carolinas with a variety of different products. The worksheet *Q5-Data* of the spreadsheet *HW8data.xlsx* lists the origin (*orig*) and destination (*dest*) zip codes and the volume (*cu*, ft^3), weight (*wt*, lb), annual demand (*ud*), and cost (*uc*, \$) of each unit of 64 products. The 3PL pays each supplier when the product is picked up and is not paid by the customer for the product until it is used (i.e., a vendor managed inventory scenario). Assuming that the demand of each customer is fairly constant throughout the year, the inventory carrying rate is 0.3, and that there is space to store up to a full truckload at each customer's location, determine the best set of routes to use. P2P TL or LTL can be used for transport for some of the shipments, in addition to the use of consolidated loads.

6. Using Shipments 1, 3, 26, and 5 of the 30 shipments in *shmtNC30.mat* (see link on schedule) with a transport rate for TL of \$2 per mile and capacities of 2,750 ft^3 and 25 tons, determine the transport charge for each shipment would be under equal charge, equal savings, and exact and approximate Shapley allocation.