ICA 3: Great Circle Distances

ISE 453: Design of PLS Systems — Spring 2020

Using a copy of the *Template-Location.xltx* spreadsheet template (see Schedule), create two separate worksheets within a single spreadsheet to solve the following three problems. You should save the template to your "Custom Office Templates" folder.

$$(lon_1, lat_1) = (x_1, y_1), \quad (lon_2, lat_2) = (x_2, y_2)$$

$$x_{\text{deg}} = \begin{cases} DD + \dfrac{MM}{60} + \dfrac{SS}{3,600}, & \text{if } E \text{ or } N \\ -DD - \dfrac{MM}{60} - \dfrac{SS}{3,600}, & \text{if } W \text{ or } S \end{cases}$$

$$d_{rad} = (\text{great circle distance in radians of a sphere})$$

$$= \cos^{-1}\left[\sin y_2 \sin y_1 + \cos y_2 \cos y_1 \cos(x_1 - x_2)\right]$$

$$R = (\text{radius of earth at equator}) - (\text{bulge from north pole to equator})$$

$$= 3,963.34 - 13.35 \sin\left(\frac{y_1 + y_2}{2}\right) \text{ mi}, \quad = 6,378.388 - 21.476 \sin\left(\frac{y_1 + y_2}{2}\right) \text{ km}$$

$$d_{GC} = \text{distance } (x_1, y_1) \text{ to } (x_2, y_2) = \boxed{d_{rad} \cdot R}$$

$$x_{\text{rad}} = \frac{x_{\text{deg}}}{180}\pi \quad \text{and} \quad x_{\text{deg}} = \frac{x_{\text{rad}} \cdot 180}{\pi}$$

1. Determine the NF location that minimizes total great-circle distance to Gainesville, FL, Baghdad, Iraq, and Rio de Janeiro, Brazil, where the *x* and *y* location (in degrees) cells for the NF are now the cells that should be changed in Solver in order to determine the optimal location for a single NF. (Note: In Solver, the box "Make Unconstrained Variable Non-Negative" should be unchecked.)

	dd	mm	ss		x (deg)	x (rad)	dd	mm	ss		y (deg)	y (rad)	d(rad)	d (mi)	f	r	w	TC
NF					0	0					0	0						12,753.24
Gainesville	82	20	11	W	-82.3364	-1.43704	29	40	27	N	29.67417	0.517912	1.454668	5760.37	1	1.00	1.00	5,760.37
Baghdad	44	22		E	44.36667	0.774344	33	14		N	33.23333	0.580031	0.929845	3681.744	1	1.00	1.00	3,681.74
Rio de Janeiro	43	12		W	-43.2	-0.75398	22	57		S	-22.95	-0.40055	0.834879	3311.126	1	1.00	1.00	3,311.13

2. A product, that will use all ubiquitous raw materials, is to be produced in a plant that will be located along I-40. Finished product will be shipped from the plant to customers in Asheville, Winston-Salem, Durham, and Wilmington. The total annual demand of these customers is 150, 120, 75, and 40 tons, respectively, and it costs $0.10 per ton-mile to ship finished goods from the plant. Determine where the plant should be located by creating a worksheet that duplicates the one below (where only shaded cells are inputs and all others are calculated), and then use Solver to determine the "optimal" location for the NF (the plant location) by changing the NF location cell (initial value 150) to minimize the total transport cost target cell (initial value $3,960).

	x (mi mark)	d (mi)	f (ton/yr)	r ($/ton-mi)	w ($/yr-mi)	TC ($/yr)
NF	150					3,960.00
Asheville	50	100	150	0.10	15.00	1,500.00
Winston-Salem	190	40	120	0.10	12.00	480.00
Durham	270	120	75	0.10	7.50	900.00
Wilmington	420	270	40	0.10	4.00	1,080.00

3. Re-solve Question 2 of ICA 2 using a spreadsheet (can now easily determine *TC*).