Module 14 Practice Problems – Draft

1) **<u>NORMAN!!!</u>**

Norman Bates is the General Manager of the 30-room Bates Motel. He has decided, based upon the urging of his mother, who owns the Bates Motel, to fix up the motel and create two kinds of rooms – Standard and Luxury. Luxury rooms will net $75 of profit per night, while Standard rooms will net $50 per night. Consider these 'fixed', as these figures have been set by Mrs. Bates with strict restrictions on modifications.

Norman, a taxidermist in his spare time, uses stuffed animals to display as decoration in the hotel rooms (people come from miles around to stay in the hotel due to the uniqueness of his taxidermy work – thus, it is also safe to assume 'away' any room demand issues). He has decided that each luxury room will get 2 such works of art, and each standard room a single animal.

The luxury rooms will also have special amenities in the shower area. Among many other items, the shower and bathroom area will be equipped with 3 pairs of Dolby speakers (linked to the in-room stereo system). Each regular room will have a single pair of speakers.

Surprisingly, based upon Norman's expertise, each luxury room will require only 10 minutes to clean each day, while each regular room will require 20 minutes. Norman wishes to allocate no more than 9 hours each day in cleaning the rooms AS A HARD CONSTRAINT.

ADDITIONALLY, TREAT THE NUMBER OF ROOMS AS A HARD CONSTRAINT (NO MORE THAN 30).

Find the optimal number of Luxury and Standard rooms that addresses the following goals stated in order of importance.

1. Use at least 50 speakers
2. Obtain $1600 of profit
3. Use no more than 40 animals.

2) **<u>Who you Going to Call – Sodbusters!!</u>**

Tulsa SodBuster Farms have a company motto – "There's more than one way to grow grass". The company grows fescue sod, and sells it to home builders and other interested parties for use in yards. You are to develop a GP model to assist their planning for the next growing year, based upon the priority order of goals specified below. First, problem specifications.

Your model should suggest how many acres of two different fescue grasses should be planted (and therefore harvested) in their two different Farms.

The two different grasses grown are called Fescue I and Tulsa Fescue.   The two farms, both of which have an ABSOLUTE maximum capacity for sod of 35 units (you may substitute whatever measure of area you would like), are aptly named Farm 1 and Farm 2.

When the sod is ready for harvesting, Fescue I sells for $45/unit, while Tulsa Fescue sells for $55/unit. The grasses sales price is independent of where it is grown.

The same is not true for the cost to grow units of Fescue I and Tulsa Fescue, due to farm topography and other soli related conditions. Fescue 1 costs $16/unit to grow at Farm 1, and $20/unit to grow at Farm 2. Tulsa Fescue costs $22/unit to grow at Farm 1 and $32/unit to grow at Farm 2.

Part a) - Your solution should address the following goals, stated in priority order. As always, sub-goals are treated equally.

1) Demand for the sod is hard to predict – try to insure that your model plants at least 20 units of each type of sod collectively across the two farms.

2) For sake of variety and caution in case there is some plague of locusts at one farm, try to have at least 5 units of each type of sod planted at each Farm.

3) Related to Goal 1, try to insure that no more than 30 units of each type of sod is collectively planted.

4) Budget wise, we can plant sod to our hearts' content – but this goal is to try not to exceed our budget of $1250.

5) Have our optimal planting schedule achieve at least $2000 of profit.

Part B) – What happens to the optimal solution if you re-run your GP with Goals 2 and 5 interchanged.

3) **<u>The Lady With The Goal Programming Tattoo</u>**

The last book in the trilogy (The Lady Who Sprayed the Wasp Nest) by the late Gregg Larsen is soon to be re-released in paperback. It is anticipated that this will lead to a spike in the sales of the other two books (The Lady With the Rattlesnake Tattoo and The Lady who Swallowed Fire) in paperback, much like what happened when the book (Wasp's Nest) first appeared in hardcover.

You have identified five different locations that can print The Lady With the Rattlesnake Tattoo and their max capacity. You also know how many books you need to get to your three warehouses (demand below W1,W2,W3). The following table provides you the per unit shipping cost. (Note the column “opencost” is not to be considered relevant for this problem).

shipping		W1	W2	W3		Opencost	Capacity
	Omaha	1	1.3	1.4		2	10
	Des Moin	1.2	1.5	1.6		1.4	8
	Little Roc	2	1.8	1.9		2.3	25
	Wichita	1.6	1.9	1.3		2.1	14
	KC	1.35	2	1.2		2.7	7
Demand		10.5	12	6			

Create a GP model that finds the optimal way to get books from where they are printed (Omaha, Des Moines, Little Rock, Wichita, KC) to where they are demanded (W1, W2, W3). The goals are specified below in strict priority order. Do not worry about integers (unless you want to, and then be careful).

Note that demand for the books at the warehouses must be met exactly, and that the amount of books being shipped from each printing location cannot exceed the stated capacity.

Goal 1: Due to contractual issues, try not to use the Wichita printing facility.

Goal 2: Keep the cost of getting books to W1 no more than 14 cost units.

Goal 3: Overall, keep cost of distributing books to warehouses less than or equal to 38 cost units.

Goal 4: For each of the five printing facilities, try not to use the highest shipping cost ‘path’ in distributing books (e.g., Omaha’s highest cost path is to ship books to W3).

Goal 5: In distributing books, use all of Little Rock’s capacity.

As is standard, treat all sub-goals equally.

4) **<u>Point me in the direction of</u> <u>Albuquerque</u>**

Arizona National Marketing is (was) an in-bound only telemarketing company located in Omaha, Nebraska (the telemarketing capital of the world). ANM’s operators take information from callers wanting to order certain products seen advertised on TV throughout the day. In scheduling employees to answer the multitude of their in-bound 1-800 calls, they have relied upon ‘seat-of-the-pants’ methodologies that leave the operations manager uneasy. She wants to take a look at a ‘clean slate’ schedule and then adjust her workforce so as to move toward this schedule in the future.

Historical records are pretty good at ANM. Because of this, the operations manager can estimate fairly accurately the number of required operators for each hour throughout the work day (8 a.m. through 10 p.m.). This is shown in the table below.

Hour	Req. Oper.	Hour	Req. Oper.	Hour	Req. Oper.
8-9am	6	1-2pm	13	6-7pm	16
9-10am	8	2-3pm	12	7-8pm	11
10-11am	10	3-4pm	10	8-9pm	9
11am-noon	11	4-5pm	13	9-10pm	5
noon-1pm	14	5-6pm	15		

Full-time operators are paid $10/hour and work 4 hours, take 1 hour off for lunch, then work another 4 hours (they're paid $80/day). Part timers work 4 consecutive hours and are paid $6/hour for each hour before 5 p.m. and $7/hour for each hour on or after 5 p.m. For simplicity sake, the schedule should only consider four possible shifts for full-time operators: 8am - 5pm, 9am-6pm, 10am-7pm and 1pm-10pm. ***All possible part time shifts should be included in the analysis. Assume shifts only start 'on the hour'.***

Obviously, any schedule generated MUST have at least the required operators on hand (shown above) for each hour time frame. Treat full and part-time operators equivalently in terms of productivity. Additionally, it is an ABSOLUTE policy requirement that no more than 5 operators can be assigned to each individual shift (i.e., no more than 5 operators starting any one of the 4 full time shifts or no more than 5 part time operators starting at x o'clock, etc.). SHIFT is DIFFERENT THAN HOUR!!!

USING INTEGER VALUE REQUIREMENTS appropriately, create and solve a goal programming model for the scheduling situation that depicts the following order of goals in decreasing order of importance:

Goal 1: Keep cost below or at $1600 per day.

Goal 2: Make sure there are at least 4 full-time employees working during each hour.

Goal 3: The combined number of full and part-time people each hour should not exceed the total required operators stated above for that hour by more than 5 people.

Goal 4: Try to schedule at least 1 person in each shift (all 15 shifts).

Goal 5: There should be no more than 10 part-time employees scheduled during each hour time frame.

For simplicity, sub-goals can be treated equally.

5) **<u>UNION ATLANTIC RAILROAD – "AFTER THE FLOODIN'" - REDUX</u>**

The floods of the Upper Midwest (the Missouri River, the situations in North Dakota, etc.) have wreaked havoc on railroad transportation.

After some additional track has been reopened with waters finally receding, a small segment of the Union Atlantic Railroad has a need to get two types of empty boxcars (Type I and Type II) that are presently in yards in Grand Island, NE and Des Moines, IA to rail yards in Minneapolis, MN and Fargo, N.D. as quickly as possible. Of course, subject to constraints that will not totally disrupt future railroad shipments.

Box car Type 1 – there is presently an inventory of 200 cars in Grand Island, and 160 cars in Des Moines. Minneapolis has requested 120 cars, Fargo 180.

Box car Type 2 – there is presently 50 cars at GI and 240 in Des Moines.   Minneapolis has a need for 175 , Fargo 40.

Because of the time the cars have sat unoccupied, all boxcars must travel through inspection stations prior to arriving at their final destinations. The three inspection stations are located in Omaha NE, Kansas City, Mo. and Sioux Falls, SD. The distance table is provided below.

	OMA	KC	SF
GI	147	287	251
DM	136	194	284
MPLS	378	436	236
FARGO	424	601	245

GI = Grand Island, DM = Des Moines, OMA = Omaha, KC = Kansas City, SF = Sioux Falls, MPLS = Minneapolis, FARGO = Fargo
Table 1 is distance from inventory yards to inspection station.
Table 2 is distance from inspection stations to desired location railroad yards.

Your task: Using formal Goal Programming (GP), find the optimal way of transporting the unused boxcar inventory through the inspections stations to the rail yards that need them for their operations. Since the learning objective here is the GP solution methodology, do not worry about integers. Perhaps, all numbers will come out as whole numbers. But don't worry about it.

Your solution to this situation should address the following goals, specified in priority order (the usual 'Barney' order). Treat all sub-goals equally (and there are a number of those).

First, system constraints: You cannot supply more boxcars than are on hand in Grand Island and Des Moines. Also, all of the usual logic must hold (IN=OUT).

Goals:

1) Try to send at least 80% of the requested boxcars (by type and location) to the rail yards who are requesting them. Note that RHS values are NUMBERS.

2) Attempt to limit the number of boxcars of ONE KIND sent between any two locations in the rail yard network to be no more than 75 cars. (So, e.g., it is okay to send 75 Type I cars from GI to OMA and 75 Type II cars from GI to OMA, but you cannot send 80 Type I cars from GI to OMA).

3) Due to the flooding, cars being sent from Omaha to Fargo are in jeopardy. Attempt to limit the number of cars sent from Omaha to Fargo to 0 (both types).

4) Attempt to meet demand for each type of rail car at each demand location. You can exceed demand (which was stated above in the problem introduction).

5) Try to allow no more than 175 total boxcars (combined types) to travel through each inspection station.

6) Try to keep at least 10% of the beginning inventory of boxcars (by type) at each of GI and DM locations. As before, RHS targets are NUMBERS.

7) Try to allow no more than 100 boxcars of EACH type to travel through each inspection station.

8) Attempt to keep total distance traveled (calculated in the conventional way) to no more than 280,000 miles.

As before, clearly (in words) identify the optimal transportation of each type of box car. Also, identify which goals are achievable and which ones are not based upon this order of goals.

6) **TSOGP – MFSB?!**

The Tri-State Oil Company refines its oil product at 2 sites (s1 and s2) and delivers the product over leased pipelines to its final distribution depot, site s10. By contractual agreement, Tri-State uses three pipeline companies, Anderson Co., Birdsong Biopipe and Carson Carriers, Inc. to deliver its product.

Anderson charges Tri-State $100/unit/pipeline link for transporting the oil product, while Birdsong charges $80/unit/pipeline link and Carson $60/unit/pipeline link. The oil product can be shipped along any parts of the pipeline distribution network described in the spreadsheet, with the final destination the depot s10. The table in the spreadsheet notes the 'to' and 'from' nodes, the pipeline capacity and the company that owns the link. Site s1 can produce 10 units daily, whereas site s2 can produce 12 units daily. There are some links with bi-directional flow capabilities (and the capacities may differ – consider them as separate pipes).

The capacity constraints shown in the table are the only system constraints.

Create and solve a goal programming model that determines how many units to ship through the pipeline network consistent with the approach described in class that addresses the following goals, stated in the following "barney" priority order. Note that some goals have equal sub-goals.

From	To	Capacity	Company		From	To	Capacity	Company
s1	s3	10	Anderson		s2	s4	12	Birdsong
s3	s5	6	Anderson		s3	s6	7	Carson
s3	s4	8	Carson		s4	s3	5	Carson
s4	s7	5	Birdsong		s5	s6	3	Carson
s5	s8	7	Anderson		s6	s5	3	Carson
s6	s8	5	Carson		s6	s7	4	Carson
s7	s6	4	Carson		s7	s9	8	Birdsong
s8	s9	6	Carson		s8	s10	11	Anderson
s9	s8	6	Carson		s9	s10	9	Birdsong

Goal 1: Deliver at least 16 units of oil to the final distribution depot, site s10.

Goal 2: Each source (individually) must provide at least 10 units of oil to the pipeline network.

Goal 3: Spend no more than $6600 in delivering the oil through the network.

Goal 4: At least $2,000 must be spent with each pipeline company.

Goal 5: Send no units along the pipeline links where the 'from' node has a larger ID number than the 'to' node. E.g., S7 to S6 link. This goal might imply – do not let flow go backwards in the network.

7) **<u>SprintSystems</u>**

Note: This problem is based upon models developed during a summer internship of a past MBA student. Many other types of scenarios in this domain could be modeled, such as minimum order size, explicit single vs. multi-sourcing decisions, other objectives/criteria, etc. This problem is just a simplified, 'tip-of-the-iceberg' situation. Thanks to the anonymous student for sharing.

SprintSystems manufactures top secret devices for the government. We cannot say more or this file will self-destruct.

Part of the procurement process involves trying to economically order parts, subject to a multitude of different, conflicting objectives. The portion we are modeling involves 7 parts and 9 suppliers. The included table provides basic specifications – part name, quantity required for the next ordering cycle, supplier name, per unit cost for parts from suppliers (no entry implies that supplier cannot provide the part), maximum capacity of total parts for each supplier (assume this is just a sum of total orders across the 7 part types), and the measure of supplier quality performance and on-time delivery performance (on a 1-100% scale).

Your assignment, Mr. Phelps, should you accept it, is to create a goal programming model that addresses this situation subject to the following system constraints and goal constraints (which are specified in explicit priority order).

Decisions to be made: How many units of <part> should be ordered from <supplier>. See note about integer requirements below.

System constraints:

a) The number of parts ordered must exactly equal the numbers shown in row 18.

b) Consider column O as the maximum number of total parts that can be ordered from one supplier.

Goal constraints (in absolute priority order):

1) Attempt to have each supplier supply at least 750 total parts.

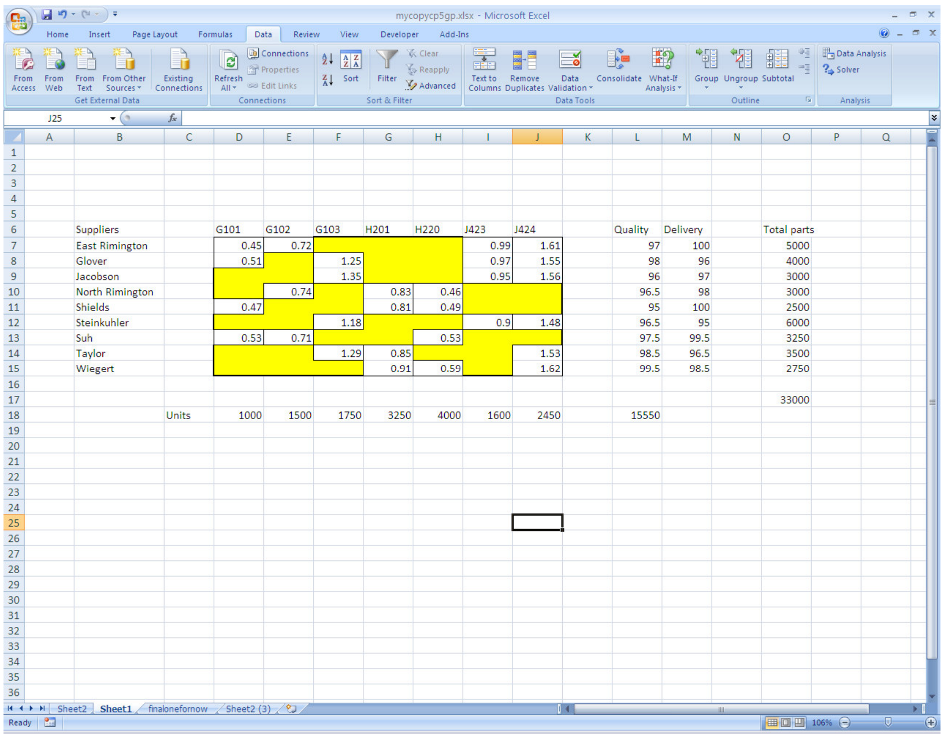
2) Because of legislative history (i.e. pork barrel legislation), try to have part G102 supplied solely from a combination (or just one) of the suppliers East Rimington and North Rimington.

3) Try to maintain quality such that each individual supplied product has a weighted average of quality performance of 97.25%. Note that we know exactly how many units will be procured (system constraints), so this target can be implemented in a very straightforward set of constraints.

4) Try to keep procurement costs less than $13,500.

5) Try to maintain delivery quality such that each individual supplied product has a weighted average of delivery quality performance of 97%. Note that we know exactly how many units will be procured (system constraints), so this target can be implemented in a very straightforward set of constraints.

Integers: It obviously makes sense to have the final solution in integers. I suggest waiting until you reach a goal that cannot be achieved later in the solution process before forcing the solution to be integers. In fact, should you wait until the very end, I wouldn't at all be upset. The relevant learning objective is to implement 'true' goal programming, and so I am not concerned about whole numbers, but I know that bothers some of you. Not heading these words may lead to excruciatingly long solution times.



Suppliers		G101	G102	G103	H201	H220	J423	J424	Quality	Delivery	Total parts
East Rimington		0.45	0.72				0.99	1.61	97	100	5000
Glover		0.51		1.25			0.97	1.55	98	96	4000
Jacobson				1.35			0.95	1.56	96	97	3000
North Rimington			0.74		0.83	0.46			96.5	98	3000
Shields		0.47			0.81	0.49			95	100	2500
Steinkuhler				1.18			0.9	1.48	96.5	95	6000
Suh		0.53	0.71			0.53			97.5	99.5	3250
Taylor				1.29	0.85			1.53	98.5	96.5	3500
Wiegert					0.91	0.59		1.62	99.5	98.5	2750
											33000
	Units	1000	1500	1750	3250	4000	1600	2450	15550		

8) **The Andromeda Strain Defense System Problem**

The Bioterrorism Treatment Facility Design Problem – You have been asked to propose a design for a system of treatment facilities for the U.S. National Security Agency in event of a bioterrorism attack. Your design should consider only the continental 48 states (omit Hawaii and Alaska from your analysis).

The ABSOLUTE design requirements are as follows:

A) Each state must have a bioterrorism treatment facility (BTF for short) either located in the state itself or in a neighboring state.
B) We are not concerned with exact location within a state.
C) We are not concerned with average distance between neighboring states, the amount of shared borders, etc. Thus, this is just a high level design.

D) We can build at most 13 of these across the lower 48 states.
E)

Criteria that the NSA has asked to be considered in deciding where to locate BTF's:

A) Locate the BTF's such that the total population in states where BTF's are located is small (data is found in supplemental spreadsheet). THIS MEANS TOTAL POPULATION OF STATES WHERE BTF's LOCATED, not STATES WITH SMALL POPULATIONS.
B) Locate the BTF's such that the total number of BTF's needed to 'cover' all states is small.
C) Locate the BTF's such that the number of occurrences where multiple BTF's 'cover' a single state is small. BTF overlap might be a better term for this criterion.
D) Locate the BTF's such that the number of Democratic states with BTF's is approximately equal to the number of Republican states with BTF's. Use present sitting Governors affiliation as your criteria for deciding whether a state is Democratic or Republican.
E)

Your task: Create a goal programming model using the concepts of absolute and goal constraints to find the best location of BTF's.

Data needed that may be provided: State populations, a 'state contiguousness' matrix, a map of Demo/Republican governors.

Goals for your solution (specified in "Barney" priority order).

Goal 1: Try to have your solution have at least 9 BTF's.
Goal 2: Try to keep the total population where BTF's are located to no more than a combined 50 million.
Goal 3: Keep the number of BTF's located in states that border Mexico or are along the Atlantic and Pacific coasts to less than or equal to 1. States next to Canada are fine. Gulf of Mexico – fine.
Goal 4: Try to minimize overlap at the individual state level. Implement this in your model by trying to insure that each state has no more than 1 overlapping BTF. Hint: Put another way, try to make sure that no more than 2 BTF's cover an individual state.
Goal 5: BTF's should be located in 4 more Democratic states as Republican states as measured in D) above. Thus, mathematically, DEM-REP must be at least 4 is the target.

Create a GP model that solves this problem. Be very clear with your model and resulting solution. A nice summary of your solution is expected. Remember; do not expect to be able to achieve all goals.