Practice Problems

1) “Attention, Y-Mart Shoppers!”

A new Y-Mart grocery store opened in a town near you early in 2012 complete with a Subway restaurant, wide aisles, well-stocked shelves, a level parking lot … and long lines at the checkout stations.

An MBA student fluent in time/motion studies was hired temporarily to observe hourly store customer checkout patterns. This same student also observed waiting times, line lengths, etc.

From the collected data and some simple simulations, the student identified the following ‘optimal’ number of checkout stations to be open (including express lanes) during each of the hourly time frames.

5	8-9am
7	9-10am
9	10-11am
10	11-noon
15	noon-1pm
14	1-2pm
12	2-3pm
14	3-4pm
20	4-5pm
25	5-6pm
20	6-7pm
15	7-8pm
12	8-9pm
10	9-10pm
8	10-11pm

Checkout specialists at this Y-Mart start at five different times – 8am, 10am, noon, 4pm and 5pm. At 8am, they work 3 hours, take an hour off, then work 2 more hours. For the other four starting times, they either work 3 hours on, 1 hour off, and then 2 hours on again, or 2 hours on, 1 hour off, and three hours on.

Checkout specialists who work the 8am shift are paid $60 ($12/hour) , those who work the 10am and noon shift are paid $50, those who work the 4pm shift are paid $54 and those who work the 5pm shift are paid $56 (daily).

Determine how many people should be assigned to each of the shifts (which you need to identify) in order to best meet the needed hourly number of checkout specialists. Minimize costs as your criteria. Make sure there are integer solution values, but it is okay to wait until after a trial ‘run’.

2) McCarthy-Bergen Memorial Hospital

You have been asked to create a ‘strategic’ schedule plan for nurse requirements for the 5th floor at Charley McCarthy- Edgar Bergen Memorial Hospital. At present, you have 46 nurses – but retirement and reassignment over the next 30 days will likely leave you with less than that. You’d like to create a schedule, if possible, that uses no more than 38 nurses (about a 20% decrease).

The first step is to create an aggregate plan of scheduling the floor operations, and worry about making specific assignments later. Based on feedback from the present nursing staff, you have decided that there are 8 good potential shifts with which you’d like to

create this aggregate schedule. Five of the shifts work 12 consecutive hours, while three shifts work 6 hours, take 6 hours off, and then work an additional 6 hours. Note that breaks within the shifts will be handled at a more tactical level.

This aggregate schedule is to be a one-day, 'wrap-around' schedule. Again, later in the process, you, as staff manager, will consider how to utilize this plan over a week time horizon. Thus, people who start work at 4pm and work 12 consecutive hours would count towards the needed requirements from 12am to 4am as well as 4pm to 12 midnight.

The existing nursing staff has given preference weight (on a scale of 1-100, 100 being most preferred) to the 8 possible shifts. For the five, 12-consecutive hour shifts: 65, for the shift starting at 12-midnight (12am), 77 for the 4am starting shift, 88 for the shift starting at 6am, 54 for the 12-hour shift starting at 10am, and 43 for the shift starting at 4pm.

For the three, 6-on, 6-off, 6-on shifts: 72 for the 6am/6pm split shift, 60 for the 8am/8pm split shift, and 59 for the noon/midnight split shift. (Since it is 6-on, 6-off, you can consider the shift starting at either am or pm, since we are considering 'wrap-arounds').

Part of policy requirements you would like to enforce in your aggregate staffing plan: no more than 8 people are assigned to any individual shift, but at least 2 people to every shift. Also, when considering nurse requirements for each two-hour time slice (shown below), there should be no more than 9 EXTRA nurses assigned for all time slices.

Nurse requirements (in 2 hour time slices):

Midnight-2am:	10	2am-4am:	11	4am-6am:	16
6am-8am:	15	8am-10am:	12	10am-Noon:	18
Noon-2pm:	22	2pm-4pm:	21	4pm-6pm:	19
6pm-8pm:	17	8pm-10pm:	16	10pm-Midnight:	14

Create an appropriate aggregate plan that maximizes the overall weighted preference measure stated above with the appropriate model constraints. Integers are reasonable, but evaluate that after an initial run (i.e., you may not have to worry about integers, they might just 'happen').

3) It's a Gasser!

Here is a petroleum blending model that is a simplified version of LP models used at refineries.

Three kinds of gasoline are to be blended from four different feedstocks of oil. The three kinds of gasoline are differentiated based upon the minimum level of octane that each averages. REG-87 must have at least an octane rating of 87, REG-89 must have at least an octane rating of 89, and PREM-93 must have at least an octane rating of 93. Also, individually, each type of gas must maintain a weighted average of vapor pressure not to

exceed 12.7 units. (Both the octane number/rating and vapor pressure are weighted averages).

For the next production period, you wish to make at least 200 bbl of REG-87, and at least 100 bbl of both REG-89 and PREM-93 individually. There is no upper limit on the amount of REG-87 to make, but you should make no more than 350 bbl of REG-89 and 200 bbl of PREM-93

Your goal in the production model is to maximize net contribution. REG-87 contributes $100/bbl, REG-89 $110/bbl, and PREM-93 $135/bbl. The cost of each of the four feedstocks is shown below in the attribute table (along with their Octane numbers and vapor pressure, and the maximum amount of the feed stock available).

A couple of other restrictions in production of the gasoline – REG-87 cannot use any oil from FS3 (feedstock 3). Also, no more than 35% of any product can be made up from any one feedstock. The appropriate data for the feedstocks (referred to as FS1 through FS4).

	FS1	FS2	FS3	FS4
Cost	85	90	115	110
Octane	90	88	97	92
Vapor Pressure	12.4	12.3	12.8	12.65
Maximum Avail	200	300	250	400
All units relates to per bbl				

Create a LP model to determine the optimal way to blend the three gasolines. Maximize net return.

4) OSUWIHC Staffing

Complaints of excessive waiting times have led the OSU Walk-In Health Clinic (OSUWIHC) to study its staffing. You have been asked to create an aggregate daily staffing plan based upon the following guidelines.

The facility is open from 9am to 6pm. Two types of medical professionals are used on a part time basis at the OSUWIHC. Physician Assistants (PA) are used, as are LPN's Staffing requirements are given on an hour by hour basis (see table below). You are to come up with a least cost way to staff the facility meeting these staffing requirements (and other relevant constraints). Your solution will be:

Number of PA's working PA shift x (x is all possible PA shifts)
Number of LPN's working LPN shift y (y is all possible LPN shifts)

PA's work 4 consecutive hours, and, except for those who start at 9am or 2pm (the last shift), are paid $160. The shifts that start at 9am and 2pm are paid $170.

LPN's work a total of three hours – 2 hours 'on', one hour 'off', then a final hour 'on'. Their pay depends on which hours they work (also see table). For instance, an LPN that works a shift starting at 9am will 'cost' 20+22+23=65 dollars (the 9am LPN shift would work from 9am-11am, then 12pm-1pm).

All possible shift combinations should be considered. Remember, shifts are different than hours. Also, only viable shifts should be considered – for instance, there can be no PA shift starting at 4pm.

To level out staffing requirements, no one shift can have a solution value of more than 4 people. Also, each hour can have no more than 3 'extra' <u>total</u> staff members present.

Find the optimal aggregate daily staffing plan. Be careful not to over-constrain the problem, nor leave out necessary model components.

PA Requirements, Total Requirements, LPN cost per hour shown below per hour.

	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6
PA	2	3	4	4	3	4	5	3	2
Total	5	6	7	9	8	7	7	9	5
LPN Cost	$20	$22	$21.5	$23	$22	$20	$25	$25.5	$26

5) Zesto's Zinging Smoothies

Zesto's, Omaha's College World Series provider of malts and shakes, has expanded into healthy smoothies at the same time they have moved downtown near TD Ameritrade Stadium (away from their historic location on South 13th by the parking lot formerly known as Rosenblatt Stadium).

They use three fruits and a variety of other ingredients to make their smoothies. For simplicity, we are only analyzing their fruit and "end product" requirements. Zesto's uses bananas, blueberries and strawberries (N,B and S abbreviations, respectively), and produces "wildFruit", "RedYellowNBlue" and "BerryMania" smoothies (WF, RYB, BM). Our units are in 'pounds', and we assume that fruit weight is additive in the smoothie products: 1 lb of bananas blended with 1 lb. of blueberries and 1 lb of strawberries would result in 3 lbs of smoothie.

For the next production period, we want to purchase fruit such that we produce at least 50 lbs. of each smoothie product. We can produce more – plenty of freezer space exists at the new downtown store.

Our suppliers have available 250 lbs of bananas, 100 lbs. of blueberries and 200 lbs. of strawberries. Cost per pound is ($6, $10.5, $8.5) for (N,B,S) respectively. This is the most we can use.

On a per pound basis, we sell WF for $12, RYB for $15 and BM for $18.

Each of our smoothie products (in aggregate) have some mix requirements as well as average ORAC (Oxygen Radical Absorbance Capacity) requirements.

wildFruit – cannot be made up of more than 40% of any one kind of fruit. Average ORAC must be at least 1000.

RedYellowNBlue – Must consist of at least 25% of each of the three kinds of fruit. Average ORAC must be at least 1100.

BerryMania – cannot consist of more than 10% bananas, and each of the two other fruits (berries) must be at least 30% of the total amount made. Average ORAC must be at least 1800.

Note that the individual ORAC ratings for bananas are 210, for blueberries 2400 and for strawberries 1540.

Find the optimal way of producing smoothies for Zesto that satisfies all requirements and maximizes profit. Whole numbers (and whole fruit) not required.

6) Kappa Upsilon Lambda Paint Fundraiser for Divided Way Charity

As Philanthropy Chair at Kappa Upsilon Lambda (KUL), you have been asked to formulate a plan to raise money for Divided Way Charity. Part of this plan involves being paid for some painting at a local Youth Activity Center.

The local YAC has needs for painting at two different locations in their building. They need at least 40 gallons of paint to be applied in one location where "Pale" paint is required. Another location, they have asked for "Bright" paint to be applied, and the estimate is for at least 35 gallons. They will pay $3.5 per gallon for "Pale" paint and $3.75 per gallon for "Bright" paint. As they will use some paint now as well as later for touch-up, there is thus a minimum requirement for the 2 paint types, but no maximum limit.

Red, green and blue paint is mixed together to create the "Pale" and "Bright" shades. Relatively equal amounts of red, green and blue mixed together will provide white paint. Therefore, to allow some flexibility, we decide to limit the amount of any one 'primary' component of "Pale" to 37.5% of the overall mixture. That is the only composition constraint for "Pale".

Consulting the “Wheel of Color”, we find that we need different restrictions to make our “Bright” shade. The total amount of blue paint cannot exceed 15% in the “Bright” mix. Additionally, the “Bright” mix must be composed of at least 40% red paint. There is no restriction on green paint in the “bright” mix.

A maximum of 40 gallons of red paint can be found at a local paint store, being sold for $3.6 per gallon. A maximum of 25 gallons of green paint can be found at a price of $2.5 per gallon, while 30 gallons of blue paint can be found at a price of $2.25 per gallon.

Determine the most profitable plan of mixing paint to meet the requirements of the YAC and the “Bright” and “Pale” paints.

Editor’s Note: The Wheel of Color used was mistakenly the one for optics, not for paint. Future versions of this problem will be corrected. Just not at this moment. It’s still a viable practice problem! Just don’t try this at home.