LIST OF GROUP PROJECT ASSIGNMENTS FOR ISE 426 FALL 2015.

THE STUDENTS WORK IN GROUPS OF FOUR/FIVE AND SUBMIT BIDS FOR THEIR PREFERERED PROJECTS.

Portfolio Optimization

Exercise 8.7 Using historical returns of the stocks in the DJIA, estimate their mean μ_i and covariance matrix. Let R be the median of the μ_i's.

(i) Solve Markowitz' MVO model to construct a portfolio of stocks from the DJIA that has expected return at least R.

(ii) Generate a random value uniformly in the interval $[0.95\mu_i, 1.05\mu_i]$, for each stock i. Resolve Markowitz' MVO model with these mean returns, instead of μ_i's as in (i). Compare the results obtained in (i) and (ii).

(iii) Repeat three more times and average the five portfolios found in (i), (ii) and (iii). Compare this portfolio with the one found in (i).

In this project you should collect your own data and indicate how you did it. We will study the Markowitz model on November 21st , but you can read up on it on the internet.

Investment optimization

Exercise 12.6 You have \$250 000 to invest in the following possible investments. The cash inflows/outflows are as follows:

	Year 1	Year 2	Year 3	Year 4
Investment 1	−1.00		1.18	
Investment 2		−1.00		1.22
Investment 3			−1.00	1.10
Investment 4	−1.00	0.14	0.14	1.00
Investment 5		−1.00	0.20	1.00

For example, if you invest one dollar in Investment 1 at the beginning of Year 1, you receive \$1.18 at the beginning of Year 3. If you invest in any of these investments, the required minimum level is \$100 000 in each case. Any or all the available funds at the beginning of a year can be placed in a money market account that yields 3% per year. Formulate a mixed integer linear program to maximize the amount of money available at the beginning of Year 4. Solve the integer program using your favorite solver.

A lockbox problem

Consider a national firm that receives checks from all over the United States. Due to the vagaries of the US Postal Service, as well as the banking system, there is a variable delay from when the check is postmarked (and hence the customer has met his/her obligation) and when the check clears (and when the firm can use the money). For instance, a check mailed in Pittsburgh sent to a Pittsburgh address might clear in just two days. A similar check sent to Los Angeles might take four days to clear. It is in the firm's interest to have the check clear as quickly as possible since then the firm can use the money. In order to speed up this clearing process, firms open offices (called lockboxes) in different cities to handle the checks.

Exercise 12.2 Consider a lockbox problem where c_{ij} is the cost of assigning region i to a lockbox in region j, for $j = 1, \ldots, n$. Suppose that we wish to open exactly q lockboxes where q is a given integer, $1 \leq q \leq n$.

(i) Formulate as an integer linear program the problem of opening q lockboxes so as to minimize the total cost of assigning each region to an open lockbox.
(ii) Formulate in two different ways the constraint that regions cannot send checks to closed lockboxes.
(iii) For the following data,

$$q = 2 \quad \text{and} \quad (c_{ij}) = \begin{pmatrix} 0 & 4 & 5 & 8 & 2 \\ 4 & 0 & 3 & 4 & 6 \\ 5 & 3 & 0 & 1 & 7 \\ 8 & 4 & 1 & 0 & 4 \\ 2 & 6 & 7 & 4 & 0 \end{pmatrix},$$

compare the linear programming relaxations of your two formulations in question (ii).

Solve each formulation and report results.

10. Lot-Sizing with Minimum Batch Sizes and Cleaning Times. Consider the problem of production of a single item. Demands $\{d_t\}_{t=1}^n$ are known in advance. Production capacity in each time period is C, but in the last period of a production sequence it is reduced to $\tilde{C}$. In each production sequence, at least a minimum amount P must be produced, and production is at full capacity in all but the first and last periods of a production sequence. There is a fixed cost of f for each period in which the item is produced, the storage costs are h per item per period, and the backlogging costs g. Solve an instance with $n = 12, d = (5, 4, 0, 0, 6, 3, 2, 0, 0, 4, 9, 0), C = 7, \tilde{C} = 4, f = 50, h = 1, g = 10$, and $P = 19$.

In this problem you are asked to determine production sequences, that is sequences of periods when productions occur. For example you can have production in periods 2,3,4 and then 7,8,9,10. In this case the production capacity at periods 2,3 and 7,8,9 should be 7and in periods 4 and 10 should be 4. The production has to be at full capacity in periods 3, 8 and 9. And in each of the production sequences at least 19 units should be produced. Backlogging is the situation when you satisfy the demand of the past period from some a current or a future period. It is like inventory in reverse.

Lot sizing

9. The Traveling Salesman Problem with Time Windows. A truck driver must deliver to 9 customers on a given day, starting and finishing at the depot. Each customer $i = 1, \ldots, 9$ has a time window $[r_i, d_i]$ and an unloading time p_i. The driver must start unloading at client i during the specified

time interval. If she is early, she has to wait till time r_i before starting to unload. Node 0 denotes the depot, and c_{ij} the time to travel between nodes i and j for $i, j \in \{0, 1, \ldots, 9\}$. The data are $p = (0, 1, 5, 9, 2, 7, 5, 1, 5, 3), r = (0, 2, 9, 4, 12, 0, 23, 9, 15, 10), d = (150, 45, 42, 40, 150, 48, 96, 100, 127, 66)$, and

$$(c_{ij}) = \begin{pmatrix} - & 5 & 4 & 4 & 4 & 6 & 3 & 2 & 1 & 8 \\ 7 & - & 2 & 5 & 3 & 5 & 4 & 4 & 4 & 9 \\ 3 & 4 & - & 1 & 1 & 12 & 4 & 3 & 11 & 6 \\ 2 & 2 & 3 & - & 2 & 23 & 2 & 9 & 11 & 4 \\ 6 & 4 & 7 & 2 & - & 9 & 8 & 3 & 2 & 1 \\ 1 & 4 & 6 & 7 & 3 & - & 8 & 5 & 7 & 4 \\ 12 & 32 & 5 & 12 & 18 & 5 & - & 7 & 9 & 6 \\ 9 & 11 & 4 & 12 & 32 & 5 & 12 & - & 5 & 22 \\ 6 & 4 & 7 & 3 & 5 & 8 & 6 & 9 & - & 5 \\ 4 & 6 & 4 & 7 & 3 & 5 & 8 & 6 & 9 & - \end{pmatrix}.$$

Hint: with the additional time window requirements you will need extra variables, and constraints, but you will be able to avoid the need to have subtour elimination constraints

Traveling salesman problem with time windows

Newspaper delivery

7. Two cyclists must deliver newspapers in Manhattan. They pick them up at 6 a.m. and have to deliver to 60 customers as soon as possible. It is well known that the streets in Manhattan form a rectangular grid, so we can assume that the distance between two points (x_1, x_2) and (y_1, y_2) is $| x_1 - y_1 | + | x_2 - y_2 |$. The coordinates of the sixty customers are

(17, 310)	(39, 85)	(48, 403)	(49, 444)	(55, 153)
(59, 250)	(59, 476)	(62, 353)	(81, 441)	(85, 367)
(85, 419)	(89, 418)	(105, 376)	(109, 258)	(110, 441)
(110, 447)	(118, 413)	(120, 49)	(120, 451)	(120, 459)
(122, 104)	(133, 410)	(142, 439)	(145, 412)	(146, 364)
(161, 190)	(161, 414)	(161, 434)	(162, 458)	(165, 374)
(167, 399)	(178, 409)	(179, 265)	(179, 365)	(179, 427)
(182, 359)	(184, 76)	(184, 198)	(185, 124)	(186, 169)
(186, 440)	(188, 63)	(194, 433)	(197, 352)	(200, 376)
(211, 462)	(212, 140)	(222, 181)	(223, 21)	(223, 328)
(233, 27)	(235, 405)	(239, 229)	(276, 231)	(284, 362)
(286, 24)	(292, 148)	(299, 188)	(302, 184)	(317, 237)

The depot is at (375, 375). Assuming that both cyclists cover 300 distance units per hour, what is the earliest time by which every newspaper can be delivered?

2. Frequency Assignment. Frequencies from the range $\{1, \ldots, 6\}$ must be assigned to 10 stations. For each pair of stations, there is an interference parameter which is the minimum amount by which the frequencies of the two stations must differ. The pairs with nonzero parameter are given below:

$e =$	$(1,2)$	$(2,3)$	$(3,4)$	$(4,5)$	$(5,6)$	$(6,7)$	$(7,8)$	$(8,9)$
	1	2	4	2	3	1	1	2
$e =$	$(9,10)$	$(1,8)$	$(2,10)$	$(3,10)$	$(5,10)$	$(7,10)$	$(2,5)$	
	3	2	1	1	4	2	2	

The goal is to minimize the difference between the smallest and largest frequency assigned.

Frequency Assignment

Steiner Tree Problem

Steiner tree is a tree that spans a subset of nodes on the graph but not the whole graph. In a directed Steiner tree you have a root node and you need to connect the root node to all terminal nodes by directed paths. You need to minimize the total length of the arcs in the tree. A Complete digraph is a graph where each node is connected both ways to each of the other nodes.

3. Find a minimum cost directed Steiner tree in the complete digraph on $n = 10$ nodes with root node $r = 1$, terminal nodes 2,5,7,8,10, and arc costs

$$\begin{pmatrix} 12 & 6 & 7 & 4 & 11 & 8 & 4 & 5 & 7 & 15 \\ 9 & 4 & 2 & 26 & 12 & 4 & 7 & 11 & 4 & 28 \\ 6 & 3 & 8 & 2 & 12 & 15 & 19 & 3 & 7 & 9 \\ 21 & 33 & 24 & 52 & 2 & 19 & 6 & 2 & 9 & 15 \\ 6 & 3 & 5 & 8 & 4 & 3 & 2 & 7 & 4 & 12 \\ 14 & 17 & 32 & 24 & 15 & 11 & 22 & 28 & 9 & 6 \\ 8 & 3 & 5 & 2 & 3 & 4 & 7 & 8 & 10 & 3 \\ 31 & 24 & 46 & 52 & 43 & 13 & 24 & 27 & 61 & 21 \\ 2 & 3 & 4 & 3 & 5 & 7 & 9 & 3 & 5 & 9 \\ 21 & 24 & 13 & 38 & 67 & 94 & 24 & 3 & 26 & 23 \end{pmatrix}.$$

Unit commitment is a problem of deciding on which generators to use to satisfy necessary demand. Ramping constraint is a constraint which does not allow generator's output to change too much in two consecutive periods.

1. Consider a unit commitment problem with 5 generators and 12 (2-hour) time periods. Period 1 follows on again from period 12, and the pattern is repeated daily. $d = (50, 60, 50, 100, 80, 70, 90, 60, 50, 120, 110, 70)$ are the demands per period, and the reserve is 1.2 times the demand, so the total capacity of the generators switched on in any period must be at least this reserve. The capacity of the generators is $C = (12, 12, 35, 50, 75)$, and their minimum levels of production are $L = (2, 2, 5, 20, 40)$. In addition each generator must stay on for at least two periods. The ramping constraints only apply to the fifth generator — when on in two successive periods, the output cannot increase by more than 20 from one period to the next, and cannot decrease by more than 15. The costs are approximate. The main cost is a start-up cost $g = (100, 100, 300, 400, 800)$. There are also fixed costs $f = (1, 1, 5, 10, 15)$ and variables costs $p = (10, 10, 4, 3, 2)$ in each period that a generator is on.

Unit commitment Problem

Movie Stars

Retailers invest heavily in predicting how customers will rate new products such as movies, books, games, and appliances. Accurate recommendations lead to increased revenue and happier customers. To make these recommendations, retailers look for correlations between different products in order to make suggestions on what other products a customer might like to buy.

Table 1 shows movie ratings from five customers for five movies. The ratings range from 1 to 5. A rating of 5 indicates that the movie was very highly liked and a rating of 1 indicates that it was not liked at all. There is one movie rating that is missing because Evan has not yet seen the movie Prognosis Negative.

Question: Using only the data in the table, what is the most likely rating that Evan will give to the movie Prognosis Negative?

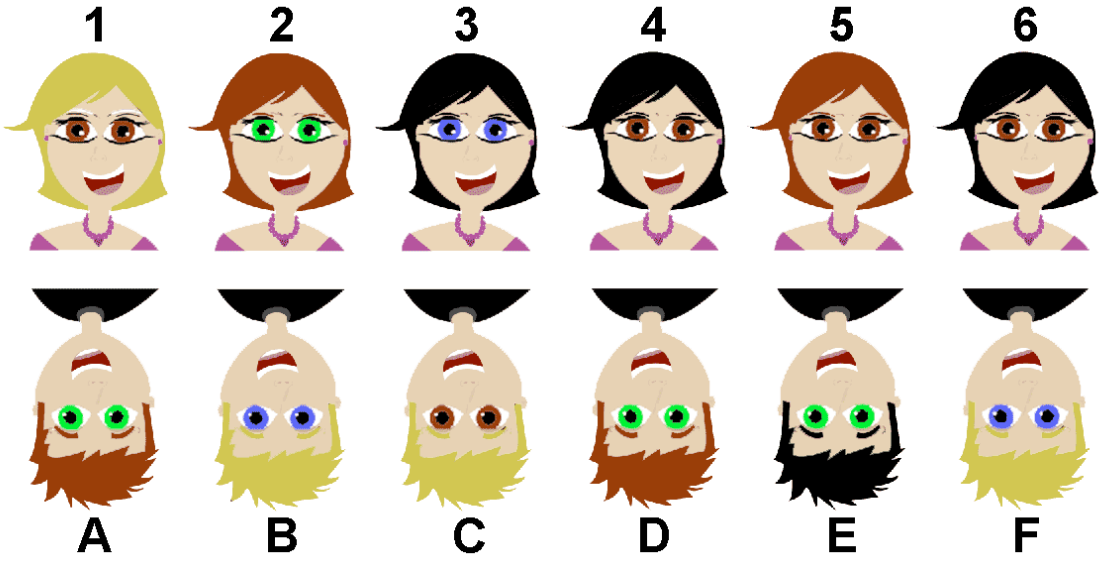
	Chunnel	Death Blow	Rochelle, Rochelle	Cry, Cry Again	Prognosis Negative
Alex	4	5	1	4	4
Bill	4	1	5	5	2
Carla	2	4	2	2	4
Dan	2	3	4	5	2
Evan	5	3	1	2	???

Matchmaker

The Matchmaker was an honored profession in past cultures, serving the valuable purpose of pairing off men and women in hopes of a long and successful relationship. The Matchmaker would carefully consider the characteristics of each partner to determine which pairs would be compatible.

Figure 1 shows six men and six women each with varying hair color and eye color. A man or woman will only accept a partner that has at least one of these traits in common. For example, Man A and Woman 5 would make a matching pair because they have at least one trait in common (same hair color). However Man A and Woman 1 would not make a matching pair because they do not have any traits in common.

Question: What pairings of men and women allow for everyone to have a partner with at least one trait in common? (There are several correct answers.)



Supply and Demand

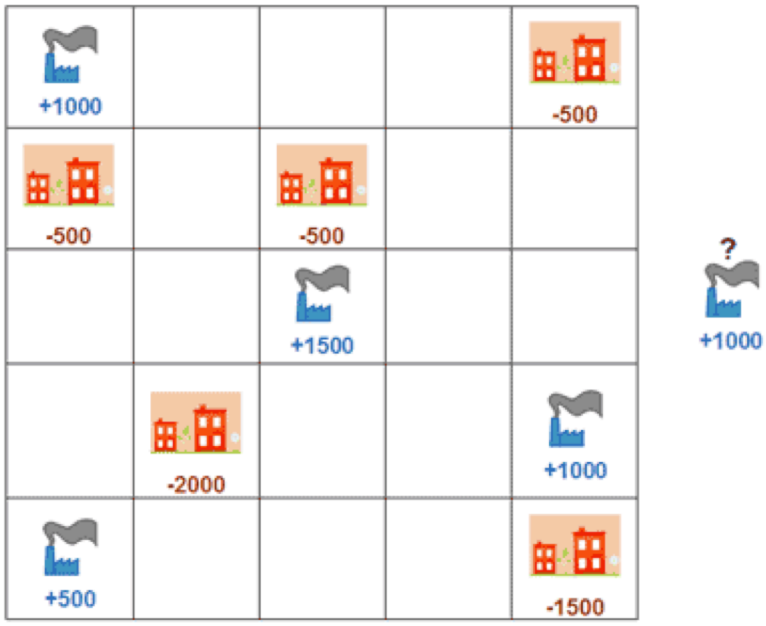


Figure 1

Moving resources efficiently from supplier to consumer is a challenging problem that can be solved using O.R. techniques. Figure 1 shows a map of blue factories that supply food to orange towns. The numbers below the factories and towns indicate how much food (in kg) each supplies and demands, respectively. Any factory can supply any amount of food to one or several towns. A new factory is being built that can supply 1000 kg of food but the location of the factory has not yet been determined. The distance between adjacent cells on the map is 1 km. The cost to transport 1 kg of food 1 km is 10 US$.

Question:
If the new factory is optimally located, what is the total transportation cost to satisfy the demand of all towns? The new factory cannot occupy a cell that already contains an existing factory or town.

Home Improvement

House Selling Price	New bathroom	New kitchen	Pool	Wood floors	New paint
$181,000		✓		✓	✓
$213,000	✓	✓	✓	✓	
$176,000		✓			✓
$169,000		✓			✓
$191,000	✓		✓		✓
$187,000	✓		✓		✓
$199,000		✓	✓		✓
$201,000		✓	✓	✓	
$200,000		✓	✓		

Preparing a house for sale may include making home improvements in order to attract buyers and increase the sales price. Some home improvements add profit to the sale of the house but most are not worth the cost.

Table 1 lists recently sold houses in your neighborhood. The selling price and any improvements the house had at the time of sale are shown. For example, the first house in the table sold for $181,000 and had a new kitchen, wood floors, and new paint.

Your house, which you are about to put up for sale, has none of the five listed improvements. You wish to identify the one improvement that will add the most profit to the sale of your house. Installation costs for the improvements are as follows: New bathroom $10,000, New kitchen $15,000, Pool $30,000, Wood floors $5,000, New paint $1,000.

Assume that, other than the five improvements, your house is very similar to the houses listed in Table 1 (sqft, land area, # bedrooms, # bathrooms, etc.) and assume all improvements are of the same quality.

Question: Which one of the five home improvements will be the most profitable for you to build?
Hint: First calculate the market value of each improvement, then compare to the installation costs.

August 2013 - Urban Planning

Urban planning requires careful placement and distribution of commercial and residential lots. Too many commercial lots in one area leave no room for residential shoppers. Conversely, too many residential lots in one area leave no room for shops or restaurants.

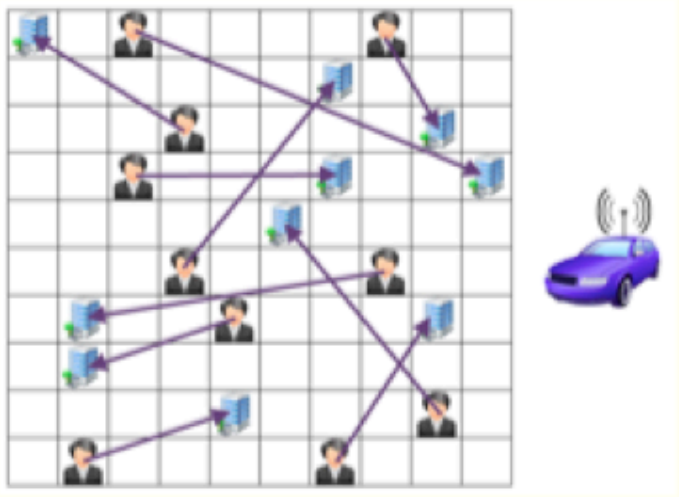
The 5x5 grid in Figure 1 shows a sample configuration of residential and commercial lots. Your job is to reorder the 12 Residential green lots and 13 Commercial red lots to maximize the quality of the layout. The quality of the layout is determined by a points system. Points are awarded as follows:

- Any column or row that has 5 Residential lots = +5 points
- Any column or row that has 4 Residential lots = +4 points
- Any column or row that has 3 Residential lots = +3 points
- Any column or row that has 5 Commercial lots = -5 points
- Any column or row that has 4 Commercial lots = -4 points
- Any column or row that has 3 Commercial lots = -3 points

For example, the layout displayed in Figure 1 has a total of 9 points:
Points for each column, from left to right = -3, -5, +3, +4, +3
Points for each row, from top to bottom = +3, +3, +3, +3, -5

Question: What is the maximum number of points you can achieve for the layout?

June 2013 - Self Driving Cars



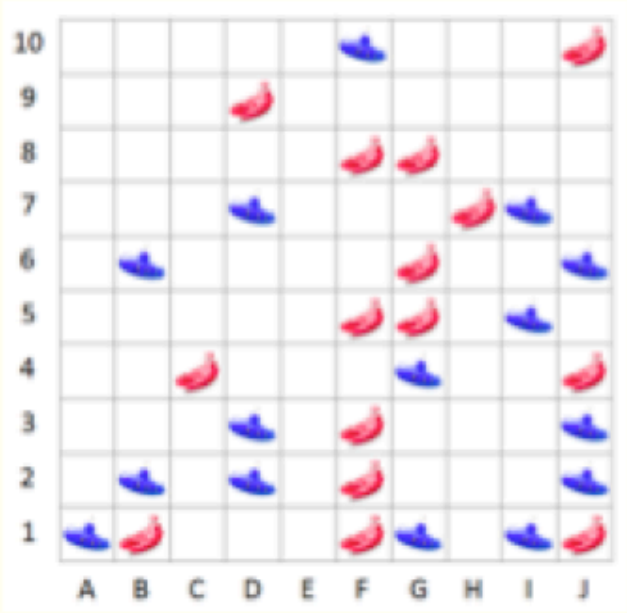
Self-driving cars are cars that can drive themselves without a human behind the wheel. This technology should be available in the not-too-distant future. New algorithms will need to be developed to help route these cars to get their passengers to their desired destinations efficiently.

Figure 1 shows 10 people in need of transportation. Their current location (the pickup point) is indicated by the person icon and their desired destination (the dropoff location) is indicated by the building icon. The purple arrow indicates the path from the pickup location to the dropoff location. Your job is to order the passengers so that they are picked up in an order that minimizes the total distance travelled by the self-driving car.

The car can start at any pickup point. You may only carry one person at a time. The car does not need to return to its starting point after the last person is dropped off. There is only one self-driving car available for use. Use Pythagorean theorem to calculate the distance between cells. For example, the distance between the person nearest the lower left corner and her dropoff point is 3.162 km.

Question: What is the minimum distance the car must travel in order to transport all of the passengers from their pickup points to their dropoff points?

April 2013 - Subs vs. Battleships



Naval warfare is a complicated undertaking due to the varying capabilities and vulnerabilities of both friendly and enemy ships. Deciding who should attack who is a critical decision that can determine the outcome of the battle.

Figure 1 shows a map of 15 blue, friendly submarines and 15 red, enemy battleships. Your goal is to move each submarine so that it occupies the same cell as a battleship. When a submarine occupies the same cell as a battleship, the battleship is destroyed. Each submarine can only destroy one battleship. Battleships cannot move.

Use Pythagorean theorem to calculate the distance between cells. For example, the distance between cells A1 and B3 is 2.236 km.

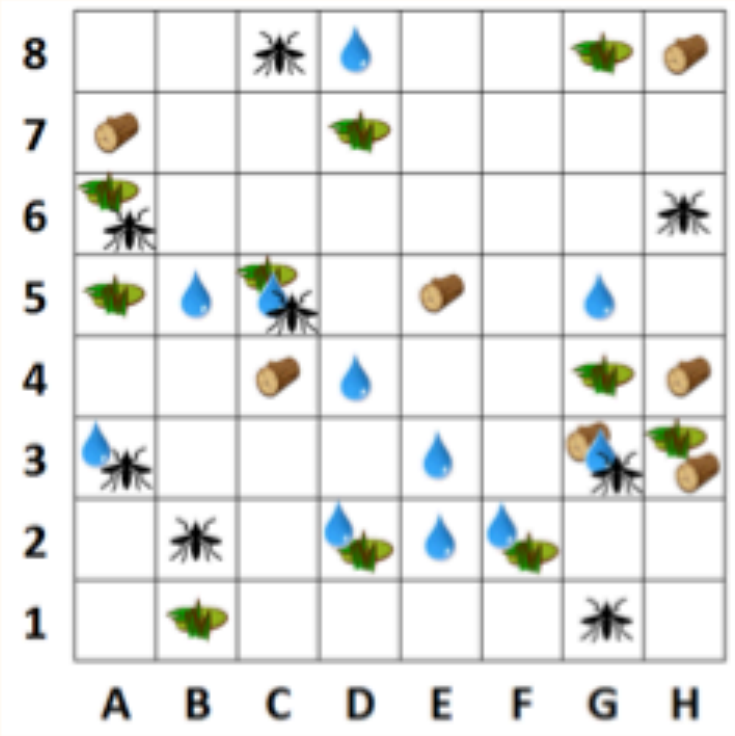
February 2013 - Chandelier Balancing

Constructing a chandelier can be a tricky undertaking because the slightest imperfection will unbalance the chandelier and cause it to be skewed.

Figure 1 shows a chandelier constructed from arms, wires, and triangles that hold weights. In order to perfectly balance the chandelier, weights must be placed into the triangles. There are 9 weights as follows: 1,2,3,4,5,6,7,8,9kg. Each triangle can only hold one weight. Assume the weight of the arms, wires, and triangles are negligible.

Question: Where should the weights be placed in order to perfectly balance the chandelier?

Campsite



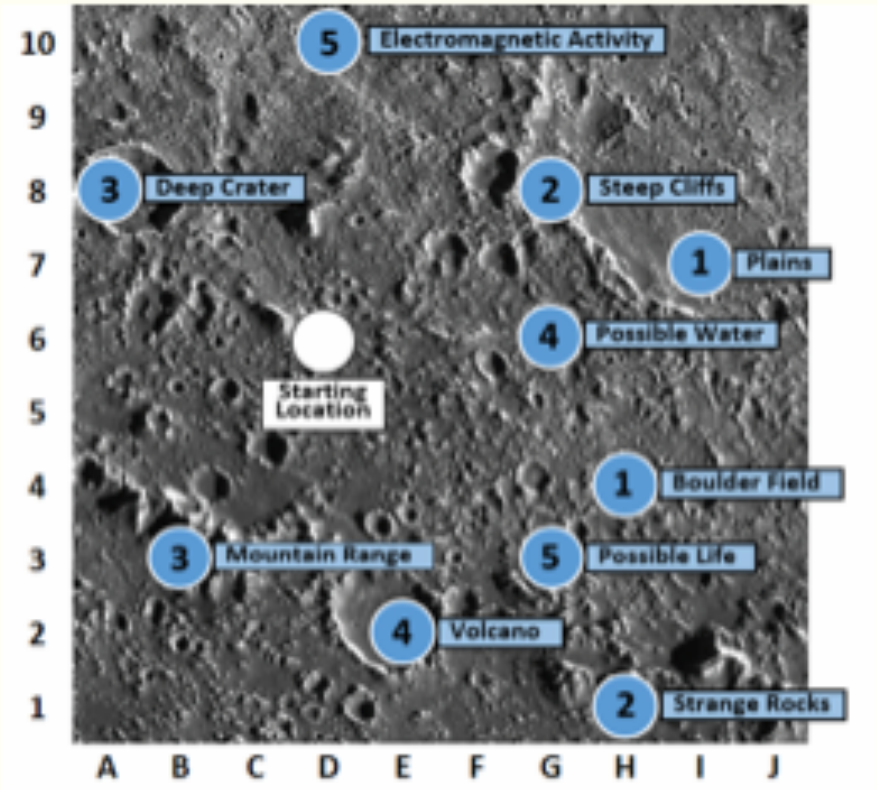
Selecting the ideal camping site requires careful consideration of many factors such as the proximity to water, availability of firewood, and protection from the elements. Your potential camping sites are shown in the corresponding map. The map consists of 64 sites each with varying characteristics including water, wood, swamp, and mosquitoes.

The quality of a site is determined by a points system. A site that contains water receives +3 points and a site that is near water receives +1 point. A site that contains wood receives +2 points and a site that is near wood receives +1 point. A site that contains swamp is -2 points and a site that is near swamp is -1 point. A site that contains mosquitoes receives -3 points and a site that is near mosquitoes is -2 points. "Near" is defined as adjacent sites including diagonals.

For example, site B5 is worth 1 point (based on +3 on water, +1 near wood, -2 near mosquitoes, -1 near swamp). Note that you only count points once for each type of characteristic.

Question: Where is the best campsite?

Moon Rover

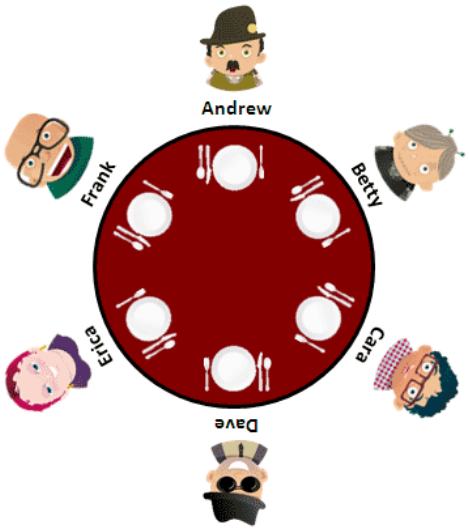


A new moon on a nearby planet has recently been discovered and a rover has been sent to the surface to explore. Many interesting features on the new moon have been identified but the rover has a limited travel distance ability so not all sites can be visited.

In order to prioritize the scientific value of a site, "Science Points" have been assigned to each of the sites of interest (as indicated by the numbers inside the circles). The rover starts at location D6. Due to the battery limitations of the rover, it can only travel a maximum distance of 25km. Use a direct line between sites to calculate travel distance (for example, the distance between G3 and H4 is 1.41km).

Question: What is the maximum number of "Science Points" you can achieve before the rover's batteries run out?

Best Host



Serving as host for dinner requires several skills to pull off a successful evening. One of your duties, aside from preparing dinner and selecting the drinks, is to make sure your guests enjoy themselves.

Image 1 shows a dinner table with 6 seats for your guests. Some guests, however, do not get along with each other. If two guests who do not get along are seated next to each other, it will create conflict at dinner. As host, you must arrange the guests in a seating order that minimizes conflict.

Andrew will only sit next to Dave and Frank; Betty will only sit next to Cara and Erica; Cara will only sit next to Betty and Frank; Dave will only sit next to Andrew and Erica; Erica will only sit next to Betty and Dave; Frank will only sit next to Andrew and Cara. In the example seating arrangement above, there are 3 conflicts (Andrew and Betty, Cara and Dave, Erica and Frank).

Question: What seating arrangement will minimize the conflict at dinner?