Module 12 Practice Problems

**1) The Tulsa Symphony Orchestra Dilemma**

Each year, the Smith, Jones and Sharda families join together to buy 6 season tickets for the TSO and use a lottery style process to decide how they will split the tickets across the performances.

This year, there are 6 performances spread out between September and May, all ‘themed’ on different countries – Germany (September), Italy (October), America (November), England (January), France (March) and Latin America (May).

Given six performances, each family will then get to attend exactly 2 separate concerts.

The families have not been satisfied with the manner in which they split up the tickets in the past, and so this year, they decide upon the following process. Each family is allocated 100 points to use to “weight” their desire to attend each individual performance. Thus, a family can ‘allocate’ 15 units to 5 of the concerts, and 25 units to another in expressing their preferences (higher is more preferred). Once the families have done this (secretly), then assignments of performances to families are done such that the overall sum of ‘assigned’ preference points is maximized. So, for instance, in the example below, if the Smith’s got the first two concerts, the Joneses’ the next two, and the Sharda family the last two, that would result in a score of 33+13+9+21+13+12 = 101.

Many factors can be considered by the families – timing of the concerts, the country being highlighted, other activities, etc.

Below is the preferences allocated by the three families.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Germany | Italy | America | England | France | L. America |
| Smith | 33 | 13 | 11 | 17 | 16 | 10 |
| Jones | 26 | 14 | 9 | 21 | 17 | 13 |
| Sharda | 34 | 9 | 12 | 20 | 13 | 12 |

Using the objective stated above, find how this process would allocate performances to families.

**2) Christopher Cross’s Crew** (adapted from John Toczek’s “Choose your crew” from April 2011 OR/MS Today, pg. 14).

The table below shows an assessment of 9 possible crew members on 3 critical skills (and their cost) for a long sea voyage. A captain’s most important decision for a long sea voyage is selecting the right crew, and the different mix of skills necessary to be successful (and survive). Such skills include fishing (have to eat), sailing (have to move forward) and navigation (can’t get lost).

History has shown that to be successful, your crew must have a cumulative skill value of at least15 units on each of the three critical skills. You can have as large as crew as you need. What is the minimal cost crew that will lead to a successful voyage?



**3) Project Selection at US EAST Communcations**

The Project Steering committee at US EAST Communications is sorting through its information system project selection process for the next quarter. Twelve projects are under consideration. Their attributes are shown below:



TYPE = Critical (CS), Enhancement (E), On-Going (OG), Experimental (EXP) and New process (NEW).

NPV = Assessed payoff in 000 – the objective to be maximized in the selection of our projects.

CAPBud – capital budget for each project.

Staff MM – estimated staff expense, in Man-months.

Last Year: Budget expense for last year. 0 implied the project is not on-going.

Next Year? – A ‘1’ indicates it is a multi-year project

Create an IP model to select the best set of projects that maximize NPV. Items to consider for selection:

a) There are 1000 units for CAPBud and 450 units for Staff MM.

b) EXP projects are very risky but might be very rewarding – select exactly one of these projects.

c) Select at least 1 critical project.

d) No more than ½ of the projects selected should be multi-year projects (“Y” for Next Year).

e) If Project B is chosen, Project J must be as well. The reverse is not true.

f) Run the model two ways – one forcing the on-going projects to be selected, another model without forcing them (letting the model decide if it should select them ‘naturally’).

4) **The China Syndrome’s Holiday Staffing- II**

Take the model you built for Jane Turner in Module 11 and add the following restrictions to a revised Integer programming model: Everyone must work at least once. People cannot work both days at Thanksgiving or at New Year’s.

**5) GBR Systems**

You manage a small software development company called GBR Systems. You have 10 employees available for assignment to 2 projects. Each employee has an assessed rating (higher means better performer) and you’ve noted which employees have earned certification A and certification B (see table below).



Project Pelini requires at least 3 team members. There needs to be at least 2 people assigned that have Certification A and at least 1 person assigned with Certification B. They can overlap, obviously. Because Pelini is an important project, the weighted average of the employees assigned to it must average at least 82.

Project Devaney also requires at least 3 team members, and 2 with Certification A. The weighted average of the employees assigned to this project must average at least 75.

More than 3 employees may be assigned to each project. Find the optimal assignment – your objective is to maximize the total employee rating of all assigned staff members (aggregately for both projects).

Perhaps it should be mentioned that each employee can be assigned at most to one of the two projects.

**6) I’m A Pod Man!**

You are a consultant to the selection committee for the Division III NAIA Basketball tournament. The Championship is determined by a 16-team, single elimination tournament. Four teams are assigned to each of four regions (KC, FARGO, ST. JOE, WICHITA). Each region must have a #1 seed, a #2 seed, a #3 seed and a #4 seed. In each region, first round games see the #1 seed play the #4 seed, and the #2 seed play the #3 seed. The winners play, and that winner advances to the Final Four.

The final 16 teams have already been determined, as have their seeds (there are 4 #1 seeds, 4 #2 seeds, etc.). Your task is to assign teams to regions while minimizing some distance metric. The distance from the school to each of the four regional sites is shown in the attached table. The schools conference affiliation and their seed are also shown in the table. Note that “None” implies that the school is not in a conference. The only other rule in assigning teams is that teams from the same conference must be assigned to different regionals (this is an absolute rule and includes considering both games played at the regional sites).

Create a model that is feasible and minimizes overall distance traveled by all teams aggregately.



**7) NCAA March Madness Scheduling – 2010 Revisited**

Each year, there are many complaints about how the NCAA Men’s Basketball Committee seeds and schedules teams in the 65-team single elimination tournament to determine the National Champion. It is inevitable that somebody is unhappy.

You have been asked to look at some different scenarios in assigning teams to regions and sub-regions using 2010 data so the committee can reevaluate their processes for subsequent years. You will be using only the 8 teams that are #1 and #2 seeds, but all 4 regions and 8 sub-regions. The criterion used will be minimizing the sum of distance traveled by all the teams involved, using their assigned regions and sub-regions as the specific measure. Distance data is provided on a separate spreadsheet.

Some of the complaints and other aspects important in assigning teams to regions and sub-regions that the committee has asked to be examined:

a) Each of the four regions (Midwest-St. Louis, West-Salt Lake City, East-Syracuse, South – Houston) will have exactly one #1 seed assigned (from Kansas, Duke, Kentucky and Syracuse) and exactly one #2 seed assigned (Kansas State, West Virginia, Villanova, Ohio State).

b) NCAA scheduling policy requires that a team not play on its home court during the tournament – so Syracuse (the team) cannot be assigned to the East region (in Syracuse, NY).

c) Due to complaints from the host sites of the sub-regionals, each sub-region MUST have either a #1 seed or a #2 seed assigned to it. Normally, this is NOT required (each sub-region typically must have TWO total #1,2,3 or 4 seeds assigned – we are not considering #3 and #4 seeds). The sub-regionals are held at sites in Buffalo, Providence, Jacksonville, Milwaukee, New Orleans, Oklahoma City, San Jose and Spokane.

d) Teams from the same conference cannot be assigned to the same region. Of the 8 teams we are considering, Kansas and Kansas State are from the Big 12 Conference, while Syracuse, West Virginia and Villanova are from the Big East Conference. Duke (Atlantic Coast Conference), Kentucky (Southeast Conference), and Ohio State (Big Eleven Conference) are the other affiliations. Note these were the conference affiliations as of 2010.

e) A team cannot be assigned to a region and sub-region such that the selections choose BOTH the “closest” region AND the “closest” sub-region. So if Team Y’s closest region is Salt Lake City and its closest sub-region is Providence , Team Y can be assigned either to Salt Lake City, OR Providence, OR neither, but NOT BOTH.

Scenario #1 - Implement an appropriate linear programming model that assigns the 8 teams to Regions and Sub-regions, minimizing the sum of overall distances subject to the items listed above.

Scenario #2 – Augment the model above by removing restriction 3 – this means that a sub-region can have 0,1, or 2 #1 and #2 seeds assigned to it.

Compare how the solution changes between Scenario #1 and Scenario #2. Use ‘words’ or ‘pictures’ or ‘tables’ or some kind of non-telepathic communication.





8**) University of South Oklahoma (USO) – Final Exams.**

Due to global warming, a freak snow storm has hit the Dallas, TX campus of the University of South Oklahoma during the first day of Finals. Six (6) business related classes had their final exam postponed.

Now that the streets have been cleared, and order has been restored, the 6 classes need to be ‘paired-up’ and scheduled in 3 different time blocks. (The actual times are irrelevant since the exam will take place on Saturday). Administration wishes to pair-up the classes (and thus give the students their finals) in such a way as to minimize the number of conflicts – students who are in both classes assigned to one Final time block. The table below shows the number of simultaneously enrolled students in each class-pair. Students with conflicts will be taken care of outside the 3 time blocks – thus, their numbers should be minimized. For instance, the table shows that the FIN and ACCT class share 15 students (there are 15 conflicts, 15 students who are taking both classes).

Create an appropriate IP model that determines how best to pair up classes, minimizing the number of conflicts.



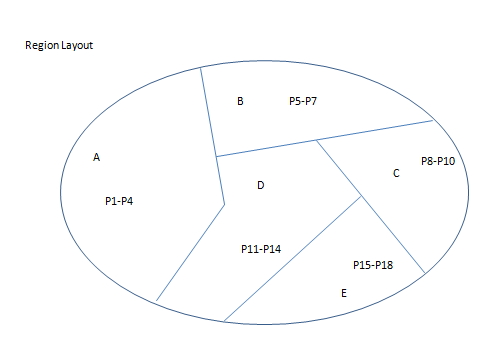
**9) Headline: Oklahoma tourism officials closing state parks**

**Associated Press**

Oklahoma City — The Oklahoma Tourism and Recreation Department says a number of state parks will close for good this year because of budget cuts.

A sign of the times – budget cuts forcing state tourism officials to close state parks. Was this process does rationally?

Assume you are a Tourism and Recreation Department Director for a local region facing similar issues. You manage 18 state parks (P1 thru P18) that are spread across 5 different sub-regions (A thru E in the picture below).



Each park is in one of the 5 sub-regions A, B, C, D or E.

Each park contains one or more of the following facilities: CAMPING, CABINS, LODGE.

Each park also has an ANNUAL budget and has a ‘VISITation’ parameter that represents a combined measure of number of annual visitors and their ‘enjoyment’ level as measured through surveys. This visitation parameter is on a scale of 1-100, with 100 being ‘mega-millions of visitors all perfectly satisfied with their experience’.

Data is shown below.

As a first attempt at determining which parks to keep open (therefore, which ones to close), you establish the following requirements.

Keep enough parks open such that their combined (summed) measure of visitation/enjoyment is at least 702 units. Obviously, you don’t want to close popular and well-visited parks if you don’t have to.

In each sub-region, keeps parks open such that there is at least 1 park that has CAMPING, 1 park that has CABINS and 1 park that has a LODGE. Note that 1 park could conceivably fill all three requirements. In this case, you want to provide a variety of park characteristics in each sub-region.

For each contiguous sub-region pair (i.e., sub-regions that border each other, such as Sub-region A and Sub-region B), there must be at least a total of 4 parks across both sub-regions combined. Similarly, you want to make sure that state parks are accessible to everyone across the different sub-regions of the state. Again, this is for sub-region PAIRS.

Your initial objective is to see how by much you can reduce the annual budget while meeting these ‘park open’ requirements in deciding whether each park should remain open or be closed.



10) **CHALCO CARTON COMPANY (CCC) - Revisited** - The Chalco Carton Company produces egg cartons (among other items) at three eastern Nebraska locations (Gretna, Louisville, and, of course, Chalco). The company has just received contract to provide a onetime shipment of egg cartons to ‘mom and pop’ grocery stores in Ashland, Greenwood, Waverly and Eagle. The contract will pay CCC a fixed amount for the satisfaction of the demand specified in the contract for the egg cartons at the grocery stores.

A quick analysis of shipping costs using historical records and basic CCC accounting principles leads to the following table which shows the per carton cost of transporting a crate of cartons from the production locations to the grocery stores.

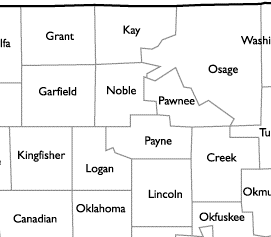
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Ashland | Greenwood | Waverly | Eagle |
| Gretna | 10 | 7 | 8 | 15 |
| Louisville | 16 | 13 | 9 | 14 |
| Chalco | 12 | 11 | 12 | 16 |

Gretna has 75 crates of cartons in stock, Louisville, 80 crates, and Chalco, 55 crates. The contract states that CCC needs to ship Ashland 50 creates, Greenwood 60 crates, Waverly 70 crates and Eagle, 65 crates.

You recognized early that you could not meet total demand, and you negotiated a penalty clause – you agree to meet the demand of 3 of the 4 grocery stores. For the grocery store whose demand was not met, there will be a penalty – Ashland’s penalty was $750, Greenwood’s $900, Waverly $800 and Eagle, $1200.

Set up an appropriate IP model (one model) that minimizes total costs (shipping plus penalty) while exactly meeting the demand of 3 of the 4 grocery stores.

11) **A&W Bottlers** supplies multiple lines of soda to the 11 county region in North Central Oklahoma shown below. A&W acquired its warehouses over time via buying up smaller operations, so it never really ‘designed’ its soda distribution supply chain. It has warehouses in Enid, Guthrie, Stillwater, Perry and Sapulpa, and has determined that all of the warehouses are likely not necessary.



Circles are warehouse locations:

Enid (Garfield), Guthrie (Logan), Stillwater (Payne), Perry (Noble), Sapulpa (Creek)

In analyzing A&W’s supply chain, the following monthly parameters have been estimated/calculated.

Warehouse capacity (cases): Enid (10,000), Guthrie (12,500), Perry (15,000), Stillwater (8,750), Sapulpa (20,000).

Monthly operating costs (if open): Enid (20,000), Guthrie (35,000), Perry (47,500), Stillwater (17,500), Sapulpa (56,500).

Monthly county demand (cases):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| County | Demand | County | Demand | County | Demand |
| Grant | 1000 | Kay | 750 | Osage | 6750 |
| Garfield | 2500 | Noble | 1500 | Pawnee | 4000 |
| Kingfisher | 1750 | Payne | 2000 | Creek | 2250 |
| Logan | 3500 | Lincoln | 5250 |  |  |

Distribution cost per case from warehouse to county (estimated):

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Grant | Garfield | Kfisher | Logan | Payne | Lincoln | Creek | Pawnee | Noble | Kay | Osage |
| Enid | 2.2 | 0.4 | 3.1 | 4.7 | 4.3 | 8.3 | 11.3 | 5.7 | 2.6 | 5 | 13.1 |
| Guthrie | 7 | 5.2 | 3.3 | 0.3 | 1.8 | 3.1 | 8.4 | 4.9 | 4.5 | 10.3 | 10.6 |
| Perry | 3.6 | 2.4 | 5.1 | 4.6 | 2 | 6.2 | 8.1 | 3.1 | 0.2 | 4.6 | 7.6 |
| Stillwater | 6 | 4.1 | 5.4 | 2.1 | 0.1 | 4.8 | 5.9 | 3 | 2 | 7.1 | 8.2 |
| Sapulpa | 15 | 13.4 | 9.6 | 7.8 | 6.3 | 5.2 | 0.8 | 5.8 | 8.4 | 8.6 | 6.9 |

Using total monthly cost as your metric, determine which warehouses should be open, and the optimal flow of soda from warehouse to county.

12) **Linking Lumber**

You are the order supervisor for a make-to-order Lumber company. You make three different kinds of lumber products (A,B,C) which require two different resources to make (RES1, RES2). You receive inquiries from two different possible customers:

Customer 1: Will pay you $7000 if you can provide 150 units of A,B,C combined in any quantity.

Customer 2: Will pay you $4000 if you can provide 100 units of B and C combined in any quantity.

Lumber A needs 2 units of both RES1 and RES2.

Lumber B needs 3 units of RES1 and 1 unit of RES2.

Lumber C needs 1 unit of RES1 and 4 units of RES2.

Both customers want their orders completed tomorrow. You have 325 units of RES1 and 275 units of RES2 available.

Create a model that helps you decide what you should promise (or which orders to take).

HINT: Find the optimal solution to an LP model where you are maximizing revenue of the two customers, subject to the two resource constraints and the two constraints that LINK the requirements for being paid and the payment (yes/no decisions on customers).