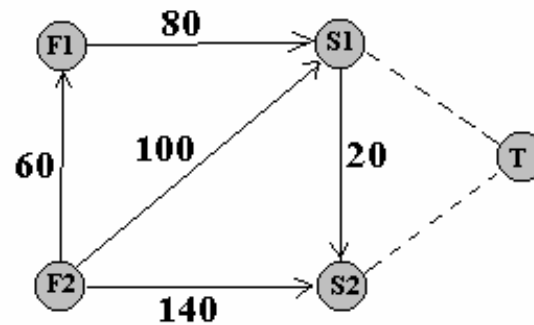# Gas Pipeline Construction

The figure below shows 5 pipelines under consideration by a natural gas company to move gas from its 2 fields to its 2 storage areas. The numbers on the arcs show the number of miles of line that would have to be constructed at $100,000 per mile.

The figure also shows that storage facilities are both already connected to the company's main terminal through existing lines. An estimated 800 million cubic feet must be shipped each year from field 1 to the terminal, and 600 million cubic feet from field 2 to the terminal. Variable shipping cost is $2000 per million cubic feet on each link of the network, and all links have an annual capacity of 1 billion cubic feet. The company wants a minimum total annual cost system for the required shipping.

Radio Station Licences

The map that follows shows the locations of 8 applicants for low-power radio station licences and the approximate range of their signals.
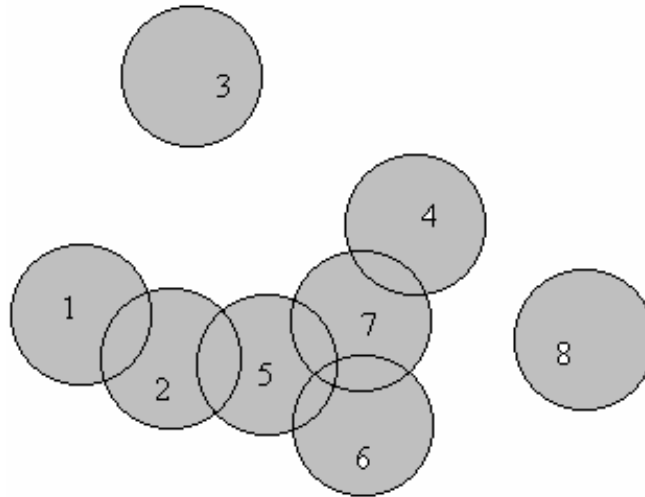
Regulators have scored the quality of applications on a scale of 0 to 100:

Applicant	1	2	3	4	5	6	7	8
Score	45	30	84	73	80	70	61	91

They wish to select the highest-quality combination of applications that has no overlap in signal ranges.

Traffic Monitoring Stations

The following map shows the 8 intersections at which automatic traffic monitoring devices might be installed:
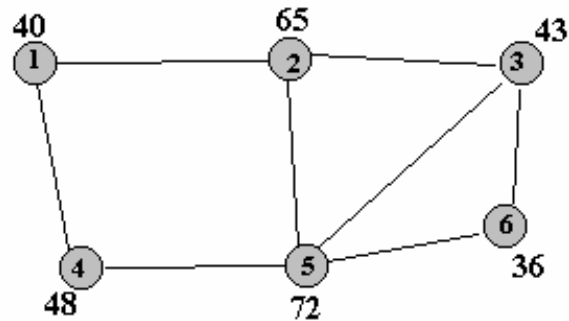
A station at any particular node can monitor all the road links meeting that intersection. Numbers next to nodes reflect the monthly cost (in thousands of dollars) of operating a station at that location.

At which nodes should stations be installed to provide full coverage at minimum total cost?

Football League Schedule

The Mathematical Football League (MFL) is composed of M teams *(where M is even)*. In a season of 2(M−1) consecutive Sundays, each team will play 2(M−1) games. Each team must play each other team twice, once at home and once at the other team's home stadium.

Each Sunday, k games from the MFL are televised. We are given a matrix $\{v_{ij}\}$ where v_{ij} is the viewing audience on a given Sunday if a game between teams i and j playing at team j's stadium is televised.

Formulate a model for generating a schedule for the MFL which maximizes the viewing audience over the entire season. Assume that viewing audiences are additive.

Are some values of k easier to accommodate than others? How?

Madonna's Latest Hits!

Based upon Problem 22, page 474 of the text *Operations Research* (3rd edition) , by Wayne Winston

You have been assigned to arrange the songs on the cassette version of Madonna's latest album. A cassette tape has two sides (side A and side B). The songs on each side of the cassette must total between 14 and 16 minutes in length. The length and type of each song are given in the table below:

Song	Type	Length (minutes)
1	Ballad	4
2	Hit	5
3	Ballad	3
4	Hit	2
5	Ballad	4
6	Hit	3
7	--	5
8	Ballad & Hit	4

The assignment of songs to the tape must satisfy the following four conditions:

i) Each side must have exactly two ballads.
ii) Side A must have at least 3 hit songs.
iii) Either song 5 or song 6 must be on side A.
iv) If songs 2 and 4 are both on side A, then song 5 must be on side B.

a. Formulate an integer LP with binary variables to find an arrangement satisfying these restrictions.
b. Using LINGO, find such an arrangement.

A warehouse facility has packing stations at both its front and back entrances. The following table shows the number of ton-feet (in thousands) of materials handling that would be required to move each of the six pending jobs to either of the two stations, along with the number of hours packing that would be required at whichever station does the work.

Schedulers seek a minimum handling plan that completes all packing within the 200 hours available at the front station and 190 hours available at the back station. Assume that jobs must go entirely to a single packing station.

JOB

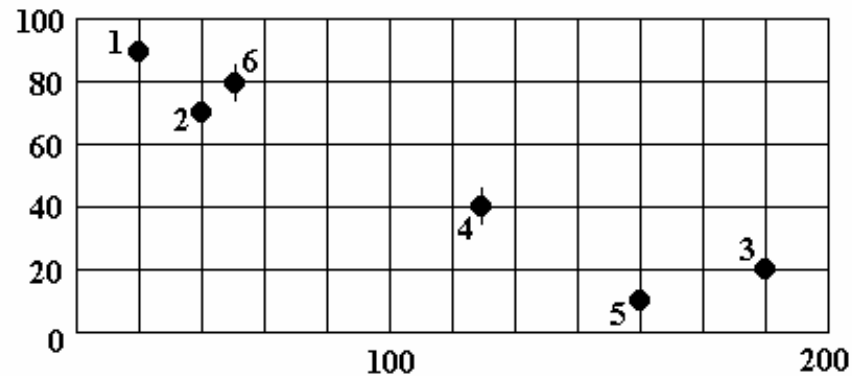|	1	2	3	4	5	6
Front	21	17	10	30	40	22
Back	13	18	29	24	33	29
Time (hrs)	44	60	51	80	73	67

Three professional baseball teams are trying to find places for six available players within their remaining salary limits of $35 million, $20 million, and $26 million, respectively. The following table shows how valuable each player would be to each team on a scale of 0 to 10, and the player's current annual salary (in $millions).

Value

Player	Team A	Team B	Team C	Salary
1	8	7	10	10
2	7	8	6	13
3	5	4	6	8
4	6	3	3	6
5	8	7	6	15
6	10	9	10	22

We want to find a maximum total score allocation of players to teams that fits within salary limits.

Engineers are designing a fixed route to be followed by automatic guided vehicles in a large manufacturing plant. The following table shows the east-west and north-south coordinates of the six stations to be served by vehicles moving continuously around the same route.

Station

	1	2	3	4	5	6
E/W	20	40	180	130	160	50
N/S	90	70	20	40	10	80

Since traffic must move along east-west or north-south aisles, designers seek a route of shortest total rectilinear length.

Black Box Company (BBC) is considering five new box designs of different sizes to package four upcoming lines of computer monitors. The following table shows the wasted space that each box would have if used to package each monitor. Missing values indicate a box that cannot be used for a particular monitor.
Monitor

Box	1	2	3	4
1	5	--	10	--
2	20	--	--	25
3	40	--	40	30
4	--	10	70	--
5	--	40	80	--

BBC wants to choose the smallest number of box designs needed to pack all products and to decide which box design to use for each monitor to minimize wasted space.

A team of auditors has divided itself into 3 groups, each to examine one category of records. Each group will review their specialty area for all 3 subsidiaries of the client being audited, but the required sequence and times differ, as shown in the following table:

		Group Time (days)		
Subsidiary	Sequence	1	2	3
1	1-3-2	4	5	12
2	2-1-3	6	18	3
3	3-2-1	5	7	3

Once a group starts on a subsidiary, it should finish all work either before it moves to another or before a different group begins on theirs. The team seeks a schedule that will complete all work at the earliest possible time.