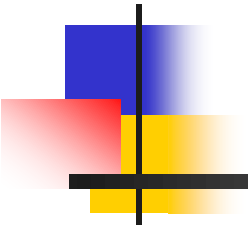


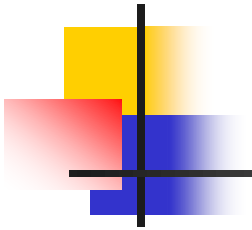
# Mathematical Programming: Modelling and Applications

September 2009

Sonia Cafieri

*LIX, École Polytechnique*

cafieri@lix.polytechnique.fr



# Outline

- Some basic AMPL useful operations & commands
- A modelling problem
- Formulation of the mathematical model
- The AMPL model
- Solution of the problem

# AMPL basic set operations

These operations become useful or necessary in many problems

- Let A, B, and U be sets

- AMPL allows simple set operations:
  - Union: U = A union B elements of A or B
  - Intersection: U = A inter B elements of A and B
  - Difference: U = A diff B elements of A and not of B

**Union**: Example

```
ampl: set MONTHS := {1,2,3,4};
ampl: set MONTHS0 := {0} union MONTHS;
ampl: display MONTHS0;
set MONTHS0 := 0 1 2 3 4;
```

# AMPL commands

AMPL recognizes a lot of commands.

- Some commands you already know are, e.g.:
  - model: switch to model mode
  - data: switch to data mode
  - exit: exit AMPL
  - display: print model entities and expressions
  - let: change data values
  - .....

- Other useful commands:
  - fix: freeze a variable at its current value
  - unfix: undo a fix command
  - delete: delete model entities
  - purge: delete model entities and their dependents

# AMPL commands

Note that fix, unfix, delete, purge,.. are used for *changing a model :*
it is possible in AMPL modifying models and data.

**Fix**: Example

fix *varname*

- This command instructs AMPL to treat the indicated variable as though fixed at its current value (e.g. in solve command): we have a constant.
- If varname is the name of an indexed collection of variables, fix (and unfix) affects all members of the collection.
- Fixing a variable we have a further constraint in the problem.

# AMPL commands: fix

```
ampl: var y{1..4} >=1;
ampl: let y[3] := 10;
ampl: fix y[3];
ampl: display y[3];
y[3] = 10

ampl: minimize somma: sum{i in 1..4} y[i];
ampl: option solver cplex;
ampl: solve;
ILOG CPLEX 10.100, licensed to "ecolepolytechnique-palaiseau",
options: e m b q use=8
CPLEX 10.1.0: optimal solution; objective 13
0 dual simplex iterations (0 in phase I)
ampl: display y;
y [*] :=
1   1
2   1
3  10
4   1
;
```

# Production planning problem

A firm is planning the production of 3 products A1, A2, A3 over a time horizon of 4 months (January to April). We know:

- The *demand* for the products over the 4 months;
- *Prices, production costs, production quotas, activation costs* and *minimum batches* for each product;

Furthermore:

- There is a different number of *productive days* over the 4 months;
- The *activation status* of a production line can be changed every month.
- *Minimum batches* are monthly.
- Each product needs to be stored. There are different *monthly rates* for renting the storage space for each product.
- Each product takes the same amount of storage space. The *total available volume* is given.

# Production planning problem: data

Demand for the products over the months:

| Demand | January | February | March | April |
|---|---|---|---|---|
| A1 | 5300 | 1200 | 7400 | 5300 |
| A2 | 4500 | 5400 | 6500 | 7200 |
| A3 | 4400 | 6700 | 12500 | 13200 |

Prices, production costs, production quotas, activation costs and minimum batches:

| Product | A1 | A2 | A3 |
|---|---|---|---|
| Selling prices | $124 | $109 | $115 |
| Activation costs | $150000 | $150000 | $100000 |
| Production costs | $73.30 | $52.90 | $65.40 |
| Production quotas | 500 | 450 | 550 |
| Minimum batches | 20 | 20 | 16 |

# Production planning problem: data

Number of productive days over the months:

| | |
|---|---|
| January | 23 |
| February | 20 |
| March | 23 |
| April | 22 |

Monthly rates for storage space:

| | |
|---|---|
| A1 | $3.50 |
| A2 | $4.00 |
| A3 | $3.00 |

Total available volume: 800 units.

**Write a mathematical program to maximize the income, and solve it with AMPL.**