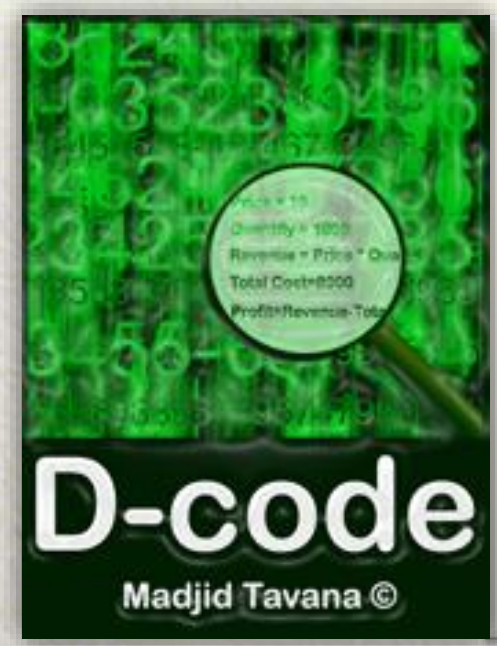
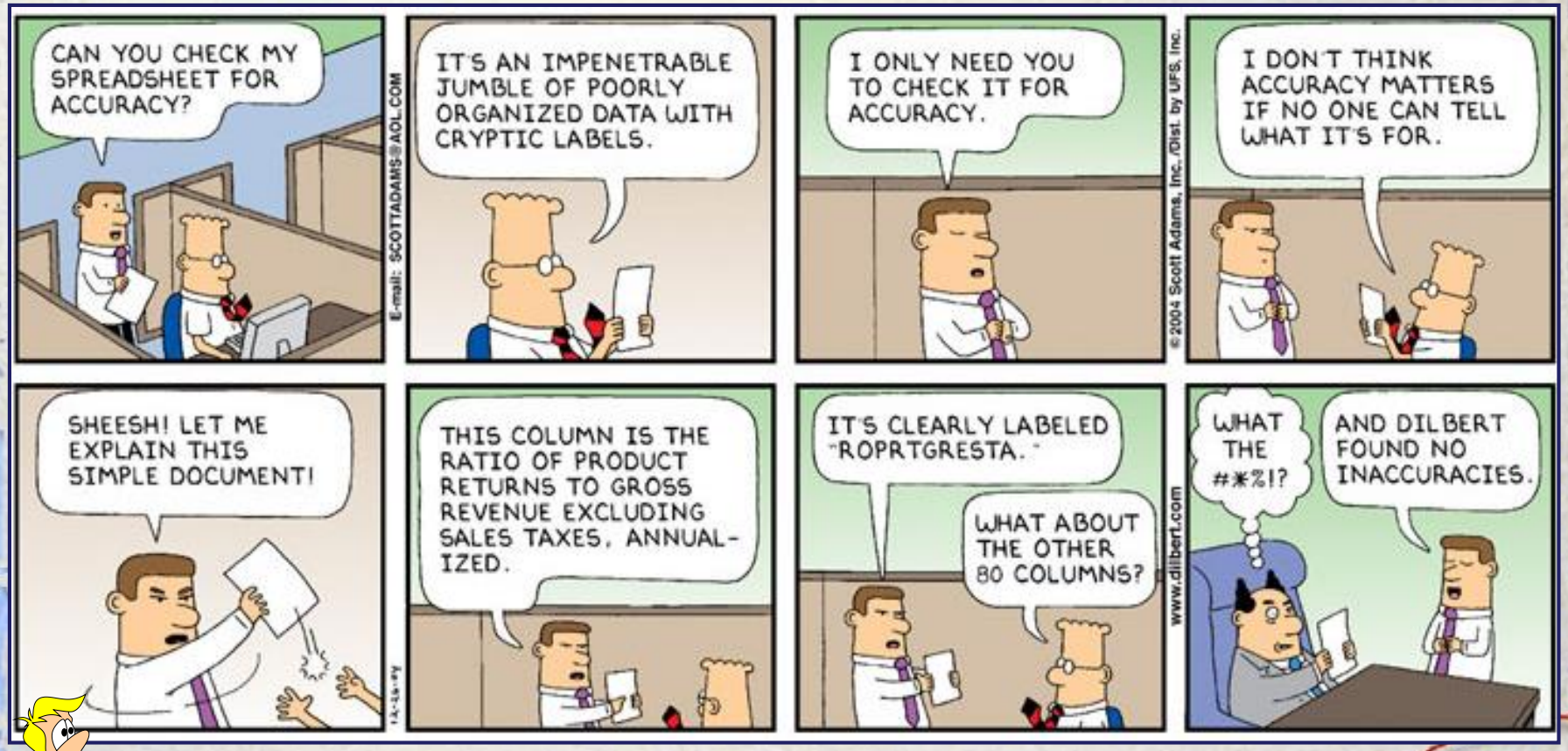
Decision Support Systems and Decision Analytics
Natural Language Programming



- Models
- Natural Language Programming
- D-code
- Example: Keystone Insurance
- Problem: The Prolog Corporation

What's Wrong with Spreadsheets

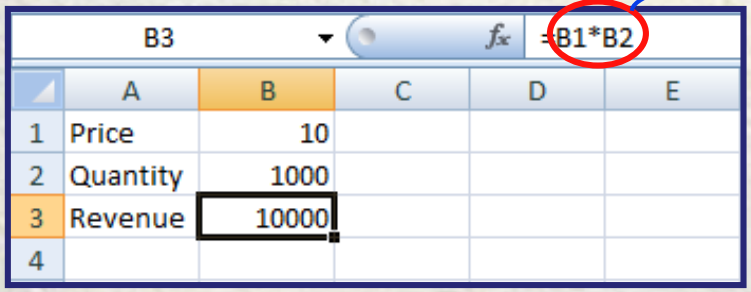
D-code is a natural language programming tool that provides an easier and faster way to build, edit and explain a spreadsheet model in a collaborative model-building environment.



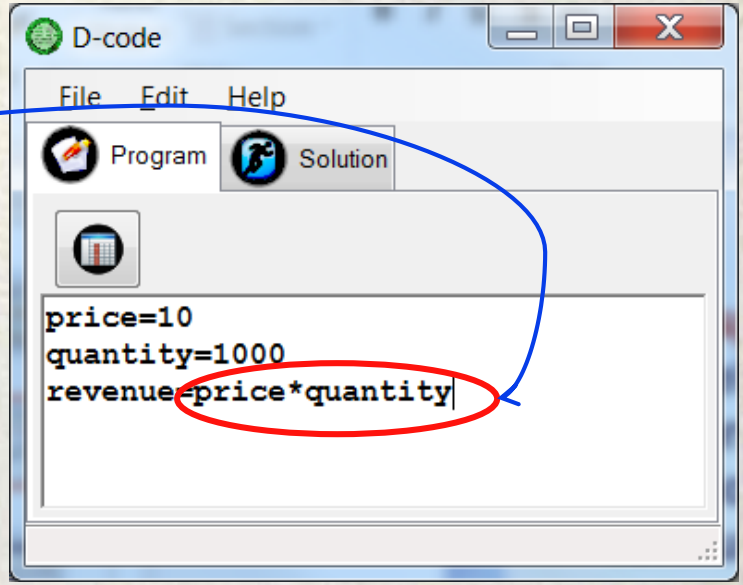
What's Wrong with Spreadsheets

- **Transparency:** Traditional spreadsheet programs hide the logic of the model behind columns and rows of data. Natural language programming and D-code makes it easy to understand how the numbers are generated by using algebraic relationships and natural-language processing instead of cells and formulas.

SPREADSHEET



D-CODE



What's Wrong with Spreadsheets

- **View:** Spreadsheets are limited to show either the formulas within the cells *or* their calculated values at a given time. D-code shows the model (input) and the solution (output) side-by-side.

- **Complication:** When working with large spreadsheets, it is difficult to follow the logic of the model by looking up the formulas in the cells. Editing and refining the model becomes a difficult task.

B5 f_x =(12*B4)+(11*C4)-((D2*(B2*B4)+D2*(C2*C4))+(D3*(B3*B4)+D3*(C3*C4)))

	A	B	C	D	E	F	G	H
1		Foldaway	Straightaway	Cost	Usage			
2	Plastic	10	15	0.1	25			
3	Labor	0.3	0.175	20	0.475			
4	Quantity	1	1					
5	Total Profit	11						
6								

- **Portability:** D-code supports Dynamic Data Exchange (DDE). The results can be exported to Excel for further manipulation or graphing.

The Benefits of Models

1. The cost of the modeling analysis is much lower than the cost of a similar experimentation conducted with a real system.
2. Models enable the compression of time. Years of operations can be calculated in minutes of computer time.
3. Manipulation of the model (changing variables) is much easier than manipulating a real system. Experimentation is therefore easier to conduct and it does not interfere with the daily operation of the organization.
4. The cost of making mistakes during a trial-and-error experiment is less when models are used rather than real systems.
5. Today's environment involves considerable uncertainty. The use of modeling allows a manager to calculate the risks involved in specific situations.
6. The use of mathematical models enables the analysis of a very sometimes infinite number of possible solutions. With today's advanced technology and communications, managers frequently have a number of alternatives to choose from.
7. Models enhance learning and training.

Computer Modeling

A computer-based model should be a good vehicle for communication, intelligible even to person untrained in the particular language. This will be true if the model builder is careful to use descriptive variable names that are as meaningful to colleagues as to the computer.

In a managerial setting timeliness with which computer generated results can be produced is critical. Unless results can be produced quickly, they will not be used, and the effort will have been wasted.

Important Features of Natural Language programming and D-code

- They have been designed to permit long descriptive variable names that can be understood by anyone.
- They are designed to handle problems that conform to a familiar worksheet format of rows and columns.
- They are non-procedural, which means that the user does not have to be concerned with the order in which variables are defined.
- They can be modified easily either to correct errors or to test alternative assumptions.
- Allows direct model building without technical help.
- Variables in the model are tied together through algebraic relationships.

Keystone Insurance

Jim Davis, the president of Keystone insurance wishes to describe his projected statement of income over the next five years. He estimates sales to be $400,000 in 2012 with annual increases of 12 percent thereafter. Gross profit will be these sales less cost of goods sold, which can be considered to be 60 percent of sales. Total expenses include fixed expenses (at $25,000 in 2012, increasing with inflation at 8 percent per year) and interest paid in a long-term average debt of $80,000 at 9.25 percent. His tax liability is 48 percent of profit before tax. What is Keystone net income projected to be each year?"

Keystone Insurance

The layout below suggests how one might start filling out a worksheet to solve the problem described above.

	2012	2013	2014	2015	2016
SALES	400,000				
GROSS PROFIT					
COSTS OF GOODS SOLD					
TOTAL EXPENSES					
FIXED EXPENSES	25,000				
DEBT LEVEL	80,000	80,000	80,000	80,000	80,000
INTEREST PAID					
TAX LIABILITY					
PROFIT BEFORE TAX					
NET INCOME					

Keystone Insurance

The next step, shown in the layout below, is to describe how to calculate the remaining worksheet entries:

	2012	2013	2014	2015	2016
SALES	400,000	(previous value * 1.12)			
GROSS PROFIT	(Sales - Costs of Goods Sold)				
COSTS OF GOODS SOLD	(.60 * Sales)				
TOTAL EXPENSES	(Fixed Expenses + Interest Paid)				
FIXED EXPENSES	25,000	(previous value * 1.08)			
DEBT LEVEL	80,000	80,000	80,000	80,000	80,000
INTEREST PAID	(.0925 * Debt level)				
TAX LIABILITY	(.48 * Profit Before Tax)				
PROFIT BEFORE TAX	(Gross Profit - Total Expenses)				
NET INCOME	(Profit Before Tax - Tax Liability)				

Keystone Insurance

D-code Input and Output

D-code

File Edit Help

Program Solution

```
sales=400000, PREVIOUS*1.12
gross profit = sales - cost of goods sold
cost of goods sold = .60 * sales
total expenses = fixed expenses + interest paid
fixed expenses =25000, PREVIOUS*1.08
debt level = 80000
interest paid = .0925 * debt level
tax liability = .48 * profit before tax
profit before tax = gross profit - total expenses
net income = profit before tax - tax liability
COLUMN total=SUM Year 2011 THROUGH Year 2015
```

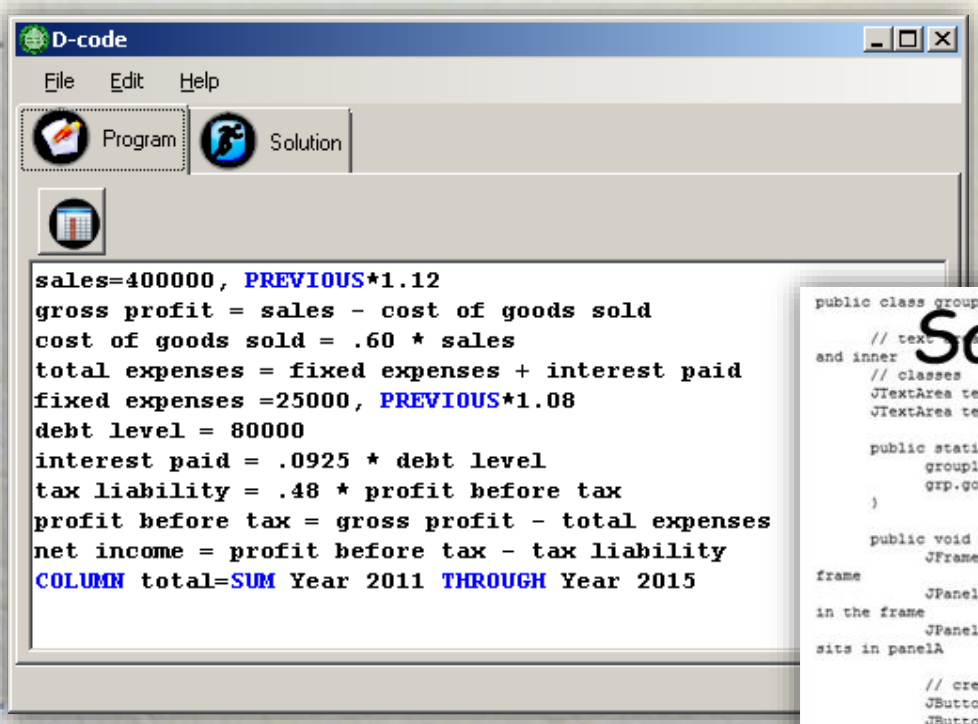
D-code

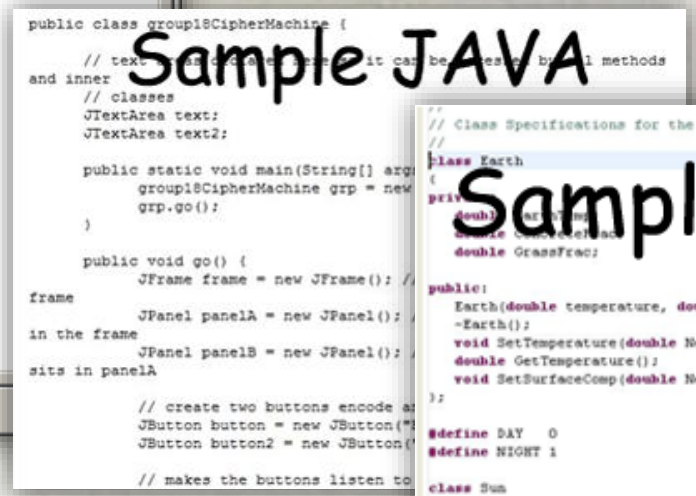
File Edit Help

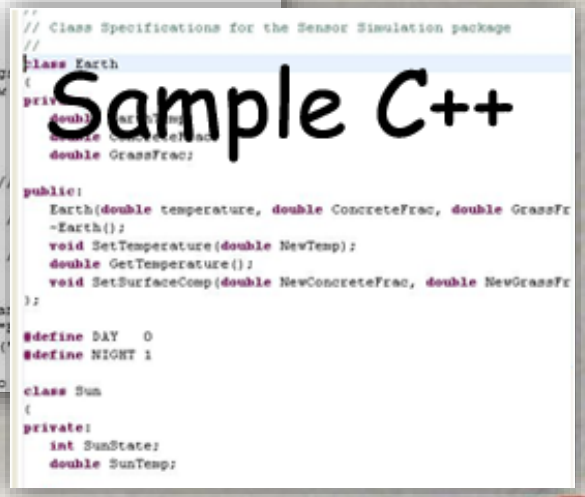
Program Solution

Object	Year 2012	Year 2013	Year 2014	Year 2015	Year 2016	total
sales	400000.00	448000.00	501760.00	561971.20	629407.74	2541138.94
gross profit	160000.00	179200.00	200704.00	224788.48	251763.10	1016455.58
cost of goods sold	240000.00	268800.00	301056.00	337182.72	377644.65	1524683.37
total expenses	32400.00	34400.00	36560.00	38892.80	41412.22	183665.02
fixed expenses	25000.00	27000.00	29160.00	31492.80	34012.22	146665.02
debt level	80000.00	80000.00	80000.00	80000.00	80000.00	400000.00
interest paid	7400.00	7400.00	7400.00	7400.00	7400.00	37000.00
tax liability	61248.00	69504.00	78789.12	89229.93	100968.42	399739.47
profit before tax	127600.00	144800.00	164144.00	185895.68	210350.87	832790.55
net income	66352.00	75296.00	85354.88	96665.75	109382.45	433051.09

D-code Model vs. Traditional Programming Languages







http://tavana.us/keys.nlp

D-code Features and Keywords

- **Commas separate the values of one column from another.**
- **Mathematical Operators and the order of operations:**

Mathematical Operators	
Addition	Plus sign (+)
Subtraction	Minus sign (-)
Multiplication	Asterisk (*)
Division	forward slash (/)
Exponentiation	Caret (^)
	x^y is x to the power of y
	x^0.5 is square root of x

The Order of Operations:

1. Brackets
2. Exponents
3. Division
4. Multiplication
5. Addition
6. Subtraction

- **<u>Variable names cannot include mathematical operators (e.g., price/unit)</u>.**
- **D-code Keywords:**
  - **COMMENT**
  - **PREVIOUS**
  - **FOR**
  - **COLUMN**
  - **SUM**
  - **THROUGH**

D-code Keywords

The **COMMENT** keyword is used to enable the user to insert comments about the model. All the comments start with the keyword **COMMENT** and all following content are ignored.

Example

COMMENT This model is about the marketing division employees and their work hours.

The **PREVIOUS** keyword is used in an equation when the value of the variable in one column is derived from that of a previous column.

Example

Sales = 20000, **PREVIOUS** * 1.07

The **FOR** keyword is used when the same value is to be repeated for a certain number of columns.

Example

Sales = 20000 **FOR** 3, 30000 **FOR** 4, 50000 **FOR** 6

The **COLUMN** keyword is used to refer and perform an operation on a column in the model. The **COLUMN** keyword is used with the **SUM** and **THROUGH** keywords. The **SUM** function is used to calculate the sum of the values of specified variables. The **SUM** function uses the **THROUGH** keyword to specify the range of variables or columns to be used in it.

Example

COLUMN total = **SUM** January **THROUGH** June

COLUMN average = **SUM** January **THROUGH** June/6

D-code Error Handling

D-code

File Edit Help

Program Solution

```
sales=400000, PREVIOUS*1.12
gross profit = sales - cost of goods sold
cost of goods sold = .60 * sales
total expenses = fixed expenses + interest paid
fixed expenses =25000, PREVIOUS*1.08
debt level = 80000
interest paid = .0925 * debt level
tax liability = .48 * profit before tax
profit before tax = gross profits - total expens
net income = profit before tax - tax liability
COLUMN total=SUM Year 2012 THROUGH Year 2016
```

D-code

File Edit Help

Program Solution

Row name, gross profits, is not defined. Error line 9.

D-code

File Edit Help

Program Solution

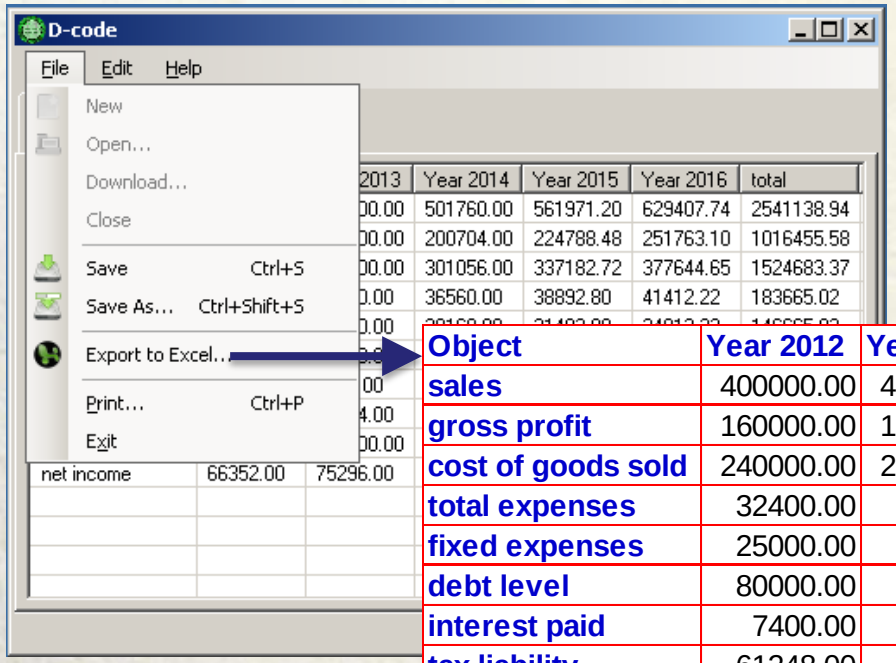
```
sales=400000, PREVIOUS*1.12
gross profit = sales - cost of goods sold
cost of goods sold = .60 * sales
total expenses = fixed expenses + interest paid
fixed expenses =25000, PREVIOUS*1.08
debt level = 80000
interest paid = .0925 * debt level
tax liability = .48 * profit before tax
profit before tax = gross profits - total expenses
net income = profit before tax - tax liability
COLUMN total=SUM Year 2012 THROUGH Year 2016
```

Note: Avoid **BLANK LINES** in your model since they result in erroneous line numbers during the troubleshooting session.

Keystone Insurance

D-code Dynamic Data Exchange (DDE)

Next, the user wants to dump the results into an Excel spreadsheet:



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net income	66352.00	75296.00	85354.88	96665.75	109382.45	433051.09

A NOTE ON THE USE OF THE PREVIOUS KEYWORD

D-code

File Edit Help

Program Solution

```
COMMENT good model-1
price1 = 10
quantity1 = 1000, PREVIOUS * 1.10
revenue1 = price1 * quantity1
COMMENT bad (not wrong) model-2
quantity2 = 1000, PREVIOUS * 1.10
revenue2 = 10 * quantity2
COMMENT very bad (not wrong) model-3
revenue3 = 10 * 1000, PREVIOUS * 1.10
COMMENT wrong model-4
revenue4 = 1000, PREVIOUS * 1.10 * 10
```

D-code

File Edit Help

Program Solution

Object	January	February	March
price1	10.00	10.00	10.00
quantity1	1000.00	1100.00	1210.00
revenue1	10000.00	11000.00	12100.00
quantity2	1000.00	1100.00	1210.00
revenue2	10000.00	11000.00	12100.00
revenue3	10000.00	11000.00	12100.00
revenue4	1000.00	11000.00	121000.00

PROLOG CORPORATION

The Prolog Corporation is planning its financing for the next six months. Prolog makes one item, which it sells through the retail shop in the front of the factory. Use the following planning figures to construct a natural language programming model with D-code for Prolog and find the monthly, average and total profits for the next six months.

Planning Period: January thru June

Unit Price	$50
Quantity	2000 (January) Up 2% Monthly

Fixed Costs Per Month:

Rent	$4,000
Salaries	$20,000
Utilities	$5000 (January) Up 1% Monthly

Variable Costs Per Unit:

Material	$20
Labor	$10 (January) Up 2% monthly

Prolog Corporation
D-code Model

Prolog Corporation
D-code Solution