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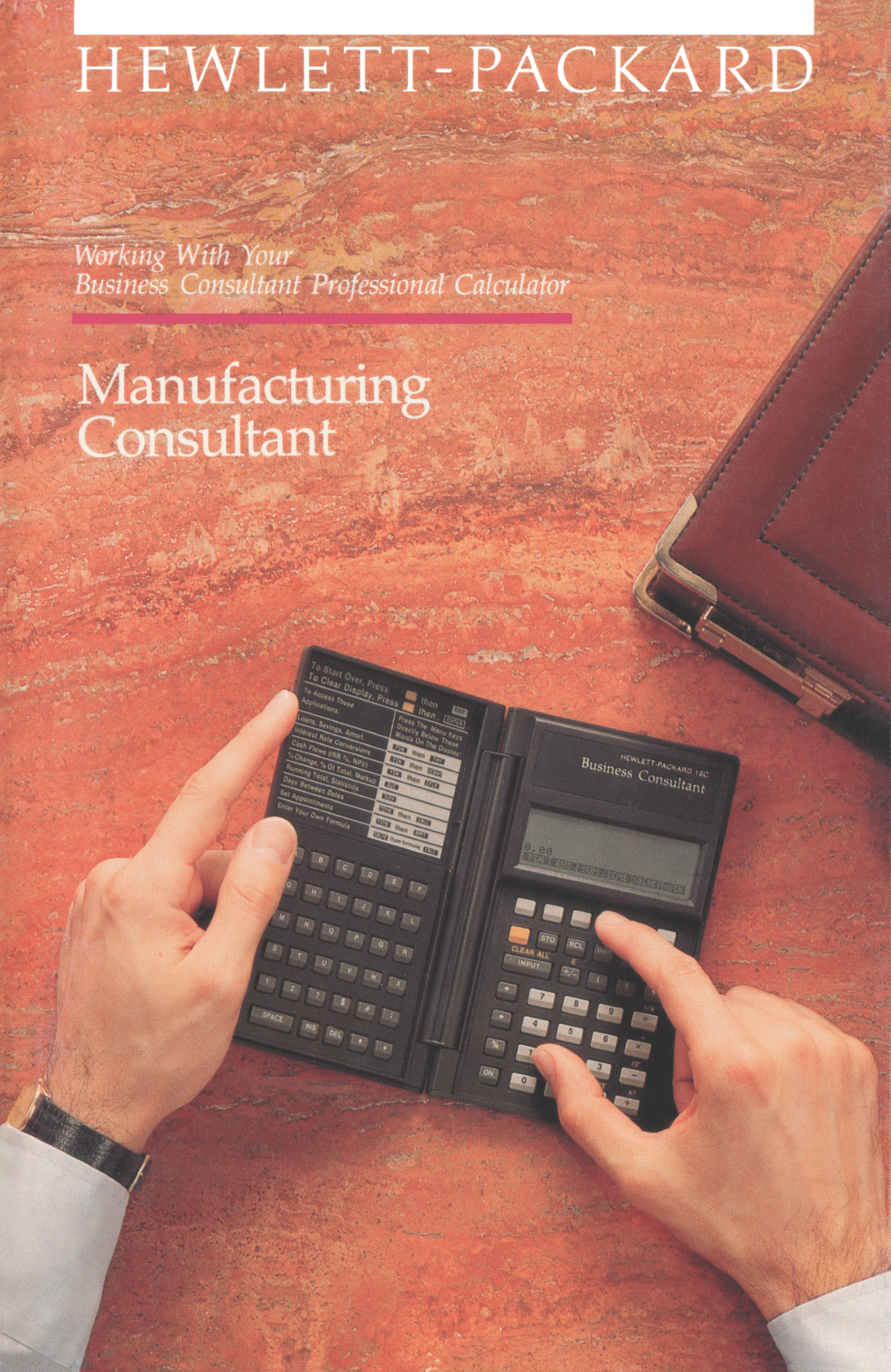
Working With Your
Business Consultant Professional Calculator

Manufacturing Consultant



Manufacturing Consultant

Business Consultant
Professional Calculator

Edition 1 April 1986
Reorder Number 00018-90037

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1000 N.E. Circle Blvd.
Corvallis, OR 97330, U.S.A.

Printing History

Edition 1 April 1986 Mfg. No. 00018-90047

Welcome...

... to the Consultant applications series! This series is designed to help you get the most from your Business Consultant professional calculator.

The purpose of the *Manufacturing Consultant* is to help you solve the specialized problems your industry or profession demands. We've worked with professionals in your field to provide a sample of analysis concepts that are useful and relevant. Included are a set of keystrokes and routines to assist you in analyzing production, labor, new investments and productivity. The *Manufacturing Consultant* is designed to serve not only as a reference but also as a starting point for the development of your unique analysis needs and to show you how your Business Consultant can help.

Before you use the solutions in this book, you should be familiar with certain concepts from the owner's manual:

- Chapter 1: the basics of your calculator—how to move from menu to menu, identify and move to the MAIN menu, and use the menu keys to do calculations.
- Chapter 9: entering and using formulas.

The examples in this book show two decimal places. If your display is set to something other than two, the answers in your display will not match exactly what is in this book. Refer to your owner's manual for more information about changing the number of decimal places.

For more information about the topics in the *Manufacturing Consultant*, refer to a basic textbook on the subject. Specific sources on the more specialized topics are included at the end of those topics.

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When Entering Formulas...

When entering formulas into your Business Consultant, follow the instructions in chapter 9 of your owner's manual. Here are hints to help you in common error situations:

1. If the calculator displays INVALID FORMULA when you press CALC, the calculator doesn't understand something in the formula. When the formula returns to the screen, the cursor is positioned where your calculator detected the error. Check the formula in the screen against the formula in the book. Make sure the parentheses match and that the operators are where they should be.
2. If the calculator accepts the formula but your answer doesn't match the example, check the values stored in the menu key variables by recalling them (press RCL, then the menu key). If the values are correct, return to the SOLVE menu and check the formula. (Press EXIT to return to the SOLVE menu and press EDIT to view and edit the formula.) Check the formula against the one in this book for accuracy. When you find an error, edit the formula and press CALC to display the custom menu again.
3. If the calculator displays INSUFFICIENT MEMORY when you press INPUT or CALC, you must free portions of memory before continuing. Refer to pages 188 and 189 of the owner's manual for additional information.

The formulas in the *Manufacturing Consultant* use variable names that are intended to remind you of what to store. Feel free to change them to something more meaningful to you.

Priority Scheduling Rule

Priority scheduling rules are used to determine the order in which customer orders should be worked. One priority scheduling rule uses an index based on the number of work hours until the delivery date, the processing time for the order and the number of operations remaining to complete the order. The lower the index, the higher the priority.

Entering and Using the PRIORITY Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the PRIORITY formula as follows:

   `PRIORITY=(WKHRS-TIME)÷#OPS`
3. Press CALC to verify the formula and display the custom menu.
4. Store the following variables:
   - Work hours until delivery date in WKHR.
   - Total processing time in TIME.
   - Number of remaining operations in #OPS.
5. Press PRIOR to calculate the priority index.

Example: Part 1. You have an order to ship in 2 weeks (80 work hours). The job has 30 hours of processing time and 5 operations remaining. What is the priority index?

Start from the PRIORITY custom menu.

Keys:	Display:	Description:
80 WKHR	`WKHRS=80.00`	Stores work hours until delivery date.
30 TIME	`TIME=30.00`	Stores remaining processing time.
5 #OPS	`#OPS=5.00`	Stores remaining operations.
PRIOR	`PRIORITY=10.00`	Calculates priority index.

Part 2. You have another customer whose order is also due in two weeks (80 hours). That order has four operations remaining, which take 45 hours. Which order has the highest priority?

4 #OPS	#OPS=4.00	Stores remaining operations.
45 TIME	TIME=45.00	Stores remaining processing time.
PRIOR	PRIORITY=8.75	Calculates priority index.

This order has a lower priority index, and thus, the higher priority.

Part 3. Your second customer calls, and changes the specifications on his order, decreasing your processing time to 39 hours. Which order now has the higher priority?

39 TIME	TIME=39.00	Stores new value for remaining processing time.
PRIOR	PRIORITY=10.25	Calculates a new priority index

Customer 1 now has the highest priority.

Source: Tom Hendrick, *Production/Operations Management*. Irwin Publishing, 1985.

Daily Production Rate

Knowing a daily production rate helps manufacturers spread production and shipping needs over the month for the most efficient use of people and equipment. The daily production rate formula can also be used to compare production, shipment, or order rates for months with different numbers of working days.

Although the formula is simple to figure on any calculator, using SOLVE means you don't have to reenter values when you have many calculations to do, or to try what-if situations.

Entering and Using the RATE Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the RATE formula as follows:

   RATE=UNITS÷DAYS
3. Press CALC to verify the formula and display the custom menu.
4. Store two of the following variables:
   - Daily rate in RATE.
   - Total units for the month in UNITS.
   - Number of work days in the month in DAYS.
5. Press the menu key to calculate the unknown variable.

Example: Part 1. The production goal for January is 1,760 units. January has 22 work days. What quantity must be produced each day to meet the plan?

Start from the RATE custom menu.

Keys:	Display:	Description:
1760 UNITS	UNITS=1,760.00	Stores production for the month.
22 DAYS	DAYS=22.00	Stores number of work days in the month.
RATE	RATE=80.00	Calculates daily rate.

Part 2. You have to figure daily rates for other products as well. The monthly production rates on three other products are:

Product #	Units/Month
1	2,477
2	700
3	4,800

What is the daily rate for each in January?

2477 UNITS	UNITS=2,477.00	Stores units.
RATE	RATE=112.59	Calculates daily rate for product #1.
700 UNITS	UNITS=700.00	Stores units.
RATE	RATE=31.82	Calculates daily rate for product #2.
4800 UNITS	UNITS=4,800.00	Stores units.
RATE	RATE=218.18	Calculates daily rate for product #3.

Part 3. Capacity constraints prevent producing more than 225 units per day of product #3. February has only 19 work days. What is the maximum number of units of product #3 that can be produced?

225 RATE	RATE=225.00	Stores maximum daily rate.
19 DAYS	DAYS=19.00	Stores number of work days.
UNITS	UNITS=4,275.00	Calculates units that can be produced in February.

Predicting Labor Hours Using Learning Rates

Learning curves are useful in analyzing new production processes to determine how productivity will improve over time. As the production team becomes more proficient, labor hours per unit decrease, leading to lower costs.

Entering and Using the LHRS Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the LHRS formula as follows:

   `LHRS=U1HRS×UNIT#^(LOG(LRN%÷100)÷LOG(2))`
3. Press CALC to verify the formula and display the custom menu.
4. Store three of the following variables:
   - Time to produce the unit in which you are interested in LHRS.
   - Time to produce the first unit in U1HRS.
   - Number of the unit in which you are interested in UNIT.
   - Learning rate as a percent in LRN%.
5. Press the menu key to calculate the unknown variable.

Example 1: Calculating the Learning Rate from Historical Data. For a certain production process, you know that the first unit took 100 hours to produce, and the 16th unit took 41 hours. What is the learning rate for this process?

Start from the LHRS custom menu.

Keys:	Display:	Description:
41 LHRS	LHRS=41.00	Stores hours to produce unit 16.
100 U1HRS	U1HRS=100.00	Stores hours to produce unit 1.
16 UNIT	UNIT#=16.00	Stores unit number.
LRN%	LRN%=80.02*	Calculates learning rate.

Example 2: Calculating the Hours to Produce a Unit. You are starting production on a new item. You expect the learning rate on the new product to be similar to that calculated in example 1, that is, 80%. The first unit took 70 hours. How long will unit 20 take?

Start from the LHRS custom menu.

Keys:	Display:	Description:
70 U1HRS	U1HRS=70.00	Stores hours to produce unit 1.
20 UNIT	UNIT#=20.00	Stores unit number.
80 LRN%	LRN%=80.00	Stores learning rate.
LHRS	LHRS=26.68	Calculates hours to produce unit 20.

* The solver searches for a numerical solution and displays intermediate estimates.

Forecasting Manufacturing Rates of Accessories

Many products have optional accessories or peripheral products. For example, cars have lots of extras, and computers have software and optional equipment.

The production rates of these optional items are often based on a percentage of the sales of the main product. The following equation helps determine production rates of these optional products.

Although this calculation is simple to do on any calculator, using SOLVE means you don't have to reenter values to calculate many optional products for one main product, or to try what-if situations.

Entering and Using the %MAIN Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the %MAIN formula as follows:

   %MAIN=OPTIONS÷MAIN×100
3. Press CALC to verify the formula and display the custom menu.
4. Store two of the following variables:
   - Percent of main product in %MAI.
   - Units of the optional product in OPTIO.
   - Units of the main product in MAIN.
5. Press the menu key to calculate the unknown variable.

Example: Part 1. Seventy-five percent of your customers are expected to order a particular software product to use with your computer. The computer is forecast to sell 1,100 units per month. What should your manufacturing plans be for the software product?

Start from the %MAIN custom menu.

Keys:	Display:	Description:
75 %MAI	%MAIN=75.00	Stores percent expected to buy the software.
1100 MAIN	MAIN=1,100.00	Stores computer forecast.
OPTIO	OPTIONS=825.00	Calculates number of optional units to manufacture.

Part 2. Last month, computer orders were 900 and software orders were 750. How much software should be produced to reflect last month's actual sales rate?

750 OPTIO	OPTIONS=750.00	Stores number of software products sold.
900 MAIN	MAIN=900.00	Stores number of computers sold.
%MAI	%MAIN=83.33	Calculates percent of computer sales.
1100 MAIN	MAIN=1,100.00	Stores computer forecast.
OPTIO	OPTIONS=916.67	Calculates new forecast for software.

Forecasting Manufacturing Rates Using Simple Moving Average

Moving averages are often useful in forecasting manufacturing rates. In a moving average, a specified number of data points are averaged. When there is a new piece of input data, the oldest data point is discarded to make room for the most recent data. This replacement scheme makes the moving average a valuable tool in following trends. The fewer the number of data points, the more trend sensitive the averages become. With a large number of data points, the average behaves more like a regular average, responding slowly to new input.

1. From the MAIN menu, press SUM to display the SUM menu.
2. Press CLEAR ALL YES to clear the list. (If you don't want to delete the list, name the old list and get a new one.)
3. Enter your data points.
4. Press CALC, then MEAN to calculate the average.
5. When you have a new data point, move the pointer to the oldest item. Enter the new item and press INPUT. The oldest item is replaced by the new one.

Example. You want to calculate a 3 month moving average for the units manufactured each month. Volumes for the first six months were:

January	4400
February	5360
March	2900
April	3670
May	4040
June	3200

Start from the MAIN menu.

Keys:	Display:	Description:
SUM *		Displays the SUM menu.
CLEAR ALL YES		Clears the list.
4400 INPUT 5360 INPUT 2900 INPUT	TOTAL=12,660.00	Enters data for the first three months.
CALC MEAN	MEAN=4,220.00	Calculates average for the first three months.
EXIT		
↑		Moves pointer to top of list.
3670 INPUT	TOTAL=11,930.00	Enters month 4 and deletes oldest item.
CALC MEAN	MEAN=3,976.67	Calculates average for months 2, 3 and 4.
EXIT		
4040 INPUT	TOTAL=10,610.00	Enters month 5 and deletes oldest item.
CALC MEAN	MEAN=3,536.67	Calculates average for months 3, 4 and 5.
EXIT		
3200 INPUT	TOTAL=10,910.00	Enters month 6 and deletes oldest item.
CALC MEAN	MEAN=3,636.67	Calculates average for months 4, 5 and 6.

* If you want to preserve the current list, skip the next step, name the list, then press GET *NEW .

Forecasting Manufacturing Rates Based on History

One method of forecasting manufacturing rates is to look at historical trends. Once you have historical data, the data are fit to a curve with time on the x-axis and the quantity you are forecasting on the y-axis. Linear curve fit is appropriate if you have a fairly constant growth rate; exponential curve fit is appropriate with compound growth, such as production rates for a new product.

1. From the MAIN menu, press SUM to select the SUM menu.
2. Press CLEAR ALL YES to clear the list. (If you don't want to delete the list, name the old list and get a new list.)
3. Enter your data. Press INPUT after each item.
4. Name your list.
5. Get a new list and enter your second list as in step 3.
6. Name your list.
7. Press CALC, MORE, then FRCST.
8. Select the list containing your x-values.
9. Select the model (LIN for linear, EXP for exponential).
10. Key in the x-value and press XLIST.
11. Press YLIST to forecast the y-value.

Example 1: Forecasting Manufacturing Rates Using Linear Curve Fit. You want to determine the manufacturing forecast for next year using a linear curve fit. The following data represents your rates for the past nine years.

Year	Number of Units Manufactured
1	100,000
2	112,100
3	130,600
4	160,750
5	205,900
6	210,000
7	240,650
8	280,720
9	325,190

Start from the MAIN menu.

Keys:	Display:	Description:
SUM *		Displays the SUM menu.
CLEAR ALL YES		Clears the list.
1 INPUT 2 INPUT 3 INPUT 4 INPUT 5 INPUT 6 INPUT 7 INPUT 8 INPUT 9 INPUT	TOTAL=45.00	Enters time values.
NAME YEARS INPUT		Names the list.

* If you want to preserve the current list, skip the next step, name the list, then press GET *NEW.

GET *NEW		Displays a new list.
100000 INPUT 112100 INPUT 130600 INPUT 160750 INPUT 205900 INPUT 210000 INPUT 240650 INPUT 280720 INPUT 325190 INPUT	TOTAL= 1,765,910.00	Enters manufacturing data.
NAME RATE INPUT		Names the list.
CALC MORE FRCST		Displays FRCST menu.
YEARS		Selects list YEARS as the x-variable.
LIN		Selects linear model.
10 XLIST	XLIST=10.00	Stores an x-value.
YLIST	YLIST=335,876.39	Forecasts the y-value—the manufacturing forecast for year 10.

Example 2: Forecasting Manufacturing Rates Using Exponential Curve Fit. The production history for your new product is shown below for the first six months after introduction.

Month	Production Units
June	3170
July	5250
August	4830
September	5660
October	7270
November	9090

Part 1. What is the projected manufacturing rate for December?

Start from the MAIN menu.

Keys:	Display:	Description:
SUM *		Displays the SUM menu.
CLEAR ALL YES		Clears the list.
1 INPUT 2 INPUT 3 INPUT 4 INPUT 5 INPUT 6 INPUT	TOTAL=21.00	Enters month numbers.
NAME MONTHS INPUT		Names the list.
GET *NEW		Displays a new list.
3170 INPUT 5250 INPUT 4830 INPUT 5660 INPUT 7270 INPUT 9090 INPUT	TOTAL=35,270.00	Enters manufacturing data.
NAME MORATE INPUT		Names the list.
CALC MORE FRCST		Displays the FRCST menu.
MONT		Selects list MONTH as the x-variable.
EXP		Selects exponential model.
7 XLIST	XLIST=7.00	Stores an x-value.
YLIST	YLIST=10,577.88	Forecasts a y-value—the manufacturing rate for December.

* If you want to preserve the current list, skip the next step, name the list, then press GET *NEW.

Part 2. Calculate the continuous compound growth rate.

B [×] 100 [=]	18.29	Calculates the estimate of the monthly continuous compound growth rate.

Estimating Inventory Availability

Availability estimates tell you approximately how long your inventory will last, based on forecast rates or usage rates. The formula below can be applied to finished goods or production parts. This formula calculates availability in weeks, based on inventory on hand and usage per month.

Entering and Using the AVAIL Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the AVAIL formula as follows:*

   AVAIL=(INVEN÷USAGE)×4.33
3. Press CALC to verify the formula and display the custom menu.
4. Store two of the following variables:
   - Availability in weeks in AVAIL.
   - Inventory on hand in INVE.
   - Forecast or usage per month in USAGE.
5. Press the menu key to calculate the unknown variable.

Example: Part 1. You have 800 units available at the end of the month. The forecast for next month is 1200 units. How long will your supply last?

Start from the AVAIL custom menu.

Keys:	Display:	Description:
800 INVE	INVEN=800.00	Stores current inventory.
1200 USAGE	USAGE=1,200.00	Stores forecast.
AVAIL	AVAIL=2.89	Calculates weeks of availability.

* This formula assumes 4.33 weeks per month. It can be easily altered to fit other situations. For example, if you omit ×4.33, the formula calculates availability in months.

Part 2. You like to keep 7 weeks of supply on hand. What should your inventory be?

7 AVAIL	AVAIL=7.00	Stores weeks of availability.
INVE	INVEN=1,939.95	Calculates inventory needed.

Economic Ordering Quantity

The economic ordering quantity is the optimum quantity to order each time an order is placed. It is based on the cost of placing and receiving an order, annual sales, carrying costs (including warehousing costs, interest on funds tied up in inventory, insurance, and obsolescence) and the purchase price of the goods.

The equation below is useful assuming that usage is at a constant rate and that delivery lead times are constant.

Entering and Using the EOQ Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the EOQ formula as follows:

   EOQ=SQRT(2×FIXCO×SALES÷(CARY%÷100×PRICE))
3. Press CALC to verify the formula and display the custom menu.
4. Store the following variables:
   - Fixed costs of placing and receiving an order in FIXCO.
   - Annual unit sales in SALES.
   - Carrying costs as a percentage of inventory value in CARY%.
   - Purchase price per unit of inventory in PRICE.
5. Press EOQ to calculate the economic ordering quantity.

Example. Your annual sales are 10,000 units. Purchase price per unit is $4.73. Carrying cost is 20% of inventory value and the cost of placing and receiving an order is $35. What is the economic ordering quantity?

Start from the CUSTOM menu.

Keys:	Display:	Description:
35 FIXCO	FIXCO=35.00	Stores fixed cost of placing an order.
10000 SALES	SALES=10,000.00	Stores annual sales in units.
20 CARY%	CARY%=20.00	Stores carrying cost.
4.73 PRICE	PRICE=4.73	Stores price per unit.
EOQ	EOQ=860.21	Calculates economic ordering quantity.

Replacing Equipment

Mechanical equipment depreciates in value while the cost of maintenance and operation goes up. As these costs rise, an optimal point in time is reached when the equipment should be replaced. This optimal point can be determined by looking at the optimum service life and the minimum average total cost of the equipment. These values can be computed if you know the purchase price, the operation and maintenance costs for the first year, and the annual rates of increase in operation and maintenance costs.

Entering and Using the ATC and LIFE Formulas:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the ATC (average total cost) formula as follows:

   `ATC=LIFE-(OPINC+MTINC)÷2+OPCO1+MTCO1`
3. Press INPUT to verify the formula.
4. Type in the LIFE formula as follows:

   `LIFE=SQRT(2×PRICE÷(OPINC+MTINC))`
5. Press CALC to verify the formula and display the LIFE custom menu.
6. Store the following variables:
   - Purchase price (less any trade-in) in PRICE.
   - Yearly increase in operating costs in OPINC.
   - Yearly increase in maintenance costs in MTIN.
7. Press LIFE to calculate the optimum service life.
8. Press EXIT to return to the SOLVE menu. Move the pointer to the ATC formula. Press CALC to verify the formula and display the ATC custom menu.
9. Store the following variables:
   - First year operating costs in OPCO1.
   - First year maintenance costs in MTCO1.
   - LIFE, OPINC, and MTIN variables are already stored.
10. Press ATC to calculate the minimum average total cost.

Example. Your company has a piece of equipment that was purchased for $28,000. The maintenance costs in the first year were $2,000; operating costs were $14,000. Maintenance costs are expected to increase by $1,200 each year; operating costs are expected to increase by $1,500 each year. What is the optimum service life and minimum average total cost?

Start from the LIFE custom menu.

Keys	Display:	Description:
28000 PRICE	PRICE=28,000.00	Stores purchase price.
1500 OPINC	OPINC=1,500.00	Stores yearly increase in operating costs.
1200 MTIN	MTINC=1,200.00	Stores yearly increase in maintenance costs.
LIFE	LIFE=4.55	Calculates optimum service life.
EXIT		Displays SOLVE menu.
↑ or ↓	ATC=LIFE-(OPINC+	Selects ATC formula.
CALC		Displays ATC menu.
14000 OPCO1	OPCO1=14,000.00	Stores first year operating costs.
2000 MTCO1	MTCO1=2,000.00	Stores first year maintenance costs.
ATC	ATC=14,654.55	Calculates minimum average total cost.

According to this model, average annual costs are decreasing for the first 4½ years. After that time, costs are increasing.

Estimating Inventory Investment versus Expected Shipment Dollars

It is useful to know the inventory cost required to produce units and to compare inventory costs to the expected revenue from shipping those products.

Entering and Using the Formulas:

1. From the MAIN menu, press SOLVE to enter the SOLVE menu.
2. Type in the $DIFF formula as follows:

   `$DIFF=$SHIP-$INVEN`
3. Press INPUT to verify the formula.
4. Type in the $SHIP formula as follows:

   `$SHIP=(PRICE×(1-%DISC÷100))×#UNITS`
5. Press INPUT to verify the formula.
6. Type in the $INVEN formula as follows:

   `$INVEN=COST×#UNITS`
7. Press CALC to verify the formula and display the $INVEN custom menu.
8. Store the following variables:
   - Standard cost per unit (labor, material, overhead) in COST.
   - Number of units produced and shipped in #UNI.
9. Press $INV to calculate the inventory investment.
10. Press EXIT to return to the SOLVE menu. Move the pointer to the $SHIP formula. Press CALC to verify the formula and display the $SHIP custom menu.
11. Store the following variables:
    - Price of the product in PRICE.
    - Discount rate as a percent at shipment in %DISC.
    - Number of units produced and shipped in #UNI (if this value was stored in step 8 above, you don't have to store it again).

12. Press $SHI to calculate the expected shipment dollars.

13. Press EXIT to return to the SOLVE menu. Move the pointer to the $DIFF formula. Press CALC to verify the formula and display the $DIFF custom menu.

14. Press $DIF to calculate the difference between inventory investment and the expected shipment dollars (values were stored in $INV and $SHI in steps 9 and 12).

Example. You plan to ship 100 units. The list price per unit is $3,000, and the units are shipped at a 40% discount. The production cost per unit is $1,500. What is the difference between inventory investment and shipment dollars?

Start from the $INVEN custom menu.

Keys:	Display:	Description:
1500 COST	COST=1,500.00	Stores cost per unit.
100 #UNI	#UNITS=100.00	Stores number of units.
$INV	$INVEN= 150,000.00	Calculates dollars of inventory.
EXIT		Displays SOLVE formulas.
↑ or ↓	$SHIP=(PRICE×(1-	Selects $SHIP formula.
CALC		Displays $SHIP custom menu.
3000 PRICE	PRICE=3,000.00	Stores unit price.
40 %DISC	%DISC=40.00	Stores discount rate.
$SHI	$SHIP=180,000.00	Calculates dollars of shipments.
EXIT		Displays SOLVE formulas.
↑ or ↓	$DIFF=$SHIP-$INV	Selects $DIFF formula.
CALC		Displays $DIFF custom menu.
$DIF	$DIFF=30,000.00	Calculates dollar difference between shipments and inventory.

Combining the Formulas. You may not be interested in the values for $SHIP and $INVEN, but only the final value, $DIFF. The three formulas on page 30 can be combined into one, as follows:

```
$DIFF=#UNITS×(PRICE×(1-%DISC÷100)-COST)
```

To use this formula, store four of the following variables:

- Dollar difference between inventory investment and expected shipments in $DIF.
- Number of units produced and shipped in #UNI.
- Price of the product in PRICE.
- Discount rate as a percent at shipment in %DISC.
- Standard cost per unit (labor, material, overhead) in COST.

Press the menu key to calculate the unknown variable.

Manufacturing Strategy Analysis

It is sometimes necessary to make decisions regarding changes in manufacturing location or manufacturing method. The formula below can help evaluate a major change in manufacturing location or strategy.

Entering and Using the INVEST Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the INVEST formula as follows:

   `INVEST=FRCST×(CURR-NEW-ADDIT)×USPV(I%;#PER)`
3. Press CALC to verify the formula and display the custom menu.
4. Store six of the following variables:
   - Initial investment required to make the change in INVES.
   - Periodic forecast or production volume in FRCST.
   - Current manufacturing cost of each item in CURR.
   - New manufacturing cost if the change is made in NEW.
   - Any additional costs per item created by the change (such as freight, duty, or increased overhead) in ADDIT.
   - Interest rate per period as a percent in I%.
   - Number of periods to break even in #PER.*
5. Press the menu key to calculate the unknown variable.

Example: Part 1. A company is currently manufacturing an item for $110. By moving the operation to a site where labor rates are lower, it is estimated that the same item could be manufatured for $90. The move would cost $150,000, including equipment, training of the new workers, re-training of the current workers, and relocation of key personnel. Freight costs of $5.30 per item would also be required to move the product back to the distribution center. If the company requires a 20% annual return on investment, how long will it take for this move to break even? The forecast is 4,500 units per year.

* If #PER is negative, the new cost plus additional costs is greater than current costs, indicating this is not a good investment, and will never break even.

Start from the INVEST custom menu.

Keys:	Display:	Description:
150000 INVES	INVEST= 150,000.00	Stores initial investment.
4500 FRCST	FRCST=4,500.00	Stores forecast production.
110 CURR	CURR=110.00	Stores current manufacturing cost.
90 NEW	NEW=90.00	Stores new manufacturing cost.
5.3 ADDIT	ADDIT=5.30	Stores additional freight costs.
MORE		
20 I%	I%=20.00	Stores required annual return on investment.
#PER	#PER=3.31*	Calculates number of years to break even.

Part 2. If the freight cost rose to $8.80, how long would it take to break even?

MORE		
8.8 ADDIT	ADDIT=8.80	Stores new freight costs.
MORE		
#PER	#PER=4.96*	Calculates number of years to break even.

* The solver searches for a numerical solution and displays intermediate estimates.

Using NPV and IRR to Make Investment Decisions

Net present value (NPV) and internal rate of return (IRR) are used to determine if an investment meets a minimum rate of return and what rate of return can be expected. The built-in CFLO menu makes it easy to calculate these two values.

The method below helps the decision-making process when choosing between two mutually exclusive options—such as deciding between two pieces of equipment. This method looks at the period by period difference between the two investments, then uses these differences as cash flows. The investment becomes the difference between option A and option B. If the net present value is positive at the desired rate of return, then the more expensive option is the better one; otherwise, the less expensive option is better.

When the differences result in a conventional series of cash flows (one sign change), you can also look at the IRR% to determine which is the better investment. (Refer to the footnote in table 5-2 on page 87 of the owner's manual for the definition of "conventional series of cash flows.") If the IRR% is higher than your required percent, the investment in the more expensive machine is a good investment. If the differences are not a conventional series of cash flows (multiple sign changes), you can still use NPV to analyze the investment.

1. From the MAIN menu, press FIN then CFLO to display the CFLO menu.
2. Press ■ CLEAR ALL YES to clear the list. (If you don't want to delete the list, name the old list and get a new list.)
3. Find the difference between the cash flows for the two options for each period. Enter the cash flows and number of periods.
4. Press CALC to display the CFLO CALC menu.
5. To calculate the net present value, enter the periodic interest rate as a percent in I%, then press NPV.
6. To calculate the internal rate of return, press IRR%.

Example. You want to compare two equipment options. The table below summarizes the initial flows, the cash flows over the five year life of the machines, and the difference between the two options.

	A	B	A−B
Initial Investment	$−35,000	$−25,000	$−10,000
Cost in year 1	−200	−1,300	1,100
Cost in year 2	−200	−1,400	1,200
Cost in year 3	−200	−2,500	2,300
Cost in year 4	−800	−2,500	1,700
Cost in year 5	15,000	7,000	8,000

Calculate the NPV and IRR% to determine which machine should be purchased. The required rate of return is 10%.

Start from the MAIN menu.

Keys:	Display:	Description:
FIN CFLO *		Displays CFLO menu.
CLEAR ALL YES		Clears list
10000 +/− INPUT		Enters initial cash flow.
1100 INPUT INPUT 1200 INPUT INPUT 2300 INPUT INPUT 1700 INPUT INPUT 8000 INPUT INPUT		Enters cash flows.

* If you want to preserve the current list, skip the next step, name the list, then press GET *NEW.

CALC		Displays CALC menu.
10 I%	I%=10.00	Stores required return on investment.
NPV	NPV=-151.75	Calculates the present value.
IRR%	IRR%=9.56	Calculates internal rate of return.

Option B is the better choice because NPV is negative and IRR% is 9.56, less than the 10% required rate of return.

Work Sampling Survey Size

Work sampling can be used to collect information about work flow and idle time. The formula below helps determine the number of operations needed to assure that your work sampling will give you accurate results. This formula assumes that you have made a small number of observations, and thus, have a preliminary estimate of the survey results.

Entering and Using the SSIZE Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the SSIZE formula as follows:

   ```
   SSIZE=NORM^2÷(%ACC÷100)^2×
   (1-#OCCR÷#OBS)÷#OCCR×#OBS
   ```

3. Press CALC to verify the formula and display the custom menu.
4. Store four of the following variables:
   - Sample size in SSIZE.
   - Normal distribution value in NORM.
   - Desired accuracy in %ACC.
   - Number of occurrances in your small sample in #OCC.
   - Number of observations in your small sample in #OBS.
5. Press the menu key to calculate the unknown variable.

Example: Part 1. You wish to identify the amount of idle time in your service department. You made 20 random observations, and on 3 occasions, an employee was idle. Now you want to conduct a statistically valid survey. How many observations are needed to be 95% sure of your results (normal distribution = 1.96), with an accuracy of ±10%?

Start from the SSIZE custom menu.

Keys:	Display:	Description:
1.96 NORM	NORM=1.96	Stores normal distribution.
10 %ACC	%ACC=10.00	Stores accuracy you desire.
3 #OCC	#OCCR=3.00	Stores number of occurances from your preliminary sample.
20 #OBS	#OBS=20.00	Stores number of preliminary observations.
SSIZE	SSIZE=2,176.91	Calculates number of observations to assure desired accuracy.

Part 2. You have the time and budget for only 1,500 observations. With that number of observations, what is your accuracy?

1500 SSIZE	SSIZE=1,500.00	Stores sample size.
%ACC	%ACC=12.05	Calculates accuracy achieved with 1,500 observations.

Source: James Dilworth, *Production and Operations Management*. Random House, 1983, pp 577–588.

Productivity Measurements

There are many ways to measure productivity. This section looks at productivity as a ratio of outputs to inputs—an index—first with a single resource, then with multiple resources.

Single Resource Productivity Measurement

Labor is a common resource for productivity measurement. The ratio of output in units or dollars to labor input in units or dollars results in a productivity index that indicates whether labor productivity is increasing or decreasing.

Entering and Using the PINDX Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the PINDX formula as follows:

   PINDX=OUT÷IN
3. Press CALC to verify the formula and display the custom menu.
4. Store the following variables:
   - Output in units or dollars in OUT.
   - Input in units or dollars in IN.
5. Press PINDX to calculate the productivity index.

Example. Last month, you produced 600 units, worth $1,400, in 80 hours at $7.00 per labor hour. This month, 660 units were produced, worth $1,500, produced in 85 hours at $7.20 per labor hour (a 2.86% increase in hourly labor cost).

Part 1. Calculate unit productivity (number of units produced divided by labor hours) for last month and this month, then find the percent change.

Start from the PINDX custom menu.

Keys:	Display:	Description:
600 OUT	OUT=600.00	Stores unit output for last month.
80 IN	IN=80.00	Stores labor input for last month.
PINDX	PINDX=7.50	Calculates unit productivity for last month.
STO 0		Stores unit productivity in register 0.
660 OUT	OUT=660.00	Stores unit output for this month.
85 IN	IN=85.00	Stores labor input for this month.
PINDX	PINDX=7.76	Calculates unit productivity for this month.
MAIN		Displays MAIN menu.
BUS %CHG		Displays the %CHANGE menu.
STO NEW	NEW=7.76	Stores unit productivity index for this month.
RCL 0 OLD	OLD=7.50	Stores unit productivity index for last month.
%CH	%CHANGE=3.53	Calculates percent change from last month to this month.

Unit productivity rose from last month to this month by 3.53%.

Part 2. Calculate value productivity (dollar value of units produced divided by dollar value of labor) for last month and this month, then find the percent change.

Start from the PINDX custom menu.

1400 OUT	OUT=1,400.00	Stores dollar value of units produced last month.
7 × 80 IN	IN=560.00	Stores labor cost last month.
PINDX	PINDX=2.50	Calculates value productivity for last month.
STO 0		Stores the value productivity in register 0.
1500 OUT	OUT=1,500.00	Stores dollar value of units produced this month.
7.2 × 85 IN	IN=612.00	Stores labor costs this month.
PINDX	PINDX=2.45	Calculates value productivity for this month.
MAIN		Displays MAIN menu.
BUS %CHG		Displays %CHANGE menu.
STO NEW	NEW=2.45	Stores new and old indexes.
RCL 0 OLD	OLD=2.50	
%CH	%CHANGE=-1.96	Calculates percent change from last month to this month.

Value productivity declined from last month to this month by 1.96%.

Part 3. Calculate the unit sales price (dollar value of units produced divided by units produced) for last month and this month, then find the percent change.

Start from the PINDX custom menu.

1400 OUT	OUT=1,400.00	Stores dollar sales last month.
600 IN	IN=600.00	Stores units produced last month.
PINDX	PINDX=2.33	Calculates unit sales price last month.
STO 0		Stores the sales price in register 0.
1500 OUT	OUT=1,500.00	Stores dollar sales this month.
660 IN	IN=660.00	Stores units produced this month.
PINDX	PINDX=2.27	Calculates unit sales price this month.
MAIN		Displays MAIN menu.
BUS %CHG		Displays %CHANGE menu.
STO NEW RCL 0 OLD	NEW=2.27 OLD=2.33	Stores new and old indexes.
%CH	%CHANGE=-2.60	Calculates percent change in unit sales price.

Unit sales price declined from last month to this month by 2.6%.

Part 4. Calculate unit labor cost productivity (dollar value of labor divided by units produced for last month and this month, then find the percent change.

Start from the PINDX custom menu.

7 [×] 80 OUT	OUT=560.00	Stores labor costs last month.
600 IN	IN=600.00	Stores number of units produced last month.
PINDX	PINDX=0.93	Calculates unit labor cost last month.
[STO] 0		Stores the unit labor cost in register 0.
7.2 [×] 85 OUT	OUT=612.00	Stores labor costs this month.
660 IN	IN=660.00	Stores number of units produced this month.
PINDX	PINDX=0.93	Calculates unit labor costs this month.
[MAIN]		Displays MAIN menu.
BUS %CHG		Displays %CHANGE menu.
[STO] NEW [RCL] 0 OLD	NEW=0.93 OLD=0.93	Stores new and old indexes.
%CH	%CHANGE=-0.65	Calculates percent change in unit labor cost.

Unit labor costs declined from last month to this month by .65%.

These ratios are useful for analyzing performance. In this case, unit productivity increased by 3.53%, while value productivity declined by 1.96%. The causes of the decline in value productivity show up in the change in unit sales price, which declined 2.6%, and the .65% decline in unit labor costs.

Wages increased 2.86%, but unit productivity increased by 3.53%, which more than offset the wage increase. This is reflected in the lesser decline in unit labor costs when compared to unit sales price.

Multiple Resource plus Inflation Productivity Measurement

This productivity index is a ratio, like the previous formula, but more resources are used in the index. Sales are considered the output; labor, energy, materials, and capital are the inputs. By watching this index over time, you can track the productivity of your company.

This formula can be used for profitability as well as productivity. However, prices and costs inflate at different rates, and this must be kept in mind when using the index over time.

Entering and Using the MPIND Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the MPIND formula as follows:

```
MPIND=SALES÷(1+IS%÷100)÷
(LABOR÷(1+IL%÷100)+ENERGY÷
(1+IE%÷100)+PARTS÷(1+IP%÷100)+
CAPIT÷(1+IC%÷100))
```

3. Press CALC to verify the formula and display the custom menu.
4. Store the following variables: (remember to press MORE to display other menu labels)
   - Sales in dollars in SALES.
   - Inflation in product prices in IS% (must be 0 for base year).
   - Labor costs in LABOR.
   - Inflation in labor costs in IL% (must be 0 for base year).
   - Energy costs in ENER.
   - Inflation in energy costs in IE% (must be 0 for base year).
   - Material costs in PARTS.
   - Inflation in material costs in IP% (must be 0 for base year).
   - Capital costs in CAPIT.
   - Inflation in capital costs in IC% (must be 0 for base year).
5. Press MPIN to calculate the productivity index for the period.

Example. The following table gives data for the base year and base year plus one.

Resource	Menu Key	Base Year*	Base Year + 1
Sales	SALES	$480,000	$540,000
Inflation in sales prices	IS%		6%
Labor costs	LABOR	180,000	203,000
Inflation in labor costs	IL%		7%
Energy costs	ENER	9,000	10,000
Inflation in energy costs	IE%		2%
Material costs	PARTS	210,000	230,000
Inflation in material costs	IP%		12%
Capital costs	CAPIT	41,000	38,000
Inflation in capital costs	IC%		1%

* By definition, inflation in the base year is zero.

Part 1. What is the productivity index for the base year?

Keys:	Display:	Description:
CLEAR ALL	0.00	Clears MPIND variables.
480000 SALES	SALES=480,000.00	Stores known values.
180000 LABOR	LABOR=180,000.00	
MORE		
9000 ENER	ENERGY=9,000.00	
210000 PARTS	PARTS=210,000.00	
41000 CAPIT	CAPIT=41,000.00	
MORE MORE		
MPIN	MPIND=1.09	Calculates productivity index for the base year.
STO 0		Stores productivity index in register 0.

Part 2. What is the productivity index for the base year plus one?

540000 SALES	SALES=540,000.00	Stores sales, costs and inflation rates for the base year plus one.
6 IS%	IS%=6.00	
203000 LABOR	LABOR=203,000.00	
7 IL%	IL%=7.00	
MORE		
10000 ENER	ENERGY=10,000.00	
2 IE%	IE%=2.00	
230000 PARTS	PARTS=230,000.00	
12 IP%	IP%=12.00	
38000 CAPIT	CAPIT=38,000.00	
MORE		
1 IC%	IC%=1.00	
MORE		
MPIN	MPIND=1.15	Calculates productivity index.
MAIN		Displays MAIN menu.
BUS %CHG		Displays %CHANGE menu.
STO NEW	NEW=1.15	Stores new and old indexes.
RCL 0 OLD	OLD=1.09	
%CH	%CHANGE=5.53	Calculates percent change in the productivity index.

Productivity rose 5½%. If you are interested in breaking this information down, use the following formula to calculate partial indexes, such as sales divided by labor or sales divided by material.

Entering and Using the PPIND Formula:

1. From the MAIN menu, press SOLVE to display the SOLVE menu.
2. Type in the PPIND formula as follows:

   PPIND=SALES÷(1+IS%÷100)÷(INPUT÷(1+II%÷100))
3. Press CALC to verify the formula and display the custom menu.
4. Store the following variables:
   - Sales (in dollars) in SALES.
   - Inflation in product prices in IS% (must be 0 for base year).
   - Dollar value of your input variable (labor, energy, materials or capital) in INPUT.
   - Inflation in your input variable in II% (must be 0 for base year).
5. Press PPIND to calculate the partial index.

Example. Using the values from the previous example, calculate partial indexes with labor as the input variable, and find the percent change.

Start from the PPIND custom menu.

Keys:	Display:	Description:
CLEAR ALL		Clears PPIND variables.
480000 SALES	SALES=480,000.00	Stores sales for base period.
180000 INPUT	INPUT=180,000.00	Stores labor costs for base period.
PPIND	PPIND=2.67	Calculates partial index for base period.
STO 0		Stores the partial index in register 0.
540000 SALES	SALES=540,000.00	Stores sales for base period plus one.
6 IS%	IS%=6.00	Stores inflation in prices for base period plus one.

203000 INPUT	INPUT=203,000.00	Stores labor costs for base period plus one.
7 II%	II%=7.00	Stores inflation in labor costs for base period plus one.
PPIND	PPIND=2.69	Calculates partial index for base period plus one.
MAIN		Displays MAIN menu.
BUS %CHG		Displays %CHANGE menu.
STO NEW RCL 0 OLD	NEW=2.69 OLD=2.67	Stores old and new indexes.
%CH	%CHANGE=0.69	Calculates the percent change in labor productivity.

Labor productivity rose .69% from the base year to base year plus one. Inflation in labor costs was 7% (from the table on page 46). According to these figures, improving labor productivity is an area that needs attention.

A

Conserving Memory

The formulas in this book are intended to provide useful solutions. The variable names are several characters long to be meaningful to you. The formulas change a percent to a decimal so you don't have to remember to do it. These features make the formulas longer and take up more memory. Here are a few hints to help you conserve memory, should you need to:

- Shorten variable names. Variables are named to be as intuitive as possible. One way to save memory is to use single letter variable names.
- Delete division by 100. The formulas using a percent are written so you enter the percentage rather than the decimal value. Examples of this are tax rate as a percent, discount rate as a percent, or interest rate. If you do delete division by 100 from the formulas, remember to divide the percent by 100, or key in the percent and press [%], before storing the value in the variable.
- Delete variables for other formulas. When the SOLVE menu is displayed and you press [CLEAR ALL] [VARS], the variables are erased, giving you more usable memory. (If you select [BOTH] instead of [VARS], all formulas and their variables will be gone.)
- Delete individual formulas. When the SOLVE menu is displayed, move the pointer to the formula you want to delete, and press [DELET] [BOTH].

Working With Your Business Consultant Professional Calculator

The *Manufacturing Consultant* contains a variety of applications, formulas and keystrokes to help you solve the specialized problems of your profession.

- Priority Scheduling Rule
- Daily Production Rate
- Predicting Labor Hours Using Learning Rates
- Forecasting Manufacturing Rates of Accessories
- Forecasting Manufacturing Rates Using Simple Moving Averages
- Forecasting Manufacturing Rates Based on History
- Economic Ordering Quantity
- Productivity Measurements
- Replacing Equipment
- Estimating Inventory Investment versus Expected Shipment Dollars
- Manufacturing Strategy Analysis
- Using NPV and IRR to Make Investment Decisions
- Work Sampling Survey Size
- Productivity Measurements

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Printed in Canada 4/86

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