# Inventory Control Overview

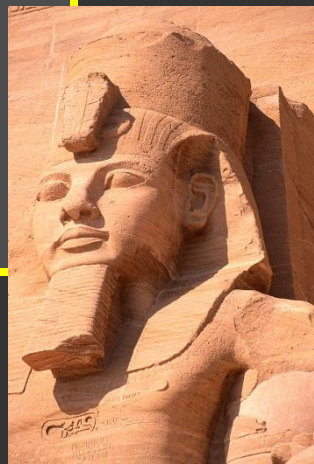
- Doctrine and Variables
- Basic EOQ Model
- Special EOQ Models
- Reorder Point Models
- Computer Applications

# Why Inventory Control Models?

It is not always possible for a firm to fax, e-mail, or telephone an inventory order to an external supplier and expect to receive that order within a two-hour time frame.

# History

- Developed in 1912 by Ford Whitman Harris, a production engineer at Westinghouse, the U.S. electrical goods manufacturer.
- Engineer, inventor, author, and patent attorney.
- No formal education beyond high school.
- Calculus-based models that allow the firm to develop an inventory control ***doctrine*** for each material or component stocked.



# History

- In 1913, the journal, *Factory: The Magazine of Management* , published an article by Harris.
- Dealing with small copper components, the article showed how mathematics could be used to identify the least-cost production run that balanced the cost of storing the output against the cost of setting up the production run.

Cu Copper

Atomic Number: 29
Atomic Mass: 63.55

# Inventory Control Doctrine Objective

TO
ORDER
or
PRODUCE
SUFFICIENT
INVENTORIES
TO
AVOID
EXCESSIVE
CARRY
COSTS
+
STOCKOUT
COSTS

TO
MINIMIZE
ORDERING
or
SETUP
COSTS

DEVELOPED FOR EACH ITEM STOCKED

# Inventory Control Doctrine Elements

***How much*** **to buy or make each time the need arises for a material, component, or product**

***When*** **to buy or make each time the need arises for a material, part, or product**

# “WHEN”


Predetermined Level of Stockage
“Buy 50 units when the inventory account balance falls to 17 units”
Specific time interval
“Buy 50 units every two weeks”

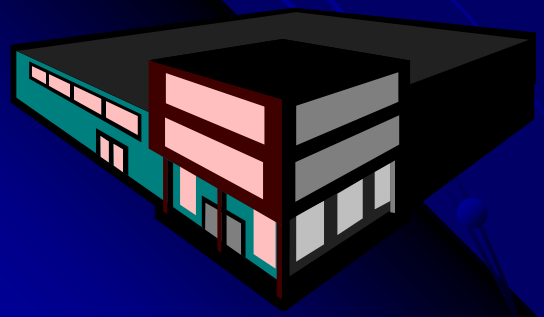
# Some Inventory Control Variables

- D or $D_A$
- H or $C_H$
- S or K or $C_o$
- R or ROP
- L
- d
- P or U
- Q* or EOQ

# Variable Interpretations

**SERVICE SECTOR**

**Q* or *EOQ* is the optimal purchase amount from an outside vendor**



**MANUFACTURING**

**Q* or *EOQ* is the optimal production run or lot size**

* ( *ECONOMIC ORDER QUANTITY* )

# Variable Interpretations

## SERVICE SECTOR

D or $D_A$ is the external annual customer demand

## MANUFACTURING

D or $D_A$ is either:

Annual wholesaler demand

**or**

Annual internal demand from sister divisions within the firm

# Variable Interpretations

## SERVICE SECTOR

**S, K, Co is the fixed administrative cost of ordering Q* regardless of the amount**

Purchase Forms
Supervisor Approvals
Shipping Costs
Delivery Inspections
Stocking Costs
Accounts Payable Processing

## MANUFACTURING

**S, K, Co is the setup cost for Q***

- Equipment Resets
- Worker Preps
- Lost Productivity
- Product Scrappage and Rework

# Variable Interpretations

**SERVICE SECTOR** + **MANUFACTURING**

**H or $C_H$ is the carrying or holding cost: the cost of storing one unit for one year**

SALARIES AND WAGES FOR WAREHOUSE EMPLOYEES
WAREHOUSE PAPER AND FORMS
WAREHOUSE DEPRECIATION
MATERIALS HANDLING
COST OF CAPITAL
OBSOLESCENCE
INSURANCE
SPOILAGE
UTILITIES
TAXES
THEFT

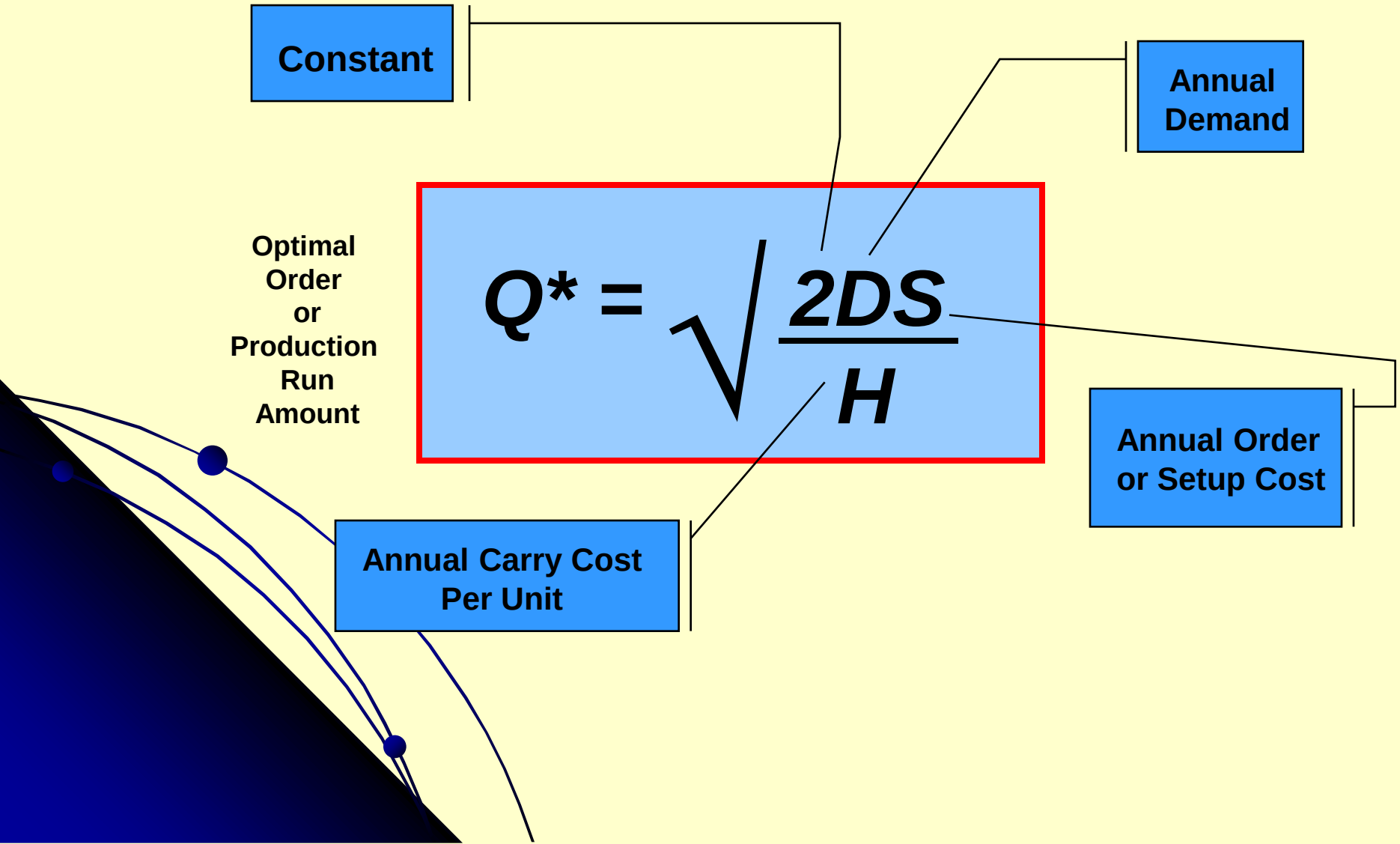
# *EOQ* Model Assumptions

## AND LIMITATIONS

- Daily, weekly, monthly, and annual demand are ***known*** and ***constant***.
- **No** stockouts are allowed.
- **No** backordering is allowed.
- **No** physical limits on warehouse capacity.
- Lead time is ***constant***.
- Order quantity is received **all at once**.
- Unit purchase price or manufacturing cost remains ***fixed***.

THE ORIGINAL 1912 MODEL

# *Optimal Q* or *EOQ* Formula



# *EOQ* Formula Example

**Given $D_A$ = 5,000 units  H = $1.00  S = $49.00**

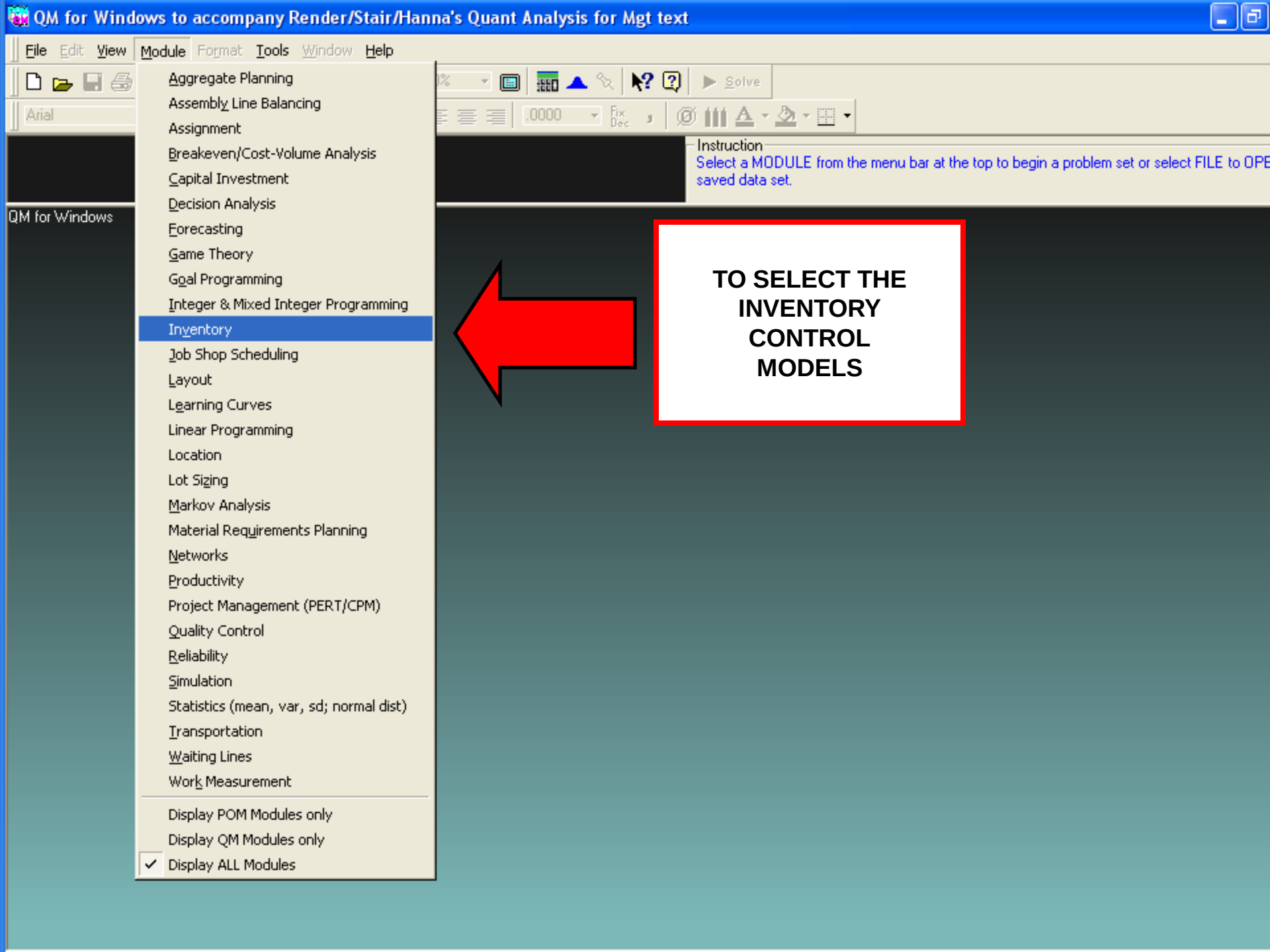
$$Q^* / EOQ = \sqrt{\frac{(2)(5000)(49.00)}{1.00}}$$

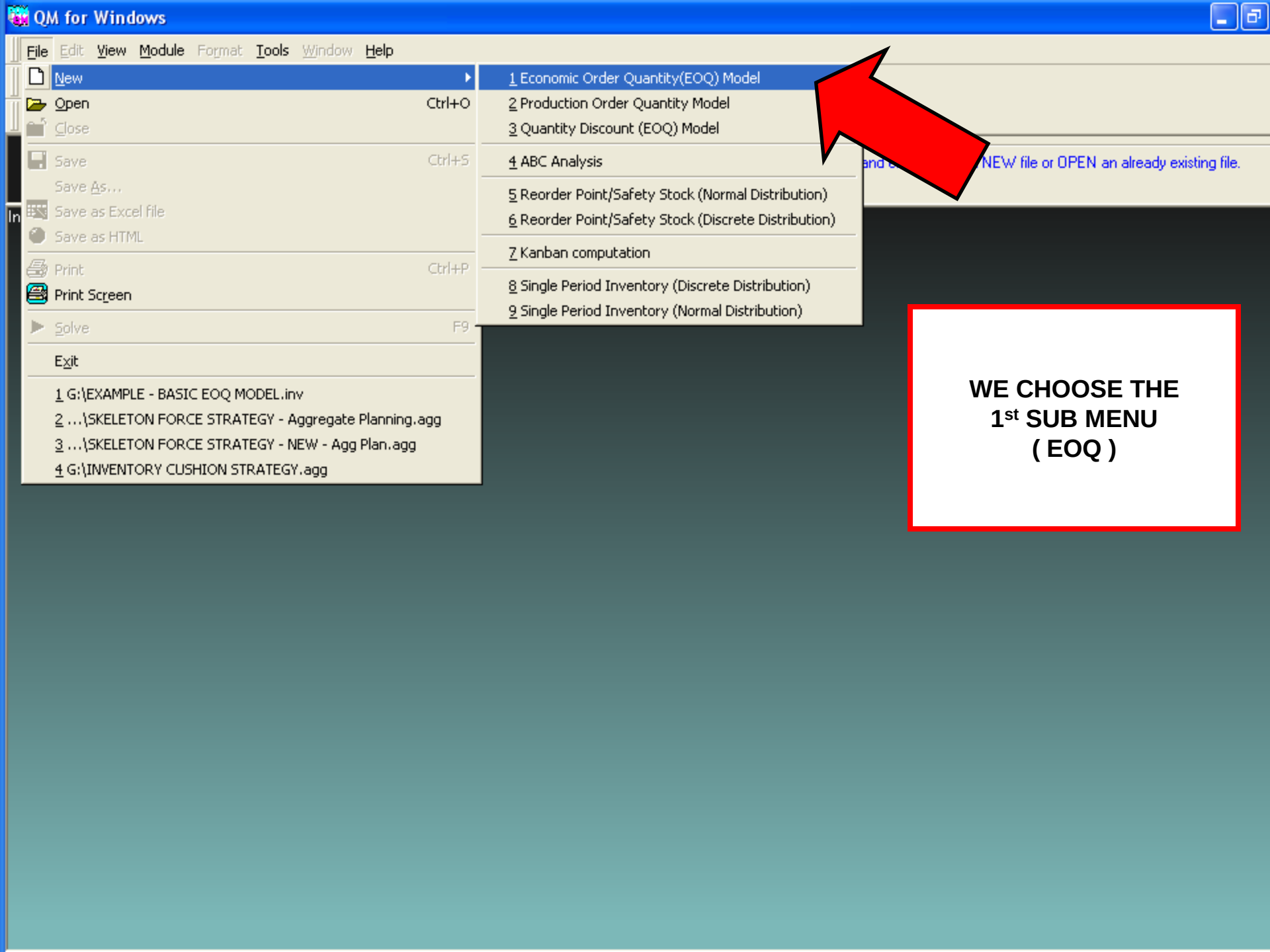
$$= \sqrt{\frac{490{,}000}{1.00}}$$

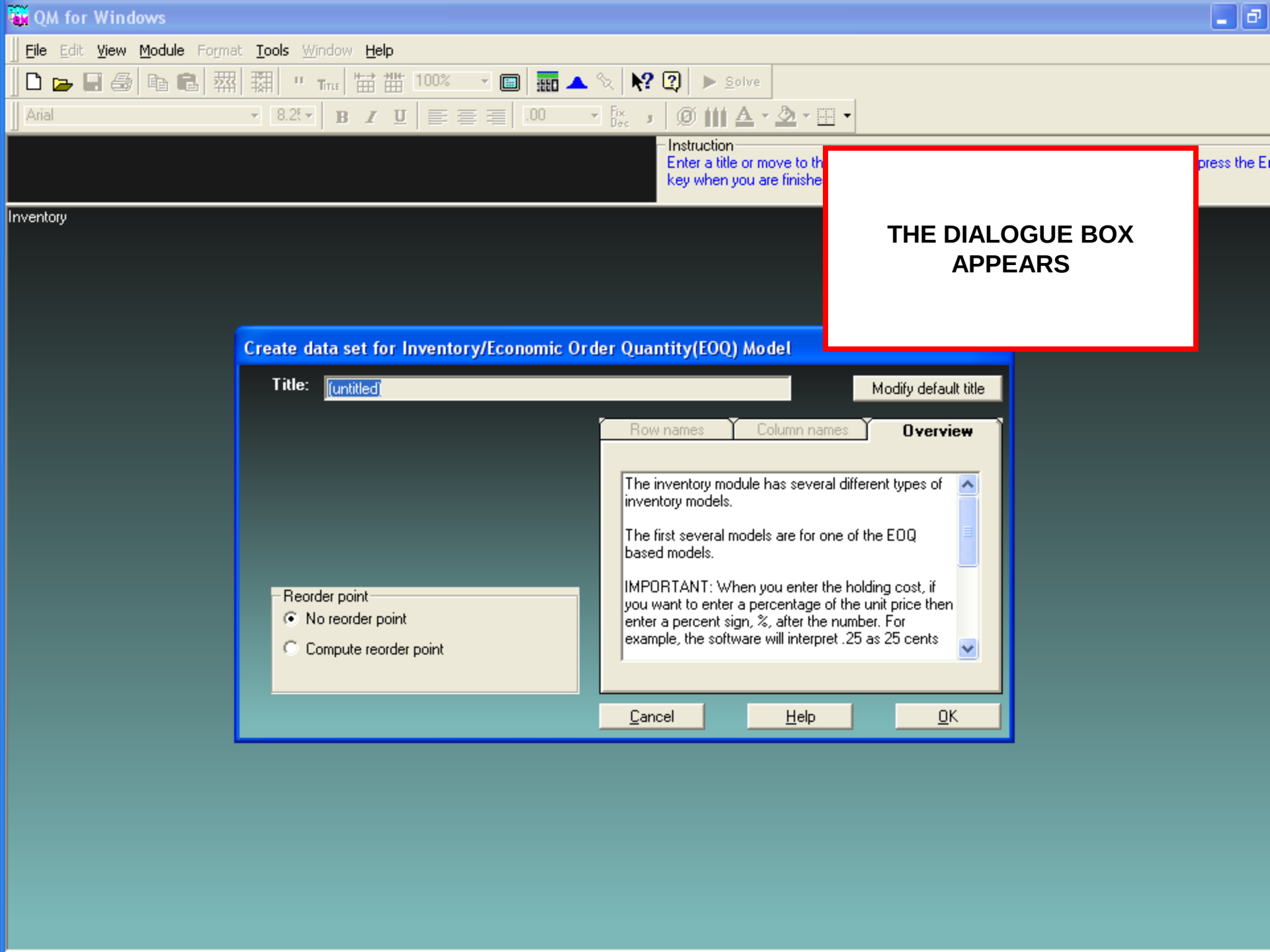
$$= 700 \text{ units}$$

# Inventory Modeling with QM for Windows

**Basic *EOQ***
**and**
***TVC* Model**


QM for Windows to accompany Render/Stair/Hanna's Quant Analysis for Mgt text
File Edit View Module Format Tools Window Help
Aggregate Planning
Assembly Line Balancing
Assignment
Breakeven/Cost-Volume Analysis
Capital Investment
Decision Analysis
Forecasting
Game Theory
Goal Programming
Integer & Mixed Integer Programming
Inventory
Job Shop Scheduling
Layout
Learning Curves
Linear Programming
Location
Lot Sizing
Markov Analysis
Material Requirements Planning
Networks
Productivity
Project Management (PERT/CPM)
Quality Control
Reliability
Simulation
Statistics (mean, var, sd; normal dist)
Transportation
Waiting Lines
Work Measurement
Display POM Modules only
Display QM Modules only
Display ALL Modules
Solve
Instruction
Select a MODULE from the menu bar at the top to begin a problem set or select FILE to OPE
saved data set.
QM for Windows
TO SELECT THE INVENTORY CONTROL MODELS


QM for Windows
File Edit View Module Format Tools Window Help
New
Open Ctrl+O
Close
Save Ctrl+S
Save As...
Save as Excel file
Save as HTML
Print Ctrl+P
Print Screen
Solve F9
Exit
1 G:\EXAMPLE - BASIC EOQ MODEL.inv
2 ...\SKELETON FORCE STRATEGY - Aggregate Planning.agg
3 ...\SKELETON FORCE STRATEGY - NEW - Agg Plan.agg
4 G:\INVENTORY CUSHION STRATEGY.agg
1 Economic Order Quantity(EOQ) Model
2 Production Order Quantity Model
3 Quantity Discount (EOQ) Model
4 ABC Analysis
5 Reorder Point/Safety Stock (Normal Distribution)
6 Reorder Point/Safety Stock (Discrete Distribution)
7 Kanban computation
8 Single Period Inventory (Discrete Distribution)
9 Single Period Inventory (Normal Distribution)
NEW file or OPEN an already existing file.
WE CHOOSE THE
1st SUB MENU
( EOQ )


QM for Windows
File Edit View Module Format Tools Window Help
Solve
Arial
Instruction
Enter a title or move to th
key when you are finishe
press the E
Inventory
THE DIALOGUE BOX APPEARS
Create data set for Inventory/Economic Order Quantity(EOQ) Model
Title:
(untitled)
Modify default title
Row names
Column names
Overview
The inventory module has several different types of inventory models.
The first several models are for one of the EOQ based models.
IMPORTANT: When you enter the holding cost, if you want to enter a percentage of the unit price then enter a percent sign, %, after the number. For example, the software will interpret .25 as 25 cents
Reorder point
No reorder point
Compute reorder point
Cancel
Help
OK

QM for Windows - G:\EXAMPLE - BASIC EOQ MODEL.inv - [Data Table]

File Edit View Module Format Tools Window Help

Solve

Arial 8.25 B I U .00 Fix Dec ,

Reorder point
- No reorder point
- Compute reorder point

Order Quantity (0=EOQ) 0

Instruction
Enter the value for the unit cost. If the holding cost is expressed as a percentage then the unit c
must be strictly positive. Any non-negative value is permissible.

EXAMPLE - BASIC EOQ MODEL - Dr. Vaccaro

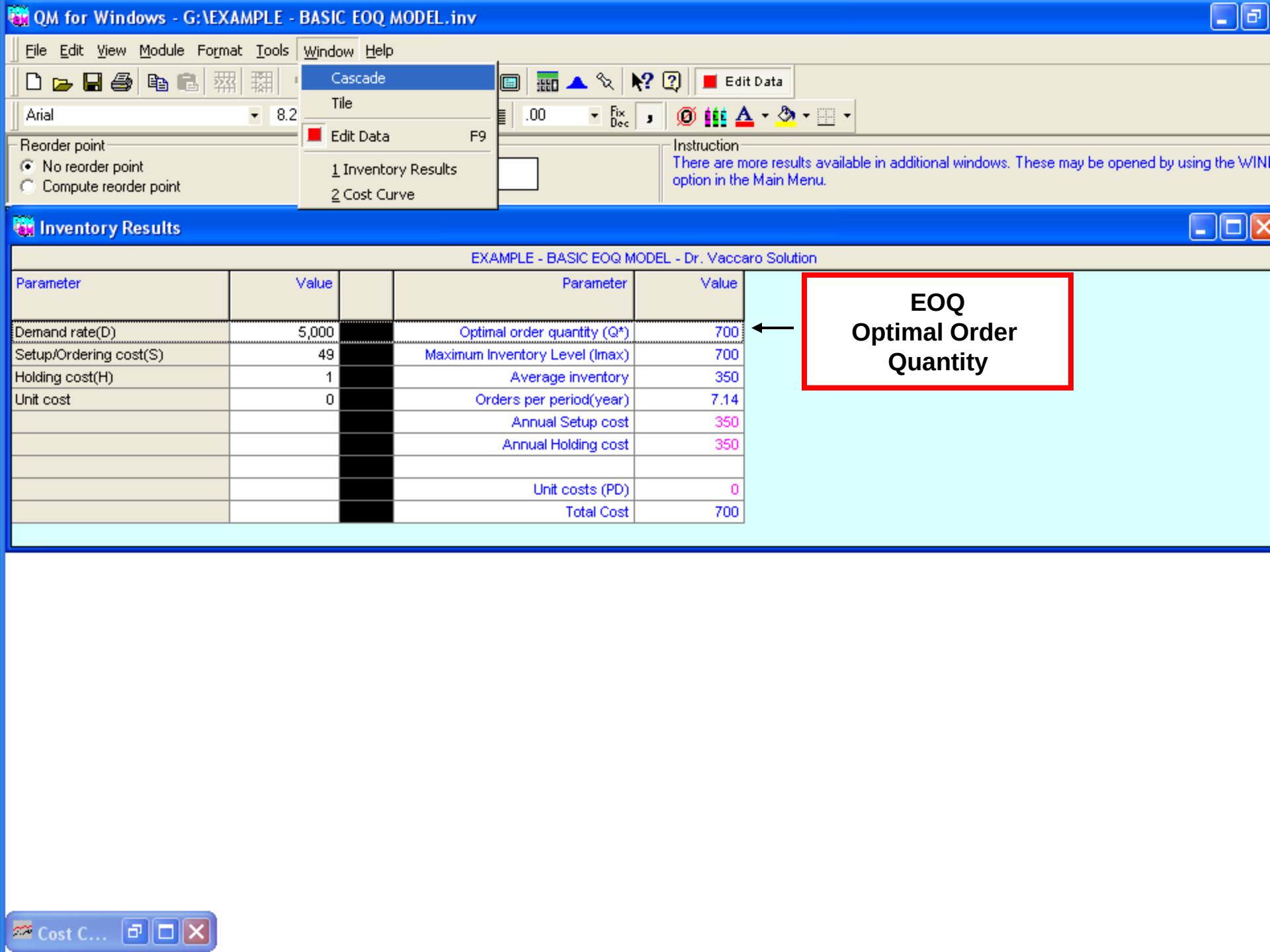
| Parameter | Value |
|---|---|
| Demand rate(D) | 5,000 |
| Setup/Ordering cost(S) | 49 |
| Holding cost(H) | 1 |
| Unit cost | 0 |

**ANNUAL DEMAND = 5,000 UNITS**

**ORDER COST = $49.00**

**CARRY COST PER UNIT = $1.00**

**( UNIT COST NEED NOT BE SPECIFIED )**


QM for Windows - G:\EXAMPLE - BASIC EOQ MODEL.inv
File Edit View Module Format Tools Window Help
Cascade
Tile
Edit Data F9
1 Inventory Results
2 Cost Curve
Edit Data
Arial
Reorder point
No reorder point
Compute reorder point
Instruction
There are more results available in additional windows. These may be opened by using the WIN
option in the Main Menu.
Inventory Results
EXAMPLE - BASIC EOQ MODEL - Dr. Vaccaro Solution
Parameter Value Parameter Value
Demand rate(D) 5,000 Optimal order quantity (Q*) 700
Setup/Ordering cost(S) 49 Maximum Inventory Level (Imax) 700
Holding cost(H) 1 Average inventory 350
Unit cost 0 Orders per period(year) 7.14
Annual Setup cost 350
Annual Holding cost 350
Unit costs (PD) 0
Total Cost 700
EOQ
Optimal Order
Quantity
Cost C...

QM for Windows - G:\EXAMPLE - BASIC EOQ MODEL.inv - [Cost Curve]

File Edit View Module Format Tools Window Help

Edit Data

Reorder point
- No reorder point
- Compute reorder point

Order Quantity (0=EOQ) 0

Instruction
Other output can be viewed by using WINDOW.

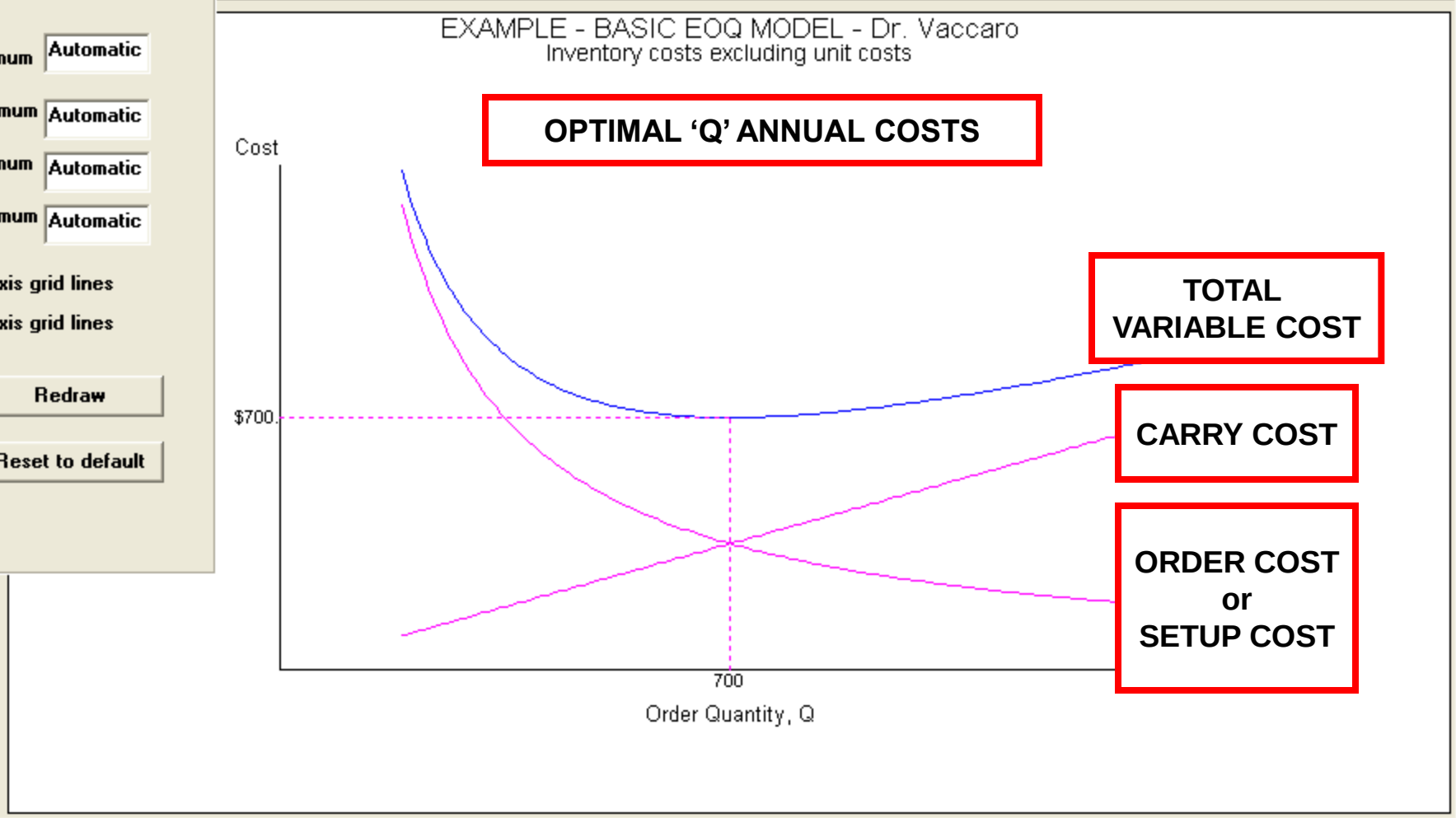
Scale Axes

| | |
|---|---|
| x minimum | Automatic |
| x maximum | Automatic |
| y minimum | Automatic |
| y maximum | Automatic |

- x axis grid lines
- y axis grid lines

Redraw

Reset to default



# Total Variable Cost ( TVC )

**The cost of each " Q " – optimal or non-optimal**

| | | | | |
|---|---|---|---|---|
| **H**<br>ANNUAL CARRY COSTS | + | **S**<br>ANNUAL ORDER / SETUP COSTS | = | **TVC**<br>TOTAL VARIABLE COSTS |

**THIS COST CHANGES WITH EVERY POSSIBLE VALUE OF Q / *EOQ* , HENCE THE NAME**

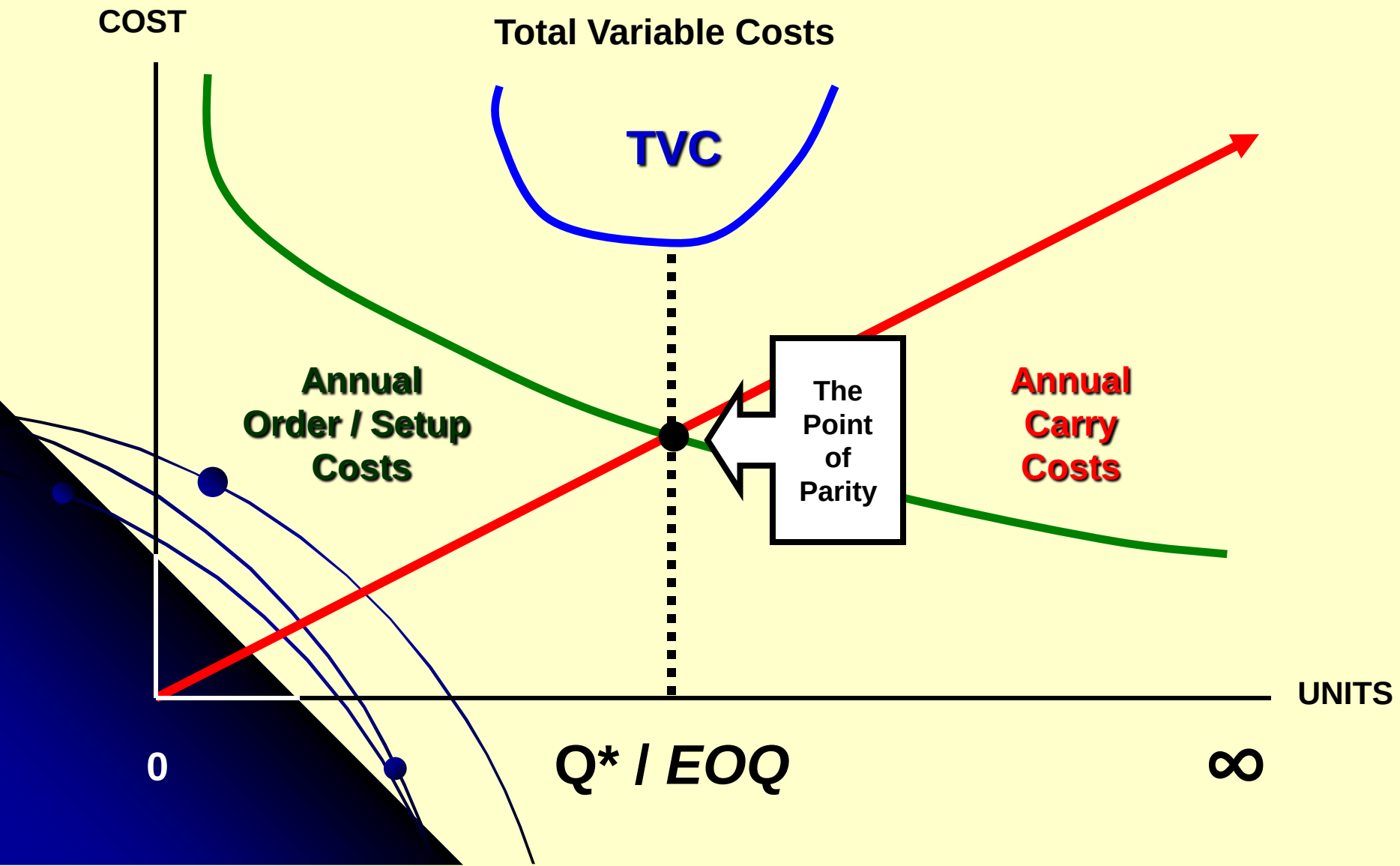
# What Happens at *Q* / EOQ*


**Annual Carry Costs ( H )**

**Annual Order or Setup Costs ( S )**

**…….AND TOTAL VARIABLE COST ( TVC ) IS MINIMIZED !**

# THE INVENTORY COST TRADEOFF



# *Total Variable Cost* ( TVC ) Formula

$$TVC = \left( \frac{Q}{2} \times H \right) + \left( \frac{D}{Q} \times S \right)$$

**Annual Carry Cost ( H )**

**Annual Order / Setup Cost ( S )**

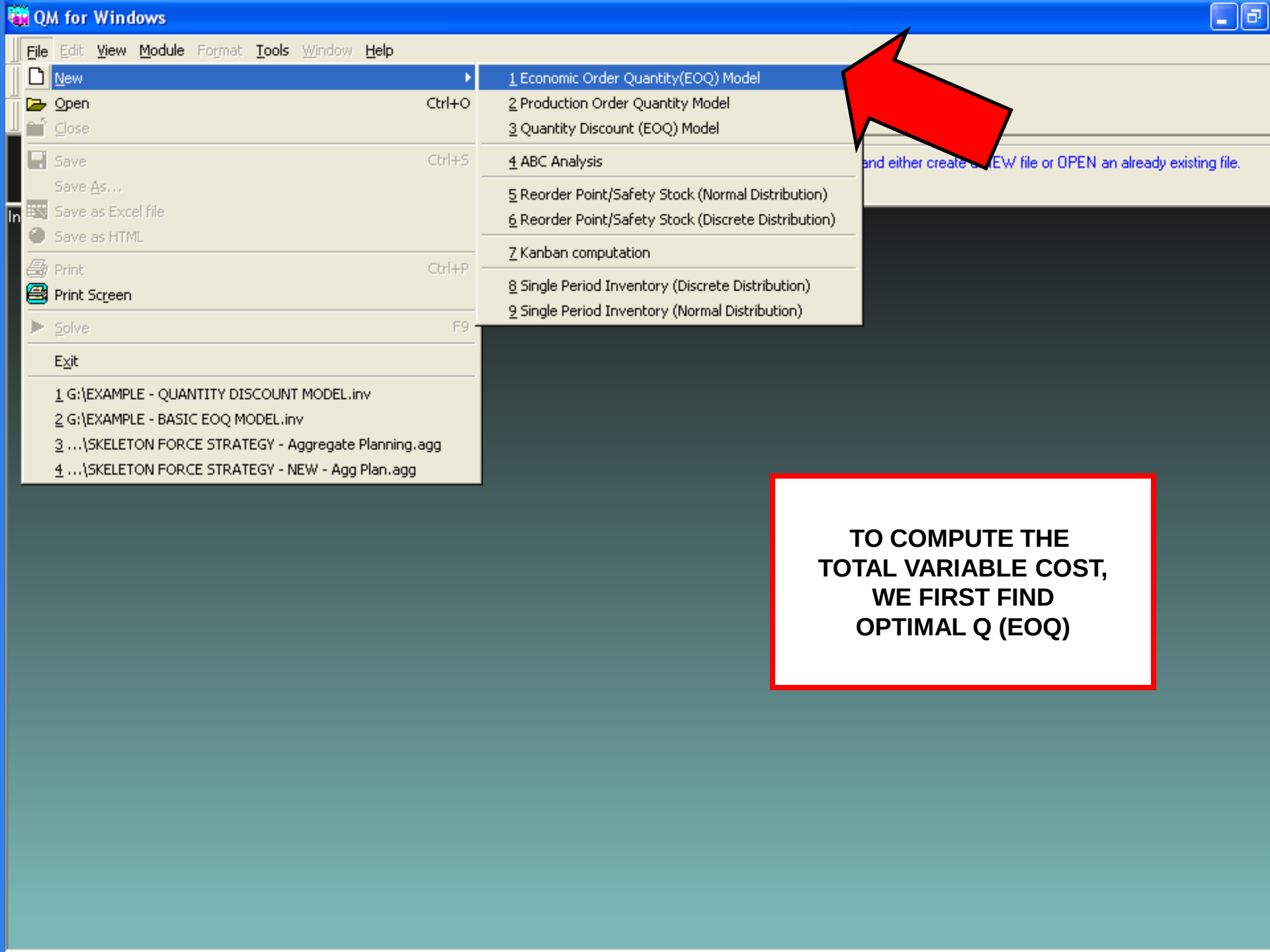
# *TVC* Formula Example

**Given $D_A$ = 1,000 units  H = $.50  S = $10.00**
**and Q* ( or any Q ) = 200 units**

$$TVC = \left( \frac{200}{2} \times .50 \right) + \left( \frac{1000}{200} \times 10.00 \right)$$

$$[\ \$50.00\ ] + [\ \$50.00\ ]$$

$$\$100.00$$


QM for Windows
File Edit View Module Format Tools Window Help
New
Open Ctrl+O
Close
Save Ctrl+S
Save As...
Save as Excel file
Save as HTML
Print Ctrl+P
Print Screen
Solve F9
Exit
1 G:\EXAMPLE - QUANTITY DISCOUNT MODEL.inv
2 G:\EXAMPLE - BASIC EOQ MODEL.inv
3 ...\SKELETON FORCE STRATEGY - Aggregate Planning.agg
4 ...\SKELETON FORCE STRATEGY - NEW - Agg Plan.agg
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2 Production Order Quantity Model
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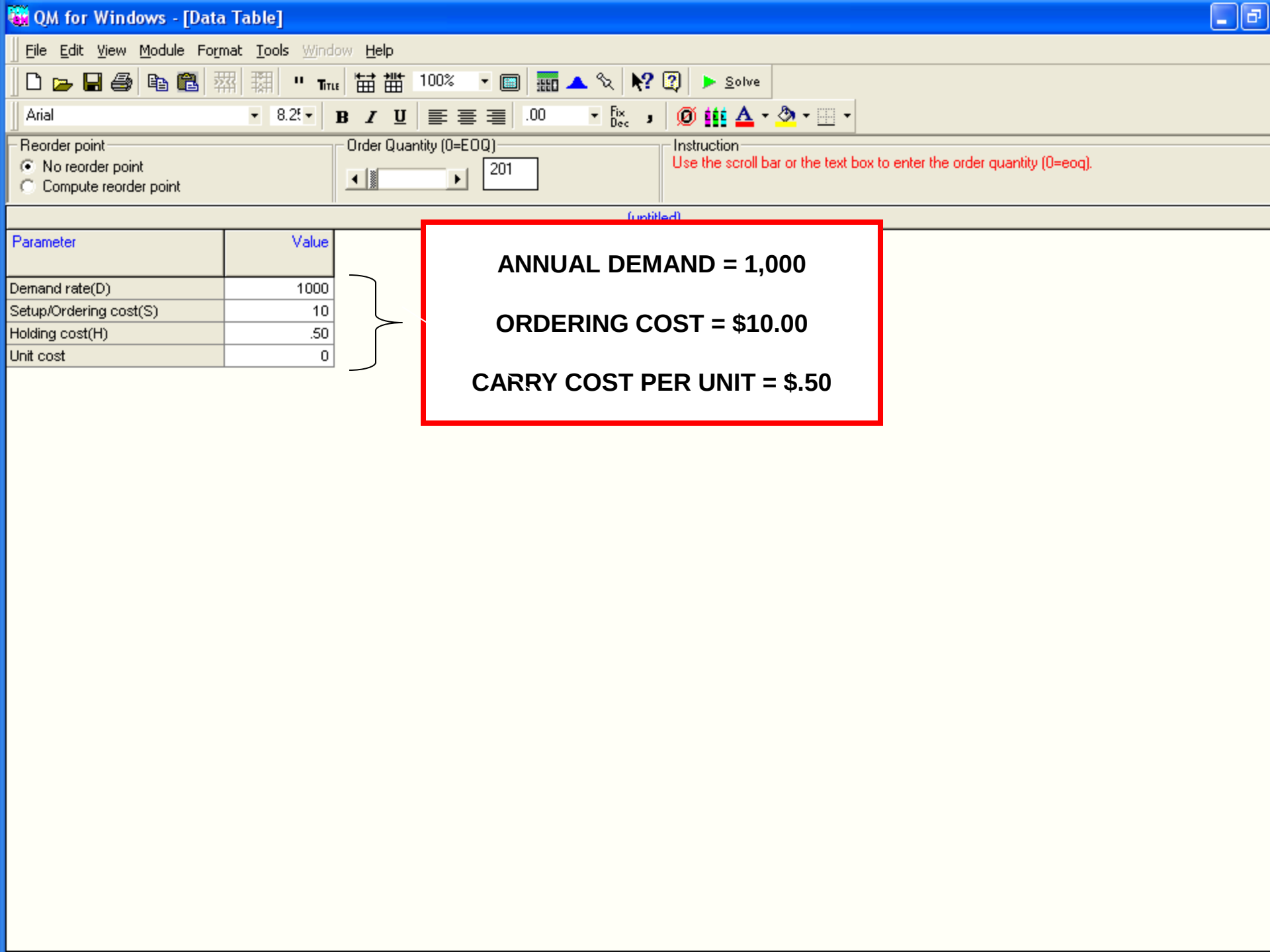
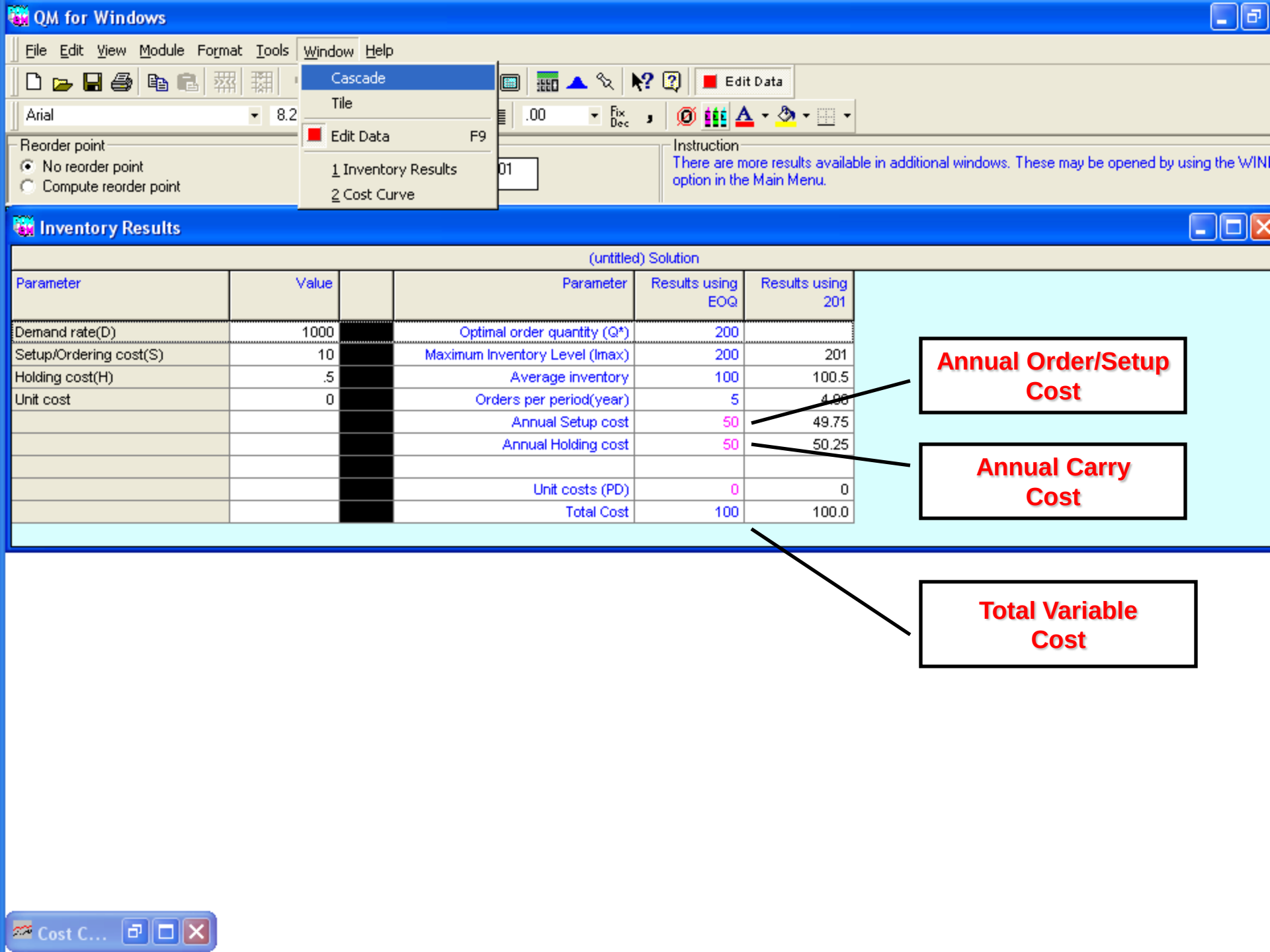
4 ABC Analysis
5 Reorder Point/Safety Stock (Normal Distribution)
6 Reorder Point/Safety Stock (Discrete Distribution)
7 Kanban computation
8 Single Period Inventory (Discrete Distribution)
9 Single Period Inventory (Normal Distribution)
and either create a NEW file or OPEN an already existing file.
TO COMPUTE THE TOTAL VARIABLE COST, WE FIRST FIND OPTIMAL Q (EOQ)


QM for Windows - [Data Table]
File Edit View Module Format Tools Window Help
Solve
Arial
Reorder point
No reorder point
Compute reorder point
Order Quantity (0=EOQ)
201
Instruction
Use the scroll bar or the text box to enter the order quantity (0=eoq).
(untitled)
Parameter
Value
Demand rate(D)
1000
Setup/Ordering cost(S)
10
Holding cost(H)
.50
Unit cost
0
ANNUAL DEMAND = 1,000
ORDERING COST = $10.00
CARRY COST PER UNIT = $.50


QM for Windows
File Edit View Module Format Tools Window Help
Cascade
Tile
Edit Data F9
1 Inventory Results
2 Cost Curve
Edit Data
Arial
8.2
.00
Fix Dec
Reorder point
No reorder point
Compute reorder point
Instruction
There are more results available in additional windows. These may be opened by using the WIN
option in the Main Menu.
Inventory Results
(untitled) Solution
Parameter
Value
Parameter
Results using EOQ
Results using 201
Demand rate(D) 1000
Setup/Ordering cost(S) 10
Holding cost(H) .5
Unit cost 0
Optimal order quantity (Q*) 200
Maximum Inventory Level (Imax) 200 201
Average inventory 100 100.5
Orders per period(year) 5
Annual Setup cost 50 49.75
Annual Holding cost 50 50.25
Unit costs (PD) 0 0
Total Cost 100 100.0
Annual Order/Setup Cost
Annual Carry Cost
Total Variable Cost
Cost C...

QM for Windows - [Cost Curve]

File Edit View Module Format Tools Window Help

Edit Data

Arial

Reorder point
- No reorder point
- Compute reorder point

Order Quantity (0=EOQ) 201

Instruction
Other output can be viewed by using WINDOW.

Scale Axes

x minimum Automatic

x maximum Automatic

y minimum Automatic

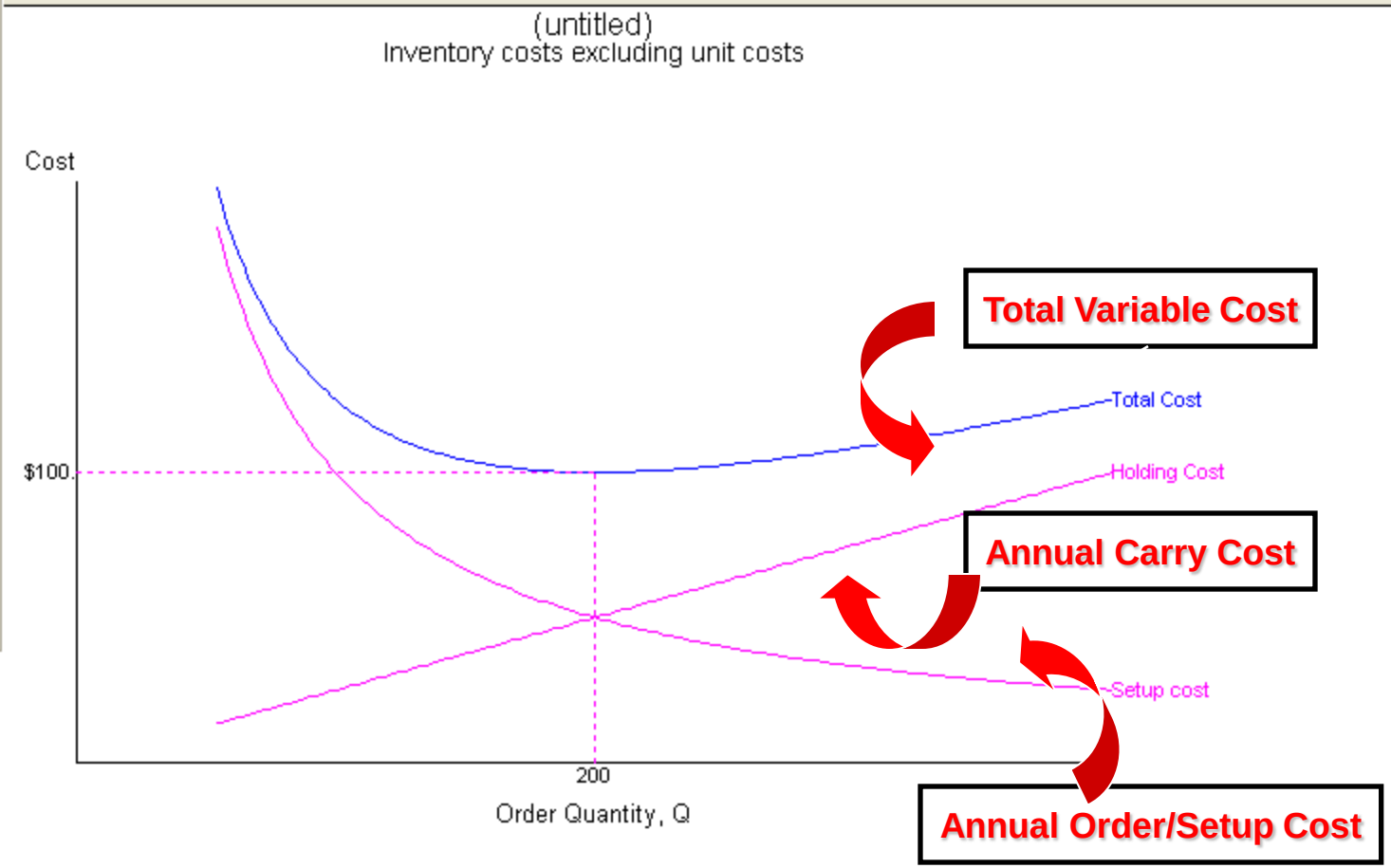
y maximum Automatic

x axis grid lines

y axis grid lines

Redraw

Reset to default



# The *Reorder Point* ( ROP )

**WHAT IT IS**

**The level of inventory stock that triggers a reorder of the Q*/ EOQ**

**PURPOSE**

**Reduces or eliminates the probability of an inventory stockout during the reorder waiting period ( *leadtime* )**

# Variable Interpretations

**SERVICE SECTOR**

**Lead time ( L ) is the period between ordering and receiving purchased items**


**MANUFACTURING**

**Lead time ( L ) is the period between starting and ending the item's production run**

# *Reorder Point* Formula

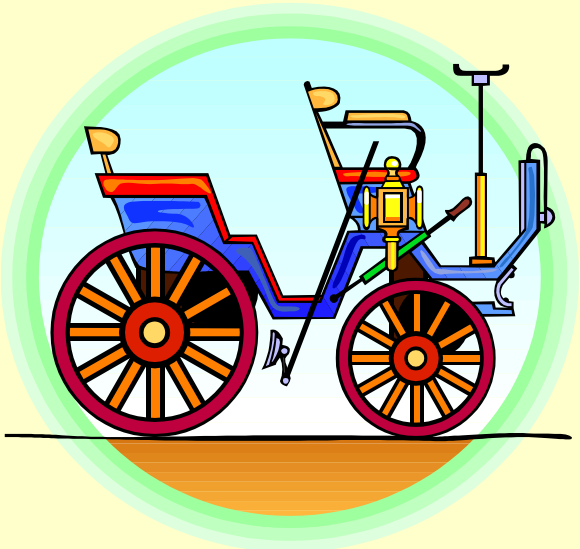
DAYS
WEEKS
MONTHS

**LEAD TIME**

$$ROP = d \times L$$

DAILY
WEEKLY
MONTHLY

**DEMAND**

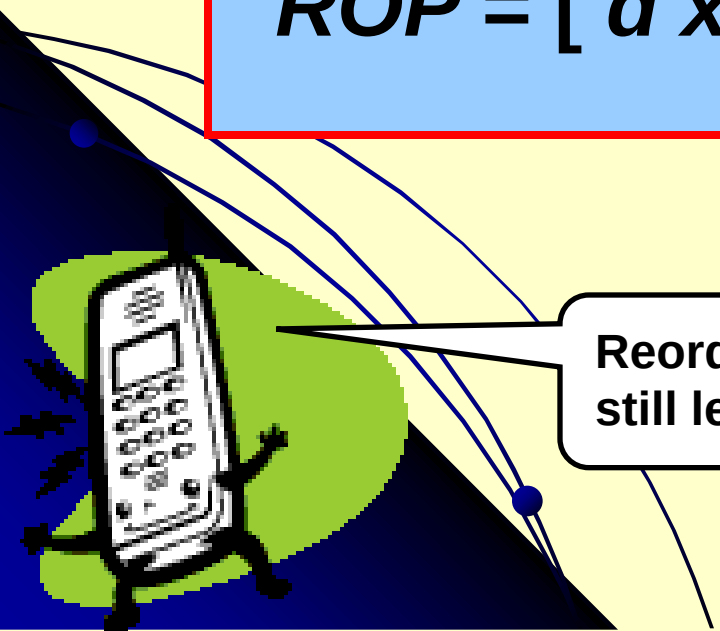


THE ORIGINAL 1912 FORMULA

# *Reorder Point* Example

**If the firm must wait 3 days for an order to arrive, during which time, the daily average demand is 8 units, then:**

$$ROP = [\, d \times L \,] = [\, 8 \times 3 \,] = 24 \text{ units}$$



**Reorder when there are 24 units still left in the account balance**

# IMPORTANT ADVICE

There is no relationship between the Q* (EOQ) and the ROP (R)

Each is computed separately

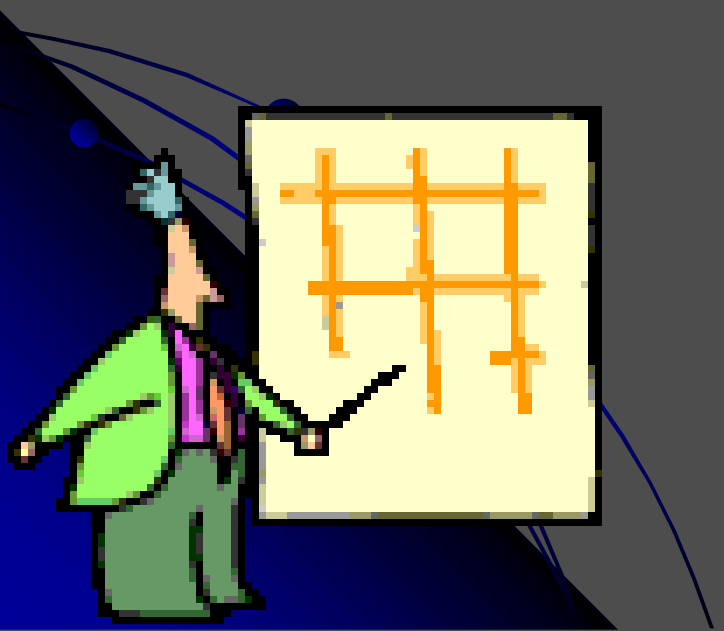
The ROP is never an optimal value

It is impossible to eliminate stockouts entirely

# *The Inventory Cycle Chart*

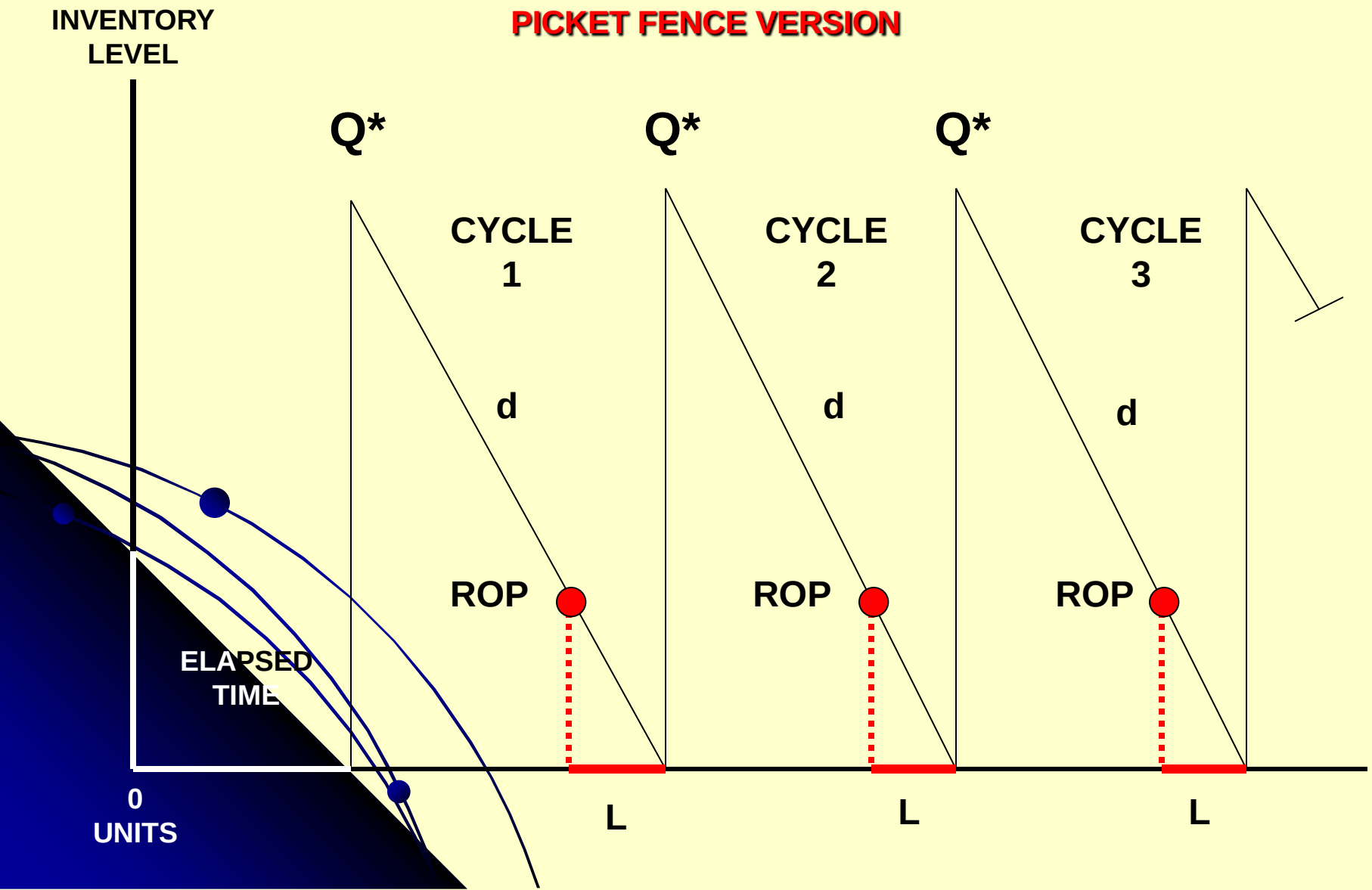
**Graphically depicts the relationship between:**

**Q* / EOQ**
***ROP***
***d***
***L***

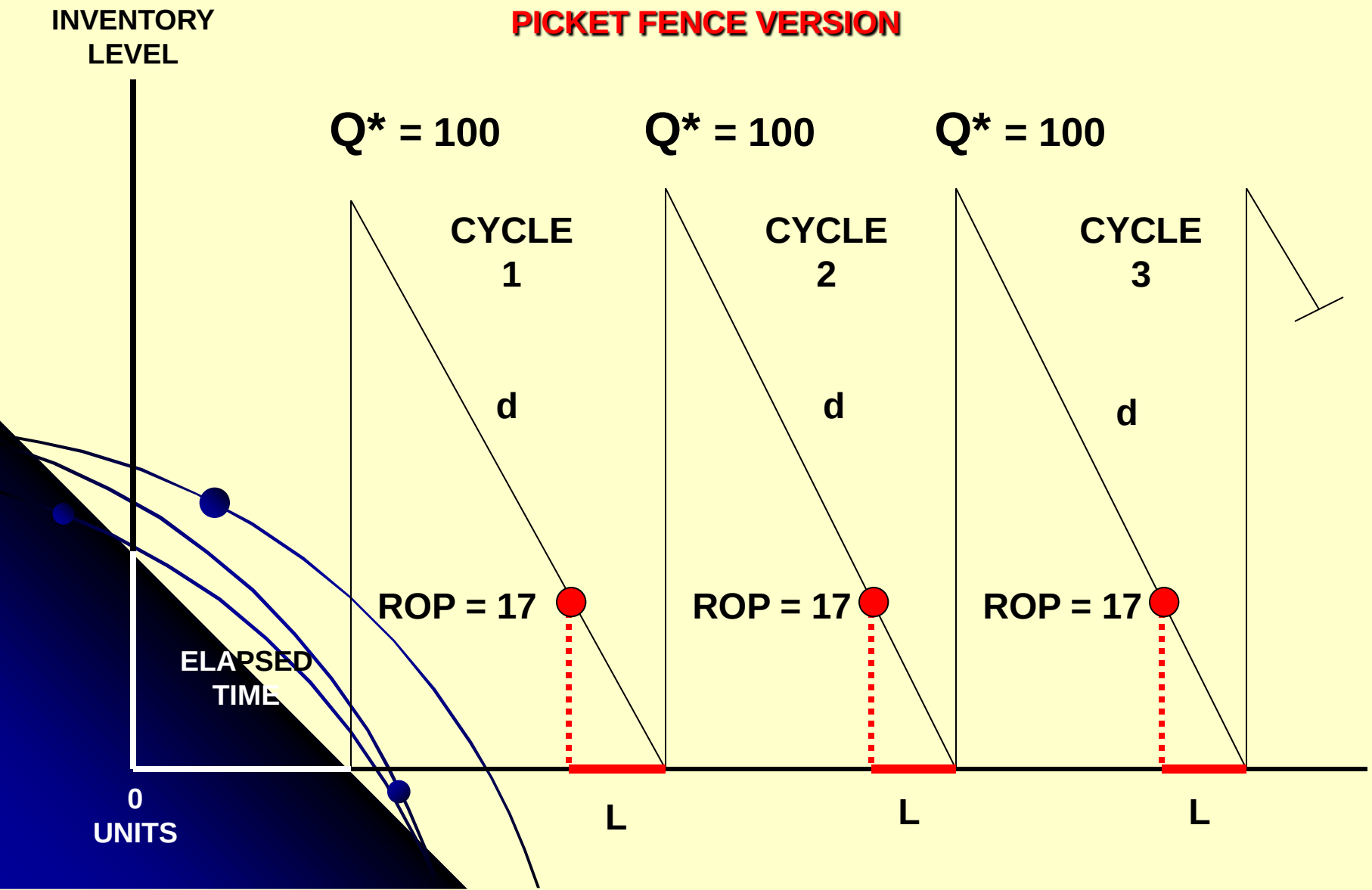


**Cycle charts enhance understanding of the basic inventory concepts**

# The Inventory Cycle Chart



# The Inventory Cycle Chart



# The *Average Inventory* Concept

**[ Q*/ 2 ] or [ Q / 2 ] = *AVERAGE INVENTORY***

| AVERAGE INVENTORY PER CYCLE | = | AVERAGE INVENTORY PER YEAR |
|---|---|---|

**IF YOU NEED 5000 UNITS ANNUALLY AND ORDER 500 UNITS AT A TIME, AVERAGE INVENTORY IS 500/2 = 250 UNITS PER CYCLE AS WELL AS PER YEAR, BECAUSE THERE CAN ONLY BE ZERO TO 500 UNITS IN THE ACCOUNT BALANCE AT ANY GIVEN TIME OF THE YEAR!**

# Variable Interpretations

**SERVICE SECTOR**

**P** or **U** is the wholesale price per unit to the retailer

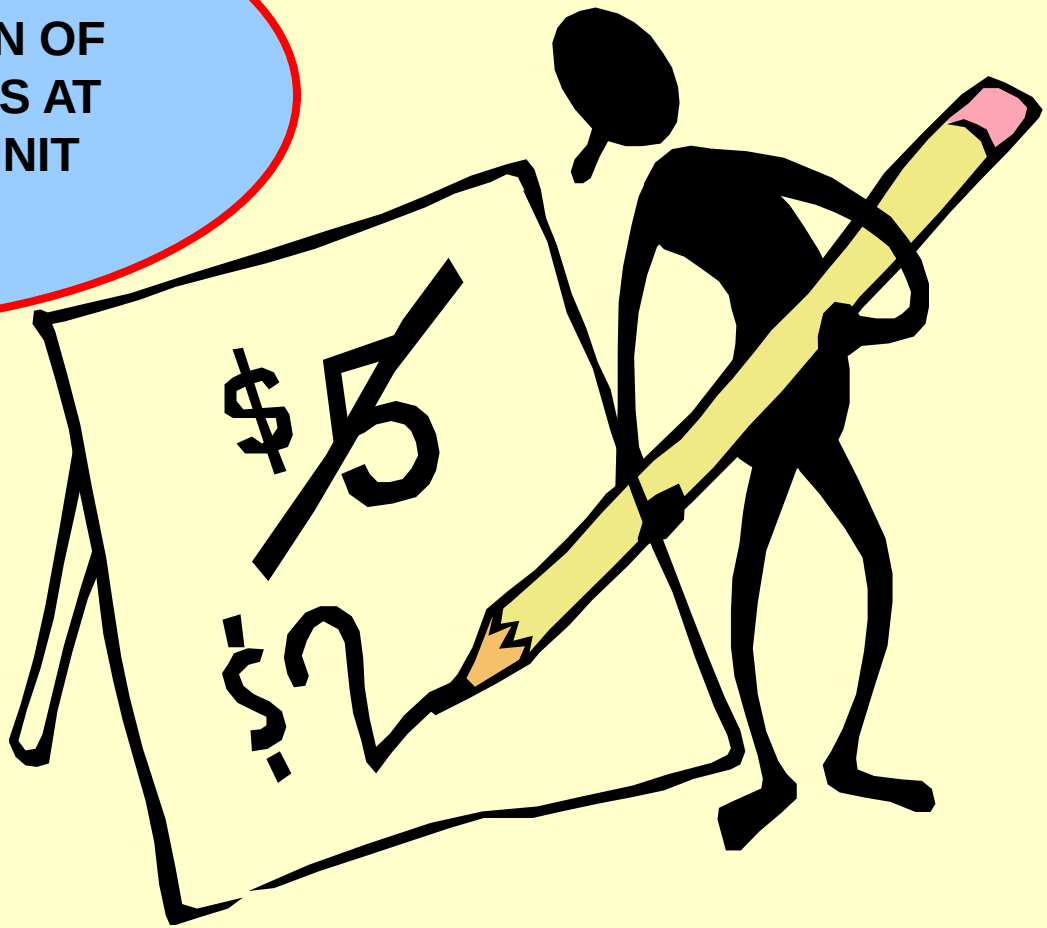
**MANUFACTURING**

**P** or **U** is the manufacturing cost per unit

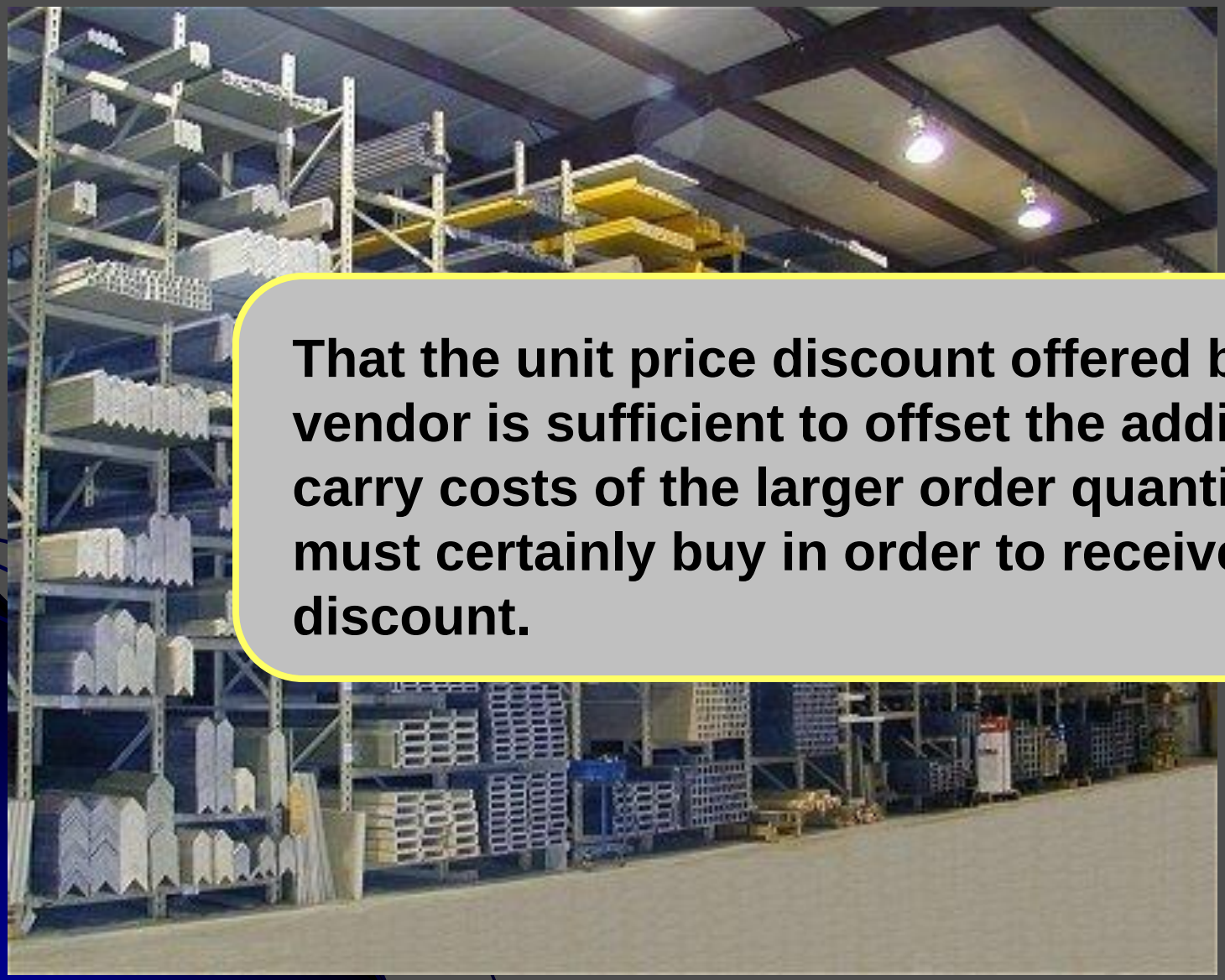
( direct materials
direct labor
applied overhead )

# The *Quantity Discount* Model

**USED WHENEVER THE FIRM IS GIVEN THE OPTION OF PURCHASING GOODS AT SEVERAL LOWER UNIT PRICES**



# *Quantity Discount Model* Expectation



**That the unit price discount offered by the vendor is sufficient to offset the additional carry costs of the larger order quantity we must certainly buy in order to receive this discount.**

# Two Special Features

## QUANTITY DISCOUNT MODEL

**The variable "H" must be computed as a function of :**

**I x P**

**WHERE "I" IS THE UNIT CARRY COST EXPRESSED AS A FIXED PERCENTAGE OF A CHANGEABLE UNIT PRICE**

**A new expression**

**P x D**

**WHERE "P" IS THE UNIT PRICE MULTIPLIED BY THE ANNUAL DEMAND FOR THE UNIT**

**THIS IS, THE AMOUNT WE ACTUALLY PAY FOR THE GOODS THEMSELVES ANNUALLY**

# Changing Carry Cost per Unit

- **If unit price = $5.00**

  **H = $1.00**

  **( $5.00 x .20 )**

- **If unit price = $4.80**

  **H = $.96**

  **( $4.80 x .20 )**

- **If unit price = $4.75**

  **H = $.95**

  **( $4.75 x .20 )**

**ASSUMING I = 20%**

# Unit Carry Costs Really Do Change with Unit Price

- Obsolescence costs are less / more
- Spoilage costs are less / more
- Cost of capital to purchase the units is less / more
- Inventory taxes are less / more

# Quantity Discount Model

**EXAMPLE**

| Quantity | Discount | Unit Price |
|---|---|---|
| 1-999 units | 0% | $5.00 |
| 1000-1999 units | 4% | $4.80 |
| 2000 or more units | 5% | $4.75 |

**THE VENDOR'S PRICE SCHEDULE**

**Annual Demand = 5,000 units  Order Cost = $49.00**
**Carry Cost as Percentage of Unit Price = 20%**

# Quantity Discount Model

**EXAMPLE**

**Step 1 – Compute *Q** at each unit price, starting with the *lowest* price**

$$Q_1^* = \sqrt{\frac{2\,(5000)\,(49.00)}{(.20)(4.75)}} = 718 \text{ units}$$

# Quantity Discount Model

**EXAMPLE**

**Step 1 – Compute *Q** at each unit price, with the next *lowest* price**

$$Q_2^* = \sqrt{\frac{2\,(5000)\,(49.00)}{(.20)(4.80)}} = 714 \text{ units}$$

# Quantity Discount Model

**EXAMPLE**

**Step 1 – Compute *Q** at each unit price, with the next *lowest* price**

$$Q_3^* = \sqrt{\frac{2\,(5000)\,(49.00)}{(.20)(5.00)}} = 700 \text{ units}$$

# Quantity Discount Model

**EXAMPLE**

**Step 2 – Recompute the $Q^*$s where necessary**

$Q_1^* = 718$ is adjusted to $Q_1 = 2{,}000$ units

( to qualify for the 5% discount )

$Q_2^* = 714$ is adjusted to $Q_2 = 1{,}000$ units

( to qualify for the 4% discount )

$Q_3^* = 700$ need not be adjusted

( to qualify for the 0% discount )

# *Total Cost ( TC ) Formula*

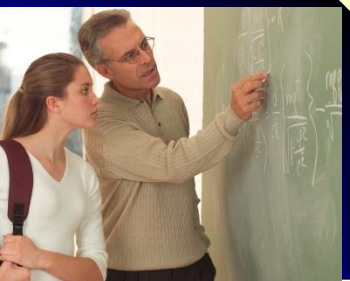
Total Variable Costs ( TVC )

$$TC = [\ (Q/2) \times H\ ] + [\ (D/Q) \times S\ ] + [\ P \times D\ ]$$

Annual Carry Costs (H)

Annual Order / Setup Costs (S)

Annual Fixed or Material Cost (FC)



# Quantity Discount Model

**TOTAL COST OF $Q_1$ = 2000 UNITS**

$$TC = \underbrace{[\ (Q/2)\ x\ H\ ]}_{\text{ANNUAL CARRY COST}} + \underbrace{[\ (D/Q)\ x\ S\ ]}_{\text{ANNUAL ORDER COST}} + \underbrace{[\ P\ x\ D\ ]}_{\text{ANNUAL FIXED COST}}$$

$$= [\ (2000/2)\ x\ (.20)(\$4.75)\ ] + [\ (5000/2000)\ x\ \$49.00\ ] + [\ \$4.75\ x\ 5000\ ]$$

$$= [\ \$950.00\ ] + [\ \$122.50\ ] + [\ \$23,750.00\ ]$$

$$= \$24,822.50$$

# Quantity Discount Model

**TOTAL COST OF $Q_2$ = 1000 UNITS**

$$TC = [ (Q/2) \times H ] + [ (D/Q) \times S ] + [ P \times D ]$$

$$= [ (1000/2) \times (.20)(\$4.80) ] + [ (5000/1000) \times \$49.00 ] + [ \$4.80 \times 5000 ]$$

$$= [ \$480.00 ] + [ \$245.00 ] + [ \$24,000.00 ]$$

$$= \$24,725.00$$

# Quantity Discount Model

**TOTAL COST OF $Q_3$ = 700 UNITS**

$$TC = [ (Q/2) \times H ] + [ (D/Q) \times S ] + [ P \times D ]$$

$$= [ (700/2) \times (.20)(\$5.00) ] + [ (5000/700) \times \$49.00 ] + [ \$5.00 \times 5000 ]$$

$$= [ \$350.00 ] + [ \$350.00 ] + [ \$25{,}000.00 ]$$

$$= \$25{,}700.00$$

# Quantity Discount Model

**EXAMPLE**

## SUMMARY

| Candidates | Annual Carry Cost | Annual Order/Setup Cost | Annual Material Cost | TOTAL COST |
|---|---|---|---|---|
| $Q_1$ 2000 units | $950.00 | $122.50 | $23,750. | $24,822.50 |
| $Q_2$ 1000 units | $480.00 | $245.00 | $24,000. | $24,725.00 |
| $Q_3$ 700 units | $350.00 | $350.00 | $25,000. | $25,700.00 |

# Quantity Discount Model

**EXAMPLE**

## SUMMARY

| Candidates | Annual Carry Cost | Annual Order/Setup Cost | Annual Material Cost | TOTAL COST |
|---|---|---|---|---|
| $Q_1$ 2000 units | $950.00 | $122.50 | $23,750. | $24,822.50 |
| $Q_2$ 1000 units | $480.00 | $245.00 | $24,000. | $24,725.00 |
| $Q_3$ 700 units | $350.00 | $350.00 | $25,000. | $25,700.00 |

THE LOWEST TOTAL COST

# Quantity Discount Model

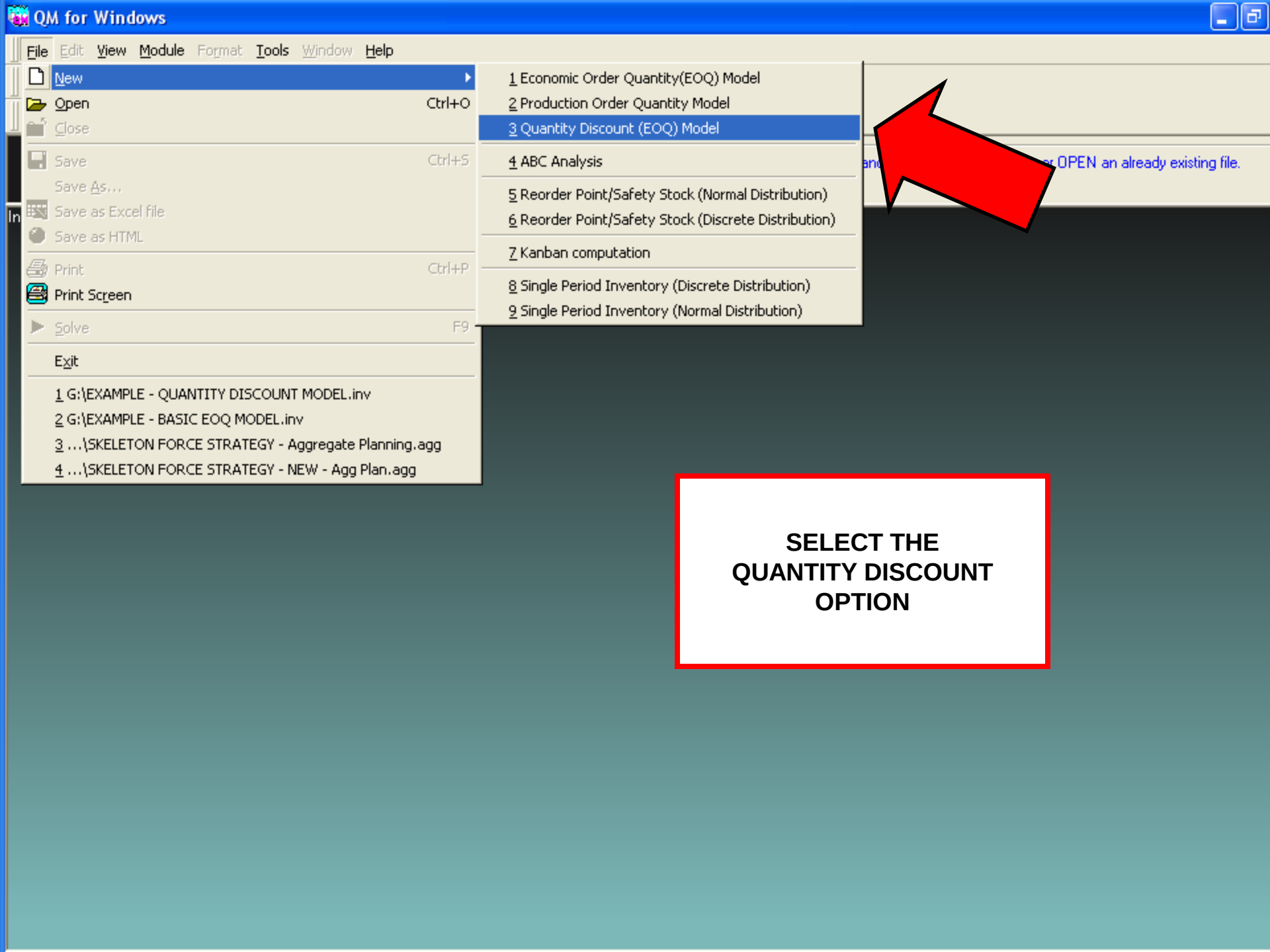
**EXAMPLE**

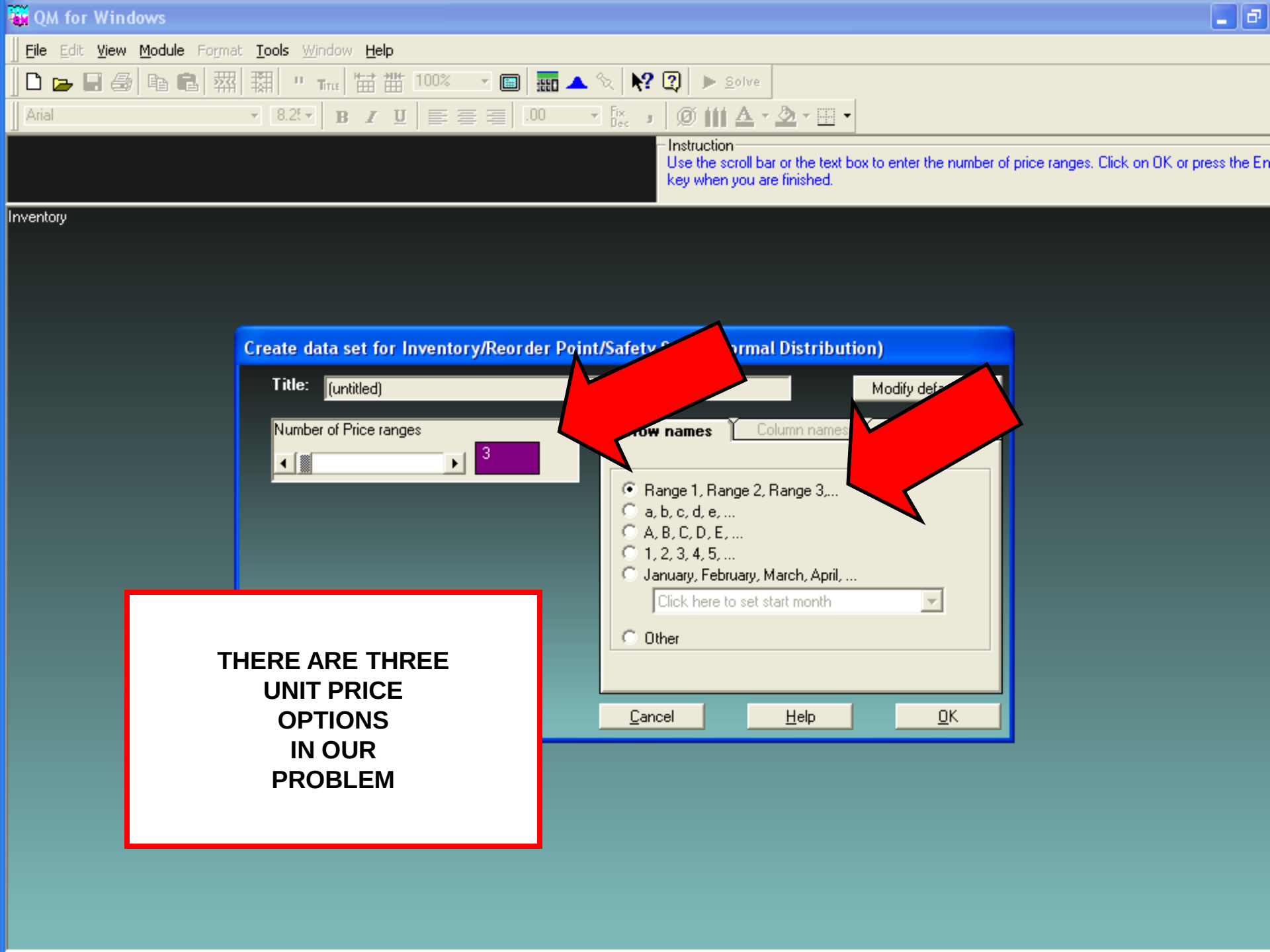
**Step 4 – Select the "Q" with the lowest total cost (TC)**

**SINCE $Q_2$ ( 1000 units ) HAS THE LOWEST TOTAL COST, THE PURCHASING DECISION IS:**

# Inventory Modeling with QM for Windows

**Quantity Discount Model**


QM for Windows
File Edit View Module Format Tools Window Help
New
Open Ctrl+O
Close
Save Ctrl+S
Save As...
Save as Excel file
Save as HTML
Print Ctrl+P
Print Screen
Solve F9
Exit
1 G:\EXAMPLE - QUANTITY DISCOUNT MODEL.inv
2 G:\EXAMPLE - BASIC EOQ MODEL.inv
3 ...\SKELETON FORCE STRATEGY - Aggregate Planning.agg
4 ...\SKELETON FORCE STRATEGY - NEW - Agg Plan.agg
1 Economic Order Quantity(EOQ) Model
2 Production Order Quantity Model
3 Quantity Discount (EOQ) Model
4 ABC Analysis
5 Reorder Point/Safety Stock (Normal Distribution)
6 Reorder Point/Safety Stock (Discrete Distribution)
7 Kanban computation
8 Single Period Inventory (Discrete Distribution)
9 Single Period Inventory (Normal Distribution)
OPEN an already existing file.
SELECT THE QUANTITY DISCOUNT OPTION


QM for Windows
File Edit View Module Format Tools Window Help
Solve
Arial
Instruction
Use the scroll bar or the text box to enter the number of price ranges. Click on OK or press the En
key when you are finished.
Inventory
Create data set for Inventory/Reorder Point/Safety
rmal Distribution)
Title:
(untitled)
Modify def
Number of Price ranges
3
ow names
Column names
Range 1, Range 2, Range 3,...
a, b, c, d, e, ...
A, B, C, D, E, ...
1, 2, 3, 4, 5, ...
January, February, March, April, ...
Click here to set start month
Other
Cancel
Help
OK
THERE ARE THREE
UNIT PRICE
OPTIONS
IN OUR
PROBLEM

QM for Windows - [Data Table]

File Edit View Module Format Tools Window Help

Solve

Arial 8.25 B I U .00 Fix Dec ,

Instruction

Enter the cost per unit for this cost range. Any non-negative value is permissible.

(untitled)

| Parameter | Value | | |
|---|---|---|---|
| Demand rate(D) | 0 | xxxxxxx | xxxxxxx |
| Setup/Ordering cost(S) | 0 | xxxxxxx | xxxxxxx |
| Holding cost(H) | 0 | xxxxxxx | xxxxxxx |
| | | | |
| Price Ranges | LOWER | UPPER | PRICE |
| 1 | 1 | 999999 | 0 |
| 2 | 1 | 999999 | 0 |
| 3 | 1 | 999999 | 0 |

**THE DATA TABLE APPEARS WITH 3 PRICE RANGES PROVIDED FOR**

QM for Windows - G:\EXAMPLE - QUANTITY DISCOUNT MODEL.inv - [Data Table]

File Edit View Module Format Tools Window Help

Solve

Instruction

Enter the cost per unit for this cost range. Any non-negative value is permissible.

EXAMPLE - QUANTITY DISCOUNT MODEL - Dr. Vaccaro

| Parameter | Value | | |
|---|---|---|---|
| Demand rate(D) | 5,000 | xxxxxxx | xxxxxxx |
| Setup/Ordering cost(S) | 49 | xxxxxxx | xxxxxxx |
| Holding cost(H) | 20% | xxxxxxx | xxxxxxx |
| | | | |
| Price Ranges | LOWER | UPPER | PRICE |
| 1 | 1 | 999 | 5 |
| 2 | 1,000 | 1,999 | 4.8 |
| 3 | 2,000 | 999,999 | 4.75 |

**ANNUAL DEMAND = 5,000**

**ORDER COST = $49.00**

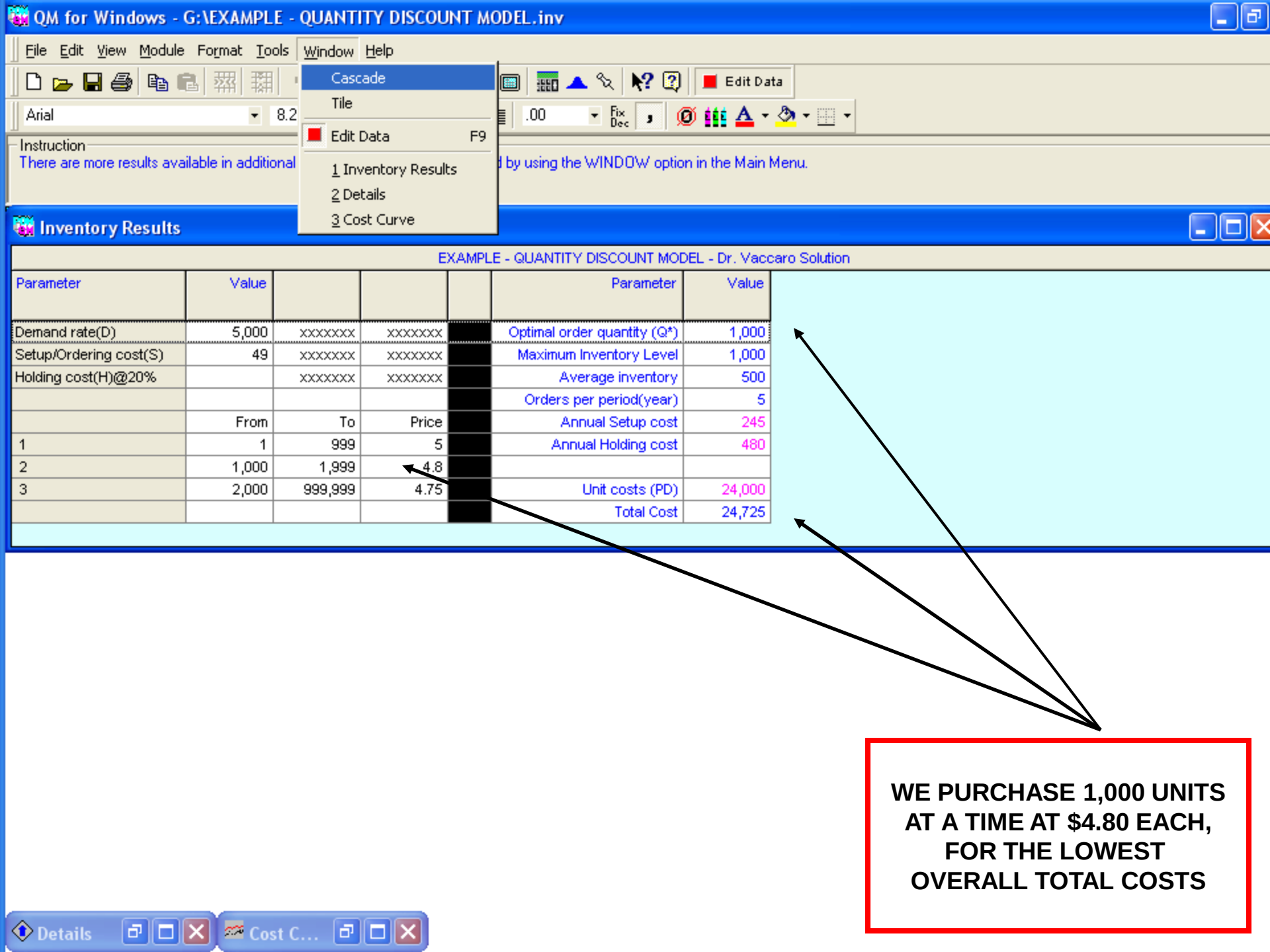
**HOLDING COST = 20%**

**VENDOR PRICE SCHEDULE**

**1 to 999 units - $5.00**

**1,000 to 1,999 units - $4.80**

**2,000 units or more - $4.75**


QM for Windows - G:\EXAMPLE - QUANTITY DISCOUNT MODEL.inv
File Edit View Module Format Tools Window Help
Cascade
Tile
Edit Data F9
1 Inventory Results
2 Details
3 Cost Curve
Edit Data
Instruction
There are more results available in additional
by using the WINDOW option in the Main Menu.
Inventory Results
EXAMPLE - QUANTITY DISCOUNT MODEL - Dr. Vaccaro Solution
Parameter Value Parameter Value
Demand rate(D) 5,000 xxxxxxx xxxxxxx Optimal order quantity (Q*) 1,000
Setup/Ordering cost(S) 49 xxxxxxx xxxxxxx Maximum Inventory Level 1,000
Holding cost(H)@20% xxxxxxx xxxxxxx Average inventory 500
Orders per period(year) 5
From To Price Annual Setup cost 245
1 1 999 5 Annual Holding cost 480
2 1,000 1,999 4.8
3 2,000 999,999 4.75 Unit costs (PD) 24,000
Total Cost 24,725
WE PURCHASE 1,000 UNITS AT A TIME AT $4.80 EACH, FOR THE LOWEST OVERALL TOTAL COSTS
Details
Cost C...

QM for Windows - G:\EXAMPLE - QUANTITY DISCOUNT MODEL.inv

File Edit View Module Format Tools Window Help

Edit Data

Arial 8.25 B I U .00 Fix Dec ,

Instruction

There are more results available in additional windows. These may be opened by using the WINDOW option in the Main Menu.

POM QM

Details

EXAMPLE - QU... DISCOUNT MODEL - Dr. Vaccaro Solution

| Range | Quantity | Total Set... | ...g ...st | Total Unit Cost | Total Cost |
|---|---|---|---|---|---|
| 1 to 999 | 700 | | 350 | 25,000 | 25,700 |
| 1000 to 1999 | 1,000 | | 480 | 24,000 | 24,725 |
| 2000 to 999999 | 2,000 | | 950 | 23,750 | 24,822.5 |

**THE LOWEST TOTAL COSTS $24,725.00 WITH THE 4% DISCOUNT**

Cost C...

QM for Windows - G:\EXAMPLE - QUANTITY DISCOUNT MODEL.inv - [Cost Curve]

File Edit View Module Format Tools Window Help

Edit Data

Instruction

Other output can be viewed by using WINDOW.

**Scale Axes**

x minimum: Automatic

x maximum: Automatic

y minimum: Automatic

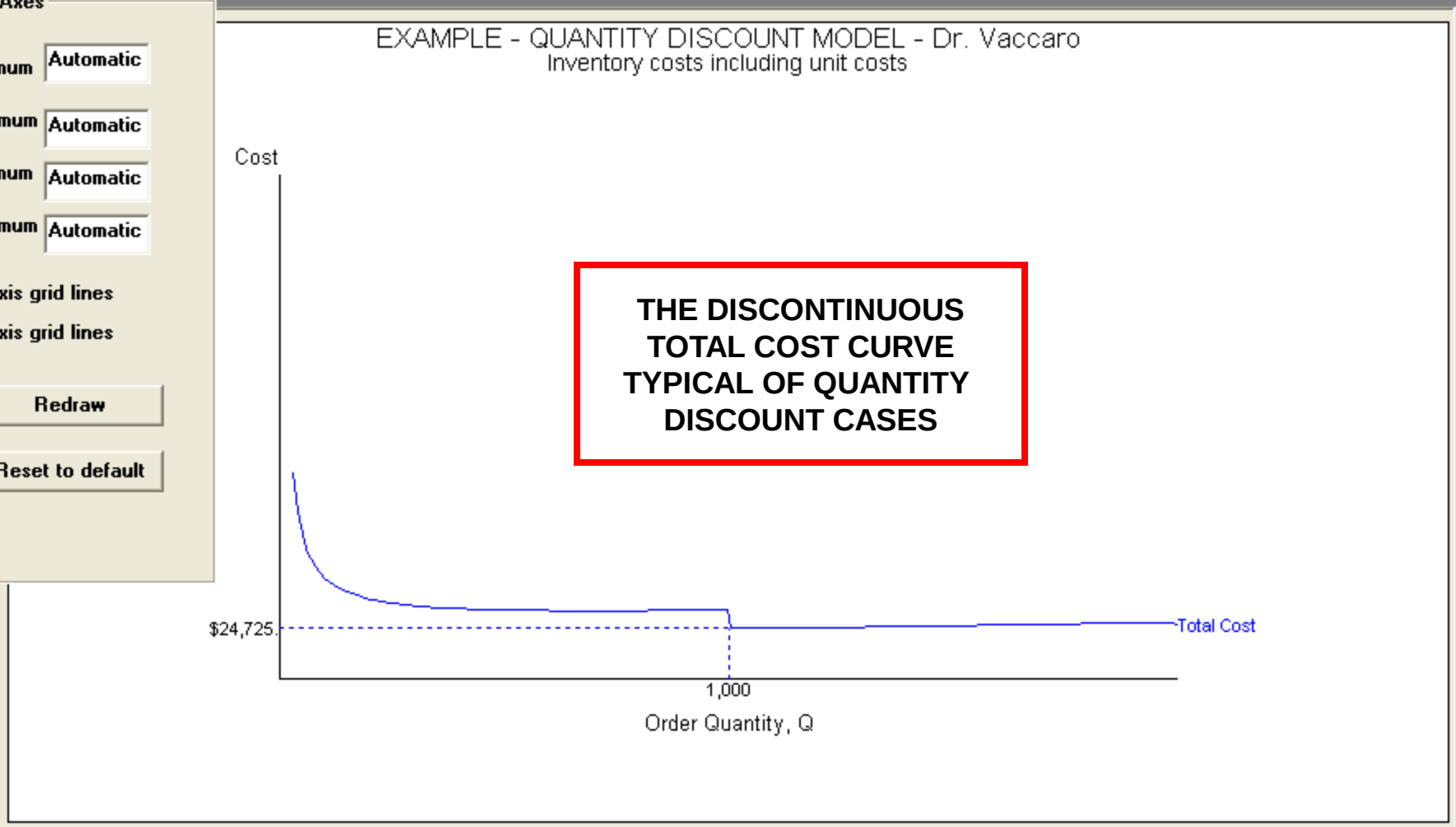
y maximum: Automatic

x axis grid lines

y axis grid lines

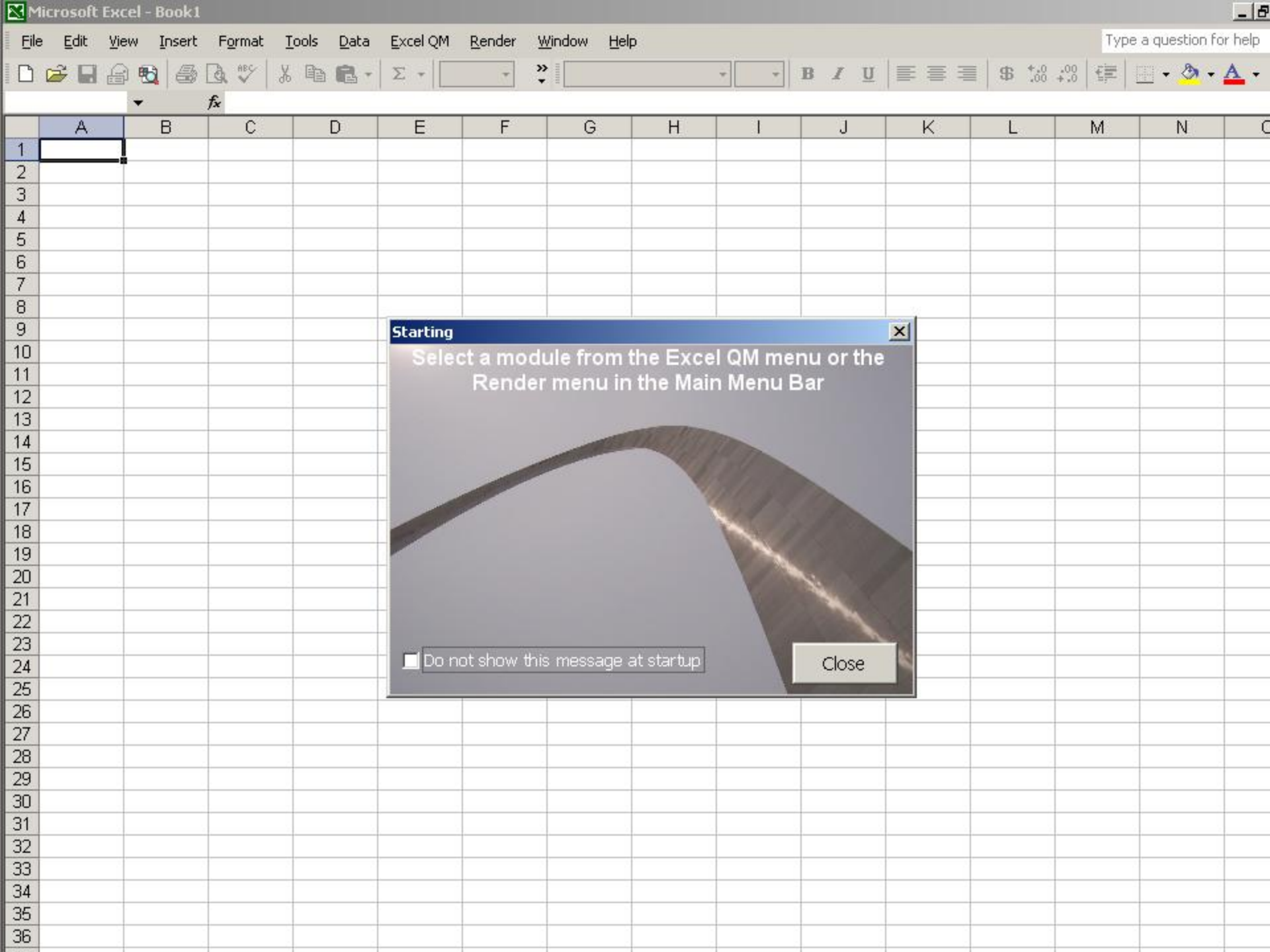
Redraw

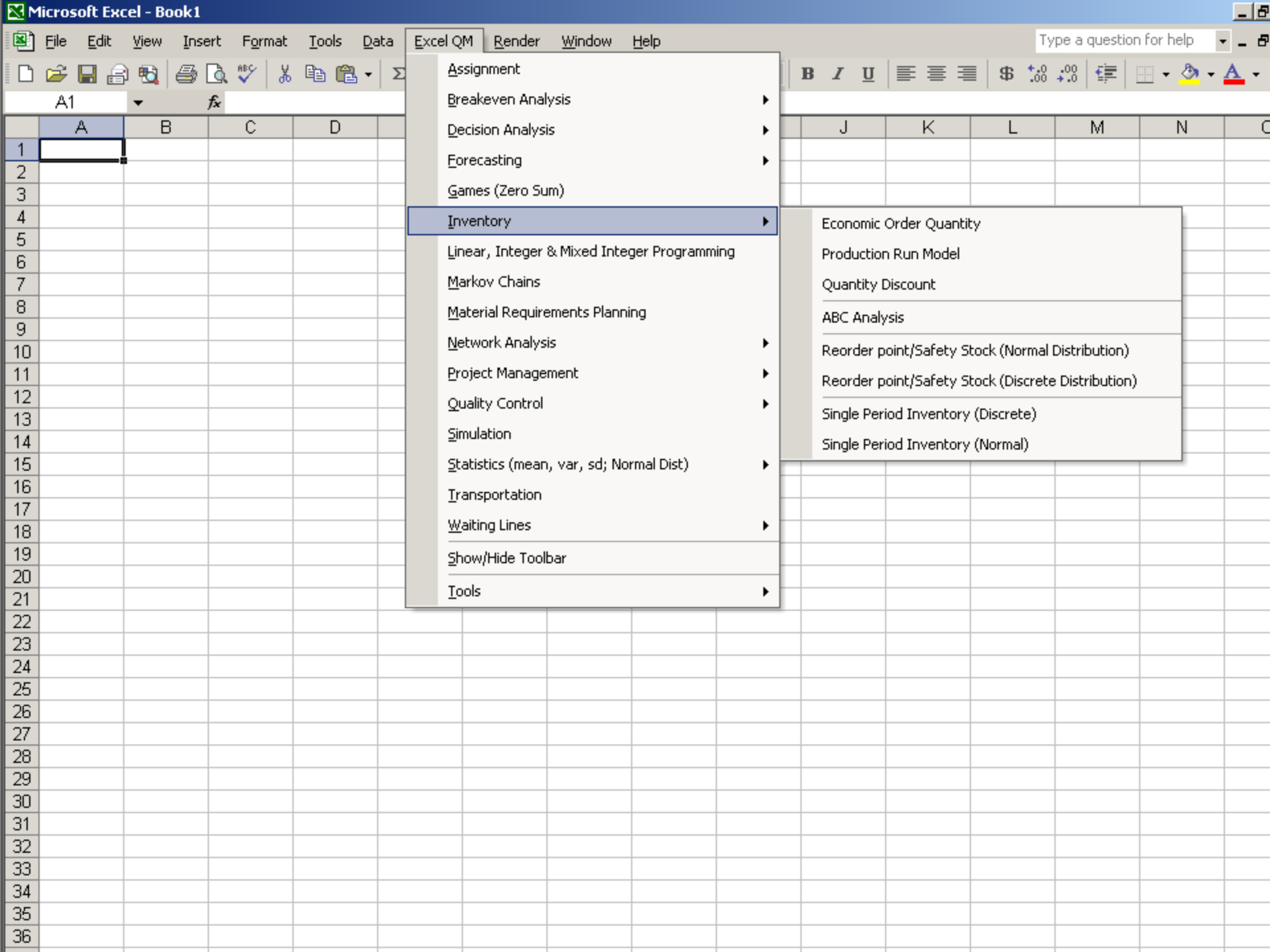
Reset to default

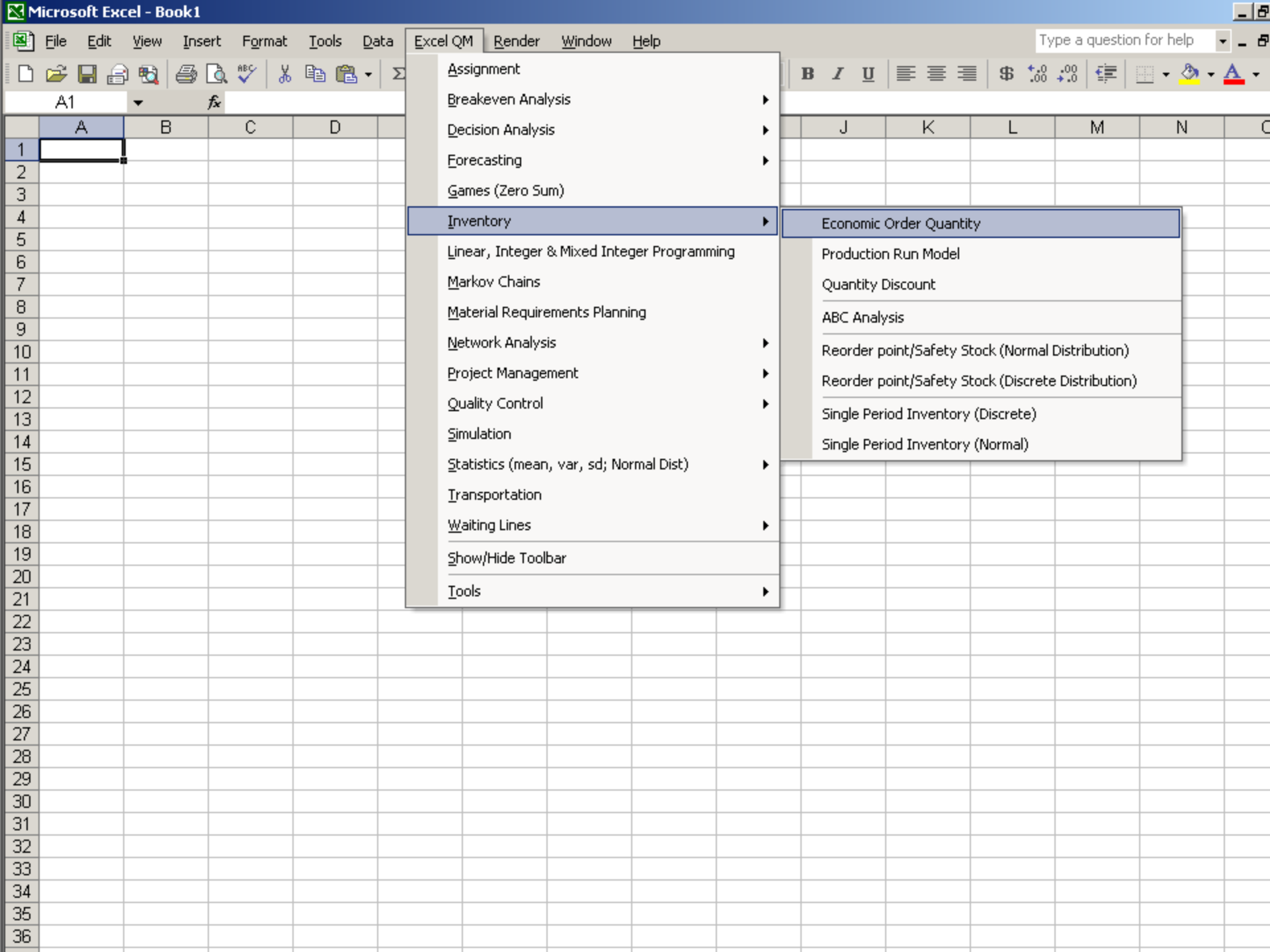


# Inventory Control Using *Excel Solver* Software

**Basic EOQ and TVC Formula**


Microsoft Excel - Book1
File Edit View Insert Format Tools Data Excel QM Render Window Help
Type a question for help
Starting
Select a module from the Excel QM menu or the Render menu in the Main Menu Bar
Do not show this message at startup
Close


Microsoft Excel - Book1
File
Edit
View
Insert
Format
Tools
Data
Excel QM
Render
Window
Help
Type a question for help
A1
Assignment
Breakeven Analysis
Decision Analysis
Forecasting
Games (Zero Sum)
Inventory
Linear, Integer & Mixed Integer Programming
Markov Chains
Material Requirements Planning
Network Analysis
Project Management
Quality Control
Simulation
Statistics (mean, var, sd; Normal Dist)
Transportation
Waiting Lines
Show/Hide Toolbar
Tools
Economic Order Quantity
Production Run Model
Quantity Discount
ABC Analysis
Reorder point/Safety Stock (Normal Distribution)
Reorder point/Safety Stock (Discrete Distribution)
Single Period Inventory (Discrete)
Single Period Inventory (Normal)


Microsoft Excel - Book1
File Edit View Insert Format Tools Data Excel QM Render Window Help
Type a question for help
A1
Assignment
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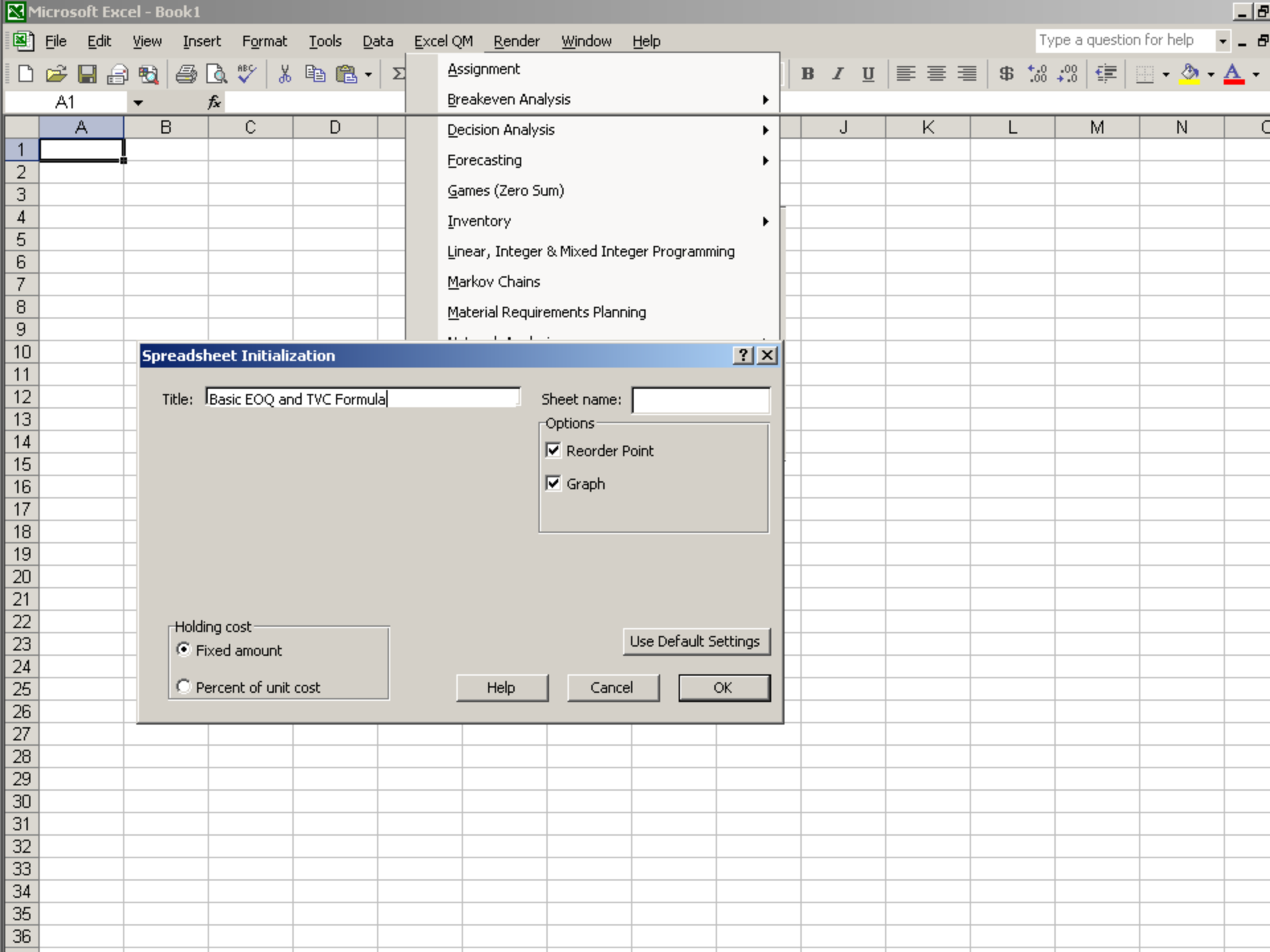
Reorder point/Safety Stock (Normal Distribution)
Reorder point/Safety Stock (Discrete Distribution)
Single Period Inventory (Discrete)
Single Period Inventory (Normal)


Microsoft Excel - Book1
File Edit View Insert Format Tools Data Excel QM Render Window Help
Type a question for help
A1
Assignment
Breakeven Analysis
Decision Analysis
Forecasting
Games (Zero Sum)
Inventory
Linear, Integer & Mixed Integer Programming
Markov Chains
Material Requirements Planning
Spreadsheet Initialization
Title: Basic EOQ and TVC Formula
Sheet name:
Options
Reorder Point
Graph
Holding cost
Fixed amount
Percent of unit cost
Use Default Settings
Help
Cancel
OK

Microsoft Excel - Book1

File Edit View Insert Format Tools Data Excel QM Render Window Help

Dr. Philip A. Vaccaro

# Basic EOQ and TVC Formula

## Inventory — Economic Order Quantity Model

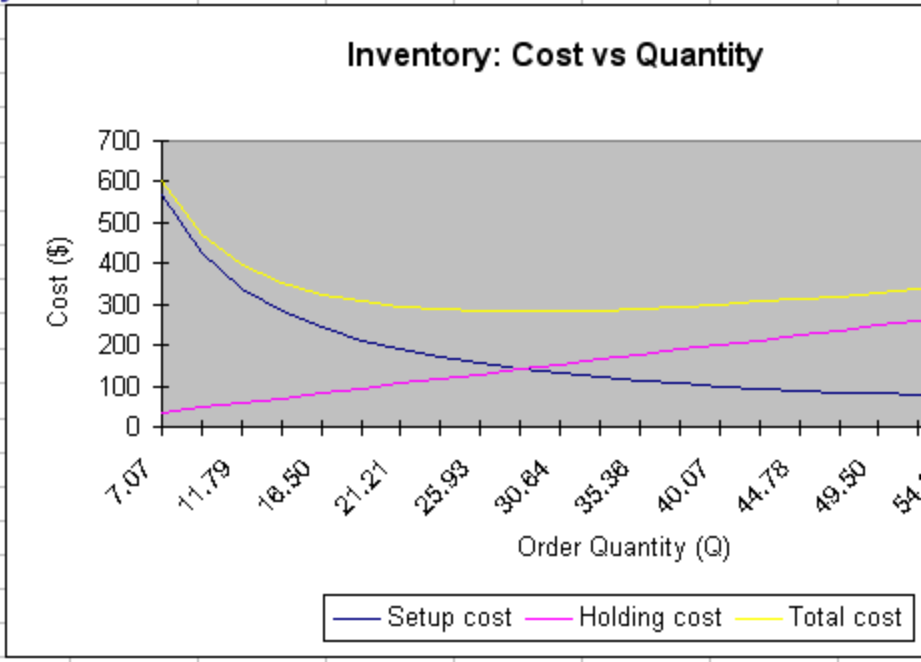
Enter the data in the shaded area

**Data**

| | |
|---|---|
| Demand rate, D | 100 |
| Setup/order cost, S | 40 |
| Holding cost, H | 10 (fixed amount) |
| Unit Price, P | 200 |
| Daily demand rate, d | 20 |
| Lead time in days, L | 3 |

**Results**

| | |
|---|---|
| **Optimal Order Quantity, Q*** | **28.28427125** |
| **Maximum Inventory** | **28.28427125** |
| **Average Inventory** | **14.14213562** |
| **Number of Orders** | **3.535533906** |
| **Holding cost** | **$141.42** |
| **Setup cost** | **$141.42** |
| **Unit costs** | **$20,000.00** |
| **Total cost, $T_c$** | **$20,282.84** |
| **Reorder Point** | **60** |




COST TABLE — Start at 7.071068 — Increment 2.357023

| Q | Setup cost | Holding co | Total cost |
|---|---|---|---|
| 7.071067812 | 565.6854 | 35.35534 | 601.0408 |
| 9.428090416 | 424.2641 | 47.14045 | 471.4045 |
| 11.78511302 | 339.4113 | 58.92557 | 398.3368 |

**Template and Sample Data**

Microsoft Excel - Book1

File Edit View Insert Format Tools Data Excel QM Render Window Help

Dr. Philip A. Vaccaro

# Basic EOQ and TVC Formula

## Inventory — Economic Order Quantity Model

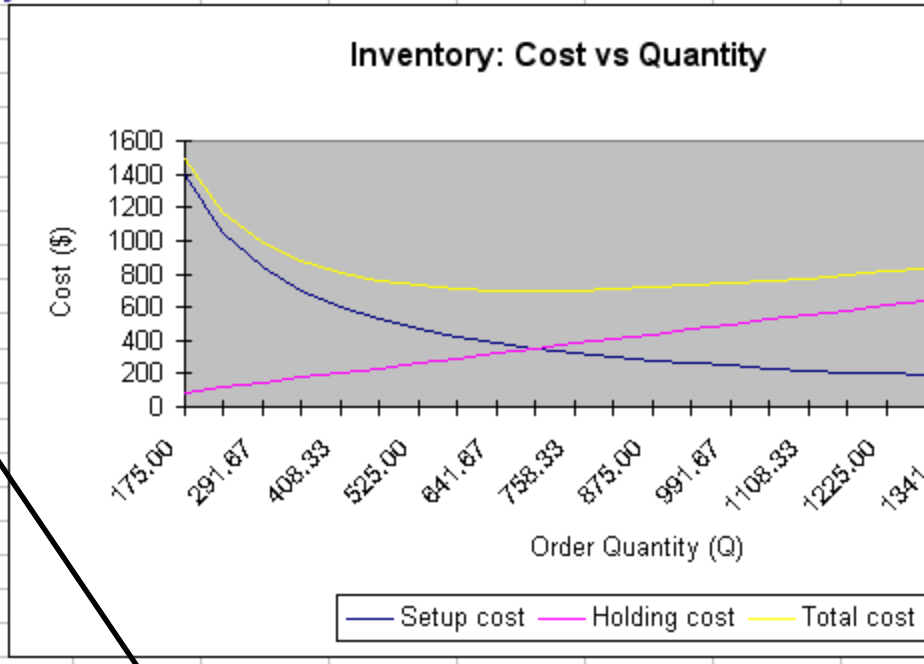
Enter the data in the shaded area

**Data**

| | |
|---|---|
| Demand rate, D | 5000 |
| Setup/order cost, S | 49 |
| Holding cost, H | 1 (fixed amount) |
| Unit Price, P | |
| Daily demand rate, d | |
| Lead time in days, L | 0 |

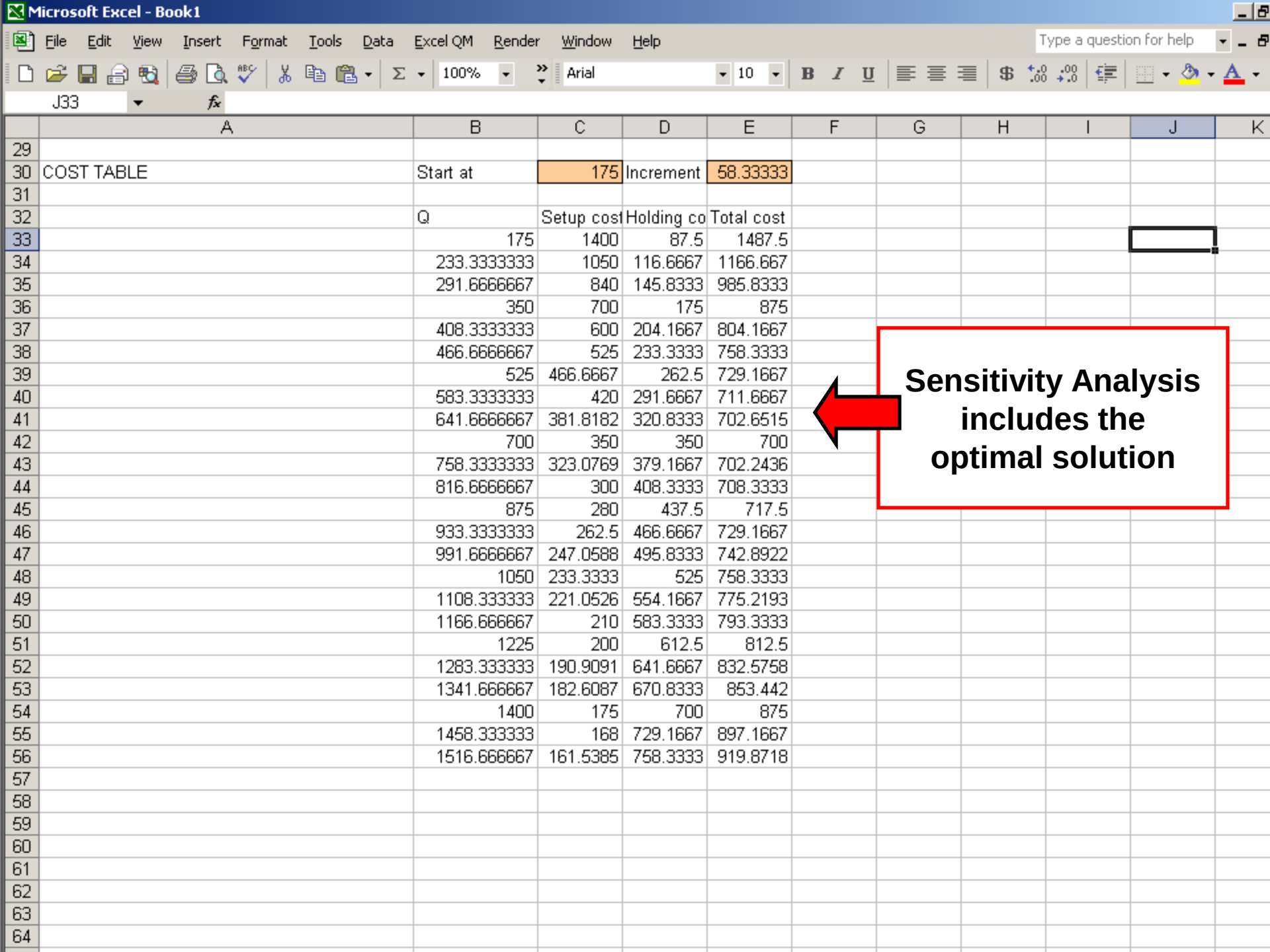
**Results**

| | |
|---|---|
| **Optimal Order Quantity, Q*** | **700** |
| **Maximum Inventory** | **700** |
| **Average Inventory** | **350** |
| **Number of Orders** | **7.142857143** |
| **Holding cost** | **$350.00** |
| **Setup cost** | **$350.00** |
| **Unit costs** | **$0.00** |
| **Total cost, $T_c$** | **$700.00** |
| **Reorder Point** | **0** |




| COST TABLE | Start at | 175 | Increment | 58.33333 |
|---|---|---|---|---|
| | Q | Setup cost | Holding co | Total cost |
| | 175 | 1400 | 87.5 | 1487.5 |
| | 233.3333333 | 1050 | 116.6667 | 1166.667 |
| | 291.6666667 | 840 | 145.8333 | 985.8333 |

**Unit price, daily demand, and lead time do not need to be specified**

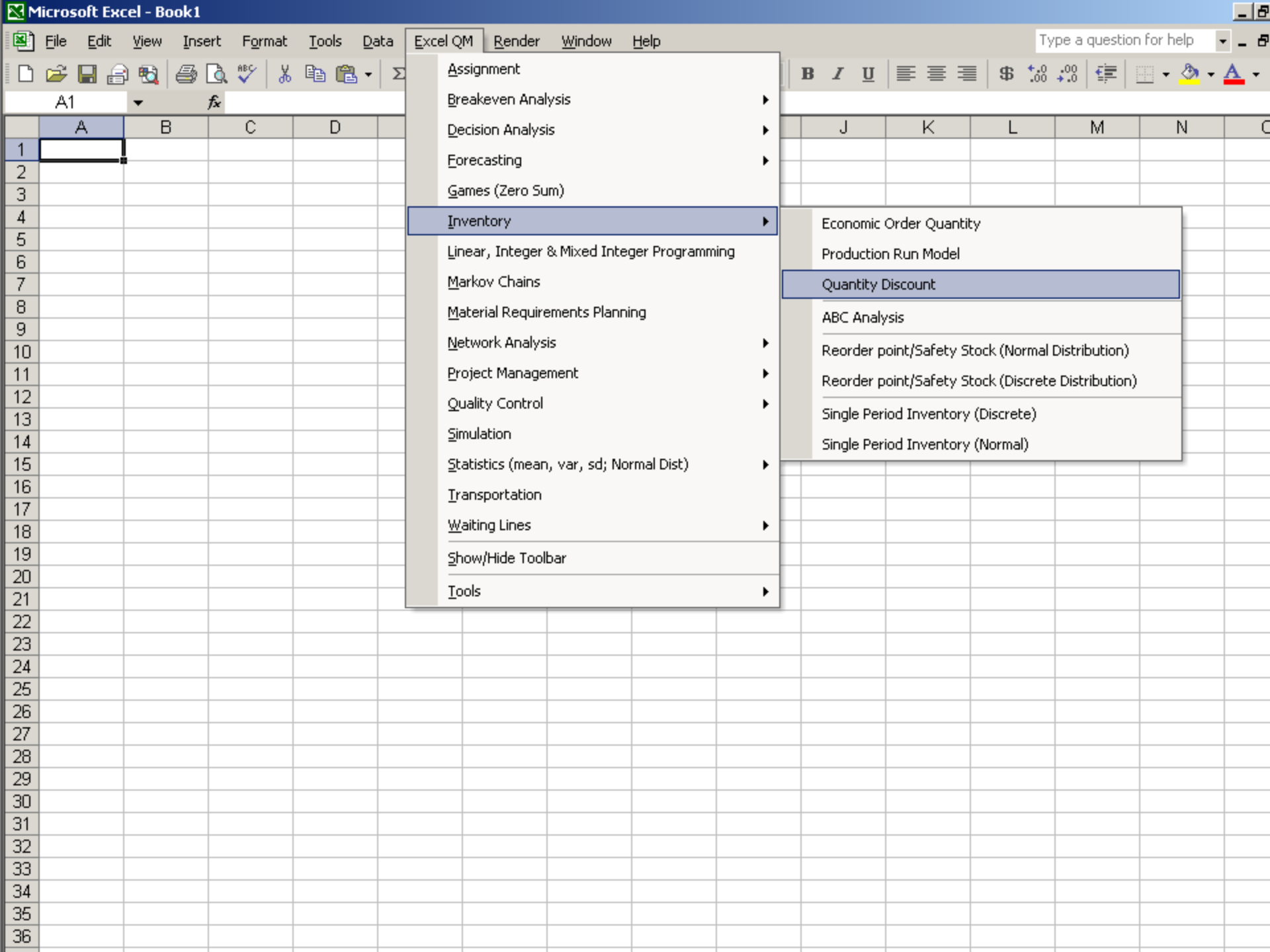



| | A | B | C | D | E |
|---|---|---|---|---|---|
| 29 | | | | | |
| 30 | COST TABLE | Start at | 175 | Increment | 58.33333 |
| 31 | | | | | |
| 32 | | Q | Setup cost | Holding co | Total cost |
| 33 | | 175 | 1400 | 87.5 | 1487.5 |
| 34 | | 233.3333333 | 1050 | 116.6667 | 1166.667 |
| 35 | | 291.6666667 | 840 | 145.8333 | 985.8333 |
| 36 | | 350 | 700 | 175 | 875 |
| 37 | | 408.3333333 | 600 | 204.1667 | 804.1667 |
| 38 | | 466.6666667 | 525 | 233.3333 | 758.3333 |
| 39 | | 525 | 466.6667 | 262.5 | 729.1667 |
| 40 | | 583.3333333 | 420 | 291.6667 | 711.6667 |
| 41 | | 641.6666667 | 381.8182 | 320.8333 | 702.6515 |
| 42 | | 700 | 350 | 350 | 700 |
| 43 | | 758.3333333 | 323.0769 | 379.1667 | 702.2436 |
| 44 | | 816.6666667 | 300 | 408.3333 | 708.3333 |
| 45 | | 875 | 280 | 437.5 | 717.5 |
| 46 | | 933.3333333 | 262.5 | 466.6667 | 729.1667 |
| 47 | | 991.6666667 | 247.0588 | 495.8333 | 742.8922 |
| 48 | | 1050 | 233.3333 | 525 | 758.3333 |
| 49 | | 1108.333333 | 221.0526 | 554.1667 | 775.2193 |
| 50 | | 1166.666667 | 210 | 583.3333 | 793.3333 |
| 51 | | 1225 | 200 | 612.5 | 812.5 |
| 52 | | 1283.333333 | 190.9091 | 641.6667 | 832.5758 |
| 53 | | 1341.666667 | 182.6087 | 670.8333 | 853.442 |
| 54 | | 1400 | 175 | 700 | 875 |
| 55 | | 1458.333333 | 168 | 729.1667 | 897.1667 |
| 56 | | 1516.666667 | 161.5385 | 758.3333 | 919.8718 |
| 57 | | | | | |
| 58 | | | | | |
| 59 | | | | | |
| 60 | | | | | |
| 61 | | | | | |
| 62 | | | | | |
| 63 | | | | | |
| 64 | | | | | |

**Sensitivity Analysis includes the optimal solution**

# Inventory Control Using *Excel Solver* Software

**Quantity Discount Formula**


Microsoft Excel - Book1
File Edit View Insert Format Tools Data Excel QM Render Window Help
Type a question for help
A1
Assignment
Breakeven Analysis
Decision Analysis
Forecasting
Games (Zero Sum)
Inventory
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Reorder point/Safety Stock (Discrete Distribution)
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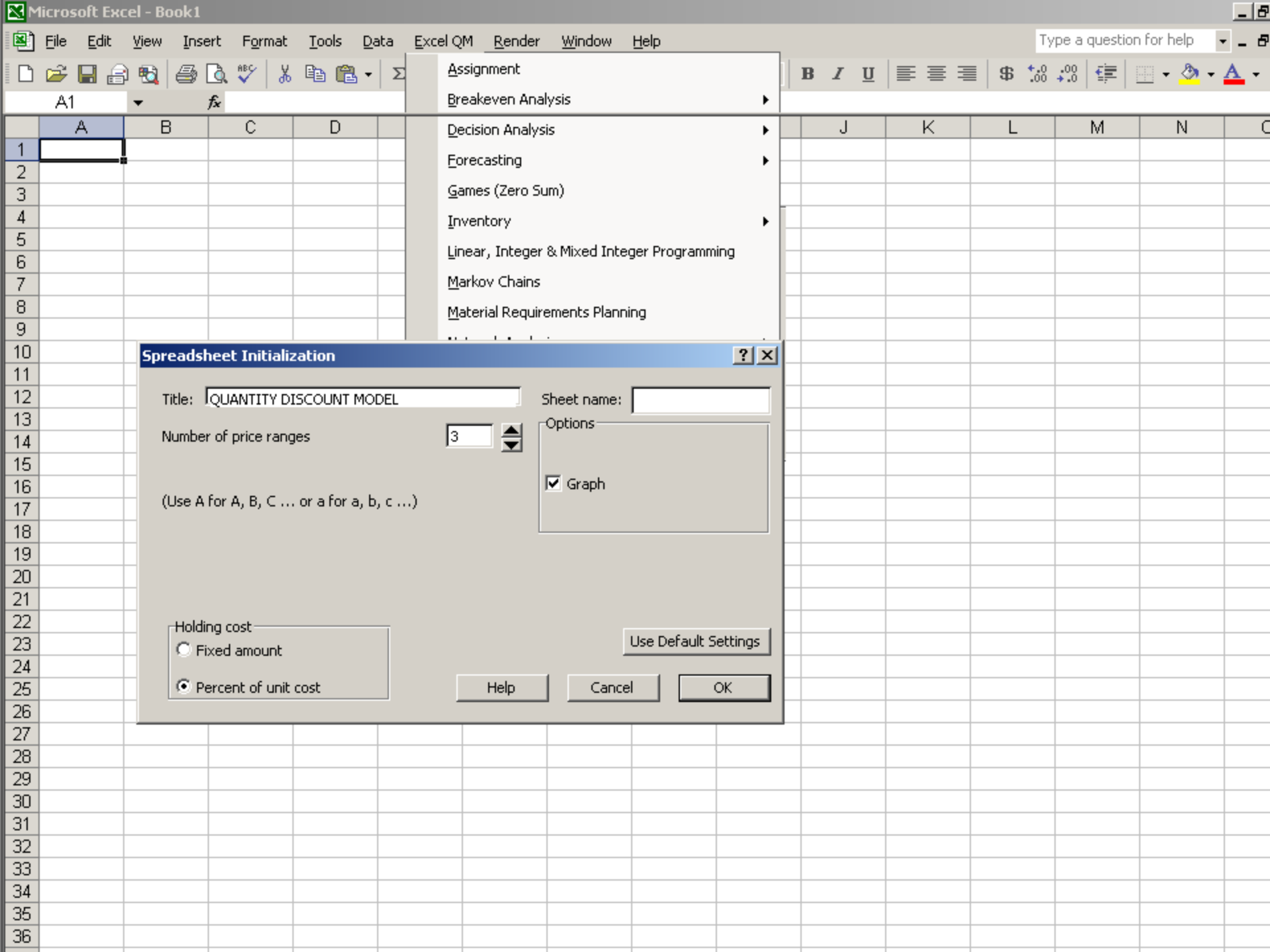
Single Period Inventory (Normal)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Games (Zero Sum)
Inventory
Linear, Integer & Mixed Integer Programming
Markov Chains
Material Requirements Planning
Spreadsheet Initialization
Title: QUANTITY DISCOUNT MODEL
Sheet name:
Number of price ranges 3
Options
Graph
(Use A for A, B, C ... or a for a, b, c ...)
Holding cost
Fixed amount
Percent of unit cost
Use Default Settings
Help
Cancel
OK

Microsoft Excel - Book1

File Edit View Insert Format Tools Data Excel QM Render Window Help

Type a question for help

A1 Dr. Philip A. Vaccaro

Dr. Philip A. Vaccaro

# QUANTITY DISCOUNT MODEL

**Template and Sample Data**

## Inventory Quantity Discount Model

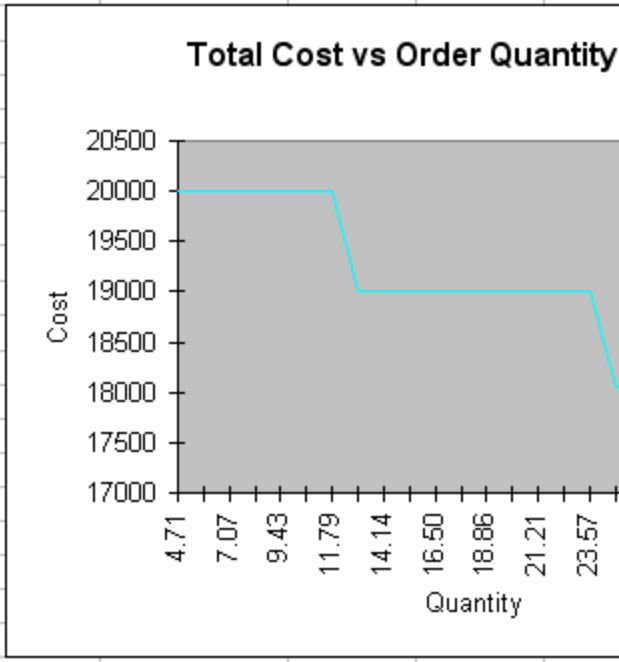
Enter the data in the shaded area. The minimum quantity is the minimum amount that needs to be ordered in order to get the price that is in the same column.

**Data**

| | | | |
|---|---|---|---|
| Demand rate, D | 100 | | |
| Setup cost, S | 40 | | |
| Holding cost %, I | 20.00% | (percentage) | |
| | Range 1 | Range 2 | Range 3 |
| Minimum quantity | 0 | 12 | 24 |
| Unit Price, P | 200 | 190 | 180.5 |

**Results**

| | Range 1 | Range 2 | Range 3 |
|---|---|---|---|
| **Q* (Square root formula)** | **14.14213562** | **14.509525** | **14.88645855** |
| **Order Quantity** | **NA** | **14.509525** | **24** |
| **Holding cost** | **NA** | **$275.68** | **$433.20** |
| **Setup cost** | **NA** | **$275.68** | **$166.67** |
| **Unit costs** | **NA** | **$19,000.00** | **$18,050.00** |
| **Total cost, $T_c$** | **NA** | **$19,551.36** | **$18,649.87** |




Base inc on 14.14213562

| Cost table | Q | Unit cost | Setup cost | Holding cost | Total unit costs | Total Costs |
|---|---|---|---|---|---|---|
| 1 | 4.714045208 | 200 | 848.5281374 | 94.28090416 | 20000 | 20942.81 |
| 2 | 5.89255651 | 200 | 678.8225099 | 117.8511302 | 20000 | 20796.67 |
| 3 | 7.071067812 | 200 | 565.6854249 | 141.4213562 | 20000 | 20707.11 |
| 4 | 8.249579114 | 200 | 484.8732214 | 164.9915823 | 20000 | 20649.86 |

Microsoft Excel - Book1

File Edit View Insert Format Tools Data Excel QM Render Window Help

Dr. Philip A. Vaccaro

# QUANTITY DISCOUNT MODEL

## Inventory — Quantity Discount Model

Enter the data in the shaded area. The minimum quantity is the minimum amount that needs to be ordered in order to get the price that is in the same column.

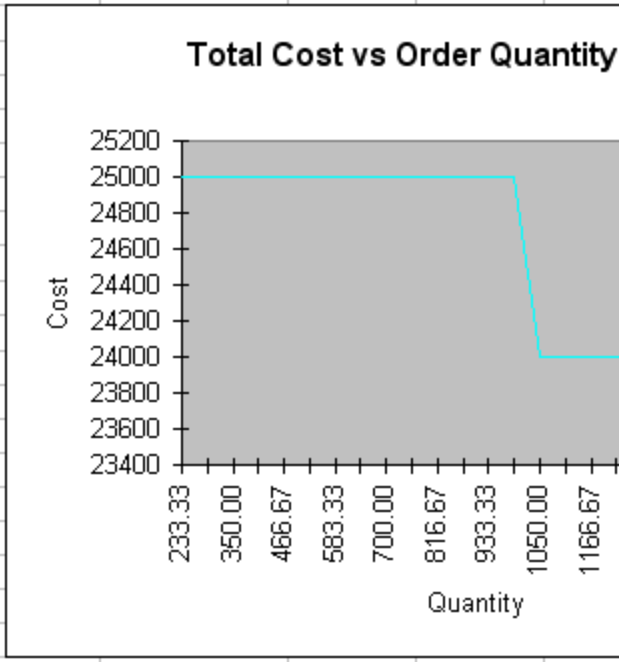
**Data**

| | | | |
|---|---|---|---|
| Demand rate, D | 5000 | | |
| Setup cost, S | 49 | | |
| Holding cost %, I | 20.00% | (percentage) | |
| | Range 1 | Range 2 | Range 3 |
| Minimum quantity | 1 | 1000 | 2000 |
| Unit Price, P | 5 | 4.8 | 4.75 |

**Results**

| | Range 1 | Range 2 | Ran |
|---|---|---|---|
| Q* (Square root formula) | 700 | 714.4345083 | 848465 |
| Order Quantity | 700 | 1000 | 2000 |
| Holding cost | $350.00 | $480.00 | $950.00 |
| Setup cost | $350.00 | $245.00 | $122.50 |
| Unit costs | $25,000.00 | $24,000.00 | 50.00 |
| Total cost, $T_c$ | $25,700.00 | $24,725.00 | $24,822.50 |

**Optimal Solution Q=1,000**




Base inc on 700

| Cost table | Q | Unit cost | Setup cost | Holding cost | Total unit costs | Total Costs |
|---|---|---|---|---|---|---|
| 1 | 233.3333333 | 5 | 1050 | 116.6666667 | 25000 | 26166.67 |
| 2 | 291.6666667 | 5 | 840 | 145.8333333 | 25000 | 25985.83 |
| 3 | 350 | 5 | 700 | 175 | 25000 | 25875 |
| 4 | 408.3333333 | 5 | 600 | 204.1666667 | 25000 | 25804.17 |

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| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 28 | **Total cost, $T_c$** | **$25,700.00** | **$24,725.00** | **$24,822.50** | | | | | |
| 29 | | | | | | | | | |
| 30 | Base inc on | 700 | | | | | | | |
| 31 | Cost table | Q | Unit cost | Setup cost | Holding cost | Total unit costs | Total Costs | | |
| 32 | 1 | 233.3333333 | 5 | 1050 | 116.6666667 | 25000 | 26166.67 | | |
| 33 | 2 | 291.6666667 | 5 | 840 | 145.8333333 | 25000 | 25985.83 | | |
| 34 | 3 | 350 | 5 | 700 | 175 | 25000 | 25875 | | |
| 35 | 4 | 408.3333333 | 5 | 600 | 204.1666667 | 25000 | 25804.17 | | |
| 36 | 5 | 466.6666667 | 5 | 525 | 233.3333333 | 25000 | 25758.33 | | |
| 37 | 6 | 525 | 5 | 466.6666667 | 262.5 | 25000 | 25729.17 | | |
| 38 | 7 | 583.3333333 | 5 | 420 | 291.6666667 | 25000 | 25711.67 | | |
| 39 | 8 | 641.6666667 | 5 | 381.8181818 | 320.8333333 | 25000 | 25702.65 | | |
| 40 | 9 | 700 | 5 | 350 | 350 | 25000 | 25700 | | |
| 41 | 10 | 758.3333333 | 5 | 323.0769231 | 379.1666667 | 25000 | 25702.24 | | |
| 42 | 11 | 816.6666667 | 5 | 300 | 408.3333333 | 25000 | 25708.33 | | |
| 43 | 12 | 875 | 5 | 280 | 437.5 | 25000 | 25717.5 | | |
| 44 | 13 | 933.3333333 | 5 | 262.5 | 466.6666667 | 25000 | 25729.17 | | |
| 45 | 14 | 991.6666667 | 5 | 247.0588235 | 495.8333333 | 25000 | 25742.89 | | |
| 46 | 15 | 1050 | 4.8 | 233.3333333 | 504 | 24000 | 24737.33 | | |
| 47 | 16 | 1108.333333 | 4.8 | 221.0526316 | 532 | 24000 | 24753.05 | | |
| 48 | 17 | 1166.666667 | 4.8 | 210 | 560 | 24000 | 24770 | | |
| 49 | 18 | 1225 | 4.8 | 200 | 588 | 24000 | 24788 | | |
| 50 | 19 | 1283.333333 | 4.8 | 190.9090909 | 616 | 24000 | 24806.91 | | |
| 51 | 20 | 1341.666667 | 4.8 | 182.6086957 | 644 | 24000 | 24826.61 | | |
| 52 | 21 | 1400 | 4.8 | 175 | 672 | 24000 | 24847 | | |
| 53 | 22 | 1458.333333 | 4.8 | 168 | 700 | 24000 | 24868 | | |
| 54 | 23 | 1516.666667 | 4.8 | 161.5384615 | 728 | 24000 | 24889.54 | | |
| 55 | 24 | 1575 | 4.8 | 155.5555556 | 756 | 24000 | 24911.56 | | |
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**Sensitivity Analysis**


# End of 1st Session

## Inventory Control Theory