Production Planning & Control BMM4823

Inventory management

by

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Chapter Description

- Aims
  - To understand the importance of inventory management
  - To understand influence factors in inventory management

- Expected Outcomes
  - Able to determine the level of control of parts storage
  - Able to determine the Economic Order Quantity
  - Able to make a decision on product discount

- References

Heizer, J and Render,B. 2011. Principles of Operations Management, 8th Edition, Pearson Prentice Hall, Inc.

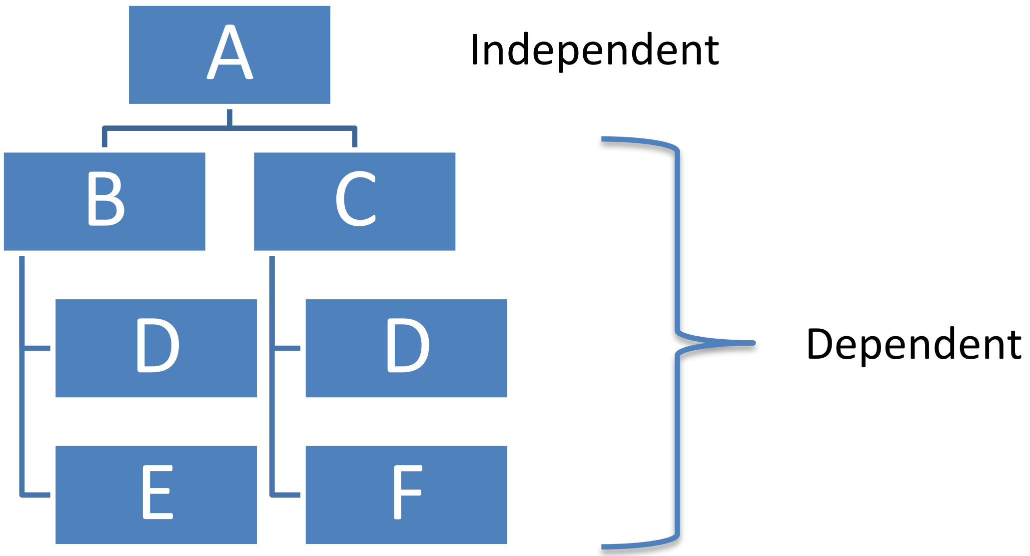
Chapman, S.N. 2006. The Fundamentals of Production Planning and Control.

Introduction

- Most of the companies are not aware the waste in their inventory
- Considered one of the challenges issue facing by the managers
- It was assumed that 50% of company funding invested on inventory
- It was discovered that holding inventory is one of major expenses
- It is good to minimise inventory as the lowest possible quantity

Introduction

- Independent – Finished product
- Dependent – parts or subassemblies



Function of inventories

1. To support production when the demand is up and down
2. To separately identify the requirement of parts
3. To segregate the value of each part
4. To take advantage of offered discount
5. To maintain the production efficiency
6. To minimise cost due to geographical location e.g. overseas

Types of inventory

- **Raw material**. New parts which not assemble yet
- **Work-in-process**. Incomplete process due to time, delay, machine breakdown and etc.
- **Maintenance/Repair/Operating (MRO)**. Uses as a spare part for machinery.
- **Finished goods**. Completed process, waiting for shipping

Disadvantage of inventory

- Cost increased due to storage, security, overhead, insurance
- May become obsolete due to model change
- May be damaged or deteriorated due to handling, whether and etc.
- May be lost, stolen
- Need special place such as hazardous material

ABC Analysis

- What is ABC analysis.?

Is a method of classifying inventories intro three categories;

Class A – high value with estimated of 20%

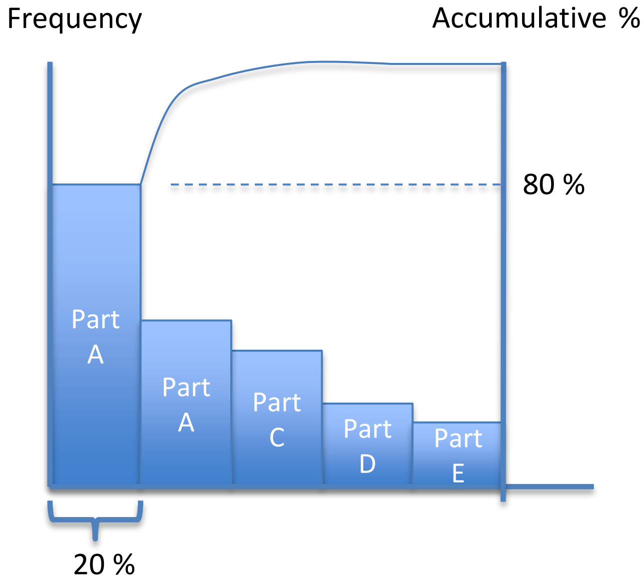
Class B - medium value with estimated of 30%

Class C - least value with estimated of 50%

Should focus on Class A rather than Class B and C.

ABC Analysis

- The concept is similar as Pareto analysis.
- 20% of inventories consumed 80% value of money spent in the inventory.



The value of A is considered 80% of total value spent in the inventory.

ABC Analysis

Steps in ABC classification:

1. Identify the unit cost and expected volume to be used;
2. Find the value of each part by multiplying the unit cost with the expected volume to be used;
3. List out all of parts in the descending value (Annual Value);

ABC Analysis

4. Compute the percentage on total inventory
5. Then, calculate the accumulative of percentage on total inventory
6. Plot a chart based on percentage items and percentage value. Then categorise into class A, B and C.

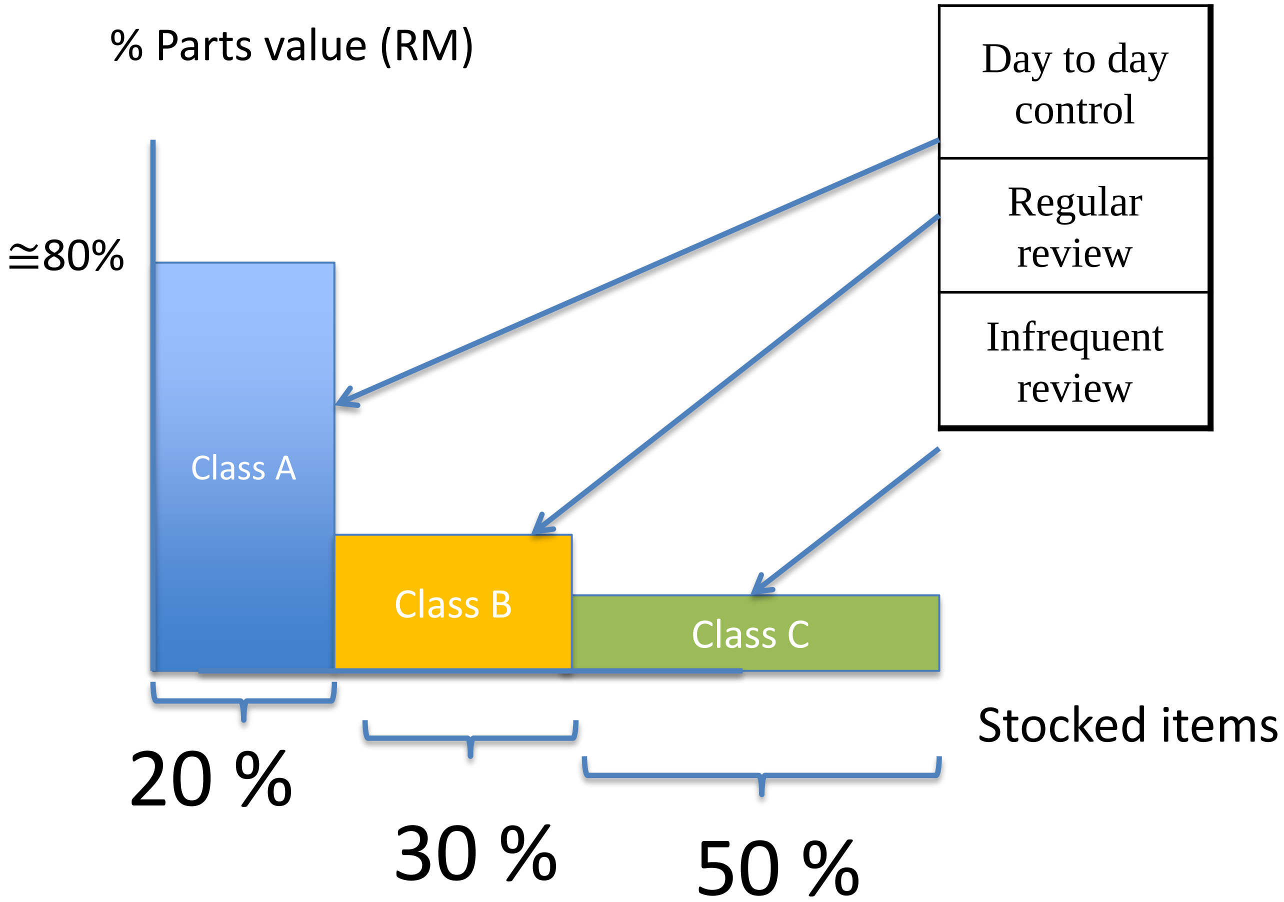
ABC Analysis

Part Number	% Parts of Stocked	Annual Volume (units)	x	Unit Cost	=	Annual RM Volume	% of Annual RM Volume		Class
#10000	20%	1,000		RM 100.00		RM 100,000	41.6%	72.8 %	*A*
#11100		500		150.00		75,000	31.2%	≅ 80%	*A*
#12000		1,550		17.00		26,350	11.0%		*B*
#10800	30%	350		43.00		15,050	6.3%	22.5 %	*B*
#10500		1,000		12.50		12,500	5.2%		*B*

ABC Analysis

Part Number	% of Parts Stocked	Annual Volume (units)	x	Unit Cost	=	Annual RM Volume	% of Annual RM Volume		Class
#12100		600		RM 14.00		RM 8,400	3.5%		*C*
#14000		2,000		.60		1,200	.5%		*C*
#01030	50%	100		8.50		850	.4%	*4.7 %*	*C*
#01300		1,200		.50		600	.2%		*C*
#10500		250		.60		150	.1%		*C*

ABC Analysis



ABC Analysis

- Also may be used in ABC analysis are
  - Anticipated model/engineering changes
  - Problems such as delivery, quality, complaints

ABC Policies

- Should closely monitoring Class A compared to others
- Should provide supplier development for Class A
- Should provide a good monitoring system for Class A
- Should provide visible areas for Class A
- Should order frequently rather than in bulk

Record Accuracy

- Effectively and efficiently running production
- Effective for ordering, scheduling, shipping
- Incoming and outgoing should be matched
- Easily to access with minimum time
- Right quantity and place as documented

Inventory Cycle Counting

- To ensure the physical quantity is match as in the system.
- To track down any causes of inaccurate record
- Improvise the system to be more accurate and efficient
- Provide accurate record to the accounts department.

Inventory cycle counting

- Counted based on periodic basis e.g. every month, 3 months, quarter and etc.
- Through ABC system;

Class	Frequency	Accuracy level
A	Every month or more frequent	1%
B	Every 3 months, quarter	5%
C	Once a year or 6 months	10

Source : Heizer 2011, Chapman 2006.

Cycle Counting

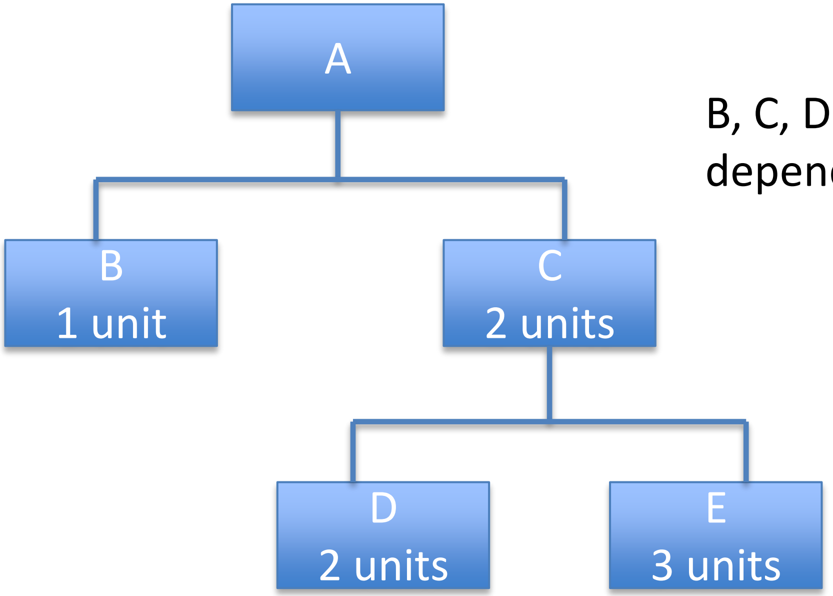
Advantages

- ☑ No interruption in the production line
- ☑ No shortages
- ☑ Develop staff for auditing inventory accuracy
- ☑ Able to identify causes and rectify the root cause

Dependent demand

Dependent demand – its depend on the demand for the other part.

Let say the customer order 10 units of product A.



B, C, D and E are considered dependent demand

Independent demand

Therefore, the company should order each of part

B – I0 units	= 1unit x As	= 1 x 10 = 10
C – 20 units	= 2units x As	= 2 x 10 = 20
D – 40 units	= 2units x Cs	= 2 x 20 = 40
E – 60 units	= 3unit x Cs	= 3x 20 = 60

Inventory for dependent demand

- Holding costs - the costs incurred of keeping the inventory
- Ordering costs – cost of ordering and receiving goods from supplier
- Setup costs – cost to set up a machine

Cost involved

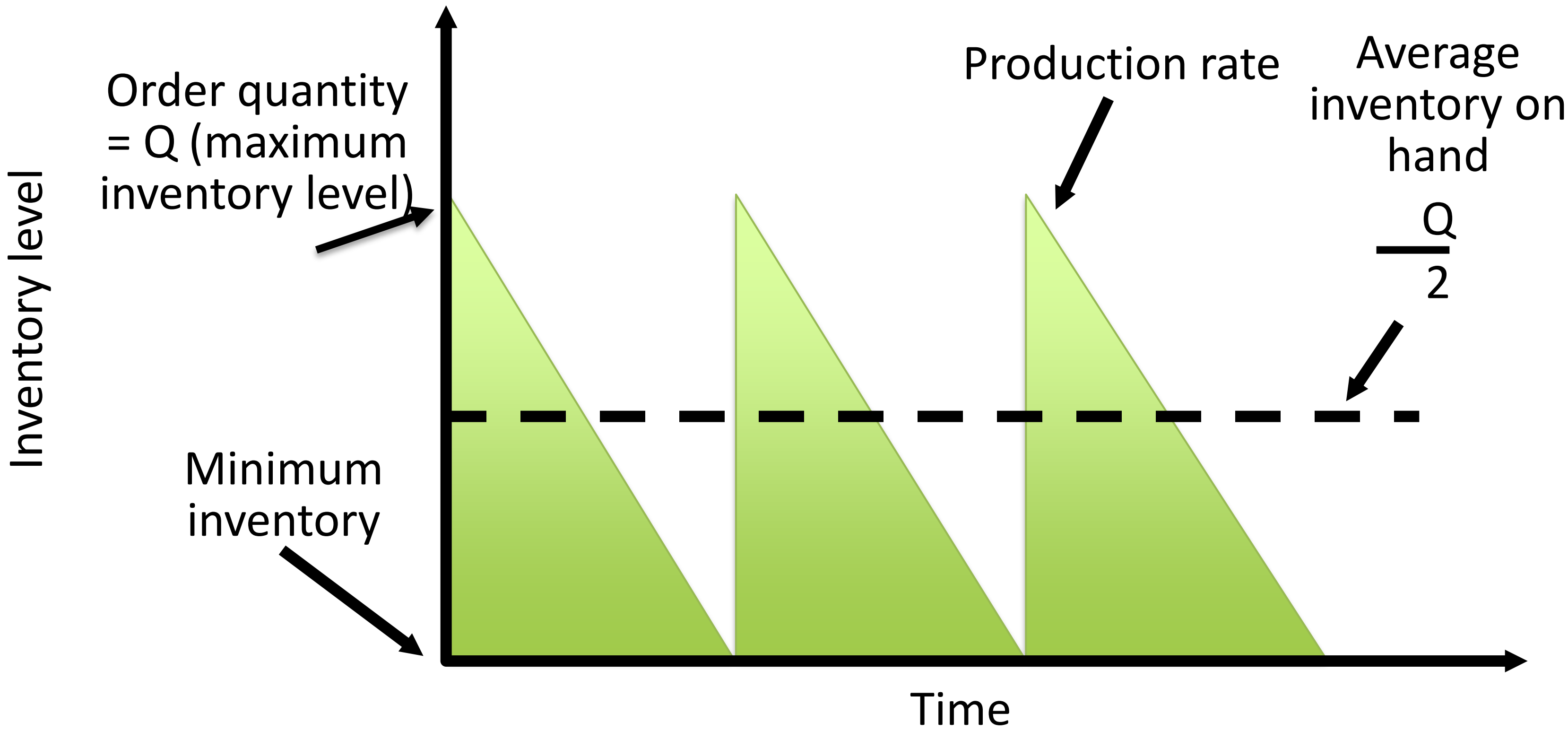
Category	*Cost (and Range) as a Percent of Inventory Value*
Housing costs (including rent or depreciation, operating costs, taxes, insurance)	6% (3 - 10%)
Material handling costs (equipment lease or depreciation, power, operating cost)	3% (1 - 3.5%)
Labor cost	3% (3 - 5%)
Investment costs (borrowing costs, taxes, and insurance on inventory)	11% (6 - 24%)
Pilferage, space, and obsolescence	3% (2 - 5%)
Overall carrying cost	26%

Source : Heizer & Render 2011

Economic Order Quantity (EOQ)

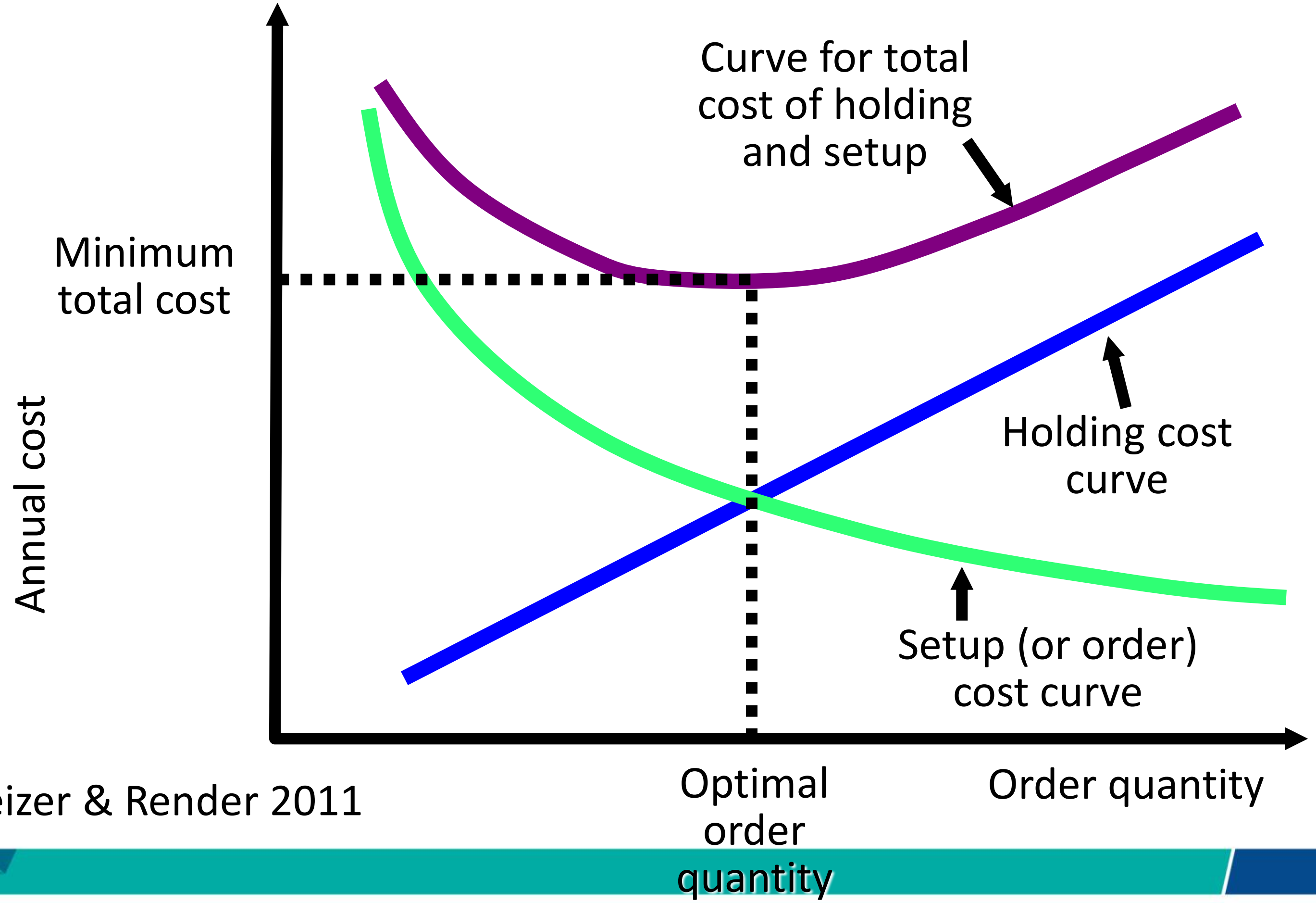
Important assumptions –independent demand

1. Annual demand should be known and constant.
2. Lead time should be known and constant
3. Instantaneous receipt of ordering quantity
4. Quantity discounts are not considered
5. Two variable costs i.e. setup and holding
6. No stock out in the model


Order quantity = Q (maximum inventory level)
Production rate
Average inventory on hand
$\frac{Q}{2}$
Inventory level
Minimum inventory
Time

EOQ graphical chart

Objective is to minimize total costs



Heizer & Render 2011

EOQ

$$\frac{D}{Q}S = \frac{Q}{2}H$$

Annual setup cost = (No. of orders placed per year) x (Setup or order cost per order) $= \frac{D}{Q}S$

Annual holding cost = (Average inventory level) x (Holding cost per unit per year) $= \frac{Q}{2}H$

EOQ

$$EOQ = \sqrt{\frac{2DS}{H}}$$

Economy order quantity is found when annual setup cost equals annual holding cost as in the EOQ graphical chart

$$\frac{D}{Q} S = \frac{Q}{2} H$$

Solving for Q*

$$2DS = Q^2H$$

$$Q^2 = 2DS/H$$

$$\text{Therefore; } Q^*(EOQ) = \sqrt{\frac{2DS}{H}}$$

EOQ

- Q = Quantity per order
- Q* = Optimal quantity per order (EOQ)
- D = Annual demand in units
- S = Setup or ordering cost for each order
- H = Annual holding or carrying cost per unit

Example

Always One a company that markets a special electronic part to Kimo company. They would like to reduce its cost by determining the optimal number of a controller to obtain per order. The details cost involved are as follow

Holding cost = RM0.50 per unit per year

Set up Cost = RM10 per order

Annual demand = 1000 units

Determine:

(a) Optimum number of controller to order

(b) Number of order per year

(c) Time between order if the factory operates 250 days per year.

(d) Total annual inventory cost

Example

- a) Determine optimal order quantity
- EOQ = $\sqrt{2DS/h}$
    - = $\sqrt{\frac{2x1000x10}{0.5}}$
    - = 200 units

- b) number of order per year
- N = Demand/EOQ
- = 1000/200

  = 5 orders

c) Time between orders if no of working days 250

T= No of working days/no of orders

= 250/5

= 50 days between orders

- D) Total inventory management cost

Total cost = Annual Setup cost + Annual Holding cost

$$\frac{D}{Q}\mathrm{S} + \frac{Q}{2}\mathrm{H}$$

$$\frac{1000}{200}10 + \frac{200}{2}0.5$$

= RM50 + RM50

=RM100

Therefore, the total cost for inventory management is RM100

Reorder Point

When is the right time to order?

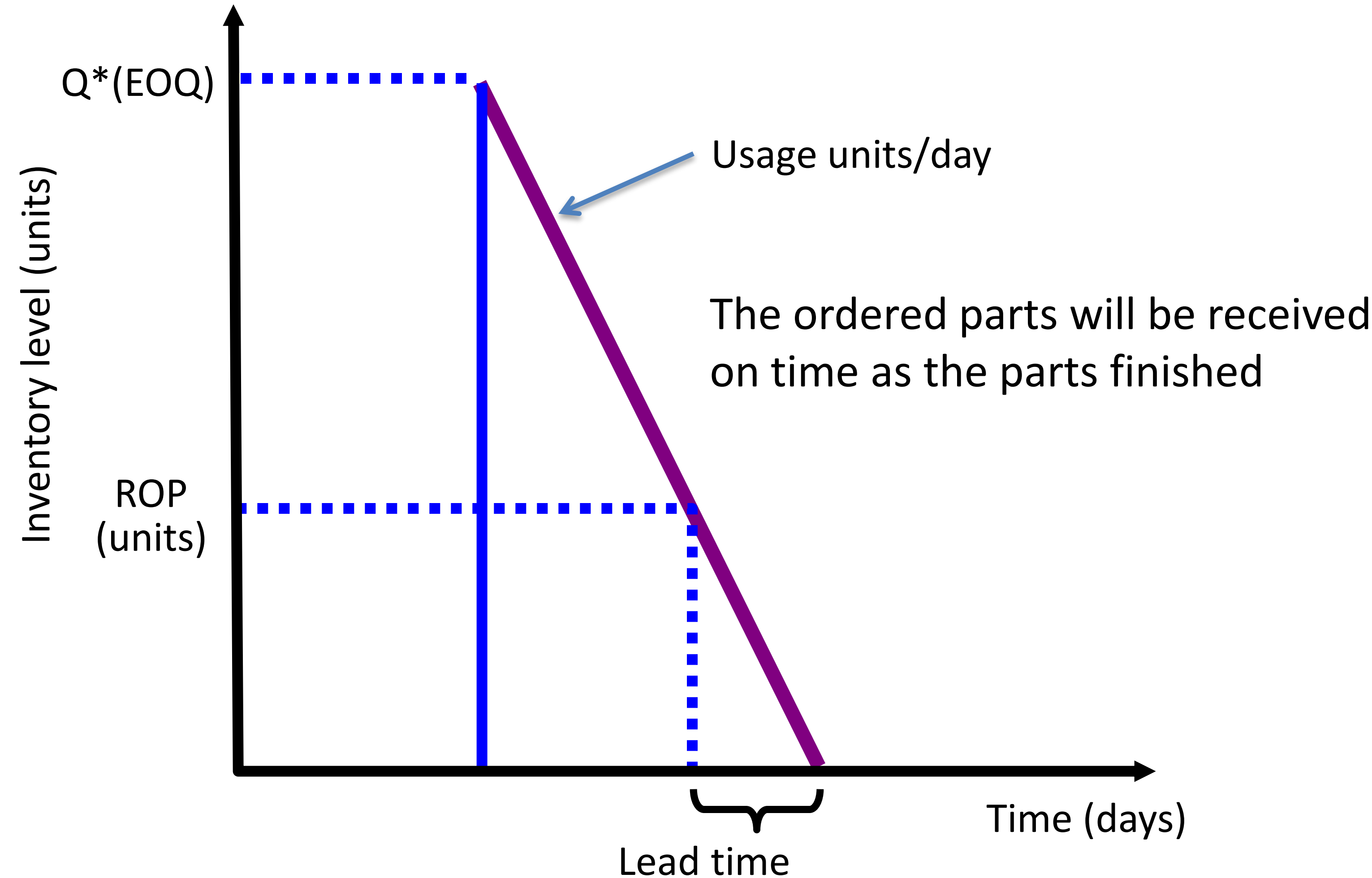
Based on EOQ, we can determine the best time for reorder day.

$$\text{ROP} = \left(\begin{array}{c}\text{Demand}\\ \text{per day}\end{array}\right)\left(\begin{array}{c}\text{Lead time for a new}\\ \text{order in days}\end{array}\right)$$

$$= d \times L$$

$$d = \frac{D}{\text{Number of working days in a year}}$$

Reorder Point



Example

Lead time for orders is 3 working days

$$d = \frac{D}{\text{Number of working days in a year}}$$

$=1000/250 = 4$ units

ROP $= d \times L$

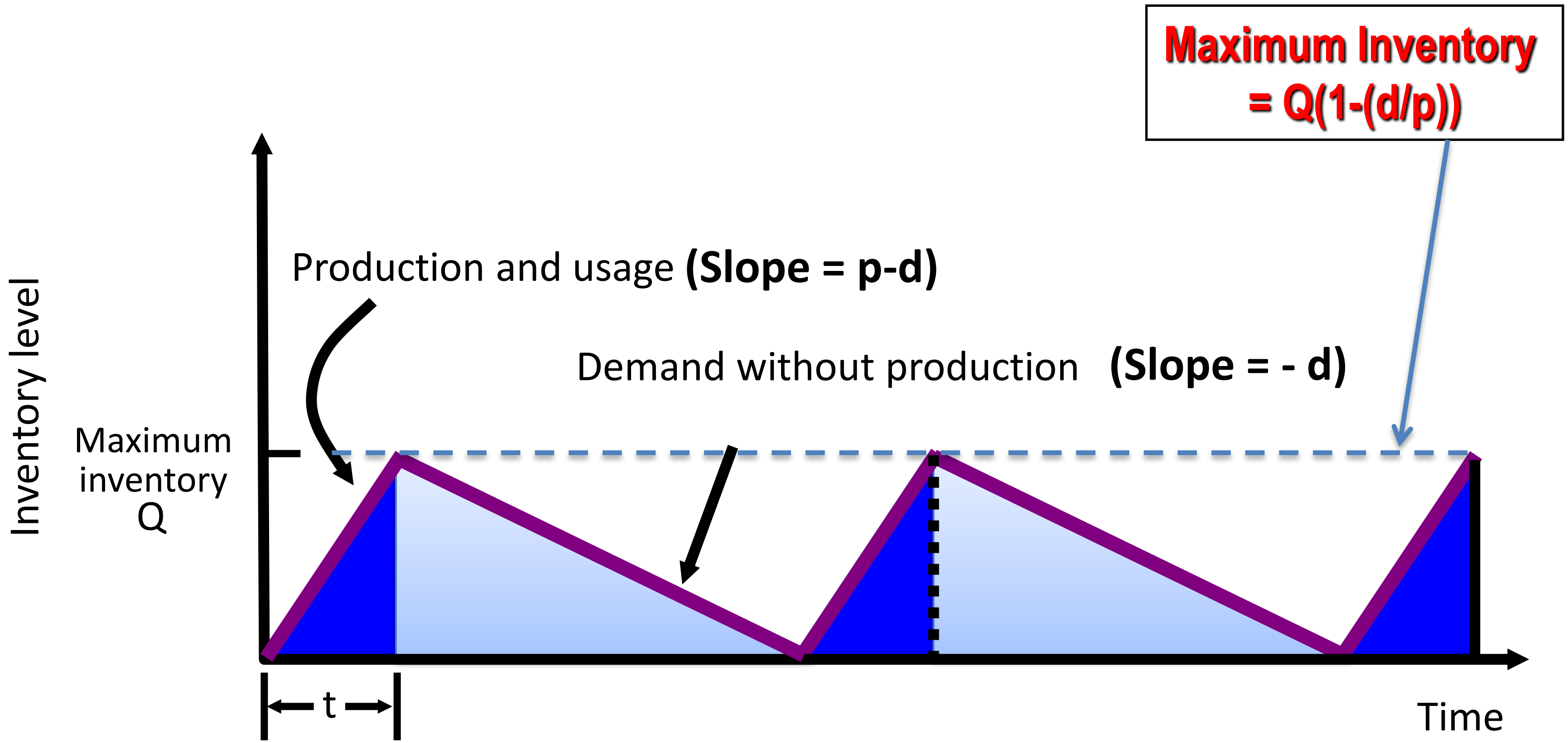
$= 4$ units per day x 3 days $= 12$ units

The purchasing department will make an order when the part level reach to 12 units

Production Order Quantity

- ☑ The parts received partially instead of instantaneously e.g. produced in house
- ☑ The parts are produced and sold simultaneously
- ☑ Produced one product at a time, then continue with other product

Production Order Quantity



Note: 1-(d/p) = fraction of production that goes into inventory

Production Order Quantity

Q = Quantity per order
H = Annual holding cost per unit
t = Production days

p = Daily production rate
d = Daily demand/usage rate

Annual inventory holding cost $= \frac{Q}{2}H$

Average inventory level $= \frac{Q}{2}$

Maximum inventory level = $Q(1- \frac{d}{p})$

$H = H(1 - \frac{d}{p})$

Maximum inventory level = Total Production during run time – Total used during run time
= pt - dt

Production Order Quantity

Setup cost = (D/Q)S

Holding cost = 1/2 HQ[1 - (d/p)]

(D/Q)S = 1/2 HQ[1 - (d/p)]

$$Q^2 = \frac{2DS}{H[1 - (d/p)]}$$

$$(Q^*) = \sqrt{\frac{2DS}{H[1 - (d/p)]}}$$

POQ

Production Order Quantity

Annual Demand = 1000

Setup cost = RM100/Set up

Annual Holding cost = RM20 per unit

Production rate(p) = 10/day

250 working days per year

d=1000/250 = 4 units per day

$$\sqrt{\frac{2DS}{H[1 - (d/p)]}}$$

$$Q_p^* = \sqrt{\frac{2 \times 1000 \times 100}{20 \times [1-(4/10)]}} = 129.1 \text{ units/run}$$

Maximum inventory level $= 129.1[1- (4/10)] = 77.46 \text{ units} \cong 78 \text{ units}$

Production Order Quantity

- Total cost = Annual Setup cost + Annual Holding cost

$$= \frac{D}{Q}S + \frac{Q}{2}(1\text{-}d/p)H$$

$$= \frac{1000}{129}(100) + \frac{129}{2}\left(1-\frac{4}{10}\right) 20$$

= RM3448.28 + RM774

= RM4222.28

Quantity Discount Model

- It is same as the EOQ.
- But the unit price is depends on the quantity ordered.

Total cost = Setup cost + Holding cost + Product cost

$$= \frac{D}{Q}S + \frac{Q}{2}H + PD$$

Quantity Discount Model

- Steps

1st Calculate the EOQ at the lowest price

2nd Determine whether the EOQ is feasible at that price

  – Will the vendor sell that quantity at that price?

3rd If yes, stop – if no, continue

4th Check the feasibility of EOQ at the next higher price

- Continue to the next slide ...

Quantity Discount Model

Recently, Always One Enterprise has been given a quantity discount schedule for the purchasing of sport shoes.

- Ordering cost RM49/order
- Demand 50000 pairs
- Inventory carrying cost 20% or 0.2

Quantity Discount Model

E.g. Offered Discount

Discount Number	*Discount Quantity*	*Discount (%)*	*Discount Price (P)*
1	0 *to* 999	*no discount*	RM50.00
2	1,000 *to* 1,999	4	RM40.80
3	2,000 *and over*	5	RM40.75

Quantity Discount Model

Calculate Q* for every discount

$$Q^* = \sqrt{\frac{2DS}{IP}}$$

$$Q_1^* = \sqrt{\frac{2(50{,}000)(49)}{(.2)(50.00)}} = 700 \text{ pairs order}$$

$$Q_2^* = \sqrt{\frac{2(50{,}000)(49)}{(.2)(40.80)}} = 714 \text{ pairs order}$$

$$Q_3^* = \sqrt{\frac{2(50{,}000)(49)}{(.2)(40.75)}} = 718 \text{ pairs order}$$

Quantity Discount Model

$$Q^* = \sqrt{\frac{2DS}{IP}}$$

Calculate Q* for every discount

$$Q_1^* = \sqrt{\frac{2(50,000)(49)}{(.2)(50.00)}} = 700 \text{ pairs order}$$

$$Q_2^* = \sqrt{\frac{2(50,000)(49)}{(.2)(40.80)}} = \cancel{714} \text{ pairs order}$$

1,000 — adjusted

$$Q_3^* = \sqrt{\frac{2(50,000)(49)}{(.2)(40.75)}} = \cancel{718} \text{ pairs order}$$

2,000 — adjusted

Quantity Discount Model

List	Unit Price	Order Quantity	Annual Product Cost PD	Annual Ordering Cost D/Q*S	Annual Holding Cost QiP/2	Total
1	RM50.00	700	RM250,000	RM3500	RM3500	RM250,700
2	RM40.80	1,000	RM240,000	RM2450	RM4800	RM240,725
3	RM40.75	2,000	RM230,750	RM1220.50	RM9500	RM240,822.50

Therefore the lowest price is 2nd option – RM40.80