Production & Operation Strategies

Table of Contents

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1 - INTRODUCTION

1.1) The following answer is not the only correct answer.

a) Strategic Decisions: long term decisions that broadly define company direction.
b) Tactical Decisions: medium term plan that is more structured and detailed than strategic decision.
c) Operational Decisions: Short term decisions and focuses on specific detailed tasks at hand.

1.2) The following answer is not the only correct answer.

a)
1. Strategic Decisions: Dominate the automobile market.
2. Tactical Decisions: Produce automobiles that are low cost and high power.
3. Operation Decisions: Develop efficient manufacturing system.

b)
1. Input: Steel and other raw material.
2. Output: manufactured automobile.
3. Transformation process: raw material into actual engine − Product Process.

c) Supply Chain from supplier to the automobile dealer to the customers.

1.3) The following answer is not the only correct answer.

a) automobile, furniture
b) lawyers, accountant
c) Mathematical model, physical model

2 - Production and Operations History and Perspective

2.1) The history of operations systems began around 5000 B.C. when Sumerian priests developed the ancient system of recording inventories, loans, taxes, and business transactions. The next major historical application of operation systems occurred in 4000 B.C. It was during this time that the Egyptians started using planning, organization, and control in large projects such as the construction of the pyramids. By 1100 B.C., labor was being specialized in China; by about 350 B.C., an archaic assembly line was formed in Greece.

In the Middle Ages, kings and queens ruled over large areas of land. Loyal noblemen maintained large sections of the monarch's territory. This hierarchical organization in which people were divided into classes based on social position and wealth became known as the feudal system. In the feudal systems, servants produced for themselves and people of higher classes by using the ruler's land and resources. The Renaissance brought about specialization in labor within the European system. This system had some of the first significant contributions that led to the industrial revolution. The industrial revolution occurred as the result of two conceptual phenomena: interchangeability of parts and division of labor.

The next generation of scientific study occurred with the development of a) work sampling and b) Predetermined Motion Time Systems (PMTS). Work sampling is used to measure the random variable associated with the time of each task.

At the beginning of the twentieth century, American Industry invented the revolutionary idea of an assembly synchronized system.

During World War II, the growth of complex systems led to the development of efficient manufacturing methods and the use of advanced mathematical and statistical tools.

2.2) The following answer is not the only correct answer.

1. Empiricism: This replaced humans with machines and increases efficiency of the production process.
2. Analysis: Evaluation of human performances
3. Synthesis: Model building for efficient problem solving.
4. Complex Systems: Examination of complex machines and systems.
5. Ecological Sound Systems: Protection of the environment while developing our own energy.

3 - Production & Operations Models

The following answer is not the only correct answer.

3.1)

a) Location Decisions – A car manufacturer wants to build a new plant. They have different options for which city to build, each with individual costs for things like transportation, labor, resources, etc. Minimizing these costs is desired when selecting the location.

b) Layout Design – Again, using the car manufacturing plant, a design layout must accommodate different areas, assembly, paint, shipping, receiving. The objectives would be to minimize the total materials flow, transportation time of parts, maximize the ease of assembly, and use as little of space possible to do it.

c) Supply Chain – Using the car manufacturing plant, a decision may be to locate the plant in a central location for all suppliers. This would help to minimize transportation costs of materials, transportation time, and maximize flexibility.

d) Transportation – A decision on how to transport equipment is required. A company may choose to transport by land, sea, air, or rail depending on the costs associated with each when moving items from point A to point B.

e) Clustering and Group Technology – Again using the car manufacturing plant, different metal stamping machines may be located in the same location which would allow them to use the same metal stock to form different parts.

f) Assembly Systems – Using the car manufacturing plant, assembling of a car can be performed in a logical step function. In the first station part A can be installed, then in the next part B, ensuring that all the steps needed to be completed prior to the next are done. This minimizes the amount of time it takes to assembly complex systems and adds a process to complete it.

3.2)

a) Forecasting – A car manufacturer has to forecast how many cars to produce of a certain model in a certain year so that there is not a lot of excess inventory before the next years models come out.

b) Aggregate Planning – A company must plan to meet a demand. They can do this by producing extra inventory, hiring more workers, subcontracting, or holding production steady and having back-orders.

c) Push and Pull Systems: MRP & JIT – Companies must decide how must raw inventory, product components, work in process pieces, and finished goods to hold; enough to meet a certain demand over a few periods or just for the current period while minimizing cost.

d) Inventory Planning: Controlling inventory to minimize cost

e) Project Management – A complex project needs to be planned from how materials will arrive, through assembly, to delivering the finished product. Project Management seeks to minimize the total cost and duration of the project while maximizing the probability of completion.

f) Scheduling and Planning – Involves sequencing tasks to be completed in the shortest time possible.

3.3)

a) Quality Control and Assurance – Verifying that all parts meet the customer specifications.
b) Reliability, Maintenance, and Replacement – Complex systems can have regularly scheduled maintenance to keep them operating longer. Likewise, parts may be replaced after their design life has been reached.
c) Work Measurement and Analysis – Modeling the steps required to complete a certain task and estimating the time it would take to complete.
d) Productivity and Efficiency – Maximizing the production of a piece through an assembly line.
e) Energy Systems – A regenerative braking hybrid automobile both generates energy and saves it depending on its mode of operation.

4 - Systems Approach &Tools

4.1) The following answer is not the only correct answer.

a) Systems Engineering and Development – Completing an initial design and then iteratively updating each piece based on changes to the other pieces.
b) System Architecting and Modeling – Making a model of a customers part so that they can visualize what the end product will be.
c) Multi-Objective Perspective – Completing trade studies which take into account multiple stakeholders and inputs to produce a solution that may not be optimized in all areas, but optimized when all the constraints are considered.

4.2) The following answer is not the only correct answer.

a) Optimization – Developing a mathematical tool which inputs all the constraints and comes up with an optimal solution for all constraints not just one.
b) Decision Analysis – Deciding to go with Option A which minimizes cost or Option B which minimizes time.
c) Queuing Systems – Developing queuing systems in fast food that allows an orderly flow to minimize customer waiting time thereby maximizing profits due to a higher throughput.
d) Simulation – Testing the failure rates of a system by simulating it over a variety of operating conditions.

5 - Multiple Criteria Production/Operation Systems*

5.1) The following answer is not the only correct answer

1) Define the problem – Which aircraft model should an airliner purchase.

2) Define and measure objectives – Want to minimize amount of unsold seats each trip. Want maximum fuel efficiency.
3) Analyze the problem – Study the current market trends for the flight path to determine the typical amount of passengers on each flight. Assume 100 passengers per flight.
4) Generate alternative solutions – Identify aircraft that are of suitable size but fit within the objectives. Aircraft A carries 120 passengers and burns 100 gallons of fuel per hour. Aircraft B carries 80 passengers and burns 50 gallons of fuel per hour.
5) Use a Multi-Criteria Decision Making Method – Assume maximum fuel efficiency is more important, aircraft B uses less fuel per passenger than aircraft A.
6) Select the best compromise alternative – Select Aircraft B.

5. 2) The following answer is not the only correct answer

Efficient alternatives contains criteria that are at least equal to or better than inefficient alternatives, where one of the criteria must be better. Inefficient alternatives on the other hand, has criteria equal to or worse than efficient alternatives, and has one of the criteria to be worse than efficient alternatives.

5.3) The following answer is not the only correct answer

For example building a hospital in a small city:

Cost: Fixed costs include installation cost, heating cost,…, and variable costs include, number of emergency patients.

Productivity: Productivity is the number of patients accepted per day.

Quality: The number of patients cured or sent back home or patients' satisfaction using surveys.

Flexibility (Reconfigurable & Agility): The ease of change for the layout for future expansion can be considered as the flexibility criteria for this hospital.

Ecological Soundness: Hospital garbage is the most important factor.

Tradeoff Analysis:

Cost versus Flexibility: There are two choices for increasing flexibility. One is expanding the current location. The other choice is to build new buildings in different locations of the city. At the current time, we need to consider an alternative that provides the most choices for cost and flexibility in the future.

Cost versus Quality: Two different choices includes ordering new state of the art facility or rent required facilities and keep the current one.

Cost versus Productivity: Serving more patients (higher productivity) can be accomplished by hiring new crew which result in more cost.

Cost versus Ecological Soundness: At present, it costs more to develop systems that are more ecologically friendly.

5.4) The following answer is not the only correct answer

a, b, and c) For example a national soft drink producer:

Level I - Strategic Planning – At executive levels, the company managers are looking to increase market share, introduce a new product, or lower the cost by utilizing a new streamlined processes.

Level II – Location and Layout Decisions – Planners decide on locations that are suited to the strategic plan. Water and other resources need to be plentiful and costs must be minimized. Transportation costs of cans, bottles and syrups used in the process and distribution to customers must be minimized. Inputs and outputs must be played out such that the receiving, bottling, canning, packaging and shipping operations are efficient with respect to sequencing and scheduling.

Level III – Capacity and Aggregate Planning Supply Chain and Transportation Decisions – equipment and labor can now be planned. Maximizing the capacity of the bottling line in terms of cans or bottles per minute, determination of how many operators will be required to run the line efficiently. Negotiate with transportation companies to minimize costs. These activities are ongoing and will require checking and feedback over time to review and update as they relate to productivity and work measure.

Level IV – Project Management, Scheduling and Sequencing - Scheduling materials such as cans, bottles and syrups used in the process to keep the line running in order to keep inventory at the distributors and not make too much product such that it can be constantly moving off the warehouse floor.

Level V – Productivity, Work Measure and Quality Control – Checks must be made on productivity of the line. Quality must be assured of the raw materials as well as the finished product and feedback shall be given to the suppliers and line workers. This can be accomplished via sampling method.

Level VI – On-line Monitoring, Supervision and Control – Empowering workers to stop the process should they see something wrong is important to the product quality and to maximizing productivity. When workers feel a pride in the product they will do everything they can to make things operate up to quality and capacity standards.

Level V - Productivity, Work Measure and Quality Control and **Level VI** On-line Monitoring, Supervision and Control interact in such a way that the production manager or quality manager may find a problem with the line and interact with the line operator in an effort to improve quality or production rates. Likewise the line operator may have interaction with maintenance personnel to "tweak" the production line in an effort to increase quality and/or production rates.

5.5)

a) Manufacturing Industry: Automobile Manufacturer

Level I - Strategic Planning – At executive levels, the company managers are looking to increase market share, produce new automobiles, or lower the cost by utilizing a new streamlined processes.

Level II – Location and Layout Decisions – Planners decide on locations that are suited to the strategic plan. Water and other resources need to be plentiful and costs must be minimized. Also, the location should allow easy transportation of raw material. Transportation costs of steels and other automobile parts used in the process and distribution to customers must be minimized. Inputs and outputs must be played out such that the receiving, manufacturing, assembly, and shipping operations are efficient with respect to sequencing and scheduling.

Level III – Capacity and Aggregate Planning Supply Chain and Transportation Decisions – equipment and labor can now be planned. Maximizing the capacity of the assembly line in terms of automobiles per day, determination of how many assemblers will be required to run the line efficiently. Negotiate with transportation companies to minimize costs. These activities are ongoing and will require checking and feedback over time to review and update as they relate to productivity and work measure.

Level IV – Project Management, Scheduling and Sequencing - Scheduling materials such as steels, cooper, and rubber used in the process to keep the line running in order to keep inventory at the distributors and not make too much product such that it can be constantly moving off the dealers.

Level V – Productivity, Work Measure and Quality Control – Checks must be made on productivity of the line. Quality must be assured of the raw materials as well as the finished product and feedback shall be given to the suppliers and line workers. This can be accomplished via sampling method.

Level VI – On-line Monitoring, Supervision and Control – Empowering workers to stop the process should they see something wrong is important to the product quality and to maximizing productivity. When workers feel a pride in the product they will do everything they can to make things operate up to quality and capacity standards.

b) Levels III, IV and V cooperate with each other to come up with planning and scheduling of production. Level I becomes the basis for all the decision making involved in the production planning process.

c) Each objective are related with other levels. For instance, in capacity and aggregate planning, the objective is to minimize scheduling cycle and in project level management, based on the results of Level III, schedules can be devised that would minimize the cycle.

6 - Product and Process Life Cycle

6.1)

Blackberry creates a new touch screen cell phone

Phase I: Introduction – The cell phone is initially brought into the market with a limited supply.

Phase II: Growth – As sales volumes increase production is increased. As production efficiencies are gained and quantity ordered increases, costs per cell phone decrease. New products from competitors arrive in the market.

Phase III: Maturity - Demand for the cell phone has peaked and is steady. The cell phone has minor improvements but is not a complete redesign.

Phase IV: Decline – Newer cell phones arrive in the marketplace which are faster, lighter, and have more functionality. The old cell phone demand decreases due to it being out of date.

6. 2)

a) VCR and audio cassettes

b) Paper towels and soft drinks (Pepsi/Coke).

6. 3)

Suppose that a new HD-TV is going to be developed. The prototype is tested and market research is completed before it is introduced to the market. There is no sale, and as a result no profit, in this phase. In the introduction stage the TV is introduced in the market.

In the growth stage sales of the product grows rapidly. On the other hand, competitor companies enter the market and even catch up with this new product. Some just copy the most successful product, or try to improve it to compete better.

In maturity phase, this continues to sale with nearly constant amount. Its reputation is still wide-spread. This is the time that the company should start introducing its new prototype to the market.

In the Decline stage, new products replace the old. Price competition becomes more vigorous. As sales decline, the firm has several options:

a) Maintain the product b) Reduce current production costs & continue to offer the product, c) Discontinue the product and selling the leftovers.

6. 4)

a) Jumbled flow / low volume – musical instrument repair

b) Disconnected Flow / multiple products – office furniture

c) Connected line flow / higher volume – large appliances

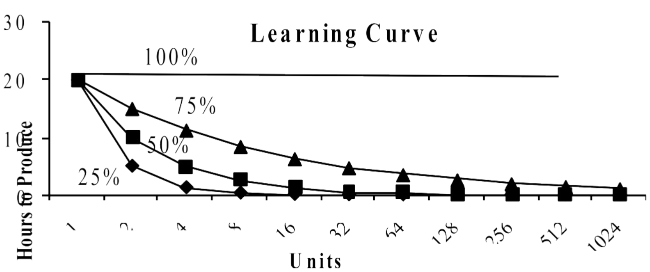
d) Continuous flow / high volume – chemical plant, national brewery

7 - Learning Curves

7. 1)

a) Manufacturing Company: The operators learn how to use system, fix problems faster.
b) Governmental Organization: The player learns the song and the keys of the instrument and improves their performance.
c) Nonprofit Organization: The player learns how the ball bounces and how to hit the ball with greater velocity and accuracy.

7.2)



7.3)

T(2n) = l T(n)

Where n = number of units

T(n) = the production time for n^{th} unit

l = the learning rate, where $0 < l \leq 1$

a)

Car #1: 10 hours: T(1) = 10
Car #2: 8 hours: T(2) = 8

T(2n) = ℓT(N)
T(2) = ℓ T(1) 8 = ℓ(10) ℓ=0.80

b = -log(ℓ) / log (2)

b = -log(0.80) / log (2) b = 0.322

b)

$T(n) = T(1)n^{-b}$
$T(n) = 10\ n^{-0.322}$
$T(5) = 10(5)^{-0.322}$
T(5) = 5.96 hours

$T(16) = 10(16)^{-0.322}$
T(16) = 4.10 hours

$T(1000) = 10(1000)^{-0.322}$
T(1000) = 1.08 hours

7.4)

a) T(n)=T(1)n^-b

12=50*5^b where b=-((log(12)-log(50))/log(5)) or b = 0.89

and *l*=2^(-b)=2^(-0.89) or *l* =(0.54)

T(8)=50*8^(-0.89) = 7.91 hours

T(10)=50*10^-(0.89) = 6.49 hours

T(90)=50*90^(-0.89) = 0.911 hours

b) T(n)=T(1)n^-b

10=50*5^b where b=-((log(10)-log(50))/log(5)) or b = 1

and *l*=2^-b=2^-1 or *l* = .5

T(8)=50*8^-1 = 6.25 hours

T(10)=50*10^-1 = 5.0 hours

T(90)=50*90^-1 =0.555 hours

c) T(n)=T(1)n^-b

14=50*5^b where b=-((log(14)-log(50))/log(5)) or b = 0.79

and *l*=2^-b=2^(-0.79) or *l* = 0.58

T(8)=50*8^(-0.79) = 9.65 hours

T(10)=50*10^(-0.79) = 8.11 hours

T(90)=50*90^(-0.79) = 1.42 hours

7.5)

a) T(50)=30*50^(-0.24)=11.7 hours

T(1500)=30*1500^(-0.24)=5.2 hours

b) *l* =2^-b = 2^(-0.24)=0.85

c) Total 50 units = 754 hours

Total 1500 units = 10215 hours

7. 6)

a) b= -((log(16.9)-log(40))/log(4))=0.62 therefore, T(2)=40*2^(-0.62)=26 hours

b) b=0.62 therefore *l*=2^(-.62)=0.65

c) T(64)=40*64^(-0.62)=3.0 hours

T(70)=40*70^(-0.62)=2.8 hours

T(3000)=40*3000^(-0.62)=0.28 hours

7. 7)

a) b = -((log(40)-log(33.75))/log(5)) = -0.106 and *l* = 2^- (-0.106)= 1.076

b) T(2)=33.75*2^-(-.106)=36.3 hours

T(15)=33.75*15^-(-.106)=45.0 hours

T(200)=33.75*200^-(-.106)=59.2 hours

7. 8)

a) b = -((log(120)-log(100))/log(30)) = -0.0536 and *l* = 2^-(-0.0536) = 1.038

b) T(100)=100*100^-(-0.0536)=128.0 hours

T(1000)=100*1000^-(-0.0536)=144.8 hours

T(10000)=100*10000^-(-0.0536)=163.8 hours

8 - Capacity Planning

8.1) The following answer is not the only correct answer.

a) Capacity leads demand.

An example would be the auto industry. Most car dealerships have extra inventory on their car lots. They do not know exactly what each buyer is looking for so they need to make sure they have models that would fit most people's desires for their car. An advantage to this is that buyers can see the car with the options and if they choose, buy it immediately versus ordering a car and having to wait for it to be built and delivered. Disadvantages are the cars on the lot cost money to keep there since most dealers finance the purchase of the cars from the manufacturer. The longer the car sits on the lot the more interest they pay on those loans.

b) Capacity lags demand.

An example would be the airline industry. Most airlines will over-book a flight because past experience has taught them that some people will cancel their reservation. If a cancellation occurred at a time close to the time of departure than the airline would lose money due to the unfilled seat. The advantage of this is that the airline can be sure that seats will be filled even if cancellations occur. A disadvantage is that sometimes cancellations do not occur and the airline must provide compensation for passengers that get "bumped" or passengers who volunteer to take a later flight.

c) Capacity matches demand.

An example would be the commercial space launch industry. Commercial launch providers do not have extra inventory of launch vehicles. They are produced as the order for launch services are received. The advantage to this is that an inventory of launch vehicles does not have to be kept on-line and constantly checked. Launch vehicles are complex, expensive, and physically large items. If they were inventoried, storage costs and maintenance costs could be significant. Disadvantages would be that "buyers" must know their need years in advance. Also, if there are no buyer's then the launch vehicle manufacturing facility is most likely not in use, however the labor and facility must be kept for when a launch vehicle order is made.

8.2)

a) Total Grills = (600 total burgers/hr) / (2 burgers/min * 60min/hr) = 5 grills

b) Total capacity for grill:

3 burgers/min grills are $1500 each. This burner produces 3*60 = 180 burgers / hour

Thus, # of grills necessary to produce 600 burgers/ hr = 600 / 180 = 3.3 or 4

Thus, 4 grills equate to an investment of 4*1500=$6,000

7 burgers/min grills. This burner produces 7* 60 = 420 burgers / hr.

Thus, # of grills necessary to produce 600 burgers/ hr = 600 / 420 = 1.4 or 2

Thus, 2 grills equate to an investment of 2*3300=$6,600

Thus, the owner should choose to use the grills that cook 3 burgers/min.

c) For a grill that cooks 3 burgers/min, the # of grills necessary to produce 800 burgers/hr = 800/ 180 = 4,44 or 5

5*1500 = $7500

For a grill that cooks 6 burgers/min, the # of grills necessary to produce 800 burgers/hr = 800/ 420 = 1.90 or 2

2*3300 = $6600

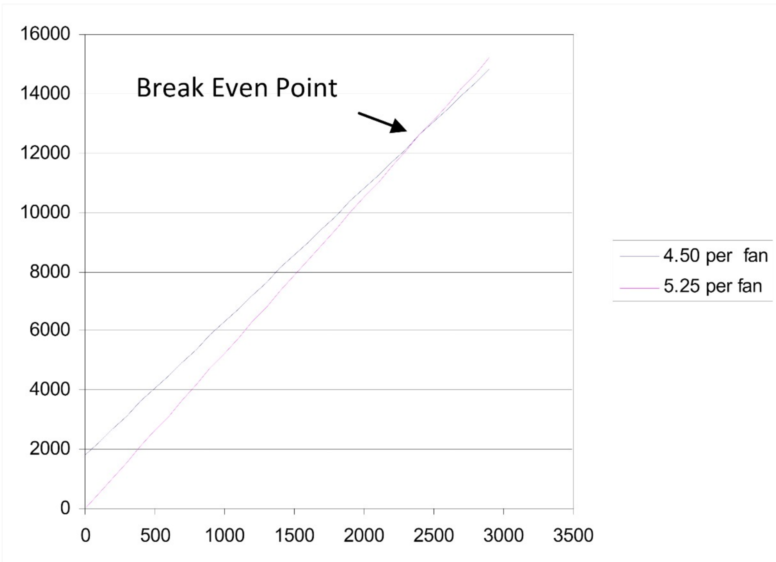
Therefore, if the needed producicitivity is 800 burgers/hour, the super-grill that cooks 7 burgers/minute is the lower cost.

8.3) I=6000 processors*(13-10)=$18,000

8.4)

a) X=I/Co-Ci = 1800/(5.25-4.50)=2400 oscillating fans

b)



9 - Machining Optimization

9.1)

a)

C = v*t^n

C = 120*40^n

C = 100*60^n

So, 120*40^n = 100*60^n

100/120 = (40/60)^n

ln(.8333) = n ln(.6667)

0.45 = n

Hence, C = 120*40^0.45 = 631

Therefore, the tool life equation is 631 = v*t^0.45

b)

631 = 110*t^0.45

631/110 = t^0.45

5.736 = t^0.45

t = 5.736^1/0.45 = 48.5 minutes

c)

631 = v*30^0.45

v = 631/4.62 = 136.6 inches/minute

9.2)

a)

C = v*t^n

50 = v*70^0.4

v = 50/5.47 = 9.1 inches/minute

b)

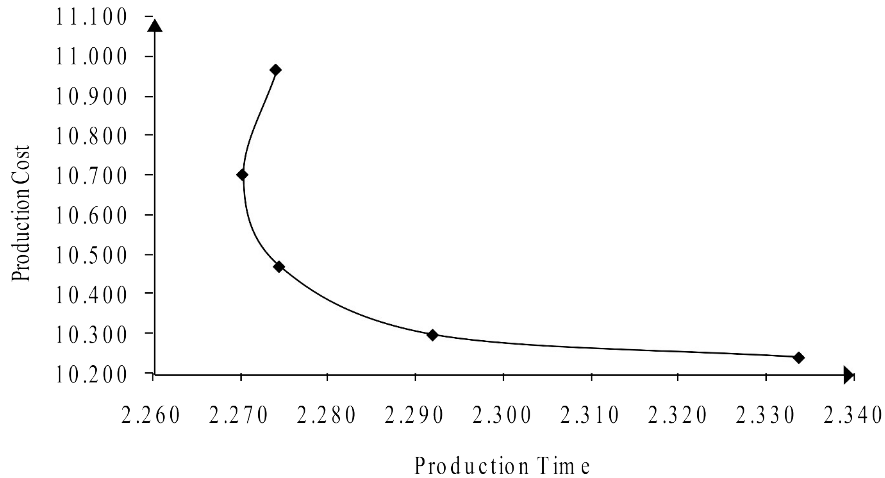
C = v*t^n

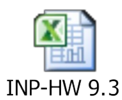
50 = 15*t^0.4

t = (50/15)^1/0.4 = 20.3 minutes

9.3)

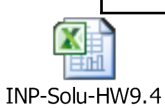
Alternative	a_1	a_2	a_3	a_4	a_5
Speed, v	100	125	150	175	200
Production Cost, $f_1(v)$	10.242	10.298	10.471	10.702	10.966
Production Time, $f_2(v)$	2.334	2.292	2.274	2.270	2.274
Efficient?	Yes	Yes	Yes	Yes	No





9.4)

Alternatives	a_1	a_2	a_3	a_4	a_5
Cutting Speed, v	80	90	100	110	120
Tool Life, t	0.309	0.230	0.177	0.139	0.112
No. tool changes, N	19429.034	26081.497	33941.125	43073.281	53540.122
Min. Cost, \$ $f_1 = c_t * N$	310864.543	417303.950	543058.008	689172.493	856641.948
Max. No. of parts $f_2 = v*T/L$	12000	13500	15000	16500	18000
Efficient?	Yes	Yes	Yes	Yes	Yes



9. 5)

Alternatives	a_1	a_2	a_3	a_4	a_5
Cutting Speed, v	20	22	24	26	28
Tool Life, t	1.324	1.143	1.000	0.884	0.789
No. tool	3625.968	4198.605	4800.000	5429.019	6084.660

changes, N					
Min. Cost, \$ $f_1 = c_t * N$	21755.806	25191.628	28800.000	32574.117	36507.959
Max. No. of parts $f_2 = v*T/L$	4800	5280	5760	6240	6720
Efficient?	Yes	Yes	Yes	Yes	Yes

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