The Dulac Box plant produces wooden packing boxes to be used in the local seafood industry. Current operations allow the company to make 500 boxes per day, in two 8-hour shifts (250 boxes per shift). There are 5 full-time workers on each shift. The company has introduced some moderate changes in equipment, and conducted appropriate job training, so that production levels have risen to 300 boxes per shift. Also, with these changes there are now 4 full-time workers on each shift. Labor costs average $10 per hour for each worker on each shift. Capital costs were previously $3,000 per day, and rose to $3,200 per day with the equipment modifications. Energy costs at $400 per day were unchanged by the modifications. The output is measured in terms of the number of boxes that are produced.

a) What is the firm's labor hours productivity after the changes?

b) What is the *percent change* in the multifactor productivity before and after the changes?

c) Suppose the company now wants to increase productivity as measured by the multifactor productivity factor by 10% at the 300 boxes per shift level of output. To achieve this target, it can only reduce its labor per box. It will use the freed up labor for other activities. How many labor hours *per shift* will each worker have available for other activities if the company achieves this new level of productivity?

2. (18 points)

Following are the number of victories for the Blue Sox and the hotel occupancy rate for the past eight years. You have been asked to test three forecasting methods to see which method provides a better forecast for the Number of Blue Sox wins.

|  |  |  |
| --- | --- | --- |
| **Year** | **Number of Blue Sox Wins** | **Occupancy Rate** |
| 1 | 70 | 78% |
| 2 | 67 | 83 |
| 3 | 75 | 86 |
| 4 | 87 | 85 |
| 5 | 87 | 89 |
| 6 | 91 | 92 |
| 7 | 89 | 91 |
| 8 | 85 | 94 |
| 9 | 87 | 92 |
| 10 | 88 | 93 |

*For the following, calculate all forecasts to one decimal place (example, 93.2%)*

You are asked to forecast the *Number of Blue Sox Wins* for Year 10. Although you believe there might be a linear regression relationship, your boss has told you to only consider the following three forecasting methods:

* *5-period moving average*,
* *3-period weighted moving average,* unfortunately, you spilled coffee on the paper with the weights for each period. You can tell that the weights for the most recent and the third most recent period are 0.7 and 0.1 respectively. The weight for the second most recent period would be consistent with the weighted moving average method we have studied in class.
* *exponential smoothing* with α = 0.30 and the forecast for Year 2 for *Number of Blue Sox Wins* is 63.0.

a) What is the forecast from each of these three methods for Year 11?

b) Using one of the forecast evaluation techniques that we have used as part of the homework assignment for this topic and using the forecasts for Years 6 through 10, which forecasting method do you recommend using for preparing your forecast for Year 11? Why?

3. (21 points)

A soft drink maker wants to expand into a neighboring country. They want the product bottled in that country to avoid political issues and to enhance the local image of the product. They have identified two options for the expansion. The first is to build a highly automated plant. The economies of scale would allow them to produce a can of soda for $0.04 and the distribution costs would be $0.02 per can. This facility would cost $1 million per year in fixed costs. The second option would be to build a semi-automated plant that would cost $650,000 per year in fixed costs. However, the cost to produce a can would be $0.07 and the distribution cost would be $0.04 per can.

a) Over what range of product would each plant be preferred?

b) Suppose the company believes that the demand would be 6,000,000 cans per year. Suppose all costs except the variable cost (sum of the production and distribution costs) for the semi- automated process are certain and can not change. What would the variable cost (the sum of the production and distribution cost) *per can* for the highly automated process have to be so that the soft drinker maker is indifferent between the two types of plants?

c) Now suppose each alternative has a different capacity. The total estimated demand for the year is 5,300,000 if the company sells each can for $0.32. However, only the highly automated process can produce and distribute this amount. If the semi-automated process is used, the company would only be able to produce and distribute 4,200,000 cans annually. To offset the lower volume, the company will raise the price of each can to $0.35. It will be able to sell all it produces at this price. Using all of the information presented in the problem, which process should it use? Why?

4. (30 points)

The specification for a plastic handle calls for a length of 6.0 inches ± 0.5 inches (5.5 to 6.5 inches). The process is known to operate at a mean thickness of 6.1 inches. The minimum acceptable process capability is 2.0. The standard deviation (σ) of the process is currently 0.08 inches.

a) Can the company meet the customer’s specification requirements at this time? If it cannot, explain if it is due to a drifting of the mean or too much variability.

b) Suppose that the mean of the process has now shifted to 5.95 inches. What is the maximum standard deviation (σ) of this process if the company wants to ensure that it can maintain a Cpk of 2.0?

c) The specification limits have not changed. Suppose that the mean of the process has now shifted to 5.9 inches with a standard deviation (σ) of 0.09. What is the range (upper and lower limits) on the mean of the process to maintain a Cpk of 2.0 or greater?

d) Suppose that the mean of the process is operating at a mean of 6.1 inches and a standard deviation of 0.1 inches and follows a normal probability distribution. The lower spec (specification) limit is 5.95 and the upper spec limit is 6.2. What percent of the values are outside of the spec limits? 5. (16 points)

Spencerville Products is expanding its operations west of the Mississippi. Its first step is to build a manufacturing facility in Denver to satisfy demand on the West Coast. Spencerville has an option to build either a large facility that has an annual output of 500,000 units per year or a smaller facility with an output of 250,000 units per year. It must build one of these two facilities - it does not have any other options.

The expected demand for the company's products is shown as either high or moderate in the table below:

Demand Level Annual Demand (units/year) Probability

High 450,000 0.4

Moderate 150,000 0.6

The small facility has a profit of $5.00 per unit. The large facility has a profit of $4.00/unit.

a) What size facility should Spencerville Products build based on expected values and using a decision tree approach? You must also provide the decision tree using the appropriate decision tree symbols.

b) Suppose that the company is not certain about the 450,000 projection for the High Demand scenario. It could be higher than this projection. How sensitive is the selection in a) to the High Demand projection. In other words, at what annual demand for the High Demand scenario would the company be indifferent between the two size facilities?

6. (20 points)

East Coast Manufacturing, Inc. plans to locate a new production facility in Hartford, Philadelphia, or Baltimore. Six location factors are important: cost per product unit, labor availability, union activities, local transportation, proximity to similar industry and proximity to raw materials. The weighting of these factors, the scale for each factor and the scores for each location are shown below. Different SME’s (subject matter experts) scored each of the non-economic factors. *So, unfortunately, the scores for the non-economic factors are scaled differently. The scales are indicated on the table. On the scale, the highest score is always the best value. For example, for the scale 1-5, the best value is 5.*  For each of the Non-economic factors, it is possible to score the maximum.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Location Factor** | **Factor Weight** | **Scale** | **Hartford** | **Philadelphia** | **Baltimore** |
| *Cost per product unit* | 0.55 |  | $48 | $59 | $52 |
| *Labor availability* | 0.15 | 0-5 | 2.5 | 4.0 | 4.0 |
| *Union activities* | 0.10 | 0-3 | 2.7 | 1.8 | 0.9 |
| *Local transportation* | 0.10 | 0-3 | 1.2 | 2.4 | 2.4 |
| *Proximity to similar industry* | 0.05 | 0-1 | 0.5 | 1.0 | 0.7 |
| *Proximity to raw materials* | 0.05 | 0-1 | 0.7 | 0.6 | 0.4 |

*For the following, calculate all results three decimal place (example, 0.xxx or x.xxx).*

a) Using the factor scoring (or equivalent the factor rating) approach we studied in class and modified as appropriate, which site do you recommend? Why?

b) With everything else remaining the same as in the problem statement, what must the *cost per product unit* for Philadelphia be so that its total factor score is equal to the total factor score for Hartford?7. (17 points)

Students in an operations management class have just received their grades on the first test. The instructor has provided information about the first test grades in some previous classes as well as the final average for the same students. Some of these grades have been sampled and are as follows:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Student** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| **1st Test Grade** | 98 | 77 | 88 | 80 | 96 | 61 | 66 | 95 | 69 |
| **Final Average** | 93 | 78 | 84 | 73 | 84 | 64 | 64 | 95 | 76 |

*Your work must reflect the correct independent and dependent variables based on the problem statements. This is part of the solution that is required.*

a) Develop a linear regression model that can be used to predict the final course average based on the first test grade for these nine students. Provide the correct independent and dependent variables and provide the linear regression relationship in terms of these independent and dependent variables.

b) Predict the final average of a student who made an 83 on the first test.

c) Would you recommend using this relationship for forecasting the final averages? Why? Base your recommendation on the regression analysis you performed and the strength of the relationship.

d) Suppose a student scored a 41 on the first test. Predict the final average of a student who had this score. What cautions would you recommend about using this linear regression relationship for predicting a final average using the information provided in this problem?

8. (21 points)

Data entry clerks at ARCO key in thousands of insurance records each day. They have just completed a new training program and want to establish a control chart based on the results of this training. Each day random samples of the work of the clerks were collected. The results are shown in the table below. Two hundred records were sampled daily and examined for errors. The number of records with errors was counted.

|  |  |  |  |
| --- | --- | --- | --- |
| **Day** | **Number of Records with Errors** | **Day** | **Number of Records with Errors** |
| 1 | 12 | 11 | 12 |
| 2 | 8 | 12 | 10 |
| 3 | 4 | 13 | 8 |
| 4 | 6 | 14 | 10 |
| 5 | 8 | 15 | 10 |
| 6 | 8 | 16 | 8 |
| 7 | 6 | 17 | 10 |
| 8 | 6 | 18 | 11 |
| 9 | 2 | 19 | 9 |
| 10 | 4 | 20 | 8 |

a) You want to set control limits for the proportion of records with errors. Assume that the past twenty days performance is adequate for establishing the control limits and performing the analysis. Using 95% control limits, what are the upper and lower control limits for the proportion of records with errors? Calculate your proportion defective and the lower and upper control limits to 3 decimal places (0.xxx). Assume that the data provided is sufficient for performing a statistical analysis.

b) Plot the control chart and the sample values.

c) What would you conclude about the process, in other words, is the process in control? Explain your decision.

d) Suppose the industry’s lower and upper control limits are 0.020 and 0.060 respectively. What can this insurance company conclude about its process relative to the industry standards?

9. (34 points)

Sharp Discounts Wholesale Club has two service desks with one server at each desk. There is one desk at each entrance of the store. Customers arrive at each service desk at an average of one every six minutes following a Poisson distribution. The average service time at each service desk is 216 seconds per customer following the exponential service distribution.

a) How many customers, on average, are waiting in line for service in front of each service desk?

b) How much total time does a customer spend at the service desk either waiting for help or receiving help?

c) Looking at only one of the service desks, what is the probability that there are at least four customers already waiting in line waiting for service when the next individual arrives at this service desk?

d) Sharp is now considering consolidating its two service desks into one location, staffed by two clerks. The clerks will continue to work at the same individual speed of 216 seconds per customer.

* How many customers, on average, are waiting in line?
* How much total time does a customer spend at the service desk?

e) Do you think the Sharp Discounts Wholesale Club should consolidate the service desks? Explain and your discussion must consider both the economics and the customer service aspects of this waiting line operation. There would be no extra cost for moving the two operations to one operation. The clerks would continue to be paid the same as they were paid at the single desk operation.

f) Suppose that it is no longer required that the clerks be paid the same under either operation. Considering the consolidated operation and based on past work experience one clerk is paid $45 per hour and the second clerk is paid $35 per hour. The estimated cost to Sharp for time a customer is at the service desk either waiting or being helped is $1 per minute. For the two service desk operation assuming that each clerk will be paid the same hourly rate, what is the maximum hourly rate that each of the clerks can be paid under this two service desk operation so that the total cost of the operation is the same for either arrangement? Assume that there is no cost for consolidating the service.