Mansoura University
Faculty of Engineering
Department of Production Engineering and Mechanical Design

Mathematical Modeling of Production Problems (1)

Master Course: Industrial Engineering (2013)

Please solve the next problems. Time allowed 3 hrs.

1-A manufacturing company plans to open a new plant for one of its products. The company can build a full-sized plant now or a small-sized plant that can be expanded 5 years later if high demand conditions prevail. Time horizon of this project is 14 years from now. The company estimates that the probabilities of high and low demands are always 0.80 and 0.20, respectively. Cost of immediate construction of a large plant is \$8 millions. A small plant costs \$3 millions. Expansion of the small plant costs \$6 millions. Building large plant takes 5 months while building small plant takes 3 months which can be expanded later within 3 months. (The company resorts to subcontracting during nonproduction times that costs \$5,000 monthly.) The income from this operation over the next 14 years is given in the next table.

Expansion of the small plant can be analyzed with 1-month market research at \$60,000 regarding the potential demand level. Possible research findings are categorized as: (**1**) favorable research report (*FRR*), i.e. high demand is fairly likely; and (**2**) unfavorable research report (*URR*), i.e. low demand is fairly likely. Previous experience indicates that $P(FRR \setminus High\ Demand) = 0.6$ and $P(FRR \setminus Low\ Demand) = 0.3$. Report and analyze the optimal overall decision.

Decision of Plant Construction	Estimated Annual Income	
	High Demand	Low Demand
Building Large Plant now	\$1,290,000	\$600,000
Building Small Plant now	\$500,000	\$400,000
Expanding Small Plant after 5 years	\$1,350,000	\$450,000

2-A cars' service center has three channels of the same capacity. The cars arriving at the center are of three types. These cars have Poisson arrivals with mean rates 8 cars per 8-hour day for first type, 10 cars per 8-hour day for second type, and 12 cars per 8-hour day for second type. The service time for a car is exponentially distributed with mean 0.5 hour. The center expends \$60 per hour for the facility and manpower. The service costs \$15 per hour. The center introduces this service for \$100 per hour. In addition, a car costs the center \$7 per hour as long as it stays in the center. Suppose that the center has a large space for cars' waiting. Which of the next two alternatives is better for the cars and which is better for the owner of the center? (Show the transition diagram of each case.)

(a) One channel is assigned exclusively for each type of cars.
(b) Three channels handle all types of cars.

3-A machine shop needs 2,000 units/year of a specific spare part. The shop can produce its needs at 5,000units/year. Each unit costs \$40 for production and \$5/year for carrying. The setup cost amounts to \$200. The maintenance strategy allows receiving potential shortages from an outer supplier once at end of the cycle, which costs \$50/unit for price and \$10/unit/year for shortage. (Let Q = production run size, D = annual demand rate, M = annual production rate, S = shortage size per cycle, p = unit production cost, w = unit price from outer supplier, h = holding cost/unit/year, c = shortage cost/unit/year, and A = setup cost.)

a) Construct a model for this inventory system based on *production run size* and *shortage size*.
b) Find the optimal total cost of this system based on the proposed model.

4-A system consists of n series components connected in series with n parallel components. All components are identical and independent in performance. The time to fail T of a component follows the exponential distribution with a failure rate of λ. Find the reliability $R(t)$ and *MTTF* of the system

My best wishes.....Prof. Dr. Hassan Soltan
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