Study Guide for Exam 2

ISE 453: Design of PLS Systems Fall 2018

The exam will be from 11:45 a.m. to 1:00 p.m. It is closed computer. You can bring one 8½ × 11 in. double-sided page of notes and your calculator. Study pp. 248–258 in *Factory Physics* (see library link on webpage; in Fig. 8.3, the low and high distribution labels should be reversed); the parts of ICAs 8–14 and HWs 2 and 3 that can be solved without the use of a computer; and the following problems.

1. Explain why it is usually preferable to use the real, as opposed to nominal, interest rate for most economic analyses.

2. A person is considering purchasing two automobiles. The first car (1) is a Toyoda vehicle and has an initial purchase cost of $28,000, a trade-in value equal to 40% of its initial cost at the end of five years, and it gets 32 miles per gallon. The second car (2) is a Dodge and has an initial purchase cost of $18,000, a trade-in value equal to 20% of its initial cost at the end of five years, and it gets 21 miles per gallon. Assume that the car will be driven 12,000 miles per year for five years, repair costs can be ignored (since both cars will be covered by warranties during the entire five-year period), gasoline costs $3.50 per gallon, and the real cost of capital is 5% compounded annually. (a) Which car is the lower cost alternative? (Ans: Dodge, NPV = $23,838 vs $24,906) (b) What annual mileage would result in the cars having the same cost? (Ans: 16,308)

3. Currently, a manual machine (MM) is being used in the plant to produce widgets. The plant manager would like to know if it is a good idea to replace the manual machine with new automated machine (AM). The operating cost is the sum of the material cost and the labor cost per widget. Although it requires five minutes to produce each widget using either machine, the AM only requires the machine operator for two minutes to load (1 min) and unload (1 min) widgets, while MM requires the operator for the full five minutes. The fully burdened labor rate of the operator is $8.00 per hour, and the operator can perform other productive tasks (valued at ≥ $8.00/hr) when not operating the AM. The current salvage value of MM is $4,000 and the cost to purchase the AM is $15,000. Demand is 7,500 widgets per year, for 15 years. Calculate the following information associated with replacing the MM with the AM:

   (a) What is the payback period (in years) associated with replacing MM with AM? (Ans: 3.67 years)

   (b) What is the net present value (NPV) associated with replacing the MM with the AM, assuming a 12% real cost of capital with annual compounding and that, at the end of 15 years, the salvage value of MM and AM will be $0 and $7,500, respectively? (Ans: $10,802.82)

   (c) If material cost is $0.50 per widget, what is the average cost per widget for both alternatives as a sum of material, labor, and equipment costs? (Ans: $1.24 for MM and $1.03 for AM)

   (d) What is the annual widget demand that would result in both MM and AM having the same cost (i.e., a cost indifference point)? (Answer: 3534.71 widgets)

4. Explain the difference between variability and randomness. (Ans: see FP)

5. Explain the difference between preemptive and nonpreemptive outages. (Ans: see FP)

6. What is more disruptive, short, frequent machine failures or long, infrequent ones? Explain your answer.

7. Each level (or floor) of a new distribution center will hold up to 3200 loads and each load will spend 42 hours at the DC, on average, before it is shipped. If the DC will operate for 112 hours per week and will receive 21,809 loads per week, on average, how many levels are needed for the DC? (Answer: 3 levels)

8. Two alternatives are being considered for the design of new system to create custom fixtures to order. The first, manual design has unit operating and unit capacity costs of $50 and $2, respectively, and the second, automated design has costs of $45 and $8, respectively. The average sales price is $100 per unit, with a 10% reduction in price for every hour of delay in fulfilling an order, and demand is expected to be 12 units per hour and Poisson. Assuming single-machine Poisson processing, which design should be used? (Answer: Manual, since the expected hourly profit for manual is $545.02 vs. $502.03 for automated)

9. A new production system is designed that consists of a single machine with an effective process time of thirty minutes per unit that can be leased for $850,000 per year and will operate at 0.85 utilization for 4000 hours per year, and will hold a maximum of two units in finished goods inventory. The operating costs are estimated to be $250 per unit. Each unit will have a sales price of $450, will be worth 20% of its original value after one month, and the revenue from the sale of each unit will be reduced by 20% after 48 hours of delay in filling an order. Estimate both (a) the expected total hourly profit and (b) the maximum possible profit possible if the design of the system were to be changed. (Answers: (a) $125.37, (b) $159.38)

10. Currently, a workstation has an output rate of 20 nondefective units per hour from a workstation, a yield fraction of 0.80, a natural process time of five minutes, and machines that have a mean time to failure of 20 hours with a mean time to repair of 5 hours. If cost incurred by the maintenance staff each time a machine fails is $18 per hour of repair time and if it has been estimated that it would require 35 total hours of maintenance crew time over the weekend (also at $18 per hour) to reconfigure the layout of workstation in order to reduce the repair time by an hour, what would be the payback period of this project if the workstation operates for 2000 hours per year? (Answer: 2.016 months)

11. Given that the desired output rate from a workstation is 10 nondefective units per hour, the average time between arrivals is expected to be totally random, it takes exactly 12 minutes to process each unit, the yield fraction of the machines is 0.85, with a mean time to failure of 15 hours and a mean time to repair of exactly 2 hours, (a) what is the expected average cycle time associated with minimizing the number of machines required at the workstation and (b) what is the expected work in process at the workstation? (Answers: (a) 0.785353 hours, (b) 9.239442 units)

12. The following information is available as part of the throughput feasible design of a new three-station serial production line. A single product will be produced using a routing of stations 1, 2, and 3, and the line will be designed to meet a maximum demand of 24,000 nondefective units per year, operating for five eight-hour shifts per week, fifty weeks per year. The average time between arrivals is expected to be totally random. For stations 1–3, each machine: costs $65,000, $250,000, and $120,000 per year, respectively; has a yield fraction of 0.85, 0.95, and 0.75, respectively; has a natural process time of 18, 7, and 11 minutes, respectively; the machines never breakdown; and the variance of the natural process time of any machine is equal to the square of its average natural process time. What will be the total machine costs for the line? (Answer: $1,250,000)

13. The desired output rate from a throughput feasible workstation is 192 nondefective units per 8-hr shift. The units arrive to the workstation from an upstream workstation and the standard deviation of the time between arrivals is three minutes. It takes exactly eight minutes to process each unit, the yield fraction of the machines is 0.8, with a mean time to failure of 20 hours and the repair times are totally random with a mean of 4 hours. That material is transferred to the workstation from the upstream workstation using a conveyor. Each unit occupies two linear feet of the conveyor is separated from other units by a six-inch gap. (a) What is the minimum length needed for the conveyor connecting both workstations? (b) Explain the advantages and disadvantages associated with increasing the length of the conveyor between the workstations beyond the minimum length? (c) Explain what changes could be made to the workstation to reduce the required length of the conveyor? (d) If scrap units from the workstation will be placed in a bin that is emptied only once per shift and each unit occupies ten cubic feet, what is the minimum cubic volume needed for the scrap bin? (Answers: (a) 287.12 ft; (b) at the minimum length, the conveyor will be full half the time, forcing the workstation to shut down and block all upstream workstations; (c) decreasing *MTTR*, c_r^2, c_a^2, or increasing *y* or *m*, where increasing *m* is likely to be the most costly change and should be considered only as a last resort; (d) 480 ft^3)