ESD.33 Systems Engineering

Exam 2 – Tools

Due Date: Tuesday, 8 August, 10:30AM EST.

Deliverable: Individual written assignment.

Time allotment: You must do the exam in a single 3 hour block of time.

Grading: This assignment represents 30% of your final course grade. The exam has 100 total points. The two essay questions are worth 40 points all together. The 30 short answer questions are worth 60 points all together.

Essay Questions (2 questions, 40 points total)

In this section you will write two essays on Systems Engineering tools. Your goal is to write essays that are insightful, accurate, specific, to-the-point, and address the questions posed.

1. (15 points) Describe the role of Quality Function Deployment and Pugh Controlled Convergence in Systems Engineering. Your answer should address the following questions as a minimum:

   a. How can multiple rooms of the House of Quality be linked to develop specifications?

   b. What is the relationship between QFD and Pugh Controlled Convergence?

   c. How are these tools used to connect the system level and the subsystem level?

   d. Describe any differences in the use of these tools at different levels of system abstraction.

   e. Select a single strength or weakness of QFD and/or Pugh Controlled Convergence and illustrate it by comparison with an alternative with which you are familiar.

2. (25 points)   Robust design, design of experiments, critical parameter management, and error budgeting are tools for achieving quality and reliability for the customer. <u>Develop a plan</u> for deploying these tools in a specific engineering organization. As a minimum, do the following:

   a. Describe your plan including the timing of the use of these tools, and how/why that timing is important.

   b. Describe how this plan promotes quality and reliability.

   c. Discuss how such a plan will affect interplay of the three cultures of technology development, product development, and production.

   d. Compare the strengths and weaknesses of your proposed plan with an alternative approach with which you are familiar.

NOTE: In your essay, please balance the holistic perspective needed to present an integrated plan with the specific details needed to demonstrate your understanding of the individual tools.

Short Questions (60 points total = 30 questions X 2 points each):

1. In the relationships matrix of the House of Quality, if there is a row with no marks in the matrix, this is an indication that _____.

2. In the relationships matrix of the House of Quality, if there is a column with no marks in the matrix, this is an indication that _____.

3. Imagine a House of Quality for a food processor has two engineering characteristics "Ease of Cleaning" and "Quiet Operation". If an engineer wishes to express the fact that design features that tend to improve "Ease of Cleaning" also tend to make the food processor louder in operation, what should the engineer record in the House of Quality (and where)?

4. In a Pugh concept selection matrix, the rows represent criteria. Name a valid reason for removing a criterion from the matrix even if it is valued by the customer.

5. In a Pugh concept selection matrix, the columns represent concepts and one is selected as a datum. List two attributes of desirable datum concept.

6. According to TRIZ, what are the three most basic categories of resolution of contradictions?

7. A Venetian blind is common window treatment composed of many rows of slats. State the problem it solves as a contradiction.

8. As stated above, a Venetian blind resolves a contradiction. In which of the three basic ways does it resolve the contradiction?

9. When a chain transmission was added to bicycles, it solved the problem of overly large front wheels, but by making the bicycle faster, it caused other problems. Give another example of an invention that was useful but caused problems in a neighboring sub-system.

10. A software program conducts 100 operations in series. Each operation takes an average of one second and has a standard deviation of 0.1 seconds. The standard deviation of the total time required for all 100 operations is

   a) 10 seconds
   b) 1 second
   c) Not enough information has been given
   d) None of the above

11. A variable is normally distributed. What is the probability that it will take a value more than three standard deviations above the mean value?

12. What is the name of the theorem that says that the sum of a large number of variables will tend to be normally distributed?

13. A block is assembled into a bracket as depicted below. The dimensions of the bracket and the block are probabilistically independent with standard deviations indicated in the figure. Will the dimensions of the bracket and the gap be correlated?

$$\sigma = 0.01"$$

$$\sigma = 0.001"$$

gap
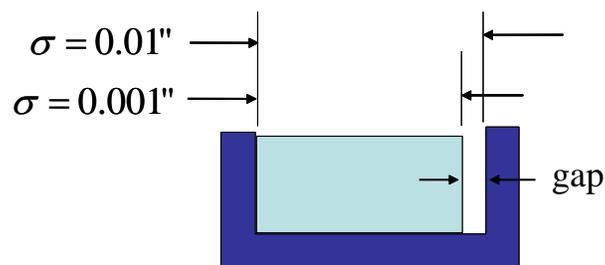
14. A material is cut into cubes. The mean length of each side is one centimeter and has a standard deviation of one millimeter. The expected value of the volume of the cube is

   a) Exactly one cubic centimeter
   b) Less than one cubic centimeter
   c) More than one cubic centimeter
   d) Not enough information is given

15. A study was conducted on the effect of tire pressure on the fuel economy of automobiles. There were 100 cars in the study all with the same car model. The regression R^2 was 0.47. Select all the inferences that can be made:

   a) The effect of tire pressure is not statistically significant at $\alpha=0.05$
   b) Variations in tire pressure account for less than half of the observed variations in fuel economy in this study
   c) Fuel economy is a linear function of tire pressure

16. The process capability index of a system C_p is 2.0. The bias is zero. Approximately what is the yield of the process?

17. The process capability index of a system C_p is 1.0. The bias is $k=1/3$. Approximately what is the yield of the process?

18. Stephan Thomke suggested that to be most effective, firms should combine both new and traditional technologies for experimentation. Normally, should the traditional technologies be used <u>before</u> or <u>after</u> the new technologies? Why?

19. In order to conduct a *full factorial* experiment on a system with 5 control factors each having 3 levels (with no replicates), how many experiments would one would need to conduct?

20. A central composite design is to be conducted to investigate the effects of consolidation time and pressure on the stiffness of a composite material. Sketch the arrangement of the samples in the design space with pressure on one axis and time on the other.

21. In order to resolve only the main effects in a system with 15 control factors each having 2 levels (with no replicates), how many experiments would one would need to conduct?

22. A full factorial experiment was conducted with factor A at three levels and factor B at two levels. If there are no interactions in the system, the factor effect plots could look like (select ALL that are correct):

a

50
40
30
20
10

B+
B-

A

b

50
40
30
20
10

B+

B-

A

c

50
40
30
20
10

B+

B-

A
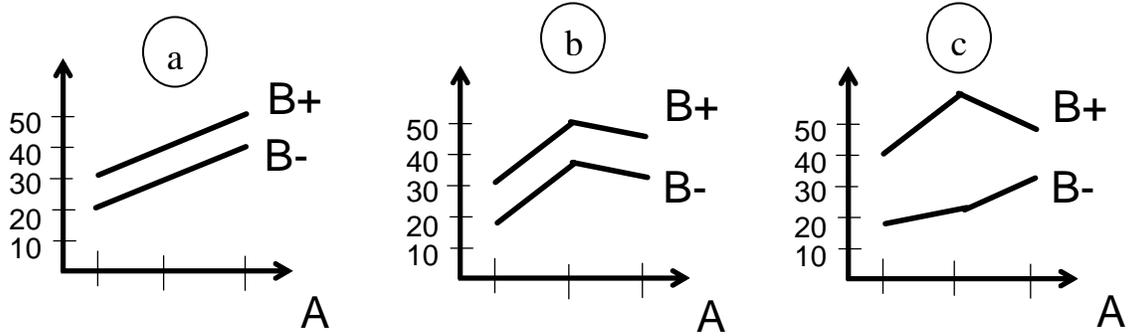
23. Select all the true statements about the matrix experiment below.

   a) the experiment is orthogonal in factors B and C
   b) the experiment below orthogonal in factors A and D
   c) the experiment is an orthogonal array

Expt. No.	Control Factors			
	A	B	C	D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	2
5	2	2	3	1
6	2	3	1	2
7	3	1	3	3
8	3	2	1	3
9	3	3	2	1

24. In robust design, the values of control factors are set by

    a) The designer of the system
    b) The user of the system
    c) The manufacturer of the system
    d) They cannot be set, they vary randomly

25. In robust design, the values of noise factors are set by
    a) The designer of the system
    b) The user of the system
    c) The manufacturer of the system
    d) They cannot be set, they vary randomly

26. Assume a response y is known to be governed by the relationship $y=mx+b$
Further assume a quadratic quality loss function with zero loss at the target value
of $y=0$.   Which settings of m and b among those listed will give the lowest
expected value of quality loss?
    a) $m=3, \ b=1$
    b) $m=1, \ b=3$
    c) $m=2, \ b=2$
    d) $m=0, \ b=5$

27. In robust design as applied to a nominal-is-best response, if a control factor
has no effect on the signal-to-noise ratio but a substantial effect on the mean
value of the response, what useful function might that control factor provide?

28. A crossed array with an 18 run inner array of control factors and a 12 run
outer array of noise factors will require 216 runs. Suggest a way to reduce
the total experimental effort.

29. You run a crossed array design with an orthogonal inner array of control
factors. The analysis suggests that the most robust control factor settings
were not a combination that was previously tested in the experiment. What
should you do?

30. You have carried out robust parameter design of several subsystems and
integrated them into a complete system prototype. What do you suggest as a
next step in the Systems Engineering process?