



**TRAIL
LIFE
USA**

Engineering Systems

Name _____

Do one requirement each from eight of the ten topics below (1-24)

Industrial and Systems Engineering

Industrial engineering involves the development, and optimization of processes and systems. Originally it was focused on manufacturing industries but now includes any field that uses engineering methods to develop or improve systems or processes.

- ____1. **Research Henry Ford’s development and use of the assembly line and do the following:**
 - ____a. Explain when and how the assembly line was used.
 - ____b. Compare a modern assembly line to Henry Ford’s version and list some differences.
- ____2. Perform a trade-off study to compare at least three alternatives with consideration of initial cost, maintenance or annualized replacement cost, and at least three performance characteristics. Use a spreadsheet to assign weighting to each trade parameter and assign numeric values to at least three levels of performance (e.g. Good, OK, Bad). For example, you might perform a trade-off study of backpacking tents using performance characteristics: weight per person, stability in storms, and durability.

System Design and Verification

- ____3. Develop a simple system that you could produce with your patrol, friends, or family by doing the following:
 - ____a. Specify at least three requirements for your system that you can verify by inspection or testing.
 - ____b. Design your system using parts or a kit that you customize in some way.
 - ____c. Build a prototype using the parts or kits specified in your design.

- _____d. Verify that your system meets the requirements you specified.
- _____4. With parental permission and under appropriate adult supervision, disassemble a battery-powered toy that converts electric power to movement. After explaining its design and function to your Mentor, ensure that all parts are still in place, replace and secure the cover, and operate the toy to ensure it works as it did before you removed the cover. Explain the following:
- _____a. How the electric motor uses energy to turn the gears to make the mechanism work
- _____b. How the gears are held in place, and how they are positioned to either transfer motion or change the mechanical advantage
- _____c. The material from which the gears are made
- _____d. The material trade-off between durability, cost, and ease of manufacturing

Engineering Economics

- _____5. Determine the costs involved in making the system you designed in requirement 3. Use the purchase prices for the prototype parts or bulk prices if available. Include any fixed costs for tools or other one-time items, direct labor costs of paying your group to produce these systems, indirect labor costs for paying a manager, overhead costs of your building rent and utilities, employment taxes, and sales tax.
- _____6. Using a spreadsheet program, create a loan amortization table for a loan of \$100,000 paid monthly over a loan period of 5 years with an annual interest rate of 12% compounded monthly. The table should be indexed by month number and include for each month: beginning balance, payment, principal, interest, cumulative principal, cumulative interest, and ending balance. Above the table, should be the loan amount, annual interest rate, interest rate per period (month), and calculated payment.
- _____7. Research how to calculate a break-even point and what is meant by fixed and variable costs.

Information Management

- _____8. Design and implement an inventory tracking database for parts and completed systems for your system design in requirement 3.

- ____9. Design and implement an inventory or checkout database system for Troop equipment or a Troop library using a spreadsheet, database, or TroopTrack. Make sure you have a simple means to uniquely identify each record and associate it to a unique item in the inventory.

Industrial Management

- ____10. Draw an organization chart for a hierarchical organization such as your Troop, church, charter organization, etc. Explain the management structure and position responsibilities and propose a streamlined organization chart.
- ____11. Research the Theory X and Theory Y motivational theories and do the following:
- ____a. Explain each theory as an attitude management holds about employees.
 - ____b. Describe which better describes how your Troop is run.
 - ____c. Compare each theory with the Trailman oath.

Human Factors and Ergonomics

The field of human factors and ergonomics integrates information from engineering, psychology, physiology, biomechanics, anthropometry, and industrial design into systems or products for human use.

- ____12. Evaluate or set-up a computer workstation to fit you based on ergonomic guidelines found in your computer manual, state or federal OSHA web sites, or other sources.
- ____13. Look at a chart containing a diagram of anthropometric data and do the following:
- ____a. List three things in your home that were designed using similar human data.
 - ____b. List three design aspects inside a vehicle that involve human factors.

Reliability

One technique of improving system reliability is to create redundant parallel paths that must all fail for that function to fail. The space shuttle avionics computers were an example of this approach.

- ____14. Research how the five space shuttle computers were used to improve system reliability and:
- ____a. Explain how four were used redundantly to reduce the chance of an error.
 - ____b. Explain what the purpose of the fifth computer was.

- ____15. Simulate two and three parallel paths and compare the resultant number of failures in 20 trials. Have two people simulate one system and three the other. Each person will flip a coin to represent one trial. For the simulated two parallel paths, the system fails if both coins are tails for a trial. For the simulated three parallel paths, the system fails if all three coins are tails for a trial. Keep track of the number of failures and the number of trials. Explain your results to your Mentor.

Simulation

Simulation is a technique of trying out aspects of a system before building it. Writing computer programs or using spreadsheet applications are two valid approaches. Simulations can also be done using objects and people such as the reliability simulation in requirement 15 using people flipping coins to simulate parallel path redundancy benefits in improving reliability.

- ____16. Devise a simulation to determine how to best answer the Monty Hall problem. On **the old Let's Make a Deal game show, the host Monty Hall would show a person three doors. Behind one was a valuable prize. After selecting one door, Monty Hall would have one of the two remaining doors opened, which was always not the prize. Then he would offer to let the person switch their selection to the other unopened door. The question is whether it is better to stay with your initial selection, switch, or it doesn't matter.**
- ____17. Devise a simulation to determine average waiting times for service at a fast food restaurant. Assume that processing each order takes an average of 1 minute. Vary the service times around the average using a uniform distribution (rand is a typical function name) and vary the arrivals around an average rate using a uniform distribution. Graph your results.

Quality

- ____18. PICK stands for Possible-Implement-Challenge-Kill. It is a six-sigma tool for selecting courses of action. Research the PICK chart and use it to select outings and service projects for your Troop, Unit, or Patrol.
- ____19. The Cause and Effect (Fishbone) diagram is a six-sigma tool for finding the root cause of a problem. Research the diagram and use it to find the root cause of a problem in the implementation of a Troop, Unit, or Patrol activity.

Professional Activities

- _____20. Research two famous engineers in systems engineering and report what engineering degrees these engineers earned, their major accomplishments, and what organizations they led or for which they performed significant engineering.
- _____21. With a parent, attend a meeting of a local professional engineering society in your locality related to systems engineering. List any scholarships or special opportunities for youth and young engineers that the Society may sponsor.
- _____22. Modern systems engineering specialties include aerospace, biomedical, chemical, computer, control systems, electrical, electronics, environmental, fire protection, industrial, mechanical, naval architecture and marine, nuclear, petroleum, power, software, systems, and transportation engineering. Choose two specialties you have not used for another Science and Technology Trail Badge and do the following:
- _____a. Describe what type of work is done in those two engineering specialties and how the work of those two specialties is related.
- _____b. Choose one specialty, and explain the education, training, and experience required to serve successfully in that profession.
- _____23. Note: This requirement is listed in multiple Trail Badges, but may only be used for one Trail Badge. Explain what it means to be an Engineer Intern and a Licensed Professional Engineer. List the requirements to become a Licensed Professional Engineer in your state.
- _____24. Note: This requirement is listed in multiple Trail Badges, but may only be used for one Trail Badge. Read the Code of Ethics or Professional Conduct for Professional Engineers for your state (or NSPE Code of Ethics for Engineers if your state does not have one). One role of the engineer is providing society with accurate facts in order to make the best possible decisions.
- _____a. Explain how the code you read relates to the Trailman Oath and good stewardship.
- _____b. List possible consequences to the public if an engineer does not follow this Code.

Trail Badge Mentor Signature

Date

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