



**TRAIL
LIFE
USA**

Engineering Mechanics

Name _____

Do nine of the following requirements from any topic (1-19)

Engineering Mechanics

- ____1. Many engineers use a computer-aided design (CAD) system to help them design their products. Research a CAD software tool (e.g. SolidWorks, CATiA, AutoCAD) and watch an introductory online tutorial for the CAD system chosen. List five types of products designed with it.
- ____2. Using common materials or a kit, make a catapult or trebuchet. Under adult supervision, demonstrate its use at a Troop or Unit meeting. Explain how potential energy is transformed into kinetic energy and motion.
- ____3. Do the following to demonstrate shear force and moment:
 - ____a. Place a deck of cards on the table, and demonstrate shear force by pushing sideways across the top of the deck. Explain what happens to the cards in the deck.
 - ____b. Have someone hold the end of a stick at least four feet long level with the floor, and hang a weight on the stick six inches from his hand. Then, take the same weight and hang it at the very end. The twisting force that is felt by the person holding the stick is called a moment. Explain why the weight exerts a greater moment when it is hung at the end of the stick than next to the hand of the person holding it.
- ____4. Gears are used to provide an increasing mechanical advantage of increasing torque or a decreasing mechanical advantage of increasing speed. Gears may also be used to change the type or direction of motion. Describe the following gear arrangements and list applications where we might see them used.
 - ____a. Gear Train



- _____b. Worm Drive
 - _____c. Bevel Gears
 - _____d. Planetary Gears
 - _____e. Rack and Pinion
- _____5. Bicycle gears are called sprockets and are connected with chains. Mechanical advantage can be experienced on a multi-speed bicycle using derailleur gears where a lower mechanical advantage is harder to pedal, but results in a faster speed for a given pedal revolutions per minute (rpm). Most bicycle sprockets sets are designed for a reduction of mechanical advantage because we design them for increasing speed. The mechanical advantage is the number of front sprocket teeth divided by the number of rear sprocket teeth and represents the fraction of a revolution of the pedals needed to turn the back wheel one revolution.
- _____a. For each possible front and rear sprocket combination of a multi-gear bicycle, compute the following:
 - _____i. Mechanical advantage (ratio of front teeth to rear teeth)
 - _____ii. Bicycle speed at 60 rpm pedaling
 - _____iii. Bicycle speed at 80 rpm pedaling
 - _____b. Test your calculations by maintaining a specified pedaling rpm in one gearing configuration over a specified distance that is accurately timed (e.g. 5th gear at 60 rpm over 1 mile).
- _____6. Build and launch a model rocket and explain the following:
- _____a. Engine thrust
 - _____b. Engine impulse
 - _____c. Ejection charge delay
 - _____d. The key purpose of the rocket nozzle design

Fluid Mechanics

- _____7. Water Pressure. Cut or Drill three holes ($\frac{1}{4}$ inch in size) up and down the side of an empty milk carton; then cover them with a single piece of tape. Fill the carton with water. Predict which stream will be strongest when the tape is removed. Explain what you observe.

- _____8. An airplane wing has an aerodynamic shape called an airfoil. Do the following:
- _____a. Draw a picture of a typical wing cross-section and label the following parts on the airfoil:
 - Leading Edge
 - Trailing Edge
 - Chord Line
 - _____b. Draw a top view of a delta wing and label the following parts. Using your diagram, learn how to graphically find the Mean Aerodynamic Chord (MAC).
 - Root Chord
 - Tip Chord
 - _____c. Explain how airfoils can produce lift for aircraft flight.
 - _____d. Explain the term angle of attack and stall as they relate to airfoils.
- _____9. Participate in a Floatable Moatable troop or unit competition –Using materials, such as a paper bowl, aluminum foil, straws, construction paper, plastic sandwich bags, and masking tape and time provided, construct a free-floating craft. Float the craft in a water-filled container. Without putting your hands over the craft or water surface, load as many marbles as possible into the craft in five minutes.

Thermodynamics

- _____10. Plan and conduct an experiment to demonstrate the differences in heat conductivity between wood, metal and plastic.
- _____11. The first law of thermodynamics (law of conservation of energy) states that if we have a certain amount of energy, it can be converted into different types of energy **but energy can't be created or destroyed. Research the fire piston type fire starter** and do the following:
- _____a. Identify the kinetic energy (energy of an object in motion) and what other energy types are found when using a fire piston.
 - _____b. Explain where the heat comes from.

- _____12. The second law of thermodynamics states that energy will naturally spread out or disperse unless something keeps it from doing so. Therefore it is not possible to raise the temperature of an object or liquid without doing work. Perform the following experiment:
- _____a. Fill a small pot half full with water and bring it to a boil.
 - _____b. Carefully drop several ice cubes into the boiling water being very careful not to splash boiling water on yourself or someone else.
 - _____c. Explain why all the water stops boiling and when it starts to boil again.
 - _____d. Explain where some of the heat from the boiling water was transferred.
- _____13. There are three basic ways heat is transferred: conduction, convection, and radiation. Research these three methods and do the following:
- _____a. Explain each method of heat transfer and give two examples of each method.
 - _____b. Explain why fiberglass used in our home construction is a good insulator.
 - _____c. Explain which heat transfer method fiberglass insulation reduces.
 - _____d. Explain how a convection oven works using convection heating.
 - _____e. Explain why color plays a role in sunlight radiation heat transfer.

History and Professional Activities

- _____14. Create and present a video or presentation to your troop, unit, or other group about the first locomotive including the history, technical challenges, and impact to life.
- _____15. Research two famous engineers in mechanics and report what engineering degrees these engineers earned, their major accomplishments, and what organizations they led or for which they performed significant engineering.
- _____16. With a parent, attend a meeting of a local professional engineering society in your locality related to engineering mechanics. List any scholarships or special opportunities for youth and young engineers that the Society may sponsor.

- _____17. Modern engineering mechanics specialties include agricultural, architectural, aerospace, biomedical, ceramic, chemical, civil, construction, control systems, industrial, materials, mechanical, metallurgical, mining, naval architecture and marine, nuclear, petroleum, structural, 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.
- _____18. 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.
- _____19. 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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