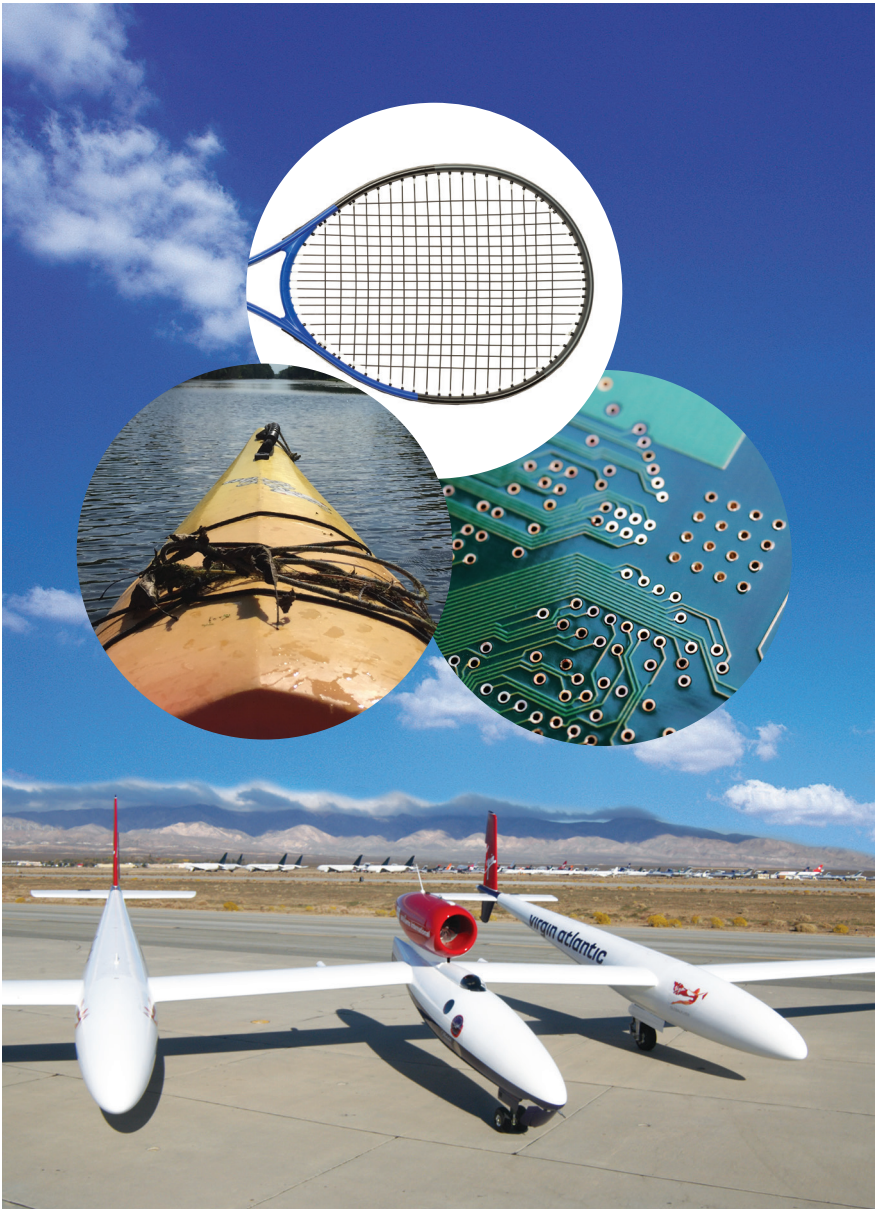
BOY SCOUTS OF AMERICA
MERIT BADGE SERIES

COMPOSITE MATERIALS

"Enhancing our youths' competitive edge through merit badges"

BOY SCOUTS OF AMERICA®



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Requirements

1. Do the following:
   a. Explain to your counselor the most likely hazards you may encounter while working with composite materials and what you should do to anticipate, mitigate and prevent, and respond to these hazards. Describe the appropriate safety gear and clothing that should be used when working with composite materials.
   b. Explain the precautions that must be taken when handling, storing, and disposing of resins, reinforcements, and other materials used in composites. Include in your discussion the importance of health, safety, and environmental responsibility and awareness.
   c. Describe what a safety data sheet (SDS) is and tell why it is used.
2. Do the following:
   a. Explain what composite materials are. Include a brief history of composites and how they have developed.
   b. Compare the similarities and differences between composites and wood, aluminum, copper, and steel. Describe the physical, electrical, mechanical, corrosive, flammability, cost, and other such properties. For each of these raw materials, give one example of how it can be shaped and used for a specific application.
3. Describe how composite materials are made. Then do the following:
   a. Discuss three different composite reinforcement materials, their positive and negative characteristics, and their uses. Obtain the SDS for each one and discuss the toxicity, disposal, and safe-handling sections for these materials.

b. Discuss three different resins used in composites, their positive and negative characteristics, and their uses. Obtain the SDS for each one and discuss the toxicity, disposal, and safe-handling sections for these materials. Include thermoset resins and thermoplastic resins in your discussion.

c. For each of the three resins you chose for requirement 3b, think of a new application that might be worth developing.

4. With your parent's permission and your counselor's approval, do ONE of the following:

   a. Visit a company that manufactures or repairs products made with composites. Discuss what you learn with your counselor.

   b. Find three composites-related websites. Share and discuss what you learn with your counselor.

5. Do the following:

   a. Use composite materials to complete two projects, at least one of which must come from the *Composite Materials* merit badge pamphlet. The second project may come from the pamphlet OR may be one you select on your own that has been approved by your counselor in advance.

   b. With your counselor's assistance, find an appropriate site where the projects can be safely completed under your counselor's supervision and/or the supervision of an adult approved by your counselor who is knowledgeable about composites.

   c. With your counselor, determine how the finished projects will be evaluated. Using those guidelines, evaluate the completed projects with your counselor.

6. Find out about three career opportunities in composite materials. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

Glossary

additive. A material added to a resin to enhance its performance. Additives include colorants and flame retardants.

advanced composite. A composite that is applied in high-performance applications, such as aircraft or military applications.

anisotropic. Materials having different strengths or properties in different directions; a quality of composites.

aramid fiber. A synthetic reinforcing fiber used in body-armor fabric and other applications; short for *aromatic polyamide,* commonly called Kevlar.

carbon fiber. A high-performance, synthetic reinforcing fiber known for its light weight, high strength, and high stiffness. It is produced by "baking" or "charring" rayon, pitch, or acrylic fibers at temperatures above 1,800 degrees Fahrenheit.

casting. A mixture of resin and fillers poured into a mold, usually without fiber reinforcement, and left to cure to form the final product.

closed-mold process. Manufacturing process where reinforcements and resins are closed to the atmosphere and processed in a two-sided mold or within a vacuum bag.

composite, or composite material. A material that is made up of two or more different materials that, when combined, are stronger than the individual materials; generally referred to as *composites.*

compression molding. A closed-mold manufacturing process in which composite materials are compressed between matched molds under high pressure and heat until the part cures. Used for molding large quantities of complex parts.

compressive strength. The ability of a material to resist a crushing or buckling force.

conductive. Capable of transferring electrical current.

crosslinking. The chemical bond that turns liquid resin into a solid material.

curing. The chemical process that converts a resin into a hardened state.

epoxy resin. A thermoset resin having excellent strength, adhesion, and corrosion protection.

exothermic. The quality of resin to give off heat when it cures.

fabric. Arrangement of fibers held together in two dimensions.

fiber. Slender, threadlike material that is much longer than it is round and is an individual strand in a fabric.

fiber-reinforced polymer (FRP) composite. Material in which a polymer resin contains reinforcing fibers providing greater strength and stiffness than either the resin or fiber alone. *FRP composite* is a more specific term than the general word, "composites." Sometimes referred to as *advanced composites.*

filament. A single element in a fiber; the smallest unit of a fibrous material.

filament winding. An open-mold manufacturing process that applies resin-saturated, continuous strands of fiber reinforcements over a rotating cylindrical mold; used for creating hollow products like rocket motor casings, pipes, and chemical storage tanks.

filler. A material added to resins to improve the appearance and performance of composites and lower the cost.

gel coat. The outermost surface layer of resin; a special polymer resin that enhances the surface appearance and performance of composites.

glass fiber. A fiber made from molten glass (silica, sand, limestone, and other minor ingredients), available in several types such as A-glass, E-glass, S-glass, and C-glass. Also called *fiberglass.*

hand lay-up. An open-mold manufacturing process in which a reinforcement is applied to the mold by hand and resin is applied with a brush or roller onto the reinforcement.

hardener. A chemical added to a thermoset resin to cause a curing reaction.

honeycomb. A manufactured core material of resin-saturated sheet material formed into six-sided cells or openings and used in sandwich construction.

hybrid composites. A composite laminate of two or more different fiber reinforcements, such as glass and carbon fiber, combined in a single structure.

impact strength. The ability of a material to resist an abrupt or shock load.

initiator. A hardener, sometimes called a *catalyst,* that causes the cure of a thermoset resin.

isotropic. Having uniform properties in all directions; a quality of metal.

laminate. Two or more layers of fiber reinforcement bonded together with a resin.

material safety data sheet (MSDS). A document that includes detailed information on a material, including health and physical hazards, exposure limits, and precautions.

mil. A unit of measurement that defines the diameter of glass fibers (1 mil = 0.001 inch).

mold. A tool for forming composite materials into the desired shapes or parts.

monomer. A single molecule that is a constituent of a polymer.

nonconductive. Incapable of transferring electrical current.

open-mold process. Manufacturing process where reinforcements and resins are exposed to the atmosphere.

ply. A term used to describe a single layer of reinforcement in composites.

polymer. A large molecule made up of many units that are linked together in a chain. Polymers can be naturally occurring, such as starch, or synthetic, such as polyester.

prepreg. A reinforcement that is saturated with resin and ready to use for molding; short for "preimpregnated," meaning the fibers have been presoaked with resin.

pultrusion. A closed-mold manufacturing process to form composites into long, consistent shapes like rods or bars. Continuous strands of reinforcement are pulled through a resin bath to saturate them, then pulled through heated steel molds that shape the composites into continuous lengths. Pultruded products include fishing rods and golf club shafts.

reinforcement. A term for fibers, particles, or "whiskers" (thin hairlike materials) used in composites. Fibers are the most common reinforcement in composites and greatly influence composites' properties.

resin. A polymer (plastic) that binds together reinforcing material in a composite.

resin transfer molding. A closed-mold manufacturing process in which reinforcement material is placed in a closed mold, into which resin is injected under pressure.

roving. A loose bundle of untwisted yarns or strands of a reinforcing material.

sandwich construction. Two relatively thin laminate sheets ("face skins") bonded to a lightweight core material such as honeycomb, balsa, or varieties of foam.

solvent. A liquid substance capable of dissolving or dispersing other substances. In working with polymer resins, solvents such as acetone are commonly used for cleanup.

spray-up. An open-mold manufacturing process in which a chopper gun is used to chop reinforcement material and add it to resin, which is then sprayed onto a mold. This process is used in boat manufacturing.

storage life. The period of time during which a liquid resin, initiator, or other chemical can be stored under specified temperatures and remain suitable for use. Also called *shelf life.*

strand. A bundle of filaments, normally untwisted.

tensile strength. The ability of a material to resist forces that stretch the material.

thermoplastic resins. Resins that are not crosslinked and so can be melted, formed, remelted, and re-formed.

thermoset resins. Resins that are converted from a liquid to a solid through irreversible crosslinking.

vacuum bag molding. A closed-mold manufacturing process in which a vacuum is created to force the laminate against a mold, thus removing trapped air and excess resin and compacting the laminate.

vinyl ester. A type of thermoset resin related to epoxy resin and commonly used in corrosion protection.

wet-out. The process of thoroughly saturating reinforcements with resin.

yarn. A twisted bundle of continuous filaments, fibers, or strands, used for weaving fabric reinforcements.

Composite Materials Resources

Scouting Literature

Chemistry, Engineering, Inventing, Model Design and Building, Robotics, and *Space Exploration* merit badge pamphlets

Books

Marshall, Andrew C. *Composite Basics,* 7th ed. Marshall Consulting Publishing, 2005.

Rutan, Burt. *Moldless Composite Sandwich Aircraft Construction.* Rutan Aircraft, 2005.

Strong, A. Brent. *Fundamentals of Composites Manufacturing: Materials, Methods, and Applications.* Society of Manufacturing Engineers, 2007.

With your parent's permission, visit the Boy Scouts of America's official retail website, www.scoutshop.org, for a complete listing of all merit badge pamphlets and other helpful Scouting materials and supplies.

Periodicals

Composites Manufacturing
American Composites Manufacturers Association
Telephone: 703-525-0511
Website: www.acmanet.org/cm-magazine

Composites Technology
Gardner Publications Inc.
Telephone: 513-527-8800
Website: www.compositesworld.com

Organizations and Websites

American Composites Manufacturers Association
Website: www.acmanet.org

American Society for Composites
Department of Civil and Environmental Engineering and Engineering Mechanics
University of Dayton
Website: www.asc-composites.org

Center for Composite Materials
University of Delaware
Telephone: 302-831-8149
Website: www.ccm.udel.edu

CompositesWorld
Website: www.compositesworld.com

MSDS Online
Website: www.ilpi.com/msds

NetComposites
Website: ww.netcomposites.com

Occupational Safety and Health Administration
Toll-free telephone: 800-321-6742
Composites safety website:
www.osha.gov/SLTC/composites/index.html