AMT 2106 –AIRCRAFT MATERIALS CONSTRUCTION AND REPAIR II
(Composite)

PRELIM PERIOD

LABORATORY MODULE II

REINFORCING MATERIALS

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REFERENCES	Ref no.
Fiber Max(2018) retrieved from https://www.fibermaxcomposites.com/shop/index_files/typesofcore.html	**1**
General Plastics Manufacturing (march 2020) retrieved from https://www.azom.com/article.aspx?ArticleID=18971	**2**

This module briefly discusses, one of the element of the composite focuses in the reinforcing materials, descriptions and its corresponding advantages when apply to aircraft structure. This module also addresses the assessment that show construction and orientation of the fabric because all design, manufacturing, and repair work begins with the orientation of the fabric.

TIMEFRAME

You should be able to complete this module including all the self-assessments, research works, assignments, and other performance tasks within **3** hours.

LEARNING OUTCOMES

Course Learning Outcomes (CLO)

CLO 1. Understand the development of the composite structure and classify its element in terms of properties , advantages and characteristics of each elements.

CLO 3. Produce clearly written, thorough and concise reports with well-founded analysis and conclusions, that explains the operation, applications of the composite structures to the aircraft

CLO 6. Exercise and demonstrate the proper mixture of the resin to reinforcing material and practice its standard ratio, application of heat and pressure and handling of different tools and equipment

CLO 9. Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria, methods and techniques.

Module Learning Outcome (MLO)

MLO 1. Exhibit memory of previously learned material by classifying different reinforcing materials by given characteristics or properties.

MLO 2. Labeling the parts of fabric and illustrate style and hybrid of the fabric being use

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Topic Learning Outcomes(TLO)

TLO 5.. Evaluate proper measurement of resin to fiber mixture ratio and proper handling and storage of the materials, laboratory requirements and standard

LABORATORY MODULE II: REINFORCING MATERIALS

COMMON TYPES OF FIBER REINFORCEMENT

FIBER GLASS

Fiberglass is an attractive, lightweight (when compared to non composite products), durable material. When fiberglass is impregnated with epoxy resin, the resulting composite has high tensile strength and is stronger than steel on an equal weight basis. This high strength for its relatively low weight is the primary reason why fiberglass composites became so popular, and are widely used for many decades now. Glass fiber can be combined with other fiber material such as Kevlar/Aramid creating a hybrid fabric. This way the properties of the composing fibers are enhanced by synergy.

Fiberglass reinforcements are classified according to their properties. There are six major types of glass used to make fibers.

- E-glass is the most common type used for fiberglass production today (more than 50% of the fibers made are from E-glass.) ‘E’ implies that it is an electrical insulator. It is inexpensive and appropriate for general purposes.

- S-glass, S2-glass, (‘S’ comes from Strength,) is (15%-25%) stronger than E-glass, has higher modulus, improved mechanical properties, higher melt temperature and is considerably more expensive.

- C-glass or T-glass is very resistant to chemicals and corrosion.

Fiberglass’ main properties are:
- Dimensional stability
- Moisture resistance
- High strength
- Fire and heat resistance
- Chemical resistance
- Electrical insulation
- Freedom of design
- Good acoustic and vibration insulation
- Good fatigue resistance
- Very good resin adhesion

Fiberglass is widely used in applications such as:
- Automotive: Body parts for trucks and buses, roofs, air fairings, side fairings, doors.

- Aerospace: Interior panels, wall, separators, toilet compartments and furniture.
- Marine: Boat hulls, decks, internal and external components.
- Windmill blades.
- Military – defense: Protective equipment e.g. armor, helmets, clothing, vehicles, radomes.
- Construction: Structural reinforcement, roofing laminate, canopies, swimming pools and spas, hot tubs.
- Electrical and telecommunications industry: printed circuit board, insulation components.
- Sports: Surfboards, kayaks, beach rackets, bicycles, masts.
- Tubes, pipes and other profiles.
- Machinery and equipment enclosures.
- Storage tanks.

ARAMID FIBER

Aramid fiber, or known by many as Kevlar (DuPont's brand name,) belongs in a family of synthetic products characterized by strength (some five times stronger than steel on an equal weight basis) and heat-resistance (some more than 500 degrees Celcius). It is appropriate for various applications such as composites, ballistics, aerospace, automotive, protective clothing against heat/radiation/chemicals, asbestos substitute, telecommunications (optical fiber cables) and many other.

The word aramid comes from a blend of the words "aromatic" and "polyamide" and is a general term for a manufactured fiber in which the fiber forming substance is a long chain synthetic polyamide, in which at least 85% is of amide linkages (-CO-NH-) attached directly to two aromatic rings, (as defined by the U.S Federal Trade Commission.)

ARAMID PROPERTIES

Fiber structure: A series of synthetic polymers in which repeating units containing large phenyl rings are linked together by amide groups. Amide groups (CO-NH) form strong bonds that are resistant to solvents and heat. Phenyl rings (or aromatic rings) are bulky six-sided groups of carbon and hydrogen atoms that prevent polymer chains from rotating and twisting around their chemical bonds.

Fiber properties: They are characterized by medium to ultra-high strength, medium to low elongation and moderately high to ultra-high modulus with the densities ranging from 1.38g/cm3 to 1.47g/cm3

Chemical properties: All aramids contain amide links that are hydrophilic. However, not all aramid products absorb moisture the same. The PPD-T (poly-phenylene terephthalamide) fiber has very good resistance to many organic solvents and salt, but strong acids can cause substantial loss of strength. Aramid fibers are difficult to dye due to their high Tg. Also, the aromatic nature of para-aramid is responsible for oxidative reactions when exposed to UV light, that leads to a change in color and loss of some strength.

Thermal properties: Aramid fibers do not melt in the conventional sense but decompose simultaneously. They burn only with difficulty because of Limited Oxygen Index (LOI) values. It should be mentioned that at 300oC some aramid types can still retain about 50% of their strength. Aramids show high crystallinity which results in negligible shrinkage at high temperature.

Mechanical properties: Aramid yarn has a breaking tenacity of 3045 MPa, in other words more than 5 times than this of steel (under water, aramid is 4 times stronger) and twice than this of glass fiber or nylon. High strength is a result of its aromatic and amide group and high crystallinity. Aramid retains strength and modulus at temperatures as high as 300oC. It behaves elastically under tension. When it comes to severe bending, it shows non-linear plastic deformation. With tension fatigue, no failure is observed even at impressively high loads and cycle times. Creep strain for aramid is only 0.3%.

To sum up, aramid general characteristics are:

- High strength
- Resistance to absorption
- Resistance to organic solvent, good chemical resistance
- No conductivity
- No melting point
- Low flammability
- Excellent heat, and cut resistance
- Sensitive to acids and ultraviolet radiation

Aramid fiber applications are divided into two categories: A) Reinforcement in composites like sport goods, aircraft, military vehicles and many other. B) Fabrics in clothing such as fire protection clothes or bullet proof vests. More elaborative uses of aramid are:

- Various forms of composite materials
- Sail cloth
- Snowboards
- Protective gloves, helmets, body armor
- Filament wound pressure vessels
- Flame and cut resistant clothing

- Asbestos replacement
- Ropes and cables
- Optical fiber cable systems
- Jet engine enclosures
- Tennis strings and hokey sticks
- Wind instrument reeds
- Reinforced tyres and rubber goods
- Circuit board reinforcement

Although every application meets its own requirements, almost all of them share aramid's major characteristics: high strength, high modulus, high toughness, thermal dimensionality stability, low creep and light weight.

ARAMID ADVANTAGES AND DISADVANTAGES

Aramid main advantages are high strength and low weight. Like graphite, it has a slightly negative axial coefficient of thermal expansion, which means aramid laminates can be made thermally stable in dimensions. Unlike graphite, it is very resistant to impact and abrasion damage. It can be made waterproof when combined with other materials like epoxy. It can be used as a composite with rubber retaining its flexibility. High tensile modulus and low breakage elongation combined with very good resistance to chemicals make it the right choice for different composite structural parts in various applications.

On the other side, aramid has a few disadvantages. The fibers absorb moisture, so aramid composites are more sensitive to the environment than glass or graphite composites. For this reason, it must be combined with moisture resistant materials like epoxy systems. Compressive properties are relatively poor too. Consequently, aramid is not used in bridge building or wherever this kind of resistance is needed. Also, aramid fibers are difficult to cut and to grind without special equipment (e.g. special scissors for cutting, special drill bits). Finally, they suffer some corrosion and are degradated by UV light. For this reason they must be properly coated.

CARBON FIBERS

Carbon fibers have high tensile strength, and are very light and very stable. Carbon crystals are bonded together in a chain, creating a very strong material, which compared to steel is 5 times stronger on an equal weight basis. Carbon fiber diameter is very small, it ranges from 5-10 microns. Production and consumption of carbon fibers has grown recently because of their great mechanical properties. High manufacturing cost is balanced by its high strength in both tension and compression, and high resistance to corrosion, creep and fatigue, low weight and high performance.

Woven Carbon fabric is used in various applications like marine, sporting goods, defense and many others. The two most common weaving styles are «plain» and «twill». Both have an equal amount of carbon fiber going each direction, and their strengths are quite similar. Other styles are satin, unidirectional, biaxial. Alternatively, fabrics can be added to a resin system (like epoxy) that hardens, and this way structural composite parts are formed. Since resin systems are strong low density materials, the composite part is also very strong and light-weight at the same time.

The dominant raw material for carbon fiber manufacturing is polyacrylonitrile (PAN), pitch follows, and a very small amount of carbon fibers are derived from rayon.

Carbon fibers are usually grouped according to the modulus or strength band in which their properties belong. These bands are commonly referred as: high strength, intermediate modulus, high modulus and ultra high modulus etc. These references for carbon fiber quality are not very clear, as different companies that produce different qualities may consider or evaluate certain quality differently. PAN fiber density ranges from 1.75gr/cm3 to 1.90gr/cm3. PAN tensile strength can be as high as 1000Ksi.

Over other materials, carbon fiber offers many advantages. The main advantageous characteristics are:

- High strength
- Light in weight
- Corrosion resistance
- Excellent creep resistance
- Good thermal and electrical conductivity
- Compatible with most resin systems
- Very high dimensional stability
- Low thermal expansion coefficient
- X-ray permeability

CARBON FIBERS APPLICATION

Carbon fiber is preferred to many applications, as it outperforms many other fiber materials. It is mainly used to high quality products to replace fiberglass, wood or alloys, as it offers lower weight, higher stiffness and better fatigue resistance. Also, as attention on environmental issues is increasing, carbon fiber use has grown. For instance, carbon fiber can reduce the vehicle weight and consequently fuel consumption. At the same time, composite product manufacturing has much less carbon footprint than metal (product) manufacturing, so this way there is an additional, (not so obvious to realize) positive impact on the environment.

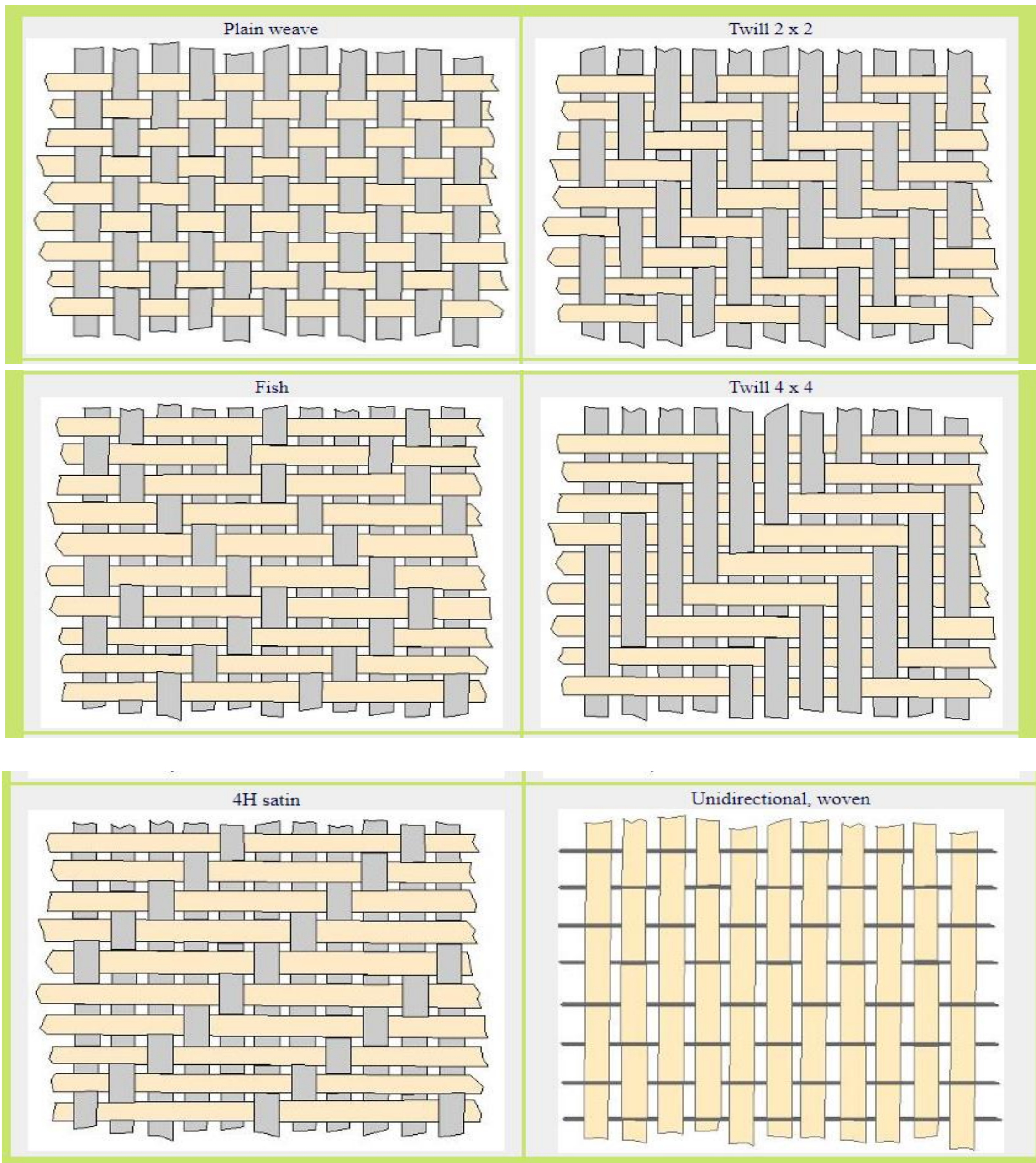
Examples of carbon manufactured products are:

- Sporting goods: Surf boards, bikes, fishing rods, tennis rackets, hokey sticks, running shoes.
- Automotive – motor racing: Bodywork parts (like doors, hoods etc,) structural components (like chassis,) mechanical (like drive shafts) and protection (like helmets, shock absorbers.)
- Marine: Manufacturing of boats, yachts and ships, structural and non structural parts.
- Defense and aerospace: Aircrafts, vehicles, armor etc.
- Musical instruments: Guitars (and other stringed,) drums, as well as wind instruments.
- Wind industry: Turbine blades.
- Electronic fields: Printed circuit, house electronic equipment, PCs, camera bodies.
- Medical science: Wheel chairs, artificial body parts, x-ray transparent operation tables.
- Construction: Bridge building, building close to sea and harsh weather conditions, old building rehabilitation.
- Environment and energy fields: Fuel batteries, oil industry.

Due to carbon fibers great properties, a significant growth in the carbon fiber market is expected. For any application, in order to produce high quality products with carbon fiber, high skills and technical equipment are required.

WEAVING STYLES

Weaving styles are not only changes on the appearance of fabrics. More or less, they affect handling, processing and laminate characteristics. The following table outlines and compares the general properties of the fabric weaving styles offered by FIBERMAX COMPOSITES.


Plain weave
Twill 2 x 2
Fish
Twill 4 x 4
4H satin
Unidirectional, woven

PRELIM LABORATORY ACTIVITY 2

Name		Instructor	
Section		Date:	
		Rating:	

MODULE I-IDENTIFYING FIBERS

LABORATORY OBJECTIVE:

- To students should be able to identify and familiarized what types of fibers are being described.

TOOLS NEEDED:

- Activity sheet
- Pen

Time Limit: 10 - 20 minutes

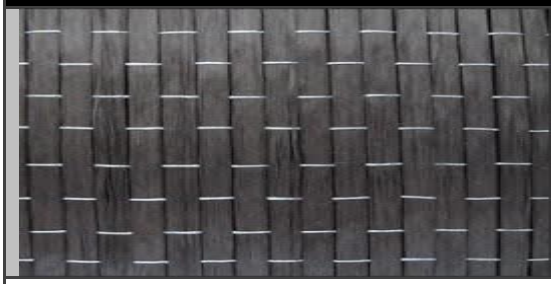
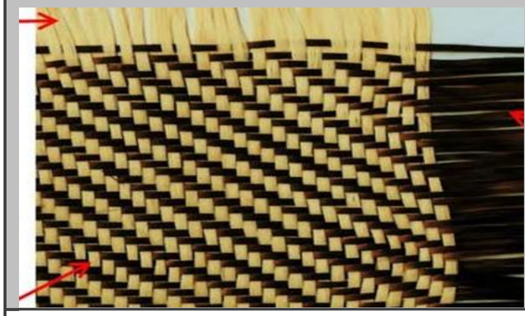
Instructions:

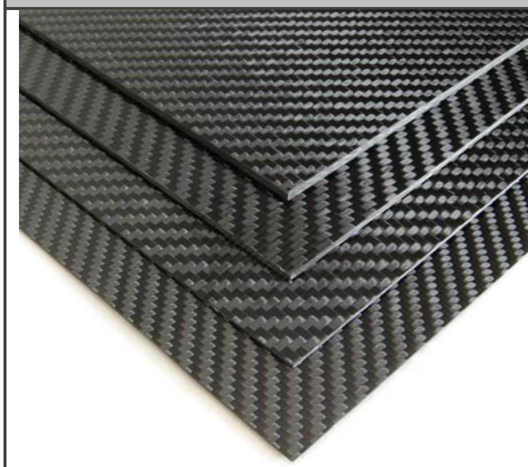
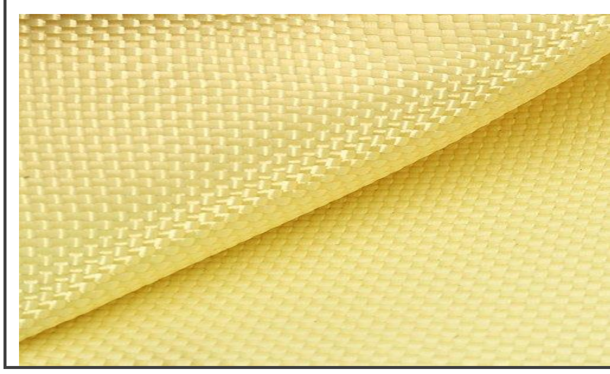
Part I: Read carefully the statement below, and base on the discussion earlier . Put a letter **FF** if the corresponding statement describing Fiber Glass Fiber; **AF** if the corresponding statement describing aramid Fiber, and **CF** if the corresponding statement describing Carbon fibers.

_____**1.** High manufacturing cost is balanced by its high strength in both tension and compression, and high resistance to corrosion, creep and fatigue, low weight and high performance.
_____**2.** This high strength for its relatively low weight is the primary reason why composites became so popular, and are widely used for many decades now.
_____**3.** High tensile modulus and low breakage elongation combined with very good resistance to chemicals make it the right choice for different composite structural parts in various applications.
_____**4.** Advantages to this materials are in their high compressive strength and degree of stiffness.
_____**5.** Another important advantage is its strength-to-weight ratio; it is very light compared to other composite materials.
_____**6.** This fibers an attractive, lightweight (when compared to non-composite products), durable material.
_____**7.** This fibers do not melt in the conventional sense but decompose simultaneously.

_____**8.** This fibers is ideal for use in aircraft parts that are subject to high stress and vibration.
_____**9.** One of the disadvantages is that it weighs more and has less strength than most other composite fibers.
_____**10.** fiber diameter is very small, it ranges from 5-10 microns.

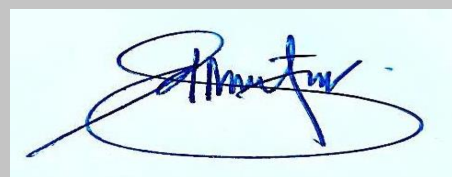
Part II – Identify the following figure what kind of style and hybrid of fabric is being shown. Or leave it blank if the figure does not represent any.

Figure	Types of fibers being used	style	Hybrid
	11	12	13
	14	15	16
	17	18	19
	20	21	22

	23	24	25
	26	27	28
	29	N/A	30

HONESTY CLAUSE

My signature below constitutes my pledge that all of my writing is my own work, with the exceptions of those portions which are properly documented



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Subject Instructor

Student Signature	Parent Signature