Syllabus

Course name: Manufacturing with renewable materials 1.

Course number: WSE 461/561.

Course credits: Four. The course meets four hours per week in lecture.

Prerequisites: WSE 210, WSE 321, WSE 322, WSE 324, or graduate standing

Course content: Manufacturing renewable materials such as wood, bamboo, hemp, and cereal straws into products requires size reduction and separation of components. The components are then further processed, in many cases by joining with glue or fasteners, to create a usable product. The major processing steps for the conversion of raw materials into products will be discussed.

Measurable student learning outcomes for WSE 461:

Week 1 - Recall the various plant-based raw materials that are used in manufacturing and identify and measure products.
   Identify potential sources of each raw material.
   Describe the advantages and disadvantages of each raw material.
   Select the type of products for which each raw material is suited.
   Calculate the amounts of material expressed on a volume or weight basis using units customary to the trade.
   Calculate weight, volume, bulk density, or moisture content from known information.
   Recall and recognize products that are derived from renewable plant-based materials.
   Identify the raw material from which the product is made.
   Describe the advantages and disadvantages of each product.
   Select the product(s) suited for an application.
   Express product quantities using units customary to the trade.
   Identify the standards that apply to various products and describe the testing that occurs to meet these standards.
   Describe the role of the ALS and Agencies in creating and monitoring lumber grades.
   Read all the information on a lumber grademark.
   Read all the information on a structural panel grademark.
   Describe the role of the product standards and Agencies in creating and monitoring the grades for structural panels.
   Describe the process for certifying a structural product such as a glulam beam.
**Week 2** – Describe how wood is machined and how wood and tool factors impact the surface quality, energy, and production speed.
- Contrast orthogonal and peripheral milling
- Identify the angles and describe geometries associated with knives and teeth.
- Describe how cutting direction impacts knife and tooth geometry.
- Describe orthogonal machining.
- Explain how the angles associated with knives and teeth affect the quality of a machined surface, cutting forces, and energy.
- Explain how various material factors affect the quality of a machined surface cutting forces, and energy.
- Recognize chip types to diagnose machining problems.
- Identify common surface defects and describe how to prevent them
- Define the terms kerf, clearance, and set.
- Identify the type of set in a saw.
- Describe why a saw is tensioned, how tensioning is accomplished, and the effect on saw stability.
- Briefly describe the steps involved in the sharpening process
- Describe the common types of saw teeth.
- Perform calculations among variables such as maximum the speed of a saw, gullet size, kerf, tooth pitch, and depth of cut.
- Contrast up milling with down-milling.
- Describe the controllable factors affecting surface quality.
- Describe the major abrasive types and their uses.

**Week 3** - Explain the initial steps in processing plant-based materials to prepare them for manufacturing.
- List the principle reasons for debarking logs.
- Describe the equipment used to remove bark from logs and the advantages and disadvantages of each type.
- Identify factors that affect the ease of bark removal.
- For a species and diameter, be able to estimate the quantity of bark to be removed.
- Name and briefly describe several methods of log scaling.
- Predict how factors such as log weight, diameter, and length affect overrun.
- Describe systems for handling non-log raw materials.
- Describe and compare systems for storing non-log raw materials.
- Explain how materials are screened and how screen size is specified.
- Know the steps to convert logs into roundwood which can then be manufactured into products such as posts, poles, and pilings.

**Week 4/5** - Describe how logs are broken down into lumber, veneer, and particles and calculate yields for each.
- State how logs are measured at the bucking operation for veneer.
- Describe how log bucking impacts lumber recovery.
- Contrast the major differences between a small- and large-log sawmill.
- Illustrate a likely cutting pattern for large grade logs.
Illustrate a likely cutting pattern for common grade logs.
Describe a cutting bill.
List four factors affecting the breakdown of a small log for maximum yield.
Describe types of saw stations used after the headrig.
Explain the principles behind and benefits of curve sawing.
Discuss the advantages and disadvantages of chipping edgers, gang edgers, top-arbor, bottom-arbor, and double-arbor edgers.
List the types of bands saws and identify where they are most often used in the Explain the function of a laser line.
Describe the impacts of sweep and crook on lumber recovery.
Calculate the volumes of lumber, sawdust, and chips expected from a log.
State how logs are measured at the bucking operation for veneer.
Describe how log bucking impacts veneer recovery.
Discuss the advantages and disadvantages of lathe types
Explain how veneer is measured for defects.
Describe how veneer is graded, both by humans and machines.
Recall the heating process for veneer logs and recognize how it impacts veneer quality and cutting forces.
Describe the impacts of sweep and crook on veneer recovery.
Identify the parts of a lathe and describe the function of each part.
Describe how wood factors impact the manufacturing of veneer.
Contrast the differences between types of chippers.
Explain factors that contribute to chip quality and the importance of size.
Contrast the differences between types of flakers.
Explain factors that contribute to flake quality and the importance of size.
Describe how logs orientation affects the operation of flaking equipment
Contrast the differences between types of hogs.
Describe stone grinding, its advantages and disadvantages, and the type of fiber that results.
Describe the roles of heat and moisture in the refining process.
Describe the preparation of non-wood fibers.
Tell how bast fibers are separated.
Discuss storage requirements for other fibers and contrast to wood.

Week 5 - Determine the energy requirements for dryers, estimate drying times, and identify the impact of drying on product quality.
Describe how temperature, humidity, and air velocity affect drying.
Know how the size and orientation of the material affects the drying rate and material temperature.
Know how temperature, humidity, air velocity, and moisture content are measured in industrial dryers.
Describe the types of dryers used for renewable materials.
Match the type of material with the appropriate type of dryer.
Calculate the energy required to dry a material.
Calculate the quantity of fuel needed to dry a material.
Describe how drying can impact the quality of lumber, veneer, and particulates.

Week 6 - Identify the steps in the manufacturing of a composite and how processing factors impact product quality.
- Describe the theories of adhesion
- Describe the process of wood adhesion
- Recall and describe the adhesives used in wood composites production
- Make preliminary diagnoses of wood adhesion problems
- Explain basic definitions and concepts in wood-based composites (laminated, strand, particulate and fiber products).
- Describe raw materials, basic manufacturing processes, equipment, operations, and key process parameters used in production of composite products from renewable materials.
- Explain the impact of various raw material characteristics and process parameters on the properties of the composite product
- Describe how raw material properties impact the pressing process.
- Identify the important press parameters and describe how they impact product properties.
- Describe how prepared raw materials, such as veneer and flakes, are formed into a mat.
- Diagram how the density, temperature, and moisture profiles change in a composite during pressing.
- Describe an extrusion process.
- Describe a molding process.
- Identify products that are petroleum based but contain fibers from natural materials as reinforcing.

Week 7 – Describe how products are finished after drying.
- Describe what a planer does.
- Contrast different types of planers.
- Know how wood factors, such as moisture content and specific gravity affect surface quality and planer speed.
- Describe how lumber is visually graded, both by humans and machines.
- Describe how lumber is machine graded and the factors that affect grade.
- Recall the principle methods for measuring moisture content in dry lumber.
- Diagram the operations in a sawmill in the correct order.
- Diagram the operations in a panel production in the correct order.

Week 7/8 - Describe the manufacturing of paper from fibers.
- Tell the differences between softwood and hardwood in terms of papermaking
- Recall the major types of pulp and the uses for each.
- Find standards for paper products
- Recall two chemical pulping methods: sulfite pulping and kraft pulping.
- Diagram the step in the sulfite pulping process and the inputs and outputs to each.
Diagram the step in the sulfate pulping process and the inputs and outputs to each.

Compare and contrast bleaching methods.

Diagram the steps in papermaking

Recall several important products from pulp such as linerboard, newsprint, stationary, bag, towel, and napkins.

Know the basic properties by which paper is measured.

Recall differences in mill configuration when converting recycled paper compared to chips to new paper products.

Find standards for paper products.

Describe differences in the equipment and techniques for producing paper from non wood fibers.

**Week 9** – Describe how wood is modifies and/or constructed to improve performance in service.

Describe the equipment used to treat renewable materials to modify their properties.

Recall the common, currently used wood preservatives and fire retardants.

Describe the common treatment processes used to treat wood.

Find standards for treated products.

Describe treatments used to modify hygroscopicity and shrinkage. (PEG, CHOH, MeOH etc).

Draw how products are constructed to account for hygroscopicity.

Determine when a part can be restrained and when it should be unrestrained.

Describe the two functions of a joint.

Recall joint names from drawing or samples.

Compare clapping systems.

Compare and contrast clamping and RF curing systems.

Discuss nail and screw withdraw (diameter, depth, grain orientation, and material specific gravity).

Determine lead and pilot hole size from screw size and workpiece specific gravity.

Describe the nail types and screw types and their application.

**Week 10** – Outline the processes of adding a synthetic surface to plant-based products, dust collection, and unitizing.

Recall the four purposes for finishing product surfaces.

Describe the five pre-finishing steps.

Discuss filler types.

Compare and contrast spray application systems.

Compare and contrast the types of top coats.

Discuss the use of powder coatings on non-metal surfaces.

Compare and contracts types of dust collection equipment.

Discuss the steps involved in preparing a product for shipment and protecting it during shipment.
Additional measurable student learning outcomes for WSE 561:

**Week 1** - Recall the various plant-based raw materials that are used in manufacturing and identify and measure products.
  - Describe the legal authority associated with a grademenk.

**Week 2** – Describe how wood is machined and how wood and tool factors impact the surface quality, energy, and production speed.
  - Summarize the important substrate-tool factors in other machining operations.

**Week 3** - Explain the initial steps in processing plant-based materials to prepare them for manufacturing.
  - Compare and contrast several methods of log scaling.

**Week 4/5** - Describe how logs are broken down into lumber, veneer, and particles and calculate yields for each.
  - Be able to describe four types of headrigs and when their use is appropriate
  - Explain how boards are measured for size and shape.
  - Contract the differences between types of disc refiners.

**Week 5** - Determine the energy requirements for dryers, estimate drying times, and identify the impact of drying on product quality.
  - Associate a fiber type with a region of the world.
  - Describe where energy is lost in the drying process.

**Week 6** - Identify the steps in the manufacturing of a composite and how processing factors impact product quality.
  - Calculate the energy required to press a composite.

**Week 7/8** - Describe the manufacturing of paper from fibers.
  - Correlate wood structures to paper strengths and ease for pulping.
  - Identify four test performed on paper products (such as burst strength, tear strength, breaking length, whiteness, and brightness).

**Week 9** – Describe how wood is modifies and/or constructed to improve performance in service.
  - Identify the mechanisms by which the hygroscopicity and shrinkage can be modifies.

**Week 10** – Outline the processes of adding a synthetic surface to plant-based products, dust collection, and unitizing.
  - Calculate the volume of a coating needed to cover a surface.

**Evaluation of student performance:** Grading will be A-F. Students will be evaluated based on three midterms, a final, and several homework assignments. Graduate students will be assigned a term paper addressing a problem or issue
in a specific area of manufacturing of interest to them. Graduate students will have separate exams addressing the extended learning outcomes. Grading will be A=90-100, B=80-90, C=70-80, D=60-70, F=<60. 2/3 of the grade will be based on exams and 1/3 assignments.

**Learning resources:** Walker, John C.F. 2006. Primary wood processing. Springer. Other readings as assigned. Instructor notes and outlines.

**Statement regarding students with disabilities:** Accommodations are collaborative efforts between students, faculty and Disability Access Services (DAS). Students with accommodations approved through DAS are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through DAS should contact DAS immediately at 737-4098

**Link to a statement of expectations for student conduct:**
http://oregonstate.edu/admin/stucon/achon.htm
Course outline:

**Week 1. Inputs and outputs**
A. Forest-derived raw materials
   - Logs and thinnings (harvest, transportation, sortyards, grading, scaling)
   - Forest biomass, vineyard-, orchard-, and urban-derived wood
   - Bark
B. Residue-derived wood
   - Coproducts from industrial processing, harvest, transportation, grading, scaling
   - Non-wood crops and residues, bamboo, flax, bagasse, hemp, palm, cereal straws
C. Overview of products that are made from renewable raw materials (wood and nonwood)
D. Standards to which products are made, measurements
   - Board foot
   - Sqft 3/8
   - Product grades

**Week 2. Cutting**
A. Orthogonal milling
   - Tool geometry
   - Cutting forces
   - Energy
   - Effect on products
B. Peripheral milling
   - Planing
   - Jointing
   - Moulding
   - Shaping
C. Saws and knives
   - Teeth, sharpening and tipping
   - Kerf, side clearance, sawdust removal
   - Speed, stability,
D. Abrasives, turning, boring, other operations

**Week 3. Material preparation 1**
A. Bark removal
   - Species, season
   - Equipment
     - Drum
     - Ring
     - Rosserheads and pole shavers
   - Quantity of bark
   - Handling the residue
   - Log handling
     - Scaling
     - Storage
     - Merchandising
       - Instrumentation for log measurement
       - Scanning
       - E-testing
     - Sorting for highest value
B. Particulate raw material handling
Measurement
Storage, bales, bins, silos, outdoor piles
Moving, conveyors, pneumatics
Screening / size classification
Bark in whole tree chips
C. Roundwood applications
   Products
   Poles
   Post
   Pilings
   Manufacture
D. Midterm 1

**Week 4. Material preparation 2**
AB. Log breakdown for softwood lumber
   Scanning, instrumentation for measuring
   Positioning, effect on yield
   Types of headrigs (chipping, band, circular; carriage, dogging)
   Edgers, resaws, curve saws
   Coproducts, chips and sawdust
   Measurement – the board foot
   Recovery, overrun
C. Log breakdown for rotary veneer
   Bucking, scanning, heating
   Positioning
   Effect on yield
   Instrumentation for measuring
   Veneer grading and sorting
   Slicing veneer
D. Log breakdown for particle-based products
   Manufacture of
   Flakes
   Particles
   Other geometries
   Size considerations

**Week 5. Material preparation 3 / Industrial drying**
A. Preparation of other fiber types
   Ginning
   Separating bast and pith fibers
B. Drying as a process
   How materials dry
   Measurement
   T, RH, V
   MC
   Air drying
CD. Types of dryers
   Kilns
   Tray or belt / jet
   Rotary, bed, flash tube
   Energy considerations
   Dryer requirements
   Fuels / conversion to energy
   Product quality considerations (defects, strength, adhesion)
Week 6. Adhesion
A. Adhesives
   Types
   - UF
   - PF
   - Isocyanate
   - Others – pva(s), animal glue, casein
Manufacture and environmental
Handling
Use / selection for an application
Application, spreaders, curtain coaters, sprays

BC. Adhesive processes 1 (Pressing)
   Equipment
   - Batch
   - Continuous
   Preparing materials for a press
Plywood
   - Layup
   - Adhesives
   - Loading / unloading
   - Blow detection equipment
   - QA sampling / tests
Particulates
   - Forming
   - Layers
   - Fiber orientation
   - Adhesives
   - Density distributions
   - Cooling or hot stacking
Heat transfer
Mass transfer
Time
Blows
Energy
Emissions

D. Wood plastic composites
   Extrusion
   Pressing/molding
   Fiber reinforcement

Week 7. Finishing / Pulp
A. Dry end of lumber production
   Planing
   Grading
   - Softwood
   - Hardwood
   Sorting
   Moisture measurement
   Unitizing
B. Dry end of panel production
C. Pulp from wood and other fiber
   Fiber and chip breakdown
   Mechanical
   Chemical
Other
Fiber modification and additives
Bleaching

D. Midterm 2

Week 8. Paper
A. Non wood fibers for paper manufacture
B. Paper manufacturing
   Forming
   Drying
   Products
   Non-wood paper
   Energy
C. Paper types and grades, testing
   Other cellulose products, rayon, triacetate
   Fibers and textiles from regenerated cellulose
   Nonwovens, electrospinning
   Nanopaper
   Films
D. Non-wood fibers for paper manufacture

Week 9.
A. Wood modification
   Preservatives, types, selection for end use
   Fire retardant, types, selection for end use
   Application, incising, vacuum/pressure, Bethel, etc
   Standards for treated products
   Treatment for hygroscopicity/antishrink, PEG, CHOH, MeOH etc
B. Product construction to account for hygroscopicity
   Adhesive processes 2 (Additional gluing)
   Fastenters
   Nails
   Screws
C. Parts diagrams
   Furniture design
D. Midterm 3

Week 10.
A. Paints and coatings, powder coating
B. Laminates, melamine, other
C. Dust collection
D. Packaging, labeling, shipping, storage