Wind Technology Curriculum

From DACUM to Development

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CREATE

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NSF National Science Foundation

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Industrial Technology
Associate of Science Degree

The INDUSTRIAL TECHNOLOGY CERTIFICATE is designed to prepare students to enter the industrial setting in the areas of renewable energy (wind/solar), engineering technology, or electronics. Within the Industrial Technology program, students can earn progressive levels of certificates toward employment and/or the degree. Area of emphasis should be selected based on employment goal: Electronics Technology, Engineering Technology, Solar Energy Technology or Wind Energy Technology. Completion of the Solar Energy Technology emphasis prepares students for the North American Board of Certified Energy Practitioners (NABCEP) PV entry-level certification exam. Employment in aerospace, mining, manufacturing, and renewable energy is projected to increase dramatically over the next several years utilizing cutting-edge technologies.

The Industrial Technology Certificate, an emphasis area certificate, and general education requirements must be met for the completion of the Associate of Science Degree in Industrial Technology

Industrial Technology Core

Industrial Technology Certificate

Complete all of the following courses (15.5 units):

BSAD C145	Business Communications	Units 3.0
CSCI C121	Beginning Word	1.0
CSCI C123	Beginning Excel	1.0
DRFT C108 or INDT C108	Reading Technical Drawings	3.0
HSCI C105	First Aid/CPR/AED	0.5
INSF C070	Occupational Safety and Health	1.0
MATH C056	Technical Math for Trades	4.0
MCTL C107	Basic Hand Tools	2.0

Areas of Emphasis

Electronics Technician Certificate

Complete the following courses (20 units):

ET C101	Electrical Circuit Analysis I	Units 4.0
ET C105	Electrical Circuit Analysis II	4.0
ET C212	Microelectronics	3.0
ET C222	Digital Circuits/Microprocessors	3.0
ET C232	Soldering (proposed)	3.0

Engineering Technician Certificate

Complete all of the following courses (12 units):

INDT C151	Introduction to Engineering Design (proposed)	Units 3.0
INDT C153	Digital Electronics (proposed)	3.0
INDT C155	Principles of Engineering (proposed)	3.0
INDT C157	Computer Integrated Manufacturing (proposed)	3.0

Solar Energy Technician Certificate

Complete all of the following courses (20 units):

INDT C100	Introduction to Renewable Energy Technology	Units 2.0
INDT C115	AC/DC Power	4.0
INDT C121	Basics of Solar Photovoltaic Technology and Applications	3.0
INDT C123	Advanced Solar Photovoltaic Tech & Systems	3.0
INDT C125	Siting and Permitting	2.0
MCTL C111	Beginning Machine Shop	3.0
WELD C101	Oxyacetylene Welding	3.0

Wind Energy Technician Certificate

Complete all of the following courses (24 units):

INDT C070	Tower Climb, Safety, and Rescue	Units 1.0
INDT C100	Introduction to Renewable Energy Technology	2.0
INDT C115	AC/DC Power	4.0
INDT C131	Wind Turbine Components and Systems	4.0
INDT C133	Principles of Transformers, Motors, Generators, and Controls	3.0
INDT C135	Power Electronics and Logic Systems	3.0
INDT C137	Wind Turbine Pneumatic and Hydraulic Systems	3.0
INDT C179	Renewable Energy Technology Internship	2.0
INDT C191	Assembling and Troubleshooting of Wind Turbine Systems	2.0

Full Performance Wind Energy Technician Certificate

The FULL PERFORMANCE WIND TURBINE TECHNOLOGY CERTIFICATE OF ACHIEVEMENT is designed to prepare students for employment as a full performance wind energy technician. Building upon the Wind Energy Technology Associate Degree, this certificate provides students with advanced wind turbine maintenance and troubleshooting practices, power generation, motor controls, installation, and permitting. Any student completing 19 units required for the major qualifies for a certificate in Full Performance Wind Turbine Technology.

Complete the following courses (20 units):

BSOT C127	MS PowerPoint	Units 1.0
CSCI C123	Beginning Excel	1.0
CSCI C125	Beginning Access	1.0
INDT C125	Siting and Permitting	2.0
INDT C233	Advanced Concepts in Power Electronics	3.0
INDT C235	Power Generation, Transmission, and Distribution	2.0
INDT C237	High Tower Installation	1.0
INDT C239	Mechanical Drive Systems	2.0
INDT C241	Advanced Wind Turbine Generator Operation and Maintenance	2.0
INDT C243	Advanced Industrial Motor Controls	3.0
INDT C291	Advanced Assembling and Troubleshooting of Wind Turbine Systems	2.0

Course Content for
Industrial Technology Certificate

BSAD C145 Business Communication Units 3.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course presents the principles and techniques of effective written and oral business communications. Students will discuss, critique, and practice business-writing strategies to produce messages, letters, reports, and presentations, while developing critical thinking skills. Business communication in a global environment is also emphasized.

Hours: 54 Lecture

Student Learning Outcomes:

A. Explain and apply the principles, techniques, and strategies of effective business communication and how to apply those principles at work, in teams, and in a multi-cultural business environment. This will be assessed through a project and scored with a rubric.

B. Prepare business communication including letters, reports, presentations, and other messages that are clear, concise, courteous, complete and grammatically correct. This will be assessed by written assignments and scored with a rubric.

C. Critique oral communication skills to determine effective techniques. This will be assessed by written critique and scored with a rubric.

D. Plan and produce visual aids using presentation software. This will be assessed with a project and scored with a rubric.

E. Identify appropriate strategies for resume writing including use of electronic media. This will be assessed with a project and scored with a rubric.

F. Practice effective business communication techniques in independent and group projects. This will be assessed with a project and scored with a rubric.

Course Topics:

A. Building Career Success with Business Communication
   1. The communication process
   2. Listening
   3. Non-verbal communication
   4. Workplace Diversity

B. The Writing Process
   1. Creating Business Messages
      a. The Basics of Business Writing
      b. Writing for Business Messages and Oral Presentations

c. Analyzing Purpose and Audience
d. Anticipating the Audience
e. Adapting to the Audience
f. Career Skills

2. Improving Writing Techniques
   a. Researching to Collect Information
   b. Organizing to Show Relationships
   c. Writing Effective Sentences
   d. Improving Writing Techniques
   e. Paragraph Coherence
   f. Composing Drafts
3. Revising and Proofreading Business Messages
   a. The Process of Revision
   b. Concise Wording
   c. The Process of Proofreading
   d. Edit and Revise Documents

C. Corresponding At Work

1. E-Mail and Memorandums
   a. Applying the Writing Process to Produce Effective E-mail Messages and Memos
   b. Analyzing the Structure of E-Mail Messages and Memos
   c. Using E-Mail Smartly and Safely
   d. Writing Information and Procedure E-Mail Messages and Memos
   e. Writing Request and Reply E-Mail Messages and Memos
2. Direct Letters and Goodwill Messages
   a. Writing Effective Goodwill Messages
   b. Direct Requests for Information and Action
   c. Direct Claims
   d. Replies to Information Requests
   e. Adjustment Letters
   f. Letters of Recommendation
   g. Writing Winning Goodwill Messages
3. Persuasive Messages
   a. Persuasive Requests
   b. Sales Letters
4. Negative Messages
   a. Strategies for Delivering Bad News
   b. Techniques for Delivering Bad News Sensitively

c. Refusing Routine Requests and Claims
d. Breaking Bad News to Customers
e. Breaking Bad News to Employees
f. Ethics and Indirect Strategy

D. Reporting Workplace Data
1. Informal Reports
a. Understanding Report Basics
b. Guidelines for Developing Informal Reports
c. Six Kinds of Formal Reports (information, progress, justification, recommendation, feasibility, minutes, and summaries.
2. Proposals and Formal Reports
a. Understanding Business Proposals
b. Informal Proposals
c. Formal Proposals
d. Preparing to Write Formal Reports
e. Researching Secondary Data
f. Organizing and Outlining Data
g. Illustrating Data
h. Presenting the Final Report

E. Developing Speaking And Technology Skills
1. Communicating in Person, In Meetings, By Telephone, and Digitally
a. Face-to-Face Workplace Communication
b. Planning and Participating in Productive Business and Professional Meetings
c. Improving Telephone, Cell Phone, and Voice Mail Skills
d. Other Digital Communication Tools in the Workplace
2. Making Effective and Professional Oral Presentations
a. Getting Ready for an Oral Presentation
b. Organizing Content for a Powerful Impact
c. Building Audience Rapport
d. Planning Visual Aids
e. Designing Multimedia Presentations
f. Polishing Delivery
g. Adapting to International and Cross Cultural Audiences

F. Communicating For Employment
1. The Job Search, Resumes, and Cover Letters
a. Preparing for Employment
b. The Persuasive Resume

c. Optimizing Your Resume for Today's Technologies
d. Applying Final Touches
e. The Persuasive Cover Letter

2. Employment Interviewing and Follow-Up Messages
   a. Types of Employment Interviews
   b. Before the Interview
   c. The Day of Your Interview
   d. Closing the Interview
   e. Other Employment Letters and Documents

G. Grammar Mechanics Review And Reinforcement Workshops

1. Nouns, Possessive Nouns, Pronouns
2. Verbs and Verb Tense
3. Verb Agreement (Subject/ Verb), Verb Mood (Indicative/Imperative/Subjunctive)
4. Voice (Active/Passive)
5. Adjectives and Adverbs
6. Prepositions and Conjunctions
7. Commas and Semi-colons
8. Other Punctuation
9. Capitalization
10. Number style

Textbook:

Guffey, M. . (2007) Essentials of Business Communication, 7th, Natorp Boulevard Thomson SouthWestern

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CSCI C121 Beginning Word Units 1.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This hands-on computer course is designed to provide basic understanding of word processing concepts using Microsoft Word. Learners create, edit, and format documents including business letters, multiple-page reports, newsletters, and cover letters. This course begins preparation for the core level Microsoft Office Specialist certification exam for Microsoft Word.

Hours: 9 Lecture, 27 Lab

Student Learning Outcomes:

A. Apply basic word processing formatting features to create, edit, merge, and print documents including business and cover letters, multiple page reports, newsletters.

B. Manage files and folders for efficient saving and retrieval of word processing documents.

C. Apply basic features of working with images, graphics, Smart Art, and Word Art in documents including inserting, cropping, drawing, and resizing,

D. Determine and apply appropriate problem solving techniques using Help and reference material off and on-line for successful creation of basic documents using Microsoft Office.

Course Topics:

A. Working with text

1. Use the Undo, Redo, and Repeat commands
2. Apply font formats (bold, italic, and underline)
3. Use the Spelling and Grammar command
4. Use the Thesaurus
5. Insert page breaks
6. Highlight text in document
7. Insert and move text
8. Cut, copy, paste, and paste special using the Office Clipboard
9. Copy formats using the Format Painter
10. Select and change font and font size
11. Find and replace text
12. Apply character effects (superscript, subscript, strikethrough, small caps, and outline)
13. Insert date and time
14. Insert symbols
15. Create and apply frequently used text with AutoCorrect

B. Working with paragraphs

1. Align text in paragraphs (center, left, right, and justified)
2. Add bullets and numbering
3. Set character, line, and paragraph spacing options
4. Apply borders and shading to paragraphs
5. Use indentation options (left, right, first line, and hanging indent)
6. Use Tabs command (center, decimal, left, and right)
7. Create an outline-style numbered list
8. Set tabs with leaders

C. Editing and formatting documents

1. Print a document
2. Use print preview
3. Use Web Page Preview
4. Navigate through a document

5. Insert page numbers
6. Set page orientation
7. Set margins
8. Use GoTo to locate specific elements in a document
9. Create and modify page numbers
10. Create and modify headers and footers
11. Align text vertically
12. Create and use newspaper columns
13. Revise column structure
14. Prepare and print envelopes and labels
15. Apply styles
16. Create sections with formatting that differs from other sections
17. Use Click and Type
18. Use Format Painter to copy paragraph formatting

D. Managing files

1. Use save
2. Locate and open an existing document
3. Use Save As (different name, location, or format)
4. Create a folder
5. Create a new document using a wizard
6. Save as Web Page
7. Use templates to create a new document
8. Create Hyperlinks
9. Use the Microsoft Office Assistant
10. Send a Word document via e-mail

E. Using tables

1. Create and format tables
2. Add borders and shading to tables
3. Table headers and row sorting
4. Revise tables (insert and delete rows and columns and change cell formats)
5. Modify table structure (merge cells, change height, and width)
6. Rotate text in a table

F. Working with pictures and charts

1. Use the drawing toolbar

2. Insert graphics into a document (clip art, and images)
3. Resizing and cropping images
4. Smart Art

G. Multiple page reports
1. Working with Headings
2. Quick Styles
3. Footnotes and Endnotes
4. Sections
5. Cover and Title Pages

H. Desktop publishing
1. Using Word Art
2. Creating columns in a newsletter
3. Balancing columns
4. Text wrapping around graphics
5. Drop Caps
6. Symbols and Special Characters
7. Page Borders

I. Mail merge
1. Understanding the mail merge process
2. Selecting a data source
3. Inserting merge fields
4. Previewing the merged document
5. Merging the main document and data source
6. Creating a blog post

TEXTBOOK:

Zimmerman, S., & Zimmerman, B.. (2008) New Perspectives on Microsoft Office Word 2007 Comprehensive, , Course Technology Cengage Learning

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CSCI C123 BEGINNING EXCEL UNITS 1.0

PREREQUISITE: None

COREQUISITE: None

LIMITATIONS ON ENROLLMENT: None

DESCRIPTION: This hands-on computer course is designed to provide a basic understanding of spreadsheets. Spreadsheet design, creation, revision, formatting and printing are covered. The learner will create basic sales or expense reports, family budgets and basic business related spreadsheet documents using Microsoft Excel features

and functions. This course begins preparation for the Microsoft Application Specialist certification exam for Excel.

Hours: 9 Lecture, 27 Lab

Student Learning Outcomes:

A. Plan, create, edit, and print Excel spreadsheet files using basic spreadsheet features for cells, worksheets, and workbooks.

B. Work with formulas and functions in an Excel spreadsheet.

C. Work with a variety of charts and graphs to represent data in an Excel spreadsheet.

D. Determine and apply appropriate problem solving techniques using Help and reference material off and on-line for successful creation of basic documents using Microsoft Excel.

Course Topics:

A. Getting started with Excel
   1. Introducing Excel
   2. Planning a workbook
   3. Enter text, dates, and numbers
   4. Editing cell content
   5. Working with columns and rows
   6. Insert and delete selected cells
   7. Cut, copy, paste, paste special, and move selected cells
   8. Working with cells and cell ranges
   9. Working with formulas
   10. Introducing Functions
   11. Entering Functions with Auto Sum

B. Working with worksheets
   1. Inserting and deleting a worksheet
   2. Renaming a worksheet
   3. Moving and Copying a Worksheet
   4. Editing (Undo, Redo, Find & Replace, Spell Checker)
   5. Previewing and printing
   6. Changing worksheet views.
   7. Viewing and printing worksheet formulas

C. Formatting a workbook
   1. Formatting workbooks
   2. Formatting text
   3. Working with color

4. Formatting data
5. Formatting worksheet cells
6. Working with the format cells dialog box
7. Copying and pasting formats
8. Applying styles
9. Working with themes

D. Formatting worksheets

1. Applying font styles (typeface, size, color, and styles)
2. Applying number formats (currency, percent, dates, and commas)
3. Modifying row and column size
4. Modifying alignment of cell content
5. Adjusting decimal places
6. Using the Format Painter
7. Applying Auto format
8. Applying cell borders and shading
9. Merging cells
10. Rotating text and changing indents
11. Defining, applying, and removing a style
12. Introducing conditional formats
13. Hiding worksheet data
14. Formatting the worksheet for printing

E. Working with formulas and functions

1. Understanding cell references when copying formulas
2. Using Relative, Absolute, and Mixed references
3. Working with functions
4. Understanding syntax
5. Inserting and typing a function
6. Entering formulas in a cell and use the formula bar
7. Using Autofill
8. Using the Paste Function to insert a function
9. Using basic functions (AVERAGE, SUM, COUNT, MIN, and MAX)
10. Using date functions (NOW and DATE)
11. Using financial functions (FV and PMT)
12. Using logical functions (IF)

13. Using the PMT function to determine a monthly loan payment

F. Working With Charts and Objects

1. Create, preview and print charts
2. Use the Chart Wizard to create a chart
3. Designing and modifying charts (chart elements, title, layout, legend)
4. Formatting a pie chart
5. Editing chart data
6. Working with column charts
7. Formatting column chart elements
8. Formatting the chart axes
9. Formatting the chart columns
10. Creating a line chart (labels, units, legend)
11. Adding a data series to an existing chart
12. Creating a combination chart
13. Working with shapes (inserting, resizing, copying, aligning, grouping)

Textbook:

Parsons, J. J., & Oja, D.. (2008) New Perspectives on Microsoft Office Excel 2007 Comprehensive., , Course Technology Cengage Learning

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DRFT C108 Reading Technical Drawings Units 3.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with the opportunity to develop skills in reading and interpreting technical drawings used in an industrial environment. Principles of technical drawing are introduced along with standard symbols and abbreviations found in industrial drawings, schematics, and diagrams. Students produce technical sketches without the use of instruments.

Hours: 54 Lecture

Student Learning Outcomes:

A. Read and accurately interpret industrial drawings. This will be assessed and scored with an exam.

B. Produce simple technical sketches. Production will be assessed by project and scored by a rubric.

Course Topics:

A. Bases for blueprint reading

B. Lines

1. The alphabet of lines and object lines

2. Hidden lines and center lines
3. Extension lines and dimension lines

C. Views
1. Three-view drawings
2. Arrangement of views
3. Two-view drawings
4. One-view drawings
5. Auxiliary views

D. D. Dimensions and notes
1. Size and location dimensions
2. Dimensioning cylinders, circles, and arcs
3. Size dimensions for holes and angles
4. Location dimensions for points, centers, and holes
5. Dimensioning large arcs and baseline dimensions
6. Tolerances: fractional and angular dimensions
7. Representing and dimensioning external screw threads
8. Representing and specifying internal and left hand threads
9. Dimensioning tapers and machined surfaces
10. Dimensioning with shop notes

E. Section
1. Cutting planes, full sections, and section lining
2. Half sections, partial sections, and full section assembly drawings

F. Computer numerical control (CNC) fundamentals
1. Datum: ordinate and tabular dimensioning

G. Geometric dimensioning and tolerance
1. Geometric dimensioning, tolerance, and datum referencing

H. Computer graphics technology
1. Computer aided drafting (CAD) and design (CADD) and robotics

I. Welding drawings
1. Symbols, representation, and dimensioning

J. Working drawings
1. Detail drawings and assembly drawings

K. Sketching lines and basic forms
1. Sketching horizontal, vertical and slant lines

2. Sketching curved lines and circles
3. Sketching irregular shapes
4. Sketching fillets, radii, and rounded corners and edges

L. Freehand lettering
1. Freehand vertical lettering
2. Freehand inclined lettering

M. Shop sketching: pictorial drawings
1. Orthographic sketching
2. Oblique sketching
3. Isometric sketching
4. Perspective sketching
5. Pictorial drawings and dimensions

Textbook:

Olivo, T. P., & Olivo, T. C. . (2005) Basic Blueprint Reading and Sketching, 8th , Thomson Learning

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HSCI C105 First Aid/CPR/AED Units 0.5

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course teaches current American Red Cross first aid instruction for “”Schools and the Community”” through discussion, demonstrations, and practical experiences. It includes Emergency Action Steps; breathing and cardiac problem recognition and care; CPR for adult, child, infant; AED Automated External Defibrillator for adult and child, and choking for conscious and unconscious person, wound care; bandaging; shock; poisoning, local poisonous plants and animals; burns; bone and joint injuries including splinting; diabetic emergencies; temperature extremes; and other sudden illnesses. It also includes disaster preparation and family planning for local emergencies.

Hours: 10

Student Learning Outcomes:

A. Demonstrate the knowledge and skills required for emergency care of the injured until medical help can be obtained. This will be assessed by the student demonstrating 100% competency of the skills check list

B. Demonstrate an attitude of safety and prevent accidents by eliminating their causes. This will be assessed by the student demonstrating safety and prevention skills at 100%

C. Analyze an emergency situation and perform adequate first aid. This will be assessed by the student demonstrating first aid skills at 100%

D. Demonstrate the emergency action principles and Community CPR procedures. This will be assessed by the student demonstrating CPR skills at 100%

E. Identify items necessary for a first aid kit for home and car. This will be assessed by the student verbally identifying all items in a first aid kit

Course Topics:

A. If not YOU, Who? The Emergency Medical System
   1. Getting permission to give care
   2. Activating the EMS in all situations
   3. Having a first aid kit handy, wear gloves

B. Taking Action - Emergency Action Steps
   1. Check scene, victim
   2. Call 911 or local emergency number
   3. Care for victims; Do no further harm

C. Checking an Ill or Injured person
   1. Checking conscious person
   2. Checking unconscious person
   3. Working with children, infants

D. When Seconds Count: Life Threatening Emergencies
   1. Conscious choking person - adult, child, infant
   2. Rescue Breathing - adult, child, infant

E. Cardiac Emergencies
   1. Signals of Heart Attack - men, women are different
   2. Cardiac emergencies in children, infants
   3. Using an AED - adult, child
   4. CPR - adult, child, infant
   5. Unconscious Choking emergencies - adult, child, infant

F. Injury Prevention
   1. Safety awareness
   2. Reducing injury in home, school, etc.

G. Soft Tissue Injuries - Cuts, Scrapes, Bruises
   1. Wounds - minor, severe; Bandaging practice
   2. Burns

H. Injuries to Muscles, Bones, Joints
   1. Sprains, strains - care for
   2. Broken bones - splinting practice; soft splint, rigid, sling, binder

I. Sudden Illnesses - recognition, care for
   1. Stroke, fainting, diabetes, seizures,

J. Poisoning - swallowed, inhaled, absorbed, injected

1. Recognize, care for each
2. Poisonous animals and plants in our area- recognition, avoidance

K. Heat and Cold-related Emergencies
1. How to recognize and care for heat stroke, heat crams, heat exhaustion
2. How to recognize and care for hypothermia and frostbite.

L. Special Situations and Circumstances
1. Older persons; very young; people with disabilities; language problems
2. Emergency childbirth

M. Asthma- recognition of problem, assist with medication

N. Anaphylaxis - recognition of problem, assist with Epi-Pen.

O. Disaster Preparedness (May include)
1. Discussion of types of disasters our community might face
2. ARC information on preparation ideas for individuals, families, communities
3. Checklist of materials to have on-hand and what to do for local emergencies
4. How to deal with household utilities - water, gas, electric shutoff procedures
5. Evaluate whether to evacuate premises or not, whether to leave town or not

Textbook:

American Red Cross. (2006) American Red Cross Participant's Manual - First Aid/CPR/AED for Schools and the Community, 3rd, StayWell.

American Heart Association. (2006) Heartsaver First Aid with CPR and AED, , AHA National Center

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INSF C070 Occupational Safety and Health Units 1.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course covers issues related to Occupational Health and Safety and includes required instruction to fulfill the training requirements for the Occupational Safety and Health Administration (OSHA) 10 Construction Outreach Training program. Successful students will receive a course completion card at the end of the course.

Hours: 18 Lecture

Student Learning Outcomes:

A. Identify and explain various fundamental Occupational Safety and Health Administration standards and procedures for the workplace.

B. Recognize, identify, and prevent potential industrial workplace hazards including those related to cranes, fires, electrical, excavations, scaffolds, stairways and ladders, fall protection, flammable and combustible liquids, hazardous materials, blood-borne pathogens, machine guarding and safe use of power tools.

C. Describe how to prevent workplace injuries through proper use of personal protective equipment, back safety, and hearing protection.

Course Topics:

A. Introduction to OSHA

1. OSH Act
2. Inspections
3. General Safety and Health Provisions – Title 29 CFR Part 1926 - Subpart C
4. Competent Person – Title 29 CFR Part 1926 - Subpart C
5. Value of Safety and Health
6. OSHA Website and available resources
7. OSHA 800 telephone number

B. Fall Protection – Title 29 CFR Part 1926 - Subpart M (minimum instructional time 15 minutes)

1. Recognize hazards of falling
2. Procedures to follow to minimize hazards
3. Employer will ensure employee is trained by a qualified, competent person
4. Stairs
5. Ladders
6. Scaffolding
7. Aisles
8. Guardrails
9. Platforms

C. Electrical - Title 29 CFR Part 1926 - Subpart K (minimum instructional time 15 minutes)

1. Ground Fault Protection
2. Employer will designate competent person to implement program
3. How electricity impacts the human body
4. How to work safely around electrical equipment
5. Electrical hazards at the workplace

D. Struck by (minimum instructional time 15 minutes)

1. Falling objects
2. Trucks
3. Cranes

E. Caught in/between (minimum instructional time 15 minutes)

1. Trench Hazards
2. Equipment

F. Personal Protective and Lifesaving Equipment – Title 29 CFR Part 1926 - Subpart E (instructional time 30 minutes)

1. Various forms of PPE
2. When PPE is necessary
3. What PPE is necessary
4. How to properly wear PPE
5. Limitations of PPE
6. Proper care, maintenance, and disposal of PPE

G. Health Hazards in Construction (instructional time 30 minutes)

1. Noise
2. Hazards communication
3. Crystalline Silica
4. Blood-borne Pathogens (A-C)
5. Back Safety

H. Materials Handling, Storage, Use and Disposal – Title 29 CFR Part 1926 - Subpart H

1. Handling of flammable and combustible liquids
2. Storage of flammable and combustible liquids
3. Use of flammable and combustible liquids
4. Flash Point, explosion and fire
5. Design and construction
6. Ventilation
7. Ignition sources and storage

I. Tools – Hand and Power – Title 29 CFR Part 1926 - Subpart I

1. Types of power tools
2. Hazards of hand and power tools
3. When to use protective gear
4. Parts of tools that must be guarded
5. General power tool precautions

J. Scaffolds – Subpart L

K. Cranes, Derricks, Hoists, Elevators, and Conveyors - Title 29 CFR Part 1926 - Subpart N

1. Basic safe crane operating procedures
2. Basics of cranes and slings inspections
3. Appropriate use of slings
4. Common Industry wide hand signals

L. Excavations – Title 29 CFR Part 1926 - Subpart P

M. Stairways and Ladders – Title 29 CFR Part 1926 - Subpart X

1. Employer supplied training
2. Recognize hazards related to ladders and stairways
3. Employer will ensure employee is trained by a qualified, competent person

N. Occupational Health and Environmental Controls, Title 29 CFR Part 1926 – Subpart D

1. Blood-borne pathogens
    a. Types of blood-borne pathogens
    b. Exposures and transmission
    c. Decontaminants
    d. Safe working practices
2. Welding and Cutting, Title 29 CFR Part 1926 - Subpart J
    a. Gas Welding and Cutting
    b. Arc Welding and Cutting
    c. Fire Prevention
    d. Welding, cutting, and heating in way of preservative coatings

O. Fire Protection and Prevention, Title 29 CFR Part 1926 - Subpart F

1. Means of egress and fire protection
    a. Fire brigades
    b. Portable of fixed fire prevention equipment
    c. Fire detection systems
    d. Preventing fires
    e. Surviving fires

P. Toxic and Hazardous Substances, Title 29 CFR Part 1926 – Subpart Z

1. "Right to Know"
2. Types of PPE used to handle hazardous materials
3. First Aid requirements for exposure to hazardous materials
4. Spills and leaks
5. Labels and Materials Safety Data Sheets (MSDS's) and their use
6. Protective measures

Q. Wind Program Specific Training

1. Confined space safety
    a. Confined space definition
    b. Hazard testing
    c. Permit and non permit spaces
    d. Entering and exiting confined spaces

2. Lockout/Tag-out
    a. Define LOTO
    b. Types of LOTO devices and requirements
    c. Written LOTO programs
    d. Categories of employees
    e. Energy sources found on equipment
    f. Lock removal
3. Machine guarding
    a. Where mechanical hazards occur
    b. What parts must be guarded
    c. Mechanical motions
    d. Cutting mechanisms
    e. Five classifications of machine safeguarding

Textbook: None.

MATH C056 Technical Math for Trades Units 4.0

Prerequisite: MATH C050

Corequisite: None

Limitations on Enrollment: None

Description: In this course students will use mathematical concepts including general mathematics, algebra, areas and volumes, measurement, along with geometric and trigonometric functions, to solve problems related to an industrial/technical environment.

Hours: 72 Lecture

Student Learning Outcomes:

A. Apply mathematical concepts in real life industrial/technical situations.

B. Demonstrate an analytical approach to solving occupational related problems.

C. Solve occupationally related practical problems using a scientific calculator or spreadsheets.

Course Topics:

Lecture:

A. Measurement
    1. Precision, Accuracy, and Tolerance
    2. Customary Measurement Units
    3. Metric Measurement Unit
    4. Steel Rules and Vernier Calipers
    5. Micrometers

B. Fundamentals of Algebra

1. The Cartesian Coordinate System and Graphs of Linear Equations
2. Systems of Equations
3. Quadratic Equations

C. Fundamentals of Plane Geometry
1. Introduction to plane geometry
2. Angular measure
3. Angular geometric principles
4. Triangles
5. Congruent and similar figures
6. Polygons
7. Circles

D. Geometric Figures: Areas and Volumes
1. Areas of common polygons
2. Areas of circles, vectors, segments, and ellipses
3. Prisms and cylinders: volumes, surface areas, and weights
4. Spheres and composite figures: volumes, surface areas, and weights

E. Basic Statistics
1. Graphs: bar, circle, and line
2. Probability
3. Measures of centrality and spread
4. Statistical process control

F. Fundamentals of Trigonometry
1. Introduction to trigonometric functions
2. Trigonometric functions with right triangles
3. Functions of Any Angle, Oblique Triangles

Textbook:

Smith, R. & Peterson, J. C. . (2007) Introductory Technical Mathematics, 5th, Thomson Delmar Learning

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MCTL C107 Basic Hand Tools Units 2.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course prepares student to identify and properly use a variety of hand tools in an industrial environment. Emphasis is placed on safety and the use of the correct tool for a specific task. Students are given hands-on experience with many of the tools during practical lab exercises and demonstrations.

Hours: 18 Lecture, 54 Lab

Student Learning Outcomes:

A. Practice clean and safe working habits that are consistent with trade practices to OSHA standards.

B. Identify tools and their appropriate use.

C. Demonstrate proper handling and care of tools and instruments.

D. Perform a variety of tasks using tools found in an industrial setting.

Course Topics:

Lecture

A. Safety
   1. Identifying workplace hazards
   2. Electrical safety
   3. Mechanical safety
   4. Face, Eye, and Ear Protection
   5. Respiratory Protection
   6. Ventilation
   7. Special Protective Clothing

B. Types of Tools
   1. Non-powered hand tools
   2. Power tools
      a. Electrically powered tools AC and DC
      b. Gas powered tools
      c. Pneumatic tools
      d. Powder actuated tools

C. General Purpose/Mechanical Tools
   1. Screwdrivers
      a. Straight
      b. Phillips
      c. Robertson
      d. Torx
      e. Special
   2. Hammers
      a. Claw
      b. Ball peen
      c. Sledge
      d. Slide
      e. Impact

3. Holding and clamping tools
    a. Pliers
    b. Clamps
    c. Vises
4. Wrenches
    a. Open end, box, and combination
    b. Adjustable
    c. Socket
    d. Pipe
    e. Special
5. Drills and drill presses
    a. Types
    b. Setup
    c. Choice of drills/accessories
6. Files, rasps, chisels, and punches

D. Woodworking Tools (A-D)

1. 1. Saws
    a. Hand
    b. Circular
    c. Miter
    d. Reciprocating
    e. Chain
2. Boring and drilling
    a. Hand held electric drills
    b. Drill presses
    c. Bits – spiral, spade, Forstner, mandrel
3. Sanders
    a. Vibration
    b. Circular
    c. Random orbit
    d. Belt
4. Nail guns
    a. Framing/roofing
    b. Finish
5. Drill/drivers
    a. Corded, cordless
    b. Type

6. Routers
    a. Straight
    b. Plunge
7. Planes and planers

E. Metalworking Tools
1. Saws
    a. Hack saws
    b. Cut-off saws
2. Drilling
    a. Electric hand drills
    b. Drill presses
3. Holding, clamping, bending
4. Grinders
    a. Angle grinders
    b. Bench grinders
5. Welding
    a. Oxyacetylene welding and cutting
    b. Electric welding and cutting

F. Measuring and Leveling Tools
1. Tape measures and rules
2. Squares
3. Spirit levels
4. Calipers
    a. Vernier
    b. Dial
    c. Digital
5. Micrometers
    a. Standard
    b. Digital
6. Electronic instruments
    a. Laser leveling and distance tools
    b. Stud finders and detection tools

TEXTBOOK: None.

Course Content for
Wind Energy Technician Certificate

INDT C070 Tower Climb, Safety, and Rescue Units 1.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: Certification of fitness and health.

Description: In this course, students gain an understanding of hazards of working at typical wind turbine tower heights that can range from around 15 to 100 meters (50 to 325 feet). Students demonstrate safe practices required to mitigate those hazards and become equipped to respond to "at-height" tower rescue situations.

Hours: 9 Lecture, 27 Lab

Student Learning Outcomes:

A. Climb a high tower typically found for wind turbines using safe climbing practices.

B. Using a dummy, simulate the rescue of distressed personnel from tower elevation to ground level.

C. Using a dummy, simulate the initial steps necessary for a first responder to aid a distressed individual that has just been lowered to ground safely.

Course Topics:

A. Safe Operational Practices (SOPs)
   1. Safety hazards
      a. Personal physical limits
      b. Weather-related hazards
      c. Equipment hazards
   2. Personal Protective Equipment (PPE)
      a. Safety Harness (usage and inspection)
      b. Lanyard (selection, usage and inspection)
      c. Helmet
      d. Tools & tool belt
      e. Face/eye protection
      f. Gloves
      g. Boots
      h. Clothing
   3. Applying safe operating practices
      a. Team communications & notifications
      b. Lock-out / Tag-out (LOTO) procedures
      c. Wind turbine power-down procedures
      d. Tower climb techniques

e. Working in nacelle
f. Working outside nacelle

B. Emergency Situations
1. Emergency evacuation procedures
a. Team communications/notifications
b. Pre-planning the evacuation
2. "At-height" rescue
a. Rescue tips and techniques (i.e. lowering injured/disabled personnel to ground)
b. Emergency medical assistance techniques

C. Tower Climb
1. Use safe operation practices
2. Personal protective equipment

D. Simulate rescue of injured/disabled personnel from tower height using a dummy
1. Safe lowering of injured/disabled personnel from tower height to ground
2. Advising medical personnel of condition of injured/disabled personnel for best initial medical response

Textbook:

Schillreff, F.. (2008) Structural Climber & Industrial Rescue Pocket Field Guide., Syntech Safety Solutions

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INDT C100 Introduction to Renewable Energy Technology Units 2.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with a broad, introductory overview to the terminology and basic concepts of wind, solar and a summary of other renewable energy sources. Students learn how wind or solar energy is captured and transformed into usable energy. Students also gain an understanding of the science behind renewable energy.

Hours: 36 Lecture

Student Learning Outcomes:

A. Explain the basics of energy capture for key wind and solar technologies.

B. Identify the appropriate use of renewable energy (RE) technology for both large scale and small scale installations.

C. Compare different renewable energy (RE) industry sectors.

D. Relate different technology sub-disciplines within the renewable energy (RE) industry to appropriate career paths.

E. Explain and apply "Safety First" principles.

F. Describe the overall system-level interaction of key components of renewable energy systems such as a (a) wind turbine generator (WTG), (b) solar photovoltaic (PV) system, or a (c) solar thermal system.

G. Explain the relationship between generated power, rotor swept area, and wind velocity for wind turbine generators.

H. Identify key siting considerations for wind turbine generators.

I. Assess when solar noon occurs for a given geographical place and date and relate it to optimized solar array placement and energy capture.

J. Propose a viable solar photovoltaic system for a residential application.

K. Explain cut-in and cut-out wind speeds and the need for furling, pitch control and parking the WTG in high winds.

Course Topics:

A. Overview of the different, major Renewable Energy systems in use
   1. Wind
   2. Solar (Photovoltaic and Thermal)
   3. Others (Hydroelectric, Geothermal, etc.)

B. Brief history of Wind and Solar Energy
   1. Examples of earliest uses of wind and solar energy
   2. Evolution of those technologies over time to that used in our 21st century

C. Introduction to geographical and siting considerations for wind and solar energy as linked to:
   1. Solar insolation
   2. Seasonal climate and weather patterns

D. Importance of "Safety First"
   1. Personal Protection Equipment (PPE) — Discuss and demonstrate how to use personal protective equipment
   2. Safe operational practices, particularly as they relate to the renewable energy sectors of wind and solar

E. Basic physics of energy conversion for wind and solar energy
   1. Basic concepts of physics and mechanics for wind turbine generators (WTGs) and thermal and photovolaic solar energy collectors
      a. vectors [e.g. wind speed & direction, airfoil forces (lift, drag & stall), momentum & angular (rotor blade) momentum, torque, etc.]
      b. energy and power [e.g. power equation for a w and power curve]
      c. energy extraction efficiency [e.g. theoretical and typical values of Cp]
      d. energy losses [e.g. operational friction & viscous losses, blade wake, acoustic and vibrational losses, wear effects, furling, component heating and ohmic losses, incorrect array tilt angles, etc.]
   2. Physics of energy conversion for solar energy collectors [e.g. thermodynamics and heat transfer, photovoltaic principle]
   3. Shadowing, Hub height and wind shear impacts

F. Major components/systems of a typical:
   1. Modern, Danish-style wind turbine generator

2. Solar Photovoltaic (PV) systems
3. Solar Thermal systems

G. Basics of electricity, energy capture, and efficiency
   1. Wind turbine generators
   2. Solar photovoltaic systems

H. Site Selection Criteria
   1. The need for micrositing studies to optimize energy [e.g. tower height impact, adjacent turbine wakes, surface topology, weather and climate patterns]

I. Overview of financial and permitting considerations for:
   1. Setting up a wind farm
   2. Setting up a solar system [residential and small-scale applications]

J. Trends in Wind and Solar Energy sectors as it relates to career paths

Textbook:

Gipe, P. (2009) Wind Energy Basics, 2nd Ed., Chelsea Green Publishing

Kemp, W. H. (2010) The Renewable Energy Handbook, , Aztext Press

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INDT C115 AC/DC Power — Units 4.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course introduces students to the basics of direct current (DC) and alternating current (AC) electricity. Students gain a broad understanding of the physics of current flow, what is a circuit, what is isolation and grounding, and what causes arcing as circuit parameters change. Students gain hands-on experience in the application of these concepts and apply safe practices to wire circuits and to troubleshoot faults.

Hours: 54 Lecture, 54 Lab

Student Learning Outcomes:

A. Identify component symbols and simple circuit schematics

B. Demonstrate safe operation practices around energized circuits by the proper selection and usage of appropriate test and personal protective equipment.

C. Demonstrate competency with Programmable Logic Controller (PLC) usage and logic tracing.

D. Perform wire tracing and isolate faults to field-replaceable components

Course Topics:

Lecture

A. Basics of electricity
   1. Basic electrical terms
   2. How voltage is generated and makes the current flow

3. A simple circuit and the flow of Direct Current (DC) in the circuit
4. What is Alternating Current (AC) and how is it generated
5. AC Frequency and its relationship over time
6. Advantages of AC over DC
7. Relationship of power and energy in terms of voltage, current, and time
8. Relationship between instantaneous, peak and RMS voltages and currents

B. Safety

1. Importance of safety and general safety rules
2. Appropriate test and personal protective equipment (PPE)
3. Safe operating procedures (SOPs) — includes proper and safe usage of test and personal protective equipment around low, medium and high voltage circuits
4. What is Arc Flash and its danger — including safe operating procedures to prevent its occurrence
5. What to do in an emergency, if it does occur

C. Electrical components and their functions in electrical energy transfer

1. Conductors
2. Resistors
3. Insulators
4. Capacitors
5. Inductors
6. Battery and other energy storage devices for renewable energy (RE) applications (including safety)

D. Ohm's and Kirchhoff's Laws

1. Ohm's Law
2. Application of Ohm's Law to circuit elements
3. Kirchhoff's Law
4. Application of Kirchhoff's Law to circuit nodes
5. Series and parallel components
6. Application of Ohm's and Kirchhoff's Laws to voltage/current divider networks
7. Explanation of superposition of signals in terms of Ohm's and Kirchhoff's Laws

E. Electrical and electronic materials

1. Periodic Table and atomic structure
2. Electron energy bands and valence electrons
3. Correlation between valence electrons and materials properties of conductors, semiconductors and Insulators
4. Common conductor materials and wire sizes
5. Doping of semiconductor materials to make N and P semiconductor layers

6. Overview of a photovoltaic (PV) cell
7. Wire Insulation: function and nomenclature
8. Overview of National Electrical Code (NEC) and applicability to wire sizing, component ratings, and protective devices

F. Practical simple circuits with emphasis on adhering to safe operating procedures together with using personal protective equipment
   1. Component symbology and understanding circuit schematics
   2. Basic test and measurement instruments
   3. Internal resistance of measuring instruments in voltage and current measurements
   4. Function of shunt and multiplier (series) resistors in ammeter and voltmeter functions respectively
   5. Examples of common circuits
   6. Circuit wiring and component and pin identification and wire tracing
   7. Fault location
   8. Fault review and corrective action

G. Isolation and grounding principles
   1. Transient line surges from lightning or other sources
   2. Surge suppression and lightning detraction/dissipation
   3. Importance of proper isolation and grounding/bonding techniques

H. Single and three phase AC power
   1. Output waveforms
   2. Typical 3Ø industrial generator

I. Digital timing concept basics
   1. Sensors and their functions for controlling processes
   2. Applications to control systems and programmable logic controllers

Lab

A. Safety
   1. Test equipment (selecting safe test equipment and operational settings & safe usage)
   2. Personal protective equipment (selecting correct PPE & safe usage)
   3. Safe operating procedures (following all appropriate safety procedures)

B. Electrical/Electronic Tools & Test instrumentation
   1. Common electrical and electronic hand tools (use/operation of)
   2. Multimeter (use/operation of)
   3. Oscilloscope (use/operation of)
   4. Power Supply (use/operation of)

C. Component identification and circuit wiring

1. Component identification to schematic on trainer/panel
2. Circuit tracing to schematic on trainer/panel
3. Circuit analysis on trainer/panel (comparing theoretical versus measured results)

D. Troubleshooting component and circuit faults

1. Troubleshoot circuit on trainer/panel (measuring multiple circuit parameters & applying logical deduction)

E. Programmable logic controllers (PLCs)

Textbook:

Herman, S. (2011) Delmar's Standard Textbook of Electricity, 5th Ed., Cengage

Solar Energy International. (2009) Photovoltaics — Design and Installation Manual, , New Society Publishers

Henry, T. (2008) Troubleshooting Electrical Circuits Workbook, , Henry Publications

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INDT C131 Wind Turbine Components and Systems Units 4.0

Prerequisite: MATH C050, INDT C100

Corequisite: None

Limitations on Enrollment: None

Description: This course introduces students to operational effects on wind turbine generator sub-systems and components and failure mechanisms. It also covers typical monitoring, operation and maintenance issues for these various components and sub-systems.

Hours: 54 Lecture, 54 Lab

Student Learning Outcomes:

A. Explain the physics behind the energy conversion process for a Wind Turbine Generator (WTG).

B. Draw a schematic highlighting the interoperability of Wind Turbine Generator (WTG) sub-systems.

C. Outline the key failure modes and most susceptible components and/or subs-systems on WTGs.

D. Isolate typical WTG sub-system fault areas on simulator/trainer.

E. Demonstrate proper set-up procedures for WTG mechanical sub-systems on simulator/trainer.

Course Topics:

Lecture

A. Basics of the mechanics and physics of energy conversion for Wind Turbine Generators (WTGs)

1. scalars and vectors
2. force and components of force
3. lift and drag (on airfoil/wind turbine blade)
4. velocity and wind velocity
5. torque
6. momentum

7. energy and rotational kinetic energy
8. power and power extraction for WTGs

B. The different electrical and mechanical (including pneumatic and hydraulic) WTG systems
1. overview of WTG safe operating procedures (SOPs) including Lock-out/Tag-out
2. blade pitch system (electric, hydraulic)
3. yawing system (electric, hydraulic)
4. gearbox and transmission (electrical, mechanical, pneumatic, hydraulic)
5. braking systems (electrical, pneumatic, hydraulic)
6. rotational shafts and bearings (mechanical)
7. sensors and gauges (electrical, pneumatic, hydraulic)

C. The operational life of major WTG systems and components and their wear contributors
1. blades
2. bearings
3. gearbox
4. transmission
5. motors
6. generator
7. ancillary systems (filters, hoses, lubricants, pumps, etc.)
8. electrical power systems
9. control electronics

D. Operation and maintenance (O&M) issues
1. SOPs and communications links
2. vibration analysis
3. proper set-up, balance and alignment of rotating power train components
4. inspection of lubricants, oil and filters
5. take lubricant and oil samples for lab analysis
6. change lubricant, oil and filters
7. conduct thermal analysis of major mechanical and electrical components
8. functional check of electrical systems
9. troubleshooting (T/S) schema and process flow
10. T/S corrective action and reporting
11. other preventive inspections and troubleshooting

Lab

A. Safety — A re-iteration

1. Proper test equipment selection and usage
2. Proper personal protective equipment (PPE) selection and usage
3. Safe operating procedures (SOPs)

B. WTG Monitoring System
1. Control panel overview and operation
2. System power-down procedure

C. Safe power down of operating WTG (on Lab-Volt simulator)
1. Lock-out tag-out procedures
2. Battery back-up/accumulator check
3. Blade-pitch control, braking, and locking
4. Locking yaw drive

D. Mechanical and Hydraulics Systems Checks
1. Mechanical component tests (e.g. vibration analysis, simulated system alignment, etc.)
2. Fluid systems inspection procedures
3. Operating hydraulics circuits (on hydraulics trainer)

E. Troubleshoot and correct simulated component/sub-system faults
1. Troubleshoot area of failure
2. Implement corrective action
3. Safely power-up and start simulated WTG system (using LabVolt trainer)

Textbook:

Brumbach, M., Clade, J.. (2003) Industrial Maintenance, , Cengage

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INDT C133 Principles of Transformers, Motors, & Generators Units 3.0

Prerequisite: INSF C070, INDT C100, INDT C115

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with principles of electromagnetic energy conversion as applicable to transformers and AC/DC motors and generators, with emphasis on those used in the wind energy industry and with a view toward safety. Students learn characteristics and applications of each type of motor and generator. Students also gain an understanding of concepts of controlling the motor or generator in an industrial system, such as wind turbine generators. Topics also include single and three phase units and connectivity. Students obtain hands-on experience wiring and controlling motors and generators, some basic troubleshooting skills, and safe practices.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Describe the workings of and compare the differences among the motor, generator, and alternator and the

different types of each found in the renewable energy industry.

B. Identify correct wiring to a motor and explain its start/stop operation.

C. Explain how transformers are used in the renewable energy industry.

D. Identify primary and secondary windings on industrial transformers and their connections.

E. Explain torque and mechanical advantage.

F. Explain the difference between single and three phase circuits and where they may be used.

Course Topics:

Lecture

A. Electromagnetism

1. Magnetism and lines of force
2. Magnetic flux
3. Link between electricity and magnetism
4. Right hand rule for Electromotive Force (EMF)
5. Magnetic induction

B. Direct and alternating currents — Brief review with emphasis on safety

1. The difference between voltage and current
2. What is Direct Current (DC)
3. What is Alternating Current (AC)
4. Differences between 1Ø, 2Ø, 3Ø AC
5. Safety around energized DC and AC circuits

C. Generation of DC and AC voltages

1. Generation of DC
2. Generation of single phase AC
3. Generation of 3Ø AC

D. Transformers

1. Principles of operation [primary and secondary windings]
2. Electrical isolation and grounding
3. Isolation transformer
4. Autotransformer
5. Step-up transformer
6. Step-down transformer

E. Conversion of AC to DC and vice versa

1. Rectification (AC to DC conversion)
2. What is a switcher power supply

3. What is an inverter
4. Converting AC to DC and back to AC using switchers and inverters
5. Other methods of AC to DC conversion and vice versa

F. Generators and alternators
1. Principles of operation
2. DC generators
3. Single phase alternators
4. 3Ø alternators
5. Asynchronous generators
6. Brushless wound-rotor doubly-fed generators
7. Applications

G. Motors
1. Principles of operation
2. DC motors
3. Single phase AC induction motors
4. 3Ø AC induction motors
5. Overview of start/stop controls

H. Basics of control circuitry for industrial rotating machines
1. SCR inverter circuit for AC induction motor
2. Torque versus slip profile for operating AC motors and generators

Lab

A. Safety — A re-iteration
1. Proper test equipment selection and usage
2. Proper personal protective equipment (PPE) selection and usage
3. Safe operating procedures (SOPs)

B. DC Circuit Measurements
1. Resistive loads
2. Reactive loads

C. AC Circuit Measurements
1. Resistive loads
2. Reactive loads
3. Power Factor

D. Transformers
1. Primary winding identification and measurements of electrical input parameters

2. Secondary winding identification and measurements of electrical output parameters

E. Motor and generator operation

1. Wiring and controls
2. Identifying shorts and opens

Textbook:

Herman, S. (2011) Delmar's Standard Textbook of Electricity, 5th Ed., Cengage

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INDT C135 Power Electronics & Logic Systems Units 3.0

Prerequisite: INSF C070, INDT C100, INDT C115

Corequisite: None

Limitations on Enrollment: None

Description: This course explains principles of power electronics components and their circuit applications and functions. Students also obtain an understanding of timing and digital logic principles, the basics of programmable logic controllers (PLCs) and their applications within the renewable energy industry. The course emphasizes safety aspects of working with high-power devices by covering the principles of proper grounding/bonding, arc-over and the proper use of personal protective equipment and test gear.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Define and demonstrate the appropriate instrumentation and safe usage of industrial control systems.

B. Identify the hazards of arc-over/arc-flash around high voltage and industrial power generating systems during operation and maintenance.

C. Define and differentiate different types of power semiconductor devices.

D. Explain DC to AC inverters.

E. Explain the hazards of working with power electronics and mitigating them through the adoption of Safe Operating Practices (SOPs) and proper use of Personal Protective Equipment (PPE) and choice of the correct test instrumentation.

Course Topics:

Lecture

A. Basics of semiconductor theory

1. What is a semiconductor (atomic structure and position in periodic table)
2. N- and P-type semiconductor doping and electron band-gap energy
3. The PN junction and diode construction
4. The diode I-V curve
5. Diode operation in forward bias
6. Diode operation in reverse bias and breakdown voltage
7. Using diodes as rectifiers

8. Using zener diodes as voltage regulators
9. Silicon controlled rectifier (SCR) characteristics and operation
10. NPN Bipolar junction transistor (BJT) construction and common emitter operation

B. Power Semiconductors
   1. Power Diode
   2. Power Thyristor (SCR)
   3. Power TRIAC
   4. Power Bipolar Junction Transistor (BJT)
   5. Power Metal Oxide Semiconductor Field Effect Transistor (MOSFET)
   6. Insulated Gate Bipolar Transistor (IGBT)

C. Types of Power Electronic Circuits
   1. Diode rectifiers
   2. AC-DC converters (controlled rectifiers)
   3. AC-AC converters (AC voltage controllers)
   4. DC-DC converters (DC choppers)
   5. DC-AC converters (inverters)
   6. Static switches
   7. 3Ø Bridge rectifiers

D. Safe Operating Procedures (SOPs) around high-power circuits
   1. Proper inspection and safe use of Personal Protective Equipment (PPE)
   2. Proper choice of test instrumentation
   3. Hazards mitigation and SOPs for high power field work

E. DC Motors, their Controls and Operating Modes
   1. Characteristics of DC motors
   2. Motoring
   3. Dynamic braking
   4. Four operating quadrants
   5. 3Ø drives
   6. Overview of microcomputer control of DC drives

F. AC Motor Types and overview of their Controls
   1. Types of AC drives (induction, synchronous)
   2. Schematic overview of indirect vector control of AC induction motors
   3. Schematic overview of volts/hertz control of synchronous motors

G. Flexible AC Transmission Systems (FACTS)

1. Overview of FACTS and applicability
2. Role of switching power electronics in FACTS

H. Industrial control systems

1. What are control systems and how they control and monitor process variables
2. Different types control signals [analog and discrete] and the different signal control devices
3. Calibration of sensing and control instrumentation
4. Sensing signals for analog programmable controllers and digital programmable logic controllers (PLCs)

Lab

A. Safety — A re-iteration

1. Proper test equipment selection and usage
2. Proper personal protective equipment (PPE) selection and usage
3. Safe operating procedures (SOPs)

B. Semiconductor properties and applications

1. Plot I-V curves for various control semiconductors (e.g. thyristor, triac, etc.)
2. Determine breakdown voltage
3. Transform AC power to DC power
4. Drive control circuit using power semiconductors

C. Programmable Logic Controllers (PLCs)

1. Logic identify circuit (e.g. motor start/stop and operation signals)

Textbook:

Schultz, M. (2011) Grob's Basic Electronics, 11th Ed., McGraw-Hill

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INDT C137 Wind Turbine Pneumatic & Hydraulic Systems Units 3.0

Prerequisite: INSF C070, INDT C131

Corequisite: None

Limitations on Enrollment: None

Description: The course introduces students to the principles of fluid (gaseous & liquid) flow, the Gas Law, volumetric flow, pressure, lubricity / viscosity, mechanical advantage, etc. Students gain an understanding of hydraulic and pneumatic systems, including understanding schematics (include: US and metric symbology and differences in fittings, etc.). Students learn how impurities and fluid breakdown can cause problems and how to minimize them. Students obtain both classroom and hands-on experience with the identification, inspection and safe hook-up of the hydraulics system components & their functions (pumps, power valves, actuators, power hoses & fittings, power gauges, etc.). This same approach is applied to the pneumatic system components & their functions (pumps, compressors, valves, gauges, etc.).

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Interpret fluid powered system prints and schematics.

B. Construct a functioning hydraulics circuit using different hydraulics components using the hydraulics lab trainer using appropriate safe operating principles (SOPs) and personal protective equipment (PPE).

C. Troubleshoot and repair hydraulics systems using appropriate safe operating practices (SOPs) and personal protective equipment (PPE).

D. Predict how hydraulics/pneumatics systems are affected by changes in the fluidics circuit components or their characteristics.

Course Topics:

Lecture

A. Basic principles of fluidics [hydraulics and pneumatics]
   1. Gas Law
   2. Volumetric flow and pressure
   3. Lubricity, viscosity and effects of viscous damping

B. Basic concepts of Hydraulics/Pneumatic cylinder operation
   1. Force production by cylinder piston
   2. Cylinder stroke
   3. Cylinder loads

C. Operation considerations for pneumatic and hydraulic cylinders and valves for in-circuit applications
   1. Review of safe operating principles (SOPs) and use of personal protective equipment (PPE)
   2. Overview of components and circuit schematics
   3. Direction control of single-action cylinders
   4. Direction control of double-action cylinders
   5. Pressure and stroke speed of pneumatic cylinders
   6. Speed control circuits for pneumatic cylinders
   7. Cylinder dwell
   8. Lubrication of short stroke air cylinders
   9. Considerations for multiple cylinders in a circuit
   10. Sequencing and speed control
   11. Cylinder drift problems
   12. Flow dividers in hydraulic circuits
   13. Sectional valves for directional control
   14. Bypass valves for sequencing
   15. Relief, by-pass and pressure-reducing valves for pressure control
   16. Speed control methods
   17. Needle valve speed control

18. Design tips to prevent overheating
19. Holding against static loads

D. D. Other Hydraulics/Pneumatic components found in a typical utility-sized wind turbine generator (WTG), and their applications
   1. Pressure intensification
   2. Typical applications for pressure intensifiers
   3. Long-holding press circuits
   4. Hydraulic motors and their comparison to electric motors
   5. Directional control of hydraulic motors
   6. Typical usage of hydraulic motors
   7. Accumulators
   8. Typical circuits using accumulators

E. Troubleshooting and repair (TS&R) of fluidics circuits
   1. Identify and observe applicable SOPs and use PPE
   2. Circuit and component inspection
   3. Leak location, system de-pressurization and repair
   4. Valve adjustments
   5. Cylinder bleed-offs
   6. Hose replacements
   7. Oil sample collection and analysis
   8. Oil and oil filter changes

Lab

A. Hydraulics Trainer (Operation with emphasis on following safe operating procedures)
   1. Safety review for hydraulics operations
   2. Schematic review
   3. Circuit tracing and line hookups
   4. Volumetric flow control and monitoring
   5. Pressure control and monitoring
   6. Linear actuator & control (adjust stroke, rate, clamp-force, and hold time)
   7. Hydraulic motor & control (clockwise and counterclockwise rotation, start, stop)

B. Hydraulics Trainer (Troubleshooting & Maintenance with emphasis on following safe operating procedures)
   1. Component Inspection
      a. Leak location, system de-pressurization and repair
      b. Hose replacements
      c. Seal replacements

2. Verification of circuit hookup to schematic
3. Verification of design monitoring checkpoints
4. Hydraulic oil level check and correction, or oil change
5. Hydraulic oil filter check and replacement
6. Purging hydraulic oil from system and oil replacement
    a. Oil sample collection and analysis
7. Set-up of flow and pressure levels to specifications
    a. Valve adjustments
    b. Cylinder bleed-offs

Textbook:

Brumbach, M., Clade, J. (2003). *Industrial Maintenance.* Cengage

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INDT C179 Renewable Energy Technology Internship Units 2.0

Prerequisite: INDT C100, INDT C115 INDT C131

Corequisite: None

Limitations on Enrollment: None

Description: This course enables the student to obtain practical experience under the supervision of managerial or supervisory level employee of a renewable energy company operating in the student's area of future work interest and major. Students gain experience in the daily tasks and operations typical of junior-level employees in the renewable energy industry such as wind or solar. This course covers job search techniques. Students are responsible for arranging their own assignments.

Hours: 18 Lecture, 60 Non-standard

Student Learning Outcomes:

A. Write a résumé suitable for internship in the renewable energy industry.

B. Perform typical tasks associated with junior-level employees in the student's area of emphasis in the renewable energy industry.

C. Describe the implications of working in a team and following supervisory instructions carefully in a renewable energy company.

D. Identify area(s) of work interest within the renewable energy industry upon completing their internship.

Course Topics:

A. Résumé and cover letter writing
    1. Self-assessment of skills
    2. Attractive attributes of target internship position/company
    3. Prioritizing relevancy of skills to target internship position(s)
    4. Creating a draft résumé and letter and getting critiques

B. Internship search

1. Career and placement counseling office
2. Job boards
3. Industry magazines
4. Company websites
5. Networking

C. Interview preparation, the actual interview process, and working at company
   1. Research on company and the target position
   2. How to address typical questions potential employers ask interviewees
   3. Workplace behavior

D. Completion of assigned tasks, working with colleagues, supervisor, and vendor/clients
   1. Inter- and intra-company communications (preferred company formats: checksheets, forms, etc.)
   2. Interaction with peers/supervisor and business environment for vendor/client meetings, etc.

Textbook: None

INDT C191 Assembling & Troubleshooting Wind Turbine Systems Units 2.0

Prerequisite: INSF C070, INDT C131, INDT C133, INDT C135, and INDT C137

Corequisite: None

Limitations on Enrollment: None

Description: This course provides the student opportunities, under the guidance of the instructor, to complete a complex wind turbine generation project that includes elements of sensor signals that drive and control either a mechanical, fluidics, or an electrical system (or a combination of these) such as would be found in a wind turbine generator. Students gain hands-on experience in assembling and troubleshooting the elements of a major sub-system of a wind turbine generator using various trainer and simulation equipment.

Hours: 18 Lecture, 54 Lab

Student Learning Outcomes:

A. Plan and construct a hybrid system composed of two or more of the following technologies: electromechanics, sensors, pneumatics, hydraulics, PLCs to meet a given design specification.

B. Troubleshoot and repair a simulated "fault" introduced into the team project for the above constructed hybrid system.

C. Demonstrate competency in setting up and maintaining a typical subsystem of a wind turbine generator

Course Topics:

A. Design concepts and goals
   1. Identification of project goals and tasks
   2. Design draft of sub-systems and interconnections
   3. Identification of component list
   4. What-if analysis on design concept

5. Finalization of design concept
6. Finalization of sub-system and component lists

B. Safe assembly of sub-systems
   1. Hook-up sub-system components
   2. Independent testing of sub-systems
   3. Sub-systems changes
   4. Verification of sub-system changes

C. Sub-systems integration (with safe operating procedures)
   1. Sub-systems hook-up & functionality check through all target nodes
   2. Integrated systems functionality check
   3. Fine-tuning systems performance
   4. Full functionality operation

Lab

A. Sub-systems — demonstrate assembly, troubleshooting, and correct operation
   1. Electro-mechanical
   2. Fluidics
   3. Electrical/Electronics
   4. Sensors and monitoring system

TEXTBOOK: None

Course Content for
Full Performance Wind Energy Technician Certificate

BSOT C127 MS PowerPoint Units 1.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This is a hands-on microcomputer course designed to provide basic understanding of Microsoft PowerPoint. Topics to be covered include planning, creating, editing, viewing, and printing. This course prepares the student to take the core level Microsoft PowerPoint Office Users Specialist certification exam.

Hours: 9 Lecture, 27 Lab

Student Learning Outcomes:

A. Use the basic features of Microsoft PowerPoint including slide show creation, editing, and a variety of formatting tools.

B. Use other basic features including table creation, graphic insertion, printing and file management.

C. Determine and apply appropriate problem solving techniques using Help and reference material off and online for successful creation of powerpoints using Microsoft Office.

Course Topics:

A. Creating a Presentation

1. Delete slides
2. Create a specified type of slide
3. Create a presentation from a template or a wizard
4. Navigate among different views (slide, outline, sorter, and tri-pane)
5. Create a new presentation from existing slides
6. Copy a slide from one presentation into another
7. Insert headers and footers
8. Create a blank presentation
9. Create a presentation using the AutoContent Wizard
10. Send a presentation via e-mail

B. Modifying a Presentation

1. Change the order of slides using Slide Sorter view
2. Find and replace text
3. Change the layout for one or more slides
4. Modify the Slide Master

5. Modify slide sequence in the outline pane
6. Apply a design template

C. Working with Text
1. Check spelling
2. Change and replace text fonts (individual slide and entire presentation)
3. Enter text in tri-pane view
4. Import text from Microsoft Word
5. Change the text alignment
6. Create a text box for entering text
7. Use the Wrap text in TextBox feature
8. Use the Office Clipboard
9. Use the Format Painter
10. Promote and Demote text in slide and outline panes

D. Working with Visual Elements
1. Add a picture from the Clip Art Gallery
2. Add and group shapes using WordArt or the Drawing Toolbar
3. Apply formatting
4. Add text to a graphic object using a text box
5. Scale and size an object including clip art
6. Create tables within PowerPoint
7. Rotate and fill an object

E. Customizing a Presentation
1. Add AutoNumber bullets
2. Add speaker notes
3. Add graphical bullets
4. Add slide transitions
5. Animate text and objects

F. Creating Output
1. Preview presentation in black and white
2. Print slides in a variety of formats
3. Print audience handouts
4. Print speaker notes in a specified format

G. Delivering a Presentation
1. Start a slide show on any slide

2. Use on screen navigation tools
3. Print a slide as an overhead transparency
4. Use the pen during a presentation

H. Managing Files

1. Save changes to a presentation
2. Save as a new presentation
3. Publish a presentation to the Web
4. Use the Microsoft Office Assistant
5. Insert hyperlink

Textbook:

Zimmerman and Zimmerman. (2011) New Perspectives on Microsoft PowerPoint 2010 Comprehensive, 1, Course Technology Cengage Learning

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CSCI C125 Beginning access Units 1.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This hands-on computer course is designed to provide an intermediate understanding of database programs. Fundamental relational database design and management as well as building and editing basic tables, forms, queries, and reports is introduced. This course begins preparation for the core level Microsoft Access Office Specialist certification exam.

Hours: 9 Lecture, 27 Lab

Student Learning Outcomes:

A. Apply a basic understanding of relational database concepts and structure to create a new database and define relationships between tables.

B. Manage a database including backup, compacting, and converting.

C. Plan, design, build, modify, and print basic database tables, forms, queries, and reports.

D. Apply guidelines for designing databases and tables and for field properties including primary key.

E. Determine and apply appropriate problem solving techniques using Help and reference material off and online for successful creation of enhanced database objects using Microsoft Access.

Course Topics:

A. Database Concepts and Terminology

1. Fields, records, tables
2. Relational database, primary key, foreign key
3. Database objects (tables, forms, queries, reports)

B. Database Management

1. Backup
2. Restore
3. Compact
4. Convert

C. Design Guidelines
1. Fields and properties
2. Table creation
3. Input and import data
4. Relationships
5. Referential integrity

D. Table Creation and Modification
1. Create tables by using the Table Wizard
2. Set primary keys
3. Modify field properties
4. Use multiple data types
5. Modify tables using Design View
6. Use the Lookup Wizard
7. Use the Input Mask Wizard

E. Query Creation and Modification
1. Design view
2. Create, run, save queries
3. Update data with a query
4. Sort and filter data in a query
5. Exact match query
6. Comparison operators
7. And/Or logical operators
8. Calculated fields in a query

F. Form Creation and modification
1. Form Wizard
2. AutoFormat
3. Find data using a form
4. Preview and print form records
5. Maintain table data
6. Form with subform

G. Report Creation and Modification

1. Report Wizard
2. Report edit
3. Add a graphic
4. Preview and print

Textbook:

Adamski, J. et al. . (2008) New Perspectives on Microsoft Access 2007 Comprehensive., 2nd , Course Technology

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INDT C125 Siting and Permitting Units 2.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with the skills to conduct site feasibility studies for wind and solar energy installations. Students evaluate the impact of geographical terrain, wind patterns, solar insolation, energy capture, and wind turbine generator or solar array placement. Students gain an understanding of permitting processes for commercial and residential applications. Students also acquire an understanding of Power Purchase Agreements and learn how to conduct research on current tax credits, rebates, and other incentives.

Hours: 36 Lecture

Student Learning Outcomes:

A. Conduct a site feasibility study for a wind or solar energy installation.

B. Describe the siting approval process from local, county, state, and/or federal regulatory, land management, zoning and planning agencies.

C. Analyze and summarize applicable local, county, and/or state regulations and zoning restrictions, etc. that are in addition to federal and industry regulations for a wind or solar energy installation.

D. Discuss differences between residential, commercial, and utility-scale siting projects.

E. Describe components of a Power Purchase Agreement.

F. Conduct research on current tax credits, rebates, and other incentives.

Course Topics:

A. Site Studies

1. Site survey (including surface topology, setbacks, conservation land, etc.)
2. Wind and solar resources
3. Environmental & other considerations
4. Data analysis & permitting proposal

B. Permitting Process

1. Land use permit
   a. transmission line route & utility connection

b. agricultural impact
c. access route
d. number, sizes, and siting of wind turbines
e. areal coverage for solar arrays
f. easements

2. Environmental and other impacts
   a. geology & soils
   b. water resources
   c. paleontological resources
   d. biological resources—flora and fauna
   e. noise and glare
   f. visual
3. Benefits
   a. cost-effective energy
   b. continuing agricultural use
   c. jobs
   d. local economy
4. Public review period

C. Power Purchase Agreements
   1. Parties involved
   2. Regulations
   3. Appropriateness
   4. Financing
   5. Timeline
   6. Operation and Metering
   7. Sales

D. Tax credits, rebates, and incentives
   1. Government
   2. Utilities
   3. Manufacturer

Textbook:

Larwood, Scott, and van Dam, C. P. (California Wind Energy Collaborative). 2006. "Permitting Setback Requirements for Wind Turbines in California." California Energy Commission, PIER Renewable Energy Technologies. CEC-500-2005-184.

County of Santa Barbara Planning & Development (Energy Division). 2010. "Lompoc Wind Energy Project"

Asmus, P., Fullerton, K., Peterson, S., Rhoads-Weaver, H., Shutak, A., and Savitz-Schwartz, S. 2003. "Permitting

Small Wind Turbines: A Handbook — Learning from the California Experience." California Energy Commission.

Rockingham Planning Commission. "Model Ordinance for Small Wind Energy Systems Ordinance"

San Luis Obispo (California), City of. 2007. Municipal Code. Section 16.18.170. "Easements for Solar Access."

Santa Barbara (California), City of. "Solar Access Packet."

INDT C233 Advanced Concepts in Power Electronics Units 3.0

Prerequisite: INDT C191

Corequisite: None

Limitations on Enrollment: None

Description: Students learn the advanced concepts of semiconductor components used in power electronics and their functions. Typical industry applications such as inverters and industrial control systems are also covered. Students learn about simulating power circuits with a schematic capture and simulation program. Emphasis is placed on safety concepts of working with high power equipment. This includes emphasis on proper grounding/bonding, arc-over, and use of personal protective equipment and test gear. Students adhere to safe operating procedures when working on trainers or circuits in the lab.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Identify different types and functions of power circuits and their applications to renewable energy industry.

B. Assess functionality of a power circuit application.

C. Demonstrate correct usage of personal protective equipment (PPE) and correct choice of test instrumentation for troubleshooting of medium and high voltage (power) circuitry.

Course Topics:

Lecture

A. Overview of semiconductor theory and development of modern semiconductors
   1. Periodic Table and electron energy bands for conductors, semiconductors, and insulators
   2. N- and P-type doping of semiconductor
   3. PN junction and diode construction
   4. Diode operating characteristics
   5. Specialty diodes — power diodes, SCRs, TRIACS, Zeners
   6. NPN and PNP transistors and their operation
   7. Specialty power devices — Bipolar junction transistors (BJTs), Metal oxide field effect transistors (MOSFETs), and Insulated gate bipolar transistor (IGBTs)

B. Types of Power Electronic Circuits
   1. Rectifier circuits — single phase
   2. Rectifier circuits — 3Ø
   3. AC-AC converters (AC voltage controllers)

4. DC-DC converters (DC choppers)
5. DC-AC converters (inverters)
6. Applications to industrial motor controls, stabilized power supplies, etc.

C. Review of Safe Operating Procedures (SOPs) around high-power circuits
1. Proper inspection and safe use of Personal Protective Equipment (PPE)
2. Proper choice of test instrumentation
3. Hazards mitigation and SOPs for high power field work [shock protection, arc-flash mitigation, proper grounding/bonding, etc.]

D. Introduction to computer circuit simulation
1. Simple circuit simulation to meet desired electrical parameters
2. Verification of desired design results by breadboarding or measuring on physical circuit
3. Fine-tune design by tweaking parameters to meet design criteria

E. AC transmission systems
1. Overview of flexible power transmission systems
2. Role of switching power electronics in transmission
3. Load balancing

Lab

A. Semiconductor Basics & Overview of Diode Characteristics
1. P- and N-type semiconductor materials
2. Diode symbology
3. Applications for diodes

B. Measurements of Diode Characteristics
1. Forward and reverse bias
2. Circuit current based on diode knee voltage
3. Normal and reverse bias operation
4. Current through diode junction and output waveform

C. Trigger Devices
1. Silicon controlled rectifiers (SCRs) – Symbology & operation characteristics
2. Trigger circuits with SCRs – Gate & Anode current measurements
3. Zeners – Reverse breakdown voltage and voltage regulation
4. Triacs – Chopping an AC waveform to control power

D. Transistors – Symbology & typical operation
1. DC bias
2. Transistor gain – emitter & collector current

E. Power Supplies

1. Half-wave rectification
2. Full-wave rectification
3. Bridge rectifiers
4. Voltage stabilization

Textbook:

Schultz, M.. (2011) Grob's Basic Electronics, , McGraw-Hill

INDT C235 Power Generation, Transmission, & Distribution Units 2.0

Prerequisite: INDT C191

Corequisite: None

Limitations on Enrollment: None

Description: In this course, the student learns the basics of high voltage transmission systems and the underlying design issues with arc-over and safety. Concepts of single and three phase electrical power generation characteristics are covered as applicable to utility-scale transformers, relays, capacitors, switchgear and related components for both common delta and wye configurations. Typical component designs and application are also topics of discussion.

Hours: 36 Lecture

Student Learning Outcomes:

A. Evaluate the various types of power generation.

B. Analyze the US grid system and the power distribution model.

C. Evaluate the choice of proper tools and explain safe operating practices (SOPs) when working with medium and high voltage equipment.

D. Categorize the different types of power transformers, transformer taps and tap changers.

E. Differentiate power quality and power correction techniques.

F. Describe key components of a typical substation and their purpose.

Course Topics:

Lecture

A. Regulatory requirements for working around medium/high power components and wiring

1. Risks and hazards (including arc-flash)
2. Hazard mitigation
3. Use of Safe Operating Procedures (SOPs) and associated personal protective equipment (PPE) and the appropriate test gear

B. Electrical Power System Overview

1. Single and 3Ø AC wiring concepts (delta and wye) for utility power
2. US power grid system

3. Power generation sub-stations and step-up transformers (primary power)
4. High voltage transmission lines (wye and delta 3Ø lines)
5. Transmission conductors and cables, line voltages and transmission distances
6. Transmission switchgear
7. Consumption center sub-stations and step-down transformers (user distribution network and secondary power)

C. Utility Power Distribution Components — Transformers
1. Understanding dielectric breakdown and arcing
2. Cooling requirements
3. Step-up and Step-down transformers
4. Safety and grounding and circuit breakers

D. Utility Power Distribution Components — Switchgear
1. Controlling arcing and flash-over
2. Typical designs and applications

E. Utility Power Distribution Components — Relays and remote switchgear
1. Power considerations
2. Controlling arcing and flash-over
3. Ancillary equipment
4. Typical designs and applications

F. Utility Power Distribution Components — Capacitors
1. Balancing reactive (inductive) loads at industrial plants
2. Sizing considerations
3. Typical designs and applications

Textbook:

Van Soelen, W.. (2005) Electrical Essentials for Powerline Workers, 2nd Ed., Cengage Learning

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INDT C237 High Tower Installation Units 1.0

Prerequisite: INDT C191

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with an understanding of site preparation, logistics, and wind turbine tower installation. Students learn how a tower is safely erected and how the nacelle and blades are mounted atop the tower for final assembly. Students also gain an understanding of necessary sub-system hook-ups and checks before commissioning.

Hours: 18 Lecture

Student Learning Outcomes:

A. Explain the logistics of putting up a high tower installation.

B. Identify the steps associated with a high tower construction for a utility-scale wind turbine generator (WTG) and the pre-commissioning safety and system checks.

Course Topics:

Lecture

A. Site inspection and survey checklist
   1. Work with site engineer and local, county, state and federal regulators
   2. Consider site access for heavy transportation, earth-moving, and crane/lifting equipment
   3. Obtain all necessary permits
   4. Inspect all equipment and ensure that it is checked and/or certified to be in safe operable condition
   5. Weather [on lift day must be clear, dry and calm (non-windy)]

B. Worker communications and safety
   1. Hand signals [between crane operator, ground, tower and nacelle crews]
   2. 2-way radio communications [between crane operator, ground, tower and nacelle crews]
   3. Personal protective equipment (PPE)
   4. Safe operating procedures (SOPs)

C. The lifting process
   1. Rigging hardware
   2. Slings
   3. Guy wires
   4. Hoists
   5. Cranes

D. D. Alignment of tower sections, nacelle and hub/blades
   1. Component guidance and communications with crane operator
   2. Alignment, bolting (to torque specifications by manufacturer), and sealing seams as applicable
   3. Connecting all communications and other cable harnesses and ancillary fittings per specification
   4. Verify all required actions against checklist

E. E. Repeat processes “C” and “D” until completion of WTG assembly
   1. Check-out all sub-systems in strict sequence as per manufacturer’s instructions
   2. Get WTG certified and commission its operation

Textbook:

INDT C239 Wind Turbine Mechanical Drive Systems Units 2.0

Prerequisite: INDT C191

Corequisite: None

Limitations on Enrollment: None

Description: In this course the student learns to identify and explain safe operating procedures, installation, alignment, and operation of various mechanical drive system components as part of normal operation and maintenance (O&M). The student also learns about test procedures to troubleshoot and repair (TS&R) such systems.

Hours: 18 Lecture, 54 Lab

Student Learning Outcomes:

A. Demonstrate adoption of safe operating practices (SOPs) as related to rotating mechanical components.

B. Inspect and refurbish or repair critical sub-components of rotating mechanical systems such as filters, gear, belt, and chain drives as per the manufacturer's specifications.

C. Inspect and align two axial rotating shafts joined by couplings to within manufacturer's specifications.

D. Replace or top-off hydraulics fluids with manufacturer specified grades.

E. Extract oil samples from wind turbine generator's gearbox or transmission for laboratory analysis.

Course Topics:

Lecture

A. Safe operating procedures (SOPs) for industrial rotating machinery
   1. Review of proper usage of personal protective equipment (PPE) and test gear
   2. Lock-out, tag-out (LOTO) of equipment and communicating action to teammate
   3. Parking of rotating and other moving components

B. Rotating Shafts
   1. Visual Analysis
   2. Vibration and Auditory Analysis
   3. Thermal Analysis
   4. Align and adjust for optimum mechanical transfer with minimized losses
   5. Highlight and report early failure warning signals

C. Bearings
   1. Visual Analysis
   2. Vibration and Auditory Analysis
   3. Thermal Analysis
   4. Take oil/lubricant sample for lab analysis
   5. Re-lubricate bearings as per specifications using recommended grades only
   6. Highlight and report early failure warning signals
   7. Remove and replace if necessary

D. Belt and chain drives
   1. Visual Analysis

2. Re-lubricate and adjust chain drives as per specifications using recommended grades only
3. Highlight and report early failure warning signals
4. Remove and replace belts/chains if necessary and check/adjust belt/chain tension

E. Gear drives

1. Visual Analysis
2. Vibration and Auditory Analysis
3. Inspect gear teeth condition
4. Take oil/lubricant sample for lab analysis
5. Highlight and report early failure warning signals
6. Re-lubricate gears/gearboxes as per specifications using recommended grades only

F. Couplings

1. Visual Analysis
2. Re-adjust/re-align as necessary
3. Change bolts if necessary, tighten/re-torque as per specifications
4. Highlight and report early failure warning signals

G. Hoses, valves and other fittings

1. Visual Analysis
2. Replace leaky fittings/components and worn/delaminated hoses as needed per specifications
3. Take oil/lubricant sample for lab analysis
4. Replace oil filters as per specifications
5. Change/top-off oil as per specifications using recommended grades only
6. Highlight and report early failure warning signals

H. Brake Pads

1. Visual Analysis
2. Re-adjust/replace pads as needed using recommended replacements

Lab

A. Nacelle Trainer

1. Safety review — interlocks, mechanical sub-system
2. Rotating shaft (alignment, vibration and thermal analysis)
3. Bearings (vibration and thermal analysis)
4. Gearbox (oil check, vibration and thermal analysis)
5. Hoses, valves and other fittings (oil leak)
6. Brake pads
7. Sensors

Textbook:

Higgins, L., Mobley, K., and Wikoff, D. (2008). *Maintenance Engineering Handbook*, 7th Ed., McGraw-Hill

Brumbach, M., Clade, J. (2003). *Industrial Maintenance*. Cengage

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INDT C241 Wind Turbine Generator Operation & Maintenance Units 2.0

Prerequisite: INDT C191

Corequisite: None

Limitations on Enrollment: None

Description: This course provides the student with an understanding of wind turbine generator manufacturers' scheduled maintenance requirements. This includes wind turbine generator component replacements, fiberglass repairs, low/high voltage cable checks and replacement techniques, and advanced analysis techniques to locate potential problems. Students learn how Supervisory Control and Data Acquisition (SCADA) is used in the operations and maintenance process. Each operations and maintenance technique is presented with an emphasis on safety.

Hours: 27 Lecture, 27 Lab

Student Learning Outcomes:

A. Relate component mean times before failure (MTBFs) to planning predictive maintenance of key sub-systems of industrial system such as a wind turbine generator.

B. Analyze imbalance of rotating machinery using vibration analysis tool and to predict component failure.

C. Analyze excessive frictional losses using infrared thermography to predict mechanical component failures.

D. Identify degradation of electrical circuit connections using infrared thermography to predict premature electrical failures.

E. Explain and select the appropriate electrical test equipment and personal protective equipment to measure insulation degradation on electrical components and cabling.

F. Troubleshoot faults across sub-systems via dependencies.

Course Topics:

Lecture

A. Overview of safe operating procedures (SOPs) relevant to working on utility-scale wind turbine generators (WTGs)
   1. Correct use of personal protective equipment (PPE) and proper test gear
   2. Lock-out, tag-out (LOTO) of equipment, and communicating action to teammate, etc.
   3. Material Safety Data Sheet (MSDS) and applicable SOPs for handling chemicals
   4. Hazards mitigation [e.g. shock protection, arc-flash mitigation, selecting appropriate test equipment, etc.]

B. Mathematical basis of component and system failure rates
   1. "Bathtub" curve of component reliability
   2. Common WTG sub-system failure rates
   3. Conversion of individual component failure rates into sub-system failure rates

4. Application of component reliability to predictive maintenance

C. Fiberglass repair and gel coat application
   1. Surface preparation [sand and smooth jagged edges of crack, solvent clean, sealant primer, etc.]
   2. Prepare and apply patch as needed over cracks
   3. Follow applicable SOPs to prepare and apply epoxy/pre-peg
   4. Allow recommended drying/cure time before applying added coats or touch-ups as needed
   5. Follow applicable SOPs to prepare and apply gel coat
   6. Allow recommended drying/cure time before applying added coats or touch-ups as needed

D. Techniques and tools to mitigate system failure
   1. Vibration analysis [locate excessive axial misalignment in rotating components]
   2. Thermography [locate high resistance hot spots in electrical circuits]
   3. Lab analysis of oils and lubricants
   4. Visual inspections to deduce leaks, moisture, and dust contaminations
   5. Electrical component checks to determine parametric deterioration [insulation breakdown, arcing, excessive heat, corrosion, charring, etc.]
   6. Repair or replace failed or soon-to-fail components identified by above methods

E. System-level troubleshooting techniques
   1. Sub-systems interconnection schematics
   2. Relate dependencies within sub-systems and across other sub-systems
   3. Identify dependencies within and across sub-systems and describe fault
   4. Trace manifestation of fault condition via dependencies and localize problem component or field replaceable unit (FRU)
   5. Repair or replace faulty component or field replaceable unit

F. Application of supervisory control and data acquisition (SCADA) system to predict WTG sub-system process and performance degradations
   1. Sensor technologies and signal monitoring principles
   2. Use of I/O signal bandwiths in SCADA to monitor and predict component failure.

Lab

A. Nacelle Trainer Operation
   1. Interlocks and lock-out, tag-out
   2. Human-machine interface
   3. Supervisory control and data acquisition
   4. Start-up and shut-down procedures
   5. Troubleshooting and maintenance

Textbook:

Brumbach, M., Clade, J.. (2003) Industrial Maintenance, , Cengage

INDT C243 Industrial Motor Controls Units 3.0

Prerequisite: INDT C191

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with hands-on experience with wiring, installing, and troubleshooting electrical devices associated with motor control applications that are typically used in wind turbine generators. Students gain an understanding of electrical diagrams of such systems and use diagrams for designing and wiring such systems. Students learn and practice safe operating procedures and proper use of test and personal protective equipment for these activities.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Interpret electrical motor control schematics and related symbols.

B. Distinguish between an electrical power circuit and an electrical control circuit.

C. Demonstrate the use of design techniques related to motor control circuits.

D. Select circuit protection devices to limit over current and the right wire gauges for the needed ampacity.

E. Demonstrate installation and termination of conductors to various electrical control devices and equipment.

F. Select and safely use test equipment for troubleshooting circuits.

G. Explain how to derive a control voltage from a power circuit.

Course Topics:

Lecture

A. Overview of safe operating procedures (SOPs) relevant to working on utility-scale wind turbine generators (WTGs)
   1. Proper use of personal protective equipment (PPEs)
   2. Selecting proper test equipment
   3. Hazards mitigation [e.g. protecting against electric shock and mitigating arc-flash possibility, etc., by using SOPs and proper test gear and PPE.]

B. Understanding Electrical Drawings and Motors
   1. Basic operation of motors
   2. Symbols and Abbreviations (US, European, Japanese)
   3. Schematics (Ladder, Block, and Wiring Diagrams)
   4. Motor terminal connections
   5. Motor starters (manual and wired)

C. Motor Transformers and Distribution Systems
   1. Transformer principles and power distribution
   2. Step-up and Step-down transformers

3. Motor control transformer

D. Motor Control Devices [stop, start, variable speed]

1. Manually operated switches
2. Mechanically operated switches
3. Motor control sensors
4. Motor control actuators
5. NEMA and IEC starter
6. Wye-delta starter
7. Autotransformer reduced voltage starter
8. Wound rotor induction motor with speed control
9. Variable Frequency Drives (VFD), Programming Parameters and use of PLCs

E. Types of motors

1. DC series motors
2. DC shunt motors
3. DC series-shunt motors
4. Single phase AC Induction motors
5. 3Ø AC Induction motors
6. Single phase Synchronous motors
7. 3Ø Synchronous motors

Lab

A. Industrial Motor Controls Trainer Operation

1. Lock-out, tag-out (LOTO)
2. Symbols & schematics
3. Fuse check & wiring basic control circuits
4. Contactors & control relays
5. Motor starters & control transformers
6. Reverse, jog, and soft starters

Textbook:

Herman, S. (2009). *Industrial Motor Control*, 6th Ed., Cengage Learning.

INDT C291 Adv. Assembling & Troubleshooting of WTS Units 2.0

Prerequisite: INDT C233

Corequisite: None

Limitations on Enrollment: None

Description: In this course, students complete a complex wind turbine generation project that uses sensor signals that drive and control multiple interconnected systems, including mechanical, fluidics, or electrical systems, such as would be found in a wind turbine generator. Students gain hands-on experience using trainers, simulators, and actual wind turbine equipment. Students also isolate and correct typical system faults on wind turbine generator systems. The students observe all applicable safe operating procedures (SOPs) and the use of proper test gear and personal protective equipment as necessary in the performance of their work to complete the project.

Hours: 9 Lecture, 27 Lab

Student Learning Outcomes:

A. Plan and construct a wind turbine generator system in a safe manner utilizing electromechanics, sensors, pneumatics, hydraulics, and control circuits to meet a given design specification.

B. Troubleshoot and repair a simulated "fault" introduced into the project for the above constructed hybrid system following applicable safe operating procedures (SOPs).

C. Set up and maintain a typical wind turbine generator subsystem following applicable safe operating procedures (SOPs).

Course Topics:

Lecture

A. Design concepts and goals
   1. Identification of project goals and tasks
   2. Design draft of sub-systems and interconnections
   3. Identification of component list
   4. What-if analysis on design concept
   5. Finalization of design concept
   6. Finalization of sub-system and component lists

B. Safe assembly of sub-systems
   1. Hook-up sub-system components
   2. Independent testing of sub-systems
   3. Sub-systems changes
   4. Verification of sub-system changes

C. Sub-systems integration (with safe operating procedures)
   1. Sub-systems hook-up & functionality check through all target nodes
   2. Integrated systems functionality check
   3. Fine-tuning systems performance
   4. Full functionality operation

D. System Faults
   1. Systems malfunctions and fault causes
   2. Fault tracing, troubleshooting and repair

Lab

A. Sub-systems design and integration (with safe operating procedures)
    1. Electro-mechanical
    2. Fluidics
    3. Electrical/Electronics
    4. Sensors and monitoring systems

Textbook:

Van Solen, W. (2005). *Electrical Essentials for Powerline Workers*, 2nd Ed. Cengage Learning.

Schultz, M. (2011). *Grob's Basic Electronics*. McGraw-Hill

Brumbach, M., Clade, J. (2003). *Industrial Maintenance*. Cengage.

Higgins, L., Mobley, K., and Wikoff, D. (2008). *Maintenance Engineering Handbook*, 7th Ed. McGraw-Hill.

Herman, S. (2009). *Industrial Motor Control*, 6th Ed. Cengage Learning.

Course Content for
Solar Energy Technician Certificate

INDT C100 Introduction to Renewable Energy Technology Units 2.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with a broad, introductory overview to the terminology and basic concepts of wind, solar and a summary of other renewable energy sources. Students learn how wind or solar energy is captured and transformed into usable energy. Students also gain an understanding of the science behind renewable energy.

Hours: 36 Lecture

Student Learning Outcomes:

A. Explain the basics of energy capture for key wind and solar technologies.

B. Identify the appropriate use of renewable energy (RE) technology for both large scale and small scale installations.

C. Compare different renewable energy (RE) industry sectors.

D. Relate different technology sub-disciplines within the renewable energy (RE) industry to appropriate career paths.

E. Explain and apply "Safety First" principles.

F. Describe the overall system-level interaction of key components of renewable energy systems such as a (a) wind turbine generator (WTG), (b) solar photovoltaic (PV) system, or a (c) solar thermal system.

G. Explain the relationship between generated power, rotor swept area, and wind velocity for wind turbine generators.

H. Identify key siting considerations for wind turbine generators.

I. Assess when solar noon occurs for a given geographical place and date and relate it to optimized solar array placement and energy capture.

J. Propose a viable solar photovoltaic system for a residential application.

K. Explain cut-in and cut-out wind speeds and the need for furling, pitch control and parking the WTG in high winds.

Course Topics:

A. Overview of the different, major Renewable Energy systems in use
   1. Wind
   2. Solar (Photovoltaic and Thermal)
   3. Others (Hydroelectric, Geothermal, etc.)

B. Brief history of Wind and Solar Energy
   1. Examples of earliest uses of wind and solar energy

2. Evolution of those technologies over time to that used in our 21st century

C. Introduction to geographical and siting considerations for wind and solar energy as linked to:
   1. Solar insolation
   2. SolarSeasonal climate and weather patterns

D. Importance of "Safety First"
   1. Personal Protection Equipment (PPE) — Discuss and demonstrate how to use personal protective equipment
   2. Safe operational practices, particularly as they relate to the renewable energy sectors of wind and solar

E. Basic physics of energy conversion for wind and solar energy
   1. Basic concepts of physics and mechanics for wind turbine generators (WTGs) and thermal and photovolaic solar energy collectors
      a. vectors [e.g. wind speed & direction, airfoil forces (lift, drag & stall), momentum & angular (rotor blade) momentum, torque, etc.]
      b. energy and power [e.g. power equation for a w and power curve]
      c. energy extraction efficiency [e.g. theoretical and typical values of Cp]
      d. energy losses [e.g. operational friction & viscous losses, blade wake, acoustic and vibrational losses, wear effects, furling, component heating and ohmic losses, incorrect array tilt angles, etc.]
   2. Physics of energy conversion for solar energy collectors [e.g. thermodynamics and heat transfer, photovoltaic principle]
   3. Shadowing, Hub height and wind shear impacts

F. Major components/systems of a typical:
   1. Modern, Danish-style wind turbine generator
   2. Solar Photovoltaic (PV) systems
   3. Solar Thermal systems

G. Basics of electricity, energy capture, and efficiency
   1. Wind turbine generators
   2. Solar photovoltaic systems

H. Site Selection Criteria
   1. The need for micrositing studies to optimize energy [e.g. tower height impact, adjacent turbine wakes, surface topology, weather and climate patterns]

I. Overview of financial and permitting considerations for:
   1. Setting up a wind farm
   2. Setting up a solar system [residential and small-scale applications]

J. Trends in Wind and Solar Energy sectors as it relates to career paths

Textbook:

Gipe, P. (2009) Wind Energy Basics, 2nd Ed., Chelsea Green Publishing

Kemp, W. H. (2010) The Renewable Energy Handbook, , Aztext Press

INDT C115 AC/DC Power Units 4.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course introduces students to the basics of direct current (DC) and alternating current (AC) electricity. Students gain a broad understanding of the physics of current flow, what is a circuit, what is isolation and grounding, and what causes arcing as circuit parameters change. Students gain hands-on experience in the application of these concepts and apply safe practices to wire circuits and to troubleshoot faults.

Hours: 54 Lecture, 54 Lab

Student Learning Outcomes:

A. Identify component symbols and simple circuit schematics

B. Demonstrate safe operation practices around energized circuits by the proper selection and usage of appropriate test and personal protective equipment.

C. Demonstrate competency with Programmable Logic Controller (PLC) usage and logic tracing.

D. Perform wire tracing and isolate faults to field-replaceable components

Course Topics:

Lecture

A. Basics of electricity
   1. Basic electrical terms
   2. How voltage is generated and makes the current flow
   3. A simple circuit and the flow of Direct Current (DC) in the circuit
   4. What is Alternating Current (AC) and how is it generated
   5. AC Frequency and its relationship over time
   6. Advantages of AC over DC
   7. Relationship of power and energy in terms of voltage, current, and time
   8. Relationship between instantaneous, peak and RMS voltages and currents

B. Safety
   1. Importance of safety and general safety rules
   2. Appropriate test and personal protective equipment (PPE)
   3. Safe operating procedures (SOPs) — includes proper and safe usage of test and personal protective equipment around low, medium and high voltage circuits
   4. What is Arc Flash and its danger — including safe operating procedures to prevent its occurrence
   5. What to do in an emergency, if it does occur

C. Electrical components and their functions in electrical energy transfer
   1. Conductors

2. Resistors
3. Insulators
4. Capacitors
5. Inductors
6. Battery and other energy storage devices for renewable energy (RE) applications (including safety)

D. Ohm's and Kirchhoff's Laws
1. Ohm's Law
2. Application of Ohm's Law to circuit elements
3. Kirchhoff's Law
4. Application of Kirchhoff's Law to circuit nodes
5. Series and parallel components
6. Application of Ohm's and Kirchhoff's Laws to voltage/current divider networks
7. Explanation of superposition of signals in terms of Ohm's and Kirchhoff's Laws

E. Electrical and electronic materials
1. Periodic Table and atomic structure
2. Electron energy bands and valence electrons
3. Correlation between valence electrons and materials properties of conductors, semiconductors and Insulators
4. Common conductor materials and wire sizes
5. Doping of semiconductor materials to make N and P semiconductor layers
6. Overview of a photovoltaic (PV) cell
7. Wire Insulation: function and nomenclature
8. Overview of National Electrical Code (NEC) and applicability to wire sizing, component ratings, and protective devices

F. Practical simple circuits with emphasis on adhering to safe operating procedures together with using personal protective equipment
1. Component symbology and understanding circuit schematics
2. Basic test and measurement instruments
3. Internal resistance of measuring instruments in voltage and current measurements
4. Function of shunt and multiplier (series) resistors in ammeter and voltmeter functions respectively
5. Examples of common circuits
6. Circuit wiring and component and pin identification and wire tracing
7. Fault location
8. Fault review and corrective action

G. Isolation and grounding principles

1. Transient line surges from lightning or other sources
2. Surge suppression and lightning detraction/dissipation
3. Importance of proper isolation and grounding/bonding techniques

H. Single and three phase AC power
   1. Output waveforms
   2. Typical 3Ø industrial generator

I. Digital timing concept basics
   1. Sensors and their functions for controlling processes
   2. Applications to control systems and programmable logic controllers

Lab

A. Safety
   1. Test equipment (selecting safe test equipment and operational settings & safe usage)
   2. Personal protective equipment (selecting correct PPE & safe usage)
   3. Safe operating procedures (following all appropriate safety procedures)

B. Electrical/Electronic Tools & Test instrumentation
   1. Common electrical and electronic hand tools (use/operation of)
   2. Multimeter (use/operation of)
   3. Oscilloscope (use/operation of)
   4. Power Supply (use/operation of)

C. Component identification and circuit wiring
   1. Component identification to schematic on trainer/panel
   2. Circuit tracing to schematic on trainer/panel
   3. Circuit analysis on trainer/panel (comparing theoretical versus measured results)

D. Troubleshooting component and circuit faults
   1. Troubleshoot circuit on trainer/panel (measuring multiple circuit parameters & applying logical deduction)

E. Programmable logic controllers (PLCs)

Textbook:

Herman, S. (2011) Delmar's Standard Textbook of Electricity, 5th Ed., Cengage

Solar Energy International. (2009) Photovoltaics — Design and Installation Manual, , New Society Publishers

Henry, T. (2008) Troubleshooting Electrical Circuits Workbook, , Henry Publications

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INDT C121 Basics of Solar Photovoltaic Tech & Applications Units 3.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with an overview of solar photovoltaic system specification and project planning for residential and commercial applications. Students also gain an understanding of solar insolation and of physical laws and concepts that are applicable to solar energy.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Compute the altitude for mounting a solar panel array based on geographic latitude.

B. Design and generate a basic photovoltaic (PV) system schematic with components and wiring diagram sized according to expected power output.

C. Prepare data sheet with pertinent cost-to-benefit PV scenario for a "customer" with at least two system options.

D. Wire and assemble a working ground-mount PV system as cumulative outcome of the lab classes and as final graded project.

E. Apply Ohm's Law to determine run resistance for a photovoltaic (PV) system to major circuit components.

Course Topics:

Lecture

A. Overall Project Planning for a solar Photovoltaic (PV) system installation
   1. Determination of client needs [annual energy usage, cost, lifestyle, etc.]
   2. Survey of the site [latitude, clear view of southern sky with no shady areas, etc.]
   3. Energy savings from efficiency implementation
   4. Cost analysis [type of photovoltaic panels and cost, tax and net-metering benefits, etc.]
   5. Zoning and permitting issues
   6. Proposing a photovoltaic system solution to client

B. Solar insolation
   1. Sun path
   2. Correction for magnetic declination
   3. Solar Pathfinder
   4. Local meteorological data on annual sunshine
   5. Shading analysis

C. System cost to benefit analysis
   1. Size of installation [number of photovoltaic panels]
   2. Fixed array or tracking system
   3. Ground or roof mount
   4. Stand-alone or grid-tie
   5. Battery back-up or not
   6. Summarize results as proposal to customer (include utility, local, state federal credits, tax subsidies)

7. Physics and chemistry basics
8. Photovoltaic technology and operational specifications
9. Ohm's law, power, conductor sizing
10. Safety [personal through personal protective equipment (PPE) and Hydrogen venting for battery storage]
11. Power losses and cable runs
12. Battery selection [deep cycle]

D. Commercial mount systems
   1. Fixed rack
   2. Solar tracking
   3. Typical site selection and assembly procedures

E. Residential and commercial solar photovoltaic installations
   1. Typical residential installations
   2. Typical commercial installations
   3. Client survey to determine system needs

Lab

A. A. Safety
   1. Safe usage of appropriate tools, test equipment and personal protective equipment
   2. Safe operating procedures (following all appropriate safety procedures)

B. Site Survey & Installation
   1. Sunpath determination and shading
   2. Equipment selection for selected site
   3. Installation and assembly
   4. System verification and inspection

Textbook:

Kemp, W. H. (2009). *The Renewable Energy Handbook*, 2. Aztext Press.

Dunlop, J. P. (2010). *Photovoltaic Systems*, 2nd Ed. American Technical Publishers.

INDT C123 Advanced Solar Photovoltaic Tech & Systems Units 3.0

Prerequisite: INDT C121

Corequisite: None

Limitations on Enrollment: None

Description: This hands-on course provides students with in-depth of knowledge and experience in system specification and project planning. Students install, troubleshoot, and maintain solar photovoltaic systems, applying safe operational practices.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Compare and contrast the three major solar energy technologies (photovoltaic, thermal, and concentrated solar power).

B. Analyze the economics of installing a solar photovoltaic (PV) system into key components such as up-front capital and labor costs, annual energy cost savings and the overall cost of ownership of the system over its useful life.

C. Design solar system installations that meet the National Electrical Code (NEC).

D. Explain the permitting and inspection process needed for commissioning a solar photovoltaic (PV) systems.

E. Demonstrate basic assembly of a roof-top solar PV system with a grid-tie inverter system.

Course Topics:

Lecture

A. Safe Operational Practices (SOPs)
    1. Proper check and use of personal protective equipment (PPE)

B. Different solar technologies
    1. Solar photovoltaic (PV) systems
    2. Solar thermal residential and small-scale commercial systems [space and water heating]
    3. Solar thermal utility-grade parabolic linear mirror systems
    4. Solar thermal utility-grade concentrated solar power (CSP) systems

C. Physics of solar energy conversion
    1. Electrochemistry and efficiency of PV cells
    2. Electrical energy storage — battery technology
    3. Thermodynamics of heat transfer in solar thermal systems
    4. Heat energy storage for solar thermal systems

D. Meeting client needs — Site selection
    1. Client needs and site parameters [assess needs and site specifics]
    2. Latitude and magnetic declination
    3. Solar insolation and solar tracking
    4. Site analysis [soil condition, wind loading, etc.]

E. E. Meeting client needs — System sizing and design
    1. Sizing methodologies
    2. Perform sizing calculations
    3. Design solar array system [load calculations and array output]

F. Meeting client needs — Permitting and inspection
    1. Building codes and regulations
    2. Permitting process

3. Inspection regulations and procedures

G. Meeting client needs — Economic Analysis
   1. Analyze total cost of ownership
   2. Discuss government incentives

H. Mechanical integration
   1. Mechanical array components
   2. Array support mechanisms
   3. Mounting platforms
   4. System integration

I. Electrical integration
   1. National Electrical Code (NEC) related to solar systems
   2. Determine voltage and current outputs for circuit panels
   3. Determine conductor sizes and wiring methods
   4. Calculate overload protection
   5. Determine proper grounding and safety disconnect system
   6. Determine battery requirements for stand-alone and hybrid systems

J. Interconnect PV system to utility power
   1. Interpret utility interconnection policies
   2. Utility interconnection of the PV system
   3. Analyze ramifications of distributed power generation

K. Installation, assembly and commissioning
   1. Ordering of PV panels, rack mounts, inverters, cabling, mounting hardware, overload protection, etc.
   2. Determine proper grounding and safety disconnect system
   3. Determine solar array orientation
   4. Installation and assembly of PV system
   5. Connection to consumer mains breaker panel and monitoring systems
   6. Discuss and plan commissioning steps
   7. System check, certification, and commission system

L. Systems maintenance and troubleshooting
   1. Compose a troubleshooting procedure
   2. Plan maintenance schedule
   3. Perform maintenance and monitor running system

Lab

A. The Solar Pathfinder instrument

1. Sun shading
2. Annual sun track
3. Recording and estimating insolation

B. Solar photovoltaic system
   1. Setting the correct array tilt angle
   2. Fixing mounting brackets
   3. Electrical interconnections
   4. Inverter hook-up
   5. Test and system start-up

Textbook:

Kemp, W. H. (2009). *The Renewable Energy Handbook*, 2nd Ed., Aztext Press.

Solar Energy International (2009). *Photovoltaics — Design and Installation Manual*. New Society Publishers.

Earthscan (2010). *Planning& Installing Solar Thermal Systems*, 2nd Ed., James & James, Ltd.

Dunlop, J. P. (2010). *Photovoltaic Systems*, 2nd Ed., American Technical Publishers

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INDT C125 Siting and Permitting Units 2.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides students with the skills to conduct site feasibility studies for wind and solar energy installations. Students evaluate the impact of geographical terrain, wind patterns, solar insolation, energy capture, and wind turbine generator or solar array placement. Students gain an understanding of permitting processes for commercial and residential applications. Students also acquire an understanding of Power Purchase Agreements and learn how to conduct research on current tax credits, rebates, and other incentives.

Hours: 36 Lecture

Student Learning Outcomes:

A. Conduct a site feasibility study for a wind or solar energy installation.

B. Describe the siting approval process from local, county, state, and/or federal regulatory, land management, zoning and planning agencies.

C. Analyze and summarize applicable local, county, and/or state regulations and zoning restrictions, etc. that are in addition to federal and industry regulations for a wind or solar energy installation.

D. Discuss differences between residential, commercial, and utility-scale siting projects.

E. Describe components of a Power Purchase Agreement.

F. Conduct research on current tax credits, rebates, and other incentives.

Course Topics:

A. Site Studies

1. Site survey (including surface topology, setbacks, conservation land, etc.)
2. Wind and solar resources
3. Environmental & other considerations
4. Data analysis & permitting proposal

B. Permitting Process
    1. Land use permit
        a. transmission line route & utility connection
        b. agricultural impact
        c. access route
        d. number, sizes, and siting of wind turbines
        e. areal coverage for solar arrays
        f. easements
    2. Environmental and other impacts
        a. geology & soils
        b. water resources
        c. paleontological resources
        d. biological resources—flora and fauna
        e. noise and glare
        f. visual
    3. Benefits
        a. cost-effective energy
        b. continuing agricultural use
        c. jobs
        d. local economy
    4. Public review period

C. Power Purchase Agreements
    1. Parties involved
    2. Regulations
    3. Appropriateness
    4. Financing
    5. Timeline
    6. Operation and Metering
    7. Sales

D. Tax credits, rebates, and incentives
    1. Government
    2. Utilities

3. Manufacturer

Textbook:

Larwood, Scott, and van Dam, C. P. (California Wind Energy Collaborative). 2006. "Permitting Setback Requirements for Wind Turbines in California." California Energy Commission, PIER Renewable Energy Technologies. CEC-500-2005-184.

County of Santa Barbara Planning & Development (Energy Division). 2010. "Lompoc Wind Energy Project"

Asmus, P., Fullerton, K., Peterson, S., Rhoads-Weaver, H., Shutak, A., and Savitz-Schwartz, S. 2003. "Permitting Small Wind Turbines: A Handbook — Learning from the California Experience." California Energy Commission.

Rockingham Planning Commission. "Model Ordinance for Small Wind Energy Systems Ordinance"

San Luis Obispo (California), City of. 2007. Municipal Code. Section 16.18.170. "Easements for Solar Access."

Santa Barbara (California), City of. "Solar Access Packet."

MCTL C111 Beginning Machine Shop Units 3.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides a basic introduction to Machine Shop theory and practice including set-up and operation of the lathe, drill press, horizontal and vertical milling machines, metal band saw and pedestal grinder. The use of hand tools and precision measuring tools, layout techniques, and tool sharpening are studied in practical shop applications.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Practice clean and safe working habits that are consistent with trade practices to OSHA standards.

B. Read and demonstrate comprehension of technical drawings.

C. Demonstrate competency in using metal working tools, machinery, and measuring instruments.

D. Accurately perform layout and setup tasks.

Course Topics:

A. Machining Processes
   1. Basic machine tool operations
   2. Nontraditional machining processes
   3. Automating the machining process
   4. The evolving role of the machinist

B. Shop Safety
   1. Safety in the shop
   2. General machine safety

3. General tool safety
4. Fire safety

C. Understanding Drawings
1. Dimensions
2. Information included on drawings
3. Types of prints
4. Types of drawings used in the shop
5. Parts lists
6. Drawing sizes
7. Geometric dimensioning and tolerancing

D. Measurement
1. The rule
2. The micrometer
3. Vernier measuring tools
4. Gauges
5. Dial indicators
6. Other gauging tools
7. Helper measuring tools

E. Layout Work
1. Making lines on metal
2. Squares
3. Measuring angles
4. Simply layout steps
5. Layout safety

F. Hand tools
1. Clamping devices
2. Pliers
3. Wrenches
4. Screwdrivers
5. Striking tools
6. Chisels
7. Hacksaw
8. Files
9. Reamers

10. Hand threading
11. Hand polishing

G. Fasteners
    1. Threaded fasteners
    2. Non-threaded fastening devices
    3. Adhesives
    4. Fastener safety

H. Drills and Drilling Machines
    1. Drilling Machines
    2. Drill Press Safety
    3. Drills
    4. Drill-holding devices
    5. Work-holding devices
    6. Cutting speeds and feeds
    7. Cutting Compounds
    8. Sharpening drills
    9. Drilling
    10. Countersinking
    11. Counterboring
    12. Spot facing
    13. Tapping
    14. Reaming

I. Offhand Grinding
    1. Abrasive belt grinders
    2. Bench and pedestal grinders
    3. Grinding wheels
    4. Abrasive belt and grinder safety
    5. Using a dry-type grinder
    6. Using a wet-type grinder
    7. Portable hand grinders

J. Sawing and Cutoff Machines
    1. Metal-cutting saws
    2. Reciprocating power hacksaw
    3. Power band saw

4. Using reciprocating and band saws
5. Circular metal-cutting saws
6. Power saw safety

K. The Lathe

1. Lathe size
2. Major parts of a lathe
3. Preparing lathe for operation
4. Cleaning the lathe
5. Lathe safety
6. Cutting tools and tool holders
7. Cutting speeds and feeds
8. Work-holding attachments
9. Turning work between centers
10. Using lathe chucks
11. Facing stock held in chuck
12. Plain turning and turning to a shoulder
13. Parting operations
14. Taper turning
15. Cutting a taper
16. Cutting screw threads on the lathe

Textbook:

Walker, John R. (2004). *Machining Fundamentals*, 8th ed. Goodheart-Willcox Co., Inc.

WELD C101 Oxyacetylene Welding Units 3.0

Prerequisite: None

Corequisite: None

Limitations on Enrollment: None

Description: This course provides practical experience in welding, brazing, soldering, and cutting of steel using oxyacetylene. Topics include safety, metals and their physical properties, setup and use of oxyacetylene equipment, and welding and cutting techniques.

Hours: 36 Lecture, 54 Lab

Student Learning Outcomes:

A. Practice clean and safe working habits that are consistent with trade practices to OSHA standards.

B. Demonstrate proper care and handling of tanks, regulators, and torches.

C. Install and correctly adjust regulators, light and adjust torches.

D. Identify different types of metals and the appropriate welding/cutting process.

E. Make a variety of oxyacetylene welds with and without filler rod and cut metal using the cutting torch.

F. Perform soldering and brazing tasks.

Course Topics:

Lecture

A. Introduction

1. Welding Safety
2. Burn Classification
3. Face, Eye, and Ear Protection
4. Respiratory Protection
5. Ventilation
6. Special Protective Clothing
7. Fire Protection
8. Shop Orientation

B. Oxyfuel Welding and Cutting Equipment Setup and Operation

1. Pressure Regulators
2. Regulator Gauges
3. Safety Release Device
4. Fittings
5. Safety Precautions
6. Regulator Care and Use
7. Welding and Cutting Torches Design and Service
8. Mixing the Gasses
9. Torch care and Use
10. Welding and Heating Tips
11. Tip Care and Use
12. Reverse Flow and Flashback Valves
13. Care of Reverse Flow and Flashback Arresters
14. Hose and Fittings
15. Hose Care and Use
16. Backfires and Flashbacks
17. Types of Flames
18. Leak Detection

C. Practice

1. Setting Up an Oxyfuel Torch Set
2. Turning On and Testing a Torch
3. Lighting and Adjusting an Oxyacetylene Flame
4. Shutting Off and Disassembling Oxyfuel Welding Equipment

D. D. Oxyfuel Gasses and Filler Materials

1. Uses of the Oxyfuel Flame
2. Characteristics of the Oxyfuel Flame
3. Characteristics of the Fuel Gas Flame
4. Fuel Gasses
5. Flame Rate of Burning
6. Acetylene (C2H2)
7. Heat and Temperature
8. Liquefied Fuel Gasses
9. Pressure
10. Production
11. Temperature and Heat
12. MAPP
13. Propane and Natural Gas
14. Hydrogen
15. Filler Metals
16. Ferrous Metals
17. Mild Steel
18. Cast Iron

E. Oxyacetylene Welding

1. Mild Steel Welds
2. Factors Affecting the Weld
3. Characteristics of the Weld
4. Practice
5. Pushing a Molten Weld Pool
6. Beading
7. Stringer Bead Flat Position
8. Practice
9. Outside Corner Joint
10. Practice

11. Butt Joint, Flat Position
12. Butt Joint w/ 100% Penetration
13. Butt Joint w/ Minimum Distortion
14. Practice
15. Lap Joint
16. Tee Joint
17. Out of Position Welding
18. Practice
19. Vertical Welds
20. Butt Joint
21. Lap Joint
22. Tee Joint
23. Horizontal Welds
24. Practice
25. Horizontal Stringer Beads
26. Butt Joint
27. Lap Joint
28. Tee Joint

F. F. Soldering, Brazing, and Braze Welding

1. Advantages of Soldering and Brazing
2. Physical Properties of the Joint
3. Fluxes
4. Soldering and Brazing Methods
5. Filler Metals
6. Joint Design
7. Building Up Surfaces and Filling Holes
8. Silver Brazing
9. Soldering
10. Practice
11. Brazed Stringer Bead
12. Brazed Butt Joint
13. Brazed Tee Joint
14. Brazed Lap Joint
15. Soldered Tee Joint

16. Soldered Copper Pipe

G. Flame Cutting

1. Metals Cut by the Oxyfuel Process
2. Eye Protection for flame Cutting
3. Cutting Torches and Tips
4. Oxyfuel Cutting, Setup, and Operation
5. Selecting the Correct Tip and Setting the Pressure
6. Practice
7. Flat cut
8. Cutting holes
9. Beveling
10. Vertical Straight Lab: Students complete guided tutorials and perform practical exercises during lab.

Textbook:

Jeffus, L. F. (2008). *Welding: Principles and Applications*, 6th ed., Thompson Delmar Learning

Appendix

Previous Iteration of the

Industrial Technology

Associate of Science Degree

The INDUSTRIAL TECHNOLOGY CERTIFICATE is designed to prepare students to enter the industrial setting in the areas of renewable energy (wind/solar), engineering technology, or electronics. Within the Industrial Technology program, students can earn progressive levels of certificates toward employment and/or the degree. Area of emphasis should be selected based on employment goal: Electronics Technology, Engineering Technology, Solar Energy Technology or Wind Energy Technology. Completion of the Solar Energy Technology emphasis prepares students for the North American Board of Certified Energy Practitioners (NABCEP) PV entry-level certification exam. Employment in aerospace, mining, manufacturing, and renewable energy is projected to increase dramatically over the next several years utilizing cutting-edge technologies.

The Industrial Technology Certificate, an emphasis area certificate, and general education requirements must be met for the completion of the Associate of Science Degree in Industrial Technology

Industrial Technology Core

Industrial Technology Certificate (18 units)

Provides student with skills to enter the industrial environment as an entry level employee.
Complete all of the following courses:

CSCI C070	Computer Literacy	Units 1.0
CSCI C121	Beginning Word	1.0
CSCI C123	Beginning Excel	1.0
DRFT C108	Reading Technical Drawings	3.0
ENGL C151	Technical Communication	3.0
INDT C101	Introduction to OSHA Required Safety	1.0
MATH C056	Technical Math for Trades	4.0
MCTL C107	Basic Hand Tools	2.0
WELD C101	Oxyacetylene Welding	3.0

Areas of Emphasis

Electronics Technician Certificate (18 units)

Provides students with skills to enter the job market as Electronics Technician.
Select from the following courses (* denotes required courses):

DRFT C151	Fundamentals of AutoCAD	Units 3.0
DRFT C161	Geometric Dimensioning and Tolerancing	3.0
ET C101*	Electrical Circuit Analysis I	3.0
ET C105*	Electrical Circuit Analysis II	3.0
ET C212*	Microelectronics	3.0
ET C222*	Digital Circuits/Microprocessors	3.0
ET C261*	Communication Systems	3.0
WEXP C101	Work Experience Seminar I	1.0
WEXP C102	Occupational/Career Work Experience	1-3.0

Engineering Technician Certificate (18 units)

Provides students with skills to enter the job market as engineering technicians as a Drafting Technician, CAD Technician or entry level Design Technician.

Select from the following courses (* denotes required courses):

DRFT C111 *	Engineering Drawing I	Units 3.0
DRFT C112	Engineering Drawing II	3.0
DRFT C151*	Fundamentals of AutoCAD	3.0
DRFT C153	3D Solids Modeling with SolidWorks	3.0
DRFT C161*	Geometric Dimensioning and Tolerancing	3.0
MCTL C111*	Beginning Machine Shop	3.0
WEXP C101	Work Experience Seminar I	1.0
WEXP C102	Occupational/Career Work Experience	1-3.0

Solar Energy Technician Certificate (12 units)

Provides students with skills to enter the job market as energy technicians as a solar technician.

Select from the following courses (* denotes required courses):

RET C104*	Introduction to Solar Power Technology	Units 1.0
RET C105*	Solar Energy II--Photovoltaic Technologies and Applications	3.0
RET C120	Introductory Hydraulics	4.0
ET C101*	Electrical Circuit Analysis I	3.0
ET C105	Electrical Circuit Analysis II	3.0
WEXP C101	Work Experience Seminar I	1.0
WEXP C102	Occupational/Career Work Experience	1-3.0

Wind Energy Technician Certificate (12 units)

Provides students with skills to enter the job market as energy technicians as a wind technician..

Select from the following courses (* denotes required courses):

RET C101	Introduction to Wind Technology	Units 1.0
RET C102*	Wind Turbine Technician I	4.0
RET C103*	Wind Turbine Technician II	4.0
RET C120	Introductory Hydraulics	4.0
ET C101*	Electrical Circuit Analysis I	3.0
ET C105	Electrical Circuit Analysis II	3.0
WEXP C101	Work Experience Seminar I	1.0
WEXP C102	Occupational/Career Work Experience	1-3.0

CURRICULUM PLAN

Wind Technician Associate Degree
Cerro Coso College

Panel Members:
Nikki Cummings, Worldwind
Linda Parker, Kern Wind Energy Association
Jon Powers, Cal Wind
Eric Preher, NextEra Energy
Larry Venner, EnXco
Ivan Vamla, World Wind Service
Jack Wallace, Frontier Pro
Dale Whinery, Kern Community College District
David Winchester, NextEra Energy
Adolfo Zavala, EnXco

Attendees:
Kathy Alfano, CREATE
Suzie Ama, Cerro Coso
Larry Board, Cerro Coso
Jill Board, Cerro Coso
Laura Hinkle, Sierra Sands Unified School District
Robert Johnston, Kern Community College District
Valerie Karnes, Cerro Coso
Kathy Salisbury, Cerro Coso
Jennifer Schwerin, Cerro Coso
Angela Sellers, Cerro Coso
David Teasdale, Kern Community College District
Bev Thompson, Tehachapi High School

Facilitator:	Dennis Faber, Principal Investigator TIME Center
Recorder:	Kathy Salisbury, Administrative Assistant to the President Cerro Coso Community College
Date:	December 2, 2010

Wind Technology Degree Framework—Industrial Technology Core Plus

General Education Requirements

Sciences	4	(Physical Science w/ lab)
Social/Behavioral Sciences	3	
Humanities	3	
English 101	3	
English 151 Tech Communications	3	(Technical Communications)
Math	4	(Technical Math for Trades)
Information Competency	1	(Beginning Power Point)
Diversity	3	
Health/Wellness	3	
Total	27	

Industrial Technology Core

CSCI 070	Computer Literacy	1	(Beginning Access)
CSCI 121	Beginning Word	1	
CSCI 123	Beginning Excel	1	
DRFT 108	Reading Tech Drawings	3	
ENGL 151	Technical Communications	3	
MATH 056	Technical Math for Trades	4	
MCTL 105	Basic Hand Tools	3	(Hand/Specialty Tools/Test Equip)
WELD 101	Oxy-Acetylene Welding	3	
INSF 070	Occupational Safety & Health	1	(Environmental Safety & Health)
Total		20	

Wind Technology Concentration (42.5 recommended units)

Environmental Safety and Health	1	(included above)
CPR and First Aid	0.5	
OSHA 10	1	
Introduction to Wind Technology	1	
Introduction to Mechanical Systems	3	
AC & DC Circuits	3	
Introduction to Hydraulics and Pneumatics	3	
Reading Technical Drawings and Manuals	3	(included above)
Electronics I	3	
Hand and Specialty Tools and Test Equipment	3	
Wind Technology I	4	
Work Experience for Wind Technicians	1	
Computer Productivity Tools	4	(included above)
Administrative Practices	1	
Technical Communications	3	(included above)
Technical Math for Trades	4	(included above)
Physical Science	4	(included above)
Total	23.5	(excludes 19 credits met by G.E. & Core)

Integrate Across the Curriculum—Communication, Trouble Shooting & Workplace Skills

Wind Technology Degree Framework—Stand Alone Degree

General Education Requirements

Sciences	4	(Physical Science w/ lab)
Social/Behavioral Sciences	3	
Humanities	3	
English 101	3	
English 151 Tech Communications	3	(Technical Communications)
MATH 056 Technical Math for Trades	4	(Technical Math for Trades)
Information Competency	1	(Beginning Power Point)
Diversity	3	
Health/Wellness	3	
Total	27	

Wind Technology Requirements

CSCI 070	Computer Literacy	1	(Beginning Access)
CSCI 121	Beginning Word	1	
CSCI 123	Beginning Excel	1	
Environmental Safety and Health		1	
CPR and First Aid		0.5	
OSHA 10		1	
Introduction to Wind Technology		1	
Introduction to Mechanical Systems		3	
AC & DC Circuits		3	
Introduction to Hydraulics and Pneumatics		3	
Reading Technical Drawings and Manuals		3	(included above)
Electronics I		3	
Hand and Specialty Tools and Test Equipment		3	
Wind Technology I		4	
Work Experience for Wind Technicians		1	
Computer Productivity Tools		4	(included above)
Administrative Practices		1	
Technical Communications		3	(included above)
Technical Math for Trades		4	(included above)
Physical Science		4	(included above)
Total		27.5	

Integrate Across the Curriculum—Communications, Trouble Shooting & Workplace Skills

Environmental Safety and Health 1 Unit—2.5 Units

A-1 Maintain a clean and safe work area **E**
A-2 Follow company and job-specific safety procedures **E**
A-3 Adhere to safe practices guidelines **E**
A-4 Discuss safety talk points with department members (daily, regularly) **E**
A-5 Complete safety training and exams **E**
A-6 Follow federal, state and local regulations **E**
A-7 Follow security requirements for the particular work area components **E**
A-8 Follow safe ergonomic practices **E**
A-10 Handle hazmats and materials according to MSDS requirements **E**
A-12 Perform safety inspections **E**
A-13 Follow environmental protection and hazardous chemical control procedures **E**
A-14 Maintain personal protective equipment **E**
A-15 Follow lock-out/tag-out procedures (energy flow/isolation) **E**
A-16 Follow company vehicle policies **E**
A-17 Participate in Job Safety Analysis (JSA) **E**
H-11 Complete incident reports **E**

H-8 Participate in audits **F**

K-17 Material Safety Data Sheets (MSDS)
K-26 Personal protective equipment

Certifications—Stand alone courses or modules within this course

CPR and First Aid	0.5 Unit	
OSHA 10	1.0 Unit	(OSHA 30 Certification may be needed in future)

K-1 Ability and willingness to work in all weather conditions
K-18 Weather patterns

Physical Requirements and Work Requirements

1. Ability to perform manual work, i.e.: standing, stooping, and walking.
2. Ability to lift up to 50 lbs.
3. Ability to climb a ladder 260+ feet above the ground without assistance on a frequent basis.
4. Ability to work outdoors in extreme cold and heat for extended periods of time from towers and platforms.
5. Pass drug and alcohol screening requirements
6. Drivers license and acceptable driving record
7. Criminal background clearance

Wind Industry Overview

- Role within renewable energy industry
- Transmission and distribution

Weather and Wind Energy Generation

Wind Farm Overview

- Types and characteristics of wind farms
- Technologies involved

Wind Turbine Components

Wind Technician Career Pathways

Skills Labs

C-1 Ensure proper fluid levels **E**
C-2 Inspect fasteners **E**
E-1 Select, control, inspect required tools and test equipment **E**
E-8 Repair/replace consumable wear components **E**
E-2 Follow operating and control check sheets and procedures **E**
E-6 Torque and tension fasteners **E**
E-5 Select and replace fasteners **E**
E-4 Lubricate bearings, gears, and top offs **E**

D-4 Repair/replace motors and generators **F**
D-7 Follow accepted standards and practices for mechanical and electrical assembly **F**
D-8 Install and replace bearings **F**
E-13 Inspect, maintain, and lubricate gearboxes **F**
E-14 Align shafts using laser alignment equipment and procedures **F**
E-15 Perform mechanical shaft alignments **F**
E-10 Measure and interpret information from test equipment and tools **F**
E-11 Perform component function tests **F**

K-12 Gear Boxes
- Characteristics of gearboxes
- Types of gear systems in gearboxes
- Maintenance and lubrication-pumps and shaft end plates
- Filters; Cleanliness; impurities
- Gear teeth condition

K-13 Lubrication—oil and grease; oil base (soap, clays, synthetic, animal byproduct);
- Types of lubricants and uses
- Lubrication methods
- Effects of poor lubrication
- Impurities; contamination control
- Byproducts
- Self lubricators; grease guns
- Maintenance and troubleshooting
- Sampling

K-14 Yaw Systems-- Function of Yaw control system including: wind vane, anemometer, yaw angle (alignment vs. misalignment), auto rewind function, yaw brakes and Yaw drive system

K-15 Principles of shaft alignment

K-16 Fasteners and torquing

AC & DC Circuits 3 Units

A-11 Follow electrical safety procedures (low/medium/high voltage) **E**
E-7 Inspect bonding and grounding points (including lightning protection) inside and outside of turbine **E**
E-2 Follow operating and control check sheets and procedures **E**

C-3 Terminate and test components **E (terminate), F (test)**
D-4 Repair/replace motors and generators **F**
D-7 Follow accepted standards and practices for mechanical and electrical assembly **F**
E-16 Inspect electrical components and connections **F**
F-3 Trace circuits **F**

K-22 Basic understanding of how a wind turbine detracts and dissipates lightning

- Understand proper grounding techniques, theory, significance
- Bonding & grounding and lightning protection

K-24 Electrical Theory

- Understand and comprehend basic electrical theory.
- AC/DC voltage and current principles; resistance (series & parallel circuits), inductance, and capacitance
- Power generation principles
- Electrical components such as: motor starters, manual switches, control relays, transformers, motor controls
- Basic Wiring
- Analog and digital signals
- PLC's—basic functions and applications

K-25 Motors & Generators—basic theory and operation

Introduction to Hydraulics and Pneumatics 3 Units

E-2 Follow operating and control check sheets and procedures **E**

D-1 Troubleshoot, repair, and/or replace hydraulic systems **F**
E-19 Synchronize pitch and yaw systems **F**

K-11 Hydraulics and pneumatics

Reading Technical Drawings and Manuals 3 Units

F-13 Interpret sketches, schematics, and blueprints **F**

K-23 Wiring diagrams, schematics, US, European and Japanese component symbols

Electronics I 3 Units

A-9 Follow ESD procedure (electro-static-discharge) **E**

C-4 Perform diagnostic checks **F**
D-5 Repair/replace PLCs and controllers **F**
E-12 Conduct circuit diagnostic testing **F**
E-11 Perform component function tests **F**
E-20 Interpret turbine operating system and efficiency data, including logs and alarms **F**
E-17 Solder electrical components **F**
E-2 Follow operating and control check sheets and procedures **E**
E-18 Tune the circuit to meet parameters and test specs **F**
F-11 Replace circuit boards **F**

K-24 Electrical/ Electronics Theory

- Understand and comprehend basic electrical theory.
- AC/DC voltage and current principles; resistance (series & parallel circuits), inductance, and capacitance
- Power generation principles
- Electrical components such as: motor starters, manual switches, control relays, transformers, motor controls
- Basic Wiring
- Analog and digital signals
- PLC's—basic functions and applications

Hand and Specialty Tools and Test Equipment 3 Units

E-1 Select, control, inspect required tools and test equipment **E**
B-1 Follow the established calibration schedule **E**
B-2 Record performance check data **E**
B-3 Red tag malfunctioning and out-of-calibration equipment **E**

B-4 Perform preventive maintenance on specialized equipment **F**
B-5 Run performance checks **F**
B-6 Maintain the test equipment where possible **F**
B-7 Evaluate the usefulness of current equipment and the need for new equipment **F**

K-19 Torque principles

G-11 Employ proper hand signals (cranes, rigging) **E**

C-4 Perform diagnostic checks **F**
C-5 Perform reliability checks **F**
D-6 Install, repair, replace equipment using cranes, hoists, and rigging techniques **F**
G-13 Recommend changes to Standard Operating Procedures **F**

C-6 Initiate pre-commissioning process **L**
C-7 Energize turbine **L**

Physical Requirements and Work Requirements

1. Ability to perform manual work, i.e.: standing, stooping, and walking.
2. Ability to lift up to 50 lbs.
3. Ability to climb a ladder 260+ feet above the ground without assistance on a frequent basis (height requirement to be finalized).
4. Ability to work outdoors in extreme cold and heat for extended periods of time from towers and platforms.

Certifications (preferred at entry but company will re-certify)

1. Confined Space
2. Tower Rescue

Installation & Commissioning process

E-9 Seek help from other resources, when needed **E**
G-2 Maintain working relationship with other departments **E**
G-3 Interact with customers and vendors in a professional manner **E**
G-4 Maintain a working relationship with co-workers **E**
G-5 Work in small groups and teams to accomplish work tasks **E**
G-6 Share information and expertise with co-workers **E**
I-1 Participate in job or equipment-specific training **E**
I-2 Maintain currency of technical skills **E**
I-3 Follow a career development plan **E**

F-10 Participate in root cause analysis sessions **F**
G-12 Mentor co-workers **F**
G-14 Supervise lower level technicians (1st line) **F**

G-16 Plan work from a technical inspection or condition report **F**
G-18 Prepare Standard Operating Procedures **L**

K-8 Work with people of other cultures, age, gender, and beliefs
K-9 Professional conduct, respectfulness, courteousness
K-10 Customer service-skills to meet customer needs

Computer Productivity Tools 4 Units

F-8 Generate a non-conformance report **F**
F-12 Load new control system software **F**
H-12 Make presentations **F**

K-5 Basic computer skills

- Complete forms
- Manage files
- Office productivity tools—word processing, spreadsheets, presentation, data bases

K-21 SCADA Basics

- Operability and limitations of physical infrastructure
- General components and connections
- Data extracted from components
- types of data collection and data use in industry
- Computer process applications and networking

Administrative Practices 1 Unit

G-8 Interpret verbal directions/instruction **E**
G-10 Follow manufacturer specifications in the operation & maintenance of equipment **E**
H-2 Participate in meetings **E**
H-3 Account for time with correct charge numbers **E**
H-4 Complete time records (electronic and manual) **E**
H-5 Maintain files and records **E**

H-7 Prepare written reports **F**
H-11 Maintain inventory as required by department **F**
H-9 Coordinate travel plans **F**
H-10 Prioritize workload based on information from managers and supervisors **F**

Technical Communications 3 Units

H-1 Complete daily logs **E**

F-8 Generate a non-conformance report **F**
F-9 Maintain detailed records and logs **F**
G-15 Prepare written reports to convey technical information to others **F**
H-7 Prepare written reports **F**

F-15 Use and/or develop troubleshooting aids and equipment manuals **F (Use), L (Develop)**
G-18 Prepare Standard Operating Procedures **L**
G-19 Communicate with regulatory agencies (written and verbal) **L**

K-3 Written and verbal communicate skills

Technical Math for Trades 4 Units

K-4 Math Skills

- Working knowledge of measurements, layout, computation formulae, functions
- Basic logic
- Add, subtract, multiply, and divide in all units of measure

Physical Science 4 Units (including lab)

K-20 Science and engineering theories and concepts

- Basics physics
- Behavior of matter
- Gasses and liquids
- Mechanical energy
- Introductory mechanical engineering concepts
- Levers, pulleys, machines
- Renewable energy processes and industries
- Environmental stewardship
- Machines, friction, and bearings
- Overview of power generation delivery grid systems from generation to end user including VARS (volts, amps, reactive)
- High voltage electrical safety standards; OSHA 1910-33, NFPA 70-E
- Aviation terminology and basic aerodynamics (physics)
- Instrumentation and control logic theory
- Fiber optics
- Basic rigging

Communications Integrate Across the Curriculum

G-1 Maintain open communication with supervisor **E**
G-7 Present verbal reports **E**
G-9 Employ three-way communication techniques **E**

H-12 Make presentations **F**
G-17 Provide informal/OJT training to co-workers **F**
F-14 Notify the appropriate department/person of troubleshooting trends and results **F**

Trouble Shooting Integrate Across the Curriculum

I-4 Suggest process and product improvements **E**

F-1 Review the equipment/product information (manuals, schematics, e.g.) **F**
F-2 Perform inspection (visual, audio, smell, touch, measurements) **F**
F-3 Trace circuits **F**
F-4 Apply troubleshooting techniques at the systems, sub-assembly and component level **F**
F-5 Seek help from other resources, when needed **F**
F-6 Verify operation of the test set/procedure **F**
F-7 Repair/replace the equipment/product **F**
F-8 Generate a non-conformance report **F**
F-14 Notify the appropriate department/person of troubleshooting trends and results **F**
F-15 Use and/or develop troubleshooting aids and equipment manuals **F (Use), L (Develop)**

Workplace Skills Integrate Across the Curriculum

A-3 Adhere to safe practices guidelines

K-3 Written and verbal communicate skills
K-6 Take initiative and work without direct supervision

Wind Technician – Future Trends

1. Companies will Increasingly replace “old” components as they wear out and as repowering opportunities emerge
    a. The industry will likely experience slow growth in building new wind farms due to the uncertain regulatory and financial environments. Helping to counterbalance these uncertainties is the impending expansion of the TRPT transmission line that will increase the capability of electric generating utilities companies to distribute the power to the CAL ISO Smart Grid

2. Although the current job outlook is somewhat flat due to the uncertainties being experience by the wind industry, the need for skilled technicians will likely grow due to:
    a. The needs for increased maintenance of existing turbines experienced by operations & maintenance, utilities, manufacturers long-term warranty services and independent service providers
    b. The demands on incumbent workers to “catch up” with both old and new technology
    c. The fairly quick turnover of employees due to demanding physical requirements and environmental work conditions

3. The increased use of climb assist devices (man lifts, elevators, e.g..) will encourage more talented and less physical workers to join this career field.

4. Bigger turbines will continue to be deployed (10-15 megawatts)

5. Technology advances will continue:
    a. There will be increased reliance on inverters and converters
    b. Reliance on condition monitoring will continue to increase
    c. Remote monitoring, trouble shooting, and repair capabilities will continue to develop
    d. Concerns about cyber security and electronic threats to control systems will continue to increase

6. The industry will likely experience some consolidation of operations & maintenance and independent service providers

Grant #1002653

7. There will continue to be increased pressure for unionization, especially in the construction and utilities sectors

8. The trends toward increased specialization of service providers and products for the wind industry will continue and perhaps accelerate
9. The balance of “old” vs.” new” technology in each company and the industry as a whole will continue to impact the skill sets needed and staffing decisions. Similarly, the regional weather and environmental differences (cold vs. warm, e.g.) will impact these same factors

Wind Technician
Occupational Profile

Wind Technicians install, maintain, inspect, and service electro-mechanical components and systems for wind turbines. They may install, troubleshoot, calibrate, maintain, and repair mechanical, electrical, electronic, composites, hydraulic and pneumatic components and systems using a variety of measuring and analytical tools and equipment. They maintain effective relationships with co-workers and stakeholders to insure a quality product.

CREATE
Grant #1002653

DUTIES		TASKS							
MAINTAIN A SAFE AND SECURE WORK ENVIRONMENT	A	Maintain a clean and safe work area A-1	Follow company and job-specific safety procedures A-2	Adhere to safe practices guidelines A-3	Discuss safety talk points with department members (daily, regularly) A-4	Complete safety training and exams A-5	Follow federal, state and local regulations A-6	Follow security requirements for the particular work area components A-7	Follow safe ergonomic practices A-8
		Follow ESD procedure (electro-static-discharge) A-9	Handle hazmats and materials according to MSDS requirements A-10	Follow electrical safety procedures (low/medium/high voltage) A-11	Perform safety inspections A-12	Follow environmental protection and hazardous chemical control procedures A-13	Maintain personal protective equipment A-14	Follow lock-out/tag-out procedures (energy flow/isolation) A-15	Follow company vehicle policies A-16
		Participate in Job Safety Analysis (JSA) A-17							
MAINTAIN AND TEST SPECIALIZED EQUIPMENT	B	Follow the established calibration schedule B-1	Record performance check data B-2	Red tag malfunctioning and out-of-calibration equipment B-3	Perform preventive maintenance on specialized equipment B-4	Run performance checks B-5	Maintain the test equipment where possible B-6	Evaluate the usefulness of current equipment and the need for new equipment B-7	
INSTALL NEW TURBINES	C	Ensure proper fluid levels C-1	Inspect fasteners C-2	Terminate and test components C-3	Perform diagnostic checks C-4	Perform reliability checks C-5	Initiate pre-commissioning process C-6	Energize turbine C-7	
PERFORM MAJOR COMPONENT REPAIR/ REPLACEMENT	D	Troubleshoot, repair, and/or replace hydraulic systems D-1	Align shafts using laser alignment equipment and procedures D-2	Perform mechanical shaft alignments D-3	Repair/replace motors and generators D-4	Repair/replace PLCs and controllers D-5	Install, repair, replace equipment using cranes, hoists, and rigging techniques D-6	Follow accepted standards and practices for mechanical and electrical assembly D-7	Install and replace bearings D-8

E = Entry-level Technicians are expected to perform these tasks
F = Full Performance Technicians are expected to perform these and entry-level tasks
L = Lead Technicians can perform all tasks

DUTIES		TASKS							
PERFORM PREVENTIVE/ PREDICTIVE MAINTENANCE	E	Select, control, inspect required tools and test equipment E-1	Follow operating and control check sheets and procedures E-2	Inspect rotors and air coils E-3	Lubricate bearings, gears, and top offs E-4	Select and replace fasteners E-5	Torque and tension fasteners E-6	Inspect bonding & grounding points (including lightning protection) inside & outside of turbine E-7	Repair/replace consumable wear components E-8
		Seek help from other resources, when needed E-9	Measure and interpret information from test equipment and tools E-10	Perform component function tests E-11	Conduct circuit diagnostic testing E-12	Inspect, maintain, and lubricate gearboxes E-13	Align shafts using laser alignment equipment and procedures E-14	Perform mechanical shaft alignments E-15	Inspect electrical components and connections E-16
		Solder electrical components E-17	Tune the circuit to meet parameters and test specs E-18	Synchronize pitch and yaw systems E-19	Interpret turbine operating system and efficiency data, including logs and alarms E-20				
TROUBLESHOOT EQUIPMENT AND PRODUCTS	F	Review the equipment/product information (manuals, schematics, e.g.) F-1	Perform inspection (visual, audio, smell, touch, measurements) F-2	Trace circuits F-3	Apply troubleshooting techniques at the systems, sub-assembly and/or component level F-4	Seek help from other resources, when needed F-5	Verify operation of the test set/procedure F-6	Repair/replace the equipment/product F-7	Generate a non-conformance report F-8
		Maintain detailed records and logs F-9	Participate in root cause analysis sessions F-10	Replace circuit boards F-11	Load new control system software F-12	Interpret sketches, schematics, and blueprints F-13	Notify the appropriate department/person of troubleshooting trends and results F-14	Use and/or develop troubleshooting aids and equipment manuals F-15	
COMMUNICATE WITH OTHERS	G	Maintain open communication with supervisor G-1	Maintain working relationship with other departments G-2	Interact with customers and vendors in a professional manner G-3	Maintain a working relationship with co-workers G-4	Work in small groups and teams to accomplish work tasks G-5	Share information and expertise with co-workers G-6	Present verbal reports G-7	Interpret verbal directions/ instruction G-8
		Employ three-way communication techniques G-9	Follow manufacturer specifications in the operation & maintenance of equipment G-10	Employ proper hand signals (cranes, rigging) G-11	Mentor co-workers G-12	Recommend changes to Standard Operating Procedures G-13	Supervise lower level technicians (1st line) G-14	Prepare written reports to convey technical information to others G-15	Plan work from a technical inspection or condition report G-16

E = Entry-level Technicians are expected to perform these tasks
F = Full Performance Technicians are expected to perform these and entry-level tasks
L = Lead Technicians can perform all tasks

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DUTIES		TASKS							
COMMUNICATE WITH OTHERS	G	Provide informal/OJT training to co-workers G-17	Prepare Standard Operating Procedures G-18	Communicate with regulatory agencies (written and verbal) G-19					
PERFORM ADMINISTRATIVE DUTIES	H	Complete daily logs H-1	Participate in meetings H-2	Account for time with correct charge numbers H-3	Complete time records (electronic and manual) H-4	Maintain files and records H-5	Complete incident reports H-6	Prepare written reports H-7	Participate in audits H-8
		Coordinate travel plans H-9	Prioritize workload based on informa-tion from managers and supervisors H-10	Maintain inventory as required by department H-11	Make presentations H-12				
MAINTAIN AND IMPROVE JOB SKILLS	I	Participate in job or equipment-specific training I-1	Maintain currency of technical skills I-2	Follow a career development plan I-3	Suggest process and product improvements I-4				

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E = Entry-level Technicians are expected to perform these tasks
F = Full Performance Technicians are expected to perform these and entry-level tasks
L = Lead Technicians can perform all tasks

Wind Technician Occupational Levels

	Job Titles	*Education/Experience Levels*	*Task Performance*
Entry Level Technician $31-37K yearly	Technician III Mechanic I (pre-Tech) Mechanic Helper (pre-Tech)	High school graduate Mechanical background Technical aptitude Hobbyist level experience	Can perform entry-level tasks with significant supervision and direction
Full Performance Technician $37-52K yearly	Technician II Advanced Mechanic Crew Leader	High school graduate Mechanical & electrical skill sets Specialized certification AA/AS degree 3 years experience	Can perform entry-level and full performance tasks with minimum supervision and direction Multi-skilled to a moderate degree Coordinates/ leads work teams Can assist and informally train entry-level workers on most job tasks
Lead Technician $60-80K yearly	Technician I Crew leader Senior Electrician	Turbine(s) specific skills Communication skills Multiple site experience Leadership skills 5-7 years experience	Can perform all tasks with no supervision or direction Coordinates/ leads work teams Multi-skilled to a high degree Can provide formal and informal training on all tasks to other technicians

Grant #1002653

← Industrial Technology Associate of Science Degree (65.5 units) →

DACUM Number	Skill	Level	Industrial Technology Core Certificate (15.5 units): Business Communications (BSAD C145)	Beginning Word (CSCI C121)	Beginning Excel (CSCI C123)	Business Communications (BSAD C145)	Read Tech Dwgs (DRFT C108)	First Aid / CPR / AED (HCRS C070)	Occupational Health & Safety (INSF C070)	Technical Math for Trades (MATH C056)	Basic Hand Tools (MCTL C107)	Wind Energy Technician Certificate Program (24 units): Tower Climb, Safety & Rescue (RET C070)	Intro to Renewable Energy Tech (INDT C100)	AC/DC Power (INDT C115)	WT Components & Systems (INDT C131)	Princ. of X-formers, Motors, Generators, & Ctrls (INDT C133)	Power Electronics & Logic Syst (INDT C135)	WT Pneumatic & Hydraulic Syst (INDT C137)	Rewnewable Energy Technology Internship (INDT C191)	Assembling Troubleshooting WTS (INDT C191)	Gen. Ed.: General Education (26 units)	Full Performance Wind Energy Technician Certificate Program (20 units): Beg. Acces (CSCI C125)	Microsoft PowerPoint (BSOT C127)	Siting and Permitting (INDT C125)	Advanced Concepts in Power Electronics (INDT C233)	Power Generation, Transmission, and Distribution (INDT C235)	High Tower Installation (INDT C237)	Mechanical Drive Systems (INDT C239)	Adv. Wind Turbine Generator Operation / Maintenance (AFT C241)	Advanced Industrial Motor Controls (INDT C243)	Adv. Assembling Trouble-shooting of WTS (INDT C295)
A-1	Maintain a clean and safe work area (across all lab curricula/practicums)	E							X					X	X	X	X	X	X	X					X			X	X	X	X
A-2	Follow company and job-specific safety procedures	E						X	X			X								X				X							
A-3	Adhere to safe practices guidelines (across all practicums)	E						X	X			X		X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X
A-4	Discuss safety talk points with department members (daily, regularly) (across all practicums)	E							X			X		X	X	X	X	X	X	X	X			X				X	X		X
A-5	Complete safety training and exams	E						X	X			X																			
A-6	Follow federal, state and local regulations	E						X	X			X			X	X	X	X	X	X	X			X				X	X		X
A-7	Follow security requirements for the particular work area components (across all practicums)	E							X		X	X			X	X	X	X	X	X	X					X	X	X	X	X	X
A-8	Follow safe ergonomic practices (across all practicums)	E							X		X	X			X	X	X	X	X	X	X			X	X	X	X	X	X	X	X
A-9	Follow ESD safety procedures	E												X		X	X	X	X	X	X			X	X	X		X	X	X	X
A-10	Handle hazardous materials according to MSDS requirements	E							X			X			X			X	X	X	X			X	X	X		X	X	X	X
A-11	Follow electrical safety procedures (low/medium/high voltage)	E										X		X	X	X	X	X	X	X	X			X	X	X		X	X		X
A-12	Perform safety inspections (across all practicums)	E							X		X	X			X	X	X	X	X	X	X			X	X	X		X	X		X
A-13	Follow environmental protection and hazardous chemical control procedures	E							X			X			X			X	X	X	X			X				X	X		X
A-14	Maintain personal protective equipment	E						X	X			X			X	X	X	X	X	X	X				X	X		X	X		X
A-15	Follow lock-out/tag-out procedures (energy flow/isolation)	E							X			X			X	X	X	X	X	X	X				X	X		X	X		X
A-16	Follow company vehicle policies	E							X											X				X							
A-17	Participate in Job Safety Analysis (JSA)	E						X	X											X				X							
B-1	Follow the established calibration schedule	E									X	X		X	X	X	X	X	X	X	X				X	X		X	X	X	X
B-2	Record performance check data	E												X		X				X					X	X		X	X	X	X
B-3	Red tag malfunctioning and out-of-calibration equipment	E							X											X					X	X		X	X		
B-4	Perform preventive maintenance on specialized equipment	F																		X					X	X		X	X		
B-5	Run performance checks	F																		X				X							X
B-6	Maintain the test equipment where possible	F																		X					X	X		X	X	X	
B-7	Evaluate the usefulness of current equipment and the need for new equipment	F																		X				X							
C-1	Ensure proper fluid levels	E														X		X	X	X								X	X		X
C-2	Inspect fasteners	E													X			X	X	X								X	X		X
C-3	Terminate & test components	E												X		X	X		X	X						X	X				X
C-4	Perform diagnostic checks	F												X		X	X		X	X						X	X				X
C-5	Perform reliability checks	F																														X
C-6	Initiate pre-commissioning process	L																						X								X
C-7	Energize turbine	L																														X
D-1	Troubleshoot, repair, and/or replace hydraulic systems	F																	X										X	X		X
D-2	Align shafts using laser alignment equipment and procedures (= E-14)	F																											X	X		X
D-3	Perform mechanical shaft alignments (= E-15)	F																											X	X		
D-4	Repair/replace motors and generators	F																											X	X		
D-5	Repair/replace PLCs and controllers	F																								X	X			X		X
D-6	Install, repair, replace equipment using cranes, hoists, and rigging techniques	F																														
D-7a	Follow accepted standards and practices for electrical assembly (across all curricula)	F																		X				X	X	X			X		X
D-7b	Follow accepted standards and practices for mechanical assembly (across all curricula)	F																		X									X		X
D-8	Install and replace bearings	F																											X			
E-1	Select, control, inspect required tools and test equipment	E							X					X						X				X	X				X		X
E-2	Follow operating and control check sheets and procedures	E							X					X						X				X	X				X		X
E-3	Inspect rotors & air coils	E													X					X									X		X
E-4	Lubricate bearings, gears, and top offs	E													X					X									X		X
E-5	Select and replace fasteners	E													X					X									X		X
E-6	Torque and tension fasteners	E									X				X				X	X									X		X
E-7	Inspect bonding and grounding points (including lightning protection) inside and outside of turbine	E							X								X			X									X		X
E-8	Repair/replace consumable wear components	E														X		X		X									X		X
E-9	Seek help from other resources, when needed (across all curricula)	E		X	X		X	X	X	X		X	X	X	X	X	X	X		X	X		X	X					X		X
E-10	Measure and interpret information from test equipment and tools	F												X	X	X	X	X						X	X	X		X	X		X
E-11	Perform component function tests	F																							X	X			X		X
E-12	Conduct circuit diagnostic testing	F																							X	X			X		X
E-13	Inspect, maintain, and lubricate gearboxes	F																										X	X		X
E-14	Align shafts using laser alignment equipment and procedures (= D-2)	F																											X		
E-15	Perform mechanical shaft alignments (= D-3)	F																						X					X		
E-16	Inspect electrical components and connections	F												X															X		X
E-17	Solder electrical components	F																											X		X
E-18	Tune the circuit to meet parameters and test specs	F																								X	X		X		X
E-19	Synchronize pitch and yaw systems	F																											X		X
E-20	Interpret turbine operating system and efficiency data, including logs and alarms	F																						X		X			X		X
F-1	Review the equipment/product information (manuals, schematics, e.g.)	F																		X				X	X	X			X		
F-2	Perform inspection (visual, audio, smell, touch, measurements)	F																		X				X	X	X			X		
F-3	Trace circuits	F																								X	X		X		
F-4	Apply troubleshooting techniques at the systems, sub-assembly and component level	F																											X		
F-5	Seek help from other resources, when needed	F																		X				X	X				X		
F-6	Verify operation of the test set/procedure	F																						X	X	X	X	X	X	X	X
F-7	Repair/replace the equipment/product	F																								X	X		X		X
F-8	Generate a non-conformance report	F																						X							
F-9	Maintain detailed records and logs	F																		X	X										X
F-10	Participate in root cause analysis sessions	F																		X	X										X
F-11	Replace circuit boards	F																								X			X		
F-12	Load new control system software	F																											X		
F-13	Interpret sketches, schematics, and blueprints	F																		X				X	X	X		X	X	X	X
F-14	Notify the appropriate department/person of troubleshooting trends and results	F																		X					X	X		X	X	X	X
F-15a	Use troubleshooting aids and equipment manuals	F																		X									X		
F-15b	Develop troubleshooting aids and equipment manuals	L																														X
G-1	Maintain open communication with supervisor (or instructor) (across all curricula)	E		X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X						X
G-2	Maintain working relationship with other departments (emulated by partnering in teams for projects)	E								X		X	X	X	X	X	X	X	X												
G-3	Interact with customers and vendors in a professional manner	E																		X				X							
G-4	Maintain a working relationship with co-workers (encouraged w/ classroom team projects thru'out curricula)	E						X		X		X	X	X	X	X	X	X	X	X				X							

←————————————— Industrial Technology Associate of Science Degree (65.5 units) ————————————————→

DACUM Number	Skill	Level	Industrial Technology Core Certificate (15.5 units)									Wind Energy Technician Certificate Program (24 units)									Gen. Ed.	Full Performance Wind Energy Technician Certificate Program (20 units)									
			Business Communications (BSAD C145)	Microsoft Word (CSCI C121)	Beg. Excel (CSCI C123)	Business Communications (BSAD C145)	Read Tech Dwgs (DRFT C108)	CPR (HCRS C070)	OSHA - 10 (INSF C070)	Tech/Trade Math (MATH C056)	Basic Hand Tools (MCTL C107)	Tower Climb, Safety & Rescue (RET C070)	Intro to Renewable Energy Tech (INDT C100)	AC/DC Power (INDT C115)	WT Components & Systems (INDT C131)	Princ. of X-formers, Motors, Generators, & C'trls (INDT C133)	Power Electronics & Logic Syst (INDT C135)	WT Pneumatic & Hydraulic Syst (INDT C137)	Rewnewable Energy Technology Internship (INDT	Assembling Troubleshooting WTS (INDT C191)	General Education (26 units)	Beg. Acces (CSCI C125)	Microsoft PowerPoint (BSOT C127)	Permitting & Siting (INDT C125)	Advanced Concepts in Power Electronics (INDT C233)	Power Generation, Transmission, and Distribution	High Tower Installation (INDT C237)	Mechanical Drive Systems (INDT C239)	Adv. Wind Turbine Generator Operation / Maintenance	Advanced Industrial Motor Controls (INDT C243)	Adv. Assembling Trouble-shooting of WTS (INDT C295)
G-5	Work in small groups and teams to accomplish work tasks (emulate with classroom team projects thru'out curricula)	E						X				X	X	X	X	X	X	X	X					X			X		X		X
G-6	Share information and expertise with co-workers (developed thru'out curricula with inter-student participation)	E						X				X	X	X	X	X	X	X	X								X				
G-7	Present verbal reports (developed thru'out curricula with inter-student participation)	E						X				X	X		X	X	X	X	X					X			X		X		X
G-8	Interpret verbal directions/instruction (developed thru (stepped) later project phases)	E						X				X		X	X	X	X	X	X	X							X		X		X
G-9	Employ three-way communication techniques	E						X											X								X				
G-10	Follow manufacturer specifications in the operation & maintenance of equipment	E								X		X		X	X	X	X	X	X	X									X		X
G-11	Employ proper hand signals (cranes, rigging)	E							X										X								X				
G-12	Mentor co-workers (encouraged thru'out curricula)	F										X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X
G-13	Recommend changes to Standard Operating Procedures	F																													X
G-14	Supervise lower level technicians (1stline)	F																	X												
G-15	Prepare written reports to convey technical information to others	F	X																X					X	X	X		X	X	X	X
G-16	Plan work from a technical inspection or condition report	F																													X
G-17	Provide informal/OJT training to co-workers	F																	X												
G-18	Prepare Standard Operating Procedures	L																													X
G-19	Communicate with regulatory agencies (written and verbal)	L	X																X												
H-1	Complete daily logs	E																	X												
H-2	Participate in meetings	E																	X												
H-3	Account for time with correct charge numbers	E																	X												
H-4	Complete time records (electronic and manual)	E																	X												
H-5	Maintain files and records (encouraged across all curricula)	E																	X												
H-6	Complete incident reports	E						X	X										X												
H-7	Prepare written reports	F	X																X												
H-8	Participate in audits	F																	X												
H-9	Coordinate travel plans	F																	X												
H-10	Prioritize workload based on information from managers and supervisors	F																	X												
H-11	Maintain inventory as required by department	F																	X												
H-12	Make presentations	F											X											X							
I-1	Participate in job or equipment-specific training	E																	X												
I-2	Maintain currency of technical skills (this is encouraged thru indep. research as part of assignments thru'out curricula)	E		X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X							X
I-3	Follow a career development plan (part of overall counseling)	E																	X												
I-4	Suggest process and product improvements	E													X	X	X	X													
K-8	Work with people of other cultures, age, gender, and beliefs (part of Gen. Ed. Needed for AS)	E	X			X													X												
K-9	Professional conduct, respectfulness, courteousness	E	X			X													X												
K-10	Customer service – skills to meet customer needs	E	X			X													X												
K-11	Hydraulics and pneumatics	E													X			X										X	X		X
K-12	Gear Boxes – Characteristics, gear types, types of wear, lubrication & maintenance issues, etc.	E													X			X										X	X		X
K-13	Lubrication – Types (oil, grease, natural v. synthetic), impurities & breakdown, sampling, TS&M, etc.	E																X										X	X		X
K-14	Yaw Systems – Function, types, yaw angle, rewind, brakes, etc.	E													X													X	X		X
K-15	Principles of shaft alignment	E													X													X	X		X
K-16	Fasteners and torquing	E													X			X										X	X		X
K-17	Material Safety Data Sheets (MSDS)	E											X															X	X		X
K-18	Weather patterns	E											X															X	X		X
K-19	Torque principles	E																X													
K-20	The following are all part of K-20: Basics physics	E											X		X			X													
	Behavior of matter	E												X				X													
	Gasses and liquids	E																X													
	Mechanical energy	E											X		X																
	Introductory mechanical engineering concepts	E											X		X																
	Levers, pulleys, machines	E											X		X																
	Renewable energy processes and industries	E											X																		
	Environmental stewardship	E											X																		
	Machines, friction, and bearings	E													X	X		X													
	Overview of power generation delivery grid systems from generation to end user including VARS (volts, amps, reactive)	E											X																		
	High voltage electrical safety standards – OSHA 1910-33, NFPA 70-E	E												X			X							X		X					
	Aviation terminology and basic aerodynamics (physics)	E											X																		
	Instrumentation and control logic theory	E												X			X			X					X	X					X
	Fiber optics	E													X										X	X					
	Basic rigging	E							X											X							X				
K-21	SCADA Basics – Operability & limitations of physical infrastructure, gen. components & connections, data acquisition & usage, networking & process applications	E													X										X	X				X	
K-22	Lightning detraction/dissipation, proper grounding (significance & theory), bonding & protection	E												X			X			X					X	X				X	X
K-23	Wiring diagrams, schematics, US, European and Japanese component symbols	E												X	X	X	X			X					X	X				X	X
K-24	Understand & comprehend basic electrical theory – Schematics & wiring, DC/AC voltage/amperage, R-L-C (series/parallel networks), power generation principles, components (motor starters, switches, relays, x-formers, & controls), Analog & digital signals. PLCs (functions & applications)	E												X	X	X	X			X					X	X				X	X
K-25	Motors & Generators—basic theory and operation	E														X									X	X				X	
K-26	Personal protective equipment	E							X			X	X	X	X	X	X	X		X				X	X	X	X	X	X	X	X
K-1	Ability & willingness to work in all weather conditions	E																	X												
K-3	Written and verbal communicate skills (Word used across all curricula for rpts & projs.)	E		X	X														X			X	X	X	X	X	X	X	X	X	X
K-4	Math: Working knowledge of measurements, layout, computation formulae, functions, Unit conversions, and Logic.	E								X									X					X	X	X	X	X	X	X	X
K-5	Basic computer skills – file management, forms, word processing, spreadsheets/DBs/etc.	E		X	X														X			X	X	X	X	X	X	X	X	X	X
K-6	Take initiative and work without direct supervision (not via class curricula but on-job experience)	E																	X												
	Wind Industry Overview – Role of wind within RE	E											X											X							
	Wind Industry Overview – Transmission & distribution	E											X											X							
	Weather and wind energy generation	E											X											X							
	Wind Farm Overview – Their types & characteristics	E											X											X							
	Technologies involved with wind farms	E											X											X							
	Wind turbine components	E											X																		
	Wind technician career pathways	E											X																		

NABCEP / Solar Energy Technician Course Skills Matrix

	Skill	Introduction to Renewable Energy (INDT	AC/DC Power (INDTC115)	Basics of Solar PV Tech. & Applications (INDT C121)	Adv. Solar PV Technology & Systems (INDT C123)	Permitting and Siting (INDT C125)	Renewable Energy Tech Internship (INDT C179)
	*** Activity checklist covered in courses with theory and/or lab as applicable**						
A	**VERIFY SYSTEM DESIGN**						
A-1	**Verify Client Needs**						
A-1	Determine Client Criteria for Install Location (Load, Equipment, Aesthetics, Budget)			✓		✓	
A-2	Address Legal Issues					✓	
A-3	Perform load analysis / assessment		✓	✓	✓		
A-4	Present Work Proposal & Get Client Buy-in			✓	✓		
A-2	**Site Survey & Review**						
A-2	Evaluate roof structure & condition (if roof install)				✓		
A-2	Evaluate site condition for array positioning, equipment, cabling, and grounding, etc.				✓		
A-2	Determine annual solar path & obstructions (including existing/potential hazards)	✓		✓	✓		
A-2	Determine PV system size & type, then select suitable solar equipment		✓	✓	✓		
A-2	Identify staging/lifting/access locations					✓	✓
A-2	Evaluate existing electrical equipment, wall structure, venting, etc. (for backup batteries)		✓	✓	✓	✓	✓
A-2	Determine roof pitch and azimuth (if roof install)	✓			✓		✓
A-2	Sketch & review (accuracy of) site drawings			✓		✓	
A-2	Assess wind exposure, soil conditions, and overall solar resource	✓			✓		
A-3	**Preparing for Install of the Solar PV System**						
A-3	Size the module mounting area based on customer's budget, energy goals & incentives		✓	✓	✓		✓
A-3	Confirm utility/authority having jurisdiction &/or restrictions			✓			✓
A-3	Determine topography of mounting area					✓	✓
A-3	Arrange PV modules in mounting area				✓		✓
A-4	**Review Design of Energy Storage System**						
A-4	Establish & verify best location for batteries (as energy storage system)					✓	✓
A-4	Establish & verify best location for meeting access requirements					✓	✓
A-4	Determine & verify critical loads and circuit runs		✓		✓		✓
A-4	Perform inspection of existing wiring and verify it meeting all required codes		✓			✓	✓
A-4	Identify multi-wire branch circuits		✓				✓
A-4	Match / size battery bank to inverters		✓		✓		✓
A-4	Confirm battery bank & technology is appropriate to usage & other charging sources		✓		✓		✓
A-5	**Calculate String Sizes**						
A-5	Determine highest & lowest design temperatures		✓		✓		✓
A-5	Account for module degradation		✓		✓		✓
A-5	Determine module V_{oc} at lowest design temperature		✓		✓		✓
A-5	Determine temperature-corrected voltage				✓		✓
A-5	Determine voltage limits of system		✓		✓		✓
A-5	Configure string to match system		✓		✓		✓
A-5	Determine inverter MPPT		✓		✓		✓
A-5	Determine V_{pmax} at highest design temperature		✓		✓		✓
A-6	**Select System Components**						
A-6	Match modules to inverters, charge controllers & to overall system		✓		✓		✓
A-6	Select combiner boxes		✓		✓		✓
A-6	Determine number of strings		✓		✓		✓
A-6	Determine / select number & type of inverters, charge controllers & mounting systems		✓		✓		
A-6	Ensure component compatibility		✓		✓		
A-6	Select string combiners		✓		✓		
A-6	Select overcurrent protection		✓		✓		
A-6	Select AC and DC disconnects		✓		✓		
A-6	Select grounding method		✓		✓		
A-6	Determine maximum number of unprotected strings in parallel		✓		✓		✓
A-6	Select GFP devices		✓		✓		✓
A-7	**Calculate Wiring & Conduit Size**						
A-7	Determine ampacity of conductors		✓				✓
A-7	Determine continuous currents		✓				✓
A-7	Determine continuous loads		✓				✓
A-7	Calculate conduit fill		✓				✓
A-7	Determine conditions of use			✓	✓		✓
A-7	Calculate temperature derating		✓				✓
A-7	Calculate conductor derating		✓				✓
A-7	Calculate voltage drop		✓				✓
A-7	Calculate power loss		✓				✓
A-7	Determine distance of run		✓		✓		✓
A-7	Determine conduit type		✓		✓		✓
A-7	Determine wire insulation type		✓				✓
A-7	Determiner environmental condition of conduit				✓	✓	✓
A-7	Calculate thermal expansion				✓		✓
A-7	Determine type of grounding conductors		✓		✓		✓

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A-7	Determine circuit current		✓		✓		✓
A-7	Calculate conduit size		✓		✓		✓
A-7	Calculate size of grounding conductors		✓		✓		✓
A-8	**Specify Overcurrent Protection**						
A-8	Calculate circuit currents	✓	✓				✓
A-8	Determine voltage requirements		✓				✓
A-8	Match overcurrent protection to conductor		✓				✓
A-8	Determine characteristices of existing distribution system		✓				✓
A-8	Select overcurrent protection device enclosures		✓				✓
A-8	Determine equipment limits of overcurrent protection		✓				✓
A-8	Determine available fault currents		✓				✓
A-8	Select equipment to match voltage (AC, DC, etc.)				✓		✓
A-8	Determine disconnecting means type		✓				✓
A-8	Determine disconnecting means amperage rating		✓		✓		✓
A-8	Determine disconnecting means location				✓	✓	✓
A-8	Determine temperature rating of OCPD		✓			✓	✓
A-8	Determine terminal temperature limits of OCPD	✓			✓		✓
A-8	Determine environmental conditions					✓	✓
A-8	Determine wire size limitations of OCPD		✓			✓	✓
A-9	**Specify Fasteners**						
A-9	Determine fastener sizes				✓		✓
A-9	Determine structural characteristics of substrate				✓		✓
A-9	Determine pull-out loads				✓		✓
A-9	Determine pull-out strengths				✓		✓
A-9	Determine wind loading				✓		✓
A-9	Assess environmental conditions					✓	✓
A-9	Determine fastener removal						✓
A-9	Determine type of mounting				✓		✓
A-9	Determine torque values				✓		✓
A-9	Determine force requirements of powder charge				✓		✓
A-9	Determine compatibility of fasteners to system				✓		✓
A-9	Select type of fastener				✓		✓
A-9	Determine necessity and size of pilot hole				✓		✓
A-9	Determine auxiliary materials				✓		✓
A-9	Select weatherproofing materials of building penetrations				✓		✓
A-9	Determine shear loads				✓		✓
A-9	Determine shear strengths				✓		✓
A-9	Determine types of loads				✓		✓
A-9	Specify fastener assembly				✓		✓
A-9	Develop bill of materials			✓	✓		✓
A-10	**Generate Plan Sets**						
A-10	Clarify design and OEM manuals						✓
A-10	Determine AHJ requirements						✓
A-10	Identify design professional						✓
A-10	Create electrical one- or three-line diagram				✓		✓
A-10	Create a site plan diagram						✓
A-10	Create map to location						✓
A-10	Create equipment layout diagram				✓		✓
A-10	Generate a safety plan					✓	✓
A-10	Assemble manufacturer’s data sheets				✓		✓
A-10	Create labeling schedule						✓
A-10	Assemble manufacturer’s instructions						✓
A-10	Address structural concerns				✓	✓	✓
A-10	Create structural details				✓	✓	✓
A-10	Determine sheet size	✓			✓		✓
A-10	Generate commissioning forms					✓	✓
A-10	Generate string diagram	✓			✓		✓
B	**MANAGING THE PROJECT [* Checklist provided in course]**						
B-1	**Conduct Pre-Construction Meetings**						
B-1	Assemble workforce, including other trades as appropriate				✓		✓
B-1	Determine daily construction goals			✓	✓		✓
B-1	Communicate construction strategy to customer			✓	✓		✓
B-1	Provide customer orientation				✓		✓
B-1	Communicate target pull-off time for crew				✓		✓
B-1	Document safety plan				✓	✓	✓
B-1	Determine community issues				✓	✓	✓
B-1	Determine customer requirements			✓	✓		✓
B-1	Plan weather contingencies				✓		✓
B-1	Resolve scheduling conflicts				✓		✓
B-1	Verify site conditions match design				✓	✓	✓

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B-1	Ensure pre-construction commitments by customer are complete				✓		✓
B-2	**Secure Permits & Approvals**						
B-2	Submit plans to utilities					✓	✓
B-2	Resolve utility conflicts					✓	✓
B-2	Secure written record of approval to interconnect					✓	✓
B-2	Obtain sign-off final building permit					✓	✓
B-2	Coordinate inspections					✓	✓
B-2	Schedule inspections					✓	✓
B-2	Submit plans to building department					✓	✓
B-2	Submit plans to fire department					✓	✓
B-2	Confirm job permits					✓	✓
B-2	Resolve AHJ conflicts					✓	✓
B-2	Determine additional agency permits (e.g., zoning, solar access, HOA, historic district)					✓	✓
B-3	**Manage Project Labor**						
B-3	Coordinate with subcontractors				✓		✓
B-3	Coordinate with other trades				✓		✓
B-3	Determine order of tasks				✓		✓
B-3	Allocate resources				✓		✓
B-3	Orient contractors to job site conditions				✓		✓
B-3	Resolve disputes				✓		✓
B-3	Supervise project crews				✓		✓
B-3	Track man hours				✓		✓
B-3	Communicate aspects of safety plan				✓		✓
B-3	Conduct toolbox talks				✓		✓
B-3	Confirm licensing compliance				✓	✓	✓
B-3	Confirm insurance compliance				✓	✓	✓
B-4	**Adapt System Design**						
B-4	Identify potential conflicts in design				✓		✓
B-4	Document changes to proposed design					✓	✓
B-4	Submit modification proposals					✓	✓
B-4	Acquire approvals to change design					✓	✓
B-4	Submit any change orders					✓	✓
B-4	Maintain as-built documentation				✓	✓	✓
B-5	**Manage Project Equipment**						
B-5	Take delivery of components				✓		✓
B-5	State site equipment				✓		✓
B-5	Schedule machinery				✓		✓
B-5	Ensure equipment operator certification				✓		✓
B-5	Install pedestrian barriers				✓		✓
B-5	Prepare site storage facilities				✓		✓
B-5	Obtain temporary facilities				✓		✓
B-5	Maintain temporary facilities				✓		✓
B-5	Schedule deliveries				✓		✓
B-5	Identify storage location for hazardous materials				✓		✓
B-5	Identify lifting and handling areas				✓		✓
B-5	Perform equipment inspection				✓		✓
B-5	Perform equipment maintenance				✓		✓
B-6	**Implement a Site-Specific Safety Plan**						
B-6	Perform hazard analysis				✓	✓	✓
B-6	Identify job site hazards				✓	✓	✓
B-6	Develop site specific safety plan				✓	✓	✓
B-6	Implement vehicle safety				✓	✓	✓
B-6	Implement ladder safety				✓	✓	✓
B-6	Install site safety barriers				✓	✓	✓
B-6	Implement fall protection plan				✓	✓	✓
B-6	Execute electrical safety				✓	✓	✓
B-6	Select PPE				✓	✓	✓
B-6	Identify access points to site				✓	✓	✓
B-6	Identify site evacuation points				✓	✓	✓
B-6	Post hospital map routes				✓	✓	✓
B-6	Post emergency contact numbers				✓	✓	✓
B-6	Post contingency plan				✓	✓	✓
B-6	Ensure MSDS is onsite				✓	✓	✓
C	**INSTALLING ELECTRICAL COMPONENTS**						
C-1	**Mitigate Electrical Hazards**						
C-1	Implement the site safety plan					✓	✓
C-1	Implement the lock-out, tag-out procedures	✓	✓		✓		✓
C-1	Determine voltage levels of interconnections	✓			✓		✓

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C-1	Maintain clear work area						✓
C-1	Clarify the maximum working voltage		✓		✓	✓	✓
C-1	Select required PPE based on system design (arc flash, shock, burn, voltage, etc.)	✓	✓	✓	✓		✓
C-1	Disconnect all unnecessary live circuits		✓	✓	✓		✓
C-1	Determine working clearances	✓	✓				✓
C-1	Demonstrate situational awareness						✓
C-1	Measure voltage on equipment before proceeding with work		✓	✓	✓		✓
C-1	Measure current on equipment before proceeding with work		✓	✓	✓		✓
C-1	Inspect safety equipment	✓	✓	✓	✓		✓
C-1	Maintain safety equipment				✓		✓
C-1	Inspect test equipment	✓	✓	✓	✓		✓
C-1	Calibrate test equipment		✓		✓		✓
C-1	Inspect hand and power tools		✓	✓	✓		✓
C-1	Maintain hand and power tools				✓		✓
C-2	**Install Grounding Systems**						
C-2	Install module grounding				✓		✓
C-2	Install inverter grounding				✓		✓
C-2	Make grounding electrode connection				✓		✓
C-2	Install mounting system grounding				✓		✓
C-2	Ground all non-current carrying metal parts				✓		✓
C-2	Install grounding electrode(s)				✓		✓
C-2	Bond metallic raceways				✓		✓
C-2	Install grounding electrode conductor				✓		✓
C-2	Install supplementary ground electrode				✓		✓
C-2	Install system grounds				✓		✓
C-2	Locate underground hazards				✓		✓
C-2	Bond all electrical equipment				✓		✓
C-2	Determine grounding conductor size				✓		✓
C-2	Install DC ground-fault protection				✓		✓
C-2	Apply anti-oxidant material				✓		✓
C-2	Prepare surfaces for electrical connections				✓		✓
C-2	**Install Conduit & Raceways**						
C-3	Plan conduit routing				✓		✓
C-3	Penetrate building envelope				✓		✓
C-3	Install underground electrical raceways				✓		✓
C-3	Install service entry mast				✓		✓
C-3	Support and secure conduit				✓		✓
C-3	Tighten all fittings				✓		✓
C-3	Select fittings according to application				✓		✓
C-3	Remove sharp edges (deburr)				✓		✓
C-3	Install above ground electrical raceways				✓		✓
C-3	Locate underground utilities				✓		✓
C-3	Create underground trenches				✓		✓
C-3	Backfill underground trenches				✓		✓
C-3	Install conduit bushings				✓		✓
C-3	Make knockouts in raceways				✓		✓
C-3	Mark underground cables				✓		✓
C-3	Mark underground trenches				✓		✓
C-4	**Install Electrical Components**						
C-4	Select location of DC disconnect				✓	✓	✓
C-4	Mount electrical enclosures				✓		✓
C-4	Install underground electrical components				✓	✓	✓
C-4	Install AC combiner				✓		✓
C-4	Install DC combiner				✓		✓
C-4	Label equipment				✓	✓	✓
C-4	Install PV system disconnects				✓	✓	✓
C-4	Install inverter disconnects				✓	✓	✓
C-4	Install utility required disconnects				✓	✓	✓
C-4	Install meter bases				✓		✓
C-4	Install array wiring transition box				✓	✓	✓
C-4	Install junction boxes in the attic (if roof mount)				✓	✓	✓
C-4	Select label materials				✓		✓
C-4	Install inverter				✓		✓
C-5	**Install Circuit Conductors**						
C-5	Pull conductors				✓		✓
C-5	Label conductors				✓		✓
C-5	Terminate conductors				✓		✓
C-5	Wire the inverter				✓		✓
C-5	Wire modules				✓		✓
C-5	Select the correct wire type, color, and gauge				✓		✓
C-5	Secure conductors				✓		✓

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C-5	Set up pull stations				✓		✓
C-5	Measure wires				✓		✓
C-5	Clear the raceway				✓		✓
C-5	Set up the wire installation (tugger, fish tape, rope)				✓		✓
C-5	Test conductor installation				✓		✓
C-5	Splice electrical conductors				✓		✓
C-5	Test DC source circuits				✓		✓
C-5	Test DC currents				✓		✓
C-6	**Install Utility Interconnection**						
C-6	Coordinate with customers & others regarding shutdowns				✓		✓
C-6	Install OCPD				✓		✓
C-6	Install generation metering				✓		✓
C-6	Install disconnects				✓		✓
C-6	Test utility voltage		✓		✓		✓
C-6	Coordinate AHJ inspection				✓		✓
C-6	Verify fill rates				✓		✓
C-6	Terminate conductors		✓		✓		✓
C-6	Test conductor insulation		✓		✓		✓
C-6	Select connection location				✓		✓
C-6	Implement lock-out, tag-out procedures		✓	✓	✓		✓
C-6	Evaluate existing service entrance equipment				✓		✓
C-6	Move existing circuits				✓		✓
C-7	**Install System Instrumentation**						
C-7	Install communication systems				✓		✓
C-7	Install power and energy metering				✓	✓	✓
C-7	Install environmental sensors				✓	✓	✓
C-7	Install controllers				✓		✓
C-7	Install electrical sensors				✓	✓	✓
C-7	Install inverter interface				✓		✓
C-7	Install power supply				✓		✓
C-7	Establish Ethernet connection				✓		✓
C-7	Program communication systems				✓		✓
C-7	Program instrumentation				✓		✓
C-7	Test system				✓	✓	✓
C-7	Calibrate system				✓	✓	✓
C-7	Install battery temp sensors				✓	✓	✓
C-7	Enroll gateway with offsite monitoring station				✓		✓
C-7	Install data communication cables				✓		✓
C-7	Install outlet for monitoring system				✓		✓
C-7	Program controllers				✓		✓
C-7	Install kiosks and displays				✓	✓	✓
C-8	**Install Battery Components**						
C-8	Confirm battery bank location			✓	✓	✓	✓
C-8	Install battery enclosure				✓	✓	✓
C-8	Install battery enclosure venting			✓	✓	✓	✓
C-8	Install battery spill containment				✓	✓	✓
C-8	Install seismic tiedown equipment				✓	✓	✓
C-8	Install batteries				✓		✓
C-8	Prepare battery terminals (e.g., clean)				✓		✓
C-8	Install battery interconnection conductors		✓	✓	✓		✓
C-8	Install battery units				✓		✓
C-8	Apply anti-oxidant compounds				✓		✓
C-8	Test each unit before placement (voltage, specific gravity, polarity)				✓	✓	✓
C-8	Terminate fine stranded cables				✓	✓	✓
C-8	Calculate ampacity		✓		✓	✓	✓
C-8	Install charge controller				✓		✓
C-8	Seal conduit entry to battery box				✓	✓	✓
C-8	Install maintenance disconnect				✓	✓	✓
C-8	Label battery units				✓	✓	✓
C-8	Label battery enclosure				✓	✓	✓
C-8	Label battery room				✓	✓	✓
C-8	Establish maintenance schedule				✓	✓	✓
C-8	Test final assembled battery polarity and voltage		✓		✓	✓	✓
C-8	Install safety station				✓	✓	✓
D	**INSTALLING MECHANICAL COMPONENTS**						
D-1	**Install Equipment Foundation**						
D-1	Locate center points of holes				✓		✓
D-1	Excavate to design specifications				✓	✓	✓
D-1	Build concrete forms				✓		✓
D-1	Coordinate foundation inspections				✓	✓	✓
D-1	Identify location of underground utilities				✓	✓	✓

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D-1	Add structural reinforcement				✓	✓	✓
D-1	Install wire raceways				✓	✓	✓
D-1	Place concrete to design specifications				✓	✓	✓
D-1	Place anchor hardware				✓	✓	✓
D-1	Install driven posts				✓	✓	✓
D-1	Strip concrete forms				✓		✓
D-1	Backfill excavation				✓	✓	✓
D-1	Place mounting posts				✓		✓
D-1	Install GEC				✓		✓
D-2	**Install Mounting System**						
D-2	Install tracking apparatus (if non-fixed, single or dual axes tracking system)				✓		✓
D-2	Install actuator motors (— ditto —)				✓		✓
D-2	Install roof attachments (if roof mount system)				✓		✓
D-2	Weatherproof penetrations				✓	✓	✓
D-2	Locate ballast for mounting system				✓	✓	✓
D-2	Install supplementary structural supports				✓	✓	✓
D-2	Install seismic and wind loading				✓	✓	✓
D-2	Locate structural roof members				✓		✓
D-2	Determine array attachment locations				✓	✓	✓
D-2	Install structural attachments				✓		✓
D-2	Install module support frame				✓		✓
D-2	Install rack components				✓		✓
D-2	Determine row spacing				✓	✓	✓
D-2	Locate array footprint				✓	✓	✓
D-2	Confirm structural analysis has been performed				✓	✓	✓
D-2	Confirm compatibility with existing roofing system				✓	✓	✓
D-2	Install structural members				✓	✓	✓
D-2	Plumb array structure				✓	✓	✓
D-2	Level array structure				✓	✓	✓
D-2	Apply corrosion protection to cut surfaces				✓	✓	✓
D-3	**Install PV Modules**						
D-3	Unpack PV modules				✓		✓
D-3	Stage PV modules				✓		✓
D-3	Test PV modules		✓		✓		✓
D-3	Prep PV modules				✓		✓
D-3	Secure module wiring		✓		✓	✓	✓
D-3	Inspect module for physical damage				✓	✓	✓
D-3	Fasten modules to structure				✓		✓
D-3	Torque module fasteners				✓		✓
D-3	Confirm module frame grounding		✓		✓	✓	✓
D-3	Align modules aesthetically				✓		✓
D-3	Determine project workflow			✓	✓		✓
E	**COMPLETE SYSTEM INSTALLATION**						
E-1	**Test the System**						
E-1	Verify mechanical connection integrity				✓		✓
E-1	Verify system grounding				✓	✓	✓
E-1	Verify electrical connection torque				✓	✓	✓
E-1	Measure insulation resistance		✓		✓	✓	✓
E-1	Verify polarity		✓		✓	✓	✓
E-1	Measure environmental levels				✓	✓	✓
E-1	Measure irradiance levels				✓	✓	✓
E-1	Measure DC voltages (string, output)		✓		✓	✓	✓
E-1	Verify inverter operation				✓	✓	✓
E-1	Measure DC currents				✓	✓	✓
E-1	Calculate expected electrical parameters				✓	✓	✓
E-1	Compare measured values with expected values				✓	✓	✓
E-1	Measure AC system values		✓		✓	✓	✓
E-1	Verify anti-islanding system				✓		✓
E-1	Verify calibration of DAS				✓		✓
E-1	Perform physical inspection				✓		✓
E-1	Verify conduit fitting tightness				✓	✓	✓
E-1	Verify conduit and wiring supports				✓	✓	✓
E-1	Confirm phase rotation				✓	✓	✓
E-1	Verify workmanship				✓	✓	✓
E-1	Test for ground fault				✓	✓	✓
E-2	**Commissioning the System**						
E-2	Verify polarity of energy storage system				✓	✓	✓
E-2	Turn on system				✓		✓
E-2	Initiate startup procedures per manufacturer instructions				✓		✓
E-2	Program variable set points				✓		✓
E-2	Measure all electrical parameters				✓	✓	✓

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E-2	Note data and time of system startup				✓	✓	✓
E-2	Compare measured values to expected values				✓	✓	✓
E-2	Monitor startup process				✓		✓
E-2	Record anomalous conditions				✓		✓
E-2	Repair anomalous conditions				✓		✓
E-2	Record environmental conditions				✓		✓
E-2	Record prior values on inverter				✓		✓
E-2	Verify anti-islanding performance				✓		✓
E-2	Photograph meter at startup				✓	✓	✓
E-2	Verify calculation of Total Solar Resource Fraction				✓	✓	✓
E-2	Measure voltage of energy storage system				✓	✓	✓
E-2	Record voltage of energy storage system				✓	✓	✓
E-2	Document design changes				✓	✓	✓
E-2	Verify as-built documentation				✓	✓	✓
E-2	Verify labeling accuracy				✓	✓	✓
E-3	**Complete System Documentation**						
E-3	Record component serial numbers				✓	✓	✓
E-3	Deliver as-built documents				✓		✓
E-3	File project photographs				✓	✓	✓
E-3	File permits				✓	✓	✓
E-3	Record certificates of inspection				✓	✓	✓
E-3	File inspection forms				✓	✓	✓
E-3	File commissioning forms				✓	✓	✓
E-3	Complete equipment warranty registration				✓	✓	✓
E-3	Complete installation warranty registration				✓	✓	✓
E-3	Complete O&M documentation				✓	✓	✓
E-3	Compile customer operations manual				✓		✓
E-3	File data sheets				✓	✓	✓
E-3	File proof of system test results				✓	✓	✓
E-3	Deliver bill to client				✓		✓
E-4	**Orient Customer to System**						
E-4	Explain startup and shutdown procedures				✓		✓
E-4	Answer customer questions				✓		✓
E-4	Address customer concerns				✓		✓
E-4	Explain safety procedures to customer				✓		✓
E-4	Explain maintenance procedures				✓		✓
E-4	Train customer on maintenance and operation procedures				✓		✓
E-4	Explain equipment clearance requirements				✓		✓
E-4	Perform customer walk-through				✓		✓
E-4	Provide contact information to customer				✓		✓
E-4	Deliver O&M documentation to customer				✓		✓
E-4	Explain normal operational performance				✓		✓
F	**CONDUCTING MAINTENANCE & TROUBLESHOOTING ACTIVITIES**						
F-1	**Perform Visual Inspection**						
F-1	Verify equipment grounding		✓		✓	✓	✓
F-1	Inspect module mounting system				✓		✓
F-1	Identify hazards				✓	✓	✓
F-1	Inspect weatherproofing systems				✓		✓
F-1	Inspect for wiring damage				✓		✓
F-1	Inspect module integrity				✓		✓
F-1	Check inverter status				✓		✓
F-1	Inspect electrical equipment		✓		✓	✓	✓
F-1	Inspect for working clearances				✓	✓	✓
F-1	Identify damage due to corrosion				✓		✓
F-1	Identify array shading				✓	✓	✓
F-1	Identify array soiling				✓	✓	✓
F-1	Inspect cells for discoloration				✓		✓
F-1	Verify grounding system integrity		✓		✓	✓	✓
F-1	Identify electrical connections damage due to overheating				✓		✓
F-1	Confirm equipment serial numbers				✓	✓	✓
F-1	Inspect module backskin				✓		✓
F-1	Check conduit fitting tightness				✓	✓	✓
F-1	Look for unsupported wiring				✓		✓
F-1	Identify damage to module glazing				✓		✓
F-1	Inspect for evidence of animals				✓		✓
F-1	Identify vegetation growth				✓	✓	✓
F-1	Identify water ponding				✓	✓	✓
F-1	Identify ice damage				✓		✓
F-1	Document findings				✓	✓	✓
F-1	Identify mismatched equipment		✓		✓		✓
F-2	**Verify System Operation**						

	Skill	Introduction to Renewable Energy (INDT	AC/DC Power (INDTC115)	Basics of Solar PV Tech. & Applications (INDT C121)	Adv. Solar PV Technology & Systems (INDT C123)	Permitting and Siting (INDT C125)	Renewable Energy Tech Internship (INDT C179)
F-2	Interview customer				✓		✓
F-2	Document customer's concerns				✓		✓
F-2	Compare historical kWh performance against expected kWh performance				✓		✓
F-2	Note inter-annual weather variability				✓		✓
F-2	Measure system electrical parameters				✓		✓
F-2	Document as-found electrical parameters				✓		✓
F-2	Calculate expected electrical parameters				✓		✓
F-2	Compare expected parameters with as-found parameters				✓		✓
F-2	Note anomalous conditions				✓		✓
F-2	Test system electrical equipment operations				✓		✓
F-2	Recommend corrective actions				✓		✓
F-2	Verify source circuits are connected				✓		✓
F-2	Measure equipment temperatures				✓		✓
F-2	Measure terminal temperatures				✓		✓
F-2	Verify operation of battery venting systems				✓		✓
F-2	Verify battery auxiliary systems				✓		✓
F-3	**Perform Corrective Actions**						
F-3	Clean arrays				✓		✓
F-3	Replace defective modules				✓		✓
F-3	Service ventilation systems				✓		✓
F-3	Clean batteries				✓		✓
F-3	Check equipment variable set points				✓		✓
F-3	Recalibrate equipment variable set points				✓		✓
F-3	Wipe down power conditioning equipment				✓		✓
F-3	Clean heat sinks				✓		✓
F-3	Schedule manufacturer onsite service call				✓		✓
F-3	Perform scheduled maintenance				✓		✓
F-3	Replace frayed wires				✓		✓
F-3	Replace blown fuses				✓		✓
F-3	Replace faulty components				✓		✓
F-3	Locate ground faults				✓		✓
F-3	Repair ground faults				✓		✓
F-3	Trim vegetation				✓		✓
F-3	Clear blocked drainages				✓		✓
F-3	Seal compromised weatherproofing systems				✓		✓
F-3	Mitigate negative local conditions				✓		✓
F-3	Perform battery maintenance				✓		✓
F-3	Perform controlled overcharge				✓		✓
F-3	Locate line to line faults				✓		✓
F-3	Repair line to line faults				✓		✓
F-3	Clean system labeling				✓		✓
F-3	Replace system labeling				✓		✓
F-3	Document corrective actions				✓	✓	✓
F-4	**Verify Effectiveness of Corrective Actions**						
F-4	Retest electrical parameters				✓		✓
F-4	Retest system operations				✓		✓
F-4	Retest environmental conditions				✓		✓
F-4	Retest weatherproofing system				✓		✓
F-4	Compare pre-maintenance values to post-maintenance values				✓	✓	✓
F-4	Re-orient customer to system				✓		✓

Course Assessment Overview Worksheet

	When Assessed					
Course	FA10	SP11	SU11	FA11	SP12	% Complete

Course Assessment Worksheet

Course:

		Assessment and Data Collection		
Outcome and Assessment Definitions		**Detailed Description of Assessment Plan**	**Results**	**Plan for Improvement and Reassessment**
A.	Upon successful completion of the course, XX% of students will be able to This will be assessed with	**Description** **Timeline** **Sample** **Pending Tasks:** •		
B.	Upon successful completion of the course, XX% of students will be able to This will be assessed with	**Description** **Timeline** **Sample** **Pending Tasks:** •		
C.	Upon successful completion of the course, XX% of students will be able to This will be assessed with	**Description** **Timeline** **Sample** **Pending Tasks:** •		
D.	Upon successful completion of the	**Description**		

	course, XX% of students will be able to This will be assessed with	**Timeline** **Sample** **Pending Tasks:** •		