SCHOOL BASED ELECTIVE MODULE

ENGINEERING APPLICATION MODULE 4: PHOTOVOLTAIC ENGINEERING

TEACHING PROGRAM

24 hours of indicative time

This module covers silicon and solar cell manufacture, photovoltaic modules, control circuits, system layouts and applications.

Outcomes

A Student:

P1.1 identifies the scope of engineering and recognises current innovations

P2.1 explains the relationship between properties, uses and applications of materials in engineering

P3.2 develops written, oral and presentation skills and applies these to engineering reports

P3.3 applies graphics as a communication tool

P4.1 describes developments in technology and their impact on engineering products

P4.3 identifies the social, environmental and cultural implications of technological change in engineering

P5.1 demonstrates the ability to work both individually and in teams

P6.1 applies knowledge and skills in research and problem-solving related to engineering

P6.2 applies skills in analysis, synthesis and experimentation related to engineering

A note to teachers and administrators: The teaching program provided includes content that is intended to be taught over a period of 24 indicative hours. However, teachers may select appropriate sections of material based on the time constraints of the individual class and school.

Students learn about:	Students learn to:
Historical and societal influences: • Historical developments of photovoltaics and how experience curve shows cost reduction over time • The effect of engineering innovation on people's lives, particularly in rural areas and developing countries • The environmental implications of photovoltaics including mitigation of global warming & the enhanced greenhouse effect • The link between photovoltaics, renewable energy, self-sufficiency & equity	• Define terminology related to the photovoltaic industry • Identify the added-value benefits for photovoltaics such as supply security, reduced transmission losses, rural independence, sustainable job creation, & grid voltage support. • Explain the mechanisms of enhanced greenhouse effect and the impact of the solutions that photovoltaics can provide (already covered ←)
Engineering mechanics • The manufacturing process of a silicon solar cell • The role of doping (see right →) • How a photovoltaic cell operates including identifying that light includes photon using the photoelectric effect • How modules are manufactured and tested • Photovoltaics Applications (assignment)	• Describe the operation of a p-n junction and compare its operation with diode • Make a flowchart of the silicon solar cell manufacture from silicon extraction & purification to cell production (see left ←) • Identify methods of linking cells to form modules and evaluate each and understand the impact of cell shading on module and system output • Describe the use of accelerated lifetime testing to determine module's life and identify common failure modes. (see left ←) • Compare and contrast between solar thermal technologies and photovoltaics • Produce a group Engineering Report on one of the photovoltaic applications given at the end of the section (assignment)
Engineering materials • The different materials used to construct solar cells, and the advantages and disadvantages of each • Thin film vs. wafer technologies, and issues • Properties of materials - Glass and Tedlar use in encapsulation - Antireflection coatings - Texturing	• Differentiate between thin-film and wafer technologies and identify the advantages and disadvantages of each. (see left ←) • Compare and contrast the different materials used to construct solar cells (see left ←) • Identify reasons for sourcing Silicon from the Integrated Circuits (IC) industry • Briefly identify the difference between

• Structure of materials
  - Interaction of photon with silicon to produce electrons
  - Crystalline structures in silicon
• Metals
  - The use of metals in contacts to collect current
	single crystal, polycrystalline, multi-crystalline, amorphous & ribbon silicon (see left ←)
	• Using diagrams to describe how texturing and antireflection coatings operate optically (see left ←)

Engineering electricity/electronics
• Basic electrical principles
  - Potential difference
  - Current
  - Simple circuits and components
  - Power and IV curve
  - Safety with DC
• Control circuits
  - Inverters & Maximum Power Point Tracker (MPPT)
  - Regulator
  - Batteries
  - Charge controller
• Islanding concerns & techniques to overcome them
• PV system sizing and configuration according to application
	• Draw a block diagrams of the workings and waveform output of inverters, charge controllers and regulators/MPPTs (see left ←)
	• Identify the use of logic gates in control equipment/devices
	• Identify the need for control systems
	• Why are batteries important to photovoltaics and how can they be best utilized, combined and configured.
	• Interpret current voltage curves (IV curves) for photovoltaic modules
	• Appreciate the importance of safety when working with DC circuits.
	• Identify the parameters involved in power losses in transmission lines.

Communication • Block diagrams and flow chart • Research methods including the Internet, CD-ROM and libraries • Collaborative work practices • Engineering Report writing	• Conduct research using computers, the world wide web and printed resources • Complete an Engineering Report in a team on one of the photovoltaic topics provided. • Use correct referencing techniques for research work • Interpret circuit diagrams

Engineering Report Topics

Off-Grid:

- Water pumping [in-class special topic]
- Remote Area Power Supplies (RAPS)
- Remote Area Telephony
- Solar Home System in Developing Countries
- Solar lighting & LEDs
- Cathodic protection in pipelines, bridges and aircraft Aluminium
- Schools & rural health clinics

On-Grid:

- Grid-connected residential, industrial and commercial buildings
- Solar transport
- Building-integrated photovoltaics

Non-terrestrial:

- Space
- Buoys & meteorological applications