**Electrical and Computer Engineering**
**Spring 2021**

*ECE 632*
**PHOTOVOLTAIC ENERGY CONVERSION**

| Term: | Spring 2021 |
|---|---|
| Instructor: | Prof. Siva Sivoththaman |
| Lecture hours: | ████████████████████████████████████ |

*Please send email to sivoththaman@uwaterloo.ca for any enquiries about this course.*

COURSE DESCRIPTON:

This course is intended for engineering graduates and educates them on fundamental and applied aspects of photovoltaics (PV) energy conversion, including PV device concepts and fabrication technologies, PV modules, power conditioning; PV systems design; grid-connection; power quality; and safety aspects.

COURSE OUTLINE:

**1. Photons and Solar Radiation**
Review of properties of photons; wave theory; solar radiation; energy distribution; scattering theory; direct and diffuse radiations; air mass; radiation standards for photovoltaic performance evaluation.

**2. Review of Semiconductor Properties for PV**
Review of semiconductor materials; band theory; dynamics of electrons and holes; photon absorption; carrier generation and recombination processes; fabrication technologies of bulk and thin-film semiconductors for PV; techniques for semiconductor material evaluation.

**3. Review of Relevant Device Physics for PV**
Junction theory, energy band-diagrams, non-equilibrium conditions; carrier-transport mechanisms; current-voltage characteristics.

**4. PV Device Operation & Performance Limits**
Operating principles of PV devices; energy conversion efficiency; spectral response; equivalent circuits; illuminated and dark I-V characteristics; theoretical efficiency limits; loss mechanisms; temperature effects; device architectures and performance; advanced concepts for future devices.

**5. PV Device Fabrication Technologies**
Baseline technologies for silicon-based, thin-film, and compound semiconductor devices; surface passivation; optical confinement; high-low junctions; industrial processes; emerging technologies for advanced PV devices.

### 6. PV Module assembly & Interconnection

Module design, interconnection schemes, I-V characteristics, temperature effects, mismatch effects and mitigation methodologies; by-passing circuits; potential-induced degradation; ageing effects

### 7. Power Conditioning for PV

Components for back-end electronics, algorithms for maximum power-point tracking, inverter circuits; storage; blocking diodes; regulators and charge controllers; battery options

### 8. PV Systems and Grid-Connection

System types and operating modes; sizing and design rules; stand-alone systems; building-integrated PV; energy management; fault detection; overvoltage protection; grid-connection; system-grid interface; power quality issues: voltage imbalance, harmonics, islanding; remedial measures.

---

MARKING SCHEME:

Quizzes/short tests: (60%)

Course Project: 40%

NOTE: Students opting to audit the course should still do the course project in order to receive the "AUDIT" grade.

TEXT:

- Detailed Course Notes will be provided

---

**ACADEMIC INTEGRITY:**

Every student must know, and fully abide by, the Academic Integrity Policy of University of Waterloo.

The information provided in the following link must be read, understood, and followed by every student:
https://uwaterloo.ca/academic-integrity/integrity-students