APPLIED PHOTOVOLTAIC ENGINEERING

1. **The sun and the solar spectrum (4 hours)**
   1. Electromagnetic spectrum
   2. Effects of Earth atmosphere, orbit and rotation on insolation
   3. Estimation and measurement of solar radiation
   4. Calculation of energy available in a place; radiation on inclined and horizontal plane, yearly energy available in place
   5. Models and Software for assessing the solar energy

1. **Semiconductors for photovoltaics (4 hours)**
   1. p‐n junction for solar cell, fundamental concept; I‐V and P‐V characteristics
   2. Model of PV cells; short circuit current, open circuit voltage, four parameter model, equivalent circuit, effect of temperature
   3. Fill factor, efficiency series
   4. Cell to panel, effect of shading and mitigation
   5. Testing of PV panel
   6. Model and simulation

1. **Modern PV cell technology (4 hours)**
   1. Thin film technology
   2. Polycrystalline silicon
   3. Thin film solar cell
   4. Epitaxial films including GaAs modern cell
   5. Solar panel standards

1. **Power electronics and control of photovoltaic system (8 hours)**
   1. Dc‐Dc converter ( buck, boost, isolating converter
   2. Inverter topology
   3. Single stage and two stage power electronics configuration
      1. Control of dc‐dc converters :Maximum power point tracking techniques
   4. Control of Inverters
      1. Isolated operation
      2. Grid connected operation

1. **Isolated PV systems (6 hours)**
   1. Storage devices: different type of batteries
   2. Charge controller; principle and circuit diagram
   3. UPS system with PV: back to back converter topology, charging scheme of UPS by PV and grid, setting priority
   4. Water pumping

1. **Grid Connected PV system (8 hours)**
   1. Phase, frequency and voltage matching
      1. Grounding
      2. Protection
      3. Transient response
      4. Power Flow analysis with PV units;
      5. Short Circuit analysis with PV units;
      6. Voltage profile
      7. Guideline for PV integration; penetration level
   2. Interconnection standards, codes and practices
      1. IEEE
      2. IEC
      3. UL
      4. Voltage ride through requirements
      5. others

1. **Design of PV system (4 hours)**
   1. Isolated PV system for residence
   2. Grid connected PV system
   3. Solar water pump

1. **Socio‐economic aspects (4 hours)**
   1. Economic assessment of PV power system (Payback period, Total Ownership cost ‐TOC, Present worth factor‐PWF)
   2. Environmental Impact analysis (EIA) and safety of PV system
   3. Production, recycling and disposal of PV system ( PV panel and batteries)
   4. Large scale integration of PV into power grid

**Practical Works (Experiment and Simulation)**

1. Study of characteristics of PV cell and module
   1. Plotting of I‐V, P‐V curve on different insolation
   2. Determination of parameters of PV panel: short circuit current, open circuit voltage, series and shunt resistance
2. Design and simulation of stand‐alone photovoltaic system: use suitable numerical tools (such as Maltlab Simulink, PSCAD)
3. Design and simulation of grid connected PV system: use suitable numerical tools (such as Maltlab Simulink, PSCAD)
4. Case study: Study of large scale PV system (one from world and Nepal each)
5. Field visit

**Reference:**

1. Photovoltaic system analysis and design, AK Mukharji, PHI 2011.
2. Kalogirou, S. A. Solar Energy Engineering: Processes and Systems, Academic Press, 2009, ISBN‐10: 0123745012
3. Renewable and Efficient Electric Power Systems, G Masters, Wiley Publication 2004.
4. Messenger, R. A., Ventre, J., Photovoltaic Systems Engineering, 2nd ed., CRC Press, 2003, ISBN‐10: 0849317932
5. Foster, R.; Ghassemi, M.; Cota, A.; Solar Energy: Renewable Energy and the Environment, CRC Press, 2009, ISBN‐10: 1420075667