Homework #10 (group) – Thursday, April 26 by 4:00 pm

5290 exercises (individual) – Thursday, April 26 by 4:00 pm

Readings for this homework assignment and upcoming lectures

- Download & read lecture notes:
  - Part 11a. Solar Energy - Insolation
  - Part 11b. Solar Energy - Collectors
  - Part 11c. Solar Energy - Storage
  - Part 12. Solar Energy - Photovoltaics

Homework Submission

- For this assignment, the 4200-portion of the homework is to be worked as a group assignment and submitted as a group in class or by dropping off at my office (MEEM 905). If you use EES for this assignment, then print a copy of the code and solution and include with the homework.
- MEEM 5290 problems are always to be worked and submitted individually.
- Extra credit exercises are always to be worked and submitted individually.
- **At the end of each problem, rank your confidence in the answer from 1 to 5; 5 being very confident and 1 being 'a guess'.**
- Include the course number (MEEM4200, MEEM5290) in the subject line of any email correspondence.

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1. A 60-mm by 30-mm photovoltaic solar cell is exposed to a solar energy flux of $I_{\text{total}} = 650\,\text{W/m}^2$ with an average photon wavelength of $0.709\,\mu\text{m}$. The light impinges on a CdTe-based photovoltaic cell with a bandgap energy of 1.41 eV.
   (a) Determine the average photon energy, in J/photon and eV/photon.
   (b) Determine the photon flux, in units of photons/$\text{m}^2\,\text{s}$.
   (c) Determine the maximum possible efficiency for electrical power generation.

   A filter is placed over the solar cell that shifts the average photon energy to 550 nm and reduces the electromagnetic flux to $485\,\text{W/m}^2$. Repeat parts (a), (b), and (c) for this new condition.

2. A solar-pond power plant operates on an ideal, simple Rankine cycle with R-134a as the working fluid. The refrigerant enters the turbine as saturated vapor at 1.6 MPa and exits at 0.7 MPa. The mass flow rate is 3 kg/s.
   (a) draw the cycle on a T-s diagram,
   (b) calculate the thermal efficiency of the cycle,
   (c) calculate the power output of the plant, and
   (d) calculate the minimum surface area of the solar pond if the solar insolation is $576\,\text{W/m}^2$ and the temperatures in the pond remain constant during plant operation.

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3. A manufacturer provides the following "name plate" data for a silicon solar cell at 27 °C:
   - short-circuit current density, $j_s = 158\,\text{A/m}^2$
   - reverse-saturation current density, $j_o = 8 \times 10^{-8}\,\text{A/m}^2$

   (a) For maximum power, determine the solar cell area required to deliver 1 kW_e (DC).
   (b) Estimate the conversion efficiency for an incident solar flux of 1200 W/m^2.