EEE124 – Tutorial questions:

1) The direction that the roof faces is important for the placement of solar panels in the UK. Tick all the roof directions that will work efficiently: (+1 for correct answer, -1 for wrong answer)
   - i) North
   - ii) South √
   - iii) East
   - iv) West
   - v) North-East
   - vi) North-West
   - vii) South-East √
   - viii) South-West √

2) An individual silicon solar cell is capable of producing 0.6V and 12A under illumination. 10 such cells are connected in series to form an array. One of the cells is damaged such that it becomes a short circuit. What is the maximum power this array can now produce?
   - i) 72W
   - ii) 7.2W
   - iii) 6.48W
   - iv) 64.8W √
   - v) 0W

3) Give one disadvantage of mono-crystalline silicon over that of amorphous silicon for solar PV modules.

   Answer: Higher cost

4) What is the typical solar irradiance reaching the earth's surface in the south of England at noon, on a clear day in July.
   - i) 1000W/m^2 √
   - ii) 100W/m^2
   - iii) 10,000W/m^2
   - iv) 10W/m^2
   - v) 1W/m^2

5) What is the typical efficiency of a commercially available mono-crystalline silicon PV panel?
   - i) 76%
   - ii) 45%
   - iii) 6%
   - iv) 27%
   - v) 15% √

6) You wish to provide a maximum voltage of 24V and maximum current of 100A from an array of solar cells under illumination. If you had a number of silicon solar cells, each capable of producing 0.6V and 10A under the same illumination conditions, how many individual cells will you need and how could they be connected?
   i) 200 cells all in series array
   ii) 400 cells all in parallel array
   iii) 40 cells in a combination of series and parallel arrays
   iv) 400 cells in a combination of series and parallel arrays. √
   v) 400 cells in a series array

7) Which of these refers to the sunlight as measured on the earth's surface when the sun is directly overhead?
   i) AM1.5
   ii) AM1.0 √
   iii) AM1.5D
   iv) AM0
   v) AM0.5

8) What does the term AM1.5 mean when used to describe the test conditions of a solar panel?
   Answer: Irradiance of sunlight when the sun is at an angle of ~48 degree to the perpendicular.

9) State two factors that will affect the current a PV module can produce?
   Answer: anything sensible from intensity of light, size of module, better efficiency, temperature, etc.

10) You have a PV module using the semiconductor material GaAs, which has a band-gap energy of 1.42eV. What is the typical voltage you might expect a single solar cell to produce under illumination conditions of AM1.5? Justify your answer briefly.
    Answer: Anything from 0.7-1.1V will be acceptable, as it is slightly larger than half the band-gap.

11) You have a PV module comprising 48 individual crystalline silicon cells, each 156mm square. It delivers 24V and 7.71A when illuminated with 1000W/m2 of AM1.5 solar spectrum at 25C when connected to a particular load. Determine the following:
    i) The efficiency of the cell when connected to that load.

ii) Is the load optimum for that PV module?

iii) If the energy gap (Eg) of silicon is 1.1eV, what array configuration are the cells most likely to be in?

Answer: (i) Efficiency = Power Out/Power In
Power out = power produced by the module = 24 x 7.71 = 185W
Power in = total sunlight falling on all the cells = 0.156 x 0.156 x 1000 x 48 =1168W
So Efficiency = 185/1168 x 100 = 15.8%
(ii) This is a good efficiency for a commercial silicon PV module, so load is probably close to optimum.
(iii) Each silicon cell will give typically between 0.5-0,7V, so to get 24V, the 48 cells are probably connected in series.

12) Mark the following statements as TRUE or FALSE. (You get 1 mark for a correct answer and -1 for a wrong answer. If you do not answer, you will be awarded 0.)

i) Amorphous silicon solar cells are more efficient than crystalline solar cells. F

ii) There are places in the UK that receive at least 1000kWh/m^2 of solar irradiance per year. T

iii) An open circuit is critical for PV modules in parallel. F

iv) Inverters are used to convert DC power to AC. T

v) It is possible to buy silicon PV modules commercially with efficiencies of 33%. F

vi) The temperature at the sun's surface is about 15,000,000K. F

vii) About 90% of the sun's power is lost in transmission through the earth's atmosphere. F

viii) You can install a domestic PV system for typically £9,000 in the UK. T

ix) The definition of kWh is the power that a PV module produces over a typical day. F

x) We expect solar power to cost about US$1/watt in a few years time. T