1. Energy storage

3.1 A water well is in a location with a mean daily solar radiation of 4.8 hours of sun. The PV powered pump is able to produce 16m^3 /day from a depth of 18m.

a) Determine the required capacity of the batteries for autonomy of 3 days.
b) Determine the required installed PV power.

3.2 How much water would have to be pumped to a tank raised 3 meters from the ground in order to be able to recover 1kWh of electricity? [Assume 100% conversion efficiency.]

2. Module temperature

2.1 A module datasheet states the following module parameters: I_{sc} = 3A; V_{oc} = 20.4V; P_{max} = 45.9W; NOCT = 43ºC. Determine the parameters (I_{sc}, V_{oc}, FF, P_{max}) of a module formed by 34 solar cells under the following operating conditions: G = 700W/m^2 ; T_a = 34ºC.

2.2 A PV module is found to operate at 60ºC, T_a = 30ºC G = 980W/m^2. Determine the NOCT of the module.

2.3 Determine de variation with ambient temperature (between -25ºC and +75ºC) of the power of a module with 36 Si cells in series each with I_{max} = 5.85A and V_{max} = 0.5V at 25ºC. [NOCT=45ºC]

3. Sizing a grid connected system

Modules as those described in Table 1 are to be connected to an inverter with the specifications presented in Table 2. The modules' temperature range is -10 to 40ºC.

Table 1: Module specification

Voc	30.2 V
Vm	24 V
Isc	8.54 A
Im	7.71 A
T coeff P	-0.485 %/ºC
T coeff V	-0.104 V/ºC

Table 2: Inverter specification

Max DC power	3200 W
Max DC voltage	600 V
MPP voltage range	268 - 480 V
DC nominal voltage	350 V
Min DC voltage	268 V
Max input DC current	12 A
Max output AC current	15 A

a) Determine the module voltage range.
b) Determine the minimum number of modules in a string, considering a 2% drop loss in the DC cables and a 10% safety margin for the minimum inverter input voltage.
c) Determine the maximum number of modules in a string, considering a 5% safety margin for the maximum inverter input voltage.
d) Determine the number of strings by matching the current specifications (neglecting temperature effects).
e) Compare the array DC power of the configuration specified in the previous questions to the max DC power of the inverter.

4. Homework

Design a stand-alone system for your hometown. Make up the modules' inclination (depends on the available roof), discuss the relevance of using tracking. Use real data for the equipment considered, i.e. modules, charge regulator, inverter, batteries (include datasheets). Consider your own demand or the load described in the table below.

Equipment	Power	Usage
4 lights	20 W	3 h/day
3 lights	60 W	2 h/day
Fridge	120 W	10 h/day
Freezer	120 W	10 h/day
Iron	1050 W	1 h/day
TV	60 W	4 h/day
Washing machine	2.2 cycle	Twice week
Dish washer	1.9 kWh/cycle	Once a day