1 MODULE TEMPERATURE

1.1 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.

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

1.3 Determine the variation with ambient temperature (between -25ºC and +75ºC) of the power of a module (under standard 1000W/m^2) with 36 Si cells in series each with I_m = 5.85A and V_m = 0.5V at 25ºC and a NOCT=45ºC.

2 SIZING A GRID-CONNECTED SYSTEM

Modules 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	12 A
Max output AC	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.

3 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 can 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 to be able to recover 1kWh of electricity? [Assume 100% conversion efficiency.]