



**SCHOOL OF COMPUTING AND ENGINEERING SCIENCES**

**MASTER OF SUSTAINABLE ENERGY TRANSITION**

**END OF SEMESTER EXAMINATION**

**MSSET 8501: SOLAR PHOTOVOLTAIC SYSTEMS**

**DATE: 22<sup>nd</sup> APRIL 2026**

**TIME: 18.00-20.30**

**INSTRUCTIONS**

1. This examination contains **FOUR** questions.
2. Attempt **Question ONE (COMPULSORY)** and any other **TWO** questions
3. All workings should be shown clearly.

**QUESTION ONE**

**[20 MARKS]**

- a)
  - i) Differentiate between grid following (GFL) and grid forming (GFM) inverters used in solar PV systems giving preferred applications of each. **[4 marks]**
  - ii) What are the main capabilities of grid-forming inverters that makes them more suitable in modern applications? **[4 marks]**
- b) What are hybrid inverters that are used in solar PV systems? Explain the additional features that are incorporated in this inverter. **[3 marks]**
- c) Unlike conventional electric generators, the output from solar PV systems is affected by a number of factors. Using IV and PV curves, illustrate and explain the effect of high temperatures and shading on the outputs from solar PV systems. **[9 marks]**

**QUESTION TWO**

**[15MARKS]**

- a) With the aid of illustrations explain how solar PV systems can be either DC or AC coupled indicating where each could be most suitable. **[9 marks]**
- b) Given the fire risks associated with lithium-ion energy storage in solar applications, identify four specific conditions that accelerate the onset and severity of thermal runaway **[6 marks]**

**QUESTION THREE****[15 MARKS]**

You have been requested to design an off-grid solar PV system to supply energy to a small scale business in remote parts of the country. The details of the loads to be supplied in the kiosk is as given below.

| No | Appliances      | Qty | Appliance rating (W) | Operating Time (Hours/day) |
|----|-----------------|-----|----------------------|----------------------------|
| 1  | Freezer         | 1   | 145                  | 24                         |
| 2  | Fridge          | 1   | 140                  | 24                         |
| 3  | Lights          | 2   | 7                    | 2                          |
| 4  | Security Lights | 1   | 50                   | 14                         |
| 5  | Phone Charger   | 2   | 22.5                 | 5                          |
| 6  | Dispenser       | 1   | 550                  | 4                          |
| 7  | Juice Blender   | 1   | 400                  | 6                          |
| 8  | Heater          | 1   | 1200                 | 3                          |

Perform a complete design of the PV system by determining the following;

- a) The daily energy requirements for the Kiosk **[3 Marks]**
- b) Number of batteries required to provide 2 days of autonomy considering
  - i) Lithium ion battery option (200 Ah, 48 V, efficiency = 99%, DOD = 90 %) **[2 Marks]**
  - ii) Lead acid AGM battery option (200 Ah, 12 V, efficiency = 85%, DOD = 70 %) **[2 Marks]**
- c) The size of the Solar PV System considering a combined de-rating factor of 15 % when using an MPPT charge controller and PSH of 5 hrs **[3 Marks]**
- d) The size of Solar Charge Controller considering a safety factor of 1.25 **[2 Marks]**
- e) The size of the inverter considering efficiency of 90% and a safety factor of 1.5 **[3 Marks]**

**QUESTION FOUR****[15 MARKS]**

Provide a technical overview of the core phases involved in solar PV system design. For each activity listed below, evaluate the underlying objectives (**why**), the standard methodologies (**how**), and the critical parameters (**factors**) that influence the final system architecture.

- a) Load (Energy) Assessment **[3 marks]**
- b) Determination of System Voltage **[2 marks]**
- c) Battery Storage Requirements **[3 marks]**
- d) Design of Inverters and charge controllers **[3 marks]**
- e) Determination of string and array fuses **[2 marks]**
- f) Determination or size of cables **[2 marks]**