



**UGANDA INSTITUTE OF INFORMATION AND COMMUNICATIONS
TECHNOLOGY**

END OF SEMESTER TWO EXAMINATIONS

ACADEMIC YEAR 2025/2026

DEPARTMENT : ICT AND ENGINEERING
SESSION : DAY/EVENING/WEEKEND
YEAR OF STUDY: TWO
PROGRAMMES: DEEE
COURSE : SOLAR POWER SYSTEM FOUNDATION
COURSE CODE : ELT2205
DATE : THURSDAY, 25TH, JUNE 2026
TIME : 2:00PM-5:00PM [3HOURS]
EXAM ROOM : TENT A

INSTRUCTIONS:

- i. This paper consists of two (2) sections: Section A and Section B
- ii. Section A is compulsory and all numbers **MUST** be attempted
- iii. Section A has a total of 40 marks
- iv. Section B contains four (4) questions each with 20 marks
- v. Attempt **ONLY** three (3) questions from section B

Question 1

A solar technician receives a complaint that a customer's battery bank has been getting damaged frequently due to deep discharge. Upon inspection, he discovers that the charge controller is not disconnecting the load when battery voltage becomes critically low.

Which feature of the charge controller is responsible for preventing this problem?

- A. High Voltage Disconnect (HVD)
- B. Maximum Power Point Tracking (MPPT)
- C. Low Voltage Disconnect (LVD)
- D. Trickle Charging

Question 2

A solar company is designing a large commercial solar installation. The PV array voltage is significantly higher than the battery bank voltage, and the client wants maximum charging efficiency.

- A. PWM Controller
- B. MPPT Controller
- C. PMW Controller
- D. Blocking Diode Controller

Question 3

An engineer is selecting an inverter for a hospital laboratory containing sensitive medical equipment. The inverter must provide electricity that closely resembles utility grid power.

Which type of inverter is most suitable?

- A. Square Wave Inverter
- B. Modified Sine Wave Inverter
- C. Pure Sine Wave Inverter
- D. Transformer Type Inverter

Question 4

A farmer in Gulu wants to install a solar-powered water pumping system for irrigation. The pump only needs to operate during sunny hours, and the farmer wants to minimize the installation cost by avoiding batteries.

Which PV system configuration is most suitable?

- A. Grid-tied PV system with batteries
- B. Stand-alone PV system with batteries
- C. Direct-coupled PV system
- D. Hybrid PV system

Question 5

A project engineer is conducting a site survey for a rooftop solar installation at a secondary school. During the inspection, he notices that the roof is partially shaded, the roofing material is old, and the roof structure appears weak.

Which factor should be considered when selecting the mounting system?

- A. Colour of the building
- B. Roof load-bearing capacity
- C. Number of classrooms
- D. Distance to the nearest road

Question 6

A telecom company is installing a solar power system for a remote cell tower. The engineer wants a battery technology that provides high performance, long life, does not release gas during charging, and is commonly used in remote telephone tower installations.

Which battery type should be recommended?

- A. Flooded Lead-Acid Battery
- B. Car Battery
- C. AGM Battery
- D. Marine Battery

Question 7

A solar technician inspects a battery bank and finds that the batteries are frequently being discharged to very low levels before recharging. After a few years, the batteries begin to fail prematurely.

What is the most likely cause of the reduced battery life?

- A. The batteries were kept fully charged.
- B. The batteries were subjected to deep discharge cycles.

- C. The batteries were installed indoors.
- D. The batteries were connected in parallel.

Question 8

A solar technician is installing a PV system at a rural home. The client suggests placing the solar modules near the kitchen roof because there is enough space. After assessing the site, the technician rejects the proposal.

Why should solar modules not be installed near a kitchen or chimney?

- A. The roof becomes too strong
- B. Smoke and soot can reduce solar panel performance
- C. The batteries will overcharge
- D. The inverter will fail

Question 9

A contractor is installing a rooftop PV system for secondary school. Before fixing the solar modules, the engineer uses a compass and inclinometer to determine the correct orientation and tilt angle of the array.

What is the main purpose of using these tools?

- A. To determine battery capacity
- B. To ensure the panels receive maximum sunlight throughout the year
- C. Measures cable resistance
- D. To determine inverter efficiency

Question 10

A solar technician is troubleshooting a PV system that produces very little electricity on a cloudy day. All system components are functioning properly, but the solar panels are receiving less sunlight than usual.

Which factor affecting the photovoltaic effect is most directly responsible for the reduced power output?

- A. Battery capacity

- B. Sunlight intensity
- C. Cable length
- D. Inverter efficiency

Question 11

A solar engineer is explaining to a group of students why a solar panel can generate electricity without any moving parts. He explains that when sunlight strikes the solar cell, energy from the photons causes electrons to break free from their atoms, creating charge carriers that eventually produce electric current.

Which stage of the photovoltaic effect is being described?

- A. Electric Field Separation
- B. Flow of Current
- C. Generation of Electron-Hole Pairs
- D. Energy Storage

Question 12

A solar company has been contracted to install a PV system on a hospital roof where space is limited. The client wants the highest possible energy output from the available roof area, even if the initial cost is higher.

Which type of solar cell should the engineer recommend?

- A. Amorphous Silicon Solar Cell
- B. Polycrystalline Silicon Solar Cell
- C. Monocrystalline Silicon Solar Cell
- D. Organic Solar Cell (OPV)

Question 13

Mark a system technician, connects solar panels in 48V and solar batteries in 12V, which best charge controller/regulator and inverter voltage do you recommend Mark to use on this system

- A. PWM 48V charge controller/ regulator and 12V inverter
- B. MPPT 48V charge controller/ regulator and 12V inverter
- C. PWM 48V charge controller/ regulator and 48V inverter
- D. MPPT 48V charge controller/ regulator and 48V inverter

Question 14

A district is looking for a renewable energy source that can convert agricultural waste, animal manure, and other organic materials into useful energy while also helping to reduce waste disposal problems.

Which renewable energy source should be recommended?

- A. Wind Energy
- B. Solar Energy
- C. Biomass Energy
- D. Tidal Energy

Question 15

A shopping mall in Kampala is connected to the national electricity grid but wants to reduce its monthly electricity bills by installing a solar PV system. The system is designed to generate electricity during the day and export excess power to the utility grid whenever production exceeds demand.

The engineer recommends a Module-Inverter-Grid configuration. This PV system configuration is also known as:

- A. Grid-Tied PV Configuration
- B. Direct Solar System
- C. Inverter System
- D. AC and DC System

Question 16

A farmer in Gulu intends to install a stand-alone solar PV system to power lighting, a television, a refrigerator, and a water pump. As the Solar Project Engineer, you have been assigned to design and select suitable system components to ensure reliable and efficient operation.

a). Define an inverter and explain its main importance in the proposed solar PV system. **(1 Mark)**

b) Before selecting system components for the farmer's installation, explain **two major factors** you would consider when choosing each of the following:

- i).** An inverter. **(1 Mark)**
- ii).** A solar charge controller/regulator. **(1 Mark)**
- iii).** A solar battery. **(1 Mark)**
- iv).** Cables. **(1 Mark)**
- v).** Solar panels. **(1 Mark)**

Question 17

A solar company has been contracted to install an off-grid PV system for a rural health centre. During the design review meeting, the project engineer asks the team to explain the purpose of some key power management components that will be used in the system to ensure efficient power conversion, battery charging, and energy utilization.

a). Write brief notes on the following components and their role in the proposed solar PV system:

- i).** DC/DC Converter. **(1 Mark)**
- ii).** Maximum Power Point Tracking (MPPT). **(1 Mark)**
- iii).** Pulse Width Modulation (PWM). **(1 Mark)**
- iv).** Batteries. **(1 Mark)**

SECTION B (60 Marks) – Choose any three questions

QUESTION 1 (20 MARKS)

A rural electrification project in Gulu District is being implemented to supply a standalone solar photovoltaic system to a household not connected to the national grid. The expected daily load includes: 6 LED lamps rated at 10 W operating for 6 hours, a 120 W television operating for 5 hours, a refrigerator rated at 150 W operating for an equivalent of 8 hours per day, and 3 phone chargers rated at 5 W each operating for 4 hours daily. The system voltage is 24 V, inverter efficiency is 90%, battery efficiency is 85%, peak sun hours are 5.5 hours per day, and required autonomy is 2 days with a maximum depth of discharge of 50%.

(a) Explain why a standalone solar PV system is more appropriate for this application than a grid-

connected system. (4 Marks)

(b) Discuss the functions and interaction of PV modules, charge controllers, batteries, and inverters in this system. (4 Marks)

(c) Evaluate environmental and operational factors in Northern Uganda that may influence system

Performance. (4 Marks)

(d) Determine the PV system size by calculating:

(i) Total daily energy consumption (Wh/day) (2 marks)

- (ii) Adjusted energy considering inverter and battery efficiencies (2 marks)
- (iii) Required PV array power (W) (2Marks)
- (iv) Number of 400 W PV modules required (2Marks)

QUESTION 2 (20 MARKS)

Kiwunda Engineering Ltd has been awarded a contract by the Ministry of Energy and Mineral Development to design, install, and commission solar photovoltaic (PV) systems for rural electrification projects in Serere District. During a project review workshop, senior engineers are tasked with assessing the technical understanding of newly recruited technicians who will participate in the installation and maintenance of the PV systems.

As a Solar PV Technician, you are required to demonstrate your understanding of key solar photovoltaic concepts that are essential for the successful design, operation, and maintenance of solar energy systems.

- (a) Explain the photovoltaic effect and describe how it enables a solar panel to generate electrical energy from sunlight. (4 marks)
- (b) Distinguish between solar irradiance (G) and solar irradiation (H), and explain the significance of each parameter in solar PV system design. (4 marks)
- (c) State the Standard Test Conditions (STC) under which solar panels are rated and explain why these conditions are important when comparing solar panel performance. (4 marks)
- (d) Identify and explain the characteristics of the two most commonly used types of solar cells in the solar industry today. (4 marks)
- (e) Explain the function of a bypass diode in a solar PV module and discuss its importance in maintaining system performance and protecting solar panels from damage. (2 marks)
- (f) A technician connects several solar panels in series to achieve a higher system voltage. Explain how the voltage and current of the solar array are affected by this connection. (2 marks)

QUESTION 3 (20 MARKS)

Green Power International Limited Ltd has been contracted to design and install a standalone solar photovoltaic (PV) power system for a rural household in Gulu District that is not connected to the national electricity grid. The proposed system must provide reliable electricity for lighting, entertainment, refrigeration, and mobile phone charging throughout the year. To ensure uninterrupted power supply during periods of low solar energy availability, the system will incorporate battery storage.

The household's daily electrical load is as follows:

- 6 LED lamps (10 W each) used for 6 hours
- A 120 W television used for 5 hours

- A 150 W refrigerator (assume 8 effective operating hours per day)
- 3 phone chargers (5 W each) used for 4 hours

The following design parameters apply:

- System losses = 20%
- Battery voltage = 12 V
- Battery efficiency = 85%
- Peak Sun Hours (PSH) = 5.5 hours/day
- Battery autonomy = 2 days
- Battery Depth of Discharge (DoD) = 50% (Lead-acid battery)

As a Solar PV Design Engineer, you are required to assess the suitability of the proposed system and determine the major design parameters.

(a) Explain why a standalone solar PV system with battery storage the most appropriate solution for this household is. (3 marks)

(b) Rural communities increasingly depend on communication services powered by solar energy. Explain why a continuous and reliable power supply is critical in telecommunications systems. (3 marks)

(c) Identify and briefly explain two suitable battery technologies that can be used in standalone solar PV systems. (4 marks)

(d) Using the data provided, calculate the following:

(i) Total daily energy consumption of the household (Wh/day). (3 marks)

(ii) Adjusted daily energy requirement after accounting for system losses. (2 marks)

(iii) Required PV array size (W). (2 marks)

(iv) Number of 400 W solar PV modules required for the installation. (1 mark)

(v) Minimum battery bank capacity required (Ah), considering the specified autonomy period, battery efficiency, and depth of discharge. (2 marks)

QUESTION FOUR (20 MARKS)

The management of Kampala Community Development Centre (KCDC) is seeking to reduce its electricity costs and improve energy reliability by installing a solar photovoltaic (PV) system integrated with battery energy storage. The Centre provides educational, health, and social

services to the surrounding community and experiences frequent power interruptions from the utility grid. To ensure uninterrupted operation of critical loads during outages, the management has engaged your engineering firm to design and recommend an appropriate solar-plus-storage solution.

As a Renewable Energy Engineer, you are required to advise the Centre on the technical requirements, battery selection, and system design considerations necessary for a reliable and cost-effective installation.

(a) Discuss the key components that would be included in the proposed solar-plus-storage system and explain their functions. For each component, indicate the important specifications that should be considered during system design. Your answer should also include a discussion of suitable battery technologies that can be integrated into the system and their advantages and limitations. (10 marks)

(b) Outline the planning and design process for sizing and installing the battery storage system. In your answer, consider factors such as energy demand assessment, autonomy requirements, battery capacity calculations, environmental conditions, and Uganda's climate and energy consumption patterns. (5 marks)

(c) Inverters are a critical component of solar PV systems. Differentiate between Modified Sine Wave (MSW) and Pure/True Sine Wave (TSW) inverters. Discuss the advantages, disadvantages, and suitability of each type for residential and community-based applications in Uganda. (5 marks)

GOOD LUCK.