MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS

2018/2019 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER

SCHOOL OF SCIENCE & INFORMATION SCIENCE

BACHELOR OF SCIENCE

COURSE CODE: PHY 3229

COURSE TITLE: SOLAR, THERMAL & PHOTOVOLTAICS

DATE: 16TH APRIL 2019 **TIME: 1100 - 1300 HRS**

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **TWO** questions

2. Use of sketch diagrams where necessary and brief illustrations are encouraged.
3. Read the instructions on the answer booklet keenly and adhere to them.

*This paper consists of **four** printed pages. Please turn over.*

QUESTION ONE (30 MARKS)

(a) Differentiate between Irradiance and Insolation **(2 Marks)**

(b) (i) Briefly explain two reasons why the solar resource of a location is important in PV design **(4 Marks)**

(ii) The solar resource of an area is broadly affected by its seasonal variation of sunshine. Describe briefly how this variation is factored in the design for optimal output throughout the seasons **(4 Marks)**

(c) Differentiate between direct and indirect solar water heating systems **(4 Marks)**

(d) Describe the functions of each of the following components of a flat plate collector

(i) Air vent **(3 Marks)**

(ii) Temperature-Pressure relief valve **(3 Marks)**

(iii) Vacuum breaker (**3 Marks)**

(e) A 3kWp solar PV system is planned for installation at a 3 star hotel close to the northern gate to Maasai Mara Game Reserve. The following information is available (at STC where applicable), for use during system design:

Module rated power = 300Wp
Module V_{oc} = 43.2 V
Module I_{sc} = 8.6 A
Module V_{mp} = 38.2
Module I_{mp} = 7.9 A
Tc for V_{oc} = -3%/^{o}C
Module dimensions (L x W) = 200 cm (L) x 100 cm (W)
Site location = 37.8^{o} E, 1.35^{o} S

Site's annual solar insolation = 2600kWh/m^{2}

Site's sun elevation at the winter and summer solstices:

TIME	**0800**	**0900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**	**1600**	**1700**	**1800**
21/06	18.98	32.34	45.04	56.24	63.88	64.51	57.7	46.87	34.33	21.04	7.41
21/12	20.93	34.39	47.28	58.77	66.63	66.76	59.07	47.64	34.77	21.32	7.62

(i) Determine the Peak Sunshine Hours (PSH) for the site **(2 Marks)**

(ii) If the system is to be mounted on the ground in two rows, determine the minimum inter-raw spacing that will not cause shading on the modules.

(5 Marks)

QUESTION TWO (20 MARKS)

(a) For a passive solar water indirect heating system

(i) Draw a schematic diagram (**7 Marks)**

(ii) State ONE advantage and ONE disadvantage a passive system has over active

(**2 Marks)**

(b) (i) Sketch and label clearly the typical I-V characteristics of a solar panel
(4 Marks)

(iii) Determine the possible short circuit current for the panel in 1 (c) above if irradiance drops to 350W/m^2
(3 Marks)

(c) If Maasai Mara Game Reserve can experience ambient temperatures of 68°C, determine the V_{oc} that a solar panel that has rated V_{oc} = 21.6 V and has a temperature coefficient of 3 % V/°C can produce.
(4 Marks)

QUESTION THREE (20 MARKS)

The following are the load requirements for a remote household in West Pokot County:

Item	**Load**	**Quantity**	**Power Rating** (W)	**Time of Usage (Hrs)**
1	Laptops	50	25	6
2	Television	2	60	5
3	Refrigerator	1	100	12

Other energy applications (e.g. phone charging) in the school are approximated at 200Wh per day

NB: All appliances are AC powered.

The available batteries and modules have the following specifications:

100W Module	**Battery**
Rated Power = 100W Power Tolerance = 5% Nominal Voltage = 12V Peak Current I_{mp}, = 4.55A Short Circuit Current, I_{sc} = 4.8A	Battery nominal voltage 12V Capacity 200 Ah Depth of Discharge 20%

a) Determine the daily energy design for the institution considering an inverter efficiency of 80%.
(4 Marks)

b) Determine a suitable battery size for this system if the system voltage is assumed to be 24V with 2 days of autonomy.
(5 Marks)

c) Determine the number of modules required if the average PSH is 6 hours.
(**5 Marks)**

d) Determine the size of charge controller for this application if the safety factor is 20%.
(3 Marks)

e) Select a suitable inverter for the above system using a safety factor of 20%.
(3 Marks)

QUESTION FOUR (20 MARKS)

A new residential house with four (4) bedrooms is being put up on the outskirts of Nairobi. The owner wishes to incorporate solar water heating system that is expected to serve five (5) adults.

(a) Determine the daily hot water demand for the household
(3 Marks)

(b) (i) Determine the suitable size for the hot water tank storage

(4 Marks)

(ii) Determine the suitable size of the collector if the client chooses to use

A: Flat plate collector **(3 Marks)**

B: Evacuated tube collectors **(2 Marks)**

(c) (i) Discuss any other TWO factors you may consider that can influence the type installation for the proposed system
(4 Marks)

(d) (i) Name ANY TWO possible hazards you may encounter when carrying out solar water heating installation.
(2 Marks)

(ii) What are the possible mitigation you can put in place to minimize or counter the risks in (i) above?
(2 Marks)

//END