

The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme



Department	: Physics
Level	: 5
Name of the Examination	: Final Examination
Course Code and Title	: PHU5315 – Renewable Energy Sources
Academic Year	: 2023/2024
Date	: 22 nd March 2024
Time	: 9.30 a.m. - 11.30 a.m.
Duration	: Two (2) hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of 6 questions in 4 pages.
3. Answer any 4 questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary
5. Relevant log tables are provided where necessary.
6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense.
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered in the front cover of your answer script.
9. Clearly state your index number in your answer script

$$g = 9.8 \text{ m/s}^2 ,$$

$$\text{Boltzmann's constant } (k) = 8.61733 \times 10^{-5} \text{ eV/K} = 1.381 \times 10^{-23} \text{ J/K}$$

$$\text{electronic charge} = 1.602 \times 10^{-19} \text{ C}$$

$$\text{Air density } \rho = 1.225 \text{ kg/m}^3$$

Answer 4 questions only.

01.

- (a) A person pushes a trolley 17 m at constant speed on level ground, against a 24 N frictional force. He pushes in a direction 22.0° below the horizontal
- What is the work done on the trolley by friction?
 - What is the work done on the trolley by the gravitational force?
 - What is the work done on the trolley by the person?
 - Find the force the person exerts, using energy considerations.
 - What is the total work done on the trolley?

(5 marks)

- (b) A bullet of mass 2.5 g traveling horizontally with a velocity of 320 m/s strikes a stationary wooden block. It can penetrate 16 cm thickness of the wooden block before it stops. Calculate the magnitude of the force exerted by the wooden block on the bullet.

(5 marks)

- (c) A water pump lifts water from 9 m level below the ground. Water is pumped vertically at a rate of $0.2 \text{ m}^3/\text{s}$ and discharge it with 11 ms^{-1} velocity.

- If 1 m^3 of water weighs 1000 kg, what is the minimum power need to raise and discharge water.
- If the pump is only 70% efficient, what should be the working power of the water pump.

(6 marks)

- (d)
- Discuss the energy conversions that occur during the production of electrical energy from nuclear energy in a nuclear power plant.
 - Explain the energy conversion chain of primary energy source into final end-use form including possible energy losses of nuclear energy generation process.

(9 marks)

02.

- (a)
- State the first law of thermodynamics for a closed system.
 - What are the limitations of the first law of thermodynamics?

(4 marks)

- (b) A gas in a closed vessel is heated with 24 J of energy, causing the lid of the vessel to rise 3 m with 5 N of force. What is the total change in energy of the system?

(3 marks)

- (c) Briefly compare the key differences between energy and exergy according to following 5 aspects,
- Definition
 - Dependency on matter, energy flow
 - Environment properties
 - Conservation
 - Destruction and production
- (8 marks)
- (d) Consider a system with a certain energy content, from which we wish to extract as much work as possible. Should the system's entropy be high or low? Is this orderly or disorderly? Structured or uniform? Explain briefly.
- (5 marks)
- (e)
- Calculate the overall efficiency of the steam thermal powerplant, if the efficiencies of the boiler, turbine and alternator are 85%, 35% and 93%, respectively.
 - A boat with a steam engine operates between 430°C and 150°C . Determine the maximum possible efficiency of this engine?
- (5 marks)

03.

- (a) Briefly describe internal structure of the sun.
- (4 marks)
- (b) Briefly explain the difference between the horizontal coordinate system and the equatorial coordinate system.
- (4 marks)
- (c) If the local longitude of standard time meridian is 81°E , determine the parameters below for a city with coordinates 28°N and 77°E .
- The value of equation of time (EOT) for March 22nd, 2024.
 - Longitude correction for the city
 - The Local solar time at 2.30 pm.
- (10 marks)
- (d) A solar power collector is tilted at an angle of 35° with the horizontal pointing the south direction at the city mentioned in part (c). Determine the parameters below for March 22nd 2024.
- Declination angle
 - Hour angle at 2 pm solar time
 - Angle of incidence
- (7 marks)

04.

(a) State the expressions for the terms below. Clearly define the symbols used

- i. Conduction heat loss of a solar collector
- ii. Collector heat removal factor

(8 marks)

(b) A solar flat plate solar collector operates under following conditions. Determine the net rate of useful energy per square meters.

Heat removal factor = 0.7995

Overall heat loss coefficient = $14.0 \text{ W/m}^2\text{C}^0$

Inlet temperature = 62^0 C and Ambient temperature = 24^0 C

$I_a = 465 \text{ Wm}^{-2}$

$\tau\alpha = 0.66$

(5 marks)

(c) Briefly discuss the following conditions associated with a typical flat plate collector.

- i. the purpose of Glazing
- ii. the mechanisms use to reduce heat loss
- iii. the advantage of black coated absorber plate

(6 marks)

(d) What is the difference between imaging and non-imaging concentrated solar collectors?

(4 marks)

(e) Briefly discuss 2 advantages of solar power tower.

(2 marks)

05.

(a)

- i. Briefly explain the Fermi level. How does the Fermi level vary in different types of semiconductors?
- ii. State the 3 basic attributes needed in the operation of a photovoltaic cell.

(5 marks)

(b) Briefly discuss 2 factors that limit the solar PV cell output.

(4 marks)

(c) Compare the differences between crystalline silicon and thin-film solar panel technologies according to materials used, efficiency, durability, and cost.

(4 marks)

(d) Explain the working principle of working principle Quantum Dot solar cell?

(3 marks)

(e) Estimate the solar cell efficiency, open circuit voltage and fill factor for a 120 cm^2 crystalline silicon solar cell at AM=1. The dark saturation current is $5 \times 10^{-11} \text{ A}$ and short-circuit photocurrent is 55 mA at 28^0C . The solar cell is illuminated with 85 W/m^2 irradiance. When the maximum current is 0.15 A at 0.65 V the cell produces its maximum power.

(9 marks)

06.

(a) Explain the roles of yaw mechanism, controller and inverters in a wind energy system.

(6 marks)

(b) What is meant by Angle of Attack, stall and furl in wind energy generation?

(6 marks)

(c) In a wind energy conversion system, the blade length is 45 m while the radius of the hub is 2 m. The rated output power for that wind energy system is 20 MW at 22 m/s. Calculate wind power density and power conversion coefficient of this wind energy system.

(3 marks)

(d) Briefly explain the types of turbines used in hydropower plants generation, based upon the direction of flow?

(5 marks)

(e) Briefly explain the working principle of Francis turbine.

(5 marks)

-----The End-----