00061

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	: 2024/2025
Date	: 26th April 2025
Time	: 1.30 p.m. - 3.30 p.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

$g = 9.8\ ms^{-2}$,
Specific latent heat of vaporization for water (L) = $2.257 \times 10^{6}\ Jkg^{-1}$
Standard atmosphere pressure = $1.013 \times 10^{5}\ Nm^{-2}$
Solar constat =1367 Wm^{-2}
Boltzmann's constant (k) = 8.61733×10^{-5} eV K^{-1} =1.381×10^{-23} J K^{-1}
Air density ρ = 1.225 kg m^{-3}

Answer 4 questions only.

01.

(a)

i. An elevator of 1400 kg mass is ascending upwards with a constant velocity. What is the work done by the tension in the elevator cable during its climb of 40 m?

ii. If the elevator ascends upwards with a constant acceleration of 5 ms^{-2}, what is the work done by the tension in the elevator cable during its climb of 40 m?

(4 marks)

(b) If the elevator in part (a) climbed up that height at a velocity of 2.5 ms^{-1},

i. What is the useful power output of that elevator motor during that climb?

ii. If the charge for the electricity is Rs 130.00 per kWh, estimate the cost for this lift?

iii. If the efficiency of the elevator motor is 65%, what was the input power of that motor?

(6 marks)

(c) Discuss the energy conversions taking place in each of the following situations. Identify all of the relevant forms of energy that are involved throughout the whole process.

i. when an archer shoots an arrow in the air

ii. when firecrackers explode

iii. when riding a bicycle on a rough road

(6 marks)

(d) Humans transfer and transform energy from the environment to power human activities.

i. What is meant by "energy systems"?

ii. Describe the energy conversion chain with energy losses using a graphical aid.

(9 marks)

02.

(a) Using the first law of thermodynamics, explain why the temperature of a well-insulated gas in a container increase when compressed, while the temperature decreases when the gas expands.

(5 marks)

(b) A system contained 1 g of water at 373 K and steam was produced at the same temperature. If the volume has changed from 1 cm^3 to 1567 cm^3, during this boiling process calculate the change in internal energy of the system.

(6 marks)

(c) A 12.5 kg wood block starts with an initial speed of 4.0 ms^{-1} and slides across the floor until friction stops it. Estimate the resulting change in entropy of the surroundings. Assume that the mechanical energy of the wood block is being converted into thermal energy due to friction and everything stays at a room temperature of 30°C.

(6 marks)

(d)

i. What is meant by Exergy?

ii. A heat engine operates with an efficiency of 36%. If the input power of that engine was 540 MW in an operating cycle, estimate the energy wasted in MJ per minute.

iii. Calculate the overall efficiency of a hydroelectric powerplant, if the efficiencies of the penstock, turbine, generator and transformer are 85%, 45% 70% and 81%, respectively.

(8 marks)

03.

(a) What are meant by air mass (AM) and AM=1 spectrum?

(4 marks)

(b) Estimate the extra-terrestrial radiation measured on a plane normal to the radiation on July 22nd, 2028.

(3 marks)

(c) A company located in a country with latitude 35^0 N plans to install a roof top solar power collector. Determine the declination angle and the number of daylight hours (day length) at that location on July 22nd, 2025.

(8 marks)

(d) If the local longitude of standard time meridian is 80^0 E, determine the parameters below for a city with coordinates 34° N and 82° E.

i. The value of equation of time (EOT) for May 25th, 2025.

ii. Longitude correction for the city

iii. The Local solar time at 10.30 am.

(10 marks)

04.

(a) The thermal performance of any type of solar thermal collector can be evaluated by energy balance.

i. State the four possible ways that define the useful energy or thermal performance of a solar collector (absorber or receiver).

ii. State the equation for useful energy or thermal performance of such a solar collector in general terms. Clearly define the symbols used.

(8 marks)

(b) A solar collector installed at the university premises operated under following conditions during a particular hour. Heat removal factor is 0.7986. Overall heat loss coefficient is 11.0 $Wm^{-2}\,^{o}C^{-1}$. Inlet temperature is $54^{0}C$, Ambient temperature is $28^{0}C$, I_a is 745 Wm^{-2}, $\tau\alpha$ is 0.71. The collector area is 0.8 m × 1.2 m. Determine the following performance factors of the solar collector.

i. The average useful energy gain per square meter

ii. Net rate of useful energy

iii. The useful energy efficiency during the period

(12 marks)

(c) State 3 disadvantages of solar concentrators.

(3 marks)

(d) If the acceptance angle is 34°, calculate the maximum concentration ratio for a dish-type concentrator.

(2 marks)

05.

(a) Briefly discuss 3 important factors of semiconductors.

(3 marks)

(b) The doping of the p- and n-regions of the solar cell are $N_A=5.5\times10^{16}cm^{-3}$ and $N_D=1.1\cdot10^{18}\,cm^{-3}$, respectively. Also, the effective densities of states in the conduction band and valance band are $2.56\times10^{19}cm^{-3}$ and $1.45\times10^{19}cm^{-3}$ respectively.

Assuming all doping atoms are ionized, estimate and illustrate the position of the Fermi level (in eV) at 315 K in respect to the conduction band in the p-type and n-type region.

(8 marks)

(c) Briefly discuss the basic parts of a Dye-Sensitized Solar Cell (DSSC) with an aid of a diagram.

(10 marks)

(d) Explain four advantages Dye-Sensitized Solar Cell (DSSC)

(4 marks)

06.

(a) Explain the basic components of a wind energy conversion system (WECS) with an aid of a block diagram.

(9 marks)

(b) Explain the effect of wind speed, turbine height, density in extractable wind power.

(6 marks)

(c) The rated output power of the recently installed wind energy system at Northwestern province is 45 MW at 26 ms^{-1}. In this wind energy conversion system, the blade length is 42 m while the radius of the hub is 3 m. Determine the following parameters of that wind energy system.

i. wind power density
ii. power conversion coefficient

(6 marks)

(d) If the overall efficiency of a mini hydropower system is 60%, determine the theoretical power of the system in watts. The water flows at a rate of 220 liters per second. The height of the dynamic head is 12 meters. Assume that the unit weight of water is 9.81 kNm^{-3}.

(4 marks)

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