ALUPE UNIVERSITY

OFFICE OF THE DEPUTY VICE CHANCELLOR

ACADEMICS, RESEARCH AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHY 433**

COURSE TITLE: **RENEWABLE ENERGY AND ENVIRONMENTAL PHYSICS**

DATE: 17TH, APRIL, 2024 **TIME: 2 PM – 5 PM**

INSTRUCTION TO CANDIDATES

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PHY 433

REGULAR – MAIN EXAM

PHY 433: RENEWABLE ENERGY AND ENVIRONMENTAL PHYSICS

STREAM: BED (Scie) **DURATION: 3 Hours**

INSTRUCTIONS TO CANDIDATES

i. *Answer the **TWO** question in **SECTION A** and any other **THREE** questions in **SECTION B.***

SECTION A (28 MARKS)

Question One (14 Marks)

a) Briefly describe how greenhouse effect has contributed to climate change? (3 Marks)

b) Define the following terms used in solar power

i) Solar constant (1 Mark)
ii) Irradiance (1 Mark)
iii) Net terrestrial radiation (1 Mark)

c) Briefly describe the following three technologies of converting biomass energy into heat and electricity

i) Direct Combustion (1 Mark)
ii) Co-firing (1 Mark)
iii) Anaerobic digestion (1 Mark)

d) What is the difference between dry steam systems, flash steam technologies and binary cycle systems? (3 Marks)

e) Define the following terms applicable in tidal energy

i) Tidal range (1 Mark)
ii) Modulated single-pool system (1 Mark)

Question Two (14 Marks)

a) Which power producing system between hydroelectric power plant and wind turbine has the highest efficiency? Explain. (4 Marks)

b) A hydraulic turbine is used to generate power by using the water in a dam. The elevation difference between the free surfaces upstream and downstream of the dam is 120 m. The water is supplied to the turbine at a rate of 150 kg/s. If the shaft power output from the turbine is 155 kW, determine the efficiency of the turbine. (3 Marks)

c) Wind is blowing through a turbine at a velocity of 9 m/s. The turbine blade diameter is 35 m. The air is at 95 kPa and 20 °C. If the power output from the turbine is 115 kW, determine the efficiency of the turbine. (Take density of air = 1.225 kg/m^3) (3 Marks)

d) Using U-235 and well labelled diagram, describe nuclear fission reaction occurring in a nuclear reactor. (4 Marks)

SECTION B (42 MARKS)

Question Three (14 Marks)

a) With help of well labelled diagrams, distinguish between water wheel and run-of-river plant. (4 Marks)

b) The water in a large dam is to be used to generate electricity by the installation of a hydraulic turbine. The elevation difference between the free surfaces upstream and downstream of the dam is 146 m. Water is to be supplied to the turbine at a rate of 4.0 m^3/s. The overall efficiency of the hydroelectric plant is 87 %. Determine the electric power produced. (3 Marks)

c) Highlight three classifications of hydropower plants based on their gross head. (3 Marks)

d) A mass of 8000 kg of slightly enriched uranium (2% U-235, 98% U-238) is exposed for 30 days in a reactor operating at heat power 2000 MW. Given that energy released per fission is 200 MeV and Avogadro's number is 6.023×10^{23} atoms. Calculate the mass of uranium fissioned per hour. (4 Marks)

Question Four (14 Marks)

a) Differentiate between power coefficient (C_P) and Capacity factor. (2 Marks)

b) If the wind speed is 11.5m/s and the speed after the turbine is 8 m/s, what is the power extraction coefficient of this wind turbine? (4 Marks)

c) Use Newton's laws to show that the wind power of air moving through area A is given by $P = \frac{1}{2}\rho A v^3$. (5 Marks)

d) An investor is to install a wind turbine in a location with an average wind speed of 7.2 m/s. The blade diameter of each turbine is 18 m and the average overall wind turbine efficiency is 33 percent. Calculate the output power. (3 Marks)

Question Five (14 Marks)

a) Define absorptivity, transmissivity, and reflectivity of a surface for solar radiation. (3 Marks)

b) With reference to solar thermal energy, differentiate between active and passive systems. (2 Marks)

c) Briefly describe how high temperature and low temperature losses limit solar cell efficiency. (4 Marks)

d) State any three effects that cause solar radiation concentration to be less than ideal. (3 Marks)

e) What are the two technologies that can be used to convert solar energy into other useful forms of energy? (2 Marks)

Question Six (14 Marks)

a) Explain how the following loss mechanisms reduce theoretical conversion efficiency of PV solar module.

i) Optic losses (1 Mark)

ii) Ohmic losses (1 Mark)

iii) Recombination losses (1 Mark)

b) Outline any three demerits of solar energy (3 Marks)

c) Find declination angle (δ), hour angle (h), solar altitude angle (α) and azimuth angle at 2 h after local noon on June 16 for a city located at 40° latitude. (8 Marks)

Question Seven (14 Marks)

a) What factors cause tidal motion (3 Marks)

b) A modulated single-pool tidal system has a tidal range, $R = 8\,m$, a total area of $A = 3\times10^{6}\,m^{2}$, the parameter $a = 0.065\,h^{-1}$ and work is produced between $t_1 = 2\,h$ and $t_2 = 4\,h$. Take the density of water to be 1025 kg/m^3. Using expression of work output as $W_{Available} = g\rho AR^{2}\left\{0.988a\left[\cos\left(\frac{\pi t_1}{6.2083}\right)-\cos\left(\frac{\pi t_2}{6.2083}\right)\right]-\frac{a^{2}}{2}(t_1^{2}-t_1^{2})\right\}$, where R is the tidal range and other symbols have their usual meaning, determine work output. (3 Marks)

c) State any three disadvantages of tidal power (3 Marks)

d) Describe three techniques of wave power conversion. (3 Marks)

e) An ocean wave is 4-m-high and lasts for a period of 3.5 s. determine the work and power potentials per unit area. Take the density of seawater to be $1025 kg/m^3$. (3 Marks)

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