



(12)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF
B.SC (RENEWABLE ENERGY AND BIOFUELS TECHNOLOGY)

COURSE CODE: PRD 472

COURSE TITLE: POWER PLANT ENGINEERING

DURATION: 2 HOURS

DATE: 3/8/2018 TIME: 9-11PM

INSTRUCTIONS TO CANDIDATES

- (i) Answer **Question 1 (Compulsory)** and any other **TWO** questions
- (ii) All symbols have their usual meaning
- (iii) Use steam tables provided

This paper consists of 4 printed pages. Please Turn Over



KIBU observes ZERO tolerance to examination cheating

QUESTION ONE (Compulsory) – 30 Marks

- a) The annual peak load on a 30MW power plant is 25MW. The power station supplies load having maximum demands of 10MW, 8.5MW, 5MW and 4.5 MW. The annual load factor is 40%.

Determine the following:

- (i) Average load (2 Marks)
- (ii) Demand factor (2 Marks)
- b) Give four safety measures that are usually provided for the safe and controlled operation of a hydro-electric plant (4 Marks)
- c) List four advantages of geothermal energy over other forms of energy (4 Marks)
- d) Explain briefly the two effects of using impure feed-water in a boiler plant. (4 Marks)
- e) What are the functions of the following in a boiler plant?
- (i) Economisers (2 Marks)
- (ii) Superheaters (2 Marks)
- f) Briefly explain two reasons for the use of waste heat recovery technology (4 Marks)
- g) State four categories of geothermal resources (2 Marks)
- h) Give four advantages of using Fluidized-Bed Combustion Boilers. (4 Marks)

QUESTION TWO – 20 Marks

Determine the percentage change in efficiency of a Diesel power plant having a compression ratio of 18 and cut-off taking place at 6% of the stroke, when the specific heat at constant volume increases by 2%. Take:

$$c_v = 0.717 \text{ kJ/kgK}, R = 0.287 \text{ kJ/kgK and } \eta = 1 - \frac{(\beta^\gamma - 1)}{\gamma(\beta - 1)r_v^{\gamma-1}}$$

(20 Marks)

QUESTION THREE – 20 Marks

A combined cycle plant has a gas turbine unit and a steam turbine unit. The exhaust from the gas turbine is supplied to the steam turbine to generate electricity. For the gas turbine; the pressure ratio is 8, the temperature of air to the inlet of the compressor is 17°C , and the maximum cycle temperature is 900°C . For the steam turbine; steam conditions at entry to turbine are 2MN/m^2 and 400°C , condenser pressure is 5000N/m^2 , and the temperature of gases leaving the steam generator is 180°C . Total power output of the plant is 60MW . Isentropic efficiencies of the air compressor, the gas turbine, and the steam turbine are 79%, 83%, and 80% respectively. For combustion gases; $C_p = 1.11\text{kJ/kgK}$, and $\gamma = 1.33$, while for air; $C_p = 1.005\text{kJ/kgK}$, and $\gamma = 1.4$. Assume that the mass flow rate of fuel, feed pump work, and all pressure losses are negligible.

- a) Draw and label a schematic diagram of the plant (3 Marks)
- b) Calculate the cycle efficiency of the gas turbine (6 Marks)
- c) If the heat supplied to the steam generator were by an external source, determine the efficiency of the steam cycle (6 Marks)
- d) Calculate the mass flow rate of air to the gas turbine, and the mass flow rate of steam to the steam turbine (3 Marks)
- e) Determine the overall efficiency of the combined cycle (2 Marks)

QUESTION FOUR – 20 Marks

A hydro-electric power station is to be designed for a catchment area of 300 km^2 , and the available rainfall per year is 1300mm . The head available is 30m . 20% of the total rainfall is lost through evaporation. Penstock efficiency is 92%, turbine efficiency is 81%, generator efficiency is 86%, and the load factor is 40%. Density of water is 1000 kg/m^3

- a) Determine the plant capacity of the station. (14 Marks)
- b) Suggest suitable turbines to be used (6 Marks)

QUESTION FIVE – 20 Marks

A steam power plant has the following data:

- Installed capacity = 120MW
- Capital cost of the plant = Kshs 3500 per kW
- Interest and depreciation = 15%
- Fuel consumption = 1kg/kWh
- Fuel cost = Kshs 50 per 1000kg
- Peak load = 100MW
- Load factor = 60%
- Salaries, wages, repairs and other operating costs per year = Kshs 10 million

Determine the generation cost per unit of energy for the steam plant.

(20 Marks)