

PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
MECHANICAL ENGINEERING DEPARTMENT
2022 SEMESTER TWO – FINAL EXAMINATIONS
ME221- THERMAL AND POWER SYSTEMS
DATE: TUESDAY 25 OCTOBER, MORNING
TIME ALLOWED: TWO (2) HOURS

INSTRUCTION TO STUDENTS:

1. You have 10 minutes to read the paper. **DO NOT** write anything during this time.
2. Answer **ALL** questions.
3. All questions must be answered **neatly** in the ANSWER BOOKLET provided, No other written materials will be accepted.
4. Calculators are permitted in the examination room.
5. Sketches must be neatly drawn and clearly labelled. Use a soft-grade pencil for drawing.
6. Write your name clearly on the front page of the answer booklet using **BLOCK LETTERS – DO IT NOW!**

MARKING SCHEME:

All questions carry equal marks unless specified otherwise

Notes:

- i. Make a justifiable assumption if not given.
- ii. The symbols represent their usual meanings.
- iii. Steam Table provided.
- iv. Assume that air composed of 23.3% O₂ and 76.7% N₂ by mass
21% O₂ and 79% N₂ by volume

QUESTION 1

- i. Draw a T-s diagram for simple Rankine cycle and derive an expression for Rankine efficiency [2 Marks]
- ii. A steam power plant operates on a reheat cycle. Steam at boiler at 150 bar, 550°C expands through the high-pressure turbine. It is reheated at a constant pressure of 40 bar to 550°C and expands through the low-pressure turbine to a condenser at 0.1 bar. Draw T-s diagram and calculate
 - a) Dryness fraction of steam at turbine exhaust [i.e., at condenser inlet] [3Marks]
 - b) Work out in kJ/kg [2 Marks]
 - c) Heat in, in kJ/kg [2 Marks]
 - d) Specific Steam Consumption in kg/kWh [1 Mark]

Assume expansion processes are isentropic. Neglect the feed pump work

QUESTION 2

- i. State two important selection criteria of a steam boiler [2 Marks]
- ii. What do you understand by the term vacuum efficiency of a condensing plant? On what factors do this efficiency depend? [2 Marks]
- iii. The nozzle angle of a simple impulse turbine is inclined at 20° to the direction of moving blades. The blade speed is 250 m/s. The enthalpy drop at nozzle is 467.5 kJ/kg. The angle of blade at outlet is 30° and the machine develops 30 kW when consuming 360 kg of steam per hour.
 - a) What is the relative velocity at inlet r_1 [2 Marks]
 - b) Determine the whirl velocity ω [2 Marks]
 - c) Determine exit velocity of steam at exit a_e [2 Marks]

QUESTION 3

- i. State two important advantages of Open Cycle gas Turbine Power Plants over Steam Power Plants

[1.5 Marks]

- ii. An open cycle gas turbine unit operates with two compressor stages having an intercooler between them. The high-pressure turbine drives the compressors and the low-pressure turbine drives the generator. The exhaust from high pressure compressor passes to combustion chamber and expand in high pressure turbine. The gases are reheated before it expands in low pressure turbine.

[8.5 Marks]

Following datas are provided.

Overall pressure ratio is 7/1

The air inlet temperature to the LPC is 20°C

Gas temperature at inlet to the HPT is 600°C

The gases are reheated to 600°C after expansion in the first turbine

The compressors have equal pressure ratios and intercooling is complete between stages

The isentropic efficiency of each compression stage is 0.82

The isentropic efficiency of each turbine stage is 0.88

Mechanical efficiency of both power shaft and compressor turbine shaft =97%

C_p for air = 1kJ/kgK, γ for air =1.4

C_{pg} for gases = 1.2 kJ/kgK, γ for gases = 1.3

Draw a neat schematic and relevant T-s diagram and calculate Net Work Output

QUESTION 4

- i. Describe the working principles of two stroke and four stroke diesel engines [4 Marks]

- ii. Consider Benzene (C_6H_6) and calculate

a) the stoichiometric A/F ratio

[2 Marks]

b) the wet and dry analysis of the combustion products

[4 Marks]