2506/305
AIRCRAFT MECHANICAL
TECHNOLOGY II
June/July 2019
Time: 3 hours

**THE KENYA NATIONAL EXAMINATIONS COUNCIL**

# DIPLOMA IN AERONAUTICAL ENGINEERING (AIRFRAMES AND ENGINES OPTION)

## MODULE III

AIRCRAFT MECHANICAL TECHNOLOGY II

**3 hours**

**INSTRUCTIONS TO CANDIDATES**

*You should have the following for this examination:*

*Answer booklet;*
*Mathematical tables/Non-programmable scientific calculator;*
*Thermodynamic and Transport properties of fluid tables by Rogers and Mayhew;*
*Drawing instruments.*

*This paper consists of* ***EIGHT*** *questions in* ***TWO*** *sections;* ***A*** *and* ***B****.*
*Answer* ***FIVE*** *questions choosing* ***THREE*** *questions from section* ***A*** *and* ***TWO*** *questions from section* ***B****.*
*All questions carry equal marks.*
*Maximum marks for each part of a question are as shown.*
***Candidates should answer the questions in English.***

**This paper consists of 5 printed pages.**

**Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.**

## SECTION A: THERMODYNAMICS

*Answer any **THREE** questions from this section.*

1. (a) Outline the **three** classes of fuels and list **two** examples for each. (6 marks)

(b) Define the following terms as used in combustion of fuels:

(i) stoichiometric air fuel ratio;
(ii) mixture strength;
(iii) flash point. (3 marks)

(c) A petrol engine uses ethylalcohol $C_2H_6O$ as the fuel. If the mixture strength is observed as 80%, determine the:

(i) stoichometric air fuel ratio;
(ii) actual air fuel ratio;
(iii) wet analysis by volume of the exhaust gases. (11 marks)

2. (a) Distinguish between impulse and reaction turbines on the basis of their operation. (4 marks)

(b) With the aid of a velocity diagram of an impulse turbine, show that the diagram efficiency of a turbine $\eta_d$ is given by:

$$\eta_d = \frac{2\mu(CWi + CWe)}{C_{ai}^2}.$$

Where: $\mu$ is the mean blade speed;
CWi and CWe are velocity of whirl at inlet and exit of the steam respectively;
Cai is the absolute velocity at inlet. (9 marks)

(c) The mean blade speed of a reaction turbine at a particular speed is 75 m/s. The steam enters the turbine at a pressure of 3 bar and a temperature of 150 ℃. The moving blade and fixed blades at this stage have inlet and exit angles at 35° and 25° respectively. Calculate the:

(i) blade height at this stage if the height is $\frac{1}{12}$ of mean blade ring diameter;
(ii) power developed by the turbine when steam flow rate is 13.8 kg/s;
(iii) diagram efficiency. (7 marks)

3. (a) Explain the principle of operation of the following heat exchangers:

(i) regenerative;
(ii) recuperative. (4 marks)

(b) Using a temperature variation along the length of a parallel heat exchanger, derive the expression for logarithmic mean temperature difference (L.M.T.D). (9 marks)

(c) A parallel flow heat exchanger carries hot and cold water streams at a rate of 0.25 and 0.6 kg/s respectively. The inlet temperature of the hot and cold streams are 80 °C and 30 °C respectively, while the exit temperature of the hot stream is 45 °C. If the heat transfer coefficient on both sides is 680 W/m$^2$K and the specific heat capacity for the water is 4.2 kJ/kgK. Determine the pipe surface area required.

(7 marks)

4. (a) With the aid of a P.V diagram showing the liquid, wet steam and superheated steam regions, explain the process of steam generation in a boiler. (6 marks)

(b) (i) Define the following terms as used in steam:

(I) specific volume;
(II) dryness fraction.

(ii) Show that the volume of wet steam V, can be expressed as:

$V=V_g-(1-x)V_{fg}$.

Where: $V_g$ is the volume of dry steam;
$V_{fg}$ is the volume of steam in the wet region.

(7 marks)

(c) 1500 kg of steam at a pressure of 20 bar and dryness fraction of 0.85 is generated by a boiler in one hour. If the temperature of boiler feed water is 40 °C, determine the heat supplied per hour to generate wet steam. (7 marks)

5. (a) (i) State the following as used in perfect gases:

(I) Joule's law;
(II) Avogadro's hypothesis.

(ii) Distinguish between specific heat capacity at constant volume and specific heat capacity at constant pressure.

(4 marks)

(b) Show that for a perfect gas, the specific heat capacity $C_V$ is given by:

$$C_v = \frac{R}{\gamma - 1},$$

where: R is the characteristic gas constant;
$\gamma$ is the adiabatic index;
$C_v$ is the specific heat capacity at constant volume.

(8 marks)

(c) A perfect gas has a molecular mass of 24 kg/mole and the adiabatic index $\gamma = 1.2$. Calculate the heat loss under the following processes:

(i) when the gas pressure decreases from 4.1 bar and 322 °C to 1.5 bar at a constant volume;

(ii) when the gas enters the pipeline at 250 °C and exits at 25 °C at a constant pressure.

Neglect changes due to velocity of the gas.
Take: $R_o = 8314.4$ J/kmolK (8 marks)

## SECTION B: FLUID MECHANICS

*Answer any **TWO** questions from this section.*

6. (a) Show that the mean velocity of viscous flow V between two parallel fixed plates due to a pressure P, in a dashpot with plates *h* distance apart and length L is given by:

$$V = \frac{Ph^2}{12\eta L},$$

where: $\eta$ is the kinematic viscousity of the fluid. (17 marks)

(b) A dashpot consists of a piston 85 mm long sliding in a cylinder 50 mm diameter with a radial clearance of 1 mm. The cylinder is filled with a fluid of kinematic viscousity 0.2 kg/m-s. If the piston is acted upon by a force of 196.2 N, determine the velocity of the piston. (3 marks)

7. (a) (i) List **three** applications of dimensional analysis.

(i) A fluid of mass density $\rho$, coefficient of kinematic viscousity $\mu$, flows through a circular pipe of diameter d and length L at a velocity V. Show by dimensional analysis that the pressure P in the pipe is given by:

$$P = \rho V^2 d\phi\left(\frac{VdL}{\mu}, \frac{L}{d}\right),$$ where: $\phi$ is a function of. (13 marks)

(b) A water pipe 40 m long and 20 mm diameter carries water flowing at a velocity of 5 m/s. The loss of head in the pipe is 25 m of water. Determine the loss of head in a 80 mm diameter pipe, 30 m long when carrying air.

Take: for air $\rho = 1.3$ kg/m³, $\mu = 1.8 \times 10^{-5}$ Ns/m²;
for water $\rho = 1000$ kg/m³, $\mu = 1.2 \times 10^{-3}$ Ns/m². (7 marks)

8. (a) Define the following as applied in pumps:

(i) manometric efficiency;
(ii) mechanical efficiency;
(iii) overall efficiency. (3 marks)

(b) A centrifugal pump has internal and external radii of the impeller $r_1$ and $r_2$ respectively. The corresponding peripheral velocities are $\mu_1$ and $\mu_2$ respectively. Derive the expression for the work done per unit weight of the fluid in terms of outer peripheral speeds $\mu_2$ and the velocity of whirl $W_2$. (8 marks)

(c) The outer diameter and width of vanes set backwards at 75° of a centrifugal blower are 520 mm and 85 mm respectively. When the speed is 980 rev/min, a pressure difference of 40 mm of water is observed and the delivery of air is 3.5 $m^3/s$. The power supplied to the blower shaft is 1.7 kW.
Neglecting the vane thickness at inlet and assuming radial inlet, determine the:

(i) manometric efficiency;
(ii) power efficiency;
(iii) overall efficiency.

(9 marks)

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