Name:_____ Index No._____

2501/304
2503/304
FLUID MECHANICS AND THERMODYNAMICS
Oct./Nov. 2015
Time 3 hours

Candidate's Signature:_____

Date:_____

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN MECHANICAL ENGINEERING (PRODUCTION OPTION)

DIPLOMA IN AUTOMOTIVE ENGINEERING MODULE III

FLUID MECHANICS AND THERMODYNAMICS

3 hours

INSTRUCTIONS TO CANDIDATES

Write your name and index number in the spaces provided above.
Sign and write the date of the examination in the spaces provided above.
You should have the following for this examination:
Mathematical table/ calculator;
Thermodynamic and transport properties of fluid tables by Rogers and Mayhew;
*This paper consists of **TWO** sections; **A** and **B**.*
*Answer **FIVE** questions; any **TWO** from section **A** and any **THREE** from section **B** in the spaces provided in this question paper.*
Maximum marks for each part of a question are indicated.
*Do **NOT** remove any pages from this question paper.*
Candidates should answer the questions in English.

For Examiner's Use Only

Section	Question	Maximum Score	Candidate's Score
A		20	
		20	
B		20	
		20	
		20	
	TOTAL SCORE	100	

This paper consists of 16 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: FLUID MECHANICS

*Answer **TWO** questions in this section.*

1. (a) Define the following terms for dimensional analysis:

(i) geometric similarity;
(ii) dynamic similarity;
(iii) kinematic similarity. (6 marks)

(b) (i) Explain the importance of dimensional analysis in model testing.

(ii) The variables controlling the motion of a floating vessel through water are the drag force F, the speed V, the length L, the density ρ, the dynamic viscosity μ and the gravitational acceleration g. Applying dimensional analysis, show that the drag force is given by the expression $F = \rho \vartheta L^2 \phi \left\{ \frac{\rho \vartheta L}{\mu}, \frac{Lg}{V^2} \right\}$. (14 marks)

2. (a) With reference to pumps, define the term cavitation and explain any **two** of its effects. (4 marks)

(b) Sketch an indicator diagram for a single cylinder, single acting reciprocating pump showing the effects of accelerations and friction on both suction and delivery pipes. (5 marks)

(c) A centrifugal pump delivers 3.5 m^3/sec of water, when running at 1500 rpm. The diameter of the impeller at the inlet is 200 mm and 550 mm at the outlet. Water enters radially at a speed of 23 m/s, and the outlet vanes are set backwards at 60° to the tangent in the direction of the impeller and the width at the outlet is 27 mm. Neglecting the blade thickness, determine:

(i) the manometric efficiency if the head rise through the pump is 60 m;
(ii) the power required for the pump if the mechanical efficiency is 93%;
(iii) the angle of the guides in the diffuser ring. (11 marks)

3. (a) Define the following terms as applied in fluid mechanics:

(i) specific gravity;
(ii) coefficient of dynamic viscosity. (4 marks)

(b) Show that the loss of head when a pipe undergoes as sudden increase in diameter is given by: $h_f = \frac{(v_1 - v_2)^2}{2g}$ where v_1 and v_2 are the velocities in the smaller and larger pipes respectively. (6 marks)

(c) Two reservoirs are connected by a pipeline which is 100 mm diameter for the first 10 m and 150 mm in diameter for the remaining 20 m. The entrance and exits are sharp and the change in section is sudden. The water surface in the upper reservoir is 7 m above that in the lower, the coefficient of friction f in both pipes is 0.01. Determine the rate of flow in m^3/s. (10 marks)

SECTION B: THERMODYNAMICS

*Answer **THREE** questions in this section.*

4. (a) Define the following terms as applied to steam:

(i) wet steam;
(ii) degree of superheat.

(4 marks)

(b) A quantity of gas has an initial pressure of 2.72 MN/m^2 and a volume of 0.0056 m^3. It is expanded according to the law $PV^{1.35} = C$ to a pressure of 340 kN/m^2. Determine the final volume and the work done. (4 marks)

(c) In an engine test, the dry product analysis was CO_2 15.5%, O_2 2.3% and the remainder N_2. Assuming that the fuel burned was a pure hydrocarbon, calculate the ratio of carbon to hydrogen in the fuel, the A/F ratio and the mixture strength. (12 marks)

5. (a) 1 kg of a fluid at 30 bar, 300° C, expands reversibly and isothermally to a pressure of 0.75 bar. Calculate the heat flow and the work done,

(i) when the fluid is air;
(ii) when the fluid is steam. (10 marks)

(b) A steel pipe carrying a process fluid has a bore of 150 mm and thickness 5 mm. The pipe is covered with a 50 mm layer of insulation of thermal conductivity 0.05 W/mK. The thermal conductivity for the pipe may be taken as 45 W/mK and the surface heat transfer coefficient as 35 W/m^{2}K for the inner surface and 7 W/m^{2}K for the outside surface of the insulation. Assuming the process fluid temperature to be constant at 300 °C and that of the ambient as 16 °C, determine the:

(i) overall heat transfer coefficient based on the outer surface of the insulation.
(ii) heat lost per length of the pipe. (10 marks)

6. (a) Define the term diagram efficiency and show that the diagram efficiency can be expressed as:

$$\eta_d = \frac{4b}{a_i}\left(\text{Cos}\alpha_i - \frac{b}{a_i}\right)$$

(8 marks)

(b) A single row impulse steam turbine is supplied with steam at 25 bar, 300° C and exhausts at 3.5 bar. The nozzles have an efficiency of 0.88 and an outlet angle of 16.5° both for the nozzles and the moving blades. The turbine receives 2.2 kg/s of steam while the blade velocity coefficient is 0.85. Assume the blade to be symmetrical. If the mean blade ring diameter is 0.65 m and the speed is 8200 rpm, determine the:

(i) power developed by the turbine;
(ii) blade inlet angle. (12 marks)

7. (a) In an ideal constant pressure cycle, using air, the overall volume ratio of the cycle is 8:1. The volume ratio of the adiabatic compression is 6:1. The pressure, volume and temperature of the air at the beginnine of the adiabatic compression are 100 kN/m^2, 0.084 m^3 and 28 °C respectively. Taking $\gamma = 1.4$, Cp = 1.006 kJ/kgK, determine for the cycle:

(i) the pressure, volume and temperature at cycle state points;

(ii) the thermal efficiency.

(8 marks)

(b) A single acting two stage compressor with complete intercooling, delivers 6 kg/min of air at 16 bar. Assuming an intake state of 1 bar and 15° C and that the compression and expansion processes are reversible and polytropic with n = 1.3, calculate:

(i) the power required;
(ii) the isothermal efficiency;
(iii) the free air delivery;
(iv) the final delivery temperature.

(12 marks)