UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: November 2017

Module Number: ME6301 **Module Name: Advanced Fluid Mechanics**

[Three Hours]

[Answer **all questions**, each question carries **twelve** marks]

Q1 a) Define the boundary layer thickness and displacement thickness. State key differences between them.

[2.0 Marks]

b) "Flow separation can occur only when there is an adverse pressure gradient". Briefly explain this phenomenon. Also, state that is there any possibility to have flow separation, even without a boundary?

[2.0 Marks]

c) Why does the laminar boundary layer give less skin friction than the turbulent boundary layer?

[2.0 Marks]

d) Considering a laminar boundary layer over a flat plate, show that the boundary layer thickness can be expressed by $\frac{\delta}{x}=\frac{5.84}{\mathrm{Re}^{1/2}}$, if the velocity profile of the boundary layer is given by $\frac{u}{U}=2(y/\delta)+2(y/\delta)^3+2(y/\delta)^4$.

Note: symbols in the above expressions indicate usual notations.

[6.0 Marks]

Q2 a) Explain the factors that affect the total drag on a body which is completely immersed in a fluid.

[2.0 Marks]

b) Discuss the variation of drag coefficient with respect to Reynolds number when a circular cylinder of infinite length is placed transversely in a uniform fluid stream.

[3.0 Marks]

c) A 244 m long and 24.5 m wide navy ship travels at a velocity of 56 kmph in the sea. The density and the dynamic viscosity of the sea water are 1104 kg/m^3 and 0.001048 Pa s, respectively. Considering boundary layer theory on a flat plate,

i) Calculate the total shear force on the ship assuming the boundary layer is completely turbulent and the surface of the hull is smooth.

[3.0 Marks]

ii) Recalculate the total shear force assuming that laminar to turbulent transition Reynolds number is 4×10^5.

[4.0 Marks]

Q3 a) Sketch the speed characteristic curves of a Fixed Capacity Pump (FCP) and a Variable Capacity Motor (VCM) combination for a constant torque load application. Discuss the suitability of this combination for the constant torque application.

[2.0 Marks]

b) In a hydraulic transmission system, a Fixed Capacity Pump (FCP) supplies oil to a Variable Capacity Motor (VCM). The pump is directly coupled to an electric motor, which is driven at a constant speed of 2000 rpm. The capacity of the FCP is 0.06 lit/rev. The maximum capacity and speed of the VCM are 0.04 lit/rev and 3500 rpm, respectively. Hydraulic pressure loss in the circuit between FCP and VCM are estimated as 5 bar. For both FCP and VCM, the volumetric and the overall efficiency are 80% and 70%, respectively. The relief valve pressure is set at 40 bar. Determine the following parameters of VCM,

i) Minimum capacity
ii) Minimum speed
iii) Maximum power output
iv) Range of speed associated with a constant torque of 8 N m.

[10.0 Marks]

Q4 a) The study of flow past a sphere is of great importance because it is the foundation of a branch of fluid mechanics called particle mechanics. For the determination of drag coefficient in particle mechanics the flow past a sphere is subdivided into three regimes. Briefly describe the three regimes by paying attention to flow structure around the sphere with increasing Reynolds number.

[3.0 Marks]

b) Consider motion of a spherical particle on vertical plane in a moving fluid as shown in Figure Q4. Let the fluid flows at a uniform velocity U in horizontal direction. Derive an equation for motion of the particle in x (horizontal) direction by clearly stating the assumptions you made. Drag force on the particle body is given by $F_D = \frac{1}{2}\rho V_r^2 A C_D$, where ρ, V_r, A and C_D denote usual notations for density of the fluid, resultant velocity of the spherical particle, projected area of the particle and drag coefficient respectively.

[5.0 Marks]

c) State five properties of a good lubricant.

[2.0 Marks]

d) Define hydrodynamic lubrication principle and discuss two examples of using this principle in bearings by sketching the diagrams.

[2.0 Marks]

Q5 a) What are the general safety rules to be followed in repairing fluid power systems?

[2.0 Marks]

b) Explain the potential causes and remedies for the following conditions related to fluid power systems during operation,

(i) Excessive noise

(ii) Excessive heat generation.

[2.0 Marks]

c) What are the functions of Pressure Control Valves (PCVs) in fluid power systems. Explain two of them commonly use in the hydraulic circuits.

[2.0 Marks]

d) Figure Q5 shows a fluid power circuit designed for a specific task. The hydraulic components of the circuit are indicated in standard graphic symbols. Analyzing the fluid power circuit,

(i) Name all hydraulic components ("A " to "J"),

(ii) Explain the functions of the component "G",

(iii) Explain the motion of the actuator "J" in forward and backward directions,

(iv) Suggest suitable practical application for this circuit.

[6.0 Marks]

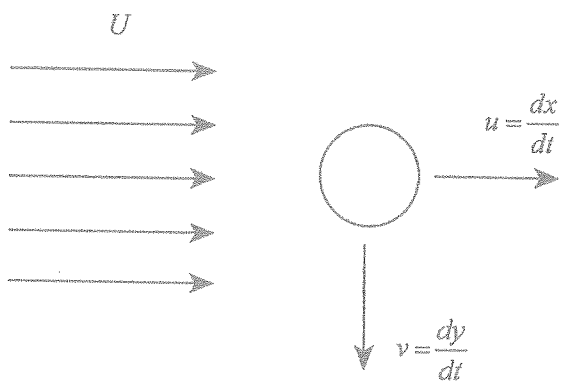

Figure Q4

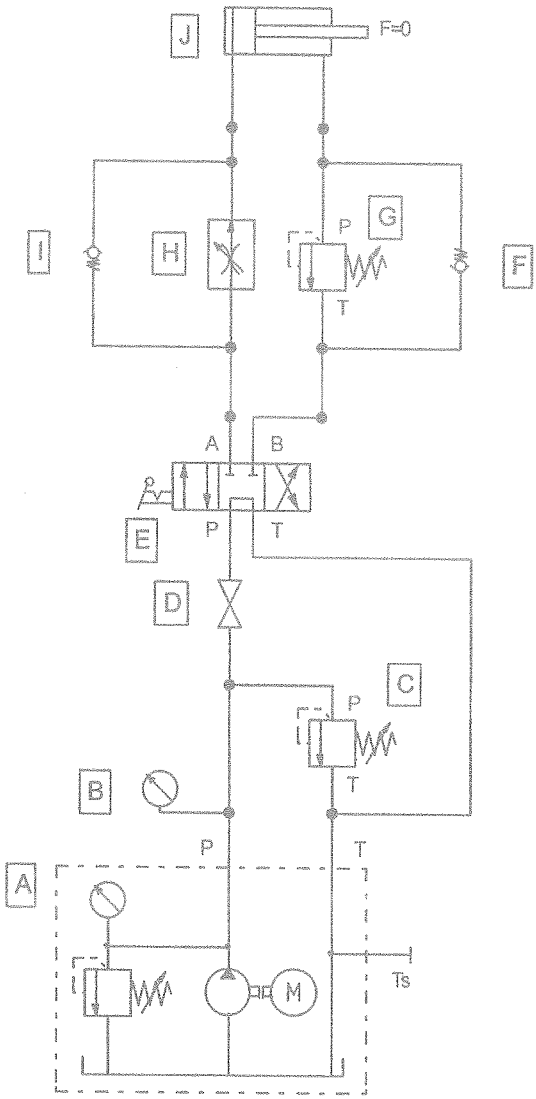

Figure Q5