UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: January 2022 (Repeat)

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

[Three Hours]

[Answer **all questions**; Each question carries **twelve marks**; Provide neat sketches where necessary; Make reasonable assumptions and state them clearly]

Q1 a) Write brief notes on the following.

i) Steady and unsteady flows.

ii) Uniform and non-uniform flows.

iii) Laminar and turbulent flows.

[1.5 Marks]

b) Briefly describe **four** methods of preventing separation of the boundary layer.

[2.0 Marks]

c) Describe the effect of pressure gradient on boundary layer separation considering a flow over a curved surface.

[2.5 Marks]

d) Water is flowing over a thin smooth plate of length 5 m and width 2 m at a velocity of 1.0 m/s. Ifthe boundary layer flow changes from laminar to turbulent at a Reynold number 5×10^5, considering density = 1000 kgm^{-3}, and dynamic viscosity(μ)= 1×10^{-3} Ns/m^2,find the followings. (Drag coefficient for a laminar flow $=\frac{1.328}{\sqrt{Re_L}}$ and for a turbulent flow $=\frac{0.072}{\sqrt[5]{Re_L}}$)

i) The distance from leading edge up to which boundary layer is laminar.

[1.0 Mark]

ii) The drag force on one side of the plate due to the laminar boundary layer.

[2.0 Marks]

iii) The drag force on one side of the plate due to turbulent boundary layer.

[3.0 Marks]

Q2 a) What are the **three** types of forces acting on the rigid particle moving through a fluid?

[1.5 Marks]

b) Mention **four** applications of fluidization.

[2.0 Marks]

c) Mention **three** restricted conditions of using drag coefficient vs Reynold's number graph of a particle.

[1.5 Marks]

d) Explain **free settling** and **hindered settling** of particle motion.

[2.0 Marks]

e) Spherical particles of density 2500 kg/m^3 and in the size range 20 - 100 μm are fed continuously into a stream of water (density, 1000 kg/m^{3}and viscosity, 0.001 Pas) flowing upwards in a vertical, large diameter pipe. What maximum water velocity is required to ensure that no particles of diameter greater than 60 μm are carried upwards with the water?

[5.0 Marks]

Q3 a) What are the advantages and disadvantages of hydraulic power transmission systems?

[2.0 Marks]

b) Explain with clear sketches the working principle of a radial flow positive displacement pump.

[2.0 Marks]

c) Figure Q3(c) shows a hydraulic circuit designed for a particular industrial application. By investigating the circuit, identify the devices in it and briefly explain the main functions of the following.

i) The unit C and its components.

ii) The device D and its actuation methods.

iii) The devices E, F, G and H.

iv) The devices A and B.

v) The overall hydraulic circuit.

Q3 is continued to page 3

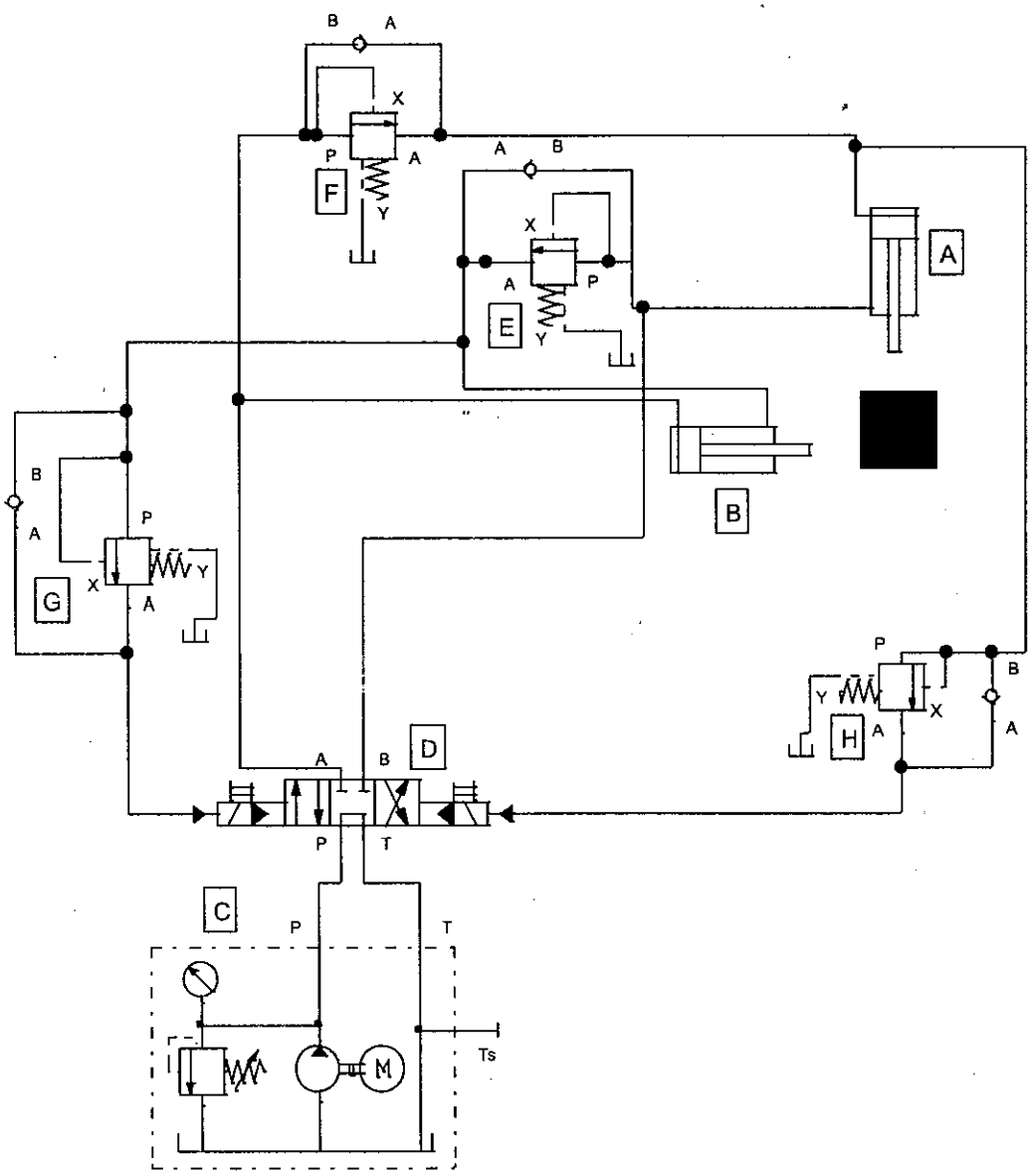

Fig. Q3 (c) A hydraulic circuit designed for a particular industrial application

[8.0 Marks]

Q4 a) A hydraulic motor control circuit consists of a Fixed Capacity Hydraulic Pump (FCP) and a Variable Capacity Hydraulic Motor (VCM). Investigating performance of this circuit, show that this circuit is not suitable for constant torque applications.

[4.0 Marks]

Q4 is continued to page 4

b) For an industrial hydraulic transmission system, a FCP supplies oil to a VCM. The FCP is directly coupled to an electric motor and is driven at a constant speed of 1450 rpm. The capacity of the FCP is 45 ml/rev. The maximum capacity and speed of the VCM are 55 ml/rev and 2800 rpm, respectively. Hydraulic losses in pipes and fitting between FCP and VCM are estimated to be 4.2 bar. For both FCP and VCM the volumetric efficiency and overall efficiency are 92% and 82%, respectively. If the relief valve pressure is set at 32 bar, determine the following.

i) The minimum capacity of the VCM to be set mechanically for ensuring safe operation.

ii) The maximum load of the VCM.

iii) The speed range of the VCM associated with a 10 Nm torque load.

[8.0 Marks]

Q5 a) Mention **four** characteristics of good lubricants.

[2.0 Marks]

b) Mention **two** major factors which affect the selection of lubricants?

[2.0 Marks]

c) Is it advisable to use the recommended lubricant of a diesel engine for lubricating gasoline engine? Explain the reasons.

[2.0 Marks]

d) Explain an advantage of using hydrostatic lubrication compared to hydrodynamic lubrication using a neat and clear sketch of a bearing system.

[2.0 Marks]

e) A circular hydrostatic pad, as shown in Figure Q5 (e), is supporting a load of W = 1000 N, and the upper disk has rotational speed of 5000 rpm. The disk diameter is 200 mm, and the diameter of the circular recess is 100 mm. The oil is SAE 10 at an operating temperature of 70 °C, having a viscosity of μ=0.01 Ns/m^2. The efficiency of the hydraulic pump system is 0.6 and that of the motor and drive system is 0.9. Calculate the pressure in the recess.

Q5 is continued to page 5

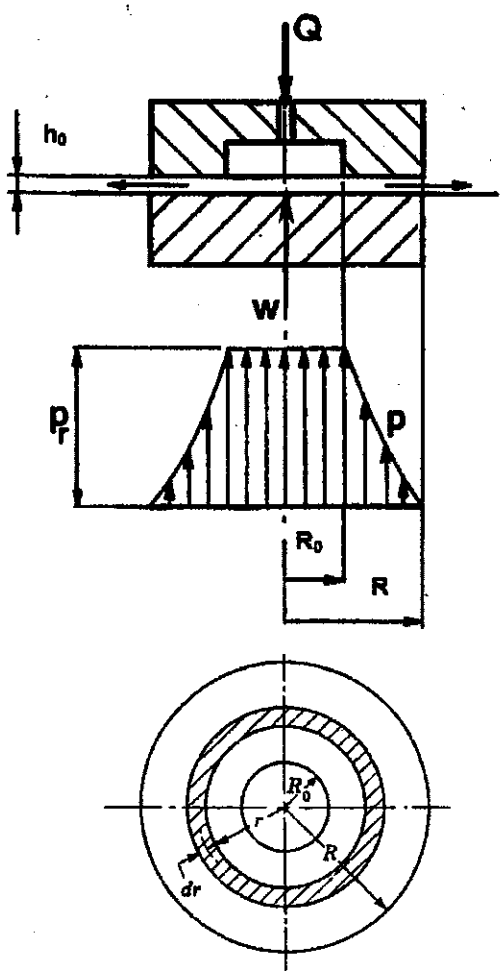

Figure Q5 (e)

[4.0 Marks]

Useful equations with usual notations.

$$V_T=\frac{D_p^2\left(\rho_p-\rho_f\right)g}{18\mu}$$

$$F_D=3\pi\mu UD_P$$

$$\Delta P=\frac{150\,\mu LU_\infty(1-\varepsilon)^2}{D_p^2\varepsilon^3}+\frac{1.75\rho LU_\infty{}^2(1-\varepsilon)}{D_p\varepsilon^3}$$

$$P=\frac{6\eta Q}{\pi h^3\cos\phi}\ln\left(\frac{R}{r}\right)$$

$$W=\frac{P_r\pi}{2\cos\phi}\left[\frac{R^2-R_0^2}{\ln(R/R_0)}\right]$$

$$H_f=2\pi^3\eta n^2\left[\frac{R_0^4}{h_r}+\frac{(R^4-R_0^4}{h\cos\phi}\right]$$