FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI
MECHANICAL ENGINEERING DEPARTMENT
RAIN SEMESTER EXAMINATION

Course Title: Fluid Mechanics II
Course Code: ENG 310
Date: August 31, 2018
Time: 2:00pm – 5:00 pm
Instructions: Answer **Question 1** and any other **Three**. Use of Gas Tables is **NOT** allowed.

Question 1

(i) The x and y components of a fluid velocity in 2D flow field are given as: u = x and v = -y. If a uniform flow field defined by $\psi = y$ is superimposed on this flow, determine the velocity potential of the combined flow.

(ii) A plane is stated to move horizontally relative to the ground at a speed twice the velocity of sound (c = 340 m/s) and that the air is moving in the opposite direction with speed equal to half of the sonic velocity relative to the ground. Determine the Mach number and Mach angle.

(iii) Mention the three main uses of dimensional analysis.

(iv) Draw the general layout of hydraulic power plant using an impulse turbine and define the following (a) Gross head (b) Net head (c) Hydraulic efficiency

(v) Sketch the arrangement of two centrifugal pumps (a) in series (b) in parallel

Question 2

(a) Derive an expression for hydraulic efficiency of a Pelton wheel.

(b) A Pelton wheel has a mean bucket speed of 10 m/s with a jet of water flowing at the rate of 0.7 m^3/s under a head of 30 m. The bucket deflects the jet through an angle of 150°. Calculate the power and efficiency of the bucket. Assume coefficient of velocity as 0.98.

Question 3

(a) Starting from first principle, show that the following relations hold in the analysis of compressible fluid flow. (i) $\frac{T_o}{T} = 1 + \frac{K-1}{2}M^2$ (ii) $\frac{P}{P_o} = \left(1 + \frac{K-1}{2}M^2\right)^{K/1-K}$

(b) Air is flowing through a duct and a normal shock wave is formed at a cross section at which the Mach number is 2.0. If the upstream pressure and temperature are 105 bar and 15°C, respectively, find the Mach number, pressure and temperature immediately downstream of the shock waves. Take k = 1.4. (**DO NOT** use the Gas Tables).

Question 4

(a) Sketch the resulting flow pattern from the combined Doublet, Vortex and Uniform rectilinear flow and give the stream function of the resulting flow pattern.

(b) A source of strength 0.25 m^2/s and a vortex with strength 1 m^2/s (anticlockwise) are located at the origin. Determine the equation for stream function and velocity potential. Also determine the velocity components at a point P(1, 0.5).

Question 5

(a) A model is built of a flow phenomenon which is dominated by the action of gravity and surface tension. Show that the length scale ratio which will ensure complete hydraulic similitude between the model and prototype is $L_r = \sqrt{\sigma_r/\rho_r}$ where σ_r and ρ_r are the ratios of the model to prototype for surface tension and density of fluids.

(b) Obtain an expression for the scale of model which satisfies both Froude's and Reynolds models laws. Oil of kinematic viscosity 5 x 10^{-5} m^2/s is used in a flow situation where the prototype is influenced both by viscous and gravity forces. For model scale ratio 1:5, what kinematic viscosity should be used with the model to achieve dynamic similarity with regard to these forces.