Exam

Indian Institute of Technology Kharagpur

Dept. Ocean Engineering and Naval Architecture

Session: **2013 – 2014** Semester: **Spring**

Subject: **Marine Hydrodynamics (NA21001)** Time: **2hrs**

Answer any three out of five Full Marks: **10×3=30**

Q1. a) State the principle behind the equation of continuity for fluid motion. **(1)**

b) Hence, derive the equation of continuity for fluid motion. **(5)**

c) A velocity vector is given by $\vec{V} = \frac{k^2\left(x\hat{j} - y\hat{i}\right)}{\left(x^2 + y^2\right)}$, k is a constant.

Show that it represents a possible incompressible fluid motion. **(4)**

Q2. a) Define stream line and path line. What happens to streamline and path lines in case of steady flow? **(3)**

b) Prove that the stream lines and equi-potential lines are orthogonal. **(3)**

c) Show that the stream lines associated with the flow described by the velocity potential $\phi = A\tan^{-1}(x/y)$, A is constant , are circular. **(4)**

Q3. a) For a two dimensional flow field, the stream function φ is given by $\varphi(x,y) = \frac{3}{2}\left(y^2 - x^2\right)$. Evaluate the magnitude of discharge occurring between the stream lines passing through points (0, 3) and (3, 4). **(2)**

b) The complex velocity potential for the uniform flow with constant velocity u_0 is given by $W(z) = u_0 z$. Apply the circle theorem to find the complex velocity potential for the uniform flow past a circular cylinder of radius $|z| = a$. **(3)**

c) Find the drag and lift forces on the cylinder described in b). **(5)**

Q4. a) Derive the stream function and velocity potential and clearly draw the streamlines and equi-potential lines for the following complex potentials

i) $W(z) = \frac{ik}{2\pi}\log z$ ii) $W(z) = m\log z$ **(8)**

b) Find the stagnation point for the flow $W(z) = z + iz^2$ **(2)**

Q5. a) Using the circle theorem, find the uniform flow past an elliptic cylinder with a and b being the semi-major and semi-minor axes and centre being at the origin. **(5)**

b) Show that the complex potential $W(z) = u\left(z + a^2/z\right) + m\log\left(z - z_0\right)$ does not represent the uniform flow past a cylinder of radius a in the presence of a source of strength m located at $z = z_0$.**(2)**

c) Give an example with reasons of a fluid flow field where the fluid is incompressible, but the motion is not irrotational. **(3)**

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