UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2009/2010 Academic Session

April/May 2010

MSG 322 – Fluid Mechanics
[Mekanik Bendalir]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of FIVE pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer **all five** [5] questions.

*[**Arahan:** Jawab **semua lima** [5] soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai].

1. (a) Verify Stokes's theorem for $\vec{A} = y - z + 2\,\hat{i} + yz + 4\,\hat{j} - xz\hat{k}$, where S is the surface of the cube $x = y = z = 0$ *and* $x = y = z = 2$ above the xy plane.

[10 marks]

(b) Define:
(i) Stream surface
(ii) Streak lines
(iii) Non-Newtonian fluid
(iv) Ideal fluid
(v) Continuum hypothesis

[5 marks]

(c) Derive the equation of continuity in Lagrangian description.

[5 marks]

2. (a) The velocity components of a two-dimensional flow system in the Eulerian description are $u = 2x + 2y + 3t$ *and* $v = x + y + \frac{t}{2}$. Find the displacement of a fluid particle in Lagrangian description.

[10 marks]

(b) Discuss the axi-symmetric flow of a viscous incompressible fluid past a stationary sphere and hence obtain the expression for velocity of the flow field.

[10 marks]

3. (a) Derive Euler's equation of motion in the general form (three dimensional) and hence deduce Lamb's hydrodynamical equations.

[10 marks]

(b) Show that the velocity potential $\phi = \frac{1}{2}\log\left[\frac{x + a^2 + y^2}{x - a^2 + y^2}\right]$ gives a possible motion. Determine the equations of streamlines and the curves of equal speed.

[10 marks]

1. (a) *Tentusahkan Teorem Stokes untuk* $\vec{A} = y - z + 2\,\hat{i} + yz + 4\,\hat{j} - xz\hat{k}$, *dengan S adalah permukaan kubus* $x = y = z = 0$ *and* $x = y = z = 2$ *di atas satah xy.*

[10 markah]

(b) *Takrifkan:*
- (i) *Permukaan strim*
- (ii) *Garis coreng*
- (iii) *Bendalir tak Newtonian*
- (iv) *Bendalir unggul*
- (v) *Hipotesis kontinuum*

[5 markah]

(c) *Terbitkan persamaan keselanjaran dalam perihalan Lagrangean.*

[5 markah]

2. (a) *Komponen halaju bagi sistem aliran dua dimensi dalam perihalan Euleran diberikan oleh* $u = 2x + 2y + 3t$ *and* $v = x + y + \frac{t}{2}$. *Cari sesaran zarah bendalir dalam perihalan Lagrangean*

[10 markah]

(b) *Bincangkan aliran simetri sepaksi bagi bendalir likat dan tak boleh mampat terhadap sfera pegun dan seterusnya dapatkan ungkapan bagi halaju medan aliran*

[10 markah]

3. (a) *Terbitkan persamaan gerakan Euler dalam bentuk am (tiga dimensi) dan seterusnya dapatkan persamaan hidrodinamik Lamb.*

[10 markah]

(b) *Tunjukkan bahawa upaya halaju* $\phi = \frac{1}{2}\log\left[\frac{x + a^2 + y^2}{x - a^2 + y^2}\right]$ *memungkinkan suatu gerakan bendalir. Tentukan persamaan garis strim dan lengkung laju sama.*

[10 markah]

4. (a) Determine the principal stresses and the principal stress directions if the stress tensor at a point is given by $\tau_{ij} = \begin{pmatrix} 5 & 2 & 2 \\ 2 & 2 & 1 \\ 2 & 1 & 2 \end{pmatrix}$.

[10 marks]

(b) State and prove Kelvin' s circulation theorem.

[10 marks]

5. (a) Discuss Hagen-Poiseuille flow for steady flow of a viscous incompressible fluid through a circular tube.

[10 marks]

(b) The motion of a fluid is specified by $q = u\hat{i} + v\hat{j} = \frac{ax - by}{x^2 + y^2}\hat{i} + \frac{ay + bx}{x^2 + y^2}\hat{j}$

(a and b are constants).

(i) Is it a possible motion for an incompressible fluid.

(ii) Is it a possible irrotational motion?

(iii) If so, find the corresponding velocity potential.

[10 marks]

4. (a) *Tentukan tegasan utama dan arahnya sekiranya tensor tegasan satu titik diberikan oleh* $\tau_{ij} = \begin{pmatrix} 5 & 2 & 2 \\ 2 & 2 & 1 \\ 2 & 1 & 2 \end{pmatrix}$.

[10 markah]

(b) *Nyatakan dan buktikan teorem sirkulasi edaran Kelvin.*

[10 markah]

5. (a) *Bincangkan aliran Hagen-Poiseuille untuk aliran mantap bagi bendalir likat dan tak boleh mampat melalui tiub bulat.*

[10 markah]

(b) *Gerakan bendalir dinyatakan oleh* $\mathbf{q} = u\hat{i} + v\hat{j} = \frac{ax - by}{x^2 + y^2}\hat{i} + \frac{ay + bx}{x^2 + y^2}\hat{j}$

(a dan b adalah pemalar).

(i) Adakah gerakan wujud untuk bendalir tak boleh mampat?

(ii) Adakah mungkin berlakunya gerakan tak berputar?

(iii) Jika demikian, dapatkan upaya halaju yang sepadan .

[10 markah]

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