
UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2011/2012 Academic Session

June 2012

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) Use differential analysis to derive the Cauchy's momentum equation for incompressible fluid flow.

[10 marks]

- (b) Define: (i) Stream line (ii) Uniform flow (iii) Axi-symmetric flow
(iv) Body force and surface force (v) Newtonian fluid

[5 marks]

- (c) For the velocity components $u = x^2/t^3$ and $v = y^4$ of a two-dimensional flow field, find the equations of path lines and streak lines.

[5 marks]

1. (a) *Gunakan analisis kebezaan untuk menerbitkan persamaan momentum Cauchy bagi aliran bendalir tak boleh mampat.*

[10 markah]

- (b) *Takrifkan: (i) garis arus (ii) aliran seragam (iii) aliran paksi simetri
(iv) daya jasad dan daya permukaan
(v) bendalir Newtonan*

[5 markah]

- (c) *Bagi komponen-komponen halaju $u = x^2/t^3$ dan $v = y^4$ dalam medan aliran dua dimensi, dapatkan persamaan-persamaan garis laluan dan garis coreng.*

[5 markah]

2. (a) State the principle of conservation of energy and hence derive the energy equation for inviscid incompressible fluids.

[10 marks]

- (b) Verify whether the velocity field $\vec{q} = \frac{A(x^2 - y^2)}{x^2 + y^2} \hat{i} + \frac{2Axy}{x^2 + y^2} \hat{j}$

satisfies the equation of motion for inviscid incompressible fluid flow. Hence, determine the pressure associated with this velocity field.

[10 marks]

2. (a) Nyatakan prinsip pengabadian tenaga dan seterusnya terbitkan persamaan tenaga bagi bendalir-bendalir tak likat tak boleh mampat .

[10 markah]

- (b) Sahkan sama ada medan halaju $\vec{q} = \frac{A}{x^2 + y^2} \frac{x^2 - y^2}{2} \hat{i} + \frac{2Axy}{x^2 + y^2} \hat{j}$ memenuhi

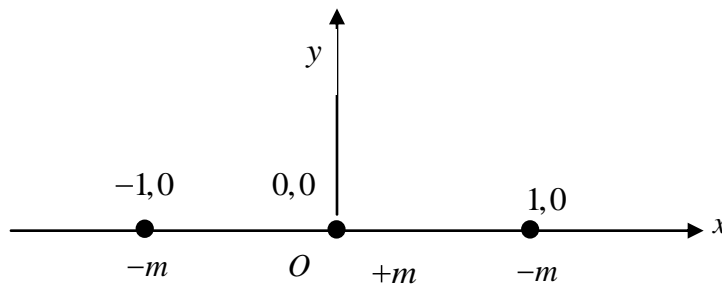
persamaan gerakan bagi aliran bendalir tak likat tak boleh mampat. Seterusnya, tentukan tekanan yang dikaitkan dengan medan halaju ini.

[10 markah]

3. (a) State and prove Kelvin's circulation theorem.

[10 marks]

- (b) There is a source of strength m at the origin and equal sinks at $(1, 0)$ and $(-1, 0)$ as shown in the following figure. Find the complex potential, complex velocity and the streamlines of the motion.

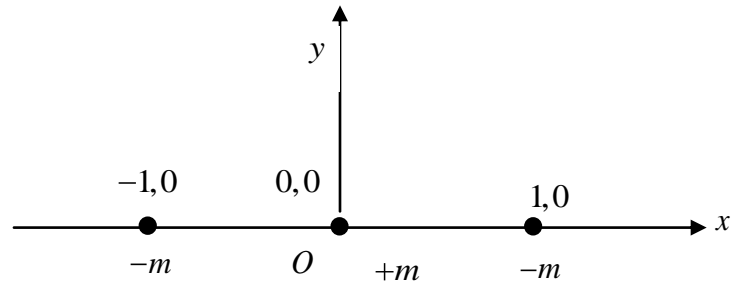


[10 marks]

3. (a) Nyatakan dan buktikan teorem edaran Kelvin.

[10 markah]

- (b) Terdapat sumber kekuatan m pada asalan dan dibenam sama pada $(1, 0)$ dan $(-1, 0)$ seperti ditunjukkan dalam rajah berikut. Dapatkan keupayaan kompleks, halaju kompleks dan garis-garis arus bagi gerakan.



[10 markah]

4. (a) Derive the Von-Karman's momentum integral equation for two-dimensional steady incompressible boundary layer flow.

[10 marks]

- (b) Obtain the expressions for maximum velocity, mean velocity, volumetric flow rate, shear stress and drag coefficient for the Hagen-Poiseuille flow of viscous incompressible fluid in a circular pipe.

[10 marks]

4. (a) *Terbitkan persamaan kamiran momentum Von Karman bagi aliran lapisan sempadan dua dimensi suatu bendalir mantap tak boleh mampat.*

[10 markah]

- (b) *Dapatkan ungkapan bagi halaju maksimum, halaju min, kadar aliran isipadu, tegasan ricih dan pekali seretan bagi aliran Hagen-Poiseuille bendalir likat di dalam paip bulat.*

[10 markah]

5. (a) Determine the principal stresses and principal stress directions if the stress

tensor at a point P is given by $\tau_{ij} = \begin{pmatrix} 3 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 3 \end{pmatrix}$.

[10 marks]

- (b) Derive Euler's equation of motion for inviscid incompressible fluid flow and hence deduce Bernoulli's equation of motion for the irrotational steady motion of an incompressible fluid under the action of conservative body forces.

[10 marks]

5. (a) Tentukan tegasan-tegasan utama dan arah-arrah tegasan utama jika tensor

tegasan pada satu titik P diberikan oleh $\tau_{ij} = \begin{pmatrix} 3 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 3 \end{pmatrix}$.

[10 markah]

- (b) Terbitkan persamaan gerakan Euler bagi aliran bendalir tak likat tak boleh mampat dan seterusnya simpulkan persamaan gerakan Bernoulli untuk gerakan mantap tak berputar bagi bendalir tak boleh mampat di bawah tindakan daya-daya jasad abadi.

[10 markah]