

NATIONAL UNIVERSITY OF SINGAPORE

ESP5402–TRANSPORT PHENOMENA IN ENERGY SYSTEMS

(Semester 2: AY2018-2019)

Time allowed: 1 hour

INSTRUCTIONS TO CANDIDATES:

1. Please write your matriculation number only below. Do NOT write your name.
2. This quiz contains **THREE (3)** questions and comprises **TEN (10)** printed pages.
3. The total number of marks for this quiz is **30**.
4. Answer **ALL** questions; read all questions carefully and provide enough details to support your answers. Write your answers on the question paper itself.
5. You can use internet, any software or books you wish etc., but do **NOT** use social media or communicate with someone else during the quiz.

Matriculation number:

1. Show if the following statement is true or false (do not use Cartesian tensor notation): **(10 marks)**

$$\nabla \cdot \mathbf{vw} = [\mathbf{v} \cdot \nabla \mathbf{w}] + \mathbf{w}(\nabla \cdot \mathbf{v})$$

2. Consider annular flow with the inner cylinder moving axially. The cylindrical rod with a radius of κR moves axially with the velocity $(0,0,v_z)$ along the axis of a hollow cylinder with the radius R . The motion of fluid through the hollow cylinder is driven solely by the axial rod motion; i.e. the pressure at both ends is the same.

Use the equations of change to find the velocity distribution in the annular region (do not use a shell balance). **(10 marks)**

3. Verify your paper-and-pen solution in question 2 with a COMSOL simulation.
(*Hint*: I needed around 5 min to set it up and it took 2 s to solve on my desktop;
the agreement with the analytical solution is excellent with a relative error
 $\lesssim 1\%$ for my mesh.) **(10 marks)**

End of quiz