

Name: _____



Quiz IV

Edgar Buckingham (1867–1940)¹

This is a 50 minute closed-book exam. Please put your name on the top sheet. Answer all four questions. Explain your working and state any assumptions you have made.

- 1 (3 points) Circle the correct answer.
1. The velocity potential
 - always satisfies Laplace's equation.
 - exists only for irrotational flows.
 - exists only for Newtonian fluids.
 - exists only for incompressible flows.
 - exists for all flows.
 2. The streamfunction
 - always satisfies Laplace's equation.
 - exists only for irrotational flows.
 - exists only for Newtonian fluids.
 - exists only for incompressible flows.
 - exists for all flows.
 3. The Buckingham Pi theorem
 - shows that π is a transcendental number.
 - applies only to irrotational flows.
 - generates dimensionless parameters.
 - is derived from Newton's Second Law.
 - is an energy equation.

¹Actually the picture is Buckingham palace; I couldn't find a picture of Edgar Buckingham on the Internet.

2 (5 points) Sketch the streamlines for the flow with streamfunction $\psi = x^2 - 3y$. Can you find a velocity potential for this flow?

3 (10 points) The pressure rise Δp across a pump can be expressed as $\Delta p = f(D, \rho, \omega, Q)$, where D is the impeller diameter, ρ the fluid density, ω the rotational speed and Q the flowrate. Determine a suitable set of dimensionless parameters.

4 (12 points) Derive the solution for flow past a cylinder in two-dimensional incompressible irrotational flow. Show that the drag on the cylinder is zero. [Explain your working clearly. You may use without proof the fact that

$$r \sin \theta \left(1 - \frac{a^2}{r^2} \right)$$

is a solution of Laplace's equation.]