2.016 Hydrodynamics
Prof. Alex Techet
Fall 2005

Assessment
Due Tuesday Sept 13, 2005

This exercise is a closed book exercise designed to generally assess your knowledge coming into this course. This will not be marked for a grade, however completion of the exercise will be noted. You may find that you do not understand some of the questions or that others are very basic – this is intentional, do not worry. Try to complete this exercise without stopping and make a note of the time you spent working on it.

Approximate time to complete exercises: _____ minutes (to the nearest 5 minutes)

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1) Given a function *f(x)*, expand *f(x)* using Taylor Series Expansion (to third order):

2) Given a continuously differentiable scalar function *f(x,y)* define its vector gradient. What does this mean qualitatively?

3) Given a continuously differentiable vector function $\boldsymbol{v}(x,y)$ define its divergence. What does this mean qualitatively?

4) Given a continuously differentiable vector function $\boldsymbol{q}(x,y)$ define its curl. What does this mean qualitatively?

5) The Material Derivative of a vector, $\vec{V}$, is written as $\frac{D\vec{V}}{Dt}$. What is the definition of a Material Derivative? Expand the Material Derivative into its components.

6) Under what conditions does a fluid become a gas?

7) As a submarine moves through the ocean far under the surface such that surface waves can be neglected, do you expect the fluid at the submarine surface to:

   a. Remain stationary
   b. Move at the speed of the sub
   c. Move at a speed slower than the sub
   d. Move at a speed faster than the sub

8) Which of the following is not conserved in a fluid system:

   a. Mass
   b. Energy
   c. Pressure
   d. Momentum

9) Rank from 1-5 the following fluids based on their dynamic viscosity. (1 == most viscous; 5 == least viscous)

   ___ Ethyl Alcohol
   ___ Gasoline
   ___ Water
   ___ Honey
   ___ Motor Oil

10) The Reynolds number represents the ratio of the following forces in a fluid flow:

a. Inertia force to gravity force
b. Pressure force to inertia force
c. Inertia force to viscous force
d. Inertia force to surface tension force

11) Assuming atmospheric pressure is equal to Po. Determine the fluid pressure at a distance D below the calm free surface, given that gravity is g.

12) Explain why cavitation occurs.

13) A sinusoidal plane progressive surface wave, in deep water, has an amplitude, *A*, a period, *T*, and a wavelength, λ. Write the expression for the corresponding free surface elevation as a function of time, relative to a reference coordinate system. Define the wave frequency, ω, and wavenumber, k, in terms of the above quantities. How does ω relate to k (hint: you need to use the gravitational constant, g)?