Guidelines for the final exams
2013-1-5

Students should be able to understand the following subjects and solve certain problems

1. Tensor notation
   a) you should be be able to prove the vector identities used in deriving governing equations in fluid mechanics, e.g., the equations in assignment 1;
2. Properties of fluids
   a) Viscosity, Newtonian/Non-Newtonian fluids
   b) Pressure in fluids
3. Stresses in fluids.
   a) Properties of the stress tensor, e.g., being symmetric...
   b) Two types of forces: body forces and surface forces
   c) Should be able to solve problem 1 in assignment 2
4. Kinematics
   a) Decomposition of fluid motion to translation, rotation and strain
      i. Material derivatives of a translating fluid particle, DV/Dt;
      ii. Rate of rotation and vorticity, remember and be able to use the expression of vorticity;
      iii. Rate of strain;
   b) Should be able to solve problems 2 and 3 in assignment 2.
5. Equation of motion
   a) Be able to use integral form of mass conservation equation and momentum equation to solve certain problems, e.g., two problems in assignment 3;
   b) Understand Stokes assumptions, remember the incompressible form of the Navier-Stokes equations, and be able to solve practical problems, e.g., assignment 5;
   c) Remember and be able to use Bernoulli equation to solve practical problems;
6. Uniform incompressible flow
   a) Be able to derive the velocity profile and the expression of friction factor C_f for a laminar flow in a circular pipe from NS equation;
   b) Understand the lubrication theory (or the gliding paper);
   c) Understand the difference between a laminar boundary layer and a turbulent boundary layer;
   d) Understand the strategies used to reduce the drag of a moving vehicle;
   e) Be able to solve the “flow in a conduit” and “boundary layer and drag” problems in assignment 6;

f) Understand the Buckingham Pi theory, able to solve the “dimensional analysis” problem in assignment 6;

7. Understand the background of the potential flow theory
   a) Velocity decomposition of the whole flow field;
   b) Idealize the expansion/compression and the rotation to a few singular points in the flow field, namely, source/sink and point vortex;
   c) Velocity potential and stream functions can be found in the incompressible and irrotational flow, they both satisfy the Laplace equation, they can also form complex potential $W(z)=\Phi+i\Psi$, where $z=x+iy$, and $dW/dz = u - iv$;
   d) For a flow field composed of a uniform incoming flow of a velocity of U and a point source with a strength m, you should be able to determine the location of the stagnation point;
   e) You should also be able to determine the stream function passing through the stagnation point and velocity magnitude along this stream function. With the velocity magnitude in hands, you should be able to calculate the pressure along the stream function using Bernoulli equation. This process was demonstrated during lectures.