1. Please explain the definitions for "specific gravity" and "specific weight", and their SI units (International System of Units). (8%)

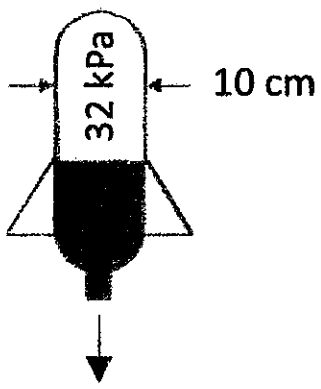
2. Please explain "bulk modulus of elasticity" and its SI unit. (6%)

3. Please explain "dynamic viscosity" and its SI unit. (6%)

4. Please draw 2 figures to explain Newtonian fluids and Non-Newtonian fluids including pseudoplastic fluids, dilatant fluids and Bingham plastic fluids. Please explain the relationship between the shearing stress and the velocity gradient in the first figure. Please explain the relationship between the apparent dynamic viscosity and the velocity gradient in the second figure. Please also explain the reasons regarding which fluid could be used to make bulletproof vest. (15%)

5. Please describe how to determine whether the flow is laminar or turbulent under pipe flow and open-channel flow. Furthermore, if you need to design a microfluidic chip with Y-channel, please describe how to determine the configuration of the Y-channel (including the channel width and depth) and the flow velocity to achieve laminar flow within the Y-channel. (15%)

6. A very popular toy on the market several years ago was the water rocket. Water (at 4°C) was loaded into a plastic rocket and pressurized with a hand pump. The rocket was released and would travel a considerable distance in the air. Assume that a water rocket has a mass of 53 g and is charged with 314 g of water. The pressure inside the rocket is 32 kPa gage. The exit area is one-tenth of the chamber cross-sectional area. The inside diameter of the rocket is 10 cm. Assume that Bernoulli's equation is valid for the water flow inside the rocket. Neglecting air friction, calculate the maximum velocity it will attain. (15%)



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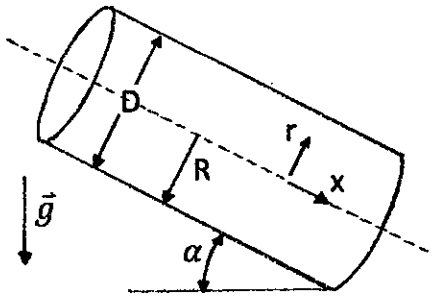
7. The discharge of a centrifugal pump is a function of the rotational speed of the pump N, the diameter of the impeller D, the head across the pump h_p, the viscosity of the fluid μ, the density of the fluid ρ, and the acceleration due to gravity g. The functional relationship is $Q = f(N, D, h_p, \mu, \rho, g)$
By dimensional analysis, find the dimensionless parameters. Express your answer in the form $\frac{Q}{ND^3} = f(\pi_1, \pi_2, \pi_3)$. (15%)

8. Consider steady, incompressible, laminar flow of a Newtonian fluid in an infinitely long round pipe of diameter D or radius $R = D/2$ inclined at angle α. There is no applied pressure gradient ($\partial P/\partial x = 0$). Instead, the fluid flows down the pipe due to gravity alone. We adopt the coordinate system shown, with x down the axis of the pipe. Derive an expression for the x-component of velocity u as a function of radius r and the other parameters of the problem. Calculate the volume flow rate and average axial velocity through the pipe. (20%)



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