Wall shear stress for incompressible fluid flowing through a constant diameter pipe

It has been proposed that the wall shear stress (force per unit wall surface area), τ_w, experienced on the inside surface of a pipe due to the flow of an incompressible fluid across it is a function of the diameter of the pipe, D, the average fluid velocity in the pipe, V, the fluid density, ρ, the fluid viscosity, μ, and the average height of a wall roughness feature, ε. (See Fig. 1.) That is,

$$\tau_w = f(V, D, \rho, \mu, \varepsilon) \tag{1}$$

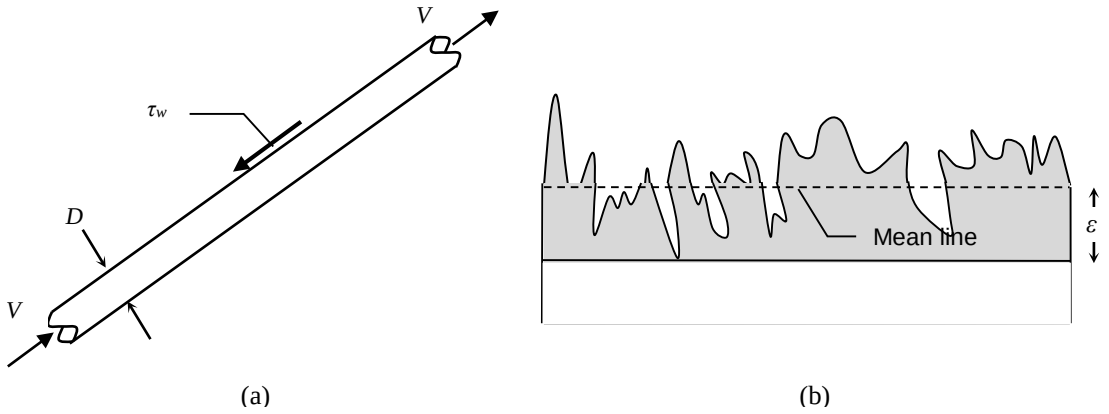

Figure 1: (a) Fluid flow through a constant diameter pipe (b) Close up view of wall surface showing roughness

You are required to perform a dimensional analysis to determine the dimensionless pi terms that express this realationship.

Hints:

- You should use D as one of your repeating variables.
- Remember to keep the repeating variables as "pure" as possible in terms of their dimensions.
- τ_w cannot be a repeating variable.