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89.352 - SEDIMENTATION & STRATIGRAPHY
PROBLEM SET I

1. A fluid is place between two ridge plates. A shear stress of 55 dynes/cm^2 is applied. At steady state the upper plate moves at a velocity of 2000 cm/sec relative to the stationary lower plate. The distance between the two plates is 0.5 cm. The density of the fluid is 1.0 gm/cm^3. Calculate:

   a. The dynamic viscosity of the fluid.

   b. The kinematic viscosity of the fluid.

   c. The fluid is flowing in a channel for which the Reynolds number for turbulent flow is 1100. The channel is 1 m deep and the mean velocity of flow is 0.5 m/sec. Calculate the Reynolds number. Will the flow be turbulent?

      To put the above calculation into perhaps more familiar terms, what is the stream velocity in miles/hour? What does this suggest to you about which is the more common type of flow (laminar or turbulent) in natural systems?

   d. For the channel in part (c) calculate the Froude number. Is the flow subcritical or supercritical?

e. A small quartz pebble (density = 2.7 gm/cm^3, diameter = 0.4 cm) is dropped into the channel and settles through the fluid with a velocity of 3 cm/sec. Calculate the eddy viscosity for this flowing fluid. Stoke's Law will probably be useful in determining this value.

2. The following questions deal with the transport of particles in a river.

   a. A river channel is rectangular in shape and has a width of 10 m. The water depth is 2 m. The gradient for the channel is 10m/km, and the specific gravity of water is 1. Calculate the boundary shear stress.

   b. For the river in part (a), calculate the dimensionless shear stress and grain Reynolds number (Appendix A, p. 647-648) for a particle whose diameter is 1 cm and whose specific gravity is 2.7. The kinematic viscosity is 0.0138 cm^2/sec and the friction velocity is 1.4 cm/sec. Will this grain be transported by the river? Refer to the Shields diagram on p. 648 of the textbook.

   c. Further downstream the slope decreases to 2m/km and the width of the stream increases to 50 m with a water depth of 5 m (assume the shape is still rectangular). The friction velocity is now 0.1 cm/sec. Calculate the dimensionless shear stress and grain Reynolds number for the particle under these conditions. Will the river transport the particle?

3. Near a coastline a water wave has a wave height of 1 m, a wavelength of 70 m, and a period of 5 sec. The water depth is 20 m. Calculate the threshold orbital velocity (Fig. 3.9 on the course web site. Note that the trigonometric function in the equation on the figure is *sinh*, not *sin h* as appears to be written.). Referring to Fig 6.15 on the course web site, what is the largest diameter quartz particle that can be moved by this wave?

4. For a surge type turbidity flow calculate the velocity of the head of the flow (Equation 2.16) given an ambient water density of 1.03 gm/cm^3, a density for the head of the flow of 1.5 gm/cm^3, and a head thickness of 200 m.

5. A river carrying sediment enters a lake. The density of the river water + sediment is 1.05 gm/cm^3 and the density of the lake water is 1.0 gm/cm^3. The lake bottom has a slope of 5m/1000m. A steady turbidity flow develops with a thickness of 2 m. The frictional resistance at the bottom of the flow is 0.0067 and the frictional resistance at the top of the flow is 0.0001. Calculate the velocity of this flow (Equation 2.17).