

Name: \_\_\_\_\_.

# Midterm Exam

CM 3110

21 October, 2008

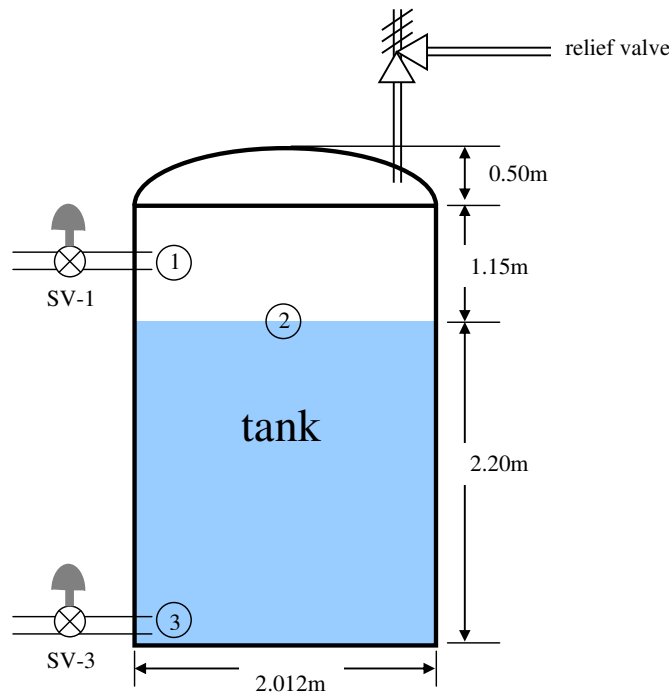
Note:

Significant figures count.

Please box your final answers.

Please be neat.

1. (10 points) When designing a system involving the packed bed, we need to calculate pressure drop as a function of flow rate. What correlation from the literature do we use to calculate pressure drop as a function of flow rate for flow through a packed bed?
2. (20 points) A sphere made of plastic (diameter 0.1002 cm, density = 1.050 g/cm<sup>3</sup>) is dropped in water (density = 1.000 g/cm<sup>3</sup>; viscosity = 1.00 × 10<sup>-2</sup> Poise). The speed of the sphere is found to be 1.23 × 10<sup>-2</sup> cm/s at steady state (terminal velocity). What is the drag coefficient  $C_D$  of the sphere?
3. (20 points) A storage tank holds a toxic chemical (density = 1.143 g/cm<sup>3</sup>, viscosity = 1.4 centipoise) that decomposes at temperatures above 200°F. The tank is protected by a pressure-release valve on the top. The inflow to the tank is through valve SV-1 and the outflow from the tank is through valve SV-3 (see diagram), both of which are closed. The vapor space above the liquid chemical is maintained at 2.00 psig (gauge pressure). What are the gauge pressures at the points 1, 2, and 3 on the diagram?



4. (20 points) Sketch Fanning friction factor as a function of Reynolds number for flow through a smooth tube. If the tube is not smooth, how does the correlation change?
  
5. (30 points) Water is flowing in a horizontal, straight pipe. The flow is turbulent, the inner diameter of the tube is 6.00 in, the length is 20.0 ft, and the fluid is water at 68°F (density = 62.4 lb<sub>m</sub>/ft<sup>3</sup>, viscosity = 6.71 × 10<sup>-4</sup> lb<sub>m</sub>/(ft s), flow rate = 2.00 ft<sup>3</sup>/s. The gauge pressure at the inlet is 62.0 psi and the gauge pressure at the outlet is 28.1 psi.
  - a. What is the total drag force on the walls? Please give your answer in lb<sub>f</sub>.
  - b. What is the roughness factor ε (Geankoplis) or k (my notes) of the pipe?