National Exams December 2016

04-Agric-A4, Fluid Flow

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. Four (4) questions constitute a complete exam paper.
   The first four questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. All questions require calculation.

Problem 1

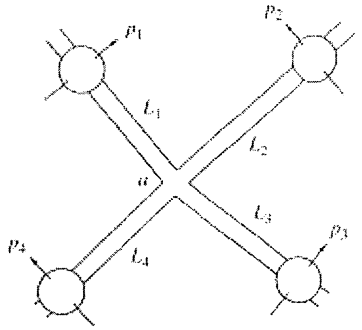
In the below figure, all four horizontal cast-iron pipes($\varepsilon/d=0.00325$) are 45 m long and 8 cm in diameter and meet at junction a, delivering water at 20°C($\rho=998$ kg/m^3, $\mu=0.001$ kg/m.s). The pressures are known at four points as shown;

$p_1=950$kPa, $p_2=350$ kPa, $p_3=675$ kPa, $p_4=100$ kPa.

Neglecting minor losses, determine the flow rate in each pipe.

Note: ρ is the density, μ is the dynamic viscosity, d is the diameter and ε is the pipe roughness

Hint: Start by guessing $p_a=530$ kPa and $f_1=0.027$. Use Moody diagram

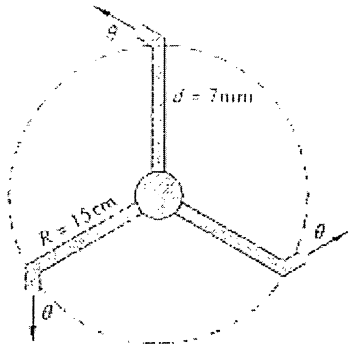


Problem 2

A small submersible moves at velocity V in 20°C water (vapor pressure p_v=**2.337 kPa**) at **2-m** depth, where ambient pressure p is **131 kPa**. Its critical cavitation number is Ca=**0.25**. At what velocity will cavitation bubbles form? Will the body cavitate if V=30 m/s and the water is cold (5°C, p_v=**863 Pa**, density=**1000 kg/m^3**)

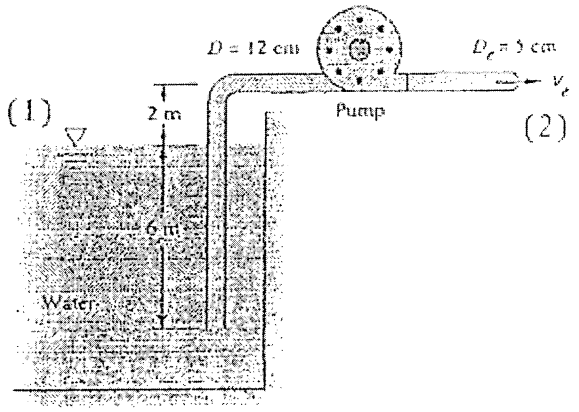
Problem 3

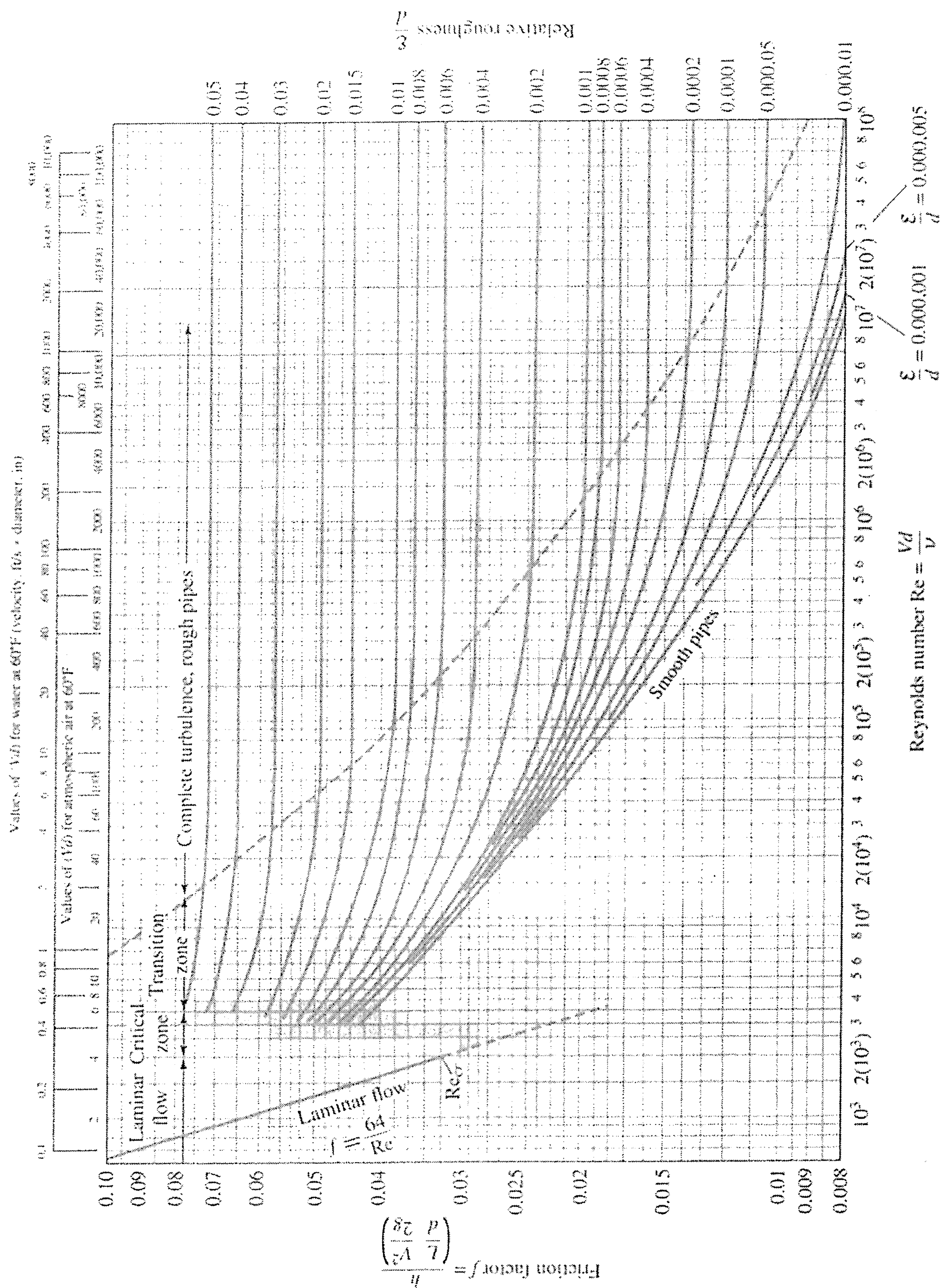
The 3-arm lawn sprinkler receives 20°C water through the center at 2.7 m^3/hr. If collar friction is neglected, what is the steady rotation rate in rev/min for (a) θ=0°; (b) θ=40°



Problem 4

When the pump in the below figure draws 220 m^3/hr of water at 20°C (ρ=998 kg/m^3) from the reservoir, the total friction head loss is 5m. The flow discharges through a nozzle to the atmosphere. Estimate the pump power in kW delivered to the water.




Values of (Vd) for water at 60°F (velocity, ft/s × diameter, in)
Values of (Vd) for atmospheric air at 60°F
Laminar flow
Critical zone
Transition zone
Complete turbulence, rough pipes
Laminar flow
f = 64/Re
Re_cr
Smooth pipes
Friction factor f = h / ((L/d)(V²/2g))
Reynolds number Re = Vd/ν
Relative roughness ε/d
ε/d = 0.000,001
ε/d = 0.000,005