AML 130
Major

Answer all questions. Clearly state all assumptions made. Time: 2 hours.

1. A rotameter has been calibrated in water (density=1000kg/m^3). It is to be used for metering brine (specific gravity=1.15). For this purpose, the density of the float has been changed from 2000kg/m^3 to 2250kg/m^3 without altering the shape or the volume of the float. What correction factor must be introduced in the original scale in order to use the rotameter for the brine solution? (7)
2. A quartz crystal, with piezo-electric properties, has a diameter of 10mm and thickness of 2mm. Its voltage sensitivity constant is 4500V/μm. Find the voltage output due to a force of 100N. Young's modulus for the material is 10^{11}Pa. (3)
3. A pyrometer is fitted with a sensor whose temperature can be controlled using Peltier cooling. This pyrometer was calibrated to measure temperatures within a furnace, whose temperature and emissivity were known at that time to be 700K and 0.9 respectively. The sensor was at 300K. Several days later, a measurement showed the furnace temperature to be 725K. To check if the emissivity had changed, another reading was taken, but with the Peltier cooling off, when the sensor was at 350K. This reading showed the furnace temperature to be 721K. What is the true furnace temperature? Had the emissivity changed? Stefan-Boltzmann constant=5.67 $\times 10^{-8}$W/m^2-K^4. (10)
4. A hot-wire probe is fitted with a 5μm wire, and is capable of measuring fluctuating velocities at frequencies up to 50kHz, in air, with a mean velocity of 10m/s. The wire breaks and a new wire of the same material but 10μm in diameter is fitted. What is the highest frequency of fluctuations that can now be measured in the same flow? The following is known: $\mu_{air}=10^{-5}$Pa-s, $\rho_{air}=1$kg/m^3 and the Nusselt and the Reynolds number are related over the wire as

$$\frac{hd}{k}=0.3+0.5\left(\frac{\rho V d}{\mu}\right)^{1/2}$$

where h is the convection coefficient over the wire, d is the wire diameter, k is the conduction coefficient for the wire material, V is the average flow velocity over the wire, ρ and μ are the density and viscosity of air respectively. (10)