# MECHANICAL TEST

Total Points: 50 | Questions: 10 | Date: February 02, 2026

*AI-generated undergraduate-level mechanical assignment. Contains 10 questions covering key concepts.*

**Question 1**

A U-tube three-fluid manometer contains mercury in the bottom, water in the left leg above the mercury, and oil ($\rho_o$ = 800 kg/$m^3$) in the right leg above the mercury. The right leg is open to the atmosphere. The height of the water column above the water–mercury interface in the left leg is $h_w$ = 0.30 m. The height of the oil column above the oil–mercury interface in the right leg is $h_o$ = 0.20 m. The mercury–upper-fluid interface in the right leg is Δz = 0.05 m higher than that in the left leg. The top of the left leg is connected to a tank at pressure $p_A$ (unknown). Find $p_A$ (gauge).

**Question 2**

In a similar setup, the right leg is open to atmosphere and contains oil of unknown density $\rho_o$. The left leg (water) is connected to a chamber at $p_A$ = 3.0 kPa (gauge). Measured heights: $h_w$ = 0.30 m (water above mercury on the left), $h_o$ = 0.35 m (oil above mercury on the right). The mercury–upper-fluid interface on the right is Δz = 0.02 m higher than that on the left. Determine the oil density $\rho_o$.

**Question 3**

A three-fluid manometer has the left leg (water) connected to a vessel at sub-atmospheric pressure $p_A$ = −1.2 kPa (gauge). The right leg contains oil with $\rho_o$ = 820 kg/$m^3$ and is open to atmosphere. Measured column heights are $h_w$ = 0.25 m (left) and $h_o$ = 0.12 m (right). Find the mercury interface height difference Δz (right interface height minus left interface height). State whether the right interface is higher or lower.

**Question 4**

Both legs of a three-fluid manometer are connected to pressurized tanks: left leg (water) to tank A, right leg (oil, $\rho_o$ = 850 kg/$m^3$) to tank B. Heights above mercury are $h_w$ = 0.18 m (left) and $h_o$ = 0.25 m (right). The right mercury interface is Δz = 0.06 m higher than the left. Find $p_A - p_B$ (gauge difference).

**Question 5**

In a three-fluid manometer (water–mercury–oil), explain: (a) why mercury is placed in the bottom segment, (b) how the sign of Δz (right mercury interface relative to left) relates to which side has higher pressure, and (c) why immiscibility and clean interfaces are critical for accuracy.

**Question 6**

Sensitivity analysis. For a three-fluid manometer with $\rho_o$ = 850 kg/$m^3$, compute the sensitivity of indicated gauge pressure $p_g$ to small changes in each measured height: $\partial p_g/\partial h_o$, $\partial p_g/\partial h_w$, and $\partial p_g/\partial \Delta z$, using $p_g = \rho_o\, g\, h_o - \rho_w\, g\, h_w + \rho_{Hg}\, g\, \Delta z$. Also report the change in $p_g$ for a 1.0 mm change in each height taken individually.

**Question 7**

You have an unknown oil used in a water–mercury–oil manometer. Propose a procedure to determine the oil's density using only the manometer, atmospheric reference, and a regulated gauge pressure source. Specify the measurements to take and the equation used to compute $\rho_o$.

**Question 8**

Temperature effect. A manometer at 20^*circ*C has $\rho_o$ = 850 kg/$m^3$, $\rho_w$ = 1000 kg/$m^3$, $\rho_{Hg}$ = 13600 kg/$m^3$, with $h_o$ = 0.20 m, $h_w$ = 0.25 m, Δz = 0.04 m. The indicated gauge pressure at 20^*circ*C is $p_{20}$. The temperature rises to 50^*circ*C; assume densities change approximately as ρ(T) ≈ $\rho_{20}$[1 − βΔT], with $\beta_o$ = 7.0×10^−4 ^*circ*C^−1, $\beta_w$ = 2.0×10^−4 ^*circ*C^−1, $\beta_{Hg}$ = 1.2×10^−4 ^*circ*C^−1. If the column heights remain the same, estimate the change in indicated pressure Δp = $p_{50} - p_{20}$ and the percent change relative to $p_{20}$.

**Question 9**

Uncertainty propagation. For the configuration in Question 1 ($h_w$ = 0.30 m, $h_o$ = 0.20 m, Δz = 0.05 m; $\rho_o$ = 800 kg/$m^3$), suppose each height is measured with an independent standard uncertainty of ±1.0 mm (1σ). Estimate the standard uncertainty in the indicated pressure $u_p$ using linear propagation, and report it and its percentage of the measured pressure.

**Question 10**

Given a three-fluid manometer with $\rho_o$ = 790 kg/$m^3$, $h_o$ = 0.25 m, $h_w$ = 0.20 m, and a known applied gauge pressure $p_A$ = 4.0 kPa on the left (right leg open to atmosphere), compute the required mercury interface height difference Δz (right relative to left, positive if right is higher).