

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 ($\rho_o = 800 \text{ kg/m}^3$) 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 $h_w = 0.30 \text{ m}$. The height of the oil column above the oil–mercury interface in the right leg is $h_o = 0.20 \text{ m}$. The mercury–upper-fluid interface in the right leg is $\Delta z = 0.05 \text{ m}$ higher than that in the left leg. The top of the left leg is connected to a tank at pressure p_A (gauge). Find p_A (gauge).

Question 2

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

Question 3

A three-fluid manometer has the left leg (water) connected to a vessel at sub-atmospheric pressure $p_A = -1.2 \text{ kPa}$ (gauge). The right leg contains oil with $\rho_o = 820 \text{ kg/m}^3$ and is open to atmosphere. Measured column heights are $h_w = 0.25 \text{ m}$ (left) and $h_o = 0.12 \text{ m}$ (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, $\rho_o = 850 \text{ kg/m}^3$) to tank B. Heights above mercury are $h_w = 0.18 \text{ m}$ (left) and $h_o = 0.25 \text{ m}$ (right). The right mercury interface is $\Delta z = 0.06 \text{ m}$ 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 $\rho_o = 850 \text{ kg/m}^3$, 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 ρ_o .

Question 8

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

Question 9

Uncertainty propagation. For the configuration in Question 1 ($h_w = 0.30 \text{ m}$, $h_o = 0.20 \text{ m}$, $\Delta z = 0.05 \text{ m}$; $\rho_o = 800 \text{ kg/m}^3$), suppose each height is measured with an independent standard uncertainty of $\pm 1.0 \text{ mm}$ (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 $\rho_o = 790 \text{ kg/m}^3$, $h_o = 0.25 \text{ m}$, $h_w = 0.20 \text{ m}$, and a known applied gauge pressure $p_A = 4.0 \text{ kPa}$ 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).