Library Copy (05)

University of Ruhuna – Faculty of Technology

Bachelor of Engineering Technology Honours Degree
Level 1 (Semester 2) Examination, June 2026
Academic year 2024/2025

Course Unit: TMS 1253/ ENT 1253 Engineering Properties of Matter (Written)
Duration: 3 Hours

Instructions to candidates of the question paper.

- This examination consists of five (05) questions on five (05) pages. Answer all five (05) questions.
- Each question carries twelve (12) marks.
- This is a closed book examination. Calculators are allowed for this examination.
- All symbols and abbreviations have their usual meaning.
- Clearly state all assumptions you made.

(Q1).

a) Explain the difference between stress and strain. (02 marks)

b) State four applications of Young's Modulus. (04 marks)

c) A cylindrical copper specimen originally 300 mm long is pulled in tension with a stress of 276 MPa. If the deformation is entirely elastic, what will be the resultant elongation? (Elastic modulus = 110 GPa) (Hint: $Y = \sigma/\varepsilon$).

I. Calculate the resultant elongation of the specimen. (03 marks)

II. If the specimen is subjected to a tensile load of 100,000 N under the same stress, determine the required radius of the specimen. (03 marks)

(Q2).

a) Surface tension and viscosity are two important properties of fluids that govern many natural and industrial phenomena ($g = 9.81\ m/s^2$).

I. Define surface tension and viscosity. (02 Marks)

II. For each property, state its SI unit and give one practical example where the property plays a significant role. (02 Marks)

b) A viscous liquid flow steadily through a horizontal pipe of internal radius 4.0 mm and length 0.80 m. A pressure difference of 240 Pa is maintained across the pipe. The volume flow rate is measured as $1.2 \times 10^{-6}\ m^3/s$. Using Poiseuille's equation $Q = {\pi r^4 \Delta P}/{8\eta L}$, calculate the viscosity of fluid. (03 Marks)

c) A glass capillary tube of internal diameter 0.60 mm is inserted vertically into a liquid of density 800 kg/m^3. The liquid rises to a height of 38 mm inside the tube. The contact angle of the liquid with the glass is 15°. Using this Equation: $\gamma = {\rho g h r}/{2\cos\theta}$

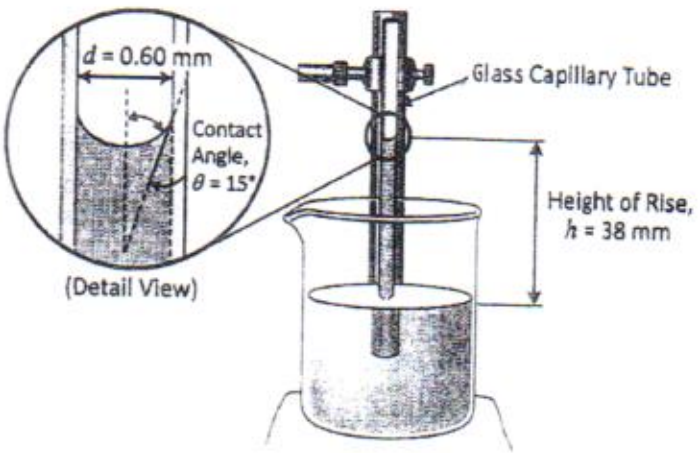


Figure 01

I. Calculate the surface tension of the liquid using the given values. (03 Marks)

II. State how the surface tension of this liquid would change if the experiment were repeated at a higher temperature and explain why. (02 marks)

(Q3).

a)

I. Define thermal expansion and explain why most materials expand when heated and contract when cooled. (02 Marks)

II. A metal ring is heated uniformly. Describe what happens to its diameter and explain your answer using the concept of thermal expansion. (02 Marks)

b) The main span of San Francisco's Golden Gate Bridge is 1275 m long at its coldest. The bridge is exposed to temperatures ranging from $-15°C$ *to* $40°C$. Determine the change in length between these temperatures. Assume that the bridge is made entirely of steel. Coefficient of Linear Expansion α in steel $12 \times 10^{-5}\ °C^{-1}$. (03 Marks)

c) An ambulance has been hijacked by an unknown individual and is traveling directly toward a large, stationary vertical rock face at a constant velocity v_s. The ambulance siren, controlled by the hijacker, emits a continuous sound frequency of $f_0 = 800$ Hz. A police car is chasing from behind, traveling in the same direction at a constant velocity $v_s = 40\ ms^{-1}$. The driver of the police car hears the reflected sound (echo) from the rock face at a frequency (f_e). Assume the speed of sound in air is $v = 340\ ms^{-1}$.

The general equation for doppler effect, $f' = \left(\frac{C \pm v_o}{C \pm v_s}\right) f$

I. Derive an expression for the speed of the ambulance (v_s) in terms of the frequency of the siren (f_0), the frequency of the echo (f_e), and the speed of the sound (v). (Assume the rock face acts as a stationary reflector). (03 Marks)

II. Using v_s as $30\ ms^{-1}$ and other values provided, calculate the frequency of the siren perceived by the stationary rock face. (01 marks)

III. Calculate the frequency of the echo heard by the driver of the police car after the sound reflects off the rock face. (01 marks)

(Q4).

a) Bernoulli's principle is widely used in fluid dynamics to analyze fluid flows.

I. State Bernoulli's equation and label the parameters. (02 marks)

II. Write down the main assumptions made when deriving Bernoulli's principle. (01 marks)

b) A cylindrical, open-topped tank of cross-sectional area $A_1 = 2.0\ m^2$ is filled with water to a depth of $h = 5.0\ m$. At the bottom, a small drain of cross-sectional area $A_2 = 10\ cm^2$ is opened, allowing water to flow out. Assuming the flow is steady, irrotational, and the water is an ideal, incompressible fluid ($\rho = 1000\ kg/m^3$ and $g = 9.81 ms^{-2}$).

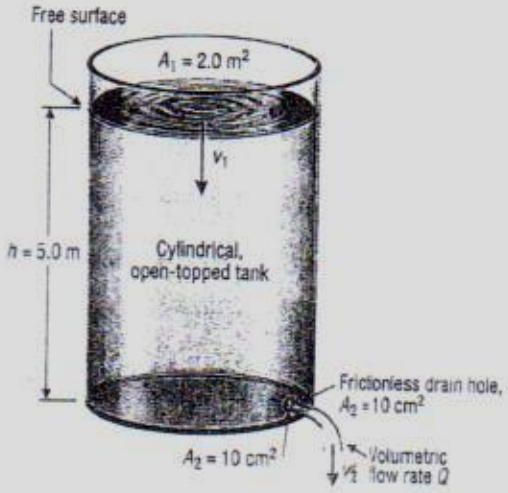


Figure 02

I. By applying Bernoulli's equation and the equation of continuity, show that the initial discharge velocity v_2 is given by $v_2 = \sqrt{\frac{2gh}{1-(\frac{A_2}{A_1})^2}}$. (03 marks)

II. Using your result from Part (b) (I), calculate the initial volumetric flow rate, Q. (02 marks)

III. Using the initial flow rate Q calculated in part (b) (II) and Continuity Equation, determine the constant downward velocity v_1 of the water's free surface at the instant the drain is opened. Furthermore, if the tank were instead being refilled at a rate of 0.005 m^3/s while draining, calculate the net rate of change of the water height (dh/dt) that same instant. (04 marks)

(Q5). A student is conducting light and optics experiments in his physics laboratory. He sets up an optical bench with a spherical concave mirror having a fixed focal length of 80 *cm*. He then places a lit candle as a light source along the mirror's principal axis.

a) Draw labeled ray diagram to demonstrate how the image is formed when the candle is placed beyond the focus of a concave mirror. (02 marks)

b) The candle, which is a height of 15 *cm*, is placed 125 *cm* in front of the concave mirror. The mirror has a fixed focal length of 80 *cm*. Calculate the height of the image formed. (03 marks)

c) Kavishka then puts the same 15 *cm* tall candle at the same 125 *cm* distance in front of a convex mirror, which also has a focal length of 80 *cm*. The images formed by the concave and convex mirrors are different. Describe two differences in the images formed and explain why these differences occur. No calculations are necessary. (03 marks)

d) The same 15 *cm* tall candle is again placed in front of the first concave mirror with focal length 80 *cm*. The candle is moved until the image is upright and is three times the size of the object.

I. Describe the nature of the image. (02 marks)

II. Calculate the distance the candle (object) is away from the mirror. (02 marks)