

BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCE AND ENGINEERING

JAN 2025

THE DEPARTMENT OF ENGINEERING AND PHYSICS

HPH112/PH102 – THERMAL PHYSICS AND WAVE MOTION

INSTRUCTIONS

TIME: 3 HOURS

Answer ALL parts of the question in Section A and any THREE questions from Section B. Section A carries 40 marks and each question in Section B carries 20 marks.

Physical Constants

Electronic charge, $q = 1.6 \times 10^{-19} \text{ C}$

Permittivity of free space, $\epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$

Permeability of free space, $\mu_0 = 4\pi \times 10^{-7} \text{ Hm}^{-1}$

Mass of electron, $m_e = 9.11 \times 10^{-31} \text{ kg}$

Mass of proton, $m_p = 1.67 \times 10^{-27} \text{ kg}$

Avogadro constant, $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

Universal Gravitation Constant, $G = 6.7 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$

Acceleration due to gravity, $g = 9.8 \text{ ms}^{-2}$

SECTION A

Attempt all parts of question 1.

1. (a) The wave function $\psi(x, t) = 0,30\sin(0,25\pi x)\cos(120\pi t)$ describes a certain wave motion. The symbols have their usual meanings and all quantities are measured in S. I. units.
- (i) Why must ψ be a function of space and time? [3]
- (ii) What are the amplitudes, (angular and cycle) frequencies and wavelengths of the superposing propagating waves? [5]
- (b) A well in a certain village has vertical sides and water at the bottom. It resonates at 7,00 Hz and at no lower frequency. The air in the well has a density of $1,10 \text{ kgm}^{-3}$ and an adiabatic modulus of $1,33 \times 10^5 \text{ Pa}$. How deep is the well? [5]
- (c) The resistance R of a thermometer decreases with rise in temperature. The resistance at normal ice-point is $R_1 = 7360 \Omega$ at normal steam-point is $R_2 = 153 \Omega$ and at normal body temperature is $R_B = 1312 \Omega$. Derive an empirical temperature scale using the normal ice-point and the normal steam-point as the standard pair. Hence determine the body temperature in degrees Celsius on your scale. Is this realistic? [5]
- (d) Imagine a physics faculty meeting with a hiring decision at stake. One opinionated professor starts shouting such that the sound volume in the room is 70 dB. Pretty soon nine (9) other professors join in, so all ten (10) are shouting simultaneously with equal volume. What is the new volume in the room? [5]
- (e) A slab of stone of area $0,36 \text{ m}^2$ and thickness 10 cm is exposed on the lower surface to steam at 100°C . A block of ice at 0°C rests on the upper surface of the slab. In one hour 4,8 kg of ice is melted. Calculate the thermal conductivity of the stone. (Latent heat of ice = 336 kJkg^{-1}) [6]
- (f) One mole of oxygen ($\gamma = 1,4$) initially at 290 K is compressed adiabatically so that its pressure rises 10 times. Sketch the process on a P - V indicator diagram and find the final temperature of the gas and the work done on the gas. [5]
- (h) Two different fuels can be used in a heat engine, operating between the fuel burning temperature and a low temperature of 350 K. Fuel A burns at 2500 K delivering 52000 kJkg^{-1} and costs \$1.75 per kilogram. Fuel B burns at 1700 K delivering, 40000 kJkg^{-1} and costs \$1.50 per kilogram. Which fuel would you buy and why? [6]