Premicah

INTERIM JOINT MATRICULATION BOARD
AHMADU BELLO UNIVERSITY
ZARIA

INTERIM JOINT MATRICULATION BOARD EXAMINATION 2016

SUBJECT: PHYSICS PAPER I

DATE SCHEDULED: SATURDAY 13TH FEBRUARY, 2016

TIME ALLOWED: THREE HOURS (3 HRS)

INSTRUCTIONS:

i. Answer **ALL** the questions in Section A and **ONE (1)** question from each of Section B and D, and **TWO (2)** questions from Section C.

ii. Non-Programmable electronic calculators can be used.

Useful constants:

Mean Radius of earth, R_E	=	6.371×10^6 m
Speed of light (free space), c	=	3.0×10^8 ms^{-1}
Universal gravitational constant, G	=	6.67×10^{-11} Nm^2 kg^{-2}
Stefan Boltzmann's constant, σ	=	5.7×10^{-8} Jm^{-2} K^{-4} s^{-1}
Acceleration due to gravity, g	=	10ms^{-2}
Density of water,	=	1.0×10^3 kgm^{-3}
Viscosity of water at 10 °C,	=	1.3×10^9 Nm^{-2}s
Speed of sound (air)	=	340 ms^{-1}
Emissivity of the earth	=	1.0
Specific heat capacity of water, C_w	=	4200 Jkg^{-1} K^{-1}
Latent heat of vaporisation of water L_w,	=	2.2×10^6Jkg^{-1}
Atmospheric pressure, P_{atm}	=	1.0×10^5Nm^{-2}

lot 4 = 14

SECTION A

Answer All the questions in this section

1. a. Convert 2.5 gmm^{-2} to kgm^{-2}.

b, Determine if the formula $T = 2\pi\sqrt{\frac{m}{F/x}}$ is dimensionally correct. Where T is time period, m is mass, F is force and x is distance.

2, a. State the conditions for two vectors to be equal. Give any four examples of the term "magnitude" as applied to vector and scalar quantities.

b. Two vectors having equal magnitudes f make an angle θ with each other. Find the magnitude of the resultant.

3,A particle of mass 40g executes a simple harmonic motion of amplitude 2. 0 cm. If the time period is 0.20 s, find the total mechanical energy of the system.

4. A load of 4.0 kg is suspended from a ceiling through a steel wire of radius 2.0 mm. Find the tensile stress developed in the wire at equilibrium.

5. a. What is a fluid? Give two examples.

b. Define the terms adhesion and cohesion

6.Consider the wave $y = 5\sin(x - 60t)$. In terms of π, Find the wave number, the frequency, wavelength and velocity of the wave.

7. Define the term entropy. A Carnot engine working between 27 ^{0}C and 127 ^{0}C takes up 800J of heat from the reservoir in one cycle. Calculate the work done by the engine and efficiency of the engine.

8. Calculate the energy radiated per second by a sphere (assumed to be a blackbody radiator) of radius 10 cm maintained at a constant temperature of 727^{0}C.

9. A particle of mass 20 g is projected vertically upwards with a speed of 10 ms^{-1}. Find the work done by the force of gravity during the time the particle goes up.

10. A platinum resistance thermometer reads 0°C when its resistance is 80 Ω and 100°C when its resistance is 90Ω. Find the temperature at the platinum scale at which the resistance is 86Ω.

The vector must be in the same direction.

SECTION B MECHANICS

Answer ONE question only from this section

11. a. (i) Distinguish between the terms *"conservative force and nonconservative force"*, give one example for each.

(ii). A simple pendulum of length l, and mass m oscillates through an angle θ. Derive the expressions for its potential energy.

(iii) Determine the potential energy of a simple pendulum of length 90 cm and mass 0.5 kg displaced at angle of 60^0.

b. (i). The heat (H) produced in a wire carrying an electric current depends on the current (I), the resistance (R) and the time (t). Assuming that, the dependence is related by the equation $H\alpha I^x R^y t^z$. Use dimensional analysis to determine the values of the indices (x, y, z). Hence, find the expression for H.

(ii) A solid object has a mass $(400.3 \pm 0.02)g$ and volume $(75.6 \pm 0.01)cm^3$. Calculate the density of the solid with the associated error.

12a. (i). Explain the terms *center of mass (CM) and center of gravity (CG)*. How do these related to the rigid body?

12a(ii) Three particles of masses 1.0 kg, 2.0 kg and 3.0 kg are placed at the corners A, B and C respectively of an equilateral triangle ABC of side 1 m as shown in figure 1. What is the center of mass of the system?

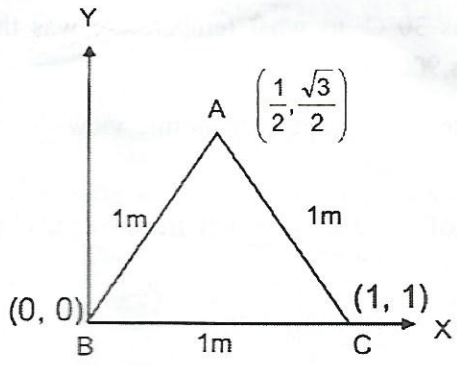

Figure 1.

12b(i). Two particles of masses 1 kg and 2 kg are placed at a separation of 50 cm. Calculate the force acting between them. Assuming that the only force acting on the particles are their mutual gravitation, find the initial accelerations of the each particle.

(ii). Calculate the escape velocity from the moon. The mass of the moon = 7.4×10^{22} kg and radius of the moon = 1740 km.

SECTION C: HEAT AND PROPERTIES OF MATTER

Answer TWO questions only from this section

13a.(i) Define the terms viscosity and coefficient of viscosity. State the SI unit and dimensions of coefficient of viscosity.

(ii). Write the mathematical expression for Stokes's law and state the meaning of each symbol.

(iii). Consider a metallic sphere of radius 'a' and density ρ to fall under gravity in a liquid of density σ. Sketch the forces acting on the sphere. Hence, Show that the terminal velocity is given by $v = \dfrac{2a^2(\rho - \sigma)g}{9\eta}$.

b(i). State two conditions for liquid to be ideal.

(ii). A liquid of mass m and volume V is flowing with velocity v, derive the expressions for its kinetic and potential energies per unit volume of the liquid in terms of ρ.

14.a(i). State the zeroth and first laws of thermodynamics.

(ii). An 0.050 kg block of Aluminum is heated and placed in a calorimeter containing 0.10 kg of water at 20°C. If the final temperature of the water was 30°C, to what temperature was the Aluminum heated? (Specific heat capacity of Aluminum is 900 $Jkg^{-1}K^{-1}$).

b. (i). State and briefly explain the three phases of matter with respect to atomic view. What causes the phase changes in matter?

(ii). How much heat is required to raise the temperature of 0.015 kg of water from −25.0°C to 125.0°C?

15a(i). Distinguish between the terms *Heat transfer and thermal conductivity.*

(ii). State and explain all the mechanisms of heat transfer.

(iii). A piece of brass is 5.0 mm thick and has a cross-sectional area of 0.010 m^2. If the temperature on one side of the metal is 65°C and the temperature on the other side is 25°C, how

much heat will be conducted through the metal in 30 s? The coefficient of thermal conductivity for brass is $120 WK^{-1}m^{-2}$.

15b. When a metallic bar is heated from 0^0C to 100^0C, its length increases by 0.05%. Obtain

(i) The coefficient of linear expansion of the metal.

(ii) The percentage increase of the volume of the bar.

16a (i) State the quantity that remains constant for each of the following thermodynamic processes.

(A) *Isobaric process* **B).***Isochoric process* **C)** *Isothermal process* **D)** *Adiabatic process.*

(ii) Show that, for a monatomic ideal gas undergoing an adiabatic process, $PV^{\frac{5}{3}} = \text{constant}$.

b(i) Write down (without proof) the efficiency for a Carnot cycle as a function of the:

A) *Heat that flows to and from the reservoirs and*

B) Temperatures of the two reservoirs.

(ii) A wire 10 m long and cross sectional area of $20\ mm^2$ is stretched 2,5cm by a 20 kg lead block when attached to it, find:

(A). The tensile stress (B) tensile strain (C) Young modulus of the wire.

(iii) The internal energy of a gas is given by $U = 1.5pV$. It expands from $100cm^3$ to $200cm^3$ against a constant pressure of 1.0×10^5 Pa. Calculate the heat absorbed by the gas in the process.

SECTION D: VIBRATION AND WAVES

Answer any ONE question from this section

17a(i). State any three differences and one similarity each of standing and travelling waves.

(ii). Two travelling waves of equal amplitudes and equal frequencies move in opposite directions along a string. They interfere to produce standing waves having the equation:

$y_1 = A\sin(\omega t - kx)$ *and* $y_2 = A\sin(\omega t + kx)$.

(A). Find the resultant when these waves superposed.
(B) What is the nature of amplitude of the resultant wave?
(C) Find the smallest points for node and antinode to be formed of the resultant wave.

b(i). White light is a mixture of light of wavelengths between the limits $400nm$ and $700nm$, When white light passes through water, what are the limits of the wavelength? Refractive index of water is 1.33.

b. (ii) A steel wire of length 64 cm weighs 5 g. If it is stretched by a force of 8 N, what would be the speed of a transverse wave passing on it?

18a(i). Define the following terms *pitch, resonance and Doppler effect* as applied to sound waves.

(ii) An ultrasound signal of frequency 50 kHz is sent vertically into sea water. The signal gets reflected from the ocean bed and returns to the surface 0.80 s after it was emitted. The speed of sound in sea water is 1500 ms^{-1}. Find the depth of the sea and the wavelength of this signal in water.

b(i). Two trains move towards each other at a speed of 90 kmh^{-1} relative to the earth's surface. One gives a 520 Hz signal. Find the frequency heard by the observer on the other train. The speed of sound wave in air is $350ms^{-1}$.

(ii) On a winter day, sound travels 336 meters in one second. Find the atmospheric temperature in ^0C. Speed of sound at $0°C = 332\ ms^{-1}$.