P510/2
PHYSICS
PAPER 2
2½ Hours
August 2023

**JINJA JOINT EXAMINATIONS BOARD**

***Uganda Advanced Certificate of Education***

**MOCK EXAMINATIONS, AUGUST 2023**

**PHYSICS**

**PAPER 2**

2 hours 30 minutes

**INSTRUCTIONS TO THE CANDIDATES:**

*Answer only **five** questions, taking at least **one** question from each of the sections **A, B, C** and **D**, but **not** more than **one** question should be chosen from **either** section **A** or section **B**.*
*Any additional question(s) answered will **not** be marked.*
*Mathematical tables and squared paper will be provided.*
*Non-programmable Silent Scientific Calculators may be used.*

***Where necessary assume the following constants:***

| | | |
|---|---|---|
| *Acceleration due to gravity, g* | = | $9.81\ m\,s^{-2}$ |
| *Speed of light in Vacuum, c* | = | $3.00 \times 10^{8}\ m\,s^{-1}$ |
| *Speed of sound in air,* | = | $340\ m\,s^{-1}$ |
| *Electronic charge, e* | = | $1.60 \times 10^{-19}\ C$ |
| *Electronic mass, $m_e$* | = | $9.11 \times 10^{-31}\ kg$ |
| *Permeability of free space, $\mu_o$* | = | $4.0\pi \times 10^{-7}\ H\,m^{-1}$ |
| *Permittivity of free space, $\varepsilon_0$* | = | $8.85 \times 10^{-12}\ F\,m^{-1}$ |
| *The Constant, $\frac{1}{4\pi\varepsilon_o}$* | = | $9.00 \times 10^{9}\ F^{-1}\,m$ |

## SECTION A

1. (a) (i) A ray of light from a fixed ray box is directed at an angle onto a plane mirror. The mirror is then rotated through an angle θ. Show with the aid of a ray diagram that the reflected ray turns through an angle 2θ. (3 marks)

(ii) Describe the structure and mode of operation of an optical lever galvanometer. (4 marks)

(b) (i) Define focal length of a convex lens. (1 mark)

(ii) Derive an expression for the lens formula, $\frac{1}{u}+\frac{1}{u}=\frac{1}{f}$ where, u, v and f are object distance, image distance and focal length respectively of the lens. (4 marks)

(c) Figure 1 shows a concave mirror M, of focal length 10.0 cm arranged coaxially with a convex lens L of focal length 8.0 cm placed a distance of 20.0 cm apart. A real point object O is placed 15.0 cm in front of the mirror M.

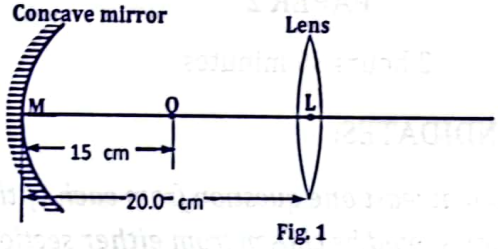


Fig. 1

(i) Determine the position and nature of the final image formed first by reflection in M then refraction by L. (4 marks)

(ii) Determine the magnification of the final image. (2 marks)

(iii) Draw a ray diagram to show the formation of the final image. (2 marks)

2. (a) (i) Define the term radius of curvature of a concave mirror. (1 mark)

(ii) Describe an experiment to determine the refractive index of a liquid using a concave mirror. (5 marks)

(b) An optical clamped above a concave mirror containing a liquid $L_1$ of refractive index 1.35 and thickness 0.2 cm coincides with its own image at a height of 15.0 cm above the liquid surface. When liquid $L_1$ is replaced with liquid $L_2$ of the same thickness, the pin coincides with its own image at a height of 18.0 cm above liquid surface. Determine the,

(i) radius of curvature of the mirror (3 marks)

(ii) refractive index of liquid $L_2$. (2 marks)

(c) (i) Draw a labelled diagram of a slide projector. (3 marks)

(ii) A slide projector having square slides of width 5.08 cm, produces an image that is 2.00 m wide on a screen located 3.50 m away.
Determine the focal length of the projector lens. (4 marks)

(d) Explain how chromatic aberration can be minimized in a camera. (2 marks)

## SECTION B

3. (a) (i) Distinguish between transverse waves and longitudinal waves. (3 marks)

(ii) Give two examples of each of the waves in (i) above. (4 marks)

(b) (i) What are ***overtones***? (1 mark)

(ii) Explain why unstopped piped instruments produce better quality musical notes than stopped piped instruments. (3 marks)

(c) (i) What is ***Doppler effect***? (1 mark)

(ii) Two sources of sound waves **A** and **B** lying on a straight line sound sirens of the same frequency f of 500 Hz. An observer O located between the sources is moving from source A towards source B at a velocity $u_0$ of 5.0 $ms^{-1}$. Given that source B is stationary while source A is moving away from source B at a velocity $u_A$ of 10 $ms^{-1}$. Write down the expressions for the apparent frequencies of sound heard by observer O from the two sources, hence calculate the beat frequency. (5 marks)

(d) Explain how beats are produced in sound waves. (3 marks)

4. (a) (i) What is diffraction of waves? (1 mark)

(ii) State two factors that influence the extent of diffraction of waves. (2 marks)

(b) (i) Define the term ***path difference*** of waves. (1 mark)

(ii) Derive an expression for the fringe separation in an air wedge. (4 marks)

(iii) Give two applications of interference of light waves. (2 marks)

(c) (i) Write down the formula for determining the fringe width or fringe separation in Young's double slit experiment and define all the terms used. (2 marks)

(ii) The distance between the second bright fringe and the $5^{th}$ dark band in Young's double slit experiment is 2.0 cm. Given that the slit separation is 1.5 mm while the plane of the slits is 3.0 m from the screen. Determine the wavelength of the light incident on the slits. (4 marks)

(d) (i) What is the effect of reducing the distance between the slits on the fringe separation? (1 mark)

(ii) State three conditions necessary for the fringes to be observed on a screen in the Young's double slit experiment. (3 marks)

## SECTION C

5. (a) Define the following terms as applied to magnetism: -

(i) Angle of dip. (1 mark)

(ii) Magnetic meridian, (1 mark)

(b) (i) Describe how a search coil of known geometry can be used to measure the angle of dip of the earth's magnetic field. (6 marks)

(ii) The horizontal and vertical components of the earth's magnetic field at a certain location are $2.52.50 \times 10^{-5}\ T$ *and* $4.33 \times 10^{-5}\ T$ respectively. Determine the resultant magnetic field and the angle of dip. (4 marks)

(c) A plane circular coil carrying a current in a vacuum, has N turns of the wire each of mean radius R. Given that the magnetic flux density in tesla at its centre is $\frac{\pi}{2}$, show that the current flowing through the coil is $\frac{\pi R}{\mu_o N}$ amperes. (3 marks)

(d) Figure 2 shows two straight and parallel wires **Q** and **R** placed 5.0 cm apart in air along the x – axis and carrying currents of **4.0A** and **3.0A** respectively out and into the x – y plane as shown.

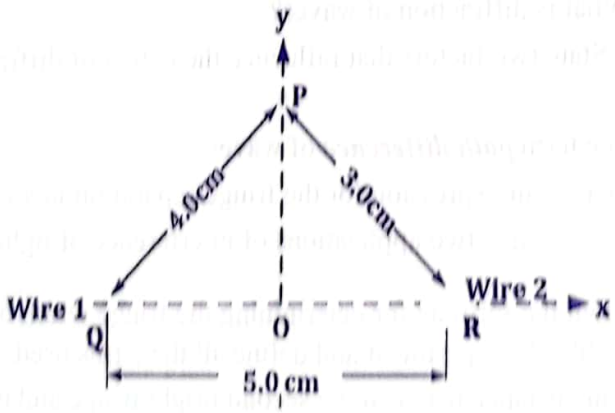



Fig. 1

Calculate the magnitude of the resultant magnetic flux density at a point **P**, located 4.0 cm from **Q** and 3.0 cm from **R**. (5 marks)

6. (a) (i) Define the term, ***electromagnetic induction***. (1 mark)

(ii) State the laws of electromagnetic induction. (2 marks)

(b) (i) Derive an expression for the e.m.f. induced across a straight conductor of length L being moved perpendicularly across a uniform magnetic field of flux density, B at a constant velocity, V. (4 marks)

(ii) A glider aircraft of wing span 40 m is moving horizontally at a velocity of 250 $ms^{-1}$ in a plane where the angle of dip is 30°. If the e.m.f. induced across the tips of the wings is 10 mV.

Find the value of the Earth's magnetic flux density and state the sign of chargeon each wing. (4 marks)

(c) Describe an absolute method of measuring resistance using Faraday's metal disc, (5 marks)

(d) A transformer inside a portable CD player has 500 turns in the primary coil. It supplies an e.m.f. of amplitude 6.8 V when plugged to the a.c. mains of amplitude 1.70 V.

(i) How many turns does the secondary coil have? (2 marks)

(ii) If the amplitude of the current drawn by the CD player has amplitude of 1.50 A, what is the amplitude of the current in the primary? (2 marks)

7. (a) (i) Define the term ***root mean square current.*** (1 mark)

(ii) Derive an expression for the average power dissipated in a resistor of resistance R when alternating current $I = I_0 \sin 2\pi ft$ amperes flows through it. (3 marks)

(b) (i) Derive an expression for reactance $X_C$ of a capacitor of capacitance, C connected across an alternating voltage $V = V_0 \cos 2\pi ft$ *volts* (4 marks)

(ii) Sketch using the same axes the variation of applied voltage and current flowing through the capacitor, with time. (2 marks)

(c) (i) Describe the structure and mode of operation of a repulsive type of moving iron ammeter. (5 marks)

(ii) Outline three advantages of the meter in (i) above over a moving coil ammeter. (3 marks)

(d) Explain why a light flattened metallic bottle top placed on top of an enameled coil of copper wire connected to a large battery via a switch, jumps off the coil and later falls back when the switch is closed. (2 marks)

## SECTION D

8. (a) (i) Define the term ***electric field intensity*** and state is SI Unit. (2 marks)

(ii) Derive an expression for the electric field intensity at a point due to a charge +Q. (3 marks)

(b) (i) What is an equipotential surface? (3 marks)

(ii) Explain why electric field lines are normal to the surface of a charged metal conductor. (4 marks)

(c) Three-point charges of $+2.5\ \mu C$, $-5.0\ \mu C$ and $+3.0\ \mu C$ and are placed at points **A**, **B**, and **C** as shown in figure 2, with point **P** located 3.0 cm from point C along the x – axis, while BC = 2.0 cm and AC = 4.0 cm.

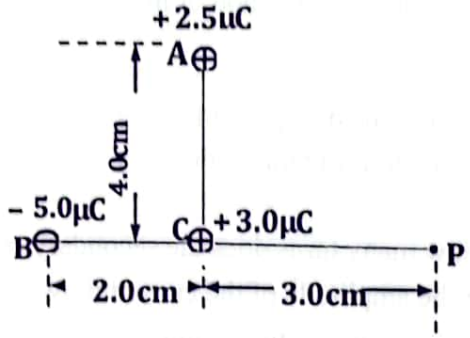



**Fig. 2**

Determine the resultant electric field intensity at point P. (5 marks)

(d) Explain how lightening is created in the earth's atmosphere. (3 marks)

9. (a) (i) What is a capacitor? (2 marks)

(ii) Give three industrial uses of capacitors. (3 marks)

(b) Derive an expression for the effective capacitance, **C** of three capacitors of capacitances $C_1$, $C_2$ and $C_3$ arranged in series all of which are connected across a battery of e.m.f, **V**. (4 marks)

(c) Six parallel plate capacitors of $1\ \mu F$, $2\ \mu F$, $3\ \mu F$, $6\ \mu F$, $8\ \mu F$ *and* $15\ \mu F$ are all connected as shown in figure 3 across a 12 V battery.

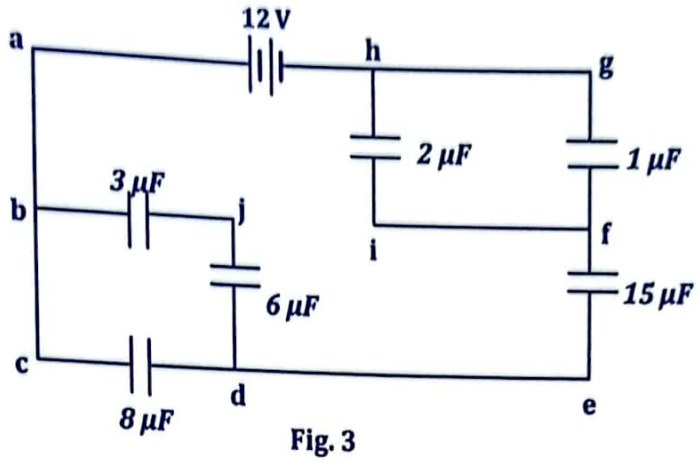



Fig. 3

Determine the;

(i) Effective capacitance of the network. (4 marks)

(ii) Charge stored in the whole system. (2 marks)

(d) Describe how a calibrated gold leaf electroscope can be used to investigate the effect of increasing the distance of separation between the plates of a charged capacitor on its capacitance. (5 marks)

10. (a) (i) Define ***temperature coefficient of resistance*** of a material. (1 mark)

(ii) Describe an experiment to measure temperature coefficient of resistance of copper. (6 marks)

(b) A variable resistance, **R**, is connected across a battery of e.m.f. **E** and internal resistance, **r**. Derive an expression for the;

(i) Efficiency of the circuit. (3 marks)

(ii) Maximum power output of the circuit. (4 marks)

(iii) Sketch using the same axes graphs of power and efficiency against resistance. (2 marks)

(c) How can a galvanometer having a coil of resistance 2 Ω and full-scale deflection of 5 mA be converted into a voltmeter having a range of (0 – 3 V)? (4 marks)

 End

P510/1
PHYSICS
Paper 1
July/August, 2023
2 ½ hours

# ASSHU ANKOLE JOINT MOCK EXAMINATIONS 2023
## Uganda Advanced Certificate of Education
## PHYSICS
## Paper 1
## 2 hour 30 minutes

**INSTRUCTIONS TO CANDIDATES**

- Attempt **five** questions including at least **one** from each section, but not more than **two** from each of the sections **A**, **B** and **C**.
- **Any** additional question(s) answered will **not** be marked.

Assume where necessary

- Acceleration due to gravity, g = $9.81\ ms^{-2}$
- Electronic charge e = $1.6 \times 10^{-19} C$
- Electron mass = $9.11 \times 10^{-31} kg$
- Plank's constant, h = $9.11 \times 10^{-31} kg$
- Speed of light in a vacuum, C = $3.0 \times 10^{8}\ ms^{-1}$
- Stefan's – Boltzmann's constant = $5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$
- Avogadro's number, NA = $6.0^{2} \times 10^{23}\ mol^{-1}$
- Density of water = $1000\ kgm^{-3}$
- Surface tension of water = $7.5 \times 10^{-2}\ Nm^{-1}$
- Surface tension of mercury = $5.47 \times 10^{-1}\ Nm^{-1}$
- Density of mercury = $13600\ kgm^{-3}$
- Mass of earth = $6.07 \times 10^{-11}\ Nm^{-2}kg^{-2}$
- Universal gravitational constant, G = $6.67 \times 10^{-11}\ Nm^{-2}kg^{-2}$
- Radius of earth = $6.4 \times 10^{6}\ m$
- Thermal conductivity of steel = $50.2\ Wm^{-1}k^{-1}$
- Specific latent heat of vaporization of water = $2.26 \times 10^{6}\ Jkg^{-1}$
- Faraday constant = 96500 C

## SECTION A

1.(a) (i) What is meant by dimensions of a physical quantity. (1 mark)

(ii) The volume rate, $\frac{V}{t}$ of a liquid flowing through a horizontal pipe of length, $l$ depends on the pressure gradient, $\frac{P}{l}$ the radius, $r$ of the pipe and the coefficient of viscosity, $\eta$ (of dimensions $ML^{-1}T^{-1}$) of the liquid. Use dimensions to derive an expression for $\frac{V}{t}$ in terms of $\frac{P}{l}$, $r$ and $\eta$ (take $k = \frac{\pi}{8}$). Hence find the volume per second of a liquid of viscosity $1.2 \times 10^{-3}\ Ns^{-1}m^{-2}$ at 25 °C that flows through a pipe of length 20 m and radius 80 cm when the pressure difference across its ends is $24.5\ Nm^{-2}$ (7 marks)

(b) (i) State Newton's second law of motion (1 mark)

(ii) What is meant by the term impulse? (1 mark)

(iii) A tennis ball of mass 75 g struck by a racket moves horizontally at a speed of $120\ ms^{-1}$. Given that the ball is in contact with the wall for 0.04 s and the area of contact with the wall is $28.5\ cm^2$, find the pressure the ball exerts on the wall. (4 marks)

(iv) Explain briefly why the ball rebounds with a reduced speed. (2 marks)

(c) A stone is projected vertically upwards from the top of a table if the stone finally lands on the floor below the table;

(i) Sketch a speed -time graph for the motion of the stone. (1 mark)

(ii) Describe briefly the features of the graph (3 marks)

2.(a) Differentiate between the terms ductility and malleability. Give two examples of materials that exhibit each of these properties. (4 marks)

(b) A body is supported by a spiral spring and causes the spring to stretch by 1.5 cm. If the mass is now set into vertical oscillation, of small amplitude, calculate the periodic time of the oscillation. (4 marks)

(c) the graph in figure 1. Shows the variation of F; the load applied to two wires P and Q and their extensions $e$. Both wires are made of iron and have the same length.

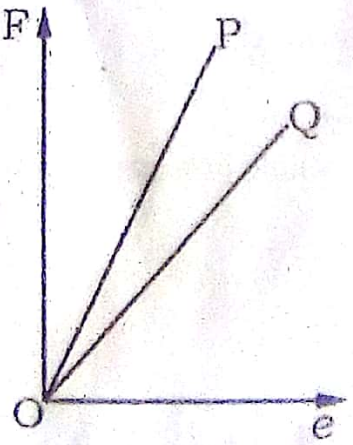



Fig.1

Which of the wires has a smaller diameter? Explain your answer. (4 marks)

(d) (i) Define simple harmonic motion. (1 mark)
(ii) State two practical examples of simple harmonic motion (2 marks)
(iii) A small mass rests on a horizontal platform which vibrates vertically in simple harmonic motion with a period of 0.5 s. find the maximum amplitude of motion which will allow the mass of remain in contact with the platform throughout the motion. (3 marks)

3.(a) Define the following terms as used in circular motion.
(i) angular velocity (1 mark)
(ii) centripetal acceleration (1 mark)

(b) A metallic bob of mass, m, is tied to a string of length, $l$, so that it is free to oscillate in a vertical plane as shown in figure 2.

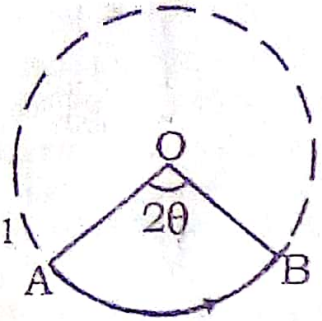


Fig.1

When pushed from position A, the bob moves describing a path as shown.

If O is the centre of the path taken,
(i) Show that the acceleration of the bob along line AB is zero and that its acceleration along AO is $\frac{V^2}{l}$ (4 marks)

(c) An object of mass 0.5 kg is rotated in a horizontal circle. Using a string of length 1m. The maximum tension in the string before it breaks is 316 N. What is the greatest number of revolutions made by the object in one second? (4 marks)

(d) (i) What is meant by a parking orbit of a satellite? (1 mark)
(ii) Calculate the height of a communication satellite above the earth's surface. (4 marks)
(iii) Show that a satellite close to the earth's surface takes about 84 minutes to move around the earth once. (4 marks)

4.(a) (i) Define surface tension in terms of surface energy. (1 mark)
(ii) Explain using Kinetic theory the temperature dependence of surface tension. (3marks)

(b) (i) Describe an experiment, to determine surface tension of a liquid using a capillary tube. (6 marks)
(ii) When a capillary tube is placed vertically in a beaker containing water, water rises in the tube 5.8 cm above that in the beaker. The tube is removed dried and placed vertically in a trough of mercury. Calculate the depression of mercury in the tube. (angle of contact for water = 0°, angle of contact for mercury = 130°)

(c) State Bernoulli's Principle of fluid flow. (1 mark)
(d) Water flows steadily along a horizontal pipe at a volume rate of

$8.0 \times 10^{-3}\ m^3s^{-1}$. If the area of cross section of the pipe is 40 $cm^2$, determine the;

(i) flow velocity of the water. (2 marks)

(ii) total pressure in the pipe if the static pressure is $3.0 \times 10^4$ Pa (3 marks)

## SECTION: B

5.(a) (i) Define specific heat capacity of a substance. (1 mark)

(ii) In reference to a continuous flow calorimeter for determining specific heat capacity of a liquid, explain why two sets of readings are used and the temperature difference for inflow and out flow liquid is made the same. (2 marks)

(ii) Oil at 15.6 °C enters a long glass tube containing an electrically heated platinum wire and leaves it at 17.4 °C. The rate of flow of the oil is 25 $cm^3$ per minute and electrical energy supplied by the coil per second is 2.30 J. When the rate of flow is reduced by 10 $cm^3$ per minute and the electrical energy supplied per second is reduced by 40%, the same temperature difference is again, achieved. Calculate the specific heat capacity of the oil given that its density is 870 $kgm^{-3}$. (6 marks)

(b) (i) Define specific latent heat of vaporization. (1 mark)

(ii) With the aid of a labeled diagram describe how specific latent heat of a liquid can be determined by a method which involves a constant rate of evaporation. (6 marks)

(iii) Explain briefly why at night it is much colder in the valley than at the top of the hills. (2 marks)

6.(a) (i) Define thermal conductivity. (1 marks)

(ii) Explain the mechanism of heat transfer in non-metal solids. (3 marks)

(b) Describe an experiment to determine thermal conductivity of iron. (6 marks)

(c) A boiler with a steel bottom 1.5 cm thick rests on a hot stove. The area of the boiler's bottom is 1500 $cm^2$. The water inside the boiler is at a temperature of 100 °C and 750 g evaporates every 5 minutes. Find the

(i) temperature of the lower surface of the boiler. (4 marks)

(ii) amount of heat passing through 80 $cm^2$ are of the bottom of the boiler per hour. (3 marks)

(d) (i) What is meant by a black body? (1 mark)

(ii) State two examples of black bodies. (1 mark)

(iii) Explain briefly why back body radiation is sometimes called temperature radiation (1 mark)

7.(a) (i) Define the terms absolute zero and an ideal gas (2 marks)

(ii) State two differences between an ideal gas and a real gas. (2 marks)

(b) (i) State and derive Dalton's law of partial pressures. (5 marks)

(ii) What is meant by saturated vapour?

(iii) The saturated vapour pressure (S.V.P) of a certain liquid vapour at 0°C is 18.5 mmHg and at 30 °C it is 54.2 mmHg.
The volume of the closed vessel is kept constant and contains air and sufficient liquid for saturation. If the observed pressure is 100 mmHg at 30°C, what will its value be at 0°C? (4 marks)

(c) (i) Define molar heat capacity of an ideal gas at constant pressure. (1 mark)

(ii) Explain why the distinction between specific heat capacity at constant pressure and that at constant volume is important for gases but less important for solids and gases. (3 marks)

(iii) The temperature of a gas in an expandable container is raised from $^{-}15$ °C to 65 °C at constant pressure.
The total heat added to the gas is $5.8 \times 10^4$ J. find the number of moles of the gas. (Molar heat capacity of the gas at constant pressure = 29.0 $Jkg^{-1}K^{-1}$) (2 marks)

## SECTION C

8.(a) (i) What are cathode rays? (1 mark)

(ii) State four properties of cathode rays. (2 marks)

(iii) Explain briefly the term thermionic emission. (3 marks)

(b) Describe briefly how frequency of an a.c signal can be determined using a cathode ray oscilloscope (C.R.O) (3 marks)

(c) A C.R.O has its y-sensitivity set to 6 $Vcm^{-1}$. A sinusoidal input, voltage is suitably applied to give a steady p.d. the time base is switched on so that the election beam takes 0.02 s to traverse the screen. If the trace seen has a peak-to-peak height of 4 cm, and containing two complete cycles, determine the;

(i) root- mean- square value of the input voltage. (3 marks)

(ii) frequency of the signal. (2 marks)

(d) In an experiment to determine charge of an electron using Millikan's oil drop method, state why a

(i) constant temperature bath is used (1 mark)

(ii) non -volatile oil is used. (1 mark)

(e) In a Millikan's oil drop experiment, a single negatively charged drop of radius $6.0 \times 10^{-3}$ mm was found to fall under gravity at a terminal velocity of 0.004 $cms^{-1}$ and to rise at 0.012 $cm^{-1}$ when an electric field of intensity $2.0 \times 10^5$ $Vm^{-1}$ was suitably applied. Given that the viscosity of the medium was $2.122 \times 10^{-5}$ $Nsm^{-2}$, determine the number of electrons on the drop, (neglect air buoyancy). (4 marks)

9.(a) (i) State any two processes of ejecting electrons from a metal surface. (2 marks)

(ii) Describe a simple experiment to determine plank's constant. (5 marks)

(b) When light of wavelength 450nm falls on a certain metal surface, it ejects phot electrons with maximum velocity of $6.0 \times 10^5$ $ms^{-1}$. Calculate the

(i) work function of the metal
(ii) threshold frequency of the metal surface (4 marks)

(c) (i) State Bragg's law of x-ray diffraction. (1 mark)

(ii) A beam of x-rays of frequency $3.56 \times 10^{18}$ Hz is incident on a potassium chloride (KCl) crystal and the first order Bragg's reflection occurs at 7°4′. The density of KCl is $1.98 \times 10^{3}$ kgm$^{-3}$ and its molecular mass is 74.5. Calculate the value of Avogadro's number. (5 marks)

(d) (i) Define Faraday constant. (1 mark)

(ii) Use the Avogadro's constant and Faraday constant to calculate the charge on an ion of a monovalent element. (2 marks)

10(a) Define the terms

(i) Radioactivity (1 mark)

(ii) Nuclear fission (1 mark)

(b) (i) State one condition for nuclear fission to occur.

(ii) Why are neutrons preferred to alpha particles for inducing nuclear reactions? (2 marks)

(c) With the aid of a labelled diameter describe how a diffusion cloud chamber is used to detect ionizing radiation (6 marks)

(d) Lanthanum has a stable Isotope, La-139 and radioactive Isotope La-138 of half-life $1.1 \times 10^{10}$ years whose atoms are 0.1% of the stable isotope. Estimate the rate of decay of La-138 with 1kg of La-139. (4 marks)

(e) Uranium $^{238}_{92}U$ nucleus decays according to the equation.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He.$$

Determine the Kinetic energy of the emitted alpha-particle given that

Mass of the nucleus of $\begin{cases} ^{238}_{92}U = 3.85395 \times 10^{-25}\text{kg} \\ ^{234}_{90}Th = 3.78737 \times 10^{-25}\text{kg} \end{cases}$

Mass of alpha particle $= 6.64807 \times 10^{-27}$ kg (5 marks)

END

P425/1
PURE MATHEMATICS
Paper 1
Jul./Aug. 2023
3 hours

# WAKISO-KAMPALA TEACHERS' ASSOCIATION (WAKATA)

## WAKATA MOCK EXAMINATIONS 2023

## Uganda Advanced Certificate of Education

PURE MATHEMATICS

**Paper 1**

3 hours

**INSTRUCTIONS TO CANDIDATES:**

*Answer* **all** *the eight questions in section* **A** *and any* **five** *questions from section* **B**.

*Any additional question(s) answered will* **not** *be marked.*

*All necessary working must be clearly shown.*

*Begin each answer on a fresh sheet of paper.*

*Silent, non – programmable scientific calculators and mathematical tables with a list of formulae may be used.*

*Neat work is a must!!*

## SECTION A (40 MARKS)

*Answer* **all** *questions in this section.*

1. Solve the equation: $(Z + 1 - 2i)^2 + 4i = 3$. *(05 marks)*

2. Given that $sin(\theta + \alpha) = a$ and $sin(\theta + \beta) = b$.
   Show that $cos2(\alpha - \beta) - 4abcos(\alpha - \beta) = 1 - 2a^2 - 2b^2$ *(05 marks)*

3. Find $\frac{dy}{dx}$ if $y = 3^{x^2+2x}$. *(05 marks)*

4. A straight line joining the points $(2, 1, 4)$ and $(a - 1,\ 4,\ -1)$ is parallel to the line joining points $(0,\ 2,\ b - 1)$ and $(5,\ 3, -2)$. Find the values of $a$ and $b$. *(05 marks)*

5. $P$ and $Q$ are two points whose coordinates are $(at^2,\ 2at)$, $\left(\frac{a}{t^2}, \frac{-2a}{t}\right)$ respectively and $S$ is a point $(a, 0)$. Show that $\frac{1}{SP} + \frac{1}{SQ} = \frac{1}{a}$. *(05 marks)*

6. Evaluate $\int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \left( \frac{\sqrt{1 + cosx}}{(1 - cosx)^{\frac{5}{2}}} \right) dx$ *(05 marks)*

7. The quadratic equation $(P + 1)x^2 - 6(P + 1)x + 3(P + 9) = 0,\ P \neq 1$ has equal roots. Find the roots of the equation. *(05 marks)*

8. Solve the differential equation; $\frac{dy}{dx} + \frac{y}{x} = x^3$ *(05 marks)*

## SECTION B (60 MARKS)

*Answer any* **five** *questions from this section. All questions carry equal marks.*

**9.** (a) The polymomial $f(x) = ax^3 + 3x^2 + bx - 3$ is exactly divisible by $(2x + 3)$ and leaves a remainder $-3$ when divided by $(x + 2)$. Find the values of $a$ and $b$. *(07 marks)*

(b) Given that $(x - 2)$ and $(x - \frac{1}{2})$ are factors of $ax^2 + 5x + b$.

Show that $a = b$. *(05 marks)*

**10.** (a) Given that $y^3 - 3xy^2 = x^3 + 3x^2y$. Find $\frac{dy}{dx}$. *(06 marks)*

(b) The volume $V$ of a liquid in a container is given by $V = (3h^2 + 4)^{\frac{3}{2}} - 8$ ; where $h$ m is the depth of the liquid. The liquid is leaking from the container. It is observed that, when the depth of the liquid is 0.6m, the depth is decreasing at a rate of 0.015m per hour. Find the rate at which the volume of liquid in the container is decreasing at the instant when the depth is 0.6m. *(06 marks)*

**11.** (a) The lines $\frac{x-1}{3k} = \frac{y-2}{1} = \frac{z-3}{-5}$ and $\frac{x-1}{-3} = \frac{y-2}{2k} = \frac{z-3}{2}$ are perpendicular.

Find the value of $k$. *(04 marks)*

(b) Find the coordinates of the point where the line through $(3, -4, -5)$ and $(2, -3, 1)$ crosses the plane $2x + y + z = 7$. *(08 marks)*

**12.** Expand $\frac{2x^2 + 5x - 10}{(x + 1)(x + 2)}$ in ascending powers of $x$, as far as the term in $x^2$. *(12 marks)*

**13.** (a) Sketch the curve $y = x^2 + 2$. *(06 marks)*

(b) The area bounded by the curve and the line $y = x + 8$ is rotated about the $x$ −axis through one revolution. Determine the volume of the solid generated. *(06 marks)*

**14.** (a) Prove that: $\frac{cosx}{1-sinx} = \frac{1+cosx+sinx}{1+cosx-sinx}$ *(08 marks)*

(b) Solve the equation $2sin\,x = \frac{4cosx-1}{tanx}$ for $0^\circ < x < 360^\circ$. *(04 marks)*

**15.** (a) Find the equation of the ellipse whose focus is $(1,-2)$, the directrix $3x-2y+5=0$ and accentricity equal to $\frac{1}{2}$. *(04 marks)*

(b) Points $A$ and $B$ are $10km$ a part and it is determined from the sound of an explosion heard at those points at different times that the location of the explosion is $6km$ closer to $A$ than $B$. Show that the location of the explosion is restricted to a hyperbola whose equation is $\frac{x^2}{9}-\frac{y^2}{16}=1$. *(08 marks)*

**16.** In a culture, the bacteria count is 100,000. The number is increased by 10% in 2 hours. In how many hours will the count reach 200,000, if the rate of growth of bacteria is proportional to the number present? *(12 marks)*

**END**

P425/2
APPLIED MATHEMATICS
Paper 2
Jul./Aug. 2023
3 hours

# WAKISO-KAMPALA TEACHERS' ASSOCIATION (WAKATA)

## WAKATA MOCK EXAMINATIONS 2023

## Uganda Advanced Certificate of Education

APPLIED MATHEMATICS

**Paper 2**

3 hours

**INSTRUCTIONS TO CANDIDATES:**

*Answer* **all** *the eight questions in section* **A** *and any* **five** *questions from section* **B**.

*Any additional question(s) answered will* **not** *be marked.*

*All necessary working must be clearly shown.*

*Begin each answer on a fresh sheet of paper.*

*Silent, non – programmable scientific calculators and mathematical tables with a list of formulae may be used.*

*Assume where necessary, acceleration due to gravity* $g = 9.8ms^{-2}$.

*Graph paper is provided.*

*Neat work is a must!!*

## SECTION A: (40 MARKS)

*Answer* **all** *questions in this section.*

1. Two forces $(i + j + k)N$ and $(i + 2j + 3k)N$ act on a particle and displace it from $(2,3,4)$ to point $(5,4,3)$. If the displacement is in meters, calculate the work done.

*(05 marks)*

2. Two hunters $A$ and $B$ hit a bird in succession. The probability of $A$ and $B$ scoring a hit correctly are 0.3 and 0.2, respectively. The second hunter will hit the bird only if the first misses the target. Find the probability that the bird is hit by the second hunter. *(05 marks)*

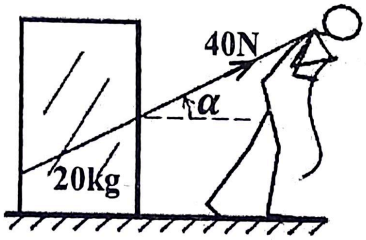
3. Given that $y = \sqrt{(2^x + x)}$.

   (a) Complete the table below, giving the values of $y$ to 3 decimal places. *(02 marks)*

| $x$ | 0 | 0.2 | 0.4 | 0.6 | 0.8 | 1 |
|---|---|---|---|---|---|---|
| $y$ | 1 | 1.161 | 1.311 | 1.455 | 1.594 | 1.732 |

   (b) Use the trapezium rule with all the values of $y$ from your table to find an approximation for the value of $\int_0^1 \sqrt{(2^x + x)}\, dx$ correct to **three** decimal places. *(03 marks)*

4. The diagram below shows a wooden block of mass 20kg being pulled in a straight line along a rough horizontal floor using a handle attached to the box.




The handle is inclined at an angle $\alpha$ to the floor, where $tan\alpha = \frac{3}{4}$ and coefficient of friction between the box and the floor is 0.14. Find the acceleration of the block. *(05 marks)*

5. The discrete random variable $X$ has the following probability distribution.

| $x$ | $a$ | $b$ | $c$ |
|---|---|---|---|
| $P(X = x)$ | $a \log_{36} a$ | $b \log_{36} b$ | $c \log_{36} c$ |

Where $a, b$ and $c$ are district integers $(a < b < c)$. Find the values of $a$, $b$, and $c$.

*(05 marks)*

6. Given the function, $y = cosx^2 - x + 3$.

   (a) Show that the function has a root $\alpha$ in the interval $\{2.5,\ 3\}$ *(02 marks)*

   (b) Use linear interpolation once on the interval $\{2.5,\ 3\}$ to find an approximation for $\alpha$ giving your answer correct to **two** decimal places. *(03 marks)*

6. A boat is moving with constant velocity. At noon, it is at a point with position vector $(3i - 4j)km$ with respect to a fixed origin **O**. At 14:30 on the same day, it is at a point with the same day, it is at a point with position vector $(3i - 4j)km$. Find the position vector of the boat at 17:00 on the same day. *(05 marks)*

7. Average IQ of a group of 800 children is 98. The standard deviation is 8. Assuming normality find the expected number of children having IQ between 100 and 120. *(05 marks)*

## SECTION B: (60MARKS)

*Answer any* **five** *questions from this section.* **All** *questions carry equal marks.*

9. The table below shows the weight of 50 farm animals whose average weight is 62.8kg.

| **Weight ($kg$)** | $0 < 20$ | $20 - <40$ | $40 - <60$ | $60 - <80$ | $80 - <100$ | $100 - <120$ |
|---|---|---|---|---|---|---|
| **Number of animals** | 5 | $x$ | 10 | $y$ | 7 | 8 |

(a) Find the value of $x$ and $y$. *(06 marks)*

(b) Draw a cumulative frequency curve for the data. Use your curve to estimate the;
   (i) median weight of the animals.
   (ii) number of animals below 70kg. *(06 marks)*

10. A particle, P moves on the $x$ – axis. At time, $t$, seconds the velocity of P is $Vms^{-1}$ in the direction of $x$ increasing, where $V$ is given by;

$$V = \begin{cases} 8t - \frac{3}{2}t^2, & 0 \le t \le 4 \\ 16 - 2t, & t > 4 \end{cases}$$

When $t = 0$, P is at the origin O. Find the;

(a) greatest speed of P in the interval $0 \le t \le 4$. *(03 marks)*

(b) distance of P from O when $t = 4s$. *(02 marks)*

(c) total distance travelled by P in the first 10s of its motion. *(07 marks)*

11. (a) Show that the equation $xe^x - 1 = 0$ has a root between 0 and 1. *(03 marks)*

(b) Use the Newton – Raphson method to find the approximate root of $xe^x - 1 = 0$, correct to **three** decimal places. *(09 marks)*

12. A continuous random variable $X$ has the following probability density function:

$$f(x) = \begin{cases} a + bx; & 0 \le x \le 5 \\ 0, & Otherwise \end{cases}$$

where $a$ and $b$ are constants. *(03 marks)*

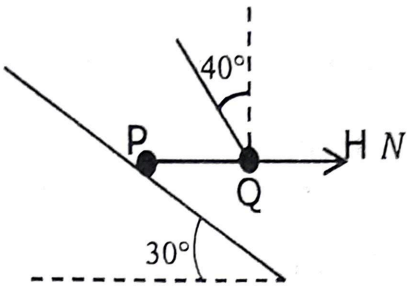
(a) Show that $10a + 25b = 2$ *(06 marks)*

(b) Given that $E(x) = \frac{35}{12}$, find the value of $a$ and $b$. *(03 marks)*

(c) Find to **three** significant figures, the median of $X$.

**Turn Over**

13. The diagram below shows a particle $Q$ lying on a slope inclined at $30°$ to the horizontal. $P$ is attached to one end of a taut light inextensible string which passes through a small ring $Q$ of mass, $mkg$. The portion $PQ$ of the string is horizontal and the other portion of the string is inclined at $40°$ to the vertical. A horizontal force of magnitude H $N$, acting away from $P$, is applied to $Q$.




The tension in the string is 6.4N, and the string is in the vertical plane containing the line of greatest slope on which P lies. Both $P$ and $Q$ are in equilibrium.

(a) Find the value of $m$ and H. *(04 marks)*

(b) Given that the weight of $P$ is $32N$, and that $P$ is in limiting equilibrium, show that the coefficient of friction between $P$ and the slope is 0.879. *(05 marks)*

(c) Determine whether $P$ remains in equilibrium when $Q$ and the string are removed. *(03 marks)*

14. (a) If $Q = \frac{X^n}{Y^m}$ and $e_x$ is the error in the measurement of $X$, $e_y$ is the error in the measurement of $Y$; show that absolute error $e_q$ in the measurement of $Q$ *is*

$$\pm\left[\frac{X^n}{Y^m}\right]\left[n\left|\frac{e_x}{X}\right| + m\left|\frac{e_y}{Y}\right|\right]$$ *(05 marks)*

(b) A teacher earns P million shillings and invests all in bank at a rate of 8% compound interest for n years.

(i) Construct a flow chart that shows the teacher's investment.

(ii) Given that the teacher invested 2million shillings on 1st January 2023, how much money will be on his account on 1st January 2027? *(07 marks)*

15. The heights of girls in a certain secondary school are normally distributed with mean $\mu$ $cm$ and standard deviation $\sigma$ $cm$. It is known that 30% of the girls are taller than $172cm$ and 5% are shorter than $154cm$.

(a) Show that $\mu = 154 + 1.6449\sigma$ *(04 marks)*

(b) Find the value of $\mu$ and $\sigma$. *(05 marks)*

(c) A girl is chosen at random from the school, what is the probability that she is taller than 160cm?. *(03 marks)*

16. Particles **A** and **B** of masses $0.4kg$ and $m$kg respectively are joined by a light inextensible string which passes over a smooth pulley. The particles are released from rest at the same height above a horizontal surface; the string taut and portions of the string not in contact with the pulley are vertical. **B** begins to descend with acceleration $2.45ms^{-2}$ and reaches the surface $0.3s$ after being released. Subsequently, **B** remains at rest and **A** never reaches the pulley. Calculate the;

(a) tension in the string while **B** in motion. *(02 marks)*

(b) momentum lost by **B** when it reaches the surface. *(05 marks)*

(c) greatest height of **A** above the surface. *(05 marks)*



**END**

Essie

Essie wa Yesu
TCN.

*Uganda Advanced Certificate of Education*

PHYSICS SEMINAR QUESTIONS

ON SATURDAY 15th JULY 2023

PAPER 1

INSTRUCTIONS TO CANDIDATES:

- *Assume where necessary:*

| | | |
|---|---|---|
| Acceleration due to gravity, $g$ | = | $9.81 ms^{-2}$ |
| Electron charge, $e$ | = | $1.6 \times 10^{-19} C$ |
| Electron mass | = | $9.11 \times 10^{-31}$ kg |
| Mass of the earth | = | $5.97 \times 10^{24}$kg |
| Plank's constant, $h$ | = | $6.6 \times 10^{-34}$ Js |
| Stefan's- Boltzmann's constant, $\sigma$ | = | $5.7 \times 10^{-8} Wm^{-2}K^{-4}$ |
| Speed of light in a vacuum, c | = | $3.0 \times 10^{8}$ $ms^{-1}$ |
| Universal gravitational constant, $G$ | = | $6.67 \times 10^{-11} Nm^2kg^{-2}$ |
| Avogadro's number, $N_A$ | = | $6.02 \times 10^{23}$ $mol^{-1}$ |
| Density of water | = | 1,000 kg $m^{-3}$ |
| Density of mercury | = | 13,600kg $m^{-3}$ |
| Universal molar gas constant, $R$ | = | 8.31 J $mol^{-1}$ $K^{-1}$ |
| Specific heat capacity of water | = | 4200 $Jkg^{-1}K^{-1}$ |
| Radius of the earth | = | $6.4 \times 10^{6}$m |
| Radius of the sun | = | $7.0 \times 10^{8}$m |
| Radius of earth's orbit about the sun | = | $1.5 \times 10^{11}$m |
| The constant $\frac{1}{4\pi\varepsilon_o}$ | = | $9.0 \times 10^{9}$ $F^{-1}m$ |



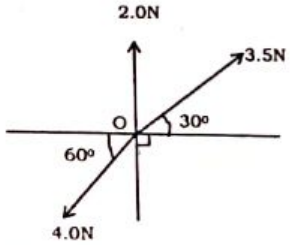


MECHANICS

(a) (i) Define the terms velocity and displacement. *(2 marks)*

(ii) Sketch a graph of velocity against time for an object thrown vertically upwards. *(2 marks)*

(b)




Three forces of 3.5N, 4.0N and 2.0N, act at point O as shown in the figure above. Find the resultant force. *(4 marks)*

(c) (i) What is meant by saying that a body is moving with velocity, V, relative to another? *(1 mark)*

(ii) A ship, A is travelling due North at $20kmh^{-1}$ and ship B is travelling due east at $15kmh^{-1}$. Find the velocity of A relative to B. *(3 marks)*

(iii) If the ship B in (c) (ii) is 10km due west of A at noon, find their shortest distance apart and when this occurs. *(5 marks)*

(d) (i) What is meant by a couple in mechanics? *(1 mark)*

(ii) State the conditions for equilibrium of a system of coplanar forces. *(2 marks)*

2. (a) (i) Define relative density. *(1mark)*

(ii) With the aid a diagram(s), describe how you would measure the relative density of a liquid using Archimedes' principle and the principle of moments. *(4mark)*

(b)(i) Define surface tension and state its dimensions. *(2 marks)*

(ii) Describe Jaeger's experiment to determine the variation of surface of water with temperature. *(3marks)*

(iii) Explain the variation of surface tension of a liquid with temperature. *(2 marks)*

(c) Mercury is poured into a glass U-tube with vertical limbs of diameters 3mm and 10mm respectively. If the angle of contact between mercury and glass is $120^{\circ}$ and the surface tension of mercury is $0.4\ Nm^{-1}$, calculate the

(i) Surface tensional force in the wider tube. *(2 marks)*

(ii) Difference in levels of mercury. *(4 marks)*

(Take the density of mercury = $1.36 \times 10^{4} kgm^{-3}$)

3. (a) (i) State the laws of friction between solid surfaces. *(3 marks)*

(ii) Explain the origin of frictional force between two solid surfaces in contact. *(3 marks)*

(iii) Describe an experiment to measure the coefficient of Kinetic friction between two solid surfaces. *(3 marks)*

(b) (i) A car of mass 1000kg moves along straight surface with a speed of $20ms^{-1}$. When brakes are applied steadily, the car comes to rest after travelling 50m. Calculate the coefficient of friction between the surface and the tyre. *(4 marks)*

(ii) State the energy changes which occur from the time the brakes are applied to the time the car comes to rest. *(2 marks)*

(c) (i) State two disadvantages of friction. *(1 mark)*

(ii) Give one method of reducing friction between solid surfaces. *(1 mark)*

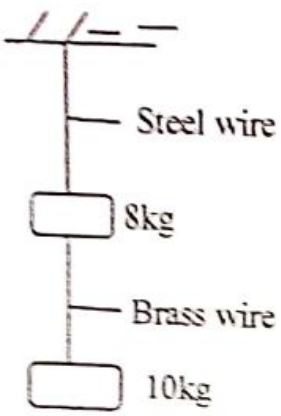
(d) Explain what happens when a small steel ball is dropped centrally in a tall jar containing oil. *(3 marks)*

4. (a) (i) Distinguish between elastic limit and limit of proportionality. *(2 marks)*

(ii) Using the same axes, sketch stress – strain graphs for a rubber cord and steel wire, state any differences between the graphs. *(4 marks)*

(b) With aid of a labeled diagram describe an experiment to determine Young's modulus of a ductile material. *(6 marks)*

(c)




A steel wire of length 2.5m and diameter 0.12cm is loaded with 8kg. it is connected in series with brass wire of length 1.5m and diameter 0.23 cm which is loaded with 10kg as shown above. Calculate the;

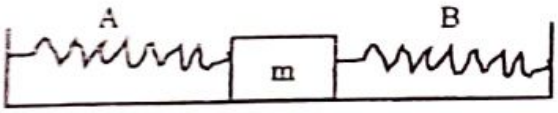
(i) Extension in each wire. *(5 marks)*

(ii) Total energy stored in the wires. *(3 marks)*

5. (a) (i) Define simple harmonic motion. *(1 mark)*

(ii) A particle of mass M executes simple harmonic motion between two points A and B about equilibrium position O. Sketch a graph of the restoring force acting on the particle as a function of distance, *r*, moved by the particle. *(2 marks)*

(b)




Two springs A and B of spring constants $K_A$ and $K_B$ respectively are connected to a mass m as shown in the figure above. The surface on which the mass slides is frictionless.

(i) Show that when the mass is displaced slightly it oscillates with simple harmonic motion of frequency, *f*, given by $f = \frac{1}{2\pi}\sqrt{\frac{K_A + K_B}{m}}$. *(4 marks)*

(ii) If the two springs above are identical such that $K_A = K_B = 5.0Nm^{-1}$ and mass m = *50g*, Calculate the period of oscillation. *(3 marks)*

(c) (i) With the aid of a diagram, describe an experiment to determine the universal gravitational constant G. *(6 marks)*

(ii) If the moon moves round the earth in a circular orbit of radius = $4.0\times10^{8}m$ and takes exactly 27.3 days to go round once, Calculate the value of acceleration due to gravity, g, at the earth's surface. *(4 marks)*

6. (a) (i) State Newton's law of gravitation. *(1mark)*

(ii) Show that Newton's law of gravitation is consistent with Kepler's third law. *(5marks)*

(b) (i) A satellite of mass 250kg is launched in a circular orbit at a height of 3.60 x $10^7$m above the earth's surface. Find the mechanical energy of the satellite. *(3marks)*

(ii) Explain what will happen to the satellite if its mechanical energy was reduced. *(3marks)*

(c) Explain the following;

(i) Damped oscillations *(2marks)*

(ii) Forced oscillations *(2marks)*

(d) An aero plane has a mass of 9,000kg and total wing area of $9.0m^{-2}$. When moving through still air, the ratio of its velocity to that of the air at its lower surface is 1.0, whereas the ratio of its velocity to that of the air above its wings is 0.25. At what velocity will the aero plane be able to just lift off the ground? (Density of air = $1.3kgm^{-3}$) *(4marks)*

7. (a) (i) Define surface tension $\gamma$ and surface energy $\sigma$. *(2marks)*

(ii) Show that surface tension and surface energy are numerically equal. *(3marks)*

(b) (i) Explain why large mercury drops tend to flatten out whereas small drops assume spherical shapes. *(3marks)*

(ii) Two soap bubbles of radii 2.0cm and 4.0cm respectively coalesce under isothermal conditions. If the surface tension of the soap solution is 2.5

x $10^{-2}Nm^{-1}$. Calculate the excess pressure inside the resulting soap bubble. *(4marks)*

(c) (i) State Bernoulli's principle. *(1mark)*

(ii)Explain the origin of the lift force on the wings of an aero plane at take-off. *(3marks)*

(ii)Water flows through a horizontal pipe of varying cross-section. If pressure of water is 8cm of mercury where the velocity of flow is $0.3ms^{-1}$, what is the pressure at another point where the velocity of flow is $0.8ms^{-1}$ *(4marks)*

8. (a) Define the following;

(i) Work

(ii) Energy

(iii) Power *(3marks)*

(b) State the conditions for a rigid body to be in mechanical equilibrium. *(2marks)*

(c) A mass of 5.0kg is suspended from the end A of a uniform beam of mass 1.5kg and length 2.0m. The end B of the beam is hinged in a vertical wall. The beam is kept horizontal by an inextensible rope attached to A and to a point C in the wall at a height 0.75m above B.

(i) Draw a sketch diagram to show the forces acting on the beam. *(2marks)*

(ii) Calculate the tension in the rope. *(3marks)*

(iii) Calculate the force exerted on the beam by the hinge. *(5marks)*

(d) A car of mass 1000kg climbs a track which rises by 1.0m for every 2.0m covered along the track. The speed of the car at the bottom of the track is $36.0kmh^{-1}$. If the coefficient of kinetic friction is 0.3 and the engine exerts a force of 4000N, how far up the track does the car move before coming to rest. *(5marks)*

9. (a) (i) What is a black body? *(1 mark)*

(ii) Explain with the aid of a diagram, how a black body can be approximated. *(3 marks)*

(iii) With the aid of sketch graphs explain the salient features of the spectral distribution of black body radiation. *(4 marks)*

(b) Give four properties of ultraviolet radiation. *(2 marks)*

(c) Describe an experiment to compare the energy radiated by two surfaces of different nature. *(4 marks)*

(d) (i) State Stefan's law. *(1 mark)*

(ii) The earth receives energy from the sun at the rate of $1.4 \times 10^3$ W $m^{-2}$. If the ratio of the radius of the earth's orbit to the sun's radius is 216, calculate the surface temperature of the sun. *(5 marks)*

10. (a) Define the following terms;

(i) Specific latent heat of vaporization of a liquid. *(1 mark)*

(ii) Coefficient of thermal conductivity. *(1 mark)*

(b) With the aid of a labeled diagram, describe an experiment to measure the specific latent heat of vaporization of water by an electrical method. *(7 marks)*

(c) An appliance rated 240V, 200W evaporates 20g of water in 5 minutes. Find the heat loss if specific latent heat of vaporization is $2.26 \times 10^6\ JKg^{-1}$. *(3 marks)*

(d) Explain why at a given external pressure a liquid boils at constant temperature. *(4 marks)*

(e) With the aid of suitable sketch, graphs, explain the temperature distribution along lagged and unlagged metal rods, heated at one end. *(4 marks)*

11. (a) What is meant by a

(i) Kelvin. *(1 mark)*

(ii) Fundamental interval. *(1 ma*

(b) (i) With the aid of a labeled diagram, describe how the temperature of furnace may be measured. *(6 marks)*

(ii) State two advantages of the method used in (b) (i) above. *(2 marks)*

(c) A resistance thermometer conducted currents of 50mA, 10mA and 20mA at the freezing point of water, boiling point and unknown temperature $\theta$ respectively. Given that the thermometer was operated at a constant voltage, determine the unknown temperature on the thermodynamic scale. *(4 marks)*

(d) (i) Distinguish between saturated and unsaturated vapours. *(2 marks)*

(ii) A long uniform horizontal capillary tube sealed at one end and open to air at the other contains air trapped behind a short column of water. The length of trapped air column at temperatures of 27°C and 87°C are 10.0cm and 360.0cm respectively. If the saturation vapour pressures are $4 \times 10^3$ $Nm^{-2}$ and $5.2 \times 10^4$ $Nm^{-2}$ respectively. Calculate the pressure. *(4 marks)*

12. (a) Define temperature gradient. *(1 mark)*

(b) (i) Describe an experiment to determine the thermal conductivity of a piece of cork. *(7 marks)*

(ii) State the precautions taken in the experiment in (b) (i) above. *(2 marks)*

(c) A metal boiler is 2.5cm thick. If 45kg of water is evaporated from the boiler per $m^2$ per hour.

(i) Find the difference in temperature between the inner and outer surfaces of the boiler. *(3 marks)*

(ii) Calculate the heat current. 9Specific latent heat of vaporization of water is $2.26 \times 10^6 Jkg^{-1}$, Thermal conductivity of metal boiler = $380 Wm^{-1}K^{-1}$). *(2 marks)*

(d) (i) Define solar constant. *(1 mark)*

(ii) Assuming the sun is a sphere at a temperature of 6000K, estimate the temperature of the surface of mars if it is a distance of $2.32 \times 10^{11}$m

from the sun and both the sun and mars are in radioactive equilibrium. *(4 marks)*

13. (a) What is meant by the following as applied to thermometry?

(i) Kelvin. *(1 mark)*

(ii) Triple point. *(1 mark)*

(b) The resistance $R_\theta$ of platinum varies the temperature $\theta^o$ C measured on the gas thermometer according to the equation $R_\theta = R_0 (1 + 7\theta + 2\times10^{-2}\ \theta^2)$. Calculate the temperature as measured by the resistance thermometer when the gas thermometer measures 60° C. *(4 marks)*

(c) (i) What is meant by a cooling correction? *(1 mark)*

(ii) Explain how a cooling correction can be obtained for a poor Conductor. *(5 marks)*

(iii) Explain why a baby must be wrapped well in a woollen cloth on a cold day. *(3 marks)*

(d) (i) Define specific heat capacity of a substance. *(1 mark)*

(ii) The temperature of 60 g of a liquid contained in a calorimeter is raised from 18°C to 48°C in 520 s, by an electrical heater dissipating at 10.0 W. When 120 g of liquid is used and the same change in temperature occurs in the same time, the power of the heater is 16.5 W. Calculate the specific heat capacity of the liquid. *(4 marks)*

14. (a) (i) Define *boiling point* of a liquid. *(1 mark)*

(ii) Use the kinetic theory to explain how evaporation causes cooling. *(3 marks)*

(b) (i) Define the following terms; *a saturated vapour* and *unsaturated vapour pressure*. *(2 marks)*

(ii) Explain the effect of volume on the saturated vapour pressure at constant temperature. *(3 marks)*

(c) Distinguish between an Isothermal change and an adiabatic change. *(2 marks)*

(d) Two litres of Nitrogen gas at a pressure of $1.01 \times 10^5$ Pa, and at a temperature of 27°C is heated at a constant pressure until it doubles. It is then cooled at a constant volume until its pressure is $2.5 \times 10^4$ Pa. The gas is then compressed adiabatically to its original volume. The ratio of $\frac{C_p}{C_v} = 1.4$ for nitrogen.

(i) Show the above processes on a labelled diagram. *(2 marks)*

(ii) Calculate the final temperature of the gas. *(4 marks)*

(iii) Find the pressure of the gas at the end of the process. *(3 marks)*

15. (a) (i) State the assumptions made in the derivation of the gas equation, $P = \frac{1}{3} \rho \overline{c^2}$ *(2 marks)*

(ii) State Dalton's law of partial pressures. *(1 mark)*

(iii) Use the expression $P = \frac{1}{3} \rho \overline{c^2}$ to deduce Dalton's law. *(3 marks)*

(b) (i) Define coefficient of thermal conductivity. *(1 mark)*

(ii) State two factors that determine the rate of heat transfer through a material. *(2 marks)*

(c) Describe with the aid of a labelled diagram, an experiment to measure the thermal conductivity of aluminium. *(6 marks)*

(d) (i) State the laws of black body radiation. *(2 marks)*

(ii) The filament of a bulb is 0.5 m long and its radius is 0.1 mm. The filament melts when it is connected across 240 V and the current flowing through it is 0.40 A. Calculate the temperature at which the filament melts. *(3 marks)*

## MODERN PHYSICS

16. (a) State Bohr's postulates of the hydrogen atom. *(2 marks)*

(b) Define the terms ionization energy and excitation energy. *(2 marks)*

(c) The energy levels in a mercury atom are -10.4 eV, -5.5 eV, -3.7 eV and -1.6 eV.

(i) Find the ionization energy of mercury in joules. *(2 marks)*

(ii) bombarded with an electron of energy

(d) (i) Explain the successes and failures of Rutherford's model of an atom. *(3 marks)*

(ii) Show that when the $\alpha$ – particles collide head on with an atom of atomic number Z, the closest distance of approach to the nucleus $x$ is given by $x = \frac{Ze^2}{\pi \varepsilon_0 m v^2}$, where e is the electronic charge, $m$ the mass of an electron and $v$, the velocity of $\alpha$ – particles. *(3 marks)*

(e) Explain the emission spectrum of hydrogen. *(4 Marks)*

17. (a) (i) Distinguish between radioactivity and nuclear fission. *(2 marks)*

(ii) Define binding energy of a nucleus. *(1 mark)*

(b) (i) What is half-life of a radioactive substance? *(1 mark)*

(ii) Derive the relationship between half-life and the decay constant of a radioactive substance. *(3 marks)*

(c) A nucleus of uranium 238 disintegrates with the emission of a nucleus X and an alpha particle.

(i) Write down the equation for the reaction. *(1 mark)*

(ii) Find the energy released in the reaction.

Mass of $^{238}_{92}U = 238.12492\ u$

Mass of X $= 234.11650\ u$

Mass of $^{4}_{2}He = 4.00387\ u$

$1\ u = 1.66 \times 10^{-27}$ kg $= 1.494 \times 10^{-12}$ J. *(5 marks)*

(d) A beam of electrons is accelerated through a potential difference of 1800 V and is directed mid-way between two horizontal plates of 4 cm and of separation 4 cm. The potential difference across the plates is 90 V.

(i) Calculate the speed of the electrons as they enter the region between the plates. *(3 marks)*

(ii) Describe the motion of the electrons between the plates. *(1 mark)*

(iii) Find the angle at which the electron beam emerges out of the fie
across the plates. *(3 marks)*

18. (a) State the laws of photo-electric emission. *(4 marks)*

(b) Sodium has a work function of 2.0 eV and is illuminated by radiation of wavelength 150 nm;

(i) Calculate the maximum speed of the emitted electrons. *(3 marks)*

(ii) Find the threshold frequency. *(3 marks)*

(c) With the aid of a well labelled diagram, describe how the stopping potential of a metal can be measured. *(5 marks)*

(d) (i) What are *positive rays*? *(1 mark)*

(ii) In a Bain bridge mass spectrometer, singly ionized atoms of $^{35}_{17}Cl$ and $^{37}_{17}Cl$ pass into the deflection chamber with a velocity of $10^5$ ms$^{-1}$. If the magnetic flux density in the chamber is 0.8 T, calculate the difference in the radii of the paths of the ions. *(4 marks)*

19. (a) What are *X-rays*? *(1 mark)*

(b) The diagram in figure 3 shows an X-ray spectrum of a metallic target bombarded by 40 kV electron beam.

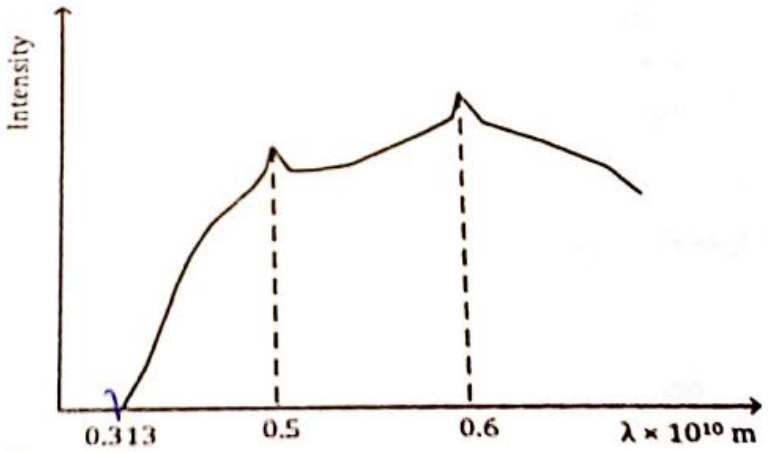



Fig. 3

(i) What features does the spectrum show? *(2 marks)*

Continuous cut off at 0.313 x10$^{10}$m

line spectrum of duration 0.6 x10$^{10}$m.

(ii) Calculate the value for $\frac{h}{e}$ from the data given on the diagram where h is Plank's constant while e is the electronic charge. *(3 marks)*

(iii) State two changes one would expect to be observed if the energy of the bombarding electrons were increased. *(2 marks)*

(c) (i) Describe Millikan's Oil drop experiment, to determine the charge of an electron. *(6 marks)*

(ii) Explain why large sized oil drops are not used in Millikan's experiment. *(2 marks)*

(d) In a Millikan's experiment, a charged oil drop of density 880 kg $m^{-3}$ is held stationary between two parallel plates 6.0 mm apart maintained at a potential of $10^3$ V. When the electric field is switched off, the drop is observed to fall a distance of 2.0 mm in 35.7 s. How many excess electrons does the drop carry? (Density of air = 1.29 kg $m^{-3}$, viscosity of air = $1.8 \times 10^{-5}$ Nsm$^{-2}$). *(4 marks)*

20. (a) (i) Define Avogadro's constant and Faraday's constant. *(2marks)*

(ii) Show that the charge carried by a monovalent ion is $1.6 \times 10^{-19}$C. *(2marks)*

(b) A charged oil drop of density 800kgm$^{-3}$ is held stationary between two parallel plates 5.0mm apart held at a potential difference of 105V. When the electric field is switched off, the drop is observed to fall a distance of 2.5mm in 36.0 seconds (viscosity of air = $1.8 \times 10^{-5}$Nsm$^{-2}$, density of air = 1.29kgm$^{-3}$)

(i) Calculate the radius of the drop. *(3marks)*

(ii) Estimate the number of excess electrons on the drop. *(3marks)*

(c) Describe how positive rays are produced. *(3marks)*

(d) (i) Explain the motion of an electron projected perpendicularly into a uniform magnetic field. *(3marks)*

(iii) An electron accelerated from rest by a p.d of 200V, enters perpendicularly into a uniform electric field of intensity $2.0 \times 10^5$Vm$^{-1}$. Find the magnetic flux density, B which must be applied perpendicularly to the electric field so that the electron passes undeflected through the fields. *(4marks)*

21. (a) Define the term:

(i) Threshold wavelength. *(1mark)*

(ii) Stopping potential. *(1mark)*

(b) Describe an experiment an experiment to verify Einstein's photo electric equation and use it to obtain Plank's constant. *(7marks)*

(c) A 165 MW beam of light of wavelength $3.0 \times 10^{-7}$m is incident on the cathode plate of a photocell.

(i) How many photons strike the cathode per second? *(3marks)*

(ii) If 90% of the incident photons emit photo electrons, find the quantity of charge released from the cathode in 1 second. *(3marks)*

(iii) If the work function of the cathode is 1.9eV, find the maximum kinetic energy of the photo electrons. *(2marks)*

(d) Explain the occurrence of band emission spectrum. *(3marks)*

22.(a) Define the following terms as used in the study of radioactivity

(i) Half-life *(1mark)*
(ii) Decay constant *(1mark)*

(b)(i) Uranium $^{238}U$ has a half-life of $4.5 \times 10^9$ years. If the earth solidified about $4.0 \times 10^9$ years ago, what fraction of $^{238}U$ then found on the earth remains un-decayed today? *(5marks)*

(ii) State any two uses of radioactivity. *(1mark)*

(c)(i) With use of a labelled diagram, describe the use of the main feature of a cathode ray oscilloscope (C.R.O) *(8marks)*

(ii) State any two uses of a C.R.O. *(1mark)*

(d) With the time base switched off, an alternating voltage with root-mean-square value 2.82 V is connected across the Y-plates. If a vertical trace of length 4.0 cm is formed on the screen, find the value at which the gain control of the C.R.O is set. *(2marks)*

END

P510/2

Physics

Paper 2

July-August 2023

2 ½ Hours

UGANDA MUSLIM TEACHERS' ASSOCIATION

UMTA JOINT MOCK EXAMINATIONS 2023

UGANDA ADVANCED CERTIFICATE OF EDUCATION

Physics

Paper 2

2 Hours 30 Minutes

**INSTRUCTIONS TO CANDIDATES:**

*Answer only **five** questions, including at least **one** question from each of the sections **A**, **B**, **C** and **D** but **not** more than **one** question from either section **A** or **B**.*
*Any additional question(s) answered will **not** be marked.*
*Mathematical tables and squared paper will be provided where need be.*
*Non-programmable scientific calculators may be used.*
*Begin each question on a fresh page of the answer sheets / booklet provided.*

**Assume where necessary:**

| | | |
|---|---|---|
| *Acceleration due to gravity, g* | = | $9.81\ m\ s^{-2}$ |
| *Speed of light in Vacuum, c* | = | $3.0 \times 10^{8}\ m\ s^{-1}$ |
| *Speed of sound in air,* | = | $340\ ms^{-1}$ |
| *Electronic charge, e* | = | $1.6 \times 10^{-19}\ C$ |
| *Electronic mass, $m_e$* | = | $9.11 \times 10^{-31}\ kg$ |
| *Permeability of free space, $\mu_o$* | = | $4.0\pi \times 10^{-7}\ H\ m^{-1}$ |
| *Permittivity of free space, $\varepsilon_0$* | = | $8.85 \times 10^{-12}\ Fm^{-1}$ |
| *The Constant, $\frac{1}{4\pi\varepsilon_o}$* | = | $9.0 \times 10^{9}\ F^{-1}\ m$ |
| *Planck's constant, h* | = | $6.6 \times 10^{-34}\ Js$ |
| *Avogadro's number, NA* | = | $6.02 \times 10^{23}\ mol^{-1}$ |
| *One electrons volt (eV)* | = | $1.6\ X\ 10^{-19}$ |
| *Specific heat capacity of water* | = | $4.2\ X\ 10^{3}\ Jkg^{-1}\ k^{-1}$ |
| *Resistivity of Nichrome wire at 25°C* | = | $1.2\ X\ 10^{-6}\ \Omega m$ |

## SECTION A:

1. (a) (i) State the laws of reflection of light. (02 marks)

(ii) Derive an expression relating the focal length, $f$, and radius of curvature $r$, of a convex mirror. (04 marks)

(b) (i) Define **critical angle** as applied to light. (01 mark)

(ii) Explain how total internal reflection is applied in rear reflectors. (03 marks)

(c) (i) Describe an experiment in which the refractive index of a liquid can be determined using an air cell. (05 marks)

(ii) Monochromatic light is made incident at an angle of $43^0$ on a glass prism of refracting angle $65^0$ in air. If the emergent light just grazes the other refracting surface of the prism, find the refractive index of the glass material. (05 marks)

2. (a) (i) Define **refractive index** of a material. (01 mark)

(ii) A ray of monochromatic light moving in air is incident on a parallel - sided glass block of width, $h$ as shown in figure1. The glass block is made out of a material of refractive index, $n$.

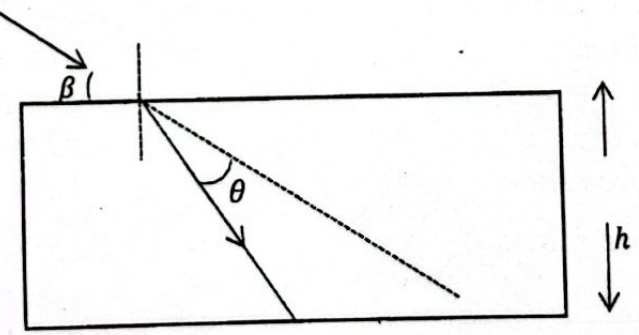



Fig.1

If the ray suffers a deviation, $\theta$, on first face of the block, show that the ray will take time, $t$, to emerge from the opposite face of the block given by;

$$t = \frac{nhcosec(\theta+\beta)}{c}$$

Where c is speed of light in vacuum. (03 marks)

(b) Define the following as applied to lenses and optical instruments;

(i) **focal length** (01 mark)

(ii) **angular magnification** (01 mark)

(c) A thin liquid lens is formed between a bi-convex lens of focal length 10 cm and a plane mirror. The focal length of the combination is found to be 16.0cm; when the lens is turned over the focal length of the combination is 16.5cm. Calculate the refractive index of the liquid if the refractive index of the glass is 1.5. (05 marks)

(d) (i) With the aid of a labeled diagram, describe how a Galilean telescope works in normal adjustment. (05 marks)

(ii) Explain the limitation of the telescope in (c)(i) above. (02 marks)

(c) State **two** differences between Microscopes and telescopes. (02 marks)

## SECTION B

3. (a) What is meant by the following;

(i) **Beats?** (01 mark)

(ii) **Doppler effect?** (01 mark)

(b) A radar speed gun emitting radio waves of frequency $f$ is pointed at an approaching car moving at speed, $v$.

(i) Derive the expression for frequency, $f_b$ of the beats registered by the speed gun. (03 marks)

(ii) Calculate speed of the car if $f = 6.0MHz$ and $f_b$=1.8Hz. (02 marks)

(c) (i) Define **fundamental note** and a **harmonic** in sound. (02 marks)

(ii) Explain why a note emitted by a string can easily be distinguished from that of a turning fork with which it is in unison. (03 marks)

(d) A string of length **1m** and mass **0.5g** is fixed at both ends and kept under tension of 20N. The string is plucked at a point 25cm from one end. Find the frequency of the note emitted by the string. (03 marks)

(e) Describe how the effect of increasing tension in a stretched string on its fundamental frequency may be investigated. (05 marks)

4. (a) (i) State Huygen's principle. (01 mark)

(i) Use Huygen's principle to show that the angle of incident is equal to the angle of reflection of light. (05 marks)

(b) (i) Define the term diffraction as applied to a light wave. (01 marks)

(ii) Describe an experiment in which the wave length of light can be determined using a diffraction grating and a spectrometer. (06 marks)

(c) (i) What is meant by interference of light waves? (01 marks)

(ii) Explain why a series of bright and dark lines are observed in an air wedge when irradiated normally with a monochromatic light. (03 marks)

(d) Two plane glass plates which are in contact at one edge are separated by a piece of metal foil **12.5cm** from that edge. Interference fringes parallel to the line of contact are observed in reflected light of wavelength $5.46 \times 10^{-7}$m and are found to be 1.50mm apart. Find the thickness of the foil. (04 marks)

## SECTION C

5. (a) (i) Define **magnetic flux density** and **a magnetic moment.** (02 marks)

(ii) Write down the expression for magnetic flux density at the centre of a plane circular coil of **N** turns, radius **R**, and carrying a current **I** in a vacuum. (01 mark)

(b) A short wire forming part of a current balance of length 2.5cm is at the centre of a coil of radius 8.0cm of 40 turns each carrying a current of 10.0A. Calculate the magnetic force experienced by the wire if a current through it is 3.0A. (04 marks)

(c) With the aid of a diagram, describe an experiment to show how the force acting on a conductor carrying current in a magnetic field depends on the magnitude of the current in the conductor. (05 marks)

(d) (i) Explain with the aid of a sketch diagram and relevant equations why a large voltage builds up across opposite faces of a conductor when a current is passed through it. (04 marks)

(ii) State the effect of increasing temperature on voltage developed in d(i). (01 mark)

(e) A slice of a semi-conductor is 2.0mm thick and carries a current of 50mA. A magnetic field flux density 0.49T correctly applied, produces a maximum hall voltage of 420mV between the edges of the slice. Calculate the number of free charge carriers per unit volume. (03 marks)

6. (a) (i) State the **laws** of electromagnetic induction. (02 marks)

(ii) Describe an experiment to verify Faraday's law of electromagnetic induction. (05 marks)

(b) Figure 2 shows a loop of wire has its shape bent into a semi-circle of radius 20cm. The normal to the plane of the loop is parallel to a uniform magnetic fieldof flux density 0.85T .

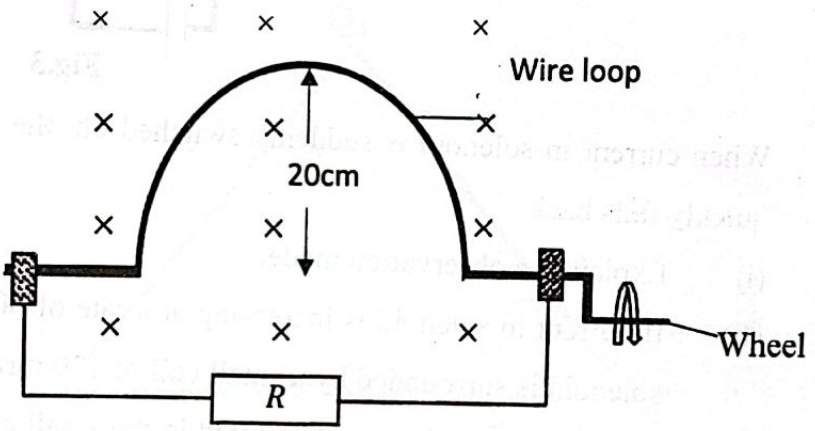



**Fig.2**

Starting with the position shown in diagram, the loop is rotated through half a revolution,

(i) find the change in magnetic flux linking the loop. (03 marks)

(ii) if the change in **(i)** takes **0.28s**, and $R = 15\Omega$, calculate the current that flows through $R$. (03 marks)

(c) (i) What is meant by **back emf** in a dc motor? (01 mark)

(ii) Show that the ***emf*** induced in a motor rotating at $\omega$ radians per second in a radial magnetic field of flux density $B$ is $E = \omega NBA$, where $N$ is the number of turns and $A$ is the area of the coil. (04 marks)

(b) **Figure 2** shows a small disc of copper lying on top of a vertical solenoid of 300 turns of wire per metre and of radius 3.0cm.

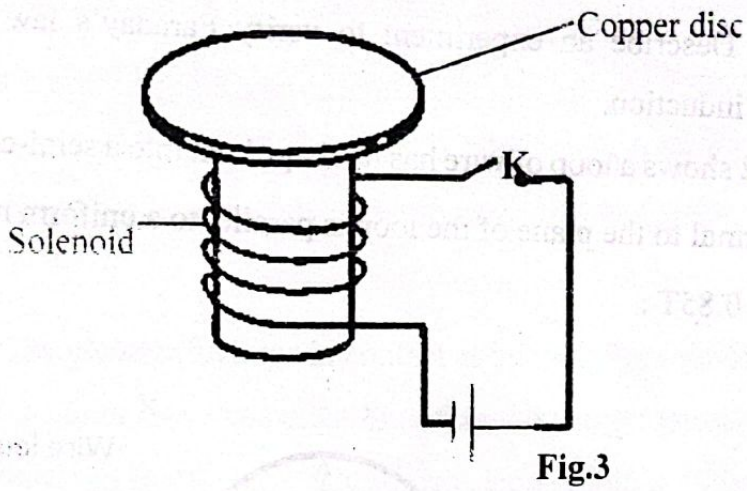



**Fig.3**

When current in solenoid is suddenly switched on, the disc flies up and very quickly falls back

(i) Explain the observation made. (03 marks)

(ii) If current in solenoid is increasing at a rate of **50A** per second, and the solenoid is surrounded by a small coil of 120 turns wound tightly round its middle, find the emf generated in the small coil while the current in solenoid is increasing. (04 marks)

(c) (i) Define the term **root mean square** value of alternating current. (01 mark)

(ii) With aid of a diagram, describe how a hot – wire ammeter is used to measure alternating current. (04 marks)

(d) A capacitor of **16.0 *F*** and an inductive coil of **300Ω** resistance are connected in series across a **20V, 50Hz** ac supply to form part of a radio circuit. The current obtained is **40mA.**

(i) Calculate the inductance of the coil. (04 marks)

(ii) find the resonant frequency of the circuit. (02 marks)

$X_L = \omega L$

$L$

## SECTION D

8. (a) (i) What is meant by the term **electrostatic induction**? (01 mark)

(ii) With aid of diagrams, describe how a metal sphere can be charged positively at zero potential. (04 marks)

(b) (i) Define electric field intensity and electric potential energy. (02 marks)

(ii) Derive an expression for electric field intensity perpendicular to a charged conductor of surface charge density $\delta$ in air. (03 marks)

(c) Charges $Q_1$, $Q_2$ and $Q_3$ of magnitude $-3\mu C$, $+2\mu C$ and $-5\mu C$ respectively are situated vertices of an equilateral triangle of side 10cm in a vacuum as shown in the figure 4.

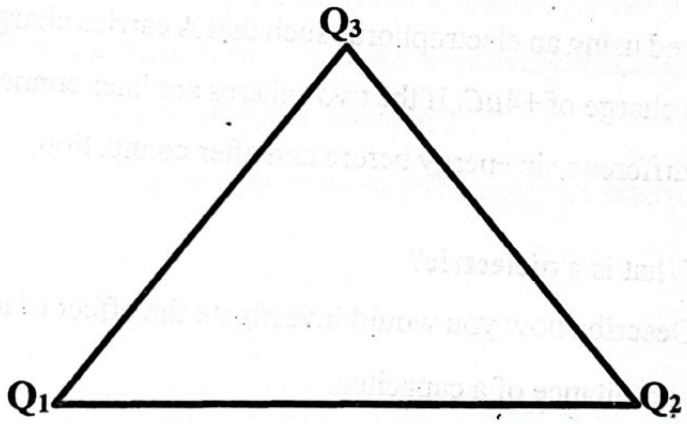



**Fig.4**

Calculate;

(i) the net force on $Q_1$ (04 marks)

(ii) the potential energy $Q_3$ (03 marks)

(d) Explain how electrostatics is applied in oil spray gun. (03 marks)

9. (a) (i) Define **capacitance** and a **farad** as applied to a capacitor. (02 marks)

(ii) Derive the expression for the effective capacitance of three capacitances of capacitances $C_1$, $C_2$ and $C_3$ connected in series. (04 marks)

(b) A capacitor is connected a dc supply of emf, **E** as shown in figure 5.

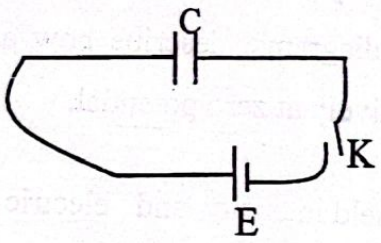



**fig.5**

(i) On same axes, sketch graphs showing variation of voltage and current from the time switch, **K** is closed. (02 marks)

(ii) Explain why the capacitor stores energy on charging. (02 marks)

(c) Two isolated metal spheres **A** and **B** of radius 80mm and 50mm respectively are charged using an electrophorus such that **A** carries charge of $+10\mu C$ while **B** carries charge of $+4\mu C$. If the two spheres are later connected using a wire, find the difference in energy before and after connection. (05 marks)

(d) (i) What is a **dielectric**? (01 mark)

(ii) Describe how you would investigate the effect of a dielectric on capacitance of a capacitor. (04 marks)

10. (a) Define the following as applied to a battery

(i) **Electromotive force** (01 mark)

(ii) **Internal resistance.** (01 mark)

(b) Explain why it is easier to start a car engine on a hot day than on a cold day. (03 marks)

(c) (i) Explain the principle of a potentiometer. (03 marks)

(ii) Describe how you would adapt the potentiometer in (i) to determine the emf of a thermocouple. (05 marks)

(d) In figure 6, **AB** is a uniform slide wire of length **100cm** and resistance **15Ω.Y** is a driver cell of ***e.m.f*** **3.0V** and negligible internal resistance.

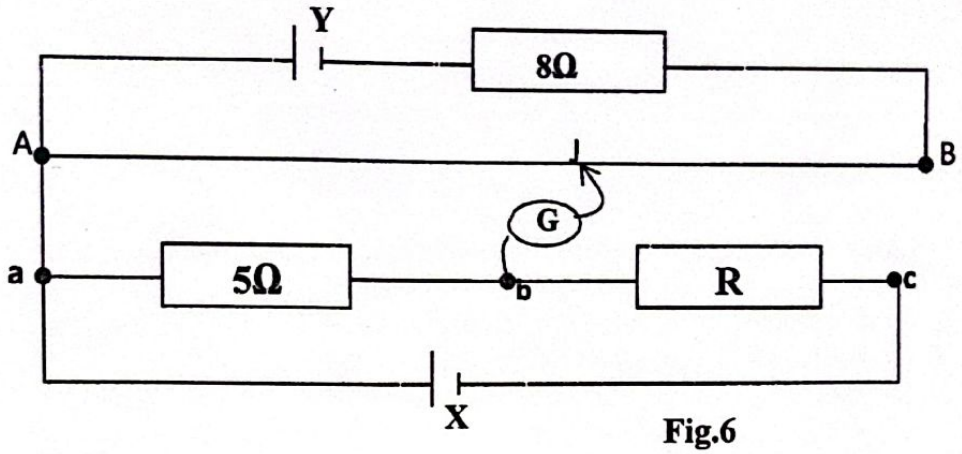



**Fig.6**

When the galvanometer, **G**, is connected in turn to points ***b*** and ***c***, the balance lengths are 62.0cm and 75.0cm respectively. Calculate the

*(i)* current flowing through the resistor, **R**. (04 marks)

(ii) e.m.f of cell **X** given that the cell has negligible internal resistance. (03 marks)

**END**

P425/1
PURE MATHEMATICS
JULY/AUGUST 2023
PAPER 1
2 ½ HOURS

**TORORO ARCHDIOCESE EXAMINATIONS BOARD**

**Uganda Advanced Certificate of Education**

**MOCK EXAMINATIONS 2023**

Mathematics

Paper 1

**2 ½ Hours**

**INSTRUCTIONS TO CANDIDATES**

- *Answer **all** the **eight** questions in section **A** and any **five** from section **B**.*
- *Any additional question(s) answered will not be marked.*
- *All necessary working must be shown clearly.*
- *Begin each answer on a fresh sheet of paper*
- *Squared paper is provided.*
- *Silent non programmable scientific calculators and mathematical tables with a list of formulae may be used.*

## SECTION A: (40 MARKS)

***Answer all questions in this section.***

1. Prove that $\tan^{-1}\frac{\sqrt{3}}{2} + tan^{-1}\frac{\sqrt{3}}{5} = \frac{\pi}{3}$ (5 marks)

2. Solve the simultaneous equations: $\log y = 2\log(x-1) and\ xy = 2$ (5marks)

3. Determine the vector equation of the line joining the points $A\ (1,1,4) and$ $B\ (3\ -1, 5)$ and show that . It is parallel to the plane $3x + 4y + 2z = 12.$

(5 marks)

4. Find the equation of the normal to the curve $y^2 + 3xy = 2x^2 - 1\ at\ (2,1)$

(5 marks)

5. Show that the equation of the tangent to the ellipse whose parametric equations are $x = 4\cos\theta\ and\ y = 3sin\theta\ at\ the\ point\ where$

$\theta = \frac{\pi}{3}\ is\ 3x + 4y\sqrt{3} = 24$ (5 marks)

6. *Evaluate* $\int_0^{\frac{\pi}{3}} sin\,2x\,cosx\,dx.$ (5 marks)

7. Solve the inequality: (5 marks)

$$\frac{x+5}{x-2} < \frac{x+2}{x-4}$$ (5 marks)

8. By method of small changes evaluate: $\sqrt[3]{67.6}$ to three decimal places. (5 marks)

## SECTION B (60 MARKS)

**Answer any five questions from this section. All questions carry equal marks.**

9. (a) Expand $(1 - 3x)^{\frac{1}{3}}$ as far as the term in $x^3$. Use your expansion to find $\sqrt[3]{24}$ to 3sf. (5 marks)

(b) The sum of the first n – terms of an Arithmetic progression is $n^2 + 5n$, determine the first four terms of the series. (7 marks)

10. (a) Prove that the circles $x^2 + y^2 - 6x - 12y + 40 = 0$ and $x^2 + y^2 - 4y = 16$ are orthogonal. (5 marks)

(b) P $(ap^2, 2ap)$ is any point on the parabola $y^2 = 4ax$ and the chord from $P$ passing through the focal point of the parabola meets the parabola again at $Q\ (aq^2, 2aq)$. Show that the locus of the mid –point M $of\ PQ$ is $y^2 = 2a\,(x - a)$ as $P\ and\ Q$ vary on the parabola. (7 marks)

11. (a) Show that the locus of $\left|\dfrac{Z - 1}{Z + 1}\right| = 2$ is a circle . Hence determine its centre and radius. (5 marks)

(b) Use DeMoivre's theorem to prove that if $z = \cos\theta + i\sin\theta$ , then $2\cos\theta = z + \frac{1}{z}$ and $2\cos n\theta = z^n + \frac{1}{z^n}$ where $n$ is positive. Hence, solve the equation $3z^4 - z^3 + z^2 + 2z^2 - z + 3 = 0$. (7 marks)

12. Find $\int \frac{3x^3 + x}{x^4 - 81}\,dx$ (12 marks)

13. (a) Solve the equation $\frac{tan\theta}{cosec\theta} + \frac{1}{cosec\theta} = tan\theta + 1$ for

$0^o \leq \theta \leq 360^o$ (6 marks)

(b) If A, B and C are vertices of a triangle, prove that

$\sin B + \sin C - \sin A = 4\cos\frac{A}{2} \sin\frac{B}{2} \sin\frac{C}{2}$. (6 marks)

14. (a) if $y^2 - 2y + 2x = 0$ show that $\frac{d^2y}{dx^2} = \frac{1}{(1-y)^3}$ (6 marks)

(b) Given that equation of a curve *is* $y = \frac{e^{2x}}{1+e^{2x}}$, show that the gradient of the curve at the point for which x = in3 is $\frac{9}{50}$. (6 marks)

15. (a) If point C divides the line joining the points A (3,-4,6) and B (1 , 2, 1) externally in the ratio 2:3. Determine the coordinates of C. ( 5 marks)

(b) The lines $L_1$ and $L_2$ have the equations $\mathbf{r}_1 = \begin{pmatrix} 3 \\ 1 \\ -1 \end{pmatrix} + \lambda \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$ and

$\mathbf{r}_2 = \begin{pmatrix} 2 \\ 5 \\ 0 \end{pmatrix} + \mu \begin{pmatrix} 1 \\ -1 \\ 1 \end{pmatrix}$ respectively . Determine:

(i) The point of intersection of $L_1$ and $L_2$.

(ii) The Cartesian equation of plane containing $L_1$ and $L_2$. (7 marks)

16. (a) Solve the differential equation $\frac{dy}{dx} + 2y\tan x = \sin x$, given that $y\left(\frac{\pi}{3}\right) = 0$.

(5 marks)

(b) When a uniform rod is heated, it expands so that the rate of increase of its length, *l*, with respect to the temperature 0°C is proportional to the length. When the temperature is 0°C, the length of the rod is *L*.

(i) Form and solve the differential equation that models this data; express l as a function of 0 and illustrate it with a sketch.

(ii) Given that the length of the rod has increased by 1% when the temperature is 20°C, find the value of 0 at which the length of the rod has increased by 5%. (7 marks) **END**

P425/2
APPLIED MATHEMATICS
Paper 2
JULY/AUGUST 2023
3 Hours

# TORORO ARCHDIOCESE EXAMINATIONS BOARD

## Uganda Advanced Certificate of Education

## MOCK EXAMINATIONS JULY - AUGUST 2023

## APPLIED MATHEMATICS

**Paper 2**

**3 Hours**

**INSTRUCTIONS TO CANDIDATES**

*Attempt all the eight questions in section A and any **five** questions from Section B.*

*Any additional question(s) answered will **not** be marked.*

***All** necessary working **must** be shown clearly.*

*Begin each answer on a fresh sheet of paper.*

*Graph paper is provided.*

*Silent, non-programmable scienfitic calculators and mathematical tables with a list of formulae may be used.*

*In numerical work, take acceleration due to gravity g to be $9.8ms^{-2}$.*

**Turn Over**

## SECTION A ( 40 MARKS)

1. Two events A and B are such that $(A) = \frac{4}{7}$, $P(AnB') = \frac{1}{3}$ *and* $P(A/B) = \frac{5}{14}$. Find;

   (i) $P(AnB)$

   (ii) $P(B)$ (5marks)

2. Acar of mass 900kg travels up ahill inclined at $10^0$ to the horizontal against a constant resistance force of 250N. If its maximum speed is 45kmh$^{-1}$. Determine;

   (i) The power output of the engine

   (ii) Initial acceleration when it reaches the level road at the hill. (5marks)

3. The table below shows the values of a function $f(x)$ with a certain range of $x$.

| $x$ | 1.2 | 2.4 | 3.6 | 4.8 |
|---|---|---|---|---|
| $f(x)$ | 0.1708 | 0.1679 | 0.1650 | 0.1622 |

   Using linear interpolation or extrapolation, determine,

   (i) $f(5.3)$

   (ii) $x\ when\ f(x) = 0.1685$ (5marks)

4. The discrete random variable X can take values 0,1,2 and 3 only.

   Given $P(x \leq 2) = 0.9, P(x \leq 1) = 0.5\ and\ E(x) = 1.4$. Find;

   (i) $p(x = 1)$

   (ii) $p(x = 0)$ (5marks)

5. A body is projected with an initial speed of 12ms$^{-1}$ at an upward angle of $30^0$ t0 the horizontal from the top of a tower 25m high. Find how long the body takes to hit the ground level. (5marks)

$$Y_{min} = \frac{P_{min} - Q_{max}}{R_{max}}$$

$$Y_{max} = \frac{P_{max} - Q_{min}}{R_{min}}$$

6. Find the limits within which the values of $Y = \frac{P-Q}{R}$ lie given that P=3.6, Q=2.13 and R=0.25. Hence find the maximum possible error in Y. (5marks)

7. The probability that a certain type of seeds will fail to germinate is 0.4. If ten of those seeds are selected at random, find the probability that at least three will germinate.

(5marks)

8. A particle Q is observed to execute simple harmonic motion with amplitude 2m and period 2seconds. If Q is initially moving at maximum speed, determine the;

(i) distance moved by the particle until its speed is Half the maximum value.

(ii) time taken by the particle to travel the distance in (i) above (5marks)

## SECTION B ( 60 MARKS )

9. The distribution of ages in a certain school is as given below

| Age(years) | 5-<20 | <30 | <40 | <50 | <60 | <65 |
|---|---|---|---|---|---|---|
| Number | 7 | 17 | 28 | 5 | 5 | 4 |

(a) Estimate,

(i) the mean

(ii) the variance ( 4marks )

(b) Draw a histogram and use it to estimate the mode (4marks)

(c) If this was a random sample taken from a population which is normally distributed, calculate the 95% confidence limits for the population mean.

(4marks)

$X \sim N(\mu, \sigma^2)$

10. (a) Abody A of mass 2kg is moving with velocity $(2i + 4j)ms^{-1}$ when it collides with a body B of mass 3kg moving with velocity $(3i + 4j)ms^{-1}$.During collision the two bodies coalesce

(i) Find the velocity of the combined body immediately after collision interms of $i$ and $j$

(ii) Calculate the loss in kinetic energy as a result of the collision (6marks)

(b) A pile driver of mass 2000kg falls from a height of 4m onto a pile of mass 1000kg and the two move together without rebounding. If the pile is driven 8cm into the ground , find the average resistance of the ground. (6marks)

11. (i) Show that the iterative formula for approximating the root of $f(x) = 0$ by the Newton Raphson's process for the equation $e^{2x} + 4x - 5 = 0$ is $\frac{e^{2x_n}(2x_n - 1) + 5}{2e^{2x_n} + 4}$ $for\ n = 0,1,2, \ldots$

(iii) show that the root of the equation in (i) above lies between 0 and 1. Hence find the root correct to 2 significant figures. (4marks)

(iv) Draw a flow chart that can be used to find the root of the equation above (4marks)

12. $X$is a continuous random variable defined by $f(x) = \begin{cases} k(1 - 2x); & -1 \leq x < 0 \\ k(1 + 2x), & 0 \leq x \leq 2 \\ 0, & elsewhere \end{cases}$

(i) Sketch the graph of $f(x)$ , hence find the value of k. (4marks)

(ii) Determine $F(x)$, hence find the $50^{th}$ and $60^{th}$ percentile range(8marks)

13. (a) A particle A moves with velocity $(2i - 3j)ms^{-1}$ from a point (4,5). At the same instant a particle B moving in the same plane with a velocity $(4i + j)ms^{-1}$ passes through a point (0,-3). If after time t the particles collide at a point D, determine the value of t and the co-ordinates of D. (6marks)

(b)If instead the particles A and B in (a) above start simultaneously from points (-1,-1) and (4,4) moving with velocities $(\#2i + j)$ *and* $(i - 2j)$ respectively. Find the time for which A and B are closest together and the closest distance taken. (6Marks)

14. (a) A rectangle measures 4.6cm by 3.8cm, all the dimensions are rounded off. Find the relative error in the area. (4marks)

(b) (i) Use trapezium rule with 8 strips to estimate $\int_0^4 \frac{6}{3x+2} dx$,truncate your answer to 4dp

(ii) Calculate the percentage error in your estimation and state how this error may be reduced. (8marks)

15. The heights of sugar in acertain plantation follow a normal distribution. It is observed that 90% are above 55cm and 95% are below 85cm in height. Determine the;

(a) Mean and standard deviation of the height of sugarcanes.

(b) Probability that a sugar cane selected at random has heights between 60cm and 76cm. (12marks)

16. (a) A pump raises 5 tonnes of water every minute from a depth of 25m. The water is delivered through a pipe of cross-sectional area of $50cm^2$. If the density of water is $g/cm^3$, find the speed of water on emerging from the pipe. (6marks)

(b). In each minute pump draws $2.4m^3$ of water from a well 5m below the ground level through a pipe of cross-sectional area of $50cm^2$. Find,

(i) the speed with which the water leaves the pipe

(ii) the rate at which the pump is working if in fact the pump is only 75% efficient (i.e 25% of the power is lost in running of the pump). Find the rate at which it must work.

(6marks)

**END**

**P510/1**
**PHYSICS**
**Paper 1**
**July/Aug. 2018**
2½ hrs

***INTERNAL MOCK EXAMINATINS – 2018***

## *Uganda Advanced Certificate of Education*

# Physics Paper 1

2 hours 30 minutes

**INSTRUCTIONS TO CANDIDATES:**

*Attempt* **five** *questions, including at least* **one** *but* **not** *more than* **two** *questions from each of the sections* **A**, **B** *and* **C**. *Any additional question(s) answered will* **not** *be marked.*

*Non-programmable scientific calculators may be used.*

*Assume where necessary:*

| | | |
|---|---|---|
| *Acceleration due to gravity, g* | = | $9.81ms^{-2}$ |
| *Electronic charge, e* | = | $1.6 \times 10^{-19}C$ |
| *Electron mass* | = | $9.11 \times 10^{-31}kg$ |
| *Mass of the earth* | = | $5.97 \times 10^{24}kg$ |
| *Plank's constant, h* | = | $6.6 \times 10^{-34}Js$ |
| *Stefan's – Boltzmann's constant* $\sigma$ | = | $5.67 \times 10^{-8}WM^{-2}K^{-4}$ |
| *Radius of the earth* | = | $6.4 \times 10^{6}m$ |
| *Radius of the sun* | = | $7 \times 10^{8}m$ |
| *Radius of earth's orbit about the sun* | = | $1.5 \times 10^{11}m$ |
| *Speed of light in a vacuum, C* | = | $3.0 \times 10^{8}ms^{-1}$ |
| *Thermal conductivity of copper* | = | $390Wm^{-1}K^{-1}$ |
| *Thermal conductivity of aluminium* | = | $210Wm^{-1}K^{-1}$ |
| *Specific heat capacity of water* | = | $4200Jkg^{-1}K^{-1}$ |
| *Universal gravitational constant, G* | = | $6.67 \times 10^{-11}\ Nm^{2}kg^{-2}$ |
| *Avogadro's number,* $N_A$ | = | $6.02 \times 10^{23}mol^{-1}$ |
| *Surface tension of water* | = | $7.0 \times 10^{-2}Nm^{-1}$ |
| *Density of water* | = | $1000Kgm^{-3}$ |
| *Gas constant, R* | = | $8.31Jmol^{-1}K^{-1}$ |
| *Charge to mass ratio,* $^{e}/_{m}$ | = | $1.8 \times 10^{11}\ Ckg^{-1}$ |
| *The constant ,* $\frac{1}{4\pi\varepsilon_o}$ | = | $9.0 \times 10^{9}F^{-1}m$ |
| *Specific heat capacity of copper* | = | $400JKg^{-1}K^{-1}$. |
| *Specific latent heat of fusion of ice* | = | $3.3 \times 10^{5}JKg^{-1}$. |
| Faraday constant, *F* | = | $9.56\times 10^{4}Cmol^{-1}$ |

**TurnOver**

## SECTION A

1. (a) (i) State Archimedes principle. (01 mark)

(ii) Describe an experiment to determine the relative density of an irregular solid which floats in water. (03 marks)

(b) A solid weighs $237.5g$ in air and $12.5g$ when totally immersed in a fluid of density $900Kgm^{-3}$. Calculate the density of the liquid in which the solid would float with one fifth of its volume exposed above the liquid surface. (06 marks)

(c) (i) What is meant by viscosity. (01 mark)

(ii) Explain the effect of temperature on the viscosity of a liquid. (03 marks)

(d) (i) State the work – energy theorem. (01 mark)

(ii) A bullet of mass 100g moving horizontally with a speed of $420ms^{-1}$ strikes the block of mass $2000g$ at rest on a smooth table and becomes embedded in it. Find the kinetic energy lost if they move together. (05 marks)

2. (a) (i) Define centre of gravity. (01 mark)

(ii) Describe an experiment to find the centre of gravity of a regular piece of card board. (03 marks)

(b) Explain using the molecular theory the laws of solid friction. (07 marks)

(c) (i) Define surface tension. (01 mark)

(ii) Explain the origin of surface tension. (03 marks)

(d) Explain why rain drops hit the ground with less force than they should. (05 marks)

3. (a) State Newton's laws of motion. (03 marks)

(b) A body $\boldsymbol{X}$ of mass $m_1$ moves with velocity $u_1$ and collides head on elastically with another body, $\boldsymbol{Y}$ of mass $m_2$ which is at rest. If the velocities of $\boldsymbol{X}$ and $\boldsymbol{Y}$ are $v_1$ and $v_2$ respectively and given that $A = m_1/m_2$ show that;

(i) $\frac{u_1}{v_1} = \frac{A+1}{A-1}$ (04 marks)

(ii) $\frac{v_2}{v_1} = \frac{2A}{A-1}$ (03 marks)

(c) Describe an experiment to determine the acceleration due to gravity using a spiral spring of known force constant. (05 marks)

(d) Explain the following:

(i) A mass attached to a string rotating at a constant speed in a horizontal circle will fly off at a tangent if the string breaks. (02 marks)

(ii) A cosmonaut in a satellite which is in a free circular orbit around the earth experiences a sensation of weightlessness even though there is influence of gravitational field of the earth. (03 marks)

4. (a) (i) What is meant by simple harmonic motion? (01 mark)

(ii) State **four** characteristics of simple harmonic motion. (02 marks)

(b) A mass, $\boldsymbol{m}$ is suspended from a rigid support by a string of length, $\boldsymbol{X}$. The mass is pulled a side so that the string makes an angle, $\theta$ with the vertical and then released. Show that the mass executes simple harmonic motion with a period $T = 2\pi\sqrt{\frac{X}{g}}$. (05 marks)

(c) A horizontal spring of force constant $300Nm^{-1}$ fixed at one end has a mass of $3kg$ attached to the free end and resting on a smooth horizontal surface. The mass is pulled through a distance of $5.0cm$ and released. Calculate;

(i) angular speed, (02 marks)

(ii) maximum velocity attained by the vibrating body. (02 marks)

(iii) acceleration when the body is half way towards the centre from its initial position. (02 marks)

(d) (i) What is meant by a couple in mechanics? (01 mark)

(ii) State the conditions for equilibrium of a system of coplanar forces. (02 marks)

(e) Explain why a person standing near a railway line is sucked towards the railway line when a fast moving train passes. (03 marks)

## SECTION B

5. (a) (i) Define thermal conductivity. (01 mark)

(ii) Explain the mechanism of heat transfer in metals. (03 marks)

(b) A double glazed window has two glass sheets of thickness $5.0mm$, separated by a layer of air of thickness $1.2mm$. If the two inner air – glass surfaces have steady temperatures of $25^oC$ and $.5^oC$ respectively, find the:

(i) temperature of the outer – glass surfaces. (03 marks)

(ii) amount of heat that flows across an area of the window of $3m^2$ in 3 hours. (03 marks)

(Conductivity of glass = $0.72Wm^{-1}K^{-1}$ and that of air $= 0.025Wm^{-1}K^{-1}$)

(c) (i) What is a perfectly black body? (01 mark)

(ii) The energy intensity received by a spherical planet from a star is $1.5 \times 10^3Wm^{-2}$, The star is of radius $7.0 \times 10^5Km$ and is $1.4 \times 10^8Km$ from the planet. Calculate the surface temperature of the star. (04 marks)

(d) Explain the green house effect and how it is related to global warming. (05 marks)

6. (a) Define specific heat capacity of a substance. (01 mark)

(b) (i) Describe an electrical method for the determination of the specific heat capacity of a metal. (06 marks)

(ii) State the assumptions made in the above experiment. (02 marks)

(c) Steam at $100^oC$ is passed into a copper calorimeter of mass $150g$ containing $340g$ of water at $15^oC$. This is done until the temperature of the calorimeter and its content is $71^oC$. If the mass of the calorimeter and its contents is found to be $525g$ calculate the specific latent heat of vaporization of water. (06 marks)

(d) (i) State the assumptions made in the derivation of the expression

$P = \frac{1}{3}\rho C^{-2}$ for the pressure of an ideal gas. (02 marks)

(ii) Use the expression in (d) (i) above to deduce Dalton's law of partial pressures. (03 marks)

7. (a) Define a thermometric property and give **two** examples. (02 marks)

(b) The resistance, $R_\theta$ of platinum varies with temperature $\theta^o C$ as measured by a constant volume gas thermometer according to the equation:

$R_\theta = 50.0 + 0.17\theta + 3.0 \times 10^{-4}\theta^2$

(i) Calculate the temperature on the platinum scale corresponding to $60^o C$ on the gas scale. (06 marks)

(ii) Account for the difference between the two values and the temperature at which they agree. (02 marks)

(c) Use the kinetic theory of matter to explain the following observations:

(i) Saturated vapour pressure of a liquid increases with temperature. (03 marks)

(ii) Saturated vapour is not affected by a decrease in volume at constant temperature. (03 marks)

(d) An ideal gas of volume $100cm^3$ at s.t.p expands a diabatically until its pressure drops to a quarter its original value. Find the new volume and temperature if the ratio of the principal specific heat capacities is 1.4 (04 marks)

## SECTION C

8. (a) (i) What is meant by the terms: radio active, decay, half life and decay constant? (03 marks)

(ii) Show that the half –life $t_{\frac{1}{2}}$ of a radio isotope is given by $t_{\frac{1}{2}} = \frac{693}{\lambda}$ where $\lambda$ is the decay constant. (Assume the decay law $N = Noe^{-\lambda t}$). (03 marks)

(b) With the aid of a diagram describe the structure and action of a diffusion cloud chamber. (05 marks)

(c) The radio isotope $^{90}_{38}X$ decays by emission of $\beta -$ particles. The half – life of the isotope is 28.8 year. Determine the activity of $1g$ of the isotope.(05 marks)

(d) (i) What are cathode rays? (01 mark)

(ii) An electron accelerated by a $p.d$ of $1000V$ passes through a uniform electric field intensity crossed with a uniform magnetic field of flux density $0.3T$. If the electron emerges undeflected, calculate the electric field intensity. (03 marks)

9. (a) (i) Define space charge as applied to thermionic diodes. (01 mark)

(ii) Draw anode current – anode voltage curves of a thermionic diode for two different filament currents and explain their main features. (06 marks)

(b) Derive the expression for the amplification factor $\mu$ in terms of anode resistance, $R_a$ and mutual conductance, $g_m$ for a triode valve. (03 marks)

(c) A triode with mutual conductance $3mAV^{-1}$ and anode resistance of $10k\Omega$ is connected to a load resistance of $20k\Omega$. Calculate the amplitude of the output signal if the amplitude of the input signal is $30mV$. (04 marks)

(d) (i) What is a photon? (01 mark)

(ii) Explain using the quantum theory, the experimental observations on photo electric effect. (05 marks)

10. (a) A beam of $\alpha$ - particles is directed normally to a thin gold foil. Explain why

(i) most of the alpha particles past straight through the foil,(02 marks)

(ii) few alpha particles are deflected through angles more than $90^o$. (02 marks)

(b) Calculate the least distance of approach of a $4.0MeV$ alpha particles to the nucleus of a gold atom. (Atomic number of gold $= 79$). (04 marks)

(c) Explain, using suitable sketch graphs, how $X$ – ray spectra in an $X$ – ray tube are produced. (06 marks)

(d) A beam of $X$ – rays of wave length $9 \times 10^{-11}m$ is incident on a sodium chloride crystal of interplanar separation $9.0 \times 10^{-10}m$. Calculate the first order diffraction angle. (03 marks)

(e) (i) Distinguish between nuclear fussion and nuclear fission. (02 marks)

(ii) State the conditions necessary for each of the nuclear reactions in (e) (i) to occur. (01 mark)

**END**