NATIONAL UNIVERSITY OF COMPUTER AND EMERGING SCIENCES FAST

Final Exam Fall-2023

1 January, 2024 (9:00 am – 12:00 pm)

Course Code: NS (1001)	Course Name: Applied Physics
Instructor Name / Names: Mr. Javaid Qureshi, Ms. Rabia Tabassum, Mr. Muhammad Rahim, Mr. Waqar Ahmed	
Student Roll No:	Section :

Instructions: Return the question paper with your answer sheet. Read each question completely before answering it. There are **10 questions and 3 pages.** All the questions must be solved according to the sequence given in the question paper.

Total Time: 3 hours

Max Marks: 100

Q1: Vector (Total Marks 3, Estimated Time :5 mints) CLO 1

(a) What is the sum of the following four vectors in (i) unit vector notation, and as (ii) a magnitude and (iii) an angle? (02)

$\mathbf{A} = (2.00\ m)\mathbf{i} + (3.00\ m)\mathbf{j}$ $\quad \mathbf{B} = 4.00m$, at 65.0°

$\mathbf{C} = (-4.00\ m)\mathbf{i} + (-6.00\ m)\mathbf{j}$ $\quad \mathbf{D} = 5.00\ m$, at -235°

(b) Find the angle between the two vectors: $\mathbf{A} = 3\mathbf{i} - 3\mathbf{j} + 6\mathbf{k}$ and $\mathbf{B} = 5\mathbf{i} + 6\mathbf{j} - 8\mathbf{k}$. (01)

Q2: Motion in 1D and 2D (Marks 7, Estimated Time:10 mints) CLO2

(a) With the help of the following velocity– time graph (Fig-1), draw the acceleration versus time graphs. (03)

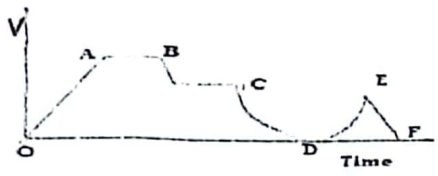

Fig-1

(b) A turtle crawls along a straight line, which we will call the x-axis with positive direction to right. The equation for the turtle's position as a function of time is

$$x(t) = 50 + 2t - 0.0625t^2$$

Find the turtle's initial velocity, initial position and initial acceleration. At what time "t" is the velocity of the turtle be zero? (04)

Q3: Motion in 2D (Marks 3, Estimated Time: 5 mints) CLO3

(a) In Fig2, a rescue plane flies at 198 km/h (=55.0 m/s) and constant height h = 500 m toward a point directly over a victim, where a rescue capsule is to land. (a) What should be the angle φ of the pilot's line of sight to the victim when the capsule release is made? Calculate. (03)

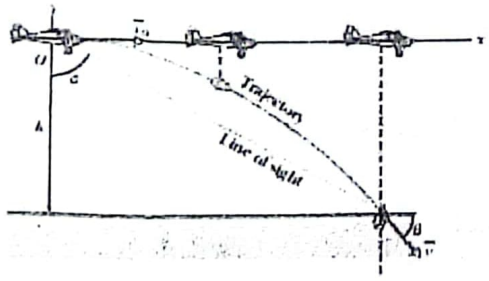

Fig-2

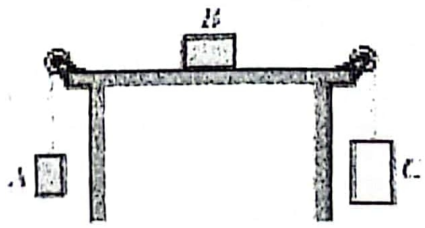

Fig-3

Q4: Newton's Law (Marks 7, Estimated Time :10 mints) CLO4

(a) Fig-3 shows three blocks attached by cords that loop over frictionless pulleys. Block B lies on a frictionless table; the masses are $M_A = 6$ kg, $M_B = 8$kg, and $M_C = 10$kg. When the blocks are released, what is the tension in the cord at the right (T_A tension at left, T_C tension at right)? (10)

Good Luck ☺

Q5: Oscillation (Marks 8, Estimated Time :15 mints) CLO5

(a) What is the phase constant for the harmonic oscillator with the velocity function v(t) given in Fig-4. If the position function x(t) has the form $x = x_m \cos(\omega t + \varphi)$? The vertical axis scale is set by $v_s = 4.0$ cm/s. (02)

(b) Fig-5 shows the kinetic energy K of a simple harmonic oscillator versus its position x. The vertical axis scale is set by $K_s = 4.0$ J. What is the spring constant? (02)

(c) What is damped oscillation, and how does it differ from undamped oscillation? Describe a real-world scenario where damped oscillations occur. (02)

(d) The acceleration $a(t)$ of a particle undergoing SHM is graphed in Fig-6. Which of the labeled points corresponds to the particle at $-x_m$? (ii) At point 4, is the velocity of the particle positive, negative, or zero? (iii) At point 5, is the particle at $-x_m$, at $+x_m$, at 0, between $-x_m$ and 0, or between 0 and $+x_m$? (02)

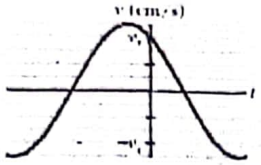

Fig-4

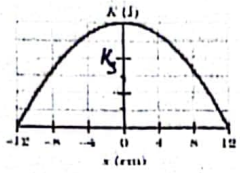

Fig-5

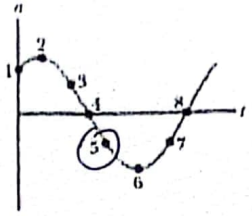

Fig-6

Q6: Wave motion (Marks 8, Estimated Time: 15 mints) CLO6

(a) A string is driven at a frequency of 5.00 Hz. The amplitude of the motion is 12.0 cm, and the wave speed is 20.0 m/s. Determine the angular frequency and wave number k for this wave, and write an expression for the wave function. (03)

(b) Fig-7 shows three waves that are separately sent along a string that is stretched under a certain tension along an x axis. Rank the waves according to their (a) wavelengths, (b) speeds, and (c) angular frequencies, greatest first. (02)

(c) Sketch the interference wave of two identical waves having phase differences: (a) $\acute{\emptyset} = 0$ and (b) $\acute{\emptyset} = \pi$. Also mention the nature of interference taking place. (03)

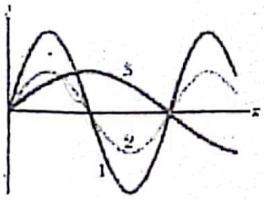

Fig-7

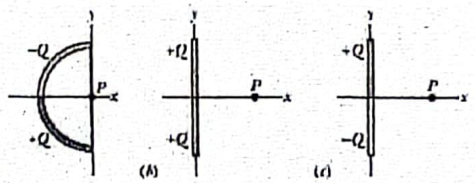

Fig-8

Q7: Electrostatics & Gauss's Laws (Marks 4+12 Estimated Time: 30 mints) CLO7

(a) The Fig-8 shows three non-conducting rods, one circular and two straight. Each has a uniform charge of magnitude Q along its top half and another along its bottom half. For each rod, what is the direction of the net electric field at point P. (02)

(b) Two positive point charges $q_1 = q_2 = 4.0\ \mu C$ are located at x = 0 m. y = 4 m and x = 0 m, y = -4 m, respectively. What is direction of the total (net) electric force that these charges exert on a third point charge $q_3 = 2.0\ \mu C$ at x = 5 m, y = 0 m? (Only draw the diagram showing all forces on it.) (02)

(c) An electric field 3j+4k (N/C) is present at a place. What will be the electric flux passing through a square plate of side 2 m. if the plate is placed in (i) the y-z plane (ii) perpendicular to the y-z plane ? (02)

(d) Explain the differences between linear, surface, and volume charge densities. With the help of examples for each briefly explain that how they are useful in solving E – field problems using Gauss' law. (03)

(e) A flat sheet of paper of area 0.250 m^2 is oriented so that the normal to the sheet is at angle of 60° to a uniform electric field of magnitude 14 N/C (i) find the magnitude of the electric flux through the sheet. (ii) Does the answer to part (i) depend on the shape of the sheet? If yes why, if not why not? (iii) For what angle between the normal to the sheet and the electric field is the magnitude of the flux through the sheet largest and smallest? Explain your answers. (06)

(f) Sketch a graph that shows the variation of the electric field with respect to the distance along x- axis for a thin, uniformly charged, spherical shell of radius R. (01)

Good Luck ☺

Q8: Electric Current (Marks 16, Estimated Time : 30 mints) CLO7

(a) Discuss the distinctions between Resistance and Resistivity, providing explanations supported by their relevant formulas. (02)

(b) The following table gives the current i (in amperes) through two devices for several values of potential difference V (in volts). From these data, determine which device does not obey Ohm's law. Give reason. (04)

Device 1		Device 2	
V	i	V	i
2.00	4.50	2.00	1.50
3.00	6.75	3.00	2.20
4.00	9.00	4.00	2.80

(c) What does a non-linear (non-Ohmic) graph look like, and how does it differ from the linear graph representing Ohm's Law? Explain by drawing both graphs. (04)

(d) Describe how the resistance of a conductor and a semiconductor changes as the temperature increases. Use a graph to visually represent the relationship between temperature and resistance for both materials. (02)

(e) A small but measurable current of 1.2×10^{-10} A exists in a copper wire whose diameter is 2.5 mm. The number of charge carriers per unit volume is 8.49×10^{28} m^{-3}. Assuming the current is uniform, calculate the (a) current density and (b) electron drift speed. (04)

Q9: Capacitors (Marks 16, Estimated Time : 30 mints)CLO 8

(a) Does the capacitance C of a capacitor increase, decrease, or remain the same (a) when the charge q on it is doubled and (b) when the potential difference V across it is tripled? Give Reason. (02)

(b) The plates of a spherical capacitor have radii 38.0 mm and 40.0 mm. (a) Calculate the capacitance. (b) What must be the plate area of a parallel-plate capacitor with the same plate separation and capacitance? (04)

(c) When a battery is connected across the capacitor, are the charges on the plates always equal and opposite even for plates of unequal size? Given reasons your answer. (01)

(d) For capacitors charged by the same battery, does the charge stored by the capacitor increase, decrease, or remain the same in each of the following situations? (i) The plate separation of a parallel-plate capacitor is increased. (ii) The radius of the inner cylinder of a cylindrical capacitor is increased. (iii) The radius of the outer spherical shell of a spherical capacitor is increased. (03)

(e) How does the presence of a dielectric alter the electric field between the capacitor plates? Explain briefly. (02)

(f) Fig-9 shows a 12 V battery and four capacitors of capacitances C_1 = 1mF, C_2 = 2mF, C_3 =3 mF, and C_4 = 4mF. Find: (i) the equivalent capacitance (ii) the charge and potential difference for each capacitor. (04)

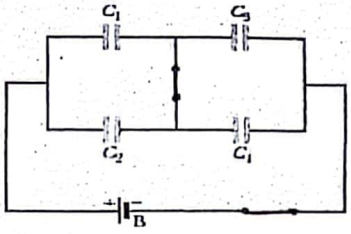

Fig-9

Q10: Magnetic Field (Marks 16, Estimated Time : 30 mints)CLO9

(a) Why is it impossible to isolate the north and south poles of a magnet from each other? (01)

(b) How can we classify different magnetic materials according to their behaviors in external magnetic field? (03)

(c) What are the three basic differences between electric and magnetic forces? (02)

(d) Can a particle move through the region without being affected by both electric and magnetic fields? If yes, provide the specific velocity value for the particle, along with the reasoning behind this scenario. (02)

(e) Discuss the properties of the magnetic force acting on the charged particle in motion. (02)

(f) A particle of mass 10 g and charge 80 mC moves through a uniform magnetic field, in a region where the free-fall acceleration is 9.8 m/s . The velocity of the particle is a constant, which is perpendicular to the magnetic field. What, then, is the magnetic field? Calculate. (03)

(g) A proton is moving through a uniform magnetic field described by $\mathbf{B} = (\beta\, i + (2.5\,\beta)\, j)$ T. At a specific moment, the proton possesses a velocity $v = (2\, i + 5j)$ m/s, and the magnetic force acting on it is $(8.5 \times 10^{-19}\text{N})\mathbf{k}$. Determine the value of β . (Charge of a proton: 1.602 x 10 -19 C) (03)

Good Luck ☺