SECTION A [40 MARKS]
ANSWER **ALL** QUESTIONS

Question 1 **[25]**

a) For each question, there are FOUR responses: A, B, C and D. Choose the corresponding letter of your response and CIRCLE it neatly. NO score will be awarded if you circle more than ONE letter.

i. Elementary particles are typically the building blocks of matter. Which one of the following is the composition of a neutron?

A Quarks
B Photons
C Neutrinos
D Electrons

ii. The figure below shows a wrecking ball demolishing large building. The acceleration (a) of a wrecking ball with a mass (m) of 50 kg is described by the equation $a(t) = -3\sin(t)$. What is the maximum force that the wrecking ball can exert on an old building? Use Newton's second law of motion $(F = ma)$ to calculate the force.

A 50 units
B 150 units
C 200 units
D 490 units

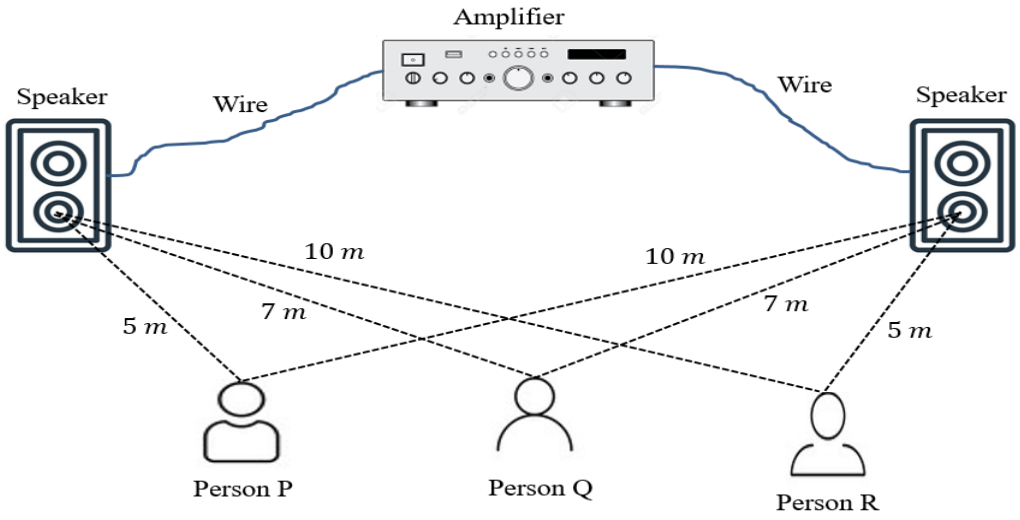
iii. Which of the following scenarios would result in an induced emf?

A A loop of wire held stationary in a uniform electric field
B A loop of wire held stationary in a uniform magnetic field
C A magnetic field through a stationary loop of wire is changed over time
D A loop of wire and a bar magnet were moved with constant speed in the same direction

iv. Surface tension is one of the crucial factors in the manufacturing of cosmetics. The surface tension of the cosmetics is kept low to

A increase the viscosity of the product.
B decrease the solubility of the product.
C increase the fragrance of the product.
D enhance the product's spreadability on the skin.

v. The figure below shows two speakers amplifying the song "I Have a Dream" through an amplifier. Three people are listening to the music. Considering that the wavelength of the sound from the speakers is 4 meters, who hears the loudest sound?



A Person P
B Person Q
C Person R
D Person P and Person R

vi. Despite the sufficient energy produced by fission reactors, many developed countries are looking forward to thermonuclear fusion reactors. This is because

I. fusion reactions do not produce radioactive waste
II. there is limited supply of fuel for fusion reaction to initiate
III. fusion reactions produce more energy than fission reaction
IV. fusion reactions require extremely high temperature and pressure to initiate

A I and II
B I and III
C III and IV
D I and IV

vii. What recommendation would you suggest for designing a capacitor of higher charge storage capacity?

A Increase the charge of the capacitor
B Increase the size of the plates of capacitor
C Decrease the size of the plates of capacitor
D Increase the distance between plates of capacitor

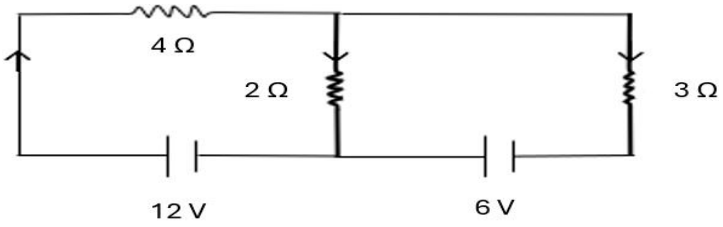
viii. Lhaki's physics teacher instructed her to obtain a same-size inverted image of an object pin using a concave mirror with a focal length of $30\ cm$. How far should the object pin be placed from the mirror?

A $15\ cm$
B $30\ cm$
C $45\ cm$
D $60\ cm$

ix. High orbital satellites are preferred to be disposed into the graveyard orbit lying beyond the geostationary orbit. This is because it

A increases the satellite's lifespan.
B improves satellite communication.
C reduces the satellite's exposure to harmful radiation.
D minimizes the risk of collision with operational satellites.

x. An electrical engineer has designed a circuit diagram for an electronic device and needs assistance in determining the current through different resistors. Using Kirchhoff's voltage law, what is the current flowing through 2 Ω resistor, if current through 4 Ω resistor is 2 A?



A 1 A
B 1.2 A
C 2 A
D 10 A

xi. Two groups of students carry out an experiment on the emission of electrons from the same metal using lasers. The first group uses a red laser, while the second group uses a green laser. Assuming both lasers have the same brightness, identify the group in which higher energy photoelectrons are ejected.

A The group using the red laser
B The group using the green laser
C Photoelectrons are not ejected in both the groups
D Photoelectrons with the same energy are ejected in both the groups

xii. In particle physics experiments and observations, why is the gravitational force not incorporated into the standard model?

A The electromagnetic force is much weaker
B The gravitational force acts only between neutral particles
C The gravitational force is negligible between elementary particles
D It is challenging to determine the gravitational force between elementary particles.

xiii. Arrange the following developmental phases of satellite development in sequential order.

I. Launch and operation
II. Breadboard model
III. Flight model
IV. Mission definition
V. Engineering model

A II, IV, V, I, III
B IV, II, V, III, I
C V, II, I, III, IV
D IV, II, III, V, I

xiv. Nuclear fission reactor is one of the solutions to energy crises in the world. How does a nuclear fission reactor produce electrical energy?

A It produces radiations to turn generator
B It produces thermal energy to turn generator
C It produces kinetic energy to turn generator
D It produces radioactive wastes to turn generator

xv. At what point along the $x - axis$ does the body have maximum potential energy as it oscillates between $-4\ cm$ and $+4\ cm$?

A At the origin
B At $2cm$ away from the origin
C At $3cm$ away from the origin
D At $4cm$ away from the origin

xvi. What happens to the electric field strength between two oppositely charged plates if the distance between them is doubled?

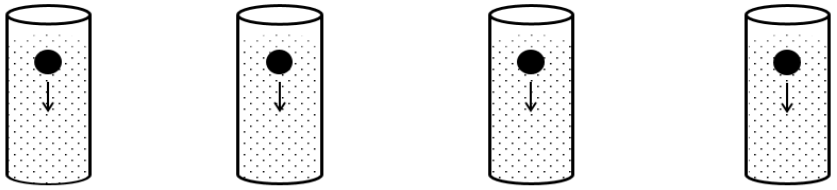
A Increases by two times
B Decreases by two times
C Increases by three times
D Decreases by three times

xvii. A swimmer in the middle of the ocean observes two waves of the same amplitude approaching him from opposite directions. If the waves reach him in phase, what is the resultant amplitude at his location?

A The resultant amplitude stays the same
B The resultant amplitude doubles, potentially putting him in danger
C The resultant amplitude decreases compared to the individual waves
D The two waves cancel each other out completely, resulting in zero amplitude, ensuring his safety

xviii. The figure given below represents the marble race experiment to determine the viscosity of four different transparent liquids. The experimental data in the table shows time taken for marble to reach the bottom of the container in different liquids. Based on the data, what can you say about the viscosity of the liquids?

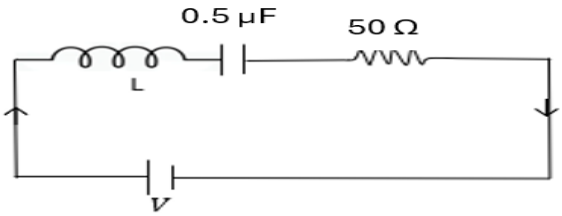
Marble race experiment



Types of liquids	Time taken (seconds)
In liquid 1	5
In liquid 2	12
In liquid 3	10
In liquid 4	7

A The viscosity of the liquid 1 is greatest
B The viscosity of the liquid 2 is greatest
C The viscosity of the liquid 3 is greatest
D The viscosity of the liquid 4 is greatest

xix. Given that the resonant frequency of an LCR circuit is 160 Hz, what should be the inductance of the inductor in the circuit shown below?



A 0.5 H
B 2 H
C 100 H
D 995 H

xx. Which of the following statements accurately distinguishes between a copper wire used in household wiring and a germanium chip used in transistors?

A The forbidden gap in copper is wider than that of germanium
B Copper conducts only at high temperatures, while germanium conducts even at room temperature
C With an increase in temperature, the resistivity of copper decreases, while in germanium it increases
D The transition of electrons from the conduction band to the valence band is much easier in copper than in germanium

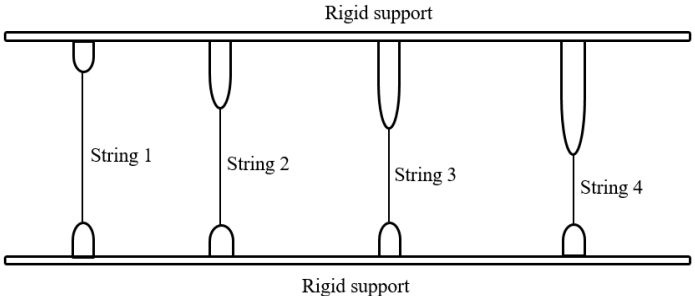
xxi. In a laboratory experiment to determine the focal length of a convex lens using the u-v method, the following data is recorded.

u(cm)	***v (cm)***	***f (cm)***
36	44	
40	42	
44	38	

Based on the experiment, the student concluded that the focal length of the given lens is

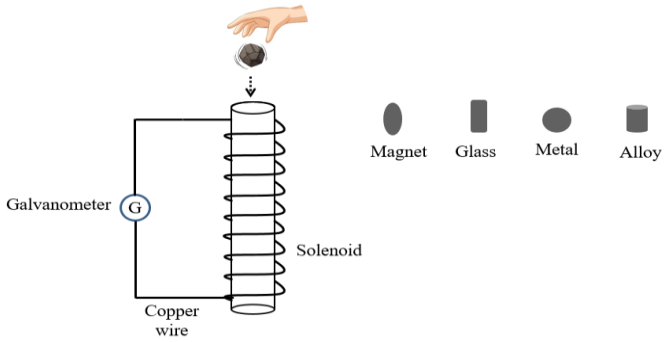
A 19.8 cm.
B 20.2 cm.
C 20.4 cm.
D 20.5 cm.

xxii. Four strings of same material are stretched between two rigid supports as shown in the figure. If the tension of the strings are equal, which set up vibrates with highest frequency upon disturbance?



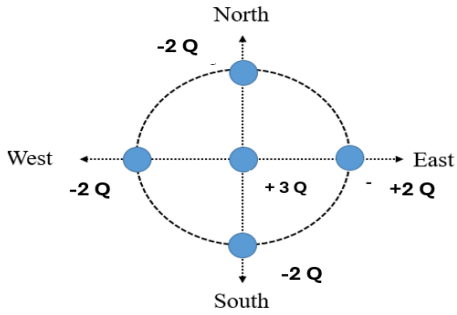
A String 1
B String 2
C String 3
D String 4

xxiii. Which material-glass, magnet, alloy, or metal -is most likely to cause a deflection in the galvanometer when dropped through the solenoid shown below?



A Alloy
B Metal
C Glass
D Magnet

xxiv. The figure below shows a centre charge (+3 Q) which is surrounded by other four charges which lies at equal distance from the centre. What is the direction of net force experienced by centre charge in the figure?



A East
B West
C North
D South

xxv. In designing a circuit board (motherboard), the parallel grouping of capacitor is preferred over series grouping. This is because

I. parallel capacitors offer higher capacitance values and enhanced reliability.
II. the voltage is distributed across the capacitors, aiding in voltage stabilization.
III. the current is same across all capacitors, making it easier for designers to determine the current.
IV. the parallel configuration ensures that if one capacitor fails, others can still function, maintaining overall circuit performance.

A I and II
B II and III
C I and IV
D III and IV

b) Fill in the blanks with the appropriate word(s). **[5]**

i.	In an AC generator, the electromotive force (emf) reaches its maximum when the plane of the armature coil is _____ to the magnetic field.	
ii.	In an LCR resonance circuit, the phase difference between the alternating voltage and current is _____.	
iii.	In a magnetic circuit, magnetic field strength is _____ proportional to magnetic force.	
iv.	The most probable speed of gas molecules is much _____ than the root-mean-square speed of the molecules.	
v.	In a vibrating spring-mass system, the _____ energy decreases while the _____ energy increases as the particle moves from the extreme position to the mean position, ensuring that the total mechanical energy in the system remains constant.	
vi.	When light travels from air to water, its velocity and wavelength decrease, but its _____ remains constant.	
vii.	To sustain the fission reaction, water is used as a _____ to slow down fast neutrons before they collide with the fuel.	
viii.	As a skydiver falls from a certain height, the skydiver's acceleration _____ exponentially with time.	
ix.	According to the equation of continuity, the velocity of blood _____ as it flows from wider arteries to narrower veins.	

c) Write TRUE or FALSE for the following statements in the space provided in the 'Answer' column. **[5]**

	Statement	Answer	
i.	The baryon number of a meson is always zero due to its composition of a quark and an antiquark.		
ii.	The motion of electrons around the nucleus is periodic, whereas the spinning of an electron about its own axis is oscillatory.		
iii.	In automobiles, a concave mirror is used as a rear-view mirror because it provides virtual and diminished image of the vehicles behind.		
iv.	Lower wavelength radiations are more suitable for the photoelectric experiment to overcome the metal's work function.		
v.	For the same length, the simple pendulum oscillates faster at low altitudes than at high altitudes.		
vi.	The breadboard model phase in satellite development undergoes rigorous tests in a simulated space environment to ensure the satellite's functionality when launched		
vii.	The wave model of light fails to account for the photoelectric effect because it suggests that the energy of photoelectrons depends on the intensity of incident light.		
viii.	The greater the binding energy of a nucleus, the higher its stability.		
ix.	According to the de Broglie hypothesis, if the mass of a particle is doubled while keeping the same velocity, the wavelength of the matter waves also doubles.		
x.	With increase in temperature, aluminium exhibits higher resistivity while silicon shows lower resistivity.		

d) Match each item in column A with the most appropriate item in column B. Write the correct letter in the space provided in the 'Answer' column. **[5]**

Column A	Column B	Answer
i. Exhibits elastic collision	a. Photoelectric effect	i.
ii. Working principle of sonometer	b. Autocollimation	ii.
iii. Resistivity of superconductor	c. Refractive index	iii.
iv. Ratio of real depth to the apparent depth	d. Resonance of sound	iv.
v. Working principle of solar panel	e. N-type semiconductor	v.
vi. Condition where object and image are at the same distance from mirror	f. Enhance the efficiency of drug delivery system in pharmaceutical	vi.
vii. Boron doped with germanium	g. Ideal gas	vii.
viii. Regulates the temperature of satellite	h. Zero	viii.
ix. Geometrical construction of wave front	i. P-type semiconductor	ix.
x. Application of nanotechnology	j. Electrical power system	x.
	k. Huygens' Principle	
	l. Thermal control system	

SECTION B [60 MARKS]

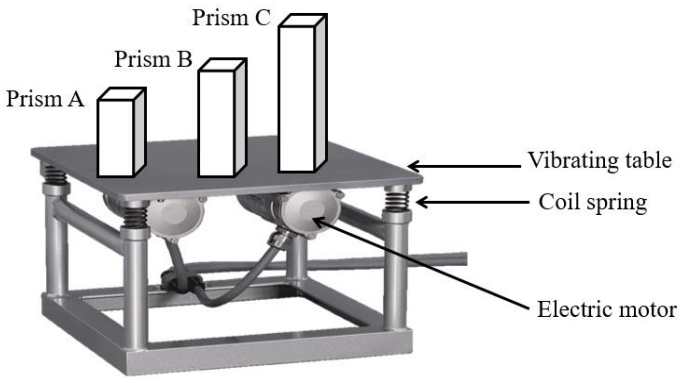
ATTEMPT **ANY SIX** QUESTIONS

Question 2

a) Why do straws on the surface of pure water move closer when sugar is added to water but move away when soap is added? **[2]**

b) Write **TWO** differences between ideal gas and real gas. **[2]**

c) The figure below shows a vibrating table built using an electric motor and coiled springs. Three prisms are placed on the table. When the electric motor is activated, the table starts vibrating. As it vibrates, the prism B topples. Why does this happen? Explain. **[2]**



d) The table below shows the mass and charge of four elementary particles. Choose a pair of particles that undergoes annihilation and explain why you selected that pair? **[2]**

Particles	Mass (Kg)	Charge (C)
A	3.56×10^{-30}	$+\frac{2}{3}e$
B	9.1×10^{-31}	$-1e$
C	3.56×10^{-30}	$-\frac{2}{3}e$
D	2.28×10^{-36}	$+\frac{2}{3}e$

e) A dental surgeon uses a small concave mirror of focal length 10 cm to see a tooth. The doctor observes an image that is twice the size of the tooth. How far is the doctor holding the mirror from the tooth? **[2]**

Question 3

a) A Young's double-slit experiment is conducted to see the interference fringes formed by a monochromatic light. What is the effect on the fringe width, if the following changes are made in the experimental set up?

i. Increasing only the distance between the slits. **[1]**

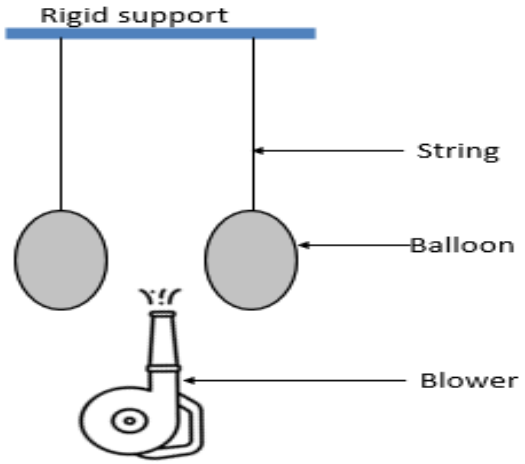
ii. Increasing only the distance between the slits and the screen. **[1]**

b) Write at least **TWO** measures undertaken to protect a spacecraft from space debris? **[2]**

c) To enhance the conductivity of an intrinsic semiconductor, impurities are added. This process is called doping. An intrinsic semiconductor doped with a dopant produces an N-type semiconductor. Do you agree? Give a reason. **[2]**

d) A parallel-plate capacitor with air between the plates has a capacitance of 8×10^{-12}F. When a dielectric material is inserted, the capacitance increases to 48×10^{-12}F. What is the dielectric constant of the material? **[3]**

e) The figure below shows two balloons hanging from a rigid support. In which direction do the balloons move when air is blown between them? Why? **[1]**



Question 4

a) How is step-down transformer different from step-up transformer in terms of its design? Describe briefly a real-life application where a step-down transformer is used. **[2]**

b) Draw a graph to show a variation of photoelectric current versus anode potential for three different intensities of light of the same frequency. **[2]**

c) Why are Command and Data Handling subsystem considered the brain of the satellite? **[1]**

d) Calculate the binding energy per nucleon for carbon-12 ($^{12}_{6}C$) and carbon-14 ($^{14}_{6}C$) with atomic mass 12.00 u and 14.003242 u respectively. Which one is more stable? **[3]**

e) In physics laboratory, a teacher has given two lenses: a convex lens and a concave lens. The task is to determine the approximate focal length of these lenses by projecting the image of a distant object onto a screen. Is the determination of focal length possible for both the lenses? Give reason. **[2]**

Question 5

a) In a diffraction experiment, the first minima is formed at an angle of 30^0.

i. What is the width of the slit if the wavelength of the light used is 6500×10^{-10} m. **[2]**

ii. Should the slit width be increased or decreased for the first minima to be formed at an angle of 30° for a light of wavelength of 7000×10^{-10} m? **[1]**

b) It is safer to stay inside a vehicle than being outdoors in an open-air during lightning strike. Justify the statement. **[2]**

c) We see roofs of houses blown off during storm. The structural design of the roof significantly influences the roof stability. How would you design a roof that is stable during storm? **[2]**

d) What do you understand by the work function of a metal? **[1]**

e) Construct a ray diagram to show the position of the image formed by a concave mirror when the object is located between the centre of curvature (C) and the focus (F). Describe the characteristics of the image formed. **[2]**

Question 6

a) How does eddy current in an electrical transformer affect its efficiency and how is it minimized? **[2]**

b) We often forget to turn off the lights, leading to unnecessary energy wastage. To overcome this, what type of circuit would you design that automatically turns off the light when it is not in use? Draw a labelled diagram of the circuit. **[2]**

c) State Heisenberg uncertainty principle. Is it applicable to macroscopic particles? Why? **[2]**

d) Two groups of students, group 1 and group 2 performed an experiment to determine the acceleration due to gravity using a simple pendulum. The table given below shows their experimental data. If both groups obtained the same value for the acceleration due to gravity, what is the length of the pendulum used by group 2? **[3]**

Group	**Time taken to complete 20 oscillations (seconds)**	**Effective length of the pendulum (m)**	**Acceleration due to gravity (m/s^2)**
1	28	0.5	10.07
2	40	?	

e) How does the use of nanotechnology help the textile industries to produce good quality products? **[1]**

Question 7

a) Why are all periodic motions not considered as oscillatory motions? Provide **ONE** real-life example of a motion that is periodic but not oscillatory. **[2]**

b) What are the benefits of establishing laws and regulations for space? **[2]**

c) Rigsel and Leki debate about the choice of lens for camera design. Leki prefers single lens, while Rigsel prefers combined lens. Whose viewpoint do you favour? Support your preference. **[2]**

d) Calculate the kinetic energy of an ejected electron when light of 500 nm wavelength falls on a metal surface with a work function of 2.3 eV. **[2]**

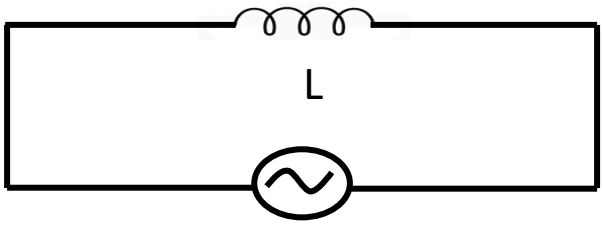
e) Do you think nuclear fusion is a promising and relevant energy source in the future? Justify. **[2]**

Question 8

a) Using Huygen's principle, prove that the angle of incidence equals the angle of reflection when plane waves fall on a reflecting surface. **[3]**

b) Which among the gas molecules - hydrogen, helium and oxygen moves the fastest in a container at the same temperature, and why? **[1]**

c) The voltage $V = V_m Sin(\omega t)$ is applied across an inductive AC circuit as shown below:



i. If the current I flows through inductor L, what is the phase difference between the voltage V and the current I? Illustrate this phase difference graphically. **[2]**

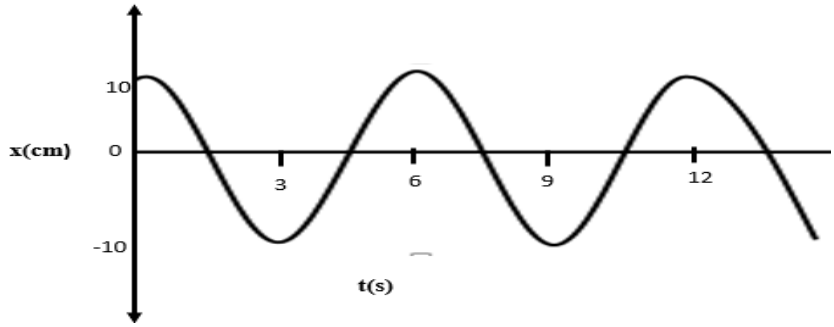
ii. What happens to the current I if the driving frequency of the circuit is increased? **[1]**

d) Two metallic spheres with charges +7 C and -2 C are brought into contact and then separated. What are the resultant charges on both the spheres? What is the nature of force existing between them? **[1]**

e) An emf of 60 V is induced in a secondary coil when the current in a primary coil decreases from 50 A to 0 A in 0. 2 s. Calculate the coefficient of mutual induction. **[2]**

Question 9

a) The figure below represents the displacement of a particle undergoing simple harmonic motion. Based on the graph, determine the maximum acceleration of the particle. **[2]**



b) In an experiment to verify Faraday's law, two setups are used. In the first setup, a magnet is moved to and fro slowly to induce an emf in a coil. In the second setup, a same magnet is moved to and fro quickly to induce an emf in the coil. Assuming the number of turns in the coils are the same in both setup, which setup generates the highest magnitude of induced emf? Explain why? **[2]**

c) In 2023, researchers discovered that lutetium hydride exhibits superconductivity at room temperature. How does the discovery of such room temperature superconductor benefit the society? **[2]**

d) Lambda is a baryon consisting of one up, one down, and one strange quark. Determine the electric charge and baryon number of lambda. **[2]**

e) Which Kepler's law of planetary motion describes the variation in a planet's speed as it orbits a star. How does this law explain this variation? **[2]**

[PHYSICAL CONSTANTS]

Acceleration due to gravity	$g = 9.8 m/s^2$
Gravitational Constant	$G = 6.67408 \times 10^{-11} N.m^2/kg^2$
Avogadro's number	$N_A = 6.022 \times 10^{23}$
Boltzmann constant	$K = 1.38 \times 10^{-23} J/K$
Density of water at 4˚C	$\rho = 1000 kg/m^3$
Electron charge	$e = 1.6 \times 10^{-19} C$
Energy equivalent	$1u = 931.5 MeV$
	$1eV = 1.6 \times 10^{-19} J$
Mass of an electron	$m_e = 9.1 \times 10^{-31} kg$
Mass of a neutron	$m_n = 1.008665u$
Mass of a proton	$m_p = 1.007276u$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} T.m/A$
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} C^2/N.m^2$
Planck's constant	$h = 6.63 \times 10^{-34} J.S$
Speed of electromagnetic wave	$c = 3 \times 10^8 m/s$
Standard atmospheric pressure	$1atm = 101325 pa$
Universal gas constant	$R = 8.31 J/mol.K$
	$\pi = 3.14$

Rough Work