SECTION A (40 MARKS)
Answer ALL questions

Question 1

a) **For each question, there are four alternatives A, B, C and D. Choose the correct alternative and circle it. DO NOT circle more than ONE alternative. If there are more than ONE circled alternatives, NO score shall be awarded.** **[25]**

i. What is the necessary relation for the occurrence of S.H.M.?

A velocity is directly proportional to displacement from equilibrium position

B acceleration is inversely proportional to displacement from equilibrium position

C restoring force is inversely proportional to the displacement from equilibrium position

D restoring force is directly proportional to displacement from equilibrium position

ii. During an atomic explosion, the energy released is due to conversion of

A mass into energy.

B protons into neutrons.

C chemical energy into heat energy.

D mechanical energy into nuclear energy.

iii. Which one of the following conditions should be considered while squeezing out toothpaste from a tube easily?

A viscosity should be low

B viscosity should be null

C viscosity should be optimum

D viscosity should be intermediate

iv. Fundamental particles are the smallest particles. What is the most common type of fundamental particle in the universe?

A proton

B meson

C neutron

D neutrino

v. Rice cooker is a device which is used for cooking. It is designed by using different types of materials. Name the material that controls the temperature precisely.

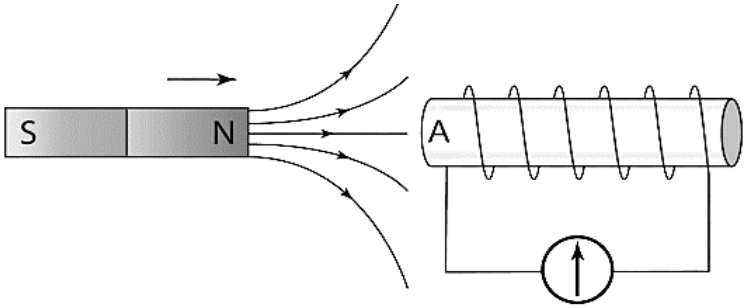
A insulator

B conductor

C semiconductor

D superconductor

vi. Which one of the following statements correctly depicts the phenomenon that takes place, when we introduce the north pole of a bar magnet near end "A" of a solenoid?



A no induced emf is developed

B the end A of the solenoid behaves like a south pole

C the end A of the solenoid behaves like a north pole

D the end A of the solenoid neither behaves as a north pole nor as a south pole

vii. Dawa bought a makeup mirror. Which of the following characteristics of an image should be considered to buy such a mirror?

A upright and enlarged image

B inverted and enlarged image

C upright and diminished image

D inverted and diminished image

viii. A student performs an experiment on a capacitor by using a simulator. He initially charges the capacitor and then disconnects the battery. What will happen if he inserts a dielectric slab between the plates?

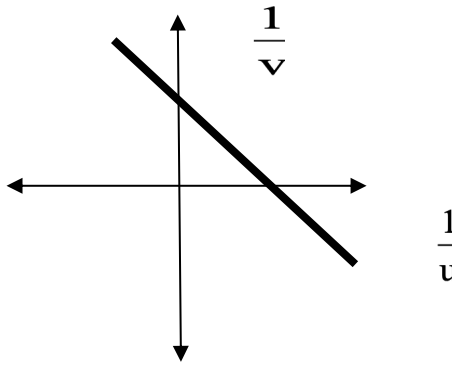
A increase in the potential difference across the plates and decrease in the charge on the plates

B increase in the potential difference across the plates and no change in the charge on the plates

C decrease in the potential difference across the plates and increase in the charge on the plates

D decrease in the potential difference across the plates and no change in the charge on the plates

ix. The figure given shows $\frac{1}{v}$ versus $\frac{1}{u}$ graph for a convex mirror. Study the graph to interpret which combination of object and image cannot be obtained by the convex mirror.



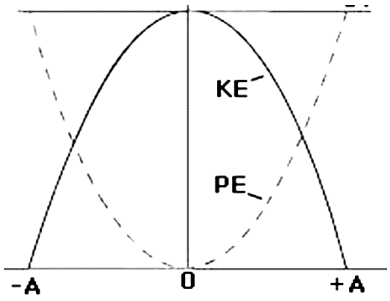
A real object and real image

B real object and virtual image

C virtual object and real image

D virtual object and virtual image

x. A student designs a toy that undergoes simple harmonic motion with amplitude A. She records the variation of mechanical energy of the toy at different positions and obtains a graph as given in the figure. At what distance from the mean position does its kinetic energy become equal to its potential energy?



A $\frac{A}{\sqrt{2}}$

B $\frac{A}{2}$

C $\sqrt{2}A$

D 2A

xi. The liquid-solid adhesive force is weak when compared to the cohesive force of a liquid contained in a vessel. What will be the shape of the meniscus?

A plane

B convex

C concave

D horizontal

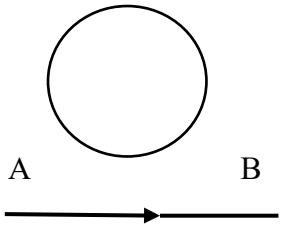
xii. In the given figure, current from A to B in the straight wire is decreasing. What is the direction of the current induced in the conducting circular loop?

A clockwise

B anticlockwise

C no current is induced

D changes direction with time



xiii. Examine the statements of a superconductor and choose the best possible answer.

Statement (I): In a superconductor, the conductivity becomes infinite.

Statement (II): The thermal energy shakes the atoms so they randomly vibrate, but this gets less as the temperature drops.

Statement (III): The superconductor is the substance that conducts electricity with resistance when it becomes cold.

A All the statements are individually true.

B Statement (I) and Statement (III) are individually correct but Statement (II) is not the correct explanation.

C Statement (II) and Statement (III) are individually correct but Statement (I) is not the correct explanation.

D Statement (I) and Statement (II) are individually correct but Statement (III) is not the correct explanation.

xiv. Some buildings do not collapse during a strong earthquake. However, in some cases, aftershocks with relatively small magnitudes destroy the buildings. Which of the following statement justifies the scientific reason behind this effect?

A It indicates the arrival of stronger earthquakes.

B This is due to the sudden change in stress of tectonic plates.

C The seismic wave of aftershocks is stronger than the earthquake.

D The magnitude of frequency of aftershocks is close to the natural frequency of buildings.

xv. A person in a nearby room can hear the sound from the television but cannot see the picture. Though both light and sound behave as waves which undergo diffraction, why is it less likely to see the light?

A frequency of light is lower than sound

B wavelength of light is longer than sound

C wavelength of light is shorter than sound

D light does not require a medium for propagation

xvi. Choose one of the properties which does not satisfy the law of conservation in the given interaction.

$n \rightarrow p + e^{-} + \nu_e$

A charge

B strangeness

C baryon number

D lepton number

xvii. Jigme took two identical metallic spheres of exactly equal masses. One is given a positive charge and the other an equal negative charge through friction. What are their masses after charging?

A The masses of the positively and the negatively charged spheres are equal.

B The masses of the positively and the negatively charged spheres remain the same.

C The mass of the negatively charged sphere is more than the positively charged sphere.

D The mass of the positively charged sphere is more than the negatively charged sphere.

xviii. λ_o and ν_o are threshold wavelength and frequency respectively, then for a light having wavelength λ and frequency *v*, the photoelectric effect will take place if

A $\lambda > \lambda_o$.

B $\nu < \nu_o$.

C $\lambda < \lambda_o$ and $v > \nu_o$.

D $\lambda > \lambda_o$ and $v > \nu_o$.

xix. You have connected a LCR circuit in series connection. How will the resonant frequency of this circuit change if you bring the plates of the capacitor closer?

A increase

B decrease

C remains same

D first increases and then decreases

xx. Sangay can see clearly only up to 3m. For him to see clearly up to 12 m, what should be the power of his spectacle lens?

A -0.25 D

B -0.5 D

C 0.25 D

D 0.5 D

xxi. Sonam conducts Young's double slit experiment and obtains the interference pattern when two slits are kept at distance 'd' and screen at distance 'D'. How would the fringe width of the interference pattern change if he decreases the slit distance by two and doubles the screen distance?

A becomes double

B remains the same

C becomes one-fourth

D increases by four times

xxii. When Tashi incidents a monochromatic light on a slit of width 0.1 mm, diffraction pattern is obtained on the screen. He measures the angular position of the first minima to be $25°$. What will be the angular width of the central maxima?

A $25°$

B $50°$

C $75°$

D $100°$

xxiii. In a nuclear reactor, uranium nucleus ($_{92}U^{236}$) disintegrates to form krypton ($_{36}Kr^{92}$) and an unknown isotope ' X ' along with emission of 3 neutrons. What is ' X '?

A $_{57}La^{142}$

B $_{57}La^{143}$

C $_{56}Ba^{142}$

D $_{56}Ba^{141}$

xxiv. You are asked to incident light of frequency 9.9×10^{14} hertz on the metal plates given in the table. Which of the metals do you think will eject electrons?

Metal	**Work function in joule**
Sodium	3.78×10^{-19}
Zinc	5.71×10^{-19}
Copper	6.66×10^{-19}
Platinum	9.6×10^{-19}

A sodium and zinc

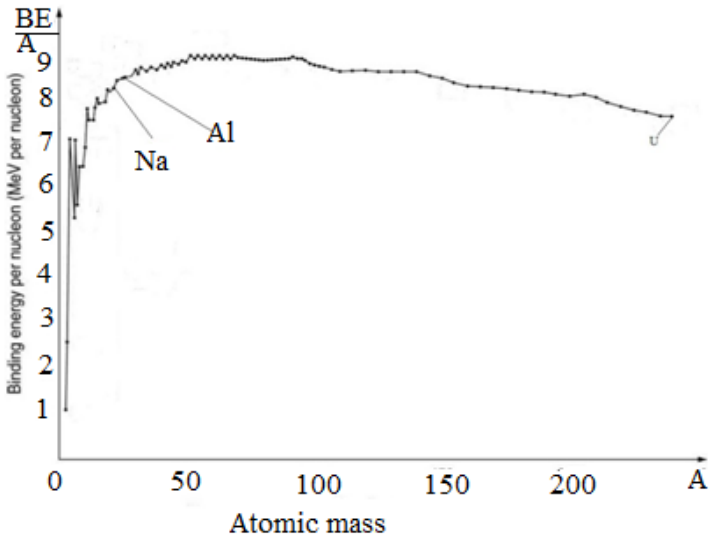
B zinc and platinum

C sodium and copper

D copper and platinum

xxv. The given figure shows the graph of the binding energy per nucleon for a

number of naturally occurring nuclides plotted against their mass number.



Which one of the following statement is a correct deduction from the graph?

A $_{11}Na^{23}$ is more stable than $_{13}Al^{27}$

B the binding energy of $_{13}Al^{27}$ is greater than $_{92}U^{238}$

C binding energy per nucleon for all the lighter atoms is low

D $_{13}Al^{27}$ will not spontaneously emit an alpha particle to become $_{11}Na^{23}$

b) **Match each item of Column A with the most appropriate item of Column B. Rewrite the correct pairs by writing the alphabet against the number in the spaces provided.** **[5]**

Column A	Column B
i. Velocity amplitude	a) plank's constant
ii. Energy gap < 3eV	b) magnetic field intensity
iii. Work done in moving a unit north pole is	c) semiconductor
iv. Same phase with same frequency	d) mass
v. No loss of thermal energy	e) $(2\pi f)^2 A$
vi. Acceleration amplitude	f) Coherence
vii. Force experienced by a unit north pole is	g) Superconductor
viii. Photoelectric equation	h) huygens' principle
ix. Laws of refraction	i) $(2\pi f)A$
x. De-Broglie wavelength	j) magneto motive force
	k) superposition principle
	l) rydberg principle

Column A	Column B
i.	
ii.	
iii.	
iv.	
v.	
vi.	
vii.	
iii.	
ix.	
x.	

c) Fill in the blanks with appropriate word/s. **[5]**

i.	Time period is _____ of frequency.	
ii.	According to Bernoulli's theorem, if water flows through the narrowest part of the horizontal pipe, there will be a decrease in _____.	
iii.	If 10 N force acts on a conductor of 5 C charge, then the magnitude of electric field intensity will be _____.	
iv.	A dielectric material increases capacitance by decreasing _____.	
v.	If the number of turns in a coil is doubled, keeping the other factors constant, the self-inductance of the coil becomes _____.	
vi.	In a series RLC circuit that is operating above the resonant frequency, the current _____ the applied voltage.	
vii.	When a ray of white light enters a lens, it undergoes a change in both velocity and _____.	
viii.	When exposed to sunlight, thin films of oil on water exhibit brilliant colours due to _____.	
ix.	Diffraction of electrons confirms the _____ nature of electrons.	
x.	The strangeness of the k+ meson made up of quark and anti-strange quark is _____.	

d) State true/false for the following statements in the boxes provided. [5]

i. If a girl swinging in a swing in a sitting position stands, the time period of the swing decreases.		
ii. When two light waves having the same amplitude interfere, the intensity of maxima becomes two times the intensity of light coming from the two slits.		
iii. With a given length of wire, you would prefer one-turn square coil to two-turn square coil for producing maximum peak emf while designing a generator.		
iv. When you connect a capacitor in DC circuit, it will allow the current to flow through the circuit.		
v. You are told by your physics teacher to add flux while soldering to increase the surface tension of the molten tin.		
vi. A metal comb when run through dry hair attracts small bits of paper.		
vii. The combined capacitors can be replaced by an equivalent capacitor having same capacitance.		
viii. Light is made up of elementary particles.		
ix. de-Broglie explained the matter-wave picture with the help of Einstein's photoelectric equation.		
x. When we view through spherical surfaces, the images are usually distorted. This defect is called achromatic aberration.		

SECTION B (60 MARKS)

Answer **ANY SIX** questions

Question 2

a) Tuning fork starts vibrating when it hits another object. What type of motion does the tuning fork undergo? **[1]**

b) Pema accidentally dips one end of a towel into a bucketful of water. It is found that after some time the towel becomes fully wet. What is the reason behind this phenomenon? **[1]**

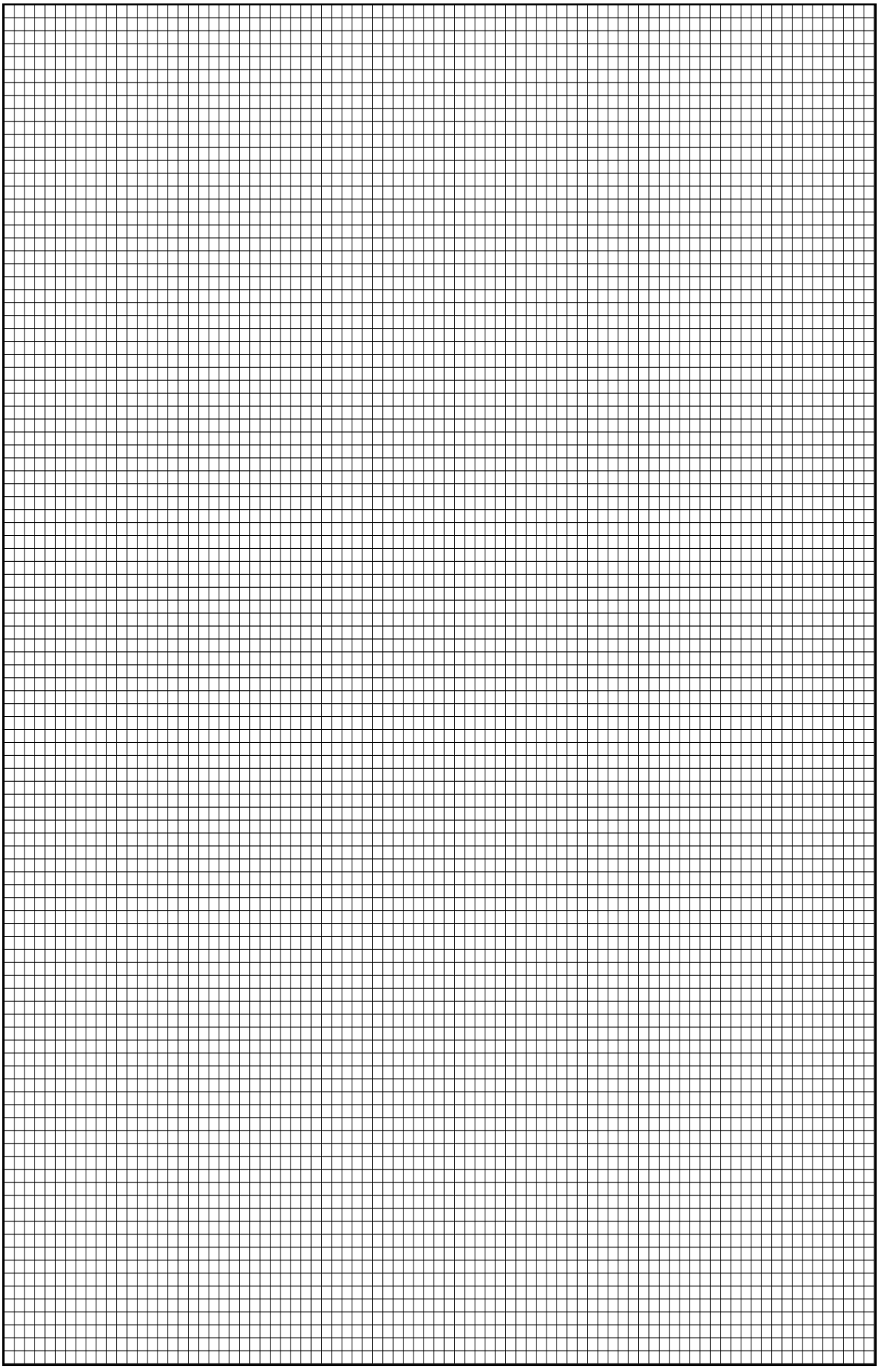
c) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil? **[2]**

d) Should Bhutan invest in the development of nanotechnology? Support your answer with **FOUR** reasons. **[2]**

e) In an experiment, a student connects a cell and a resistor (r) in series and uses a variable resistor (R) as an external load. The current flowing through the circuit is measured with a suitable milliammeter and the potential difference across the variable resistor is measured with a voltmeter for a range of resistance values. **[2]**

i. Plot a graph of the results. The data collected was as follows:

Voltage (V)	**Current (mA)**
1.60	0.00
1.30	13.1
1.14	20.0
0.96	28.2
0.80	35.2



ii. Determine the slope of the graph. What does it signify? $[1\frac{1}{5}]$

iii. Give the value of emf from the graph. $[\frac{1}{5}]$

Question 3

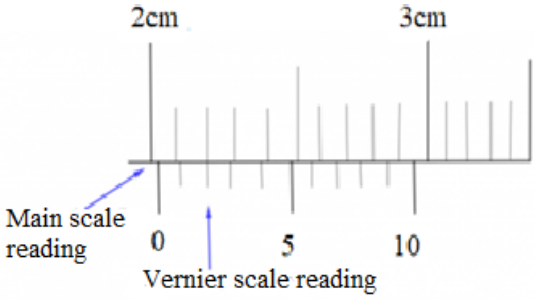
a) You have a bulb lit in your room. If you move away from this bulb, how will the wave-front change? **[1]**

b) What type of spring would you use to increase car's stability? Explain your answer. **[1]**

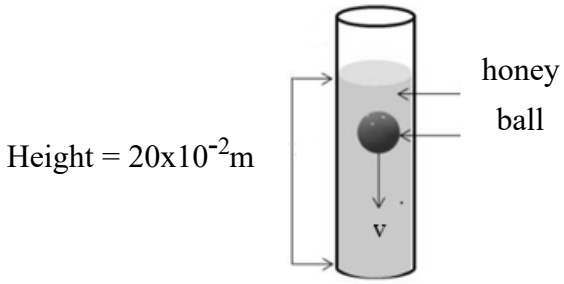
c) Maya incidents ultraviolet light of photon energy $8.76\times10^{-19}\,\text{J}$ from a 100 W mercury source on a photocell made of molybdenum metal while working on a photoelectric simulator. She finds the stopping potential to be 1.3 V. What would be the work-function of the metal? **[2]**

d) You are provided with pure honey of density, $\rho f = pf1400 kg/m^3$ and a spherical ball of mass 10 g. Determine the viscosity of the honey using the following procedures.

i. When you keep the ball between the jaws of vernier calliper, you get the readings as shown in the figure. Calculate the radius of the ball from the figure. **[1]**



ii. Now when this ball is dropped into the honey in a measuring cylinder which is up to the height of 20×10^{-2} m, it takes 10s to reach the bottom of the cylinder. Calculate the velocity of the ball falling through the fluid. **[1]**



iii. Calculate the viscosity, V_s of the fluid using the following equation: **[1]**

$$\eta = \frac{2r^2g(\rho_s - \rho f)}{9V_s}$$

where g is acceleration due to gravity (9.8 m/s^2) and the calculated density ρ_s of the ball is 2314.8 kg/m^3.

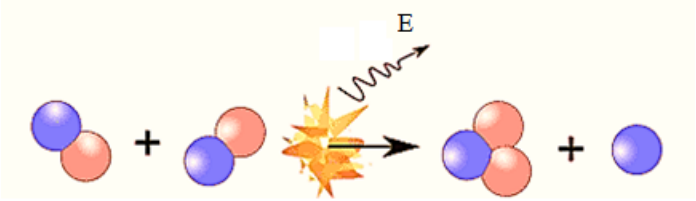
iv. How would the result change if you conduct this experiment at a higher temperature? **[1]**

e) Tashi plans to design a solar cooker. Which mirror, convex or concave, should he choose as a reflector and why? Where should he keep the cooking pot to get maximum heat? **[2]**

Question 4

a) If 110V DC heater is used as a AC source such that the amount of heat produced is same. What should be the rms value of the alternating voltage? **[1]**

b) Describe the phenomenon illustrated in the diagram. **[1]**



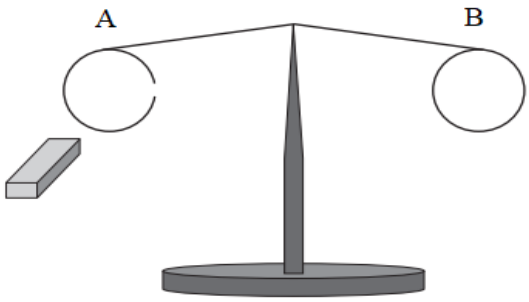
c) You are assigned to fill up the given table using the simulation on the capacitor. Represent the change in the charge, capacitance, voltage and stored energy of the capacitor if you increase the area of plates of an isolated charged capacitor. **[2]**

Plate Area	**Charge**	**Capacitance**	**Stored Energy**	**Voltage**
Increase				

d) Can a convex lens behave as a concave lens? Justify your answer. **[2]**

e) In the single-slit diffraction pattern, the intensity of the maxima keeps on decreasing while region of minimum intensity is always dark. Explain how dark bands are formed on the screen with the diagram. **[2]**

f) The diagram shows two rings A and B connected to a balancing arm which swings freely on a pivot. Ring A has a split in it as shown. **[2]**

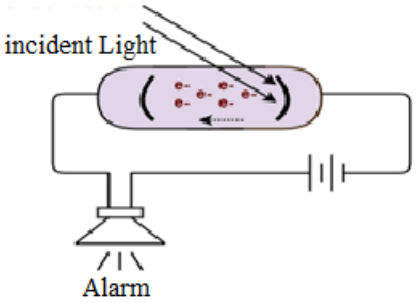


When a bar magnet is pushed into one of the rings, the whole balancing arm begins to rotate and when pulled out, the balancing arm begins to rotate in opposite direction. When the magnet is pushed in and out in the other ring, the apparatus does not move at all. Discuss the course of action using conservation of energy.

Question 5

a) Two neutral bodies A and B are rubbed together to charge them. If these charged bodies A and B are kept at a certain distance apart, draw the electric lines of force due to these two charged bodies. **[1]**

b) The operating principle of photocell given in the picture cannot be explained on the basis of wave nature of light. Give **TWO** reasons. **[2]**



c) In the given reaction, an electron is ejected from an unstable nucleus.

$$^{32}_{15}P \rightarrow {}^{32}_{16}S + {}_{-1}e^{0} + \bar{\nu}_e$$

i. Show the change in the quark in the above reaction using an equation. **[1]**

ii. Write an equation which shows the reverse change in the quark. **[1]**

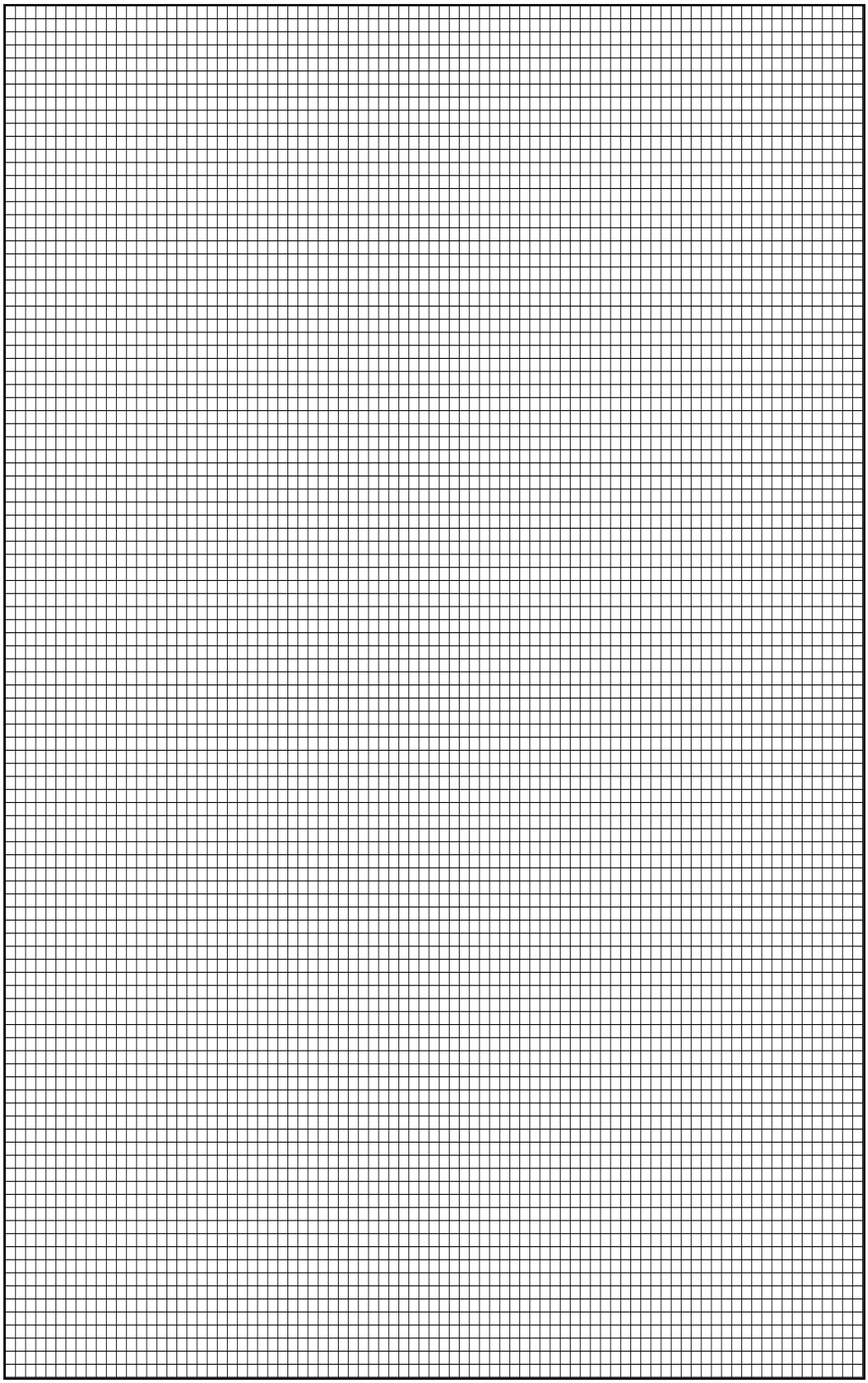
iii. What will happen when an electron and a positron come together? Represent your answer in the equation form. **[1]**

d) A student conducts an experiment using pendulum bob to determine the acceleration due to gravity in the physics laboratory. She records the time taken for 10 oscillations at varying length of the string as shown in the table.

Length (m)	**Time taken for 10 oscillations (s)**	**Time period T (s)**	**T^2 (s^2)**	**g (m/s^2)**
2.00	28.5	2.85	8.10	9.75
1.91	27.7	2.77	7.68	9.81
1.82	27.2	2.72	7.41	9.69
1.73	26.7	2.66	7.11	**????**
1.64	25.7	2.57	6.59	9.82

i. Find the missing value of acceleration due to gravity (**g**). $[\frac{1}{5}]$

ii. From the given data, plot a graph of L against T^2. **[2]**



iii. Determine the slope S of the graph and multiply it with $4\pi^2$. **[1]**

iv. What does this value represent? $[\frac{1}{5}]$

Question 6

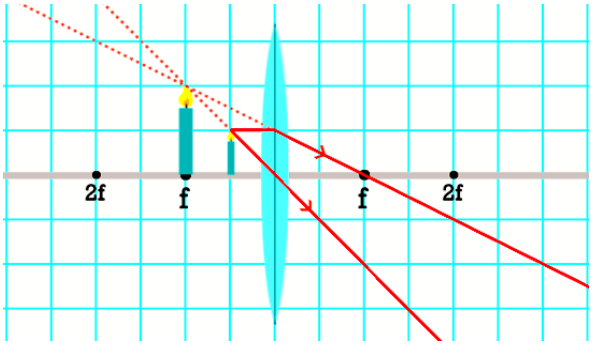
a) Out of six quarks, why are up and down quarks generally considered as stable and most abundant in the universe? **[1]**

b) Why does dust accumulate on ceiling fans? **[2]**

c) Saturn is moving with uniform angular speed $2\pi f$ along the circumference of its orbit around the Sun with radius R, having centre O. At any time, the angular position of Saturn is $(2\pi f)t$ and the displacement in SHM at that time t is given by $x(t) = R \cos (2\pi f)t$. Find its acceleration and plot the graph with respect to time. **[2]**

d) Draw an electric circuit diagram and write three equations to represent Kirchhoff's laws using the diagram. **[2]**

e) The given figure is a screenshot of a simulation on ray optics. **[3]**

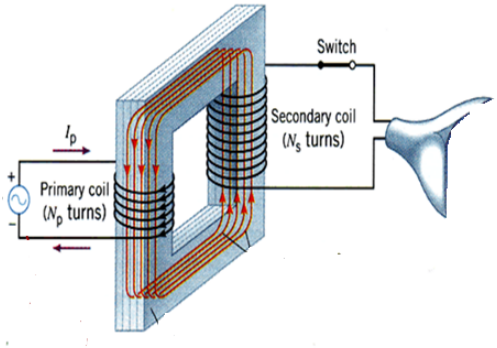


In the given table, the underlined words are the correct description of the image formed when the object is kept mid-way between f and lens as seen in the screenshot. From the options given, circle the correct location, orientation, size and type of image formed when the object is kept at three different positions mentioned in the table.

Object Position	**Image Description**			
	Location	**Orientation**	**Size**	**Type**
Mid way between f and lens	**<u>At f</u>** Beyond 2f Between 2f and f	**<u>Upright</u>** Inverted	**<u>Magnified</u>** Same Size Reduced	Real **<u>Virtual</u>**
1. At 2f	At 2f Beyond 2f Between 2f and f	Upright Inverted	Magnified Same Size Reduced	Real Virtual
2.Between f and 2f	At 2f Beyond 2f Between 2f and f	Upright Inverted	Magnified Same Size Reduced	Real Virtual
3.Away from 2f	At 2f Beyond 2f Between 2f and f	Upright Inverted	Magnified Same Size Reduced	Real Virtual

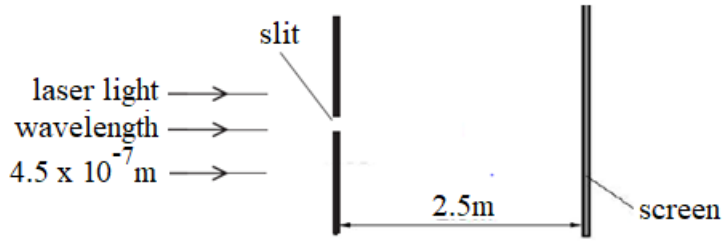
Question 7

a) What is working principle of the given device? Does this device increase or decrease the voltage? **[1]**



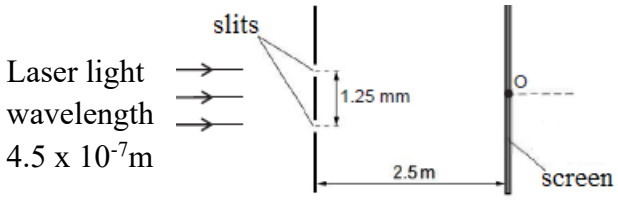
b) Commercial fusion power plant is still a dream which is inching toward planet-saving reality. Discuss any one of the approaches under study to generate controlled nuclear power. **[1]**

c) A laser is placed in-front of a slit as shown in the figure. $[1\frac{1}{5}]$



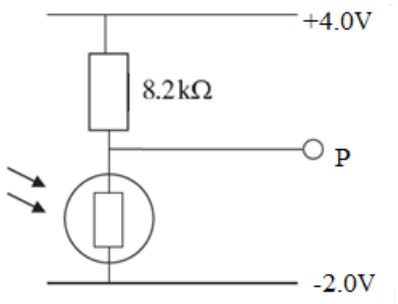
i. The laser emits light of wavelength 4.5 x10^{-7} m on the slit of width 0.50 mm. The distance of the slit from the screen is 2.5 m and the width of the central fringe as observed on the screen is y. Show that y is 4.5 mm.

ii. The slit is replaced by a double slit as shown in the figure. The separation of the slits is 1.25mm. The centre of the interference pattern formed on the screen is at O. $[1\frac{1}{5}]$



Show that there are five bright fringes in the region which was previously occupied by the central maxima of diffraction pattern.

d) In the given circuit diagram, imagine that an alarm is connected in parallel with the LDR. A laser beam is directed at the LDR in a simple burglar alarm system. When a burglar blocks the laser that is shining continuously on the LDR, the alarm is triggered. Explain clearly how the LDR is used to turn on or off the alarm in such a system. **[2]**



e)

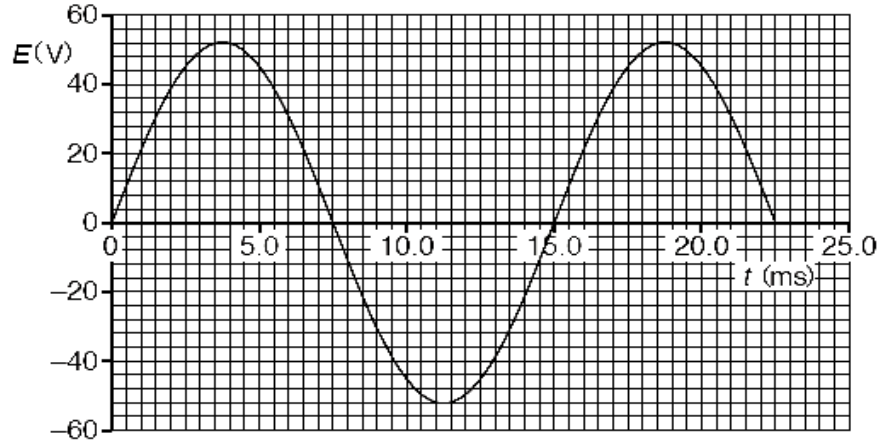
i. Is the idea of establishing nuclear power plants instead of other energy production systems, positive? Support your claim with reasons. **[$1\frac{1}{5}$]**

ii. If you are given a choice to build nuclear power plant in Bhutan, which one, fusion or fission power plant would you build? Justify your stand. **[$1\frac{1}{5}$]**

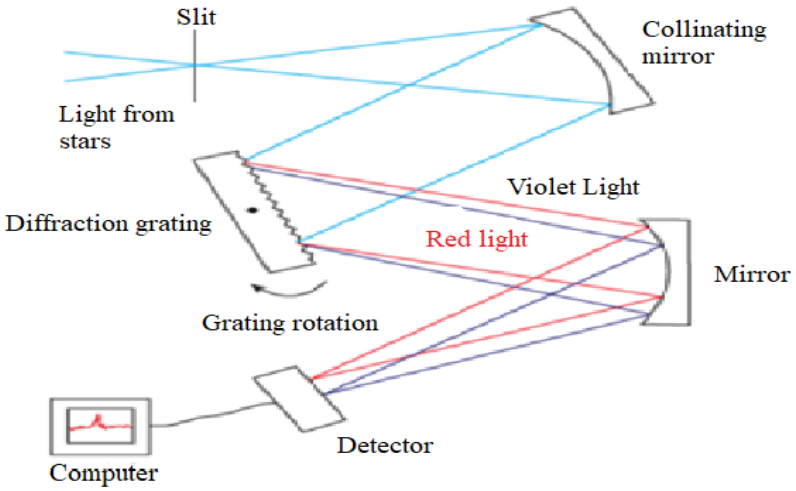
Question 8

a) Einstein proposed that light is absorbed or emitted by objects. Give an example each for objects that undergo photon absorption and photon emission. **[1]**

b) An alternating voltage of peak value 150 V is applied across the 1200 turns of the primary coil. The variation with time t of the emf E induced across the secondary coil is shown in the figure. Calculate the number of turns of the secondary coil. **[2]**



c) The schematic diagram given shows the main components of a modern slit spectrograph.

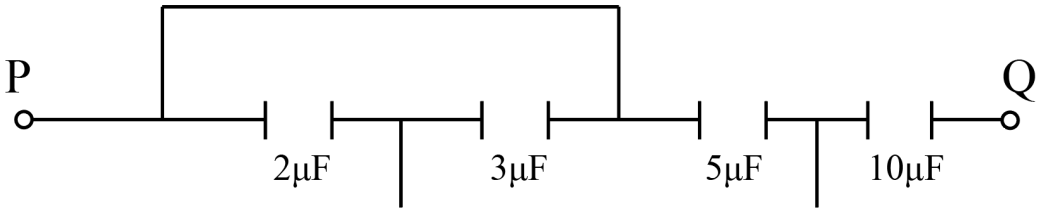


[1]

i. How do you think the splitting of light will change if diffraction grating is replaced by prism?

ii. Which one would you prefer and why? **[2]**

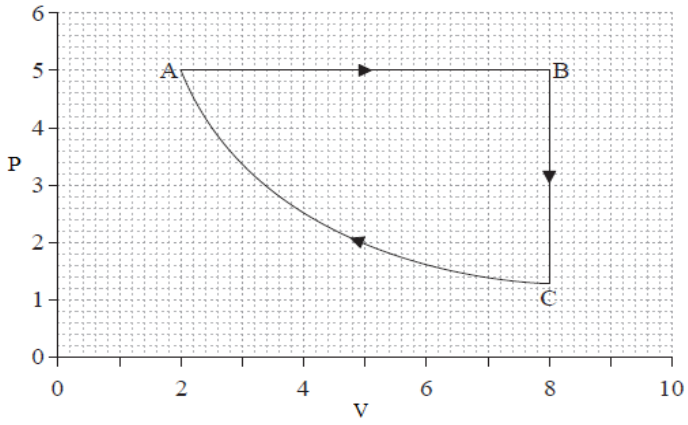
d) Four capacitors are connected as shown in the figure given. Calculate the equivalent capacitance between the points P and Q. **[2]**



e) Is kinetic energy of all photoelectrons same when emitted from certain metals? Justify your claim. **[2]**

Question 9

a) The pressure-volume (pV*)* diagram shows a cycle ABCA of a heat engine. The working substance of the engine is a fixed mass of an ideal gas. Identify the position of maximum temperature of the gas during the cycle. **[1]**



b)

i. Space business is now focussed on space travel and exploration. To ensure success, this industry must understand the risks associated with the unique hazards of space environment. Explain any **FOUR** risks involved in space exploration. **[2]**

ii. Astronauts living in space needs same hygiene as people on Earth. They need to take bath and go to the toilet. How do they take care of themselves in a microgravity environment? **[2]**

c) Is root mean square speed V_{rms} of the molecules in a gas always equal to its average speed V_{avg}? Justify your answer with the calculation. **[2]**

d) Long-period comets, such as Leonard, which had its last perihelion on 22nd July, 2021 and its next perihelion is predicted to be in the year 2667, are believed to have come from the Oort cloud that lies far beyond the outermost planets. In our solar system, Leonard travels in an elliptical orbit around the Sun and spends most of its time beyond the outermost planets. Explain how the motion of Comet Leonard in its orbit supporting Kepler's second law with a diagram. **[3]**

[PHYSICAL CONSTANTS]

Acceleration due to gravity	$g = 9.8\ m/s^2$
Gravitational Constant	$G = 6.67408 \times 10^{-11} m^3 kg^{-1} s^{-2}$
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	1 u = 931.5 MeV
Mass of an electron	$m_e = 9.1 \times 10^{-31}$ kg
Mass of a neutron	$m_n = 1.008665$ u
Mass of a proton	$m_p = 1.007276$ u
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ TmA^{-1}$
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$
Planck's constant	$h = 6.63 \times 10^{-34}$J.s
Speed of electromagnetic wave	$c = 3 \times 10^8\ ms^{-1}$
Standard atmospheric pressure	1 atm=101325 Pa
Universal gas constant	R = 8.31 J/mol.K
1 electron volt	$1eV = 1.6 \times 10^{-19}$ J
	$\pi = 3.14$