WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2022

PHSACOR03T-PHYSICS (CC3)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and *two* questions from the rest

1. Answer any ***ten*** questions from the following: 2×10 =20

(a) Show that the mutual inductance between two coils of self-inductance L_1 and L_2 cannot exceed $\sqrt{L_1 L_2}$.

(b) A coil of radius 1.5 cm and of 500 turns links with a magnetic field of 50 G. If the magnetic field is reversed in 0.01 sec, calculate the average e.m.f. induced in the coil.

(c) Show that, $\delta(ax) = \frac{1}{a}\delta(x)$, $a > 0$.

(d) Find the electric field at $(2, \pi/2, 0)$, if the potential is given by $V = \frac{10}{r^2}\sin\theta\cos\phi$.

[Components of gradient in spherical polar coordinates are given by $\left(\frac{\partial}{\partial r}, \frac{1}{r}\frac{\partial}{\partial \theta}, \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}\right)$.]

(e) Find the force on a square loop of side *s*, lying on the *y*-*z* plane, centered at the origin, if the loop carries a current *I* and the magnetic field is $\vec{B} = kz\,\hat{i}$, k is a constant.

(f) Consider a point charge q situated at the origin and a dipole of moment $\vec{p}$ is situated at $\vec{r}$ with $\vec{p}$ oriented along $\vec{r}$. Find the force on the dipole due to q.

(g) State Gauss's law in presence of dielectric.

(h) At each corner of a square is a particle with charge q. Fixed at the centre is a point charge of opposite sign, of magnitude Q. What value must Q have to make the total force on each of the four particles zero?

(i) The electrostatic potential in free space is given by

$$\phi = \alpha - \beta(x^2 + y^2) - \gamma \ln\sqrt{x^2 + y^2}$$

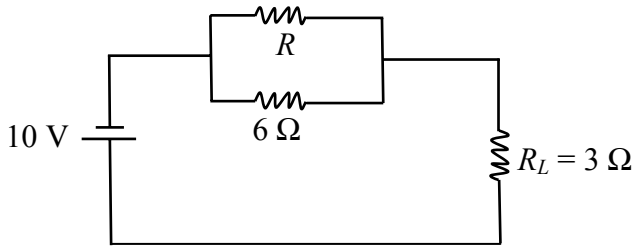
where α, β, γ are constants. Find the charge density in the region.

(j) A dielectric cylinder is defined by $x^2 + y^2 = r^2$, $z = 0$ and $z = h$. The polarizatic at a point (x, y, z) in the cylinder is $\vec{P} = x^2\hat{i} + y^2\hat{j}$. Determine the surfac densities of polarization charge.

(k) Using the magnetic vector potential $\vec{A} = e^{-x}\sin y\hat{i} - (1+\cos y)\hat{j}$, determine the magnetic induction.

(l) Write a short note on the reciprocity theorem in electromagnetic induction.

(m) In the following circuit the value of R for maximum power transfer to the load $R_L = 3\ \Omega$ is :



(n) In a series RLC circuit, L = 10 mH, C = 1 μF, calculate the value of R for which the capacitor discharge is critically damped.

2. (a) A point charge 'q' is placed at a distance 'd' from the centre of a grounded conducting sphere of radius R, with $d > R$. Determine the position and magnitude of the image charge and also the distribution of charge over the surface of the sphere such that the net potential on the surface of the sphere is zero. $1\frac{1}{2}+1\frac{1}{2}+2$

(b) A point charge +6 esu is located 6 cm from the centre of a grounded conducting sphere of radius 5 cm. Determine the force of attraction experienced by the point charge. 2

(c) Consider a magnetized material with magnetization $\vec{M}$. Show that the magnetic vector potential is equivalent to that produced by a volume current $\vec{J} = \vec{\nabla}\times\vec{M}$ and a surface current $\vec{K} = \vec{M}\times\vec{n}$. 3

3. (a) Two insulating planar dielectric slabs having permittivity ε_1 and ε_2 respectively, are bonded together. Slab 1 has electric field $\vec{E}_1$ making an angle θ_1 to the surface normal. Find corresponding electric field $\vec{E}_2$ and angle θ_2 in absence of surface charge at the boundary. 2

(b) What are the components $\vec{E}_2$ and angle θ_2 in presence of surface charge at the boundary? 2

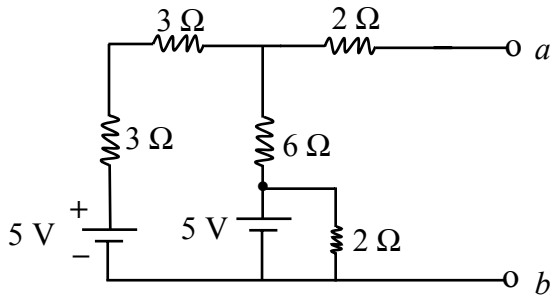
(c) The electric potential inside a dielectric sphere of radius a and permittivity ξ is $\phi(r, \theta) = kr\theta$, where k is a constant. Determine the volume density of polarization charge. 3

(d) A conducting wire of length 2 m and parallel to the y-axis is located at $z = 0$, $x = 1$ m in a region of uniform magnetic field of induction $\vec{B}$. The wire carries a current of 10 A in the negative y direction and experiences a force $\vec{F} = \frac{10^{-2}}{\sqrt{2}}(-\hat{i} + \hat{k})$ N. Find the x and z-components of $\vec{B}$. 3

4. (a) Show how a small current loop can be treated as a magnetic dipole. What is it dipole moment? 2+1

(b) A straight conducting wire of length $l = 1\hat{k}$ m moves with a velocity $\vec{v} = (2\hat{i} - 3\hat{j} + \hat{k})$ m/s in a region of uniform magnetic induction $\vec{B} = (2\hat{i} + \hat{j})\ T$. Find the voltage induced between the ends of the wire. 3

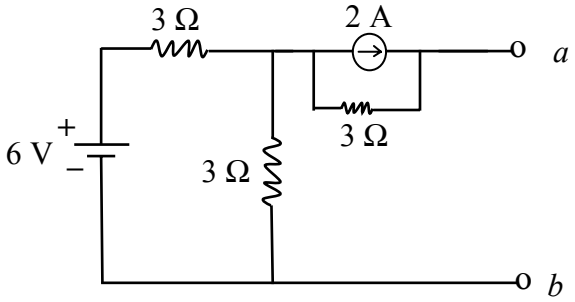
(c) 3+1



Find the Thevenin equivalent circuit of the above circuit diagram. Draw the Norton equivalent circuit also.

5. (a) A series combination of a resistance R and a capacitance C is connected in parallel to an inductance L. Determine the parallel resonant frequency. 3

(b) For the circuit below, determine the Norton equivalent source current and resistance with respect to the terminals a, b: 4



(c) An alternating source of 200 volt, 50 Hz is connected in series with a resistance of 20 Ω and an inductance of 1 Henry. What capacitance should be put in series with the combination to obtain maximum current? Find the potential difference across resistance, inductance respectively under the maximum current condition. 3

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within* 1 *hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

——×——

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2022

PHSACOR04T-PHYSICS (CC4)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Question No. 1 is compulsory and answer any *two* from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

   (a) What are the combination tones?

   (b) State the 'principle of superposition' of waves.

   (c) What do you mean by 'temporal' and 'spatial' coherence?

   (d) Is it possible to have interference without diffraction? — Explain.

   (e) What are the differences between 'in-line-holography' and 'off-axis-holography'?

   (f) State Rayleigh's criteria on resolution.

   (g) A plane transmission grating having 6000 lines is used to obtain a spectrum of light from a sodium lamp in second order. Calculate the angular separation between two sodium lines with wavelengths are 5890 Å and 5896 Å respectively.

   (h) In a Newton's ring experiment, the diameters of the n^{th} ring (bright) with air film and liquid film are 2.4 mm and 2.0 mm respectively. Calculate the refractive index of the liquid.

   (i) Explain, why extended light source is required to observe the interference with thin film.

   (j) What is the difference between the fringes produced by Michelson's interferometer and Newton's ring?

   (k) Define 'bel' and 'phon'.

   (l) State and differences between grating spectra and prism spectra.

   (m) A two slit interference pattern is observed in air (refractive index 1). Then the entire system is immersed in water (refractive index 1.33). Mention the changes observed in the fringe system.

   (n) Show that $f(ct-x)$ is a solution of the one dimensional wave equation where the symbols have their usual meanings.

2. (a) What are beats? Explain graphically and mathematically their production. Also, derive an expression for the frequency of beats. 2+(2+2)+2

(b) Two tuning forks A and B, the frequency of B being 512, produce 5 beats per sec. A is filed and the beats are found to occur at shorter intervals. Find the frequency of A. 2

3. (a) Briefly describe the formation of stationary waves for the transverse vibration of string under tension and fixed at two ends. 3

(b) A whistle emits a note of frequency 1000 Hz, when hydrogen gas (molecular weight 2) is passed through it. When an unknown diatomic gas is passed, the note gets down to 225 Hz. What is the molecular weight of the unknown gas? 3

(c) What is your idea of a wave group? Derive the relation $c_g = c - \lambda \frac{dc}{d\lambda}$, where the symbols have their usual meaning. 1+3

4. (a) Apply Huygen's Principle of wave propagation to prove laws of refraction for a plane surface. 3

(b) Show that in Young's double slit experiment, if we place a thin transparent slab in the path of one of the interfering rays then the entire fringe pattern is shifted (upward) on the screen. 3

(c) Newton's rings are formed with a source of light containing two wavelengths λ_1 and λ_2. If m^{th} order dark ring due to λ_1 coincides with $(m+1)^{th}$ order dark ring due to wavelength λ_2, then prove that the radius of the m^{th} dark ring of λ_1 is equal to $\sqrt{\frac{\lambda_1\lambda_2 R}{(\lambda_1 - \lambda_2)}}$, where R is the radius of curvature of the plano convex lens. 4

5. (a) Introducing the concept of half period zone in diffraction of light prove that the amplitude due to a large wave front at a point in front of it is just half that due to the first half period zone. Hence, give Fresnel's explanation of the rectilinear propagation of light. 3+1

(b) Derive an expression for intensity at a point in Fraunhofer type of distribution produced by two nearby parallel narrow slits illuminated by monochromatic light. Draw a diagram to indicate the distribution of intensity. 3+1

(c) What is the highest order of spectrum, which may be observed with monochromatic light of $\lambda = 500$ Å by means of a grating with 5000 lines/cm? 2

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within* 1 *hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

——×——

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2021

PHSACOR03T-PHYSICS (CC3)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

(a) Suppose the electric field in some region is found to be $\vec{E} = kr^3\hat{r}$, in spherical polar coordinates (k is some constant). Find the charge density $\rho(r)$.

(b) Establish the relation

$$\vec{p} = \varepsilon_0(K-1)\vec{E}.$$

Hence prove that polarization vanishes in vacuum.

(c) Find the r.m.s value of the ac voltage represented by

$$e(t) = \begin{cases} e_0 \cos\left(\omega t + \dfrac{\pi}{2}\right) & \text{for } 0 \le \omega t \le \pi \\ 0 & \text{for } \pi \le \omega t \le 2\pi \end{cases}$$

(d) Show that the dimension of ϵ/σ is the dimension of time. Where ϵ and σ denote the permittivity and conductivity of the medium respectively.

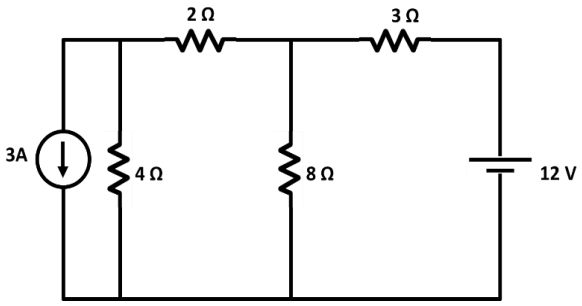
(e) Why a parallel LC circuit is inductive but a series LC circuit is capacitive at resonant frequency?

(f) Magnetic field arises due to charges in motion. Can a system have magnetic moment even though its net charge is zero? Give example.

(g) A pure dipole p is situated at the origin in the Z direction. What is the force on a point charge q at (a, 0, 0) (Cartesian Co-ordinate) due to the dipole?

(h) A point charge q is placed at a distance d from an infinite conducting plane. Find the work necessary to move the charge to infinite distance from the plane.

(i) Using the rule of transformation from a constant current source to a constant voltage source or vice versa, find the voltage across the 8Ω resistance ($V_{8\Omega}$) in the network given below:



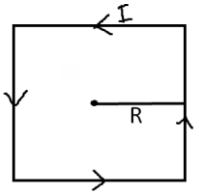
(j) Explain why the electric field inside a hollow spherical charge distribution is zero.

(k) Determine the effect when an electric dipole is placed in a homogenous electric field and a non homogeneous electric field.

(l) In a certain region of space electric field is given by $\vec{E} = \hat{j}E_0 \cos(\omega t - kx)$. Using the differential form of Faraday's law find the corresponding magnetic field $\vec{B}$.

(m) Calculate the magnetic dipole moment due to the orbital motion of an electron.

(n) Find the magnetic field at the center of a square loop that carries a steady current *I*. Let *R* be the distance from the center to the side as shown in the figure.



2. (a) Using Coulomb's law of electrostatics and the principle of superposition of electric field, prove that the electric field generated by any static charge distribution obeys the relation 2

$$\vec{\nabla} \times \vec{E} = 0$$

(b) An electron of charge *e* and mass *m* is released on the axis of a large circular loop of wire carrying uniform distribution of positive charge *Q*. Assuming that the electron starts a short distance away from the centre of the loop, show that it will execute a S.H.M. with angular frequency 3

$$\omega = \left[\frac{eQ}{4\pi\varepsilon_0 m r^3} \right]^{1/2}$$

(c) Find the potential inside a uniformly charged solid sphere of radius *R* and charge *q*. 3

(d) Find the electrostatic energy stored in a uniformly charged solid sphere of radius *R* and charge *q*. 2

3. (a) Establish Gauss's law in Dielectric and hence define Electric Displacement (D). Can we write $\vec{\nabla} \times \vec{D} = 0$ like $\vec{\nabla} \times \vec{E} = 0$? Explain. 2+1+1

(b) A sphere of radius *R* carries a polarization $\vec{P}(r) = k\vec{r}$ where *k* is a constant and $\vec{r}$ is the vector from the centre.

(i) Calculate the bound charge densities σ_b on the surface and ρ_b. (1+1)

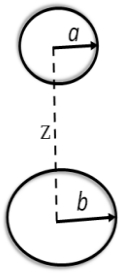
(ii) Find the electric field inside and outside the sphere. 2+2

4. A small loop of wire (radius *a)* is held at a distance *z* above the center of a large loop (radius *b*) as shown in figure below. The planes of the two loops are parallel and perpendicular to the common axis.

(i) Suppose current *I* flows in the large loop. Find the flux through the small loop. (The small loop is so small that you may consider the field of the large loop to be essentially constant). 3

(ii) Suppose current I flows in the small loop. Find the flux through the large loop. (The small loop is so small that you may treat it as a magnetic dipole.) 3

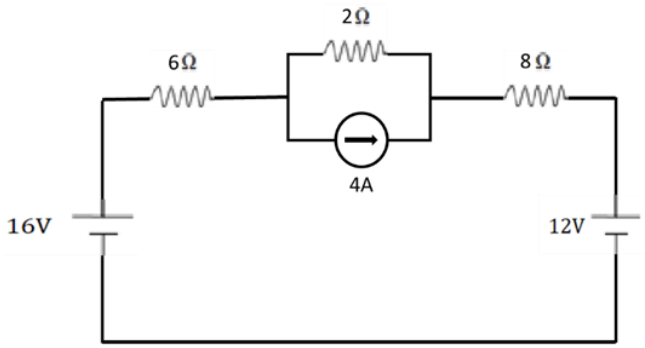
(iii) Find the mutual inductances and confirm that $M_{12} = M_{21}$ 3+1



5. (a) "Ampere circuital law is bound to fail for non steady currents" – Justify the statement. 2

(b) A 100V, 100W lamp is operated at 200V, 50Hz mains. What (i) pure resistance, (ii) ideal inductance to be connected in series to get normal glow of the lamp? Why is 220V *ac* more dangerous than 220 V *dc*? 3+1

(c) Using Thevenin's theorem, find the current through 8Ω resistance in the following network. 4



N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

———×———

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2021

PHSACOR04T-PHYSICS (CC4)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Question No. 1 is compulsory and answer any *two* from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

   (a) Show that $\psi(x,t) = f(ct-x)$ represents a wave propagating along positive x-axis with a velocity c.

   (b) State the conditions for production of sustained interference fringes.

   (c) Compare a zone plate with a convex lens.

   (d) Calculate the fringe width of interference pattern produced in Young's double slit experiment with slits 10^{-3}meter apart on a screen 90 cm away. Wavelength of light is 6000 Å.

   (e) How can stationary waves be formed from progressive waves?

   (f) Two closed pipes of lengths 1.1 m and 1.046 m are sounded together at the fundamental modes. If the speed of sound in air is 340 m/sec, calculate the number of beats generated per second.

   (g) Distinguish between Fresnel and Fraunhofer diffraction.

   (h) Construct the Lissajous figure along with the direction of the trajectory for the following motions: $x = \cos 2\omega t, y = \sin 2\omega t$.

   (i) What do you mean by absent spectra in a diffraction grating pattern?

   (j) What are the corrections introduced by Laplace in the Newton's formula for velocity of sound in a gaseous medium?

   (k) Explain in brief how does straight fringes are produced in Michelson Interferometer.

   (l) A He-Ne laser has a coherence length of 10 m. Determine the value of the corresponding coherence time.

   (m) What do you mean by fringes of equal thickness? Give an example.

   (n) Define plane and spherical waves.

2. (a) For a plane progressive wave, show that the instantaneous energy density is not constant, but its average value over a complete period is constant. 4

(b) A particle moves in *xy* plane such that its position at any instant of time *t* is given by $x = a\cos\omega t$ and $y = b\cos 2\omega t$. Show that the particle describes an arc of a parabola.

(c) Two strings A and B of the same material, cross-sectional area and length are fixed at their ends and subjected to tension in the ratio of 2.89:1 respectively when the strings are vibrated, 8 beats per second are heard between the third harmonic of string A and the fifth harmonic of string B. Calculate fundamental frequencies of each string.

3. (a) What do you mean by 'string'? Find the expression for kinetic energy for transverse vibration of a string. 1+4

(b) A string vibrates with a frequency **n** under a certain tension. When the tension is increased by 2 kg-wt, the frequency becomes $(3/2)$**n**? What was the original tension? 2

(c) Show that in vibration of air column in an open pipe all harmonics can be generated. 3

4. (a) What are Newton's rings? Explain how the Newton's ring experiment can be used to determine the refractive index of an unknown liquid. 2+3

(b) Why is it necessary to use narrow source for Biprism and extended source for Newton's ring? 2

(c) In a biprism experiment, the fringe-width is 0.3 mm at a distance 150 cm from the biprism for light of wavelength $\lambda = 6\times10^{-5}$ cm. The biprism is made of glass of refractive index 1.5 and is placed 25 cm away from the illuminated slit. Calculate the vertex angle of the biprism. 3

5. (a) What are Fresnel's half period zones? Show that areas of all these zones are same. 1+2

(b) Find the expression of intensity of Fraunhofer diffraction pattern due to a single slit. Discuss the conditions for maxima and minima. 3+2

(c) A grating of width 2 cm has 500 lines per cm. Can it resolve D_1 and D_2 line of sodium in 1st order? 2

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

——×——

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2020

PHSACOR03T-PHYSICS (CC3)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

(a) The electrostatic field is given by $\vec{E} = 2axi + byj$. What is the charge density that produces this field?

(b) Show that the function $\phi = 4x^2 + 5y - 4z^2$ can represent the electrostatic potential in a charge free region.

(c) Which one of the following is an impossible magnetic field?

(i) $\vec{B} = 3xi + 5yj - 7zk$; (ii) $\vec{B} = 4xi - 7yj + 3zk$

(d) A series LCR circuit is used in a radio set to tune into an FM station broadcasting at 103.7 MHz. The resistance in the circuit is 10 Ω and the inductance is 2.0 μH. What is the value of the capacitance that should be used in the circuit?

(e) State Thevenin's theorem for a linear network.

(f) A positively charged particle is placed at the origin of the xy plane in a region where there is a non-zero uniform magnetic field B in the $+z$ direction and a non-zero uniform electric field E in the $+y$ direction. Draw the possible trajectory of the particle.

(g) A thin non conducting ring of radius R has a charge Q, uniformly spread out on it. What is the electrostatic potential at a point P, located on the axis of symmetry at a distance x from the centre of the ring?

(h) A spherical capacitor with inner radius a and outer radius b is filled with an inhomogeneous dielectric with permittivity $\epsilon = \frac{\epsilon_0 k}{r^3}$ for $a < r < b$. The outer sphere is grounded and a charge is placed on the inner sphere. Find the capacitance of the system.

(i) What is magnetomotive force? What is its unit?

(j) A $3\,\mu F$ capacitor is connected in series with a $6\,\mu F$ capacitor. If a 300V potential difference is applied across this combination, find the total energy stored in the system.

(k) Show that the quantity CR in an RC circuit has the dimension of time.

(l) An ac generator has a fixed internal impedance $R_g + jX_g$ and is used to supply power to a passive load that has an impedance $R_g + jX_l$, where $j = \sqrt{-1}$. For maximum power transfer, find the value of X_l.

(m) Find the r.m.s. value of the ac voltage represented by

$$e(t) = e_0 \cos\left(\omega t + \frac{\pi}{2}\right) \quad , \quad \text{for } 0 \le \omega t \le \pi$$
$$= 0 \quad , \quad \text{for } \pi \le \omega t \le 2\pi$$

(n) Two very thin spherical shells of radius *d*, made of non-conducting material, each carrying uniformly distributed charge $+Q$, are located at a distance $10d$ from each other. A point charge $+q$ is placed inside one of the shells at a distance $\frac{d}{2}$ from the centre on the line connecting the centres of the two shells. What is the net force on the charge $+q$?

2. (a) Write down Poisson's equation of electrostatics and state its connection with uniqueness theorem. 2

(b) The electric field in a certain region is given by $\vec{E} = 4r^3\hat{r}$. Prove that charge contained in a spherical surface of radius *d*, centred at the origin, is $16\pi\epsilon_0 d^5$. 3

(c) Determine the interaction energy between two electric dipoles of moments $\vec{P}_1$ and $\vec{P}_2$ separated by a distance $\vec{r}$. Hence find the condition for minimum energy. 3+2

3. (a) Calculate the magnetic field $(\vec{B})$ at a point *P* at a large distance *r* from the centre of a small current carrying loop, where *P* lies on the axis of the loop. Assume that the loop is equivalent to a magnetic dipole, placed at the origin, whose field at an arbitrary point $\vec{r}$ can be expressed in the form 4

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{1}{r^3}[3(\vec{m}.\hat{r})\hat{r} - \vec{m}],$$

where $\vec{m}$ is its magnetic dipole moment. Hence find an expression for the magnitude of $\vec{m}$ for the loop.

(b) A small circular conducting loop of radius *a* is located at the centre of a much larger circular loop of radius *b*, resting in the same plane. The larger loop carries an alternating current $I = I_0 \cos\omega t$, where I_0 and ω are constants. Calculate the value of the induced e.m.f. in the smaller loop. 4

(c) Write down Ampere's circuital law inside magnetized materials. 2

4. (a) Starting from Biot-Savart law show that the magnetic field is solenoidal. 2

(b) Find an expression for the work done due to Hysteresis in a ferromagnetic material. 3

(c) Two long parallel wires *A* and *B* are separated by 3cm and carry currents in two opposite directions. The current through each wire is 6A. Calculate the magnetic field midway between these two wires. 2

(d) A coil with inductance L and internal resistance R is connected in parallel to a capacitance C. Find the resonant angular frequency when this combination is connected to an ideal ac source. 3

5. (a) Show that Kirchoff's first law of network analysis is consistent with the principle of conservation of charge and the second law is consistent with the law of conservation of energy. 2+2

(b) In an RC circuit the capacitor is initially charged when the circuit is open. After closing the switch, how much time will be required to dissipate half the energy initially stored in the capacitor? 3

(c) A series LCR circuit consists of a resistance $R = 10{,}000\ \Omega$, an inductance L = 25 mH, and a variable capacitor C. The ac generator supplies a signal with amplitude of 40V and angular frequency of 1000 radians per second. Find the value of C for which the amplitude of the current will be maximum and also find the maximum value. 2+1

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

——×——

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2020

PHSACOR04T-PHYSICS (CC4)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Question No. 1 is compulsory and answer any *two* from the rest

1. Answer any ***ten*** questions from the following: 2×10 = 20

(a) Show that in a non-dispersive medium the phase velocity and the group velocity of a progressive wave are equal.

(b) If the equation $y = a\sin^2(kx - \omega t)$ represents a progressive wave, then find out the amplitude and frequency of the wave.

(c) Explain how Laplace corrected the Newton's formula for the velocity of sound.

(d) In Melde's experiment the number of loops on the string decreases from 5 to 4 when the tension is increased by 45 gm-wt. What was the initial value of the tension?

(e) Two SHMs produce Lissajous' figures. It is found that the trajectory looks like the "figure of eight". If the frequency of one fork is 250 Hz, then find the probable frequencies of the other.

(f) Define 'decibel' and 'phon'.

(g) State the 'principle of superposition' of waves.

(h) Write Huygens' principle of propagation of light wave.

(i) A plane diffraction grating has 104 lines per mm. Monochromatic light of wavelength 589 nm is incident normally on the grating. What is the highest order of the principal maximum visible in the spectra?

(j) What will happen to the fringe pattern if the acute angles of the biprism are increased?

(k) Write the basic differences between Fresnel and Fraunhofer diffraction.

(l) Find the missing orders of a double slit Fraunhofer diffraction pattern if the slit widths are 0.1 mm and they are 0.8 mm apart.

(m) What is the relation between the resolving power and the dispersive power of a plane transmission grating?

(n) State any two differences between the fringes produced by Michelson interferometer and Newton's ring?

2. (a) Derive the resultant motion when two SHMs with same frequency, but with different amplitudes, at right angles to each other are superposed. Draw the resultant trajectory when the phase difference between them is π.

   (b) Two wires of the same material are stretched with the same load. Their lengths are 40 cm and 60 cm and their diameters are 1.2 mm and 1.5 mm respectively. The first string resonates with a fork of frequency 384 Hz. Find the frequency of the other.

   (c) Write the conditions of formation of stationary waves. 2

3. (a) Derive an expression for velocity of a plane longitudinal wave in a fluid medium. 4

   (b) For a plane progressive wave, show that the instantaneous energy density is not constant, but its average value over a complete period is constant. 4

   (c) Two open pipes, blown together, produce 5 beats per second (due to the fundamentals). If the shorter pipe is 1 m long, calculate the length of the longer pipe. Given, speed of sound in air is 340 m/s. 2

4. (a) What do you mean by interference of light? 2

   (b) Show that in Young's double slit experiment, the locus of the point, corresponding to the maxima or minima is a hyperbola. 4

   (c) Show that the diameter D_n of the *n*-th (dark) Newton's ring, when the surfaces of radii R_1 and R_2 are placed in contact, is given by, $\frac{1}{R_1} \pm \frac{1}{R_2} = \frac{4n\lambda}{D_n^2}$. 4

5. (a) What is a zone plate? Prove that a zone plate has multiple foci. Compare the actions of a zone plate and those of a converging lens. 1+2+2

   (b) State Rayleigh's criterion for the resolution of spectral lines. 2

   (c) A diffraction grating of 2 cm width is just able to resolve sodium D-lines in the second order. Find the number of rulings per mm. 3

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

——×——

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2019

PHSACOR03T-PHYSICS (CC3)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: $2\times10=20$

(a) Show that $\delta(ax)=\delta(x)/|a|$, where, δ denotes the Dirac delta function.

(b) The electrostatic field at every point in a given region of space is along x axis. Show that Electric field is independent of y and z in that region.

(c) Can $\vec{E}=k[xy\hat{i}+2yz\,\hat{j}+3xz\hat{k}]$ represents an electrostatic field?

(d) Establish Poisson's equation from Gauss' law.

(e) The interior of a circular cylinder $x^2+y^2=R^2$ is occupied by a polarized material with the polarization $\mathbf{P}=(ax^2+b+cy+a)x\hat{i}+px\,\hat{j}$. Find the volume and surface polarization charge densities.

(f) State the boundary conditions at the surface of separation of two dielectric media of dielectric constants ε_1 and ε_2.

(g) Show that the dipole moment is independent of the choice of origin if the total charge of the distribution is zero.

(h) For a uniform magnetic induction $\vec{B}$, check the possibility of a vector potential given by $\vec{A}=\frac{1}{2}(\vec{B}\times\vec{r})$.

(i) Sketch graphically how the current grows with time in a series R-L circuit.

(j) State Norton's theorem for electric circuits.

(k) A single turn loop is situated in air, with a uniform magnetic field normal to its plane. The area of the loop is 5 meter^2. What is the emf appearing at the terminals of the loop if the rate of change of flux density is 2 webers/meter^2/sec?

(l) What is sharpness of resonance? How is it related to the Q factor?

(m) In the interior of a permanent magnet **H** and **B** fields are opposite to each other. Which part of the Hysteresis loop corresponds to such magnetic state.

(n) A long solenoid of length L, carrying current I, is moving with uniform velocity v, towards a ring of radius a, slightly larger than that of the solenoid so that it can pass through the ring. Graph the emf induced in the ring as a function of time.

2. (a) Using Gauss' law find the electric field at a distance z from a straight infinite line charge of uniform charge density. Calculate the potential at that point. 2+1

(b) A static charge distribution produces a radial electric field 3+2

$$\vec{E} = A\frac{e^{-br}}{r}\hat{e}_r$$

where A and b are constants. Find the charge density ρ and the total charge Q over all space.

(c) Consider an assembly of n fixed point charges $q_1, q_2, \ldots\ldots, q_n$ in vacuum. For simplicity, assume $q_i > 0$ for all i. Let $\vec{E}(\vec{x})$ be the electric field produced by these charges. Can we find a point $\vec{X}$ in space such that a test charge Q placed there will be in stable equilibrium? 2

3. (a) Using Biot-Savart law (for volume distribution of current), show that magnetic field is *Solenoidal*. 3

(b) Find the magnetic field at a distance z along the axis of a circular ring of radius a carrying current I. If a very small circular loop of radius r $(r << a)$ is placed at a distance z on the axis making an angle θ with the larger ring, find the mutual inductance of this system. 3+1

(c) Consider a magnetized material with magnetization $\vec{M}$. Show that the magnetic vector potential is equivalent to that produced by a volume current $\vec{J} = \vec{\nabla} \times \vec{M}$ and a surface current $\vec{K} = \vec{M} \times \vec{n}$. 3

4. (a) A thin circular ring of radius 'a' has a uniform line charge of density λ on it. Calculate the field and potential at a point P on the axis of the ring at a distance z from its plane. Where is $E(z)$ maximum? 2

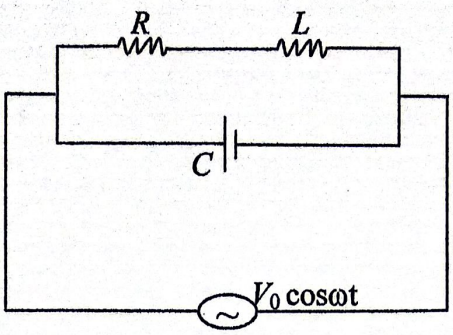
(b) Show that the energy of a dipole in an electric field is given by $U = -\vec{p}.\vec{E}$. 2

(c) A charge $+q$ is placed in front of an earthed infinite conducting plane. Show that the net charge induced on the plane is $-q$. 3

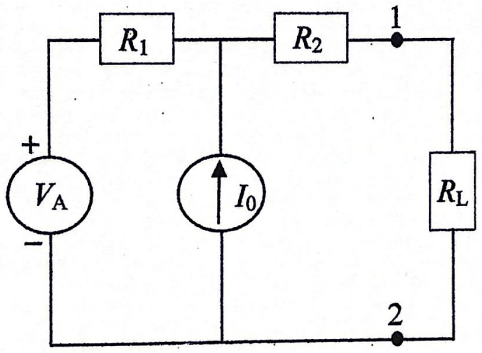
(d) Show that the electric field produced by a uniformly polarized sphere outside it is same as that of a point dipole at the origin with dipole moment equal to the net dipole moment of the sphere. 3

5. (a) What are the characteristics of a constant current source and a constant voltage source? 2

(b) A parallel LCR circuit is shown in figure. Find the resonant frequency. Show that the impedence of the circuit at resonance is equal to L/CR.



(c) In the circuit (shown in the figure) $V_A = 4\,\text{V}$, ideal current source with current $I_0 = 2\text{A}$, $R_1 = 2\,\Omega$ and $R_2 = 3\,\Omega$. Find the Thevnin equivalent voltage V_{TH} and the resistance, R_{TH} for the network to the left of terminals 1 and 2. 1+2+1



What would be the maximum power delivered to the resistance R_L?

——×——

WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2019

PHSACOR04T-PHYSICS (CC4)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and any *two* questions from the rest

1. Answer any ***ten*** questions from the following: $2\times10 = 20$

(a) State Huygen's Principle.

(b) In a Lloyd's mirror experiment, calculate the ratio of the intensities at the interference maxima and minima if the mirror reflects only 75% of the light incident on it.

(c) Distinguish between grating spectra and prism spectra.

(d) Why is it necessary to use narrow source for biprism and extended source for Newton's rings?

(e) What are the basic characteristics of a LASER source?

(f) State Rayleigh's criterion of resolution.

(g) In Michelson's interferometer, 100 fringes cross the field of view when the movable mirror is displaced through 0.02948 mm. Calculate the wavelength of the monochromatic light used.

(h) Explain why the quality of sound is richer in an open organ pipe than a closed organ pipe.

(i) Give one example of each of struck string and plucked string instrument.

(j) Give the main difference between the fringes produced by a biprism and those produced by a Lloyd's mirror.

(k) Deduce the expression for frequency of the fundamental tone in case of pipe open at both ends.

(l) Show that the first order and second order spectra will never overlap when a grating is used for studying a light beam containing wavelength components from 400 nm to 700 nm.

(m) Discuss about the requirements of holography.

(n) Show that the velocity of longitudinal wave in a solid is larger than the velocity of transverse wave.

2. (a) Write the expression for Fraunhofer diffraction pattern of a double slit.

(b) Deduce the expression for maxima and minima for intensity distribution of double slit.

(c) A parallel beam of light of wavelength 5460 Å is incident at an angle 30° on a plane transmission grating which has 6000 lines/cm. Find the highest order of spectrum that can be observed. 3

(d) Explain absent spectra. 3

3. (a) 'n' number of simple harmonic motions along the x-axis having the same amplitude 'a' and the same angular frequency 'ω' but equal successive phase advancement δ, are superposed. Find the resultant motion. 4

(b) Define group velocity and phase velocity. Deduce the relation $v = c - \lambda \frac{dc}{d\lambda}$, 2+3+1

where v is the group velocity and c is the phase velocity. In which type of medium will the two velocities be equal?

4. (a) What are stationary waves? Give the theory of formation of stationary waves. 1+3

(b) An object placed in air is vibrating with a frequency 250 Hz and releasing sound energy uniformly in all directions at a rate 10 J/s. Calculate the intensity and amplitude of the wave at a distance of 100 m from the source. Given density of air = 1.3 kg/m^3 and the speed of waves in air = 340 m/s. Assume no loss of energy in air during propagation. 2

(c) Consider the formation of a hologram with a point object and a plane reference wave. Choose the z axis to be along the normal from the point source to the plane of the photograph assumed to be coincident with the plane $z = 0$. Obtain the interference pattern recorded by the hologram. (Assume the reference wave to fall normally on the photographic plate). 4

5. (a) State the conditions for the production of sustained interference fringes. 2

(b) Show that the diameters of Newton's dark rings are proportional to square root of natural number. 3

(c) What is the difference between the fringes produced by Michelson interferometer and Newton's ring instrument? 2

(d) When a narrow monochromatic source of light of wavelength 5893 Å is placed at a distance 50 cm from the biprism, width of the fringes obtained on a screen placed 1 m from the biprism is found to be 0.12 mm. Find the obtuse angle of the biprism. (R.I. of material of biprism is 1.5) 3

——x——