# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2022

## PHSACOR13T-PHYSICS (CC13)

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 any *two* questions from the rest**

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

(a) Show that for a good conductor, the phase lag of $\vec{H}$ behind $\vec{E}$ is $\frac{\pi}{4}$.

(b) The intensity of the sunlight reaching the earth's surface is about 1300 $W/m^2$. Calculate the strength of the electric field of the incoming sunlight.

(c) Find out the dimension of Poynting Vector $\vec{S}$.

(d) Show that TEM waves cannot occur in hollow wave guide.

(e) What are the differences between single mode and multimode fibers?

(f) What are positive and negative crystals?

(g) The conductivity of silver is $3\times10^7 mho.m^{-1}$. Calculate its skin depth at a frequency of 9.5 Hz.

(h) Calculate the thickness of half-wave plate of wavelength 5893Å, Given $n_0 = 1.544$ and $n_e = 1.553$.

(i) The refractive index of the core of an optical fibre is 1.55. What should be the refractive index of the cladding for an acceptance angle of 25°?

(j) A 20 cm long tube containing sugar solution given a rotation of 10.6° of the plane of vibration of a plane polarised light. Find the strength of the solution. Given the specific rotation of sugar = 66.5 $dm^{-1}g^{-1}.cm^{-3}$.

(k) Show that for electromagnetic waves in free space, energy in equally shared between electric and magnetic fields.

(l) Show that the frequency of an electromagnetic wave remains unchanged upon reflection or refraction.

(m) Describe the state of polarization of the electromagnetic wave represented by $\vec{E}(z,t) = \hat{i}\,E_0\cos(kz-\omega t) - \hat{j}\,E_0\cos(kz-\omega t)$.

(n) Explain the concept of displacement current.

2. (a) What is Babinet's compensator? Explain, how it can be used to analyse circularly polarized light. 1+3

(b) When do Maxwell's equation become uncoupled? What is the consequence? 2+1

(c) Write that the Maxwells' equations for plane polarised electromagnetic waves in a dielectric medium having finite values of $\mu$ and $\varepsilon$ but $\sigma = 0$ and derive its solution. 3

3. (a) Establish the boundary conditions that must be satisfied by the field vectors. when an electromagnetic wave is incident at the interface between two dielectric media. 3

(b) Show that the Maxwell's equations are Lorentz invariant. 4

(c) Define optic axis of a crystal. What is principal section of a crystal? 2+1

4. (a) Write Fresnel's theory of rotation of the plane of polarisation by an optically active substance. 4

(b) What are H-polaroid and K-polaroid? 3

(c) An electromagnetic wave polarized perpendicularly to the plane of incidence impinges at 30° on a glass slab having refractive index 1.5. Find the amplitude reflection and transmission coefficients. 3

5. (a) Show that average energy density in a harmonic electromagnetic field is 4

$$\langle u \rangle = \frac{1}{4} \mathrm{Re}[\vec{E} \cdot \vec{D}^* + \vec{H} \cdot \vec{B}^*],$$

where $\vec{D}^*$ and $\vec{B}^*$ are complex conjugates of $\vec{D}$ and $\vec{B}$.

(b) Light is incident from air on a glass of refractive index 1.5. Calculate Brewster's angle. 2

(c) Compute the thickness of quarter wave plate for negative crystal. 2

(d) Describe with necessary diagram, the step index and graded index optical fibre. 2

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2022

## PHSACOR14T-PHYSICS (CC14)

### STATISTICAL MECHANICS

Time Allotted: 2 Hours | Full Marks: 40

*The figures in the margin indicate full marks.*
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*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) Draw the phase space trajectory of 1-D simple harmonic oscillator.

(b) State Ergodic hypothesis in statistical mechanics.

(c) What do you mean by ultraviolet catastrophe?

(d) In how many ways can two identical bosons be distributed in two energy states? Show the distribution diagrammatically.

(e) State Kirchoff's law and Stefan Boltzmann law.

(f) How does Sackur Tetrode equation resolve Gibbs paradox?

(g) How chemical equilibrium is defined?

(h) State the principle of equipartition of energy.

(i) Define microstates and macrostates.

(j) Explain the statistical idea of entropy.

(k) A spherical black body with radius $R$ and at the temperature $T$ (K) emits an energy $E$ J/S. Another similar black body with radius $2R$ is at temperature $2T$ (K). What is the energy emitted by the second black body?

(l) State Saha ionization formula. What is its significance?

(m) Distinguish between canonical and grand-canonical ensembles.

(n) Two dices are rolled simultaneously. Enumerate the microstates and the macrostates.

(o) Assuming a typical white dwarf star comprises a strongly degenerate electron gas, calculate the Fermi temperature of a typical white dwarf star.
(Given $m_e = 9.1\times10^{-31}$ kg, $k_B = 1.38\times10^{-23}$ JK$^{-1}$, $h = 6.627\times10^{-34}$ J.s and number density $N/V = 10^{36}$)

2. (a) Consider $N$ independent, distinguishable, one dimensional quantum harmonic oscillators having energy spectrum $\varepsilon_n = \left(n + \frac{1}{2}\right)\hbar\omega$. Calculate the single particle partition function. Show that $N$ oscillator partition function is given by $z = e^{-\frac{N}{2}\beta\hbar\omega}\{1 - e^{-\beta\hbar\omega}\}^{-N}$. 3

(b) Calculate internal energy $U$ and $C_V$ for the above system. 2+2

(c) Two states with energy difference $4.83\times10^{-7}$ J occur with relative probability $e^2$. Calculate the temperature. Given $k = 1.38\times10^{-23}\,\text{J.K}^{-1}$. 3

3. (a) State Liouville's theorem of ensemble theory. What information does it carry regarding the reversibility of a macroscopic process? 2+1

(b) A system has two energy states $E$ and $3E$, the lower level is 6 fold degenerate and the upper level is 2 fold degenerate. If there are $N$ particles, calculate the fraction of molecules at the upper level. 3

(c) Show that the density of state $g$ for molecules obeying Maxwell Boltzmann distribution is 4

$$g(p)dp = \frac{4\pi p^2 dp}{h^3}$$

4. (a) Starting from Fermi-Dirac distribution law derive the expression for energy distribution of free electrons in metal. 4

(b) Calculate the Fermi energy at absolute zero. 3

(c) Evaluate the temperature at which there is one percent probability that a state with an energy 0.5V above the Fermi Energy will be occupied by an electron. 3

5. (a) Write the chemical potential in terms of energy, Helmholtz's free energy and Gibb's free energy. 3+4+3

(b) Calculate the chemical potential for ideal gas.

(c) State law of mass action and Saha Ionization formula.

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2022

## PHSADSE04T-PHYSICS (DSE3/4)

Time Allotted: 2 Hours | Full Marks: 50

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

1. Answer any ***fifteen*** questions from the following: 2×15 = 30

(a) $x + y = 10$ is defined in natural number $N$. Show that this relation is not *transitive*.

(b) Show that the centre of a group, $Z(G)$, forms a subgroup.

(c) Show that Inverse of an element in a subgroup is the inverse of the element of the group.

(d) Show that two left cosets of a subgroup $H$ either coincide completely, or else have no elements in common at all.

(e) Show three cube roots of unity form an abelian group under multiplication.

(f) Give irreducible representation of SU(2) group.

(g) Prove that the group of order two is always cyclic.

(h) A random number $\tilde{x}$ is distributed uniformly between [0, 1]. Find its variance.

(i) A book of 1000 pages contains 20 typographical errors. What is the probability that there is at least one error in a single page?

(j) In a one dimensional random walk, the probability of moving one step in the right is $p$ for each step. Find the probability of reaching the starting point by a random walker after taking $2n$ number of steps.

(k) Find the standard deviation of the uniform distribution $f(x) = \frac{1}{n}$ ; $(x = 0, 1, 2, \cdots, n)$.

(l) Let $x$ be distributed in the Poisson form. If $P(x = 1) = P(x = 2)$; Find the expectation value.

(m) Four coins are tossed simultaneously. Find the probability of obtaining 2 heads and 2 tails.

(n) Show that total area under a normal curve is unity.

(o) State the condition when a binomial distribution can be approximated to normal distribution.

(p) Let a homomorphism $f:(G,\bullet)\to(H,\bullet)$. Show that $f(e_G)=e_H$, where $e_I$ is the identity element of group *I*.

(q) State the nature of the equations:

(i) $4\frac{\partial^2 U}{\partial x^2}+\frac{\partial^2 U}{\partial y^2}=0$ (ii) $\frac{\partial^2 U}{\partial x^2}-2\frac{\partial^2 U}{\partial x\partial y}+\frac{\partial^2 U}{\partial y^2}=0$

(r) Find the solution of one dimensional Laplace's equation, where at the boundaries, the solution $\psi(x=0)=\psi(x=l)=0$.

(s) Determine the condition under which the following differential equation can be solved by the method of separation of variables:

$C_1\frac{\partial\phi(x,t)}{\partial t}+C_2\nabla^2\phi(x,t)+V(x,t)\phi(x,t)=0$, where $C_1$ and $C_2$ are constants.

(t) Show that the equation $\left[a^2\frac{\partial^2}{\partial x^2}-b^2\frac{\partial^2}{\partial y^2}\right]\phi(x,y)=0$ can be expressed as the product of two linear partial differential equations with real coefficients.

2. (a) A multiplication table of a Group consists 6 elements is given below 3+2+2

$$\begin{Vmatrix} e & a_1 & a_2 & a_3 & a_4 & a_5 \\ a_1 & e & a_4 & a_5 & a_2 & a_3 \\ a_2 & a_5 & e & a_4 & a_3 & a_1 \\ a_3 & a_4 & a_5 & e & a_1 & a_2 \\ a_4 & a_3 & a_1 & a_2 & a_5 & e \\ a_5 & a_2 & a_3 & a_1 & e & a_4 \end{Vmatrix}$$

(i) Identify the two elements and 3 elements subgroups

(ii) Find the left cosets of any one 2 elements subgroup.

(iii) Show that three elements subgroup is the invariant subgroup.

(b) Show that the set $\{1,-1,i,-i\}$ forms a cyclic group for multiplication. Find its generator. 3

3. (a) Using the method of least squares, fit a straight line to the four points: 4

| $x$ | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| $y$ | 1.7 | 1.8 | 2.3 | 3.2 |

(b) Let $f$ be a homomorphism from $G\to G'$. Denote by *K* the set of all elements of *G* which are mapped to the identity element of $G'$, Then *K* forms an invariant subgroup of *G*. Prove it. 3

(c) Statistical average of some function $f(x)$ is defined as 3

$\langle f(x)\rangle=\sum_i f(x_i)P_i$. Show that $\left(\frac{d^k}{dt^k}\langle e^{tx}\rangle\right)_{t=0}=\langle x^k\rangle$

4. (a) Prove that Poisson distribution may be obtained as a limiting case of Binomial distribution. 3

(b) In a bolt factory, machines $A_1$, $A_2$ and $A_3$ manufacture respectively 25, 35 and 40% of the total. Of their output 5, 4 and 2% are defective bolts. A bolt is drawn at random and found it defective. What is the probabilities that it was manufactured by the machine $A_1$, $A_2$ or $A_3$? 4

(c) Deduce the expression for mean of a binomial distribution. 3

5. (a) Solve: $\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial y^2}=0$ given 4

$T(0, y)=0$; $T(x, \infty)=0$

$T(a, y)=0$; $T(x, 0)=\sin\left(\frac{\pi x}{a}\right)$

(b) Let U and V are two solutions of Laplace's equation. If both of them satisfy either Dirichlet or Neumann boundary condition, then show that they are at most differ by a constant otherwise identical. 3

(c) Show that following transformation forms a group under multiplication, 3

$$\begin{pmatrix} ct' \\ x' \end{pmatrix}=\begin{pmatrix} \cosh\Psi & \sinh\Psi \\ \sinh\Psi & \cosh\Psi \end{pmatrix}\begin{pmatrix} ct \\ x \end{pmatrix}$$

Ignore the fact that range of $\Psi, (-\infty, \infty)$ is not finite.

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2022

## PHSADSE05T-PHYSICS (DSE3/4)

### ASTRONOMY AND ASTROPHYSICS

Time Allotted: 2 Hours | Full Marks: 50

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*All symbols are of usual significance.*

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

1. Answer any ***fifteen*** questions from the following: 2×15 = 30

(a) Draw a schematic diagram of different layers of the Sun's atmosphere.

(b) With the help of a diagram and proper labelling, describe the Horizon Coordinate system.

(c) A main sequence star has mass $10M_{\odot}$. Compute the luminosity of the star in terms of $L_{\odot}$. Where $M_{\odot}$ and $L_{\odot}$ are mass and luminosity of Sun respectively?

(d) What is the qualitative difference between a main sequence star and a compact star?

(e) Why is the temperature of sunspots lower than their surrounding?

(f) What is active galaxy? Give one such example.

(g) Give arguments in support of the expanding universe.

(h) The apparent magnitude of the full Moon is –11.7 and that of the Sun is –26.7. Compare their brightness.

(i) A galaxy of absolute magnitude of –20 is at a distance of 100 Kpc. Would it be visible to the unaided eye? Give explanations.

(j) What do you understand by the hydrostatic equilibrium of a star?

(k) Calculate the magnitude of the faintest object that a 3.5 m telescope can detect, if the naked eye with a pupil of diameter 5 mm can see down to 6 magnitude.

(l) The masses of four main sequence stars are $15M_{\odot}$, $10M_{\odot}$, $5M_{\odot}$ and $1M_{\odot}$. Place them correctly on the H-R diagram.

(m) What do you mean by Sidereal time? What is the difference between the solar day and sidereal day?

(n) What is flash spectra?

(o) How galactic distance can be measured using Cepheid variables?

(p) State de Vaucouleurs law for galaxies.

(q) Find the temperature at which the number density of hydrogen atoms in the fundamental state is equal to that of its second excited state.

(r) Estimate the age of the universe, given that the Hubble's Constant is 70 km $sec^{-1}$ $Mpc^{-1}$.

(s) Write down the complete chain of reactions of the CNO-cycle inside a main sequence star.

(t) Explain, why gas in elliptical galaxies is expected to be hot.

2. (a) Explain the equatorial system of coordinates with the help of a diagram. 4

(b) What are the factors which determine the resolving power of a telescope? How does light gathering power of a telescope affect its resolving power? 1+2

(c) Calculate the diffraction limit of resolution of a 3 m telescope for the wavelength of 600 nm. 3

3. (a) Draw the differential rotation curve of Milky Way galaxy. Hence explain that how this leads to the prediction of Dark Matter in the Universe. 1+4

(b) Compute the size of a star in terms of the radius of Sun, $R_\odot$, if the star's surface temperature is 5000 K and luminosity is $5L_\odot$. Assume the surface temperature of sun is 6000 K. 2

(c) A star, made up of hydrogen, has a mass of $10^{33}$ gm and radius of $10^{11}$ cm. Determine the order of magnitude of the average temperature in the interior of the star in units of Kelvin. Given that, Gravitational Constant, $G = \approx 10^{-7}$, Boltzmann Constant, $k_B \approx 10^{-16}$, mass of hydrogen atom, $m_H \approx 10^{-24}$gm . 3

4. (a) Suppose that the surface temperature of two stars A and B is the same and the luminosity of star A is higher than star B. Which of the two stars is bigger in size? Explain you answer. 4

(b) Explain briefly the spectral classification of stars. 4

(c) Discuss the characteristics of Globular Clusters. 2

5. (a) Briefly describe the nebular model of the origin of the solar system. What features of the solar system is this model able to account for? 5+1

(b) What are the advantages of reflecting telescope over refracting telescope? 2

(c) What is magnetic flux freezing? 2

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2022

## PHSADSE06T-PHYSICS (DSE3/4)

### COMMUNICATION ELECTRONICS

Time Allotted: 2 Hours | Full Marks: 40

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

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

(a) Explain, what is channels and base band signals.

(b) What is 'means and modes' in communication system?

(c) An AM signal with a carrier of 1 kW has 200 Watts in each side band. What is the percentage of modulation?

(d) What is overmodulation in AM? Draw the corresponding waveform for it.

(e) A carrier wave of frequency 10 MHz and peak value 10V is amplitude modulated by a 5 kHz sine wave of amplitude 6V. Draw the frequency spectrum.

(f) Write the uses of Pulse Amplitude Modulation (PAM).

(g) State the sampling theorem and explain it briefly.

(h) A digital communication link carries binary coded words representing samples of input signal

$$x(t) = 3\cos 600\pi t + 2\cos 1800\pi t$$

What is the sampling frequency?

(i) What are the advantages of digital communication over analog communication?

(j) Why is the downlink frequency less than the uplink frequency?

(k) Mention the advantages of geostationary satellites.

(l) What is Time Division Multiplexing (TDM) in analog pulse modulation?

(m) In cellular phone network, why the cells are taken as hexagonal in shape, instead of any other shapes?

(n) What is the reason for using sim number in a mobile sim?

2. (a) Draw the diagram of amplitude modulated carrier wave for 100 percent modulation (modulation index $m_a = 1$) and Zero percent modulation ($m_a = 0$), respectively. 4

(b) An AM broadcast transmitter radiates a power of 50 kW. If the modulation factor is 0.8, calculate the carrier power and power of side frequencies. 4

(c) What are the advantages of SSB-SC transmission? 2

3. (a) Explain briefly the working principle of superheterodyne type of AM radio receiver. 2

(b) Show that an amplifier having an input ($v_i$) output ($v_o$) characteristic given as $v_0 = a_1 v_i + a_2 v_i^2$ where ($a_1$) and ($a_2$) are constants, can be used to design an amplitude modulator. 3

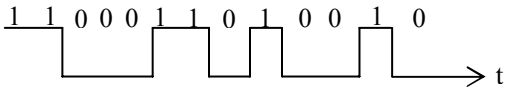
(c) What is the need of guard band in the frequency spectrum used in satellite communication? What is its typical value in a C-band communication satellite? 2

(d) Draw a schematic circuit diagram of a resistance noise generator. An amplifier operating over the frequency range from 18 to 20 MHz has a 10k Ω input resistance. What is the rms noise voltage at the input to this amplifier if the ambient temperature is 27°C? 1+2

4. (a) What do you mean by (i) look angle and (ii) geo-stationary satellite in case of satellite communication? 2+2

(b) Explain the modulation technique for PAM. 4

(c) 2




The above is the Binary data sequence for a carrier signal. What is BPSK waveform?

5. (a) Show that for a hexagonal cell of arm-length $R$ and diameter $2R$, the co-channel reuse ratio is proportional to $7^{1/2}$ or $\sqrt{7}$, if the network system is 7 cell reuse system. 5

(b) What is cell sectoring? Mention the advantages. 2+1

(c) What is signal to interference ratio (SIR) and what is its implication in mobile network system? 2

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2021

## PHSACOR13T-PHYSICS (CC13)

### ELECTROMAGNETIC THEORY

Time Allotted: 2 Hours | Full Marks: 40

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

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

(a) Show that another form of Faraday's law is

$$\vec{E} = -\frac{\partial \vec{A}}{\partial t}$$

where $\vec{A}$ is the magnetic vector potential.

(b) The conduction current density in a dielectric medium is given by $\vec{j} = 0.02\sin\left(10^9 t\right)$ Amp/m$^2$. Find the displacement current density if $\sigma = 10^3$ mho/m and $\varepsilon_r = 6.5$.

(c) State Poynting's theorem for electromagnetic wave.

(d) Write an expression for a linearly polarized wave of angular frequency $\omega$ moving along positive $z$ direction having plane of vibration 60° with the $x$-$y$ plane.

(e) Show that in a conductor the electric and magnetic fields are not in phase.

(f) 'The terms poor and good conductor depend on frequency'— Explain.

(g) A plane polarized wave propagates from air into a dielectric medium at Brewster's angle 75°. Find the relative permittivity $\varepsilon_r$.

(h) What do you mean by electromagnetic momentum density? What is its unit?

(i) An EM wave is incident normally from air on an air-glass interface. Taking refractive index of glass as 1.5, find the amplitude reflection coefficient and the percentage of total incident energy that is transmitted into glass.

(j) State and explain Malus Law.

(k) A black dot is marked on a white paper. It is then viewed through a calcite crystal from the top. How many images are expected to be seen and why?

(l) Calculate the thickness of quarter-wave plate for light of wavelength 5893Å , given $n_0$ = 1.544 and $n_e$ = 1.553.

(m) Write the advantages of optical fiber over coaxial cable.

(n) 'In the microwave region the surface of a pure silver waveguide and that of a silver coated brass waveguide appear identical' – Explain.

2. (a) Given the total electromagnetic energy 4

$$W = \frac{1}{2}\int (\vec{E}\cdot\vec{D} + \vec{H}\cdot\vec{B})\, dv\,.$$

Show from Maxwell's equation that

$$\frac{\partial W}{\partial t} = \oint (\vec{E}\times\vec{H})\cdot\overrightarrow{ds} - \int (\vec{E}\cdot\vec{J})\, dv$$

(b) Assuming a source-free region, derive the following wave equation from Maxwell's Equations 3

$$\nabla^2\vec{E} = \mu\sigma\frac{\partial\vec{E}}{\partial t}$$

(c) Show that under a gauge transformation of the vector potential $\vec{A}$ and the scalar potential $\phi$, the electromagnetic field vectors are invariant. 3

3. (a) Starting from the wave equation in a conductor, find the expression for 'skin depth' of a conductor in terms of its conductivity and frequency of the incident wave. 4

(b) Calculate the skin depth for radio waves of wavelength 3 m (in free space) in copper, given that $\sigma$ for copper is $6 \times 10^7\ \Omega^{-1}\,\text{m}^{-1}$. 2

(c) Starting from boundary conditions satisfied by the electromagnetic fields at an interface between two dielectric media, deduce Snell's law. 4

4. (a) A plane electromagnetic wave falls obliquely on the interface between two simple dielectric media. Assuming the electric vector to be perpendicular to the plane of incidence obtain the expression for the reflection coefficient. 4

(b) Explain the phenomenon of total internal reflection from Fresnel's formula. 2

(c) How is plane polarized light obtained using double refraction in a crystal? 2

(d) Let $x$ and $y$ components of the electric vector of an electromagnetic wave be given by $E_x = a_1 \sin\omega t$ and $E_y = a_2 \sin(\omega t + \delta)$. Show that for $\delta = 2n\pi$ where $n = 1, 2, 3...$, the electromagnetic wave is linearly polarized. 2

5. (a) Explain the operation of a Laurent half-shade polarimeter to find the concentration of sugar solution. 3

(b) 'Dielectric waveguides do not support TEM modes' – why? 2

(c) What do you mean by numerical aperture? Obtain an expression for numerical aperture and acceptance angle of an optical fiber in terms of the refractive indices. 1+2

(d) Any initial charge density in a conductor dissipates in a characteristic time $\tau = \frac{\varepsilon}{\sigma}$. Establish this statement from Maxwell's equation. 2

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2021

## PHSACOR14T-PHYSICS (CC14)

### STATISTICAL MECHANICS

Time Allotted: 2 Hours | Full Marks: 40

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*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) Explain the statistical idea of entropy.

(b) What is meant by the term 'equal a priori probability'?

(c) Draw a phase space trajectory of a simple harmonic oscillator of energy $E$.

(d) A classical particle is free to move in a cube of side $l$. If its energy $\leq E$ find the volume of the phase space available to it.

(e) What is ergodic hypothesis?

(f) What do you mean by 'ultraviolet catastrophe'?

(g) Find differences among microcanonical, canonical and grand canonical ensembles.

(h) What is the most probable kinetic energy $\tilde{\varepsilon}$ corresponding to Maxwellian velocity distribution?

(i) State Pauli's exclusion principle.

(j) What are distinguishable and indistinguishable particles?

(k) What is Bose-Einstein condensation?

(l) Show that the volume element

$$d\tau = \prod_{i=1}^{3N} (dq_i dp_i)$$

of the phase space remains invariant under a canonical transformation.

(m) State and explain Wien's displacement law.

(n) Prove that total pressure of diffused radiation is $P_{\text{rad}} = \frac{1}{3}u$, $u$ being the energy density of radiation.

(o) From the knowledge of partition function $Z$, write an expression for entropy $S$ in ideal Fermi gas.

**Answer any *two* questions from the following** 10×2 = 20

2. (a) Distinguish between microstates and macrostates. 2
   (b) Two dices are rolled simultaneously. Write the number of microstates and number of macrostates. 2
   (c) What is meant by a stationary ensemble? Give one example of a stationary ensemble. 2
   (d) Write all possible microstates of two quantum harmonic oscillators having total energy $4\varepsilon$, $\varepsilon$ being the spacing between the energy levels. Neglect the zero point energy. 2
   (e) State the principle of equipartition of energy. 2

3. (a) Show that average energy, $\langle E \rangle = -\dfrac{\partial \ln Z}{\partial \beta}$ where $Z = \sum_r e^{-\beta E_r}$ is the partition function. 2
   (b) Consider a system consisting of $N$ independent harmonic oscillators, whose Hamiltonian is given by,

$$H(p,q) = \frac{p_i^2}{2m} + \frac{1}{2} m\omega^2 q_i^2, \ (i = 1, 2, \ldots, N).$$

   (i) Calculate the partition function for the system using canonical distribution and show that Helmholtz free energy is given by $A = Nk_BT \ln\left(\dfrac{\hbar\omega}{k_BT}\right)$. 2+2
   (ii) Find an expression for the entropy of the system. 2
   (iii) Show that the internal energy of the system is $U = Nk_BT$. 2

4. (a) Plot and compare Fermi-Dirac, Bose-Einstein, and Maxwell-Boltzmann distribution function as a function of energy. 3
   (b) Show that at $T$ = 0, the average energy of an electron in a metal is $\frac{3}{5}E_F$ where, $E_F$ denotes the Fermi energy. 4
   (c) What is Gibbs paradox and how is it resolved? 3

5. (a) What is Bose-Einstein statistics? What are the basic postulates used? Derive an expression $n_i = g_i/(e^{\alpha}e^{\beta E_i} - 1)$ for the most-probable distribution of the particles of a system obeying B.E. statistics, hence deduce Planck's blackbody radiation formula. 1+1+3+3
   (b) Consider $N$ non-interacting two level system with energy $\pm\varepsilon$. Show that the maximum entropy is $Nk_B \ln 2$. 2

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2021

## PHSADSE04T-PHYSICS (DSE3/4)

Time Allotted: 2 Hours | Full Marks: 50

*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 ***fifteen*** questions from the following: 2×15 = 30

(a) For a Poisson distribution; $P(x=0)=P(x=1)$ find the $P(x>0)$.

(b) What do you mean by proper subset? Explain with an example.

(c) Distinguish between Onto and Into mapping.

(d) If $N$ is the set of all positive integers, then show that division and subtraction are not binary operations in $N$.

(e) When can a binary relation be called an equivalence relation?

(f) For what value of $a$ will be the function $f(x)=ax$; $x=1,2,3,\ldots n$ be the probability mass function of a discrete random variable $x$?

(g) Show that the set of matrices $A_\alpha=\begin{bmatrix}\cos\alpha & -\sin\alpha\\ \sin\alpha & \cos\alpha\end{bmatrix}$, where $\alpha$ is real forms a group under multiplication.

(h) Prove that if event $A$ and $B$ are independent, $\overline{A}$ and $\overline{B}$ are also independent.

(i) Show that the identity of a subgroup of a group is the same as that of the group.

(j) Show that the intersection of any two normal subgroups of a groups is a normal subgroup.

(k) If $(R,\cdot)$ be a multiplicative group and $x\in R$, then find homomorphisms and their kernels in the mapping $x\to|x|$.

(l) What do you mean by faithful representation? Give an example.

(m) If in an experiment with random outcome the number of outcomes favouring an event $A$ is less than the number of outcomes favouring event $B$ in a large number of trials $N$, show that $P(A)<P(B)$. The symbols have their usual meaning.

(n) A dice is rolled six times. Find the probability that each of the six faces appears only once.

(o) If $f(x)=e^{-x}$, $0\le x\le\infty$ show that it is a probability density function and find it's mean.

(p) Write down the limitations of separation of variable technique of solving partial differential equation.

(q) Explain with example, what are homogeneous and non-homogeneous partial differential equations.

(r) Show that if there exists a relation among the three variables $x, y, z$ like $f(x, y, z) = 0$, then show that $\left(\frac{\partial x}{\partial y}\right)_z \left(\frac{\partial y}{\partial z}\right)_x \left(\frac{\partial z}{\partial x}\right)_y = -1$.

(s) For what value of $x$ and $y$ the equation

$$(y+1)\frac{\partial^2 u}{\partial x^2} + 2x\frac{\partial^2 u}{\partial x \partial y} + \frac{\partial^2 u}{\partial y^2} = x + y$$

is parabolic?

(t) Write down the Laplace's equation in spherical polar coordinates.

2. (a) Define order of an element of a group. Prove that the order of an element $a$ of a group is the same as that of its inverse $a^{-1}$. 3

(b) Show that the group formed by the set $(1, \omega, \omega^2)$, $\omega$ being cube root of unity, is a cyclic group of order 3 with respect to multiplication. 2

(c) Write down orthogonality theorem for the Irreducible representation of a group and prove it. 2+3

3. (a) Find the regular permutation group isomorphic to the group $G = (a, b, c, d)$ with the composition table. 3

(b) If a matrix commutes with all the matrices of an irreducible representation, then show that it is a multiple of unit matrix. 4

(c) For any two events $A$ and $B$, the probability that either $A$ or $B$ or both occur is given by $P(A \cup B) = P(A) + P(B) - P(A \cap B)$. 3

4. (a) Consider the Gaussian distribution $\rho(x) = Ae^{-\lambda(x-a)^2}$, where $A$, $a$, $\lambda$ are constants. Determine $\sigma^2$. 4

(b) If $A$ and $B$ are two events such that $P(A) = \frac{3}{8}$, $P(B) = \frac{5}{8}$ and $P(A \cup B) = \frac{3}{4}$, find $P\left(\frac{A}{B}\right)$ and $P\left(\frac{B}{A}\right)$. Are $A$ and $B$ independent? 3

(c) If $X$ denotes a random variable having binomial distribution with mean 6 and variance 3. Obtain $P(X \geq 1)$. 3

5. (a) Solve $\frac{\partial^2 u}{\partial x^2} = \frac{\partial u}{\partial t}$ where $u = 0$ for $t = \infty$ and for $x = 0$ or 1. 4

(b) Solve $\frac{\partial^2 u}{\partial x^2} = \frac{\partial^2 u}{\partial y^2} = 0$ for $0 < x < \pi$, $0 < y < \pi$ subject to the conditions $u(0, y) = u(\pi, y) = u(x, \pi) = 0$ and $u(x, 0) = \sin^2 x$. 6

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2021

## PHSADSE05T-PHYSICS (DSE3/4)

Time Allotted: 2 Hours | Full Marks: 50

*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 ***fifteen*** questions from the following: 2×15 = 30

(a) The luminosity of a star is 10 times, the luminosity of the Sun. Calculate the difference in their absolute magnitudes.

(b) What do you mean by 'mean sun'?

(c) What are Solar Flares? What is the source of energy in solar flares?

(d) What are the differences between absorption and emission spectra of stars?

(e) With the help of a diagram with proper labelling, describe the Equatorial Coordinate System.

(f) Show that the altitude of the pole star is equal to the latitude of the observer.

(g) Define nautical mile.

(h) Estimate the radius of a typical star in terms of the radius of the Sun. It is given that the star's temperature is two-thirds that of the Sun and its luminosity is 100 times the luminosity of the Sun.

(i) Our nearest star Proxima Centauri makes a parallax of 0.75 arc sec. How far is it from the earth?

(j) Explain the term geodesic.

(k) Why does 'limb darkening' happen?

(l) What is meant by electron degeneracy pressure?

(m) Distinguish between spiral and elliptical galaxies giving one example of each type.

(n) Calculate the diffraction limit of resolution of a telescope of diameter 5 m for $\lambda$ = 457 nm.

(o) What are the different parts in atmospheric window? How are these formed?

(p) Why does the O type stellar spectra form at high temperature?

(q) Explain why older galaxies should be redder.

(r) Briefly explain the physical significance of 'main sequence' on H-R diagram.

(s) State Hubble's law and explain its significance.

(t) In a diagram show the diurnal circles of stars on the celestial sphere as seen from the North pole.

2. (a) How do you estimate magnetic field at solar surface? What is butterfly pattern and how does it form? 2+(1+1)

(b) Find the transformation relation between equatorial and horizontal system. 3

(c) The coordinate of star Arcturus are $\alpha$ = 14 h 15 min, $\delta = 19^\circ 1'$. Find the sidereal time at the moment Arcturus rises in Boston whose latitude is $42^\circ 19'$. 3

3. (a) What is differential rotation? Derive Oort's formula related to differential rotation of milky way. 1+3

(b) What are the inferences drawn by Jan H. Oort by his derivation about the Milky way galactic rotation? 1

(c) If the Oort's constants; $A$ = 15 km/s/kpc and $B$ = –10 km/s/kpc, what is the value of angular velocity of the Sun? 2

(d) Explain the important branches in the HR diagram. 3

4. (a) What are the special features of Cepheid Variables? How are these used to measure distance? 1+2

(b) The magnitudes of the components of a binary star are 1 and 2 respectively. What will be the total magnitude of the system? 3

(c) Why do you get continuous band in solar spectra? 2

(d) Why is the Newton's theory of gravity not consistent with special theory of relativity? 2

5. (a) Describe the physical environment and processes to obtain the emission line spectra and absorption line spectra from the stars. 4

(b) By which procedure the Corona region of Solar atmosphere has maintained a high temperature? 2

(c) Draw mass-radius graph for white dwarf stars and discuss the significance of Chandrasekhar Mass Limit. 4

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# WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 6th Semester Examination, 2021

## PHSADSE06T-PHYSICS (DSE3/4)

### COMMUNICATION ELECTRONICS

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.*

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

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

(a) Why modulation is necessary in electronic communication system?

(b) What do you mean by signal to noise ratio?

(c) Draw a simple block diagram of basic communication system and explain the function of channel.

(d) A carrier wave of 20-MHz is modulated by a 2-kHz audio sine wave. If the carrier voltage is 5 V and the maximum deviation is 10 kHz, write the equation of this modulated wave in the case of FM.

(e) Explain how FM can be converted to AM?

(f) Determine the maximum bit rate for an FSK signal with a mark frequency of 48 kHz, a space frequency of 52 kHz, and an available bandwidth of 10 kHz.

(g) In a noise-free binary coding system, calculate the channel capacity when the allowed bandwidth is 4 kHz.

(h) Why noise immunity of pulse width modulation (PWM) is better than that of pulse amplitude modulation (PAM)?

(i) Explain amplitude shift keying (ASK) with waveform diagram.

(j) Distinguish between SIM number and IMEI number in mobile communication systems.

(k) What are the frequency bands in India for the following mobile technology: (i) GSM (2G) (ii) CDMA (iii) 4G LTE (iv) WCDMA (3G).

(l) What are uplink and downlink frequencies in satellite communication?

(m) What is Curson's rule relating bandwidth of FM waves?

(n) In PWM, PPM, and PAM system, modulated signal consists of discrete pulses, but they are not digital modulation — Explain.

2. (a) Find out the frequency components present in an AM wave. Find out the bandwidth of an AM wave. 2+1

   (b) Explain the operation of an envelope diode detector for AM wave. What is Diagonal clipping? 3+1

   (c) Explain the basic principle of generation of PAM wave. 3

3. (a) A frequency modulation (FM) transmitter sends out a 100 MHz carrier wave frequency modulated by a 15 kHz sinusoidal audio signal. The maximum frequency deviation is 30 kHz. Find (i) the modulation index, (ii) channel width for three significant side frequency pairs. 2+1

   (b) Explain the concept of single side band (SSB) generation (by any method) in AM with a neat block diagram. 3

   (c) What is the difference between shift keying and modulation? 2

   (d) Calculate the height of the geosynchronous orbit from the mean sea level. 2

4. (a) Explain the need of super heterodyne receiver and give its block diagram. 1+2

   (b) Explain the terms sampling and quantization in pulse code modulation. 2+2

   (c) Show that, an increase in the number of bits in the code word by 1 enhances the output signal to noise ratio by 6 dB in pulse code modulation (PCM). 3

5. (a) If in a cellular network, signal to interference ratio (S/I) is 20 dB and path loss exponent (n) is 4, determine the co-channel reuse ratio (d/R) and minimum cluster size (N). 4

   (b) Draw a block diagram of mobile communication network and discuss briefly the role of each component. 3

   (c) What is angle of elevation in connection of satellite telecommunication and why it is kept larger than 5°? 2+1

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