Total Pages : 9

B.Sc./6th Sem (H)/PHS/23(CBCS)

2023

6th Semester Examination

PHYSICS (Honours)

Paper : DSE 4-T

[CBCS]

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

[Digital Signal Processing]

Full Marks : 40 Time : Two Hours

Group - A

Answer any ***five*** questions : 2×5=10

1. Define convolution theorem. 2

2. Explain the advantages of digital filters over analog filters. 2

3. Find the inverse *Z*-transform of $X(z) = \sin Z$. 2

4. Define ROC in Z-transform. 2

5. Write down properties of Discrete Time Fourier transform (DTFT). 2

6. Define IIR and FIR filters. 2

P.T.O.

7. What is an LTI system. 2

8. What are phase delay and group delay? 2

Group - B

Answer any ***four*** questions : 5×4=20

9. Prove the Convolution theorem for DTFT. 5

10. Find the inverse Fourier transform of

$$X(e^{jw}) = \frac{1}{1-\frac{1}{3}e^{-jw}}.$$ 5

11. What is the magnitude of the frequency response of the cascade of the following two systems :

(a) $H_1(e^{jw}) = \frac{e^{-jw}-0.5}{1-0.5e^{-jw}}$

(b) $h_2(n) = \delta(n) - \frac{\sin\left(\frac{n\pi}{4}\right)}{n\pi}$ 2+3=5

12. Evaluate the integral : 5

$$\int_{-\pi}^{+\pi} \frac{e^{jw}}{1-0.3e^{-jw}} dw$$

13. Consider the discrete time sequence 5

$$x(n)\cos\left(\frac{n\pi}{8}\right)$$

14. Find the inverse of the following Z-transform 5

$$X(Z) = 4 + 3\left(Z^{2} + Z^{-2}\right)$$

$$0 < |z| < \infty$$

Group - C

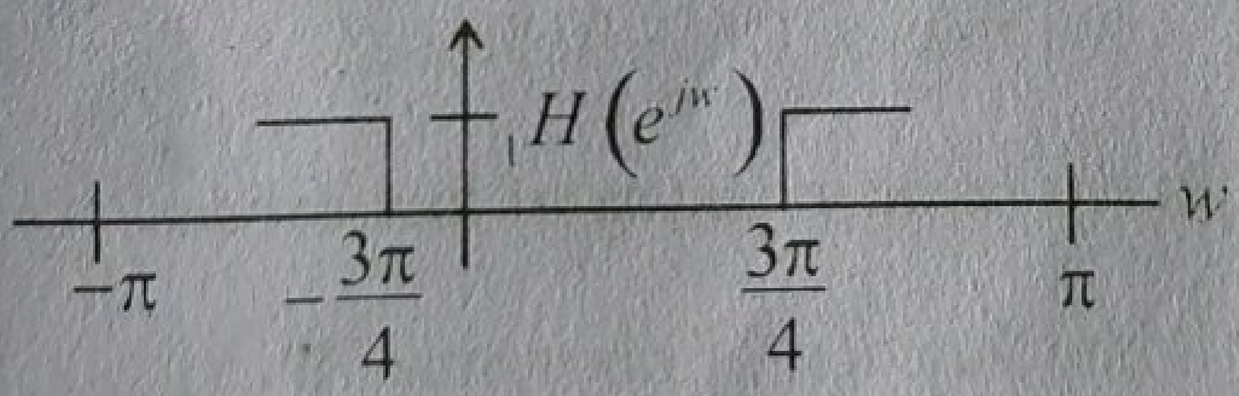
Answer any ***one*** question : $10 \times 1 = 10$

15. Find the group delay for each of the following systems : $5+5=10$

(a) $H_1\left(e^{jw}\right) = 1 - \alpha e^{-jw}$

(b) $H_2\left(e^{jw}\right) = \dfrac{1}{1 - \alpha e^{-jw}}$

16. Consider the high-pass filter that has cut off frequency $w_c = 3H/4$ as shown in the following figure.



(a) Find the unit sample response, $h(n)$.

(b) A new system is defined so that its unit sample response is $h_1(n) = h(2n)$. Sketch the frequency response, $H_1(e^{jw})$. $5+5=10$

OR

[Biological Physics]

Full Marks : 60 Time : Three Hours

Group - A

Answer any ***ten*** questions : 2×10=20

1. What is the structure of amino acid? What is the number of essential amino acids in a human body?
2. What is the composition of cell membrane?
3. Which neurotransmitter is responsible for calmness and pleasure?
4. Compare mitosis with meiosis.
5. What are the functions of cytoskeleton?
6. What is the role of RNA primer?
7. What is the role of DNA helicase?
8. What is the basic structure of nucleotides?
9. What is the function of ribosomal RNA?
10. What is the difference between active and passive transport?
11. What are the steps of enzymatic catalysis?
12. What do you mean by "codon"? How many codons are there?

13. What is paracrine signalling?

14. Which type of stem cell gives rise to red and white blood cells?

15. Name the proteins that influence the external phenotype of drosophila fruit fly.

Group - B

Answer any ***four*** questions : 5×4=20

16. Discuss how circadian oscillators work to maintain time.

17. What are the various mechanism by which cells migrate from one place to other?

18. Obtain an expression for the binding probability of RNA polymerase to promoter region.

19. Explain how DNA transcription takes place.

20. Write down the stoichiometric matrix for the following reactions :

$$H_2O + CO \rightleftharpoons CO_2 + H_2$$

$$H_2O + H \rightleftharpoons H_2 + OH$$

$$OH + CO \rightleftharpoons CO_2 + H$$

21. Write down the various classifications of memory.

P.T.O.

Group - C

Answer any *two* question : $10 \times 2 = 20$

22. Discuss how bicoid protein gives rise to morphogenic stripes on drosophila fruit fly. Establish the equation involving decay constant. What is synaptic plasticity? Write down the names of three excitatory neurotransmitters. 5+2+3

23. The elasticity of polymer chains in our body can be well explained by random walk model in 3D. Develop the model and show why circular structure of DNA is statistically preferred. 5+5

24. What are the three most important energy storage units in cells? Describe the storage mechanism in each case. 3+7

25. What is the objectives and motivation behind FRAP experiment? Establish the diffusion equation from Fick's law and mass conservation. 5+5

OR

[Experimental Techniques]

Full Marks : 40 Time : Two Hours

Group - A

1. Answer any ***five*** of the following questions. 2×5=10

(i) Count the total number of significant figures in the following measurements :

(a) 0.0500 (b) 2400

(c) 9500 (d) 5.70×10^5

(ii) Round off the following numbers to three significant figures :

(a) 24.937 (b) 36.350

(c) 42.450×10^9 (d) 742396

(iii) The mass and density of a solid sphere are measured to be (12.4 ± 0.1)kg and (4.6 ± 0.2)kg/m^3. Calculate the volume of the sphere with error limits.

(iv) Calculate equivalent resistance with error limit of two resistors R_1 and R_2 in parallel, where $R_1 = (9 \pm 0.2)\Omega$ and $R_2 = (6 \pm 0.1)\Omega$.

(v) Write down the working pressure ranges of Rotary pump, Diffusion pump, Pirani gauge and Penning gauge.

P.T.O.

(vi) What do you mean by noise figure?

(vii) What is thermal noise?

(viii) Write two differences between analog and digital instruments.

Group - B

Answer any *four* of the following questions : 5×4=20

2. The diameter of a wire as measured by a screw gauge in a number of measurements was found to be 2.620, 2.625, 2.630, 2.628 and 2.626 cm.

   Calculate (i) mean value of diameter (rounding off to three decimal places) (ii) mean absolute error (iii) fractional error and (iv) percentage error. 5

3. Write down the properties of transfer functions of an instrument. What do you mean by the zero-order instrument? Give two examples of it. 2+2+1=5

4. A rotary pump removes air from a 300-litre chamber at the rate of 0.5 litre/sec. What would be the pressure in the chamber after 20 sec if the initial pressure were 1 atm. 5

5. Write down the two methods for measurement of linear displacement using capacitive transducer. 2½+2½=5

6. What is Q meter? Write its uses. 3+2

7. What are periodic and non-periodic signals? Determine whether the signal $x(t)=\left[\cos(2\pi t)\right]^2$ is periodic or not. If periodic, find the fundamental period. 2+3

Group - C

Answer any ***one*** of the following questions : 10×=10

8. (a) Define Gauge factor (G) of a strain gauge. Derive the expression,

$G=1+2\sigma+\frac{\Delta\rho/\rho}{\Delta l/l}$, where, σ is the Poisson's ratio and ρ is the resistivity of the wire.

(b) Write down the working principle of a metallic strain gauge and a semiconductor type strain gauge. 1+4+2½+2½=10

9. What is transducer? Write the working principle of a Linear Variable Differential Transformer (LVDT). How does a scintillation detector work? What are the different temperature transducers? 2+4+2+2

Total Pages : 3

B.Sc./6th Sem (H)/PHS/23(CBCS)

2023

6th Semester Examination

PHYSICS (Honours)

Paper : C 14-T

[Statistical Mechanics]

[CBCS]

Full Marks : 40 Time : Two Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Group - A

Answer any ***five*** questions : 2×5=10

1. Show that electron gas in a white dwarf star is strongly degenerate and relativistic in nature. 2

2. Write statistical definition of temperature in terms of accessible microstates. Assuming the number of accessible microstates $\Omega(E,V)\alpha\left(V^N E^{\frac{3N}{2}}\right)$, find the molar specific heat at constant volume. 2

3. Which among the Bose-Einstein and Fermi-Dirac statistics will be followed by (i) Neutrons, (ii) Alpha particles, (iii) Deuterium nuclei, and (iv) ${}_2He^3$ atoms? 2

P.T.O.

4. Find the Fermi energy at $T = 0$k for metallic silver containing one free electron per atom. The density of silver is 10.5gm/cc and atomic weight of silver is 108. 2

5. What do you mean by 'ultraviolet catastrophe'? 2

6. What is 'λ-transition' in liquid Helium? 2

7. In a system 8 distinguishable particles are distributed in 2 compartments with equal a priori probability. Calculate the probabilities for the macrostates (i) (4, 4) and (ii) (3, 5). 2

8. What is Chandrasekhar limit? 2

Group - B

Answer any ***four*** questions : 5×4=20

9. What is Gibbs paradox? How is it resolved? 1+4

10. Define Saha's ionization formula and discuss one of its applications. 5

11. Explain B-E condensation in 3 dimension. How does it differ from ordinary condensation? Derive an expression for the critical temperature at which the phenomenon sets in. 5

12. For a completely degenerate Fermi gas of N molecules the density of states is given by

$$g(\varepsilon)d\varepsilon = ag_s V\varepsilon^n$$

where a and n are constants, g_s is spin degeneracy and V is the volume. Calculate the Fermi energy and total energy of the system at zero Kelvin temperature. 5

13. The specific heat of a metal (in three dimensions) at low temperatures can be represented by $C_v = aT + bT^3$, where a and b are constants. Explain the origin of the first term with necessary deduction. 5

14. Starting from Planck's law deduce (i) Rayleigh-Jeans law and (ii) Wien's law. 2½+2½

Group - C

Answer any ***one*** question : 10×1=10

15. (a) Calculate deviation of an ideal Fermi gas equation from the perfect gas equation for weak degeneracy. How is it related to gas degeneracy? 5+2

(b) An atom has a non-degenerate ground state with energy $\varepsilon_0 = 0$ and a doubly degenerate excited state with energy $\varepsilon_1 = \varepsilon$. Calculate the specific heat at very low temperature $(\beta\varepsilon >> 1)$. 3

16. Write down the single particle partition function for a system having two non-degenerate energy levels with energies : $\varepsilon_1 = -\mu H$ and $\varepsilon_2 = \mu H$. Evaluate entropy for this system. Hence discuss the concept of negative absolute temperature of such a two-level system.

4+4+2

$U = NkT^2 \frac{d}{dV}(\ln z)$

Total Pages : 8

B.Sc./6th Sem (H)/PHS/23(CBCS)

2023

6th Semester Examination

PHYSICS (Honours)

Paper : DSE 3-T

[CBCS]

Full Marks : 40 Time : Two Hours

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[Medical Physics]

Group - A

Answer any ***five*** questions : 2×5=10

1. Where do you find phalanx in human skeleton? 2
2. What is a ligament? 2
3. Which two proteins are responsible for dark and light bands on the myofibril? 2
4. What is the role of pectoral bones in the body movement? 2
5. Fill in the blanks : The human cranium is made of _____ bones. 2
6. How does our body lose heat? 2

P.T.O.

7. What do you mean by cold sweat? 2

8. What is the role of corti in human hearing process? 2

Group - B

Answer any *four* questions : 5×4=20

9. Discuss the basic principle of Mammography. 5

10. Compare cyber knife with gamma knife as a method of radiosurgery. 5

11. Discuss how brachytherapy is different from external beam radiotherapy. 5

12. Write down the working principle of thimble ionization chamber. 5

13. What is the role of cochlea in our ears? What are the common causes of reduced hearing? 3+2

14. What is the cautery procedure? What is monopolar and bipolar cautery? 5

Group - C

Answer any *one* question : 10×1=10

15. In radioisotope imaging, what are the various methods of production of artificial radionuclides? Explain the mechanism of image formation due to interaction of radioisotope with matter? 5+5

16. Draw a clear diagram of X-ray Coolidge tube and label important parts. Define tissue maximum ratio and tissue phantom ratio. 3+3+2+2

OR

[Nanomaterials and Applications]

Group - A

Answer any ***five*** questions : $2\times5=10$

1. Draw the Density of states $D(E)$ as a function of energy (E) for zero, one and two dimensional nanostructure materials.

2. If the position $\left(\Delta x = 10^{-9} m\right)$ of an electron is accurately determined, calculate the uncertainty of velocity. (Given $m_e = 9.11 \times 10^{-31}$kg)

3. What are the disadvantages of electron beam evaporation technique?

4. When a radiation $\left(\lambda = 0.154nm\right)$ is used, the diffraction peak having full width half maxima (FWHM) ~ 0.6 is obtained at an angle $\theta = 35°$. Calculate the crystallites size by considering the Scherrer constant = 0.92.

5. What is quantum confinement in nanomaterials?

6. What do you mean by 'ballistic conduction'?

7. What is the function of photo-resist in context of lithography?

8. Write two applications of a carbon nanotube (CNT).

P.T.O.

Group - B

Answer any *four* questions : 5×4=20

9. What is quantum dot? Define top-down and bottom up approaches. What are the differences between top-down and bottom up approaches? 1+2+2

10. Write down the basic working principle of hydrothermal method for synthesis of nanostructure materials. What are the advantages of molecular beam epitaxial (MBE) growth technique? 3+2

11. Explain the basic working principle of Physical Vapor Deposition (PVD) process. 5

12. What is exciton? How is it formed? Why the direct band gap materials are preferred over indirect band gap materials for optoelectronic device application? 1+1+3

13. Draw the schematic diagram of atomic force microscopy (AFM). Define three modes of operation. 2+3

14. Write a short note on Micro-electromechanical systems (MEMS). What is NEMS? 4+1

Group - C

Answer any *one* question : 10×1=10

15. What is SEM? Sketch a schematic diagram of a SEM and discuss its working principle. What is its magnification? How can the magnification of a SEM be improved? 2+5+1+2

16. (i) Write down the working principle of light emitting diode.

(ii) The work function of a metal is 2.5 *eV*. Calculate the density of electrons ejected in thermionic emission at 1227°C. Given $A = 120\text{A cm}^{-2}\text{K}^{-2}$ and $K_B = 1.38 \times 10^{-23}\text{JK}^{-1}$.

(iii) What is "Mott law" and "Efros-Shklovskii law" for variable range hopping conductivity? How Coulomb gap is formed in the vicinity of Fermi level? Comment on the change of hopping conductivity with the decrease in temperature. 3+2+(2+2+1)

OR

[Communication Electronics]

Group - A

Answer any *five* questions : 2×5=10

1. What is the necessity of modulation? 2

2. Why frequency modulation is considered to be superior than amplitude modulation? 2

3. What is a vocoder? 2

4. What types of modulation methods are used with 4G cell phones? 2

5. Define Pulse Width Modulation (PWM). 2

6. Write down the advantages and disadvantages of geosynchronous satellites. 2

7. What do you mean by noise? Define signal-to-noise ratio. 2

8. What is the necessity of digital communication? 2

Group - B

Answer any *four* questions : 5×4=20

9. What is the bandwidth of a GSM channel? How many users can share a channel in GSM? Differentiate between GSM and CDMA. 1+1+3

10. What is the basic function and purpose of a communication satellite? 5

11. What do you mean by frequency shift keying? Determine the peak frequency deviation, minimum bandwidth and baud for a binary FSK signal with a mark frequency of 49 kHz, a space frequency of 51 kHz and an input bit rate of 2 kbps. 2+3

12. What do you mean by information capacity? What is Shanon limit for information capacity? For a standard telephone circuit with a signal to noise power ratio of 1000 and a bandwidth of 2.7 kHz, determine the Shanon limit for information capacity. 5

13. What do you mean by thermal noise? How is the noise power related to different parameters for the noise generated by resistor? An amplifier operating in the frequency range from 18 to 20 MHz has a $10K\Omega$ input resistor. What is the rms noise voltage at the input to this amplifier if the ambient temperature is 27°C? 2+1+2

14. Derive the formula for the instantaneous value of an AM voltage and define modulation index. Sketch roughly the waveforms of carrier wave, modulating wave and amplitude modulated wave. 3+2

Group - C

Answer any ***one*** question : 10×1=10

15. (a) List four major applications of FM.

(b) State the four main benefits of single sideband (SSB) signal over conventional amplitude modulated (AM) signal.

(c) What do you mean by transponder? What are the basic functions of transponder? Draw the block diagram of satellite transponder. 2+4+(1+1+2)

16. (a) Derive the relation between the output power of an amplitude modulated wave and depth of modulation.

(b) A 400-watt carrier is modulated to a depth of 75%. Calculate the total power in the modulated wave.

(c) Draw the circuit diagram using transistor for generation of amplitude modulated wave and explain its operation. 4+2+(2+2)

Total Pages : 3

B.Sc./6th Sem (H)/PHS/23(CBCS)

2023

6th Semester Examination

PHYSICS (Honours)

Paper : C 14-T

[Statistical Mechanics]

[CBCS]

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8. What is Chandrasekhar limit? 2

Group - B

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16. Write down the single particle partition function for a system having two non-degenerate energy levels with energies : $\varepsilon_1 = -\mu H$ and $\varepsilon_2 = \mu H$. Evaluate entropy for this system. Hence discuss the concept of negative absolute temperature of such a two-level system.

4+4+2

$U = NkT^2 \frac{d}{dV}(\ln z)$

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B.Sc./6th Sem (H)/PHS/23(CBCS)

2023

6th Semester Examination

PHYSICS (Honours)

Paper : C 13-T

[Electromagnetic Theory]

[CBCS]

Full Marks : 40 Time : Two Hours

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Answer any ***five*** questions from Q.1-Q.-8. 2×5=10

1. The space-time dependence of the electric field of a linearly polarized light in free space is given by $\vec{E} = E_0 \cos(\omega t - kz)\hat{i}$, where E_0, ω and k are the amplitude, the angular frequency and the wave vector, respectively, Find the time average energy density associated with the electric field.

2. How is the wave vector of an incident electromagnetic wave modified for the propagation of the wave through a conducting medium? What is its consequence?

3. What do you mean by gauge transformation?

P.T.O.

V-6/51 - 1300

4. What do you mean by Phase Retardation plates?

5. If the vector potential $\vec{A} = ax\hat{i} + 2y\hat{j} - 3z\hat{k}$, satisfies the Coulomb gauge, find the value of the constant α.

6. What is birefringence? Give some of its application in display devices.

7. A uniform volume charge density is placed inside a conductor (with resistivity 10^{-2} Ωm). Calculate the time when the charge density reduces to $(1/e)$ time of its initial value.

8. Explain why only a thin coating of gold is sufficient to manufacture a highly conducting wire.

Answer any ***four*** questions from Q.9-Q.14.

$5\times4=20$

9. A dilute electron gas with free electron concentration N is subjected to a simple harmonic electric field of angular frequency ω.

   (a) Determine the velocity of an electron.

   (b) Derive the expressions of the conduction current density and displacement current density.

   (c) Show that the effective dielectric constant of the electron gas is $1-\left(Ne^2/m\varepsilon_0\omega^2\right)$. 1+2+2

   [Symbols have their usual significance]

10. (a) Write the physical significance of the Poynting

vector. What is the relation between the Poynting vector, electromagnetic energy density, and phase velocity? 1+1

(b) Show that the time averaged electric and magnetic energy densities in vacuum are equal. 3

11. (a) What do you mean by linearly polarized, circularly polarized, and elliptically polarized waves? Give the expression for the $\vec{E}$ field in each case. 2+2

(b) Show that TEM waves cannot occur in a waveguide. 1

12. (a) Consider a rectangular waveguide with the dimensions $a = 3.33$ cm and $b = 2.50$ cm. For the propagation of the TE_{11} mode find the range of frequencies. Which kind of filter does this waveguide behave like in this case? 2+1

(b) A step-index fiber has a core index of refraction of $n_1 = 1.425$. The cut-off angle for light entering the fiber from air is found to be 8.50°. What is the numerical aperture of the fiber? What is the index of refraction of the cladding of this fiber? 1+1

13. (a) Derive, considering TE waves, the expressions of the cut-off wavelength and guide wavelength for propagation of an electromagnetic wave between parallel plates. 3

P.T.O.

(b) Show that $v_p g_g = c^2$ where v_p and v_g are the phase and group velocities, respectively, and c is the velocity of light. 2

14. Show that normal component of electric displacement vector is not continuous at the boundary. How does birefringence explain double refraction? 3+2

Answer any ***one*** question from Q.15-Q.16. 10×1=10

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

(b) What are Biot's laws for rotatory polarization? Define specific rotation of a solution. 2+1

(c) A TEM wave of frequency 300 GHz propagates in vacuum along the positive x-direction. It has an electric field of amplitude 28.28 V/m. The wave is linearly polarized with the plane of vibration of the electric field at an angle of 45° to the xz-plane. Give the expressions of the electric and magnetic fields. 3

16. (a) What are the s-polarization and p-polarization of electromagnetic waves? 1

(b) Deduce the expressions of amplitude coefficients for reflection and transmission for a p-polarized electromagnetic wave and discuss their variations. 4

(c) How is the concept of Brewster's angle explained for *p*-polarized wave in specific conditions? Show diagrammatically. 2+1

(d) Find the reflectance and the transmittance of a plane electromagnetic wave incident normally from air on a dielectric surface of refractive index 1.4. 2
