Total No. of Printed Pages—7

5 SEM TDC DSE CHM
(CBCS) 1 (H/NH)

2021

(Held in January/February, 2022)

CHEMISTRY

(Discipline Specific Elective)

(For Honours/Non-Honours)

Paper : DSE–1

(Analytical Methods in Chemistry)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option : 1×6=6

(a) The wave number corresponding to 25 μm is

(i) 2500 cm^{-1}

(ii) 4000 cm^{-1}

(iii) 250 cm^{-1}

(iv) 400 cm^{-1}

(b) The correct expression of relative error is (where x_i = experimental value and x_t = true value)

(i) $E_r = \frac{x_i - x_t}{x_i}$

(ii) $E_r = \left[\frac{x_i - x_t}{x_t} \times 100\right]\%$

(iii) $E_r = x_i - x_t$

(iv) $E_r = x_t - x_i$

(c) In pH metric titration, the indicator electrode used is

(i) calomel electrode

(ii) glass electrode

(iii) quinhydrone electrode

(iv) Pt electrode

(d) Chromatography with solid stationary phase is called

(i) partition chromatography

(ii) solid chromatography

(iii) adsorption chromatography

(iv) None of the above

(Continued)

(e) Solvent extraction is governed by which law?

(i) Boyle's law

(ii) Ostwald dilution law

(iii) Nernst distribution law

(iv) Beer's law

(f) In UV-visible spectroscopy, the cuvette is made of

(i) glass

(ii) quartz

(iii) plastic

(iv) KBr

2. Answer the following questions : 2×6=12

(a) What is a reference electrode? Mention three common reference electrodes used in potentiometry.

(b) In conductometric titration, the titrant should be 10–100 times concentrated than the solution to be titrated. Why?

(Turn Over)

(c) What is fingerprint region in IR spectroscopy?

(d) What are the various visualization techniques used in TLC?

(e) What is meant by retention time in HPLC?

(f) Sketch the conductometric titration curves for neutralization titrations of the following :

(i) Strong acid vs. Strong base

(ii) Weak acid vs. Strong base

3. What are systematic errors? Mention different types of systematic error. 1+2=3

Or

The molarity of a solution is determined by four separate titrations and the results are 0·2041, 0·2049, 0·2039 and 0·2043. Calculate the mean, median and range for the data. 3

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

(a) Deduce the Lambert-Beer law. What is molar extinction coefficient? 3+1=4

(b) What are single beam and double beam configuration in UV-vis spectrophotometer? 4

(c) Explain the effect of solvent polarity on (i) $n \rightarrow \pi$ and (ii) $\pi \rightarrow \pi^*$ transition. 4

(d) What are group frequencies in IR spectroscopy? Match the following groups with their approximate frequencies : 2+2=4

Group	*Approximate frequency* (in cm^{-1})
—OH	1100
$—CH_3$ (stretching)	3600
$>C=O$	2970
$>C=S$	1750

(e) Write four differences between atomic absorption spectroscopy (AAS) and flame emission spectroscopy (FES). 4

(f) Discuss various sampling techniques used for the preparation of solid sample. 4

5. What are the main components of a TGA instrument? 3

Or

Explain the basic principles of TGA with example. 3

6. Answer any *three* of the following questions : 3×3=9

(a) What is R_f value in chromatography? Explain the significance of R_f value.

(b) Give the principles of HPLC.

(c) Based on mechanism of separation, classify chromatographic techniques.

(d) Show that multistep extraction with a solvent is more efficient than a single-step extraction.

(e) What are the different solvent extraction methods of metal ions from aqueous solution?

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5 SEM TDC DSE CHM (CBCS) 2 (H)

2021

(Held in January/February, 2022)

CHEMISTRY

(Discipline Specific Elective)

(For Honours)

Paper : DSE–2

(Green Chemistry)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×6=6

(a) The Bhopal Disaster (1984) was occurred due to

(i) methyl cyanide

(ii) methyl isocyanide

(iii) methyl isocyanate

(iv) methyl cyanate

(b) The Japanese disease *Itai-Itai* has been attributed to

(i) lead poisoning

(ii) mercury poisoning

(iii) cadmium poisoning

(iv) arsenic poisoning

(c) 12 green chemistry principles are postulated by

(i) Professor Paul T. Anastas

(ii) Professor John C. Warner

(iii) Professor Paul T. Anastas and Professor John C. Warner

(iv) Professor John R. Asthana

(d) The formula of adipic acid is

(i) $HOOC—(CH_2)_2—COOH$

(ii) $HOOC—(CH_2)_6—COOH$

(iii) $HOOC—(CH_2)_4—COOH$

(iv) $HOOC—(CH_2)_3—COOH$

(e) Which of the following reactions is an example of microwave-assisted reaction in water?

(i) Hoffmann elimination

(ii) Oxidation of toluene

(iii) Oxidation of alcohol

(iv) All of the above

(f) An efficient, green synthesis of a compostable and widely applicable plastic made from corn is

(i) polylactic acid

(ii) polyacetic acid

(iii) polyvinyl chloride

(iv) polyacrylic acid

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

(a) Explain the term 'green chemistry'.

(b) What are the goals of green chemistry?

(c) Define atom economy.

(d) How can you improve the atom economy of a reaction?

(e) How can you compare the greenness of solvents?

(f) What is chemoselective reaction? Give one example of it.

(g) What is enantioselective reaction? Give one example of it.

(h) Write the reactions involved during the depletion of ozone layer by CFCs.

(i) Write the green approach of synthesis of adipic acid.

(j) Write the alternative approach to Strecker synthesis for the synthesis of disodium iminodiacetate (DSIDA).

(k) Write the greener approach to the Bhopal Gas Tragedy.

(l) What are solid-state reactions? Give one example.

3. Write short notes on any *three* of the following : 3×3=9

(a) Principles of green chemistry

(b) Ionic liquids as green solvents

(c) supercritical carbon dioxide

(d) Protection of a functional group

4. Answer any *three* of the following questions : 3×3=9

(a) Compare the oxidation of toluene and oxidation of alcohols using microwave conditions in water with other conventional procedures.

(b) Compare the Simmons-Smith reaction using ultrasound conditions with other conventional procedures.

(c) How can we design the environmentally safe marine antifoulant?

(d) Write a note on surfactants for carbon dioxide.

5. Answer any *three* of the following questions : 3×3=9

(a) What will be the future trends in green chemistry in the field of oxidative transformations and catalysis?

(b) "Green chemistry is sustainable chemistry." Explain the statement.

(c) What will be the future trends in green chemistry in the field of biominimetic, multifunctional reagents?

(d) What will be the future trends in green chemistry in the field of proliferation of solventless reactions?

★★★

5 SEM TDC CHMH (CBCS) C 12

2021

(Held in January/February, 2022)

CHEMISTRY

(Core)

Paper : C–12

(Physical Chemistry)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer from the following : 1×4=4

(a) The degeneracy of rotational level of a diatomic molecule having energy $\frac{h^2}{4\pi^2 I}$ is

(i) 0

(ii) 1

(iii) 2

(iv) 3

(b) Vibrational transition exists in

(i) infrared region

(ii) microwave region

(iii) visible region

(iv) radio-frequency region

(c) The degeneracy of a particle of mass m confined in a three-dimensional box having energy level equal to $\frac{14h^2}{8ma^2}$ is

(i) 7

(ii) 14

(iii) 6

(iv) 8

(d) In photosynthesis, chlorophyll acts as a

(i) catalyst

(ii) photosensitizer

(iii) photoinhibitor

(iv) All of the above

2. Answer any *four* questions from the following : 2×4=8

(a) Microwave studies are done only in gaseous state. Explain.

(b) Explain why the nuclei H^1 and ^{13}C are suitable for NMR investigation.

(c) Write a short note on fingerprint region.

(d) What is chemiluminescence? Give one example.

(e) Show that the functions $\psi_1 = \left(\frac{1}{2\pi}\right)^{1/2}$ and $\psi_2 = \left(\frac{1}{\pi}\right)^{1/2} \cos x$ in the interval $x = 0$ to $x = 2\pi$ are orthogonal to each other.

(f) Show that $\sin 4x$ is an eigenfunction of the operator $\frac{d^2}{dx^2}$. Find the eigenvalue.

UNIT—I

3. Answer any *four* questions from the following : 4×4=16

(a) What are normalized and orthogonal wave functions? For the function $\psi(\theta) = \sin\theta$, where the variable θ changes continuously from 0 to 2π, determine whether it is normalized or not. If it is not, find the normalization factor. 1+2+1=4

(b) ψ_i and ψ_j represent the wave function corresponding to two different states of a particle moving freely in a one-dimensional box. Show that they are orthogonal to each other. 4

(c) Consider a particle of mass m confined in a two-dimensional box of edge lengths a and b. Find the energy and wave functions by solving the Schrödinger's equation. The potential energy

$V(x, y) = 0$, for $0 \le x \le a$ and $0 \le y \le b$

$= \infty$, elsewhere

Also write the expression for energy when $a = b$. 3+1=4

(d) (i) What does the term 'degenerate levels' mean? Determine the degree of degeneracy of the level $\frac{17h^2}{8ma^2}$ of a particle in a cubical box. 1+1=2

(ii) Form Schrödinger wave equation for a one-dimensional simple harmonic oscillator. 2

(e) (i) The distance between the atoms of a diatomic molecule is r and its reduced mass is μ. If the angular momentum is L and moment of inertia is I, then prove that kinetic energy $T = \frac{L^2}{2\mu r^2}$. 3

(ii) Write the expression for energy for a rigid rotator. 1

(f) (i) Write down the Schrödinger wave equation in polar form for H-atom. 1½

(ii) Calculate the most probable distance r_{mp} of the electron from the nucleus in the ground state of hydrogen atom, given that the normalized ground state wave function is

$$\psi_{1s} = \frac{1}{\sqrt{\pi} a_0^{3/2}} e^{(-r/a_0)}$$

Given $a_0 = 0{\cdot}529$ Å. 2½

(g) (i) Write down the equation showing Hamiltonian operator for one-dimensional harmonic oscillator. 2

(ii) Sketch the variation of radial probability density against the distance from the nucleus for 2s state for hydrogen atom. 2

UNIT—II

4. Answer any *two* questions from the following : 8×2=16

(a) (i) Show that the lines in the rotational spectrum of a diatomic molecule are equispaced under the rigid rotator approximation. 3

(ii) A transition from $J=0$ to $J=1$ in the rotational spectrum of CO corresponds to $3{\cdot}84235\ cm^{-1}$. Calculate the moment of inertia and bond length. 2+2=4

(iii) Write the selection rule for rotational spectra. 1

(b) (i) Show that the frequency of the absorbed radiation in pure vibrational spectra is equal to the fundamental frequency of vibration ν_0 of the molecule. 2½

(Continued)

(ii) Prove that the ratio of wave numbers of fundamental, first overtone and second overtone is approximately 1 : 2 : 3. 2½

(iii) Roughly sketch the fundamental modes of vibrations of CO_2 and show the infrared active vibrations. 3

(c) (i) State and explain Franck-Condon principle. 3

(ii) Explain why TMS is used as a reference substance in NMR spectroscopy. 2

(iii) Calculate the NMR frequency (in MHz) of the proton (^1H) in a magnetic field of intensity 1·4092 tesla, given that $g_N = 5{\cdot}585$ and $\mu_N = 5{\cdot}05\times10^{-27}\ JT^{-1}$. 2

Or

Briefly discuss Born-Oppenheimer approximation.

(iv) Write any one difference between fluorescence and phosphorescence. 1

(Turn Over)

UNIT—III

5. Answer any *two* questions from the following : 4½×2=9

(a) State and explain Lambert-Beer law. Write the significance of molar extinction coefficient. 4½

(b) Explain the term 'quantum yield'. Discuss briefly the reasons for high and low quantum yields. 1½+3=4½

(c) What is photochemical equilibrium? Give example of a photochemical equilibrium in which only one reaction is light sensitive. Deduce an expression for equilibrium constant of a photochemical equilibrium. 1+1+2½=4½

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5 SEM TDC CHMH (CBCS) C 11

2021

(Held in January/February, 2022)

CHEMISTRY

(Core)

Paper : C–11

(Organic Chemistry)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Select the correct answer from the following (any *three*) : 1×3=3

(a) In the double helix of DNA, guanine of one coil involves pairing with cytosine of the other

(i) through one H-bond

(ii) through two H-bonds

(iii) through three H-bonds

(iv) Not through H-bond

(b) DNA multiplication is called

(i) translation

(ii) transduction

(iii) transcription

(iv) replication

(c) Which one of the following is a compound lipid?

(i) Triolein

(ii) Glyceryl linoleate

(iii) Myricyl palmitate

(iv) Phosphatidylserine

(d) Which of the following reactions is used to form a C=C in a synthesis?

(i) Aldol condensation

(ii) Michael condensation

(iii) Knoevenagel reaction

(iv) Dieckmann reaction

UNIT—I

2. (a) Distinguish between nucleotide and nucleoside. 2

Or

Synthesize one important pyrimidine base present only in RNA. 2

(Continued)

(b) What are complementary bases? Draw the structure to show hydrogen bonding between adenine-thymine. 1+1=2

(c) Define genetic code. Write the important structural and functional differences between DNA and RNA. 1+2=3

Or

How does DNA replicate? How is the process responsible for preservation of heredity? 3

UNIT—II

3. (a) Give one example of a tri-peptide showing N-terminal and C-terminal end. 2

(b) Synthesize alanine with the help of Strecker's synthesis. 2

(c) Discuss the α-helical structure of protein. 2

(d) Write a short note on electrophoresis of amino acids. 2

(e) What happens when alanine reacts with ninhydrin? 1

(Turn Over)

UNIT—III

4. *(a)* Define enzyme. How does pH affect the activity of enzymes? 1+1=2

Or

Write a short note on specificity of enzymes with the help of a suitable example. 2

(b) Define the term 'active site'. Give a brief diagram for the mechanism of enzymatic action. 1+2=3

(c) How does trypsin breakdown peptide bonds in a protein? Write the mechanism of the reaction. 3

Or

What are the cofactors present in enzymes? Give an example of a coenzyme with a specific reaction. 3

UNIT—IV

5. *(a)* What is hydrogenation of oil? What is its importance in lipid chemistry? 1+1=2

(b) What is rancidity? How can you prevent rancidity? 1+1=2

Or

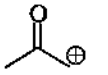
What is saponification value of a fat? What is its significance in determining the quality of lipid? 2

(c) What are triglycerides? Give two examples with structures. 1+1=2

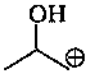
(d) How do you isolate carboxylic acid and alcohol from fats and oil? 2

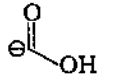
UNIT—V

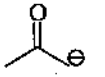
6. *(a)* Write the synthetic equivalents and also find the logical and illogical synthons of the following (any *two*) : 2

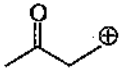
(i) 

(ii) 

(iii) 

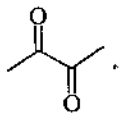
(iv) 

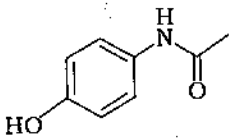
(v) 

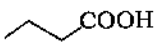
(vi) 

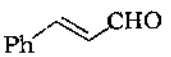
(b) Write a short note on umpolung. 2

(c) With the help of the retrosynthetic analysis, write down the synthesis of the following TMs (any *three*) : 2×3=6

(i) 

(ii) 

(iii) 

(iv) 

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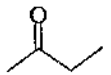
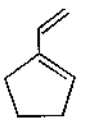
(vi) 

(vii) 

UNIT—VI

7. Answer any *four* questions : 2×4=8

(a) Synthesize a drug which is used to bring down body temperature during fever.

(b) Sulpha drugs work like antibiotics but they are not antibiotics. Is this a valid statement and why?

(c) Write in brief about the medicinal importance of azadirachtin present in neem.

(d) Draw the structure of chloramphenicol and write in brief about its clinical properties.

(e) Starting from *m*-chloroaniline, how would you synthesize chloroquine?

(f) What are antacids? Give the structure of ranitidine.

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Total No. of Printed Pages—7

5 SEM TDC PHYH (CBCS) C 11

2021

(Held in January/February, 2022)

PHYSICS

(Core)

Paper : C–11

(Quantum Mechanics and Applications)

(Theory)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer from the following : 1×5=5

(a) A wave function $\psi(\vec{r}, t)$ is admissible, if

(i) ψ is single-valued and finite

(ii) ψ is single-valued

(iii) ψ is finite

(iv) ψ is finite and multi-valued

(b) Stationary states are those for which the probability density ρ is

(i) time-dependent

(ii) time-independent

(iii) space-dependent

(iv) space-independent

(c) The zero-point energy of the simple harmonic oscillator is

(i) ∞

(ii) $\frac{1}{2}\hbar\omega$

(iii) $\frac{3}{2}\hbar\omega$

(iv) 0

(d) The electron in a hydrogen atom moves in a potential which is regarded as

(i) asymmetric

(ii) spherically symmetric

(iii) coulombian

(iv) None of the above

(Continued)

(e) Possible values of the Z-component of spin angular momentum are given by

(i) $\pm h$

(ii) $\pm\frac{\hbar}{2}$

(iii) $\pm\hbar$

(iv) $\pm 2\hbar$

2. Prove that the relation $\frac{\partial\rho}{\partial t}+\vec{\nabla}\cdot\vec{J}=0$, where $\vec{J}$ is the probability current density and ρ is the probability density. 3

Or

What do you understand by normalized wave function? Find the normalization constant of the particle described by the Gaussian wave packet wave function $\psi(x)=Ae^{-\alpha^2\frac{x^2}{2}}e^{ikx}$, (given $\int_{-\infty}^{\infty}e^{-\alpha^2x^2}dx=\frac{\sqrt{\pi}}{\alpha}$).

3. Show that position and linear momentum operators do not commute, i.e., $[\hat{x}, \hat{p}_x]=i\hbar$. 2

Or

Find the expectation value of momentum for the wave function $\psi(x)=\sqrt{\frac{2}{L}}\sin\frac{n\pi}{L}x$ in the region $0<x<L$.

(Turn Over)

4. Plot graphically the Gaussian wave packet given by the equation $\psi(x) = \frac{1}{\sqrt{\sigma\sqrt{\pi}}} e^{-x^2/2\sigma^2}$ where $\sigma^2 = \hbar c$ and explain its properties. 4

Or

State and prove Heisenberg's uncertainty principle for wave packets. If the product of uncertainties in position and momentum is minimum, find the form of the function.

5. Find out momentum wave function expression for a free particle in three dimensions. 3

6. Show that the energy of a particle trapped in a one-dimensional box of length a is

$$E_n = \frac{n^2\hbar^2\pi^2}{2ma^2}$$ 3

7. Write down the Schrödinger equation of a one-dimensional harmonic oscillator. What is the energy of this oscillator when it is in the eigenstate associated with the quantum number n? Discuss the significance of its zero-point energy. 5

Or

Write the general and normalized wave function of a harmonic oscillator. State the first two normalized wave functions of the oscillator.

8. If the expectation values of the square of the displacement harmonic oscillator is

$$< x^2 >= \left(n + \frac{1}{2}\right) \hbar / m\omega$$

what is the expectation value of the potential energy? 3

9. Write down the time-independent Schrödinger equation for the motion of the electron in hydrogen atom, assuming the proton to be at rest.

Given

$$\nabla^2 \equiv \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 \frac{\partial}{\partial r}\right) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta \frac{\partial}{\partial\theta}\right) + \frac{1}{r^2 \sin^2\theta}\frac{\partial}{\partial\phi^2}$$

Separate the Schrödinger equation into one radial and two angular parts. 1+4=5

Or

What is azimuthal component of Schrödinger's wave equation of hydrogen atom? Obtain its solution and normalized eigenfunction. What is the significance of the quantum number predicted by it? 1+3+1=5

10. The radial part of wave function for hydrogen in the ground state is given by

$$R = \frac{2}{a_0^{3/2}} e^{-\frac{r}{a_0}}$$

Find the expression for ground-state energy of hydrogen atom ($n = 1, l = 0$). 3

11. Describe the Stern-Gerlach experiment for verification of space quantization. 5

12. What is normal Zeeman effect? On the basis of quantum theory, explain the effects of magnetic field on energy levels of an atom. 4

13. Discuss the *L-S* coupling scheme. 4

14. How can the states of an atom be represented in spectral notation? 4

Or

What is meant by fine structure of spectral lines? Describe how the spin orbit coupling explains the fine structure of alkaline spectra. 1+3=4

★★★

Total No. of Printed Pages—7

5 SEM TDC PHYH (CBCS) C 12

2021

(Held in January/February, 2022)

PHYSICS

(Core)

Paper : C–12

(Solid-State Physics)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct option from the following : 1×5=5

(a) Every reciprocal lattice vector is

(i) parallel to lattice plane

(ii) normal to lattice plane

(iii) inclined at an angle of 45° to the lattice plane

(iv) None of the above

(b) According to Dulong and Petit's law, the molar specific heat capacity of a solid at temperature T is

(i) $\frac{1}{2}k_BT$

(ii) $3R$

(iii) $\frac{3}{2}R$

(iv) $3k_BT$

(c) Which of the following materials does not have permanent magnetic dipoles?

(i) Antiferromagnetic

(ii) Paramagnetic

(iii) Diamagnetic

(iv) Ferromagnetic

(d) Temperature dependence of polarizability is observed in case of

(i) ionic polarization

(ii) orientation polarization

(iii) electronic polarization

(iv) space charge polarization

(e) The slope of the logarithm of conductivity ($\ln\sigma$) versus $1/T$ plot is a measure of

(i) mobility

(ii) resistivity

(iii) band gap

(iv) carrier concentration

2. Answer any *five* from the following : 2×5=10

(a) Draw the (110) plane for a simple cubic structure.

(b) Define a primitive unit cell. Can a unit cell be primitive?

(c) What is phonon? Which statistics does it obey?

(d) Does dielectric constant vary with frequency of applied field? Write the relation between optical constants and complex dielectric constant of a medium.

(e) What are Curie law and Curie temperature?

(f) Draw the potential experienced by an electron in Kronig-Penney model.

(g) What are the conditions for a material to be a superconductor?

3. (a) Show that f.c.c. lattice is reciprocal to b.c.c. lattice. 3

(b) Draw the dispersion curve for a linear diatomic lattice showing acoustical and optical modes. 2

(c) Give the qualitative interpretation of the band structure of electronic energy levels in a semiconductor. 3

4. (a) Show that in a cubic crystal of side a, the inter-planar spacing between consecutive parallel planes of Miller indices (hkl) is $d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$. Calculate the inter-planar spacing d of planes (111) in a simple cubic lattice of side a. 4+1=5

Or

State Bragg's law of crystal diffraction. If X-ray of wavelength 1·75 Å is diffracted at an angle of 30° in the first-order reflection from (1, 1, 1) planes of a crystal, what is the spacing between the adjacent planes of the crystal? Calculate the interatomic spacing. 5

(b) How does Debye's theory of heat capacity of solids differ from those of Einstein's theory? Discuss the predictions of this model for very high and very low temperatures and state the Debye T^3 law. 2+2=4

Or

Derive the expression for the dispersion relation for a linear monoatomic chain of atoms. 4

5. (a) Discuss the B-H loop and explain it with the help of domain theory. 4

(b) Develop the Clausius-Mosotti relation for elemental dielectric system by determining Lorentz field. 4

(c) Explain the meaning and origin of piezoelectricity. Give an example of a crystal that is piezoelectric but not ferroelectric. 4+1=5

Or

What are ferroelectric materials? Explain the ferroelectric nature with the example of barium titanate. Mention two of its applications. 1+3+1=5

6. Find the intrinsic carrier concentration of germanium if its conductivity is $2{\cdot}13\ \text{ohm}^{-1}\,\text{m}^{-1}$. Given that electron and hole mobilities as $\mu_e = 0{\cdot}39\ \text{m}^2\text{V}^{-1}\text{s}^{-1}$ and $\mu_p = 0{\cdot}19\ \text{m}^2\text{V}^{-1}\text{s}^{-1}$ 3

Or

What is Hall effect? Write the expression for Hall coefficient. State its significance.

7. *(a)* Define penetration depth related to superconductor when it is placed in an external magnetic field. 1

(b) What do you mean by flux exclusion in a superconductor? Distinguish between type-I and type-II superconductors using Meissner effect. 1+3=4

Or

Describe the effect of an external magnetic field on superconducting state of material. What is critical magnetic field and how does it vary with temperature? What is its value at the critical temperature? 4

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Total No. of Printed Pages—4

5 SEM TDC DSE PHY (CBCS) DSE 1 (H)

2021

(Held in January/February, 2022)

PHYSICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE–1

(Classical Dynamics)

Full Marks : 80
Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×5=5

(a) A particle of mass m moves along a straight line and attached towards a point on this line with a force proportional to the distance x from the point. The Lagrangian of the system is

(i) $\frac{1}{2}mv^2+\frac{1}{2}kx^2$ *(ii)* $\frac{1}{2}mv^2-\frac{1}{2}kx^2$

(iii) $mv^2+\frac{1}{2}kx^2$ *(iv)* $\frac{1}{2}mv^2-kx$

(b) The rest mass of an electron is m_0. What will be its mass when it moves with velocity $0{\cdot}6c$?

(i) m_0 *(ii)* $\frac{5}{4}m_0$

(iii) $\frac{4}{5}m_0$ *(iv)* $2m_0$

(c) A body with a charge q starts from rest and acquire a velocity 0·5c. Then the new charge on it is

(i) $q\sqrt{1-(0\cdot5)^2}$ (ii) $\frac{q}{\sqrt{1-(0\cdot5)^2}}$

(iii) $q\sqrt{1-0\cdot5}$ (iv) q

(d) If ϕ is the scalar potential and $\vec{A}$ is the vector potential, the total potential energy of a charged particle in an electromagnetic field is

(i) $q\phi+\frac{q}{c}(\vec{A}\cdot\vec{B})$ (ii) $q\phi+\frac{q}{c}(\vec{A}\cdot\vec{E})$

(iii) $q\phi-\frac{q}{c}(\vec{A}\cdot\vec{v})$ (iv) $q\phi+\frac{q}{c}(\vec{A}\cdot\vec{\phi})$

(e) For a linear oscillatory system, the total energy is proportional to

(i) square of the time period

(ii) amplitude

(iii) square of the amplitude

(iv) square of the frequency

2. (a) Discuss qualitatively the equations of motion of Newton, Lagrange and Hamilton highlighting the difference between the three. 5

(b) Set up the Lagrange's equation for a simple pendulum and solve for θ. 4+3=7

(c) State and explain Hamilton's (variational) principle and derive Lagrange's equation from it. 2+4=6

Or

Explain homogeneity of time and isotropy of space and their connection with conserved quantities. 3+3=6

(d) Given that the Hamiltonian has implicit dependence on time, prove that it is a constant of motion. 5

Or

Show that the shortest distance between two points in a plane is a straight line.

3. (a) Explain dynamical equilibrium with examples. 2

(b) Find the expressions for frequencies of two-coupled one-dimensional harmonic oscillator. 6

4. (a) A muon (life time 2×10^{-6} sec) traveling through the laboratory at three-fifths the speed of light. How long does it last in the laboratory? 4

(b) Two electrons are leaving a radioactive sample in opposite directions, each having a speed 0·67c with respect to the sample. The relative speed of one electron to the other is 1·34c according to classical physics. What is the relativistic result? 3

(c) Show that the space-time interval is an invariant under Lorentz transformation. 4

(d) Write down the Lorentz transformation equation in matrix form. 3

Or

Is it possible for an external force to be acting on a system and relativistic momentum to be conserved? Explain.

(e) Construct Minkowski space and calibrate it. 5

(f) Explain simultaneity, length contraction and time dilation with the help of space-time diagram. 3

(g) Discuss the physical conditions of space-like and time-like intervals. 2+2=4

(h) Deduce the relativistic energy momentum relation $E^2 = p^2c^2 + m_0^2c^4$. 4

Or

Discuss Doppler effect from four-vector perspective.

(i) Define four-vector, rest mass energy, world line and proper time. 1×4=4

5. (a) Define fluid, liquid and gas, and establish the equation of continuity for fluid. 3+5=8

(b) Write the expression for Reynolds' number and explain the states of flow of liquid for lower and higher Reynolds' number. 2

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Total No. of Printed Pages—19

5 SEM TDC DSE PHY (CBCS)
DSE 2 (H) A/B/C

2021

(Held in January/February, 2022)

PHYSICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE–2

The figures in the margin indicate full marks for the questions

Paper : DSE–2 (A)

(Astronomy and Astrophysics)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

1. Choose the correct answer from the following : 1×8=8

(a) The largest unit of distance among the following is

(i) light-year

(ii) parsec

(iii) astronomical unit

(iv) Mpc

(b) The apparent brightness of a star is the
  (i) total amount of power it radiates into space
  (ii) total amount of light it radiates into space per unit time
  (iii) amount of light reaching as per unit area from the star
  (iv) None of the above

(c) The apparent magnitude of a faint star in comparison to a bright star is
  (i) positive and high
  (ii) negative and high
  (iii) negative and low
  (iv) imaginary

(d) On the celestial sphere, the north pole has a declination of
  (i) 0 (ii) $-\frac{\pi}{2}$
  (iii) $+\frac{\pi}{2}$ (iv) π

(e) The source of energy of a star is
  (i) chemical in nature
  (ii) mechanical in nature
  (iii) thermonuclear in nature
  (iv) gravitational in nature

(f) The spiral arm where the sun is located in our Milky Way galaxy is
  (i) Cygnus Arm
  (ii) Norma Arm
  (iii) Perseus Arm
  (iv) Orion Arm

(g) The transition region in the solar atmosphere lies
  (i) below photosphere
  (ii) above corona
  (iii) in between chromosphere and corona
  (iv) in between photosphere and chromosphere

(h) The mass-luminosity relation is
  (i) $L \propto M$ (ii) $L \propto M^{2.5}$
  (iii) $L \propto M^{0.5}$ (iv) $L \propto M^{3.5}$

2. Answer any *eight* from the following : 2×8=16

(a) What is parsec? Convert 1 parsec into kilometer.

(b) Explain the direct method of determining the radii of stars.

(c) Write the difference between sidereal time and solar time.

(d) State the virial theorem.

(e) Name two telescope mounting systems which are widely used. Mention the different axes used in these systems.

(f) Explain the terms 'angular magnification' and 'light gathering power' associated with an optical telescope.

(g) Two stars of spectral class O and A have temperatures 40000 K and 10000 K, respectively. Draw their black-body radiation curves.

(h) A star is found to radiate like a black-body with peak wavelength at 1·45 nm. Calculate its temperature. Assume that the constant for Wien's displacement law is equal to $2{\cdot}9\times10^{-3}$ mK.

(i) What is lenticular galaxy? How is it different from spiral galaxy?

(j) What is sunspot? Why does it appear dark?

(k) What is exoplanet? Name one of the techniques of detecting it.

(l) What are the characteristics of spiral galaxies?

3. (a) Draw the celestial sphere showing the celestial poles, celestial equator, ecliptic, vernal equinox and autumnal equinox. 3

(b) Compare the brightness of the sun and Sirius B, given that the apparent magnitude of the sun $(m_{sun}) = -26{\cdot}81$ and the apparent magnitude of Sirius B $(m_{Sirius\ B}) = +8{\cdot}68$. 3

(c) Show how the parallax method is used for determination of stellar distance. Why is it not possible to measure very distant object by this method? 3

Or

Obtain the relation connecting the absolute magnitude with apparent magnitude and the distance of the star in parsec.

(d) With proper sketches, explain the horizon coordinate system to locate the position of a star. What are the shortcomings of this system? 4+1=5

Or

What is a visual binary? Show how the masses of stars are determined by analyzing binary stars. 1+4=5

4. *(a)* Describe the different layers of solar atmosphere with a diagram on variation of temperature with distance. 3

(b) Write a short note on any *one* of the following : 3

(i) Nebular theory

(ii) Solar activity

(c) Explain briefly the spectral classification of stars. Also explain its dependence on stellar temperatures. 5

(d) Draw an H-R diagram and explain its significant features. 3

5. *(a)* Discuss how spiral galaxies differ from elliptical galaxies. Give one example of each. 2+1=3

(b) Differentiate between population–I stars and population–II stars. 3

(c) Draw the rotation curve of the Milky Way galaxy. 3

(d) Discuss the basic structure and properties of Milky Way with a sketch labeling different components. 5

6. *(a)* What is the interstellar medium of a galaxy? 2

(b) Explain Hubble's scheme of galaxy classification with an appropriate diagram. 4

(c) Explain how the Cepheid variables are used to estimate astronomical distances. 4

(d) State Hubble's law. On the basis of this law, explain the phenomenon of expanding universe. 4

Or

What are the dimensions of the Hubble constant? If the age of the universe is estimated to be 14 billion years, calculate the value of Hubble's constant in the units of $kms^{-1}\ Mpc^{-1}$.

Paper : DSE–2 (B)

(Physics of Devices and Instruments)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

1. Choose the correct answer from the following : 1×5=5

(a) A JFET has three terminals, namely

(i) cathode, anode and grid

(ii) ammeter, base and collector

(iii) source, gate and drain

(iv) None of the above

(b) In an *L-C* filter, the ripple factor

(i) increases with load current

(ii) increases with load resistance

(iii) remains constant with load current

(iv) has the lowest value

(c) An *N*-channel MOSFET preferred over a *p*-channel MOSFET because

(i) it allows fast switching

(ii) it is TTL compatible

(iii) of its low input impedance

(iv) of low noise

(d) In an amplitude modulated wave, useful power is carried by

(i) carrier

(ii) sidebands

(iii) both carrier and sidebands

(iv) None of the above

(e) In frequency modulation

(i) frequency of the carrier remains constant

(ii) carrier frequency varies in accordance with the modulating signal frequency

(iii) carrier frequency varies in accordance with the modulating signal amplitude

(iv) Both *(i)* and *(ii)* are true

2. *(a)* Discuss the emitter characteristics of a unijunction transistor (UJT). 2

(b) Describe the working principle of a MOSFET. Give a comparison between E-MOSFET and D-MOSFET. 2+2=4

3. Write short notes on any *two* from the following : 3×2=6

(a) CMOS

(b) Tunnel diode

(c) Charge coupled device

4. *(a)* Discuss a power supply with block diagram. 3

(b) Define low pass, high pass, band pass and band reject filters. 2

Or

Show how the input voltage wave is modified in presence of the C filter.

5. With a neat sketch, explain the working of a monostable multivibrator. 3

6. *(a)* What is phase locked loop (PLL)? Discuss its necessity. 2

(b) Show how an XOR gate can be used as phase detector and discuss its phase detector response curve. 3

Or

Discuss varactor as a voltage-controlled oscillator.

7. Describe the basic steps involved in integrated circuit fabrication process. 3

Or

Discuss electronic grade silicon mentioning its properties.

8. What do you mean by positive and negative masking effects in the fabrication process? 1+1=2

9. Write a short note on any *one* from the following : 2

(a) Defects in lattice

(b) Optical lithography

(c) Electron lithography

10. How many communication wires are available in an RS232 serial bus? Write down the full form of UART. 1+1=2

11. Discuss the three handshaking lines of GPIB. 3

Or

Discuss the characteristics of GPIB.

12. *(a)* Draw the block diagram of electronic communication system. 2

Or

Why is modulation important in communication system?

(b) Explain any *one* of the following types of digital modulations : 3

(i) FSK types

(ii) ASK types

(iii) PSK types

(c) Give the mathematical analysis of AM wave. 3

13. Discuss the operation of diode detector as demodulator for AM wave. 3

Or

In a broadcasting studio, a 100 MHz carrier having an amplitude of 50 V is amplitude modulated by a 5 kHz audio signal having an amplitude of 20 V. Find the modulation index and sideband frequencies.

Paper : DSE-2 (C)

(Physics of Earth)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

1. Choose the correct answer/Fill in the blanks (any *eight*) : 1×8=8

(a) Milky Way galaxy is a/an

(i) peculiar galaxy

(ii) irregular galaxy

(iii) elliptical galaxy

(iv) spiral galaxy

(b) The hydrosphere is the mass of water found

(i) on the earth

(ii) under the earth

(iii) above the surface of a planet

(iv) All of the above

(c) Freshwater accounts for ____ of the water on the earth.

(i) 2·5%

(ii) 5%

(iii) 7·5%

(iv) 10%

(d) What is the point on the earth's surface directly above an earthquake form?

(i) Earthquake centre

(ii) Epicentre

(iii) Fault

(iv) Focus

(e) Volcanoes are associated with all of the following areas, *except*

(i) rift zone

(ii) epicentre

(iii) subduction zone

(iv) hot spots

(f) The combined portion of the earth in which all living things exist is called

(i) biome

(ii) ecosystem

(iii) community

(iv) biosphere

(Continued)

(g) Eons and eras are units of ____.

(h) What is the atmospheric layer closest to the ground?

(i) Mesosphere

(ii) Troposphere

(iii) Thermosphere

(iv) Stratosphere

(i) Gravitational force is ____ (strongest/weakest) at the centre of the earth.

(j) Photosynthesis, decomposition, respiration and combustion are the four steps of

(i) water cycle

(ii) nitrogen cycle

(iii) carbon cycle

(iv) phosphorous cycle

2. Answer the following questions :

(a) What are meteorites and asteroids? What are terrestrial and zovian planets? 1½+1½=3

(b) Discuss the rotational and revolution parameters of the earth. 2+2=4

(Turn Over)

(c) Explain the origin of cosmic microwave background and its relationship to the big bang. 5

(d) Discuss about the energy and particle fluxes incident on the earth. 5

Or

Define meteorology. Describe different stages of formation of a planet.

3. Answer the following questions :

(a) Define geothermal energy and mention three main uses of it. 1½+1½=3

(b) What do you mean by cryosphere? How do glacier ice sheets and polar ice caps formed? 1+3=4

(c) What are the main three layers of the earth? What do you mean by continental and oceanic crusts? Mention three most common elements of the earth's crust. 1+2+2=5

(Continued)

(d) Discuss about variation of temperature, density and composition of the atmosphere with altitude. 5

Or

Discuss in detail about the three basic components of the biosphere.

4. Answer the following questions :

(a) What do you mean by seafloor spreading? Explain how convection currents may be related to plate tectonics. 1+2=3

(b) What are tides and how are they useful? What happens when a tsunami enters shallow water? 2+2=4

(c) What causes earthquakes? Compare and contrast primary, secondary and surface waves. Define Richter scale. 1+3+1=5

(d) How do volcanoes form? Discuss about different types of volcanoes and their products and distribution. 1+4=5

(Turn Over)

Or

Write a short note on water cycle. 5

5. Answer the following questions :

(a) Discuss about the principle of uniformitarianism. 3

(b) Give a brief discussion on Nebular and Catastrophic hypotheses on origin of the earth. 2+2=4

(c) Define geological time scale. Discuss about some major geological events. 1+4=5

(d) Discuss the origin of life on the earth. 5

Or

How does biosphere help the environment? How does the evolution of the solar system may lead to the death of the earth? 2+3=5

6. Answer any *two* from the following questions : 2×2=4

(a) What is the difference between global warming and climate change?

(*Continued*)

(b) How does the growth of population and deforestation affect the environment?

(c) What are nuclear hazards? How can they lead to environmental pollution?

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Total No. of Printed Pages—3

5 SEM TDC ZOOH (CBCS) C 11

2021

(Held in January/February, 2022)

ZOOLOGY

(Core)

Paper : C–11

(Molecular Biology)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Fill in the blanks : 1×5=5

(a) The diameter of A-DNA is _____.

(b) In *E. coli*, the origin of replication is known as _____.

(c) _____ subunit of RNAP holoenzyme initiates transcription in prokaryotes.

(d) During translation, amino acids are attached to the _____ end of the respective tRNA molecules.

(e) Lactose acts as an _____ of *lac* operon.

2. Explain precisely any *two* of the following : 4×2=8

(a) DNA polymerase-III

(b) Repair of DNA molecule

(c) RNA interference

3. Write explanatory notes on any *two* of the following : 4×2=8

(a) Wobble hypothesis

(b) tRNA structure and function

(c) Processing of mRNA

(d) Okazaki fragment

4. Describe the structure of DNA double-helix model. Explain the synthesis of lagging strand of DNA with suitable diagram(s). 4+4=8

Or

Explain with suitable diagram(s) the experiment that conclusively proved that DNA replicates in semiconservative way. Why is DNA replication said to be semi-discontinuous? 6+2=8

5. What are the sequence elements found in the promoter of genes transcribed by RNA pol II? Write a short note on General Transcription Factors (GTFs) and their roles in transcription of mRNA in eukaryotes. 3+5=8

Or

Write short notes on Rho-dependent and Rho-independent termination of prokaryotic transcription. How transcription in prokaryotes differ from eukaryotes? 4+4=8

6. Write the biochemical reaction catalyzed by aminoacyl-tRNA synthetase. Write a note with suitable diagram on the formation of initiation complex in bacterial protein biosynthesis. 3+5=8

Or

Elaborate the process of elongation of protein synthesis in prokaryotes. 8

7. If *E. coli* is grown in a medium containing both glucose and lactose, which carbon source will it prefer and why? Explain your answer with reference to operon concept using suitable diagrams. 1+5+2=8

Or

What is operon? Describe the structure of tryptophan operon. Add a note on eukaryotic transcription activators and repressors. 1+4+3=8

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Total No. of Printed Pages—3

5 SEM TDC ZOOH (CBCS) C 12

2021

(Held in January/February, 2022)

ZOOLOGY

(Core)

Paper : C–12

(Principles of Genetics)

Full Marks : 53

Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Fill in the blanks with appropriate words : 1×5=5

(a) The number of linkage group in human male is _____.

(b) The sequence of DNA coding for a functional protein is called _____.

(c) The genotypic ratio in F_1 generation of monohybrid cross is _____.

(d) _____ is an example of sex-linked inheritance.

(e) Abnormality in the structure of chromosome is known as chromosomal _____.

2. (a) Write briefly on any *two* of the following : 3×2=6

(i) Lethal alleles

(ii) Pleiotropy

(iii) Polygenic inheritance

(b) Distinguish between any *two* of the following : 3×2=6

(i) Transformation and Transduction

(ii) Complete linkage and Incomplete linkage

(iii) Recombination and Hybridization

3. Define incomplete dominance and codominance. Explain each with suitable examples. 4+5=9

Or

Write explanatory note on crossing over. Describe how crossing over can be used to measure the relative distance between genes in a chromosome. 4+5=9

4. Define epistasis. Explain dominant epistasis with suitable example. 3+6=9

Or

Explain the mechanism of sex determination in *Drosophila*. 9

5. What is mutation? Describe different types of gene mutations. 2+7=9

Or

What is extrachromosomal inheritance? Explain with suitable example. 2+7=9

6. What are transposons? Give examples of transposable elements in bacteria and human. 2+7=9

Or

What is a bacteriophage? Explain the mechanism of gene conjugation in bacteria. 2+7=9

★★★

Total No. of Printed Pages—3

5 SEM TDC DSE ZOO (CBCS) 3 (H)

2021

(Held in January/February, 2022)

ZOOLOGY

(Discipline Specific Elective)

(For Honours)

Paper : DSE–3

(Endocrinology)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Fill in the blanks : 1×5=5

(a) ADH is released by _____ part of pituitary.

(b) Hyposecretion of _____ hormone leads to cretinism.

(c) The hormone insulin is secreted by _____ cells of islet of Langerhans.

(d) Glucagon and _____ are antagonistic in function.

(e) Adrenocorticotrophic hormone stimulates _____ part of the adrenal gland.

2. Write briefly on any *four* of the following : 4×4=16

(a) Classification of hormones

(b) Physiological effects of estrogen

(c) Functions of insulin

(d) Feedback mechanism in regulation of hormone secretion

(e) Neurohormones

3. What is endocrinology? Write four general characteristics of hormones. Add a note on neurosecretion. 2+4+2=8

Or

Write a note on the history of endocrinology. Briefly describe the transport of hormones in our body. 5+3=8

4. "Hypothalamus is known as the bandmaster of endocrine orchestra." Explain. Write the function of any two hormones secreted by adenohypophysis. 8

Or

What do you mean by hypothalamo-hypophysial portal system? Write briefly the significance of the hormones secreted by neurohypophysis. 4+2+2=8

5. Describe the histological structure of the gland that secretes thyroxine with suitable diagram. How does thyroxine regulate the basal metabolic rate in human? 4+2+2=8

Or

Explain the structure of adrenal cortex with suitable diagram. Write the functions of glucocorticoids. 3+2+3=8

6. What are hormone receptors? How does it help in signal transductions? Write the role of hormone in maintaining homeostasis. 2+3+3=8

Or

Write the general mechanism of action of protein hormones with suitable diagram. 8

★★★

Total No. of Printed Pages—3

5 SEM TDC DSE ZOO (CBCS) 4 (H)

2021

(Held in January/February, 2022)

ZOOLOGY

(Discipline Specific Elective)

(For Honours)

Paper : DSE–4

(Biology of Insecta)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Fill in the blanks : 1×5=5

(a) Honeybees belong to the order _____.

(b) Royal jelly is produced by _____.

(c) Compound eyes of insects consist of visual units are known as _____.

(d) The tracheal system bearing ten pairs of functional spiracles is known as _____.

(e) Exoskeleton of insects is made-up of _____.

2. Write short notes on/Answer any *two* of the following : 3×2=6

(a) General characters of insects

(b) Write the systematic position of any silkworm up to order.

(c) Haemolymph

3. Answer any *three* of the following questions : 4×3=12

(a) Distinguish between mechanical and biological vectors with suitable examples.

(b) Give an account of the advantages of social life in insects.

(c) Write a short note on mosquitoes as an important insect vector.

(d) Write a short note on insect's sensory receptors.

4. Write briefly about the types of antennae found in insects with suitable diagrams. 6

Or

Write a note on different types of mouthparts adapted for feeding in insects along with suitable diagrams. 6

5. Give an account of respiratory or excretory system in insects. 7

6. Elaborate the endocrine system or reproductive system in insects. 8

7. Define metamorphosis. Give an account of the process of insect metamorphosis. 9

Or

Write short notes on any *two* of the following : 4½×2=9

(a) Phytophagous insects

(b) Theory of coevolution of plants and insects

(c) Digestive glands in insects

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Total No. of Printed Pages—4

5 SEM TDC DSE BOT (CBCS) 1 (H/NH)

2021

(Held in January/February, 2022)

BOTANY

(Discipline Specific Elective)

(For Honours and Non-Honours)

Paper : DSE–1

(Analytical Techniques in Plant Science)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. *(a)* Choose the correct answer of the following : 1×3=3

(i) If the average of a series of values is 10 and their variance is 4, then the coefficient of variance is 10% / 40% / 20% / 80%.

(ii) Millimeter / Nanometer / Centimeter / Decimeter is the smallest unit of measurement.

(iii) The PAGE stands for Poly-acrylamide Gel Electrophoresis / Polymerization and Genetic Engineering / Post Application of Genetic Engineering / Poor Adaptation of Genetic Engineering.

(b) Fill in the blanks : 1×2=2

(i) _____ unit is used for sedimentation of coefficient gradient in centrifuge.

(ii) The technique to distinguish the individual based on their DNA print pattern is called _____.

2. Write short accounts on any *three* of the following : 4×3=12

(a) Marker enzymes

(b) Autoradiography

(c) Ultracentrifugation

(d) GLC

(e) X-ray crystallography

3. What is electrophoresis? Write on the different types of electrophoresis. Also describe on western blotting. 2+7+3=12

Or

What is resolving power? How will you calculate the magnification of a compound microscope? Also mention the components of dark-field microscope. 1+8+3=12

4. What are radioisotopes? Write briefly the application of radioisotopes in biological sciences. 2+10=12

Or

Write notes on the following : 6+6=12

(a) Mass spectrometry

(b) FISH

5. What is chromatography? Write briefly on different types of chromatography and their utility. 2+5+5=12

Or

What is standard deviation? Calculate mean, median and mode of the data given below :

3+3+3+3=12

Class Interval	*Frequency*
15–25	4
25–35	11
35–45	19
45–55	14
55–65	0
65–75	2

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Total No. of Printed Pages—3

5 SEM TDC DSE BOT (CBCS) 4 (H)

2021

(Held in January/February, 2022)

BOTANY

(Discipline Specific Elective)

(For Honours)

Paper : DSE–4

(Industrial and Environmental Microbiology)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following in very brief : 1×5=5

(a) What is bioremediation?

(b) Write the full form of BOD.

(c) Who discovered fermentation technique?

(d) Give example of a media used to cultivate fungi.

(e) What is enzyme immobilization?

2. Answer the following in short : 2×4=8

(a) Mention one advantage of continuous fermentation.

(b) Give example of cell disruption technique.

(c) What is the working principle of centrifugation?

(d) How can you determine the total dissolved solid (TDS)?

3. Write short notes on any *two* of the following : 3×2=6

(a) Biological nitrogen fixation

(b) Antibiotics

(c) Arbuscular mycorrhiza

4. Answer the following : 4+4+5+5=18

(a) Write a note on bioremediation of contaminated soil.

(b) "Mycorrhiza is used to reclaim soil fertility." Explain.

(c) Write an explanatory note on downstream processes.

(d) With suitable example, describe about the use of microorganism in controlling water pollution.

5. Write an account on enzyme immobilization and mention its advantages. 3+3=6

Or

Describe about various types of micro-organisms that are traced for monitoring water quality. 6

6. Describe how ethanol is produced by fermentation process and mention some uses of ethanol. 7+3=10

Or

Write an account on different types of bioreactors used in fermentation process. 10

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5 SEM TDC BOTH (CBCS) C 12

2021

(Held in January/February, 2022)

BOTANY

(Core)

Paper : C–12

(Plant Physiology)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. *(a)* Choose the correct answer of the following : 1×3=3

(i) Transpiration is minimized by the deposition of cellulose / pectin / cutin / mucilage.

(ii) The example of a selective permeable membrane is cell wall / chloroplast membrane / plasma membrane / mitochondrial membrane.

(iii) The direction and rate of water movement from cell to cell is based on WP / TP / DPD / plasmolysis.

(b) Fill in the blanks : 1×2=2

(i) Loss of water droplets from the outer surface in any part of the plant body is called _____.

(ii) The movement of plants influenced by light is called _____.

2. What is transpiration? Write about the mechanism of opening and closing of stomata. How do plants adapt itself to check excessive transpiration? 2+8+2=12

Or

What do you mean by mineral nutrition? Mention the function and deficiency symptoms of nitrogen, potassium and phosphorus in the plants. 2+10=12

3. Explain the evidence which proves that phloem is the channel of transport of organic substances in plants. Describe the 'mass flow hypothesis' of translocation of solutes in plants. Give its demerits. 4+6+2=12

Or

Write explanatory notes on the following : 6+6=12

(a) Seismonastic movements in plants

(b) Active absorption of ions by plants

4. What are phytohormones? Describe bioassay and physiological role of auxin. 1+6+5=12

Or

Write briefly on the following : 4×3=12

(a) Water potential

(b) Antitranspirants

(c) Low energy response (LER) of phytochrome

5. What do you mean by phytochrome? Give its chemical nature and role in flower initiation. How do the two forms of phytochrome regulate the flowering mechanism? 2+2+8=12

Or

What is seed dormancy? Mention the types of dormancy. Write the causes of seed dormancy and explain the mechanism of breaking of seed dormancy. 1+1+5+5=12

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Total No. of Printed Pages—4

5 SEM TDC BOTH (CBCS) C 11

2021

(Held in January/February, 2022)

BOTANY

(Core)

Paper : C–11

(Reproductive Biology of Angiosperms)

Full Marks : 53
Pass Marks : 21

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. *(a)* Choose the correct answer of the following : 1×3=3

(i) In angiosperms the endosperms is

(1) triploid (3n)

(2) diploid (2n)

(3) haploid (n)

(4) None of the above

(ii) When the body of the ovule, embryo sac, micropyle and funicle, all lie in one vertical plane the ovule is

(1) anatropous

(2) orthotropous

(3) amphitropous

(4) campylotropous

(iii) The process of double fertilization (triple fusion) was discovered by

(1) Nawaschin

(2) Leeuwenhoek

(3) Strasburger

(4) Hofmeister

(b) Fill in the blanks of the following : 1×2=2

(i) Finger-like projections present in synergids are called _____.

(ii) Typical 8-nucleate embryo sac is called _____.

2. Write precise notes on the following : 4×3=12

(a) Double fertilization and its significance

(b) NPC system

(c) Apomixis

3. What is microspore? Describe the formation of microspores within the microsporangium. Draw diagram where necessary. 2+8+2=12

Or

Answer/Write explanatory note of the following : 6+6=12

(a) "The flower is equivalent to a modified shoot." Justify the statement with reasons.

(b) Polyembryony and its significance

4. What do you mean by embryogenesis? Describe the stages of development of a typical dicot embryo giving necessary diagram. 2+8+2=12

Or

Write notes of the following : 4×3=12

(a) Monosporic type of embryo sac

(b) Parthenocarpy and its significance

(c) Difference between dicot and monocot embryo

5. What is self-incompatibility? Describe about the homomorphic and heteromorphic self-incompatibility. What are the methods to overcome self-incompatibility? 2+6+4=12

Or

Describe the different types of contrivances of cross-pollination giving example in each case. Why nature prefers cross-pollination? 8+4=12

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Total No. of Printed Pages—20

5 SEM TDC DSE MTH (CBCS)
2.1/2.2/2.3/2.4/(H)

2021

(Held in January/February, 2022)

MATHEMATICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE–2.1/2.2/2.3/2.4

The figures in the margin indicate full marks for the questions

Paper : DSE–2.1

(Mathematical Modeling)

Full Marks : 60
Pass Marks : 24

Time : 3 hours

1. *(a)* What do you mean by an ordinary point of the equation $\frac{d^2y}{dx^2} + P(x)\frac{dy}{dx} + Q(x)y = 0$? 1

(b) Define Bessel's equation of order n. 1

2. *(a)* Determine whether $x = 0$ is an ordinary point or a regular singular point of the differential equation

$$2x^2 \frac{d^2y}{dx^2} + 7x(x+1)\frac{dy}{dx} - 3y = 0 \qquad 3$$

(b) Find the general power series solution near $x = 0$ of the Legendre's equation

$$(1-x^2)\frac{d^2y}{dx^2} - 2x\frac{dy}{dx} + p(p+1)y = 0$$

where p is an arbitrary constant. 6

Or

Solve the Bessel's equation $x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} + (x^2 - n^2)y = 0$ in series, taking $2n$ as non-integral.

3. *(a)* If $\mathscr{L}[f(t)]$ and $\mathscr{L}[g(t)]$ are Laplace transformations of $f(t)$ and $g(t)$ respectively, then show that

$$\mathscr{L}[af(t) + bg(t)] = a\mathscr{L}[f(t)] + b\mathscr{L}[g(t)]$$

where a and b are constants. 2

(b) If $\mathscr{L}[F(t)] = f(s)$, then prove that

$$\mathscr{L}[F''(t)] = s^2 f(s) - sF(0) - F'(0) \qquad 3$$

(c) Evaluate using convolution theorem (any *one*) : 4

(i) $\mathscr{L}^{-1}\left[\frac{s}{(s^2 + a^2)^2}\right]$

(ii) $\mathscr{L}^{-1}\left[\frac{1}{s^2(s+1)^2}\right]$

(d) Apply Laplace transformation and solve

$$\frac{d^2y}{dt^2} + 2\frac{dy}{dt} + 5y = e^{-t}\sin t,\ y(0) = 0,\ \left.\frac{dy}{dt}\right|_{t=0} = 1 \qquad 5$$

4. *(a)* Write two principal advantages of Monte Carlo simulation technique. 2

(b) Write the algorithm that gives the sequence of calculations needed for a general computer simulation of Monte Carlo technique for finding the area under a curve. 3

5. *(a)* Who developed the middle-square method for generating random numbers? How does their method work? 1+3=4

(b) Use middle-square method to generate 10 random numbers using $x_0 = 1009$. 3

(c) Use linear congruence method to generate a sequence of 10 random numbers by the rule

$$x_{n+1} = (ax_n + b) \bmod (c)$$

using $a = 5$, $b = 1$ and $c = 8$. 3

6. Write a short note on any *one* of the following : 5

(a) Harbor system simulation algorithm

(b) Morning rush hour queuing model

7. Answer any *one* of the following : 6

(a) A furniture manufacturer makes two products—chairs and tables. Processing of these products is done on two machines P and Q. A chair requires 2 hours on machine P and 6 hours on machine Q. A table requires 5 hours on machine P and no time on machine Q. There are 16 hours per day available on machine P and 30 hours on machine Q. Profit gained by the manufacturer from a chair and a table is ₹2 and ₹10 respectively. What should be the daily production of each of the two products? (Use graphical method of linear programming model.)

(b) Using Simplex method, solve the following linear programming model :

$$\text{Maximize } 25x_1 + 30x_2$$

subject to

$$20x_1 + 30x_2 \leq 690$$

$$5x_1 + 4x_2 \leq 120$$

$$x_1, x_2 \geq 0$$

8. A company wants to produce three products—A, B and C. The unit profits on these products are ₹4, ₹6 and ₹2 respectively. These products require two types of resources, manpower and raw material. The LP model formulated for determining the optimal product mix is

$$\text{Maximize } 4x_1 + 6x_2 + 2x_3$$

subject to the constraints

(i) Manpower constraint

$$x_1 + x_2 + x_3 \leq 3$$

(ii) Raw material constraint

$$x_1 + 4x_2 + 7x_3 \leq 9$$

and $$x_1, x_2, x_3 \geq 0$$

where x_1, x_2, x_3 are number of units of products A, B, C respectively to be produced.

(a) Find the optimal product mix and the corresponding profit of the company. 5

(b) Find the range of the profit contribution of product C in the objective function such that current optimal product mix remains unchanged. 4

Paper : DSE–2.2

(Mechanics)

Full Marks : 80
Pass Marks : 32

Time : 3 hours

1. *(a)* Define moment of a force about a point. 1

(b) Three forces $\vec{P}, \vec{Q}, \vec{R}$ act along the sides *BC*, *CA*, *AB* of a ΔABC, taken in order; if their resultant passes through the incentre of ΔABC, then prove that

$$\vec{P}+\vec{Q}+\vec{R}=\vec{0}$$ 3

(c) Prove that any system of coplanar forces acting on a rigid body is equivalent to a single force acting at arbitrarily chosen point together with a single couple. 6

Or

Prove that two coplanar couples of equal moments but of opposite sense acting on a rigid body balance each other.

2. *(a)* Write an example of distributed force system. 1

(b) Define equivalent point load. 2

(c) Prove that the necessary and sufficient conditions for the equilibrium of a rigid body under the action of a system of coplanar forces acting at different points of it are that the sums of the resolved parts of the forces in any two mutually perpendicular directions vanish separately and the sum of the moments of the forces about any point in the plane of the forces vanishes. 7

Or

Draw the free body diagram of the beam supported at *A* by a fixed support and at *B* by a roller. Explain the significance of each force on the diagram.

Given $W=40\frac{\text{lb}}{\text{ft}}$ (lb stands for pound)

$a=3$ ft, $b=4$ ft and $\theta=30°$

3. *(a)* Write the Coulomb's law of friction formula. 1

(b) Write the law of Coulomb's friction. 2

(c) A smooth sphere of weight *W*, rests between a vertical wall and a prism, one of whose face rests on a horizontal plane, if the coefficient of friction between the horizontal and the prism is μ. Show that the least weight of the prism consistent with equilibrium is $W\left(\frac{\tan\alpha}{\mu}-1\right)$, where α is the inclination to the horizon of the face in contact with the sphere. 7

Or

What is a simple screw jack? A screw jack has a thread of 10 mm pitch. What effort will be required at the handle 40 mm long to lift a load of 2 kN (kilonewton), if the efficiency at this load is 45%?

4. *(a)* Define first moment of area. 1

(b) Determine first moment of area of a rectangular section of width b and length h about centre of gravity. 3

(c) Write the relation between second moments and products of area. 2

(d) State the transfer theorem for moment of inertia. 2

(e) State and prove Pappus-Guldinus theorem. 7

Or

The lengths AB and CD of the sides of rectangle $ABCD$ are $2a$ and $2b$. Show that the inclination of AB of one of the principal axis at A is

$$\frac{1}{2}\tan^{-1}\left(\frac{3ab}{2(a^2-b^2)}\right)$$

5. *(a)* Write whether True or False : 1

Fundamental forces like gravity and electric force are conservative.

(b) Write the definition of conservative force field. 2

(c) Prove that the kinetic energy of a system of particles is equal to the kinetic energy of the whole mass moving with the velocity of the centre of mass together with kinetic energy of the particles in their motion relative to the centre of mass. 4

(d) State and prove the principle of conservation of energy. 6

Or

If the sum of the moments of the impulses about a certain line vanishes, then prove that angular momentum about that line remains the same before and after the application of the impulses.

6. *(a)* Write whether True or False : 1

The change in kinetic energy of a body is equal to the work done by the acting force.

(b) State the laws of rotational motion of a body. 3

(c) If a particle moving in a plane curve under a conservative system of forces, then prove that the sum of the kinetic energy and potential energy is constant. 3

(d) Prove that for rigid body rotating about a point the kinetic energy

$$T = \frac{1}{2}\vec{\omega}\cdot\vec{h}$$

where $\vec{\omega}$ = angular velocity and $\vec{h}$ = angular momentum. 5

Or

Find the moment of momentum of a rigid body rotation about a fixed point.

7. (a) Write the value of time derivative of a unit vector. 1

(b) How is velocity related to the reference frame? 1

(c) What are the three ways of acceleration? 2

(d) State and prove Chasles' theorem. 6

Or

Find the velocity, speed and acceleration of a particle whose motion in space is given by the position vector

(i) $\vec{r}(t) = (2\cos t)\hat{i} + (2\sin t)\hat{j} + (5\cos^2 t)\hat{k}$

(ii) $\vec{r}(t) = (\sec t)\hat{i} + (\tan t)\hat{j} + \frac{4}{3}t\hat{k}$

Paper : DSE–2.3

(Number Theory)

Full Marks : 80
Pass Marks : 32

Time : 3 hours

1. (a) Find $\pi(101)$. 1

(b) Solve the linear Diophantine equation

$$172x + 20y = 1000$$

in positive integers. 4

(c) Answer any *one* of the following : 4

(i) Show that the linear Diophantine equation

$$ax + by = c$$

admits a solution if and only if $d|c$.

(ii) Using prime number theorem, show that

$$\lim_{x\to\infty} \frac{n\log n}{P_n} = 1$$

where P_n is the nth prime.

2. (a) Prove or disprove : 2

For the integers a, b and $n > 1$

$a^2 \equiv b^2 \pmod{n}$ implies $a \equiv b \pmod{n}$.

(b) Solve the simultaneous congruences : 4

$$x \equiv 1 \pmod 3$$
$$x \equiv 2 \pmod 5$$
$$x \equiv 3 \pmod 7$$

3. Answer any *one* of the following : 5

(a) State and prove Fermat's little theorem.

(b) Show that the quadratic congruence

$$x^2 + 1 \equiv 0 \pmod p$$

where p is an odd prime, has a solution if and only if

$$p \equiv 1 \pmod 4$$

4. (a) Find $\sigma(10000)$. 1

(b) Show that the function τ is multiplicative. 2

5. (a) If $p_1^{k_1} p_2^{k_2} \cdots p_j^{k_j}$ is the prime factorization of the integer $n > 1$, then show that

$$\sum_{d \mid n} \mu(d)\tau(d) = (-1)^j$$ 3

Or

Find the highest power of 5 that divides 1000!.

(b) Show that for each integer $n \geq 1$

$$\sum_{d \mid n} \mu(d) = \begin{cases} 0, & \text{if } n > 1 \\ 1, & \text{if } n = 1 \end{cases}$$ 4

Or

Verify that the quadratic residues of 13 are 1, 3, 4, 9, 10 and 12.

6. Show that

$$[x] + [-x] = \begin{cases} 0, & x \text{ is an integer} \\ -1, & x \text{ is not an integer} \end{cases}$$ 2

7. (a) Define Euler's ϕ function. 1

(b) If $p_1^{k_1} p_2^{k_2} \cdots p_j^{k_j}$ is the prime factorization of the integer $n > 1$, then show that

$$\phi(n) = n\left(1 - \frac{1}{p_1}\right)\left(1 - \frac{1}{p_2}\right) \cdots \left(1 - \frac{1}{p_j}\right)$$ 5

Or

State and prove the Möbius inversion formula.

(c) State Euler's theorem. Use Euler's theorem to the unit digit of 3^{100}. 1+3=4

(d) Show that

$$\phi(n) = n\sum_{d \mid n} \frac{\mu(d)}{d}$$ 2

8. *(a)* Define reduced set of residues modulo n, where $n \geq 1$ is an integer. 1

(b) Show that the integers

$-5, -4, -3, -2, -1, 1, 2, 3, 4, 5$

form a reduced set of modulo 11. 2

9. Using Goldbach conjecture, show that for each even integer n, there are integers a and b with $\phi(a) + \phi(b) = n$. 3

Or

Show that $\phi(n)$ is even for the integer $n > 2$.

10. *(a)* Define a primitive root of the integer n. 1

(b) Show that the only incongruence solutions of $x^2 \equiv 1 \pmod{p}$ are 1 and $p-1$, where p is an odd prime. 3

(c) Let the integer a has order k modulo n. Then show that $a^i \equiv a^j \pmod{n}$ if and only if $i \equiv j \pmod{n}$. 5

Or

Show that there are exactly $\phi(p-1)$ incongruence primitive roots of p, where p is a prime.

11. *(a)* Determine all the primitive roots of 3^2. 2

(b) Show that the integer 2^k, $k \geq 3$, has no primitive roots. 4

12. Solve $x^2 + 7x + 10 \equiv 0 \pmod{11}$. 4

13. *(a)* Let p be an odd prime and $\gcd(p, a) = 1$. Then show that $(a^2 / p) = 1$. 2

(b) Show that there are infinitely many primes of the form $4k+1$. 3

14. *(a)* Define encrypting. 1

(b) Show that the radius of the inscribed circle of a Pythagorean triangle is always an integer. 5

Or

State and prove Euler's criterion.

Paper : DSE–2.4

(Biomathematics)

Full Marks : 80
Pass Marks : 32

Time : 3 hours

UNIT—I

1. Answer any *two* of the following questions : 7½×2=15

(a) A population is originally 100 individuals, but because of the combined effects of births and deaths, it triples each hour.

(i) Make a table of population size for $t = 0$ to 5, where t is measured in hours.

(ii) Give two equations modeling the population growth by first expressing P_{t+1} in terms of P_t and then expressing ΔP in terms of P_t.

(iii) What can you say about the birth and death rates for this population?

(b) In the early stages of the development of a frog embryo, cell division occurs at a fairly regular rate. Suppose you observe that all cells divide and hence the number of cells double, roughly every half-hour.

(i) Write down an equation modeling this situation. You should specify how much real-world time is required by an increment of 1 in t and what the initial number of cells is.

(ii) Produce a table and graph of the number of cells as a function of t.

(c) Obtain a simple prey-predator model, explaining in detail the assumptions taken. Also find the equilibrium positions.

(Continued)

UNIT—II

2. Answer any *two* of the following questions : 7½×2=15

(a) Consider the SI epidemic model. If the contact rate is 0·001 and the number of susceptible is 2000 initially, determine—

(i) the number of susceptible left after 3 weeks;

(ii) the density of susceptible when the rate of appearance of new cases is a maximum;

(iii) the time (in weeks) at which the rate of appearance of new cases is a maximum;

(iv) the maximum rate of appearance of new cases.

(b) In a SIS model, if the infection is spread only by a constant number of carriers, then show that

$$I(t) = \left(I_0 - \frac{\alpha CN}{\alpha C + \beta} e^{[-(\alpha C + \beta)t]} \right) + \frac{\alpha CN}{\alpha C + \beta}$$

where I and C are the number of infectives and carriers; N is total population; α and β are contact rate and susceptible rate respectively; I_0 is the infectives at $t = 0$.

(Turn Over)

(c) Let x and y respectively denote the proportion of susceptibles and carriers in a population. Suppose the carriers are identified and removed from the population at a rate β, so that $\frac{dy}{dt} = \beta y$.

Suppose also that the disease spreads at a rate proportional to the product of x and y, thus

$$\frac{dx}{dt} = -\alpha xy$$

(i) Determine the proportions of carriers at any time t, where $y(0) = y_0$.

(ii) Use (i) to find the susceptibles at time t, where $x(0) = x_0$.

(iii) Find the proportion of population that escapes the epidemic.

UNIT—III

3. Answer any *two* of the following questions : 7½×2=15

(a) Consider the competition model for two species with populations N_1 and N_2

$$\frac{dN_1}{dt} = r_1 N_1\left(1 - \frac{N_1}{K_1} - b_{12}\frac{N_2}{K_1}\right)$$

$$\frac{dN_2}{dt} = r_2 N_2\left(1 - b_{21}\frac{N_1}{K_2}\right)$$

where only one species N_1 has limited carrying capacity. Investigate their stability and sketch the phase plane trajectories. [Here K_1, K_2 are carrying capacities; r_1, r_2 are linear birthrates of the populations N_1 and N_2 respectively. b_{12}, b_{21} measure the competitive effect of N_2 on N_1 and N_1 on N_2 respectively.] 4+3½=7½

(b) What is Routh-Hurwitz criteria? Explain with reference to multiple species communities. 2+5½=7½

(c) Discuss bifurcation and limit cycle with respect to any biological model.

UNIT—IV

4. Answer any *two* of the following questions : 7½×2=15

(a) Write short note on any *one* of the following :

(i) One species model with diffusion

(ii) Two species model with diffusion

(b) For a blood vessel of constant radius R, length L and driving force $P = P_1 - P_2$, show that the average velocity of the flow is equal to half of the maximum velocity and the resistance is proportional to $\frac{L}{R^4}$.

(c) Consider arterial blood viscosity

$$\mu = 0 \cdot 027 \text{ poise}$$

If the length of the artery is 2 cm and radius 8×10^{-3} cm and $P = P_1 - P_2 = 4 \times 10^3$ dynes/cm^2, then find *(i)* $q_z(r)$ and the maximum peak velocity of blood and *(ii)* the shear stress at the wall.

(Here q_z denote velocity along z-axis, p_1 and p_2 denote pressure at two ends of the artery.)

UNIT—V

5. Answer any *two* of the following questions : 10×2=20

(a) Let D and d, and W and w respectively denote allele for tall and dwarf, and round and wrinkled seeds of peas. Find the outcome of the product DdWw×ddWw using Puneet square or using probability. Also find the probability that the progeny of DdWw×ddWw is dwarf with round seeds. 6+4=10

(b) Explain in detail the Hardy-Weinberg equilibrium, mentioning the assumptions considered for the equilibrium.

(c) Compare and contrast stage structure model with age structure model.

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Total No. of Printed Pages—16

5 SEM TDC DSE MTH (CBCS)
1.1/1.2/1.3 (H)

2021

(Held in January/February, 2022)

MATHEMATICS

(Discipline Specific Elective)

(For Honours)

Paper : DSE–1

Full Marks : 80
Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

Paper : DSE–1.1

(Analytical Geometry)

1. Answer the following questions :

(a) Write the processes to sketch the parabola. 3

(b) Identify and sketch the curve

$$x = y^2 - 4y + 2$$

and also label the focus, vertex and directrix. 6

(c) Describe the graph of the curve

$$3(x+2)^2+4(y+1)^2=12$$

Also find its centre and foci. 6

Or

Describe the graph of the hyperbola

$$16x^2-y^2-32x-6y-57=0$$

and sketch its graph.

2. Answer the following :

(a) Fill in the blank : 1

The set of points in the plane, the sum of whose distances from two fixed points is a positive constant greater than the distance between the fixed points is ____.

(b) Write True or False : 1

A hyperbola is the set of all points in the plane that are equidistant from a fixed line and a fixed point not on the line.

(c) Suppose that an ellipse has semi-major axis a, semi-minor axis b and foci $(\pm c, 0)$. Then write the expression c in terms of a and b. 1

(d) Find the equation of the parabola that has its vertex at (1, 2) and focus at (4, 2). Also state the reflection property of parabola. 6

(e) Find the equation of the ellipse whose length of major axis is 26 and foci $(\pm 5, 0)$ and also sketch it. 6

Or

Find and sketch the curve of the hyperbola whose foci (6, 4) and (–4, –4) and eccentricity is 2.

3. Answer the following questions :

(a) Write the condition that the quadratic equation

$$Ax^2+Bxy+Cy^2+Dx+Ey+F=0$$

represents hyperbola. 1

(b) Determine a rotation angle θ that will eliminate the xy-term of the conic

$$2x^2+xy+2y^2+x-y=0$$ 2

(c) Consider the equation

$$x^2-xy+y^2-6=0$$

Rotate the coordinate axes to remove the xy-term. Then identify the type of conic represented by the equation and sketch its graph. 6

(d) Let an $x'y'$-coordinate system be obtained by rotating an xy-coordinate system through an angle $\theta = 30°$.

(i) Find the $x'y'$-coordinate of the point whose xy-coordinate is (2, 4).

(ii) Find an equation of the curve

$$2x^2 + 2\sqrt{3}xy = 3$$

in $x'y'$-coordinate. 6

Or

Identify and sketch the curve

$$153x^2 - 129xy + 97y^2 - 30x - 40y - 200 = 0$$

4. Answer the following questions :

(a) Define sphere. 1

(b) Write the equation of the sphere whose end points of the diameter is given. 1

(c) Find the equation of the sphere whose centre is (2, 3, 1) and radius is 5 units. 4

(d) Find the equation of the sphere through the origin and intersecting coordinate axes at distances a, b and c from the origin. 5

Or

A plane passes through a fixed point (a, b, c) and meets the axes in A, B, C. Show that the locus of the centre of the sphere $OABC$ is

$$\frac{a}{x} + \frac{b}{y} + \frac{c}{z} = 2$$

5. Answer the following questions :

(a) Define great circle. 1

(b) Write the condition that the plane

$$ax + by + cz + d = 0$$

be a tangent plane to the sphere

$$x^2 + y^2 + z^2 = r^2$$ 1

(c) Find the radius and centre of the circle

$$x^2 + y^2 + z^2 - x - y - z - 1 = 0,\ x + y + z = 0$$ 5

(d) Find the equation of the sphere for which the circle

$$x^2 + y^2 + z^2 + 7y - 2z + 2 = 0$$

and $$2x + 3y - 4z = 8$$

is a great circle. 5

Or

Find the equation of the tangent planes of the sphere

$$x^2+y^2+z^2-4x-4y-4z+10=0$$

which are parallel to the plane $x-z=0$.

6. Answer the following questions :

(a) Write the name of cylindrical surface given by the equation

$$\frac{x^2}{4}+\frac{y^2}{9}-\frac{z^2}{12}=1$$ 1

(b) Prove that the two spheres

$$x^2+y^2+z^2+6y+2z+8=0$$

and $$x^2+y^2+z^2+6x+8y+4z+20=0$$

intersect each other orthogonally. 2

(c) Show that the plane

$$2x-2y+z+12=0$$

touches the sphere

$$x^2+y^2+z^2-2x-4y+2z-3=0$$

Also find the point of contact. 4

(d) Classify and sketch the surface

$$9x^2+4y^2+z^2=36$$ 5

Or

Classify and sketch the surface

$$x^2+2z^2-6x-y+10=0$$

Paper : DSE–1.2

(Portfolio Optimization)

1. Answer any *five* of the following as directed : 1×5=5

(a) Define investment.

(b) What is portfolio?

(c) Define risk.

(d) "Return increases with the increase in risk."

(Write True or False)

(e) Define risk-free asset.

(f) What is diversification?

2. *(a)* If an investment that costs \$250 and is worth \$350 after being held for two years, find annual holding period return (annual HPR) and annual holding period yield (annual HPY). 4

(b) Define expected return of an investment. Calculate the expected rate of return of the following economic scenarios : 1+2=3

Economic Condition	*Probability*	*Rate of Return*
Strong economy	0·15	0·20
Weak economy	0·15	–0·20
No major change in economy	0·70	0·10

(c) Write the measures of risk in terms of variance and standard deviation of the estimated distribution of expected returns. What is the value of variance of risk-free investment? 2+2+1=5

(d) Describe different types of risk of an investment. 5

Or

Describe the relationship between risk and return.

(e) Write a short note on mutual fund. 4

(f) Describe the investment objectives for 25-year-old investors and 65-year-old investors. 4

3. *(a)* What is risk aversion? 2

(b) What are the assumptions of the Markowitz's portfolio theory? 5

(c) Write the formula for the expected return for a portfolio of investments. Calculate the expected return of portfolio of risky assets given by the table : 1+2=3

Weight (w_j) (percent of portfolio)	*Expected Security Returns* (R_i)
0·20	0·10
0·30	0·11
0·30	0·12
0·20	0·13

(d) What are the variance and standard deviation of returns for an individual investment? Calculate the variance for an individual risky asset given by the following table : 2+2+3=7

Possible rate of return (R_j)	*Expected Security Return* [$E(R_j)$]	*Probability* (P_i)
0·08	0·103	0·35
0·10	0·103	0·30
0·12	0·103	0·20
0·14	0·103	0·15

Or

Describe variance and standard variation of returns for a portfolio of investments. 7

(e) Define risk-free portfolio using standard deviation of a portfolio of investments. 2

(f) Write short notes on any *two* of the following : 3×2=6

(i) Optimal portfolio

(ii) Efficient frontier

(iii) Portfolio with short sales

4. Answer any *three* of the following questions : 5×3=15

(a) Write five assumptions of capital market theory.

(b) Derive the risk-return combination equation of capital market theory.

(c) Derive the equation of the capital asset pricing model (CAPM).

(d) Determine the expected rate of return with CAPM for the following five stocks :

Stock	*Beta*
A	0·70
B	1·00
C	1·15
D	1·40
E	–0·30

where economy's RER = 0·05 and expected return on the market portfolio $E(R_M) = 0 \cdot 09$.

5. What is security market line (SML)? What are the differences between capital market line (CML) and security market line (SML)? 1+2=3

6. Suppose that during the most recent 10 years period, the average annual total rate of return including dividends on an aggregate market portfolio was 14 percent ($\overline{R_M} = 0 \cdot 14$) and the average nominal rate of return on government *T*-bills was 8 percent ($\overline{RFR} = 0 \cdot 08$). As administrator of a large pension fund that has been divided among three money managers during the past 10 years. Decide by calculating *T* values whether to renew their investment management contracts based on the following results :

Investment Manager	*Average Annual Rate of Return*	*Beta*
W	0·12	0·90
X	0·16	1·05
Y	0·18	1·20

Also plot their portfolios with security market line (SML). 7

Or

Describe sharp portfolio performance measure with example.

Paper : DSE–1.3

(Financial Mathematics)

UNIT—I

1. Answer the following questions : 1×4=4

(a) Define cash flow.

(b) Write to which greater expected return is related.

(c) If the interest rate is *r*, then write the price of an investment that pays *A* after one year.

(d) Write which entirely determines internal rate of return.

2. Answer the following questions : 2×4=8

(a) Explain the viewpoint of investment.

(b) Write about the investment and return for the situation represented by cash flow (–1, 1·4).

(c) Write the relation between present value and future value.

(d) Explain callable bond.

3. Answer any *four* of the following questions : 4×4=16

(a) Explain comparison principle.

(b) Write the main features of hedging.

(c) Write the objectives of pure investment.

(d) Show that growth under compound interest is geometric.

(e) Compute the future value of the cash flow stream (–4, 1, 2, 1).

(f) Describe effective interest rate and nominal rate.

4. Answer any *two* of the following questions : 6×2=12

(a) Find the internal rate of return by solving the equation $x^3 + x^2 + x = 2$ (use Newton-Raphson method).

(b) State and prove the main theorem of internal rate of return.

(c) Describe duration.

(d) Show that derivation of price P with respect to yield λ of a fixed income security is

$$\frac{dP}{d\lambda} = -D_m P$$

where D_m is modified duration.

UNIT—II

5. Answer the following questions : 1×4=4

(a) Define random variable.

(b) Define diversification.

(c) Write one property of feasible set.

(d) Write through which capital market line passes.

6. Answer the following questions : 2×4=8

(a) Write about short selling.

(b) Find the expected value of the number of spots on a roll of a die.

(c) Write two properties of expected value.

(d) Define covariance of two random variables x_1, x_2.

7. Answer any *four* of the following questions : 7×4=28

(a) Show that the rate of return acts like an interest rate.

(b) Find the mathematical expression for total return.

(c) Show that the variance of the return of the portfolio

$$\sigma^2 = \sum_{i,\, j=1}^{n} w_i w_j \sigma_{ij}$$

(d) State the capital asset pricing model and prove it.

(e) Define mean standard deviation diagram and show that

$$\text{var}(x) = E(x^2) - \bar{x}^2$$

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5 SEM TDC MTMH (CBCS) C 11

2021

(Held in January/February, 2022)

MATHEMATICS

(Core)

Paper : C-11

(Multivariate Calculus)

Full Marks : 80

Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. *(a)* Define limit of a function of two variables. 1

(b) Find

$$\lim_{(x, y)\to(0, 1)} \frac{x - xy + 3}{x^2y + 5xy - y^3}$$ 1

(c) Show that the function

$$f(x, y) = \begin{cases} \dfrac{xy^3}{x^2 + y^6}; & (x, y) \neq (0, 0) \\ 0 \quad ; & (x, y) = (0, 0) \end{cases}$$

is not continuous at (0, 0). 3

(d) If $u = e^{xyz}$, then show that

$$\frac{\partial^3 u}{\partial x \partial y \partial z} = (1 + 3xyz + x^2y^2z^2)e^{xyz}$$ 3

Or

If $w = x\sin y + y\sin x + xy$, then verify that $w_{xy} = w_{yx}$.

2. (a) Define total differential of a function of two variables. 1

(b) For changes in a function's values along a helix $w = xy + z$, $x = \cos t$, $y = \sin t$ and $z = t$. Find $\frac{dw}{dt}$. 2

(c) State and prove sufficient condition for differentiability of a function of two variables. 4

Or

Express $\frac{\partial w}{\partial r}$ and $\frac{\partial w}{\partial s}$ in terms of r and s if $w = x + 2y + z^2$, $x = \frac{r}{s}$, $y = r^2 + \log x$ and $z = 2r$. 2+2=4

3. (a) Find the equation of tangent plane at (1, 1, 1) for the curve $x^2 + y^2 + z^2 = 3$. 2

(Continued)

(b) Find the local extreme values of the function

$$f(x, y) = xy - x^2 - y^2 - 2x - 2y + 4$$ 3

(c) Find the extreme values of $f(x, y) = xy$ taken on the ellipse $\frac{x^2}{8} + \frac{y^2}{2} = 1$ by the method of Lagrange's multipliers. 5

Or

The plane $x + y + z = 1$ cuts the cylinder $x^2 + y^2 = 1$ in an ellipse. Find the points on the ellipse that lie closest to and farthest from the origin.

4. (a) Find ∇f, if

$$f(x, y, z) = x^2 + y^2 - 2z^2 + z\log x$$ 1

(b) Prove that $\text{div}\,\vec{r} = 3$. 2

(c) Find curl $\vec{f}$, where

$$\vec{f} = x^2y\hat{i} + xz\hat{j} + 2yz\hat{k}$$ 2

5. (a) Write one property of double integral. 1

(Turn Over)

(b) Evaluate

$$\iint_R f(x, y)\, dA$$

for $f(x, y) = 1 - 6x^2y$, $R: 0 \le x \le 2$ and $-1 \le y \le 1$. 2

(c) Find the area enclosed by the Lemniscate $r^2 = 4\cos 2\theta$. 3

6. (a) Define triple integrals. 2

(b) Evaluate : 2

$$\int_{y=0}^{3}\int_{x=0}^{2}\int_{0}^{1}(x + y + z)\, dz\, dx\, dy$$

(c) Find the volume of the upper region D cut from the solid sphere $\rho \le 1$ by the cone $\phi = \frac{\pi}{3}$. 5

Or

Find the volume of the region enclosed by the cylinder $x^2 + y^2 = 4$ and the planes $z = 0$ and $y + z = 4$.

7. (a) Write the formula for triple integral in cylindrical coordinates. 1

(Continued)

(b) Evaluate : 4

$$\int_0^{2\pi}\int_0^{\theta/2\pi}\int_0^{3+24r^2} dz r\, dr\, d\theta$$

Or

Find the volume of the region in the first octant bounded by the coordinate planes, the plane $y = 1 - x$ and the surface $z = \cos\frac{\pi x}{2}$, $0 \le x \le 1$.

8. (a) Find the Jacobian $\frac{\partial(x, y)}{\partial(u, v)}$ for the transformation $x = u\cos v$ and $y = u\sin v$. 1

(b) Evaluate

$$\int_0^4\int_{x=\frac{y}{2}}^{x=\frac{y}{2}+1} \frac{2x - y}{2}\, dx\, dy$$

by applying the transformation $u = \frac{2x - y}{2}$, $v = \frac{y}{2}$. 3

(c) Integrate $f(x, y, z) = x - 3y^2 + z$ over the line segment C joining the origin and the point (1, 1, 1). 3

(Turn Over)

Or

Evaluate $\int_C (xy + y + z)\, ds$ along the curve

$$\vec{r}(t) = 2t\hat{i} + t\hat{j} + (2 - 2t)\hat{k}, \quad 0 \le t \le 1$$

9. *(a)* Define vector field and write the formula for vector field in three dimensions. 1+1=2

(b) A coil spring lies along the helix

$$\vec{r}(t) = (\cos 4t)\hat{i} + (\sin 4t)\hat{j} + t\hat{k}; \; 0 \le t \le 2\pi$$

The spring density is a constant $\delta = 1$. Find the spring's mass and moments of inertia and radius of gyration about the z-axis. 4

Or

Find the work done by the force

$$\vec{F} = (y - x^2)\hat{i} + (z - y^2)\hat{j} + (x - z^2)\hat{k}$$

over the curve $\vec{r}(t) = t\hat{i} + t^2\hat{j} + t^3\hat{k}$; $0 \le t \le 1$ from (0, 0, 0) to (1, 1, 1).

(c) Write the fundamental theorem for line integrals. 2

10. *(a)* State Green's theorem in flux-divergence form. 1

(b) Evaluate the integral $\oint_C (xy\,dy - y^2\,dx)$ by using Green's theorem, where C is the square cut from the first quadrant by the lines $x = 1$ and $y = 1$. 3

(c) Evaluate $\int_C \vec{F} \cdot d\vec{r}$ by using Stokes' theorem, if $\vec{F} = xz\hat{i} + xy\hat{j} + 3xz\hat{k}$ and C is the boundary of the portion of the plane $2x + y + z = 2$ in the first octant and traversed counter-clockwise. 5

Or

Find the surface area of a sphere of radius a with parametrization formula

$$\vec{r}(\phi, \theta) = (a\sin\phi\cos\theta)\hat{i} + (a\sin\phi\sin\theta)\hat{j} + (a\cos\phi)\hat{k}$$

where $0 \le \phi \le \pi$ and $0 \le \theta \le 2\pi$.

(d) State and prove divergence theorem. 6

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5 SEM TDC MTMH (CBCS) C 12

2021

(Held in January/February, 2022)

MATHEMATICS

(Core)

Paper : C–12

(Group Theory—II)

Full Marks : 80
Pass Marks : 32

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. *(a)* Let $H = \{(1), (12)\}$. Is H abelian? 1

(b) Define commutator subgroup and characteristic subgroup. 2+2=4

(c) Prove that if G is a cyclic group, then Aut$G$ is abelian. 3

(d) Let G be a cyclic group of infinite order. Then prove that $O(\text{Aut}G) = 2$. 3

(e) Prove that a group G is abelian if and only if I_G is the only inner automorphism. 3

(f) Let G be a group, then prove that $f : G \to G$ defined by $f(x) = x^{-1}$, $\forall x \in G$ is automorphism if and only if G is abelian. 4

2. Answer any *two* of the following : 6×2=12

(a) Let $I(G)$ be the set of all inner automorphisms on a group G, then prove that—

(i) $I(G)$ is normal subgroup of Aut$G$;

(ii) $I(G) \cong \frac{G}{Z(G)}$.

(b) Let G be a cyclic group generated by a and $O(G) = n > 1$, then prove that a homomorphism $f : G \to G$ is an automorphism if and only if $G = < f(a) >$.

(c) Let G be a group and G' be the commutator subgroup of G, then prove that—

(i) G' is normal subgroup of G;

(ii) $\frac{G}{G'}$ is abelian;

(iii) if N is any normal subgroup of G, then G/N is abelian if and only if $G' \subseteq N$.

(d) Let G be group and $Z(G)$ be the centre of G, then prove that if $\frac{G}{Z(G)}$ is cyclic, then G is abelian.

3. (a) Define internal direct product. 2

(b) Let $G_1, G_2, \cdots, G_n$ be a finite collection of groups such that

$$G_1 \oplus G_2 \oplus \cdots \oplus G_n = \{(g_1, g_2, \cdots, g_n) : g_i \in G_i\}$$

then prove that

$$|(g_1, g_2, \cdots, g_n)| = \text{lcm}(|g_1|, |g_2|, \cdots, |g_n|)$$ 3

(c) If s and t are relatively prime, then prove that $U(st) \cong U(s) \oplus U(t)$. 4

(d) Suppose that a group is an internal direct product of its subgroups H and K. Then prove that—

(i) H and K have only the identity element in common;

(ii) G is isomorphic to the external direct product of H by K. 5

Or

Prove that a group G is internal direct product of its subgroups H and K if and only if—

(i) H and K are normal subgroups of G;

(ii) $H \cap K = \{e\}$.

(e) If m divides the order of a finite abelian group G, then prove that G has a subgroup of order m. 6

Or

Let G be a finite abelian group of order $p^n m$, where p is prime and $p \nmid m$, then prove that $G = H \times K$ where $H = \{x \in G : x^{p^n} = e\}$ and $K = \{x \in G : x^m = e\}$.

4. *(a)* Write the class equation for the group G. 1

(b) Define sylow p-subgroup and conjugacy class. 2+2=4

(c) If $|G| = p^2$, where p is prime, then prove that G is abelian. 3

(d) Let G be a finite group and $Z(G)$ be the centre of G. Then prove that

$$O(G) = O(Z(G)) + \sum_{a \notin Z(G)} \frac{O(G)}{O(N(a))}$$ 3

(e) Answer any *two* of the following : 4×2=8

(i) Let G be a group. Then prove that $O(C(a)) = 1$ if and only if $a \in Z(G)$.

(ii) Prove that every abelian group of order 6 is cyclic.

(iii) Prove that a group of order 12 has a normal sylow p-subgroup or sylow 3-subgroup.

(Continued)

(f) Prove that no group of order 30 is simple. 5

Or

Prove that a sylow p-subgroup of a group G is normal if and only if it is the only sylow p-subgroup of G.

(g) Suppose that G is a finite group and $p|O(G)$ where p is a prime number, then prove that there is an element a in G such that $O(a) = p$. 6

Or

Let G be a group of finite order and p be a prime number. If $p^m | O(G)$ and $p^{m+1} \nmid O(G)$, then prove that G has subgroup of order p^m.

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