C 22723 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2022

(CUCSS)

Physics

PHY 4E 20—MICROPROCESSORS AND APPLICATIONS

(2017 to 2018 Admissions)

Time : Three Hours Maximum : 36 Weightage

The symbols used in the question paper have their usual meanings.

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Briefly explain about the shift register.
2. Name the common microprocessor peripherals.
3. What are the differences between instruction cycle and clock cycle ?
4. Write the applications of 8253.
5. Name the different modes of operations in 8255 PTC chip ?
6. Explain the use of stack in 8085.
7. Explain the application of the decoder 7448.
8. Briefly explain the timing and control unit of 8085 microprocessor.
9. Distinguish between a micro controller and a micro-computer.
10. Explain the concept of formation of a control word.
11. Explain the purpose of timing diagram.
12. Explain serial data transfer.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 6.

13. Discuss about the organization and internal architecture of the Intel 8085.
14. Explain enabling, disabling and masking of interrupts. Discuss with suitable examples how transfer data using interrupts.

Turn over

15. Explain how 8259 programmable interrupt controller is used to manage multiple interrupts.

16. Draw the interfacing circuit for ADC 0800 and discuss the main features of ADC 0800.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*

Each question carries weightage 3.

17. In 8085 instructions, write a program for adding two 16-bit numbers.

18. Discuss the instruction cycle, machine cycle and state.

19. Explain the main features of display interface 8279.

20. Explain the functions of a Sample and Hold circuit with a neat block diagram.

21. With the help of timing diagram explain the Data read machine cycle in 8085 processor.

22. Explain the 8051-microcontroller architecture.

(4 × 3 = 12 weightage)

C 22720 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (SUPPLEMENTARY) EXAMINATION APRIL 2022

(CUCSS)

Physics

PHY 4E 13—LASER SYSTEMS, OPTICAL FIBRES AND APPLICATIONS

(2017 to 2018 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

12 *short questions, each answerable within* 5 *minutes.*
Answer **all** *questions.*
Each question carries weightage 1.

1. Name some properties, which make laser light different from ordinary light.
2. Write down the equation for number of stimulated absorptions per unit time per unit volume.
3. Discuss various pumping methods used in the Lasers for obtaining population inversion.
4. What is holography ?
5. What do you mean by spontaneous emission and stimulated emission ?
6. What is coherence ?
7. Determine the SI units of Einstein's coefficients.
8. Define Acceptance angle.
9. Differentiate between step index and graded index fibre.
10. What is total internal reflection ?
11. Draw a simplified block diagram of a laser fusion electric-generating system.
12. What are various signal attenuation and losses in optical fibre ?

(12 × 1 = 12 weightage)

Section B

4 *Essay questions, each answerable within* 30 *minutes.*
Answer any **two** *questions.*
Each question carries weightage 6.

13. Discuss in detail the construction, theory and working of He-Ne laser.
14. With figure explain Non-linear Polarization Rotation.

Turn over

15. What is Spatial Frequency Filtering ? Explain one application.

16. Explain in detail second and third harmonic generation.

(2 × 6 = 12 weightage)

Section C

5 problem questions, each answerable within 15 minutes.

Answer any **four** *questions.*

Each question carries weightage 3.

17. Find the core radius necessary for single mode operation at 820 nm. of step index fiber with $n1$ = 1.482 and n2 = 1.474 (single mode step index = 2.405).

18. Explain isotope separation using lasers.

19. Explain Symmetry requirement for second Harmonic generation

20. Calculate the expression for NA for OFCs.

21. Explain propagation of light through optical fibre.

22. What is Z scan technique ? Why is it used ?

(4 × 3 = 12 weightage)

C 22717 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. (CUCSS) DEGREE [SUPPLEMENTARY] EXAMINATION, APRIL 2022

Physics

PHY4C12—ATOMIC AND MOLECULAR SPECTROSCOPY

(2017 to 2018 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

(12 short questions, each answerable within 5 minutes)

Answer **all** *questions.*

Each question carries weightage 1.

1. What is Paschen back effect ?
2. Figure the normal modes of water molecule.
3. What are the parts of Raman spectrometer ?
4. What is mono chromator ?
5. List out techniques used to reduce fluorescence in Raman effect.
6. Define depolarization ratio of Raman scattered light.
7. List out some industrial applications of Raman spectroscopy.
8. Explain the importance of Raman effect for phase transition studies.
9. Define nuclear magneton.
10. Define gyro magnetic ratio.
11. What is chemical shift.
12. What is the relation between polarization and applied electric field ?

(12 × 1 = 12 weightage)

Section B

(4 Essay questions, each answerable within 30 minutes)

Answer any **two** *questions.*
Each question carries weightage 6.

13. Explain diatomic vibrating rotator.

14. Explain rotational fine structure of electronic vibration spectra. Explain P,Q and R branches.

15. Derive Bloch equations

16. Explain with figure the instrumentation of IR spectrometer. Explain the techniques used for recording the spectra ?

(2 × 6 = 12 weightage)

Section C

(6 problem questions, each answerable within 15 minutes)

Answer any **four** *questions.*
Each question carries weightage 3.

17. Rotational and centrifugal distortion constants of HCl molecule are 10.593 cm^{-1} and 5.3×10^{-4} cm^{-1} respectively. Estimate the vibrational frequency and force constant of the molecule.

18. The Raman lines associated with a vibrational mode which is both Raman and IR active is found at 4600 A° when excited by light of wavelength 4.358 A°. Calculate the wavelength of the corresponding IR band.

19. Explain with figure vibrational coarse structure.

20. Explain dissociation.

21. The band origin of a transition in C2 is observed at 19,378cm^{-1} while rotational fine structure indicates that the rotational constants in excited and ground states are respectively B' = 1.7527 cm^{-1} and B' = 1.6326 cm^{-1}. Estimate the position of the band head.

22. Derive the classical theory of Raman scattering.

(4 × 3 = 12 weightage)

C 22596 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 25—SPACE PHYSICS

(2020 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short questions, each answerable within 7.5 minutes)
Answer **all** *questions.*
Each carries weightage 1.

1. What are sun spots and solar flares ?
2. What is the heliosphere of the sun and how far it is extended ?
3. Briefly discuss the evolution of protoplanetary disks.
4. Distinguish between geo-corona and airglow.
5. What is meant by planetary migration ?
6. Write a note on the historical development of satellites.
7. Write a short note on reliability and space qualification.
8. What is Telemetry Tracking and Command system ?

(8 × 1 = 8 weightage)

Turn over

Section B

(4 Essay questions, each answerable within 30 minutes)
Answer any **two** *questions.*
Each carries weightage 5.

9. What is the Chapman layer ? How does the Chapman profile of the ionosphere form? Briefly discuss the production of ionospheric layers by solar radiation ?

10. Explain the evolution of protop lanetary disk and planetesimal formation.

11. Describe spacecraft and its subsystems.

12. What are the commonly used techniques to detect exoplanets ?

(2 × 5 = 10 weightage)

Section C

(7 Problem questions, each answerable within 15 minutes)
Answer any **four** *questions.*
Each carries weightage 3.

13. Haley's Comet approaches the sun to within 0.570 A.U., and its orbital period is 75.6 years. (A.U. is the abbreviation for astronomical units, where 1 A.U. = 1 .5 × 10^{11} m is the mean Earth-Sun distance.) How far from the sun will Haley's comet travel before it starts its return journey ?

14. The planet Mercury travels around the Sun with a mean orbital radius of 5.8 × 10^{10} m. The mass of the Sun is 1.99 × 10^{30} kg. Use Newton's version of Kepler's third law to determine how long it takes Mercury to orbit the Sun.

15. Calculate the altitude at which a satellite of mass 2105 kg orbits the Earth. The gravitational force is 649 N, universal constant of gravitation G is 6.673 × 10^{-11} Nm^2/kg^2. and mass of the Earth is 5.988 × 10^{24}kg respectively.

16. Find the height and speed of a geosynchronous satellite above Earth's surface ?

17. Two objects with a combined mass of 12.3 solar masses orbit one another with a period of 3.33 years. What is their average separation ?

18. The period of the moon is approximately 27.2 days (2.35 × 10^6 s). Determine the radius of the moon's orbit and also the orbital speed of the moon (Given : M_{earth} = 5.98 × 10^{24} kg, R_{earth} = 6.37 × 10^6 m)

19. Suppose the Space Shuttle is in orbit about the earth at 400 km above its surface. Use the information given (M_{earth} = 5.98 × 10^{24} kg, G = 6.673 × 10^{-11} Nm^2/kg^2, R_{earth} = 6.37 × 10^6 m) to determine the orbital speed and the orbital period of the Space Shuttle.

(4 × 3 = 12 weightage)

C 22595 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 24—BIO-PHYSICS

(2020 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short questions, each answerable within 7.5 minutes)

Answer **all** *questions.*
Each question carries weightage 1.

1. Describe electron flow in photophosphorylation schematically.
2. Explain a coupled reaction.
3. What are semiconductor quantum dots ?
4. Write a note on optical biosensor ?
5. What are biosensors ? Give its classification based on transducing elements.
6. Define Wearable biosensor and explain its importance.
7. What is meant by hydrogels ? Give any two of its application.
8. Give the importance of natural biomaterials over other materials.

(8 × 1 = 8 weightage)

Turn over

Section B

(4 Essay questions, each answerable within 30 minutes)

Answer any **two** *questions.*
Each question carries weightage 5.

9. What are the reactions happening during photosynthesis ? Explain each reactions in details.
10. Illustrate bio-materials and its following types : (a) Metallic ; (b) Polymer ; (c) Ceramic ; and (d) Composites.
11. What are bio-materials ? Analyze its uses in cardiovascular applications.
12. Schematically explain : (a) Surface Plasmon Resonance (SPR)-based optical biosensors ; and (b) CNT-based electrochemical bio-sensors.

(2 × 5 = 10 weightage)

Section C

(7 Problem questions, each answerable within 15 minutes)

Answer any **four** *questions.*
Each question carries weightage 3.

13. Give an account on structure and functions of pyridine nucleotides.
14. Briefly explain the structure of virus.
15. Give the common characteristics and differences between adhesives and sealants.
16. Briefly explain bio-glasses and glass ceramics with its applications.
17. Briefly explain and sketch an electrochemical biosensor ?
18. Schematically explain evanescent wave fluorescence biosensors.
19. What are quantum dots and how do they work in the field of bio-imaging ?

(4 × 3 = 12 weightage)

C 22594 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 23—MICROPROCESSORS, MICROCONTROLLERS AND APPLICATIONS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 *Short questions, each answerable within* 7.5 *minutes.*
Answer **all** *questions.*
Each carries weightage 1.

1. Briefly describe Port D of the AVR and explain some of its functions.
2. Write short note on three C language data types for AVR programming. Any three data types, their size, their domain etc to be described by student.
3. Distinguish between ROM and RAM.
4. With an example explain a programmable peripheral interface ?
5. Explain branching operations in assembly level programming.
6. Explain Programmed I/O.
7. Enlist the programmable register of 8085 microprocessor.
8. Explain the logical instructions of 8085 microprocessor.

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions.*
Each carries weightage 5.

9. With a neat diagram explain the instruction cycle in 8085 microprocessor.
10. With suitable examples explain the interrupts of 8085 microprocessor.
11. Explain the data transfer schemes of 8085 based on DMA.
12. With a schematic diagram explain the architecture of the AVR.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions.*
Each carries weightage 3.

13. Write the line code by which a bit can be set using macro definitions in AVR.
14. Write the code lines for AVR so that "All PORTA pins are set as inputs with pull-ups enabled and then read data from PORTA"
15. Write an assembly level programme for the division of two 16 bit numbers stored at consecutive address.
16. What logic operation is implemented with the below program in AVR ?

```
int main()
{
DDRB = 0xff ;
PORTB = 0x00 ;
while(1)
{
delay_ms(500) ;
tbi(PORTB, PB0) ;
}
return 0 ;
}
```

17. Find2's compliment with carry of an 8 bit number stored at address 2050. Result is to be stored at address 3050 and 3051. Starting address of program is taken as 2000.
18. Write a programme to multiply two 8 bit numbers stored at address 2050 and 2051 and store the result at the address 3050 and 3051.
19. Write a program using C for AVR micro controller such that it will "Turn LED On when Button are Pressed based on Bit Positions".

(4 × 3 = 12 weightage)

C 22593 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 22—PHYSICS OF SEMICONDUCTORS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 *Short questions answerable within* 7.5 *minutes*
Answer **all** *questions, each question carries weightage* 1.

1. Explain Franz-Keldysh effect.
2. Why does the energy band gap decrease in semiconductors as temperature is increased ?
3. Explain an application of Quantum Hall effect.
4. Distinguish between quantum dot and a quantum well structures.
5. With a schematic diagram explain the structure of a HEMT.
6. How does a Light emitting diode work ?
7. Enlist the characteristics of an ideal diode.
8. Explain an application of thermoelectric electromotive force.

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes
Answer any **two** *questions, each question carries weightage 5.*

9. With neat diagram explain the quantum mechanical tunnelling in a tunnel diode.

10. Explain the concept of Fermi level in semiconductors and its variation with doping density. With proper mathematical steps show the Fermi level in an intrinsic semiconductor is located in the middle of the forbidden gap.

11. Write explanatory notes on any two methods of preparation of low dimensional semiconductor structure like quantum wells and quantum dots.

12. Explain how the LASER action is used in making p-n junction based laser diode.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

1. A potential well has a height of 0.05 eV. What should be the width of the well so that the binding energy of the electron ($m^* = 0.063\ m_e$) would be equal to 0.025 eV.

2. Electron mobility in Si is 1400 $cm^2\ V^{-1}s^{-1}$. Calculate the mean free time in scattering of electrons. Effective mass is $m_e^*/m0 = 0.33$.

3. Consider a silicon crystal at room temperature, doped with both donor and acceptor atoms so that $N_D = 2 \times 10^{15}\ cm^{-3}$ and $N_A = 1 \times 10^{15}\ cm^{-3}$. What type of material would this yield ? What will the hole concentration be in this material ? Intrinsic carrier concentration for Si is $1.45 \times 10^{10}\ cm^{-3}$.

4. The Hall co-efficient (R_H) of a semiconductor is $3.22 \times 10^{-4}\ m^3\ C^{-1}$. Its resistivity is $8.50 \times 10^{-3}\ \Omega$-m. Calculate the mobility and carrier concentration of the carriers.

5. Calculate the space charge width at zero bias for a Schottky contact with the following parameters : capacitance permittivity $\varepsilon_S = 11.7$, built in potential barrier $V_{bi} = 0.334$ V, doping density $N_d = 10^{16}\ cm^{-3}$.

6. Find the diffusion co-efficient of electrons in Silicon at 300 K if μ_e is 0.19 m^2/V-s. Use $k_B = 1.38 \times 10^{-23}$ J/K.

7. A white LED with a forward volt drop of 2 V is connected to a 5.0 V stabilised DC power supply using a 100 Ω resistor in series to the diode. What will be the current flowing through the diode ?

(4 × 3 = 12 weightage)

C 22592 (Pages : 3) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

April 2021 Session for SDE/Private Students

(CBCSS)

Physics

PHY 4E 21—MODERN OPTICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

Covid Instructions are not applicable for Pvt/SDE students (April 2021 session)

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short questions answerable within 7.5 minutes)

Answer **all** *questions.*
Each cany weightage 1.

1. What is the principle of FTIR spectroscopy ?
2. What were the observations of the Hanbury Brown and Twiss expertiment ?
3. What is Faraday rotation ?
4. Explain the significance of Cornu spiral.
5. What is significance of Poynting vector ?
6. Explain relation between diffraction from a slit and Fourier transform.
7. Explain double refraction phenomenon.
8. Describe an optical element which uses diffraction to focus light.

(8 × 1 = 8 weightage)

Turn over

Section B

(4 essay questions answerable within 30 minutes)

Answer any **two** *questions.*
Each carry weightage 5.

9. Using Jones calculus method arrive at the matrix representation of polarization.

10. With a neat diagram explain the theory of diffraction grating.

11. Using Maxwell equation describe the propagation of light waves in a homogenous dielectric media.

12. Explain the principle of working of a Fabry-Perot Interferometer. Comment on its resolving power and finesse.

(2 × 5 = 10 weightage)

Section C

(7 problems answerable within 15 minutes)

Answer any **four** *questions.*
Each carry weightage 3.

13. Determine the result of the super position of the following harmonic waves :

$E_1 = 7\cos(\{\pi/3\} - \omega t)$, $E_2 = 12\sin(\{\pi/4\} - \omega t)$ and $E_3 = 20\cos(\{\pi/5\} - \omega t)$.

14. Consider a single slit diffraction pattern for a slit width w. It is observed that for light of wavelength 400 nm the angle between the first minimum and the central maximum is $4^* 10^{-3}$ radians. What is the value of w ?

15. A FPI with two plates separated by an air gap of 20 mm is used to study the hyperfine structure of the Hg green line $(\lambda = 546\text{ nm})$. If the reflectance of the surfaces is R = 0.90, what is : (a) The finesse ; and (b) The resolving power ?

16. Find the radius of first zone is a zone plate of focal length 25 cm for light of wavelength 5000 A.

17. The electric field of a traveling electromagnetic wave is given by :

$$E(z,t) = 10\cos(\pi \times 107t + \pi z/15 + \pi/6)(\text{V/m})$$

Determine : (a) The wave frequency f ; (b) Its wavelength X ; and (c) Its phase velocity V_p.

18. Analyse the Jones vector $\begin{bmatrix} 2i \\ 2 \end{bmatrix}$ to identify the polarization.

19. A radio station transmits a 10-kW signal at frequency of 100 MHz. For simplicity, assume that it radiates at a point source. At a distance of 1 km from the (point source) antenna, what will be the amplitudes of the electric and magnetic field strengths ?

(4 × 3 = 12 weightage)

C 22591 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 20—ADVANCED CONDENSED MATTER PHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 *Short questions answerable within* 7.5 *minutes*

Answer **all** *questions, each question carries weightage* 1.

1. Write a short note on Magnons.
2. Define alloy formation.
3. Differentiate between Schottky defects and Frenkel defects.
4. Outline the principle of the photographic process.
5. Neatly draw the density of states diagram of a one dimensional system.
6. What makes nanomaterials different from bulk materials ?
7. Distinguish between a thin and thick films.
8. Briefly describe how a thin film photodeteclor works.

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes
Answer any **two** *questions, each question carries weightage 5.*

9. Derive the Lindhard equation for the dielectric constant of free electron gas and comment on the real and imaginary parts of the dielectric constant.

10. With the help of a phase diagram explain the physics of alloy formation.

11. What is density of states ? Discuss density of states in quantum wires and quantum dots with neat diagrams.

12. Give a detailed outline of solar cells. Describe a thin film solar cell.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

13. Describe the phonon dispersion relations.

14. Describe quantum well structures.

15. Describe ionic conductivity etching.

16. Explain the crack initiation and propagation in solids.

17. Compare the energy levels of semiconductor quantum dots with that of bulk semiconductors.

18. Discuss any method for the synthesis of quantum dots.

19. Discuss the merits and demerits of vacuum deposition processes.

(4 × 3 = 12 weightage)

C 22588 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 17—ASTROPHYSICS AND POSITIONAL ASTRONOMY

(2020 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short questions answerable within 7.5 minutes).
Answer **all** *questions.*
Weightage 1 *for each question.*

1. What is special when Sun appears in the sky at the intersection of the ecliptic and the celestial equator ? How often does it happen ?
2. What is meant by galactic latitude and longitude ?
3. Define parsec. Write the conversion between parsec, AU and light year.
4. Briefly discuss the working of gravitational wave detector.
5. Outline the importance of Hertzsprung-Russell diagram.
6. What is a 21 cm line ? How does it play a crucial role in astronomy ?
7. What are cosmic rays ? Where are they coming from ?
8. Write a note on galaxy clusters and superclusters.

(8 × 1 = 8 weightage)

Turn over

Section B

(4 essay questions answerable within 30 minutes).
Answer any **two** *questions.*
Weightage 5 for each question.

9. What is a celestial sphere ? How do you represent the position of an object in the celestial sphere ? Represent the horizon, the celestial equator, the ecliptic, and the latitude, longitude, declination, right ascension, hour angle, zenith distance and the azimuth of a star in a diagram.

10. (i) What are the basic components of an optical telescope ? Explain the purpose of each component

    (ii) Why do larger telescopes use mirrors instead of lenses ? Note down the limitations of refractive telescopes in comparison to reflecting telescopes.

    (iii) Explain the advantages of adaptive optics. Why don't we use adaptive optics for space telescopes ?

11. Explain the morphological classification of galaxies. In which of the classification does Milkyway belong ?

12. Discuss the properties, classification and unification of AGN.

(2 × 5 = 10 weightage)

Section C

(6 problems answerable within 15 minutes).
Answer any **four** *questions.*
Weightage 3 for each question.

13. Alpha Centauri is the closest star to the Sun which is only 1.3 pc away from us. What would be the parallax shift expected for Alpha Centauri ?

14. The North Galactic Pole is at Right Ascension 12h49m, declination +27°24'.

    What is the tilt of the galactic plane to the celestial equator ?

15. If an object is traveling at a velocity of 5000 km/s away from us, where would the hydrogen feature that is normally observed at 912 Å appear at in this objects spectrum ?

16. If the absolute magnitude of the supernova was - 18 mag, what was it's apparent magnitude from the Earth ?

17. The active galactic nucleus in the galaxy NGC 4151 is observed as basically a point source with a V-band magnitude of 12. If the $H\alpha$ line (rest = 656.3 nm) from the nucleus is observed at 658.5 nm, then what is the galaxy's distance (assume Ho = 75 km/sec/Mpc) ?

18. The Virgo cluster of galaxies is at a distance of 65 million light-years, and has a redshift equivalent to 1400 km/sec. Assuming the speed has remained constant throughout the past and the cluster has no tangential motion, then when were we and the cluster at the same location ?

(4 × 3 = 12 weightage)

C 22587 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 16—SYNTHESIS, CHARACTERIZATION TECHNIQUES AND APPLICATIONS OF NANOMATERIALS

(2020 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 *Short questions, each answerable within* 7.5 *minutes*
Answer **all** *questions. Each question carries weightage* 1.

1. Four-point probe is better than a two-point probe. Comment.
2. Explain the principle of Hall Effect.
3. What is surface charging in SEM ? How can it be avoided ?
4. Explain the principle of XPS.
5. What is the basic difference between CVD and PVD ?
6. Write a short not on self-cleaning coatings ?
7. List out the challenges faced by nanotechnology.
8. What is LaMer diagram ?

(8 × 1 = 8 weightage)

Turn over

Section B

4 Essay questions, each answerable within 30 minutes
Answer any **two** *questions. Each carries weightage 5.*

9. Discuss the different physical methods based on evaporation for the synthesis of nanomaterials.

10. Differentiate between MEMS and NEMS. Discuss the major challenges faced in constructing nano-size devices.

11. What is Bragg's law ? Explain the Scherrer powder method in nanoparticle size analysis with a suitable XRD diagram.

12. Discuss the conductivity measurement technique of nanomaterials with respect to two probe and four probe method.

(2 × 5 = 10 weightage)

Section C

7 Problem questions, each answerable within 15 minutes.
Answer any **four** *questions. Each question carries weightage 3.*

13. Explain the principle and working of Vibrating Sample magnetometer.

14. Calculate the angle at which the :

    (a) First-order diffraction and

    (b) Second-order diffraction will occur in an X-ray diffractometer when x-rays of wavelength of 1.54 Å is diffracted by atoms of a crystal whose interplanar spacing is 4.04 Å.

15. A solution of thickness 2 cm, the transmitted light is 0.12 times of the incident light, molar absorptivity is 0.35 M^{-1} cm^{-1}. Calculate the concentration of the solution and the absorbance.

16. An electron microscope uses electrons accelerated by a voltage of 50 kV. Determine the debroglie wavelength associated with the electrons. Also compare the resolving power of electron microscope with an optical microscope that uses yellow light of wavelength 599 nm.

17. Write a short note on molecular beam epitaxy.

18. Write a short note on Antibacterial coatings.

19. Explain the principle of MEMS accelerator with a neat labeled diagram.

(4 × 3 = 12 weightage)

C 22586 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 15—COMMUNICATION ELECTRONICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short questions answerable within 7.5 minutes)

Answer **all** *questions.*
Each carries weightage 1.

1. Differentiate DSB and SSB modulation schemes
2. What do you mean by Ratio Detector ?
3. Give the capacity of a channel given its bandwidth and noise level.
4. What is the basic principle of the Telegraph system ?
5. What is the significance of the IF amplifier in receivers ?
6. What is the basic principle of Telegraph transmitters ?
7. Differentiate energy and power signals ?
8. Define the directivity of an antenna ?

(8 × 1 = 8 weightage)

Turn over

Section B

(4 essay questions answerable within 30 minutes)

Answer any **two** *questions.*
Each carries weightage 5.

9. With a neat block diagram explain die basic stages in the PCM system.

10. With a neat block diagram explain a superheterodyne receiver.

11. State and prove any 3 properties of convolution.

12. Obtain the power radiated by a current element.

(2 × 5 = 10 weightage)

Section C

(7 problems answerable within 15 minutes)

Answer any **four** *questions.*
Each carries weightage 3.

13. The RMS antenna current of an AM radio transmitter is 10 A when unmodulated and 12 A when sinusoidally modulated. Calculate the modulation index.

14. A PCM system is to have a signal-to-noise ratio of 40 dB. The signals are speech and an RMS-to-peak ratio of – 10 dB is allowed for. Find the number of bits per codeword required.

15. A system has a bandwidth of 4kHz and a signal-to-noise ratio of 28dB at the receiver input. Calculate the capacity of the channel if its bandwidth is doubled, while the transmitted signal power remains constant.

16. Explain the superheterodyne receiver tuning process of an AM station for 640 kHz having a local oscillator with a predetermined frequency of 1095 kHz.

17. Prove that a discrete-time sinusoid is periodic only if its frequency is a rational number

18. Determine whether the following systems are linear or not

    a) y $(n) = nx\ (n)$; b) $y\ (n) = x\ (n^2)$; and c) $y\ (n) = x^2(n)$.

19. Obtain the signal in volts received by an antenna in free space having effective height h_r = 10m which is placed at a distance d = 10m from a transmitting antenna having an effective height h_t = 2m for an antenna current I = 2A and wavelength λ = 100m.

(4 × 3 = 12 weightage)

C 22585 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 14—LASER SYSTEMS, OPTICAL FIBRES AND APPLICATIONS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 Short questions answerable within 7.5 minutes
Answer **all** *questions, each question carries weightage* 1.

1. Briefly explain mode locking
2. Define quality factor of a laser cavity.
3. Explain Multi photon absorption.
4. What is acceptance angle in a fibre ? Show that it does not depend on fibre dimension.
5. What is spatial frequency filtering ? Give one application.
6. How does light propagation take place in an optical fiber ?
7. Briefly explain laser induced fusion.
8. State and explain the threshold condition for laser action.

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions, each question carries weightage 5.*

9. Explain the basic principle of Laser and derive an expression for Einstein co-efficients.
10. What is Holography ? Discuss about the basic principle of holography.
11. Describe the theory and experimental techniques of third harmonic generation.
12. Derive wave equations a for a step index fiber.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

13. Explain industrial applications of laser.
14. A step index fibre has a numerical aperture of 0.26, core refractive index of 1.5 and a core diameter of 100 μm. Calculate the refractive index of cladding, the acceptance angle and the maximum number of modes with a wavelength of 1 μm that the fibre can carry.
15. A He-Ne laser emitting at 633 nm has a line width of 0.002 nm. Determine its coherence length. Also determine the coherence length if the same laser was frequency stabilized to a frequency uncertainty of 100 kHz.
16. Explain optical parametric oscillator.
17. A laser range finder produces a laser spot of diameter 4 m at a target located at a distance of 8 km from the source. Determine the full angle divergence of the laser beam.
18. A certain laser has a bandwidth of 22 GHz. Determine the theoretically possible shortest mode-locked pulse width it can generate.
19. Differentiate three level lasers from four level laser systems.

(4 × 3 = 12 weightage)

C 22584 (Pages : 3) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 13—ELECTRONIC INSTRUMENTATION

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short questions answerable within 7.5 minutes)

Answer **all** *questions, each carry weightage* 1.

1. Write a short note on an average responding electronic AC voltmeters.
2. What is purpose of delay line in a CRO ?
3. Explain how the power of a fiber optic equipment is measured.
4. Enlist a few measurements that can be used to test an amplifier.
5. What is the need for saturable reactor controls ?
6. Explain the function of optical time domain reflectometer.
7. What is the significance of an oscilloscope probe ?
8. Explain the working of a Bolometer.

(8 × 1 = 8 weightage)

Turn over

Section B

(4 essay questions answerable within 30 minutes)

Answer any **two** *questions, each carry weightage* 5.

9. Explain armature voltage control method for regulating the speed of a DC motor.

10. What is a function generator ? What are its capabilities ? What function generator controls are associated with it and enlist a few applications ?

11. Write notes on the following : (1) Electrocardiographs ; and (2) Electroencephalogram.

12. Explain the features of General Purpose Interface Bus. Also mention its advantages and disadvantages.

(2 × 5 = 10 weightage)

Section C

(7 problems answerable within 15 minutes)

Answer any **four** *questions, each carry weightage* 3.

13. A 0 to 100 V voltmeter has a guaranteed accuracy of 5 % of full scale reading. The voltage measured by the instrument is 50 V. What is the percentage of limiting error ?

14. A resistive strain gauge, G = 2.2, is cemented on a rectangular steel bar with the elastic modulus E = 205 × 106 KN/m^2, width 3.5 cm and thickness 0.55 cm. An axial force of 12 KN is applied. Determine the change of the resistance of the strain gauge, ΔR, if the normal resistance of the gauge is R = 100 Ω.

15. What is the value of anode current of SCR comprising two-transistor analogy with the gate current of 40 mA if the gain of PNP and NPN transistors are 0.3 and 0.4 respectively ?

16. A photo-detector has a quantum efficiency of 80% at 1000 nm. A radiation of optical power 0.01 watt/m at this wavelength is incident on the device which has a receiving area of 1 mm . The detector has a dark current of 5 nA and a shunt resistance of 10 ohms. If the bandwidth of operation is 100 MHz, calculate the dark noise and shot noise current of the detector.

17. Initially a d.c shunt motor having r_a = 0.5 Ω and R_f = 220 Ω is running at 1000 r.p.m. drawing 20 A from 220 V supply. If the field resistance is increased by 5%, calculate the new steady state armature current. Assume the load torque to be constant.

18. If an audio amplifier produces an output 10 times greater than its input, what will its power gain be, measured in decibels ?

19. A circuit tuned to a frequency of 1.5 MHz and having an effective capacitance of 150 pF. In this circuit, the current falls to 70.7 % of its resonant value. The deviates from the resonant frequency are 5 kHz. What is the effective resistance of the circuit is ?

(4 × 3 = 12 weightage)

C 22583 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (REGULAR/SUPPLEMENTARY) EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 12—MATERIALS SCIENCE

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short questions answerable within 7.5 minutes).
Answer **all** *questions.*
Weightage 1 *for each question.*

1. What is Brittle Fracture ?
2. Draw tensile stress strain graph and explain it.
3. Explain atomic model of diffusion.
4. What is linear polymers ?
5. Briefly explain lithographic techniques.
6. Write four properties of dislocations.
7. What do you mean by surface imperfections ?
8. Differentiate top-down and bottom up approach.

(8 × 1 = 8 weightage)

Turn over

Section B

(4 essay questions answerable within 30 minutes).
Answer any **two** *questions.*
Weightage 5 for each question.

9. Explain Dislocations in solids and their importance in material science.

10. Explain different type of fractures and also explain the techniques used to prevent fracture.

11. Explain lithographic process with suitable diagram and also point out the advantages and disadvantages.

12. Explain Carbon nanostructures, classification of carbon nanostructures and their applications.

(2 × 5 = 10 weightage)

Section C

(7 problems answerable within 15 minutes).
Answer any **four** *questions.*
Weightage 3 for each question.

13. The half length of cracks in a steel is 2 μm. Taking Y = 200 GN m^{-2}, estimate the brittle fracture strength at low temperatures.

14. Find the equilibrium concentration of vacancies in aluminium and nickel at 0 K, 300 K and 900 K.

15. A steel tank contains hydrogen at a constant pressure of 10 atm, with a vacuum outside. The hydrogen concentration at the inner surface of the tank is equal to 10 kg m^{-3}. The diffusion coefficient of hydrogen in steel at room temperature is 10^{-9} m^2 s^{-1}. Calculate the rate at which hydrogen escapes through the wall of the steel tank, which has a thickness of 5 mm.

16. If there are 10^{10} m^{-2} of edge dislocations in a simple cubic crystal, how much would each of these climbs down on an average when the crystal is heated from 0 to 1000 K ? The enthalpy of formation of vacancies is 100 kJ mol^{-1}. The lattice parameter is 2 Å. The volume of one mole of the crystal is 5.5×10^{-6} m^3 (5.5 cm^3).

17. At atmospheric pressure (pressure arbitrarily chosen), a material of unknown composition shows four phases in equilibrium at 987 K. What is the minimum number of components in the system?

18. The surface of a copper crystal is of the {111} type. Calculate the surface energy (enthalpy) of copper.

19. How much proeutectoid ferrite is there in a slowly cooled 0.6% steel ? How much eutectoid ferrite is there in the same steel ?

(4 × 3 = 12 weightage)

C 22580 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4E 09—ADVANCED ASTROPHYSICS

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

(8 Short Answer Questions, each answerable within 7.5 minutes)

Answer **all** *questions.*
Each carries weightage 1.

1. Write equation explain Wein's displacement law.
2. Draw the energy distribution curves for the three laws of black body radiation.
3. What is red shift.
4. What is gravitational collapse ?
5. Define Synchrotron radiation.
6. What is Compton effect.
7. Determine the field equations for the gravitational field.
8. Derive Schwarzschild metric.

(8 × 1 = 8 weightage)

Turn over

Section B

(4 Essay Questions, each answerable within 30minutes)

Answer any **two** *questions.*
Each carries weightage 5.

9. Write a note on gravitational waves
10. Write notes on : i) RV Tauri variables with light curve ; ii) Mira Type variables with Energy curve.
11. What is a galaxy ? Explain the classification.
12. With figure explain the Bohr concept of Hydrogen atom.

(2 × 5 = 10 weightage)

Section C

(7 Problem Questions, each answerable within 15minutes)

Answer any **four** *questions.*
Each carry weightage 3.

13. Derive distance modulus. Calculate the absolute magnitude of a star at distance 2pc. Apparent magnitude is 0.14.
14. How can we relate gravity with Geometry ?
15. Calculate the maximum wavelength of the Lyman series
16. Explain physics in a curved space time.
17. Write note on galactic nuclei.
18. Determine the energy of a photon in eV and the number of photons emitted per second by a P = 2 mW He-Ne laser that operates on the wavelength λ = 632.8 nm.
19. X-rays of wavelength 70.7 pm are scattered from a graphite block : (a) Determine the energy of a photon ; and (b) Determine the shift in the wavelength for radiation leaving the block at an angle of 90° from the direction of the incident beam.

(4 × 3 = 12 weightage)

C 22578 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE [REGULAR/SUPPLEMENTARY] EXAMINATION, APRIL 2022

(CBCSS)

Physics

PHY 4C 12—ATOMIC AND MOLECULAR SPECTROSCOPY

(2019 Admission onwards)

Time : Three Hours Maximum : 30 Weightage

General Instructions

1. *In cases where choices are provided, students can attend* **all** *questions in each section.*
2. *The minimum number of questions to be attended from the Section / Part shall remain the same.*
3. *The instruction if any, to attend a minimum number of questions from each sub section / sub part / sub division may be ignored.*
4. *There will be an overall ceiling for each Section / Part that is equivalent to the maximum weightage of the Section / Part.*

Section A

8 Short questions answerable within 7.5 minutes.
Answer **all** *questions, each question carries weightage* 1.

1. Explain clearly the phenomenon of normal and anomalous Zeeman effect.
2. Mention the concepts underlaying vector atom model of the atom and the different quantum numbers associated with it.
3. Explain the principle of Fourier transformation I R Spectroscopy.
4. With the help of a diagram, explain fortrat parabola.
5. Obtain a simple relation for the relative intensity of Stokes lines and anti-Stokes lines. How does the intensity vary with temperature ?
6. Briefly explain recoilless emission and absorption of γ-rays.
7. Distinguish between spin lattice and spin-spin relaxation.
8. Explain the basic principle of Stimulated Raman Scattering.

(8 × 1 = 8 weightage)

Turn over

Section B

4 essay questions answerable within 30 minutes.
Answer any **two** *questions, each question carries weightage 5.*

9. Discuss the theory of the rotational spectrum of symmetric top molecule, what is the information derived from Rotational Spectrum ?

10. Describe the rotational Raman spectrum of symmetric top molecules. Bring out the salient features.

11. Discuss the rotational fine structure of the electronic vibrational transitions. Explain band head formation.

12. Explain the Bloch equations and the steady state solutions in the case of NMR.

(2 × 5 = 10 weightage)

Section C

7 problems answerable within 15 minutes.
Answer any **four** *questions, each question carries weightage 3.*

13. Consider a hydrogen atom in the $^{D}3/_{2}$ state, (i) Find the possible values of I_Z. (ii) What are the different orientations of the J-vector in space.

14. Rotational and centrifugal distortion constants of HCl molecule are 10.593 cm^{-1} and 5.3×10^{-4} cm^{-1} respectively. Estimate the vibrational frequency and force constant of the molecule.

15. If the bond length of H_2 is 0.07417nm, what would be the positions of the first three rotational Raman lines in the spectrum ?

16. The vibrational structure of the absorption spectrum of O_2 becomes a continuum at 56876 cm^{-1}. If the upper electronic state dissociates into one ground state atom and one excited atom with excitation energy 15875 cm^{-1}, estimate the dissociation energy of the ground state of O_2 in cm^{-1} and in $kJmol^{-1}$.

17. What is the nuclear g_N factor for F^{19} nucleus which has a magnetic moment of 2.6273 μ_N. Nuclear spin quantum number $I = 1/2$.

18. Calculate the recoil velocity of a free Mossbauer nucleus of mass 1.67×10^{-25} kg (equivalent at wt. 100) when emitting a γ-ray of wavelength 0.1 nm. What is the Doppler shift of the γ-ray frequency to an outside observer ?

19. A free electron is placed in a magnetic field of strength 1.3T. Calculate the resonance frequency if g = 2.0023.

(4 × 3 = 12 weightage)

C 21078 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER P.G. DEGREE EXAMINATION, APRIL 2022

(CCSS)

Physics

PHY 4E 10—ADVANCED MATERIALS SCIENCE

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer **all** *questions.*
Each question carries 2 *marks.*

1) State Fick's laws.
2) Explain edge dislocation.
3) State Hume Rothery rules.
4) What is a binary phase diagram ?
5) What is meant by solubility limit ?
6) Explain about the structure of silicates.
7) What are solid solutions ? How are they classified ?
8) Differentiate addition and condensation polymerization.
9) What are thermosetting resins ?
10) Mention any four applications of liquid crystals.
11) Explain the quantum confinement effect.
12) What are fullerenes ?

(12 × 2 = 24 marks)

Section B

Answer any **two** *questions.*
Each question carries 14 *marks.*

13) Discuss about the interstitial diffusion in solids. Also determine and explain the expression for diffusion co-efficient.
14) With the help of neat diagram, discuss the working principle behind scanning tunnelling microscopy.

Turn over

15) Write a note on polymers. Also discuss about the classification of polymers based on mode of formation, thermal response and structure.

16) Discuss any two methods used for the synthesis of nanomaterials.

(2 × 14 = 28 marks)

Section C

Answer any **four** *questions.*
Each question carries 7 marks.

17) Estimate the energy of formation of an edge dislocation of unit length.

18) State and derive the Lever rule.

19) What are ceramic materials ? Discuss about the electrical properties of ceramics.

20) Write a note on plastic deformation of layered structures.

21) Explain the important application of polymers.

22) Discuss about any one electron microscope used for the characterization of nanomaterials.

(4 × 7 = 28 marks)

C 21077-B (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER P.G. DEGREE EXAMINATION, APRIL 2022

(CCSS)

Physics

PHY 4E 08—ADVANCED ASTROPHYSICS

(2020 Admission onwards)

Time : Three Hours Maximum : 80 Marks

Section A

12 short questions ; each answerable within 5 minutes.
Answer **all** *questions. Each questions carries 2 marks.*

1. With equation explain Wein's displacement law.
2. Define Synchrotron radiation.
3. Explain radiation pressure.
4. What is gravitational collapse ?
5. Determine the field equations for the gravitational field.
6. Write a note on gravitational wave.
7. What are globular clusters.
8. What is a black hole ?
9. What is a variable star ?
10. What is the relation connecting period and luminosity ?
11. What is the importance of Chandrasekhar limit ?
12. Write a note on steady state cosmology.

(12 × 2 = 24 marks)

Section B

4 Essay questions, each answerable within 30 minutes.
Answer any **two** *questions. Each questions carries 14 marks.*

13. With figure explain the Bohr concept of Hydrogen atom.

14. Write notes on i) RV Tauri variables with light curve ; and ii) Mira Type variables with Energy curve.

15. Explain i) Zeeman effect ; and ii) Doppler effect.

16. What is a Galaxy ? Explain the classification.

(2 × 14 = 28 marks)

Section C

5 problem questions, each answerable within 15 minutes
Answer any **four** *questions. Each questions carries 7 marks.*

17. Derive distance modulus. Calculate the absolute magnitude of a star at distance 2pc. Apparent magnitude is 0.14.

18. How can we relate gravity with Geometry ?

19. Calculate the maximum wavelength of the 1. Balmer series 2. Lyman series.

20. Explain the pulsation theory of variable stars.

21. The temperature of a person skin is θ_{Skin} = 35 °C. Determine the wavelength at which the radiation emitted from the skin reaches its peak.

22. Explain Schwarzschild metric and gravitational collapse.

(4 × 7 = 28 marks)

C 21077 (Pages : 3) Name.....

Reg. No.....

FOURTH SEMESTER POST GRADUATE DEGREE EXAMINATION APRIL 2022

(CCSS)

Physics

PHY 4E 07—ADVANCED NUCLEAR PHYSICS

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

(12 Short questions answerable within 5 minutes)

Answer **all** *questions.*

Each question carries 2 marks.

1. Compare nuclear shells with atomic shells.
2. Explain Schmidt diagram for nuclear quadrupole moments.
3. Derive the energy levels of an odd A nucleus with infinite square well potential.
4. Give an account of rotational states of even -even nuclei.
5. Explain Nilsson Potential.
6. Classify the nuclear reactions on the basis of reaction mechanism.
7. What is the Q value of a nuclear reaction?
8. Draw the mass distribution curve for fission fragments and write down the important characteristics of mass distribution.
9. Give a qualitative account of fission on the basis of liquid drop model.
10. Give an example of an electrostatic generator. Explain its working.
11. List the advantages and disadvantages of LINAC over other particle accelerators?
12. Write a short note on synchrotron radiation.

(12 × 2 = 24 marks)

Section B

(4 Essay questions answerable within 30 minutes)

Answer any **two** *questions.*

Each question carries 14 marks.

13. (a) What are the limitations of extreme single particle shell model?

    (b) Derive the single particle Hamiltonian and arrive at single particle states of deformed nuclei by perturbation method

14. (a) Explain why nuclei do not possess electric dipole moment and magnetic quadrupole moments.

    (b) Derive expressions for magnetic dipole moment and electric quadrupole moment due to collective motion of nuclei.

15. (a) Explain the features of Compound nuclear reactions.

    (b) Give an account of statistical theory of nuclear reactions and compare the experimental results with the theoretical calculations of cross sections.

16. (a) Explain Semi-empirical Mass formula and apply it to nuclear fission.

    (b) Give an account of theory of spontaneous fission based on barrier penetration of a one dimensional inverted harmonic oscillator potential barrier.

(2 × 14 = 28 marks)

Section C

(6 Problems answerable within 15 minutes)

Answer any **four** *questions.*

Each question carries 7 marks.

17. Find the spin, magnetic dipole moment and electric quadrupole moment of the following nuclei in ground state on the basis of extreme single particle shell model: (a) ${}_{8}O^{17}$; (b) ${}_{16}S^{33}$; (c) ${}_{29}Cu^{63}$.

18. By tabulating the possible m states of 2 quadrupole phonons ($\lambda = 2$) and their symmetrized combinations show that the permitted resultant states are 0^+, 2^+, 4^+.

19. The isotope ${}_{98}Cf^{252}$ with a half life 60.5 days decays by spontaneous fission. The energy released per fission is about 225 MeV.

    (a) Calculate the total fission power produced by 10 μ g of ${}_{98}Cf^{252}$.

    (b) Calculate the rise in temperature of the Cf sample per minute due to fission heating.

20. Assuming the nucleus to be a black sphere of radius R show that the total reaction cross section σ_t for low energy neutrons having $l < \frac{R}{\lambda/2\pi}$ is twice the geometrical cross section of the nucleus

21. Deuterons are accelerated in a fixed frequency cyclotron to the maximum dee orbit of 88 cm. The magnetic field is 1.4 Tesla

    (a) Calculate the energy of the deuteron beam on its emergence and the frequency of the cyclotron.

    (b) What should be the magnetic field to accelerate tritons (^3H) ?

22. Calculate the energy loss per turn for an electron in a synchrotron in which the electrons are moving with the energy of 5GeV on a radius of 26 m. Also calculate the power rating of the oscillator necessary to supplement this loss for a bunch of 10^{22} electrons.

(4 × 7 = 28 marks)

C 21076 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER POST GRADUATE DEGREE EXAMINATION APRIL 2022

(CCSS)

Physics

PHY 4C 17—SPECTROSCOPY

(2019 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

(12 Short questions answerable within 5 minutes)

Answer **all** *questions.*

Each question carries 2 marks.

1. Give the classification of molecules with one example each on the basis of the relative values of their three principal moments of inertia.
2. How do the rotational spectra of polyatomic molecules differ from that of diatomic molecules ?
3. Explain Morse curve.
4. What are hot bands? Why are they called so?
5. What are the conditions for a vibration to be Raman active?
6. How does Stimulated Raman Scattering (SRS) differ from ordinary Raman scattering? Give a schematic representation for SRS experimental set up.
7. Explain progressions and sequences with reference to electronic spectra of molecules.
8. How do you account for pre-dissociation in certain molecules?
9. Explain nuclear magnetic resonance.
10. Explain the different relaxation mechanisms in spin resonance.
11. What are the basic requirements for an ESR spectrometer?
12. Give an account of quadrupole interaction effects of Mossbauer spectra.

(12 × 2 = 24 marks)

Turn over

Section B

(4 Essay Questions answerable within 30 minutes)

Answer any **two** *questions.*

Each question carries 14 marks.

13. With a schematic diagram explain the IR spectrometer and give an account of the different techniques for recording the IR spectra.
14. Discuss the various methods of structure determination of molecules using IR and Raman spectroscopy.
15. Explain the rotational fine structure of electronic-vibrational transitions.Explain the terms band origin and band head with the help of a neat sketch for a diatomic molecule.
16. Give the fundamental principles of Mossbauer spectroscopy. Explain how they are achieved in Mossbauer spectrometer.

(2 × 14 = 28 marks)

Section C

(6 Problems answerable within 15 minutes)

Answer any **four** *questions.*

Each question carries 7 marks.

17. The observed spectrum of HF shows the J = 0 → J = 1 absorption at 41.11 cm^{-1}. The spacing between adjacent absorptions is 40.08 cm^{-1} around J – 5 → J = 6 transitions and only 37.81 cm^{-1} around J = 10 → J = 11 transition. Calculate B values and I values. Give an explanation for the variation in B and I values.
18. Derive the transition frequencies in the rotational spectra of rigid symmetric top molecules. How is it different from non rigid symmetric top molecules?
19. The fundamental band for HCl is centered about 2886 cm^{-1}. Assuming that the inter nuclear distance is 1276 Å calculate the wave numbers of the first two lines of P and R branches of HCl.
20. The Raman line associated with a vibrational mode which is both IR and Raman active is found to be 4600 Å, when excited with a wavelength of 4358 Å. Calculate the wavelength of the corresponding IR band.
21. Limit of continuum in the electronic vibration spectrum for a diatomic molecule occurs at 499.5 Å. When it dissociates one atom goes to excited state and another into ground state. The energy of the excited atom is 21.70 Kcal per mole. Calculate the dissociation energy of the molecule.
22. The recoil energy of a Mossbauer nucleus ^{57}Fe making transition from an excited state to ground state is 2×10^{-3} eV. Find the gamma ray energy and recoil velocity.

(4 × 7 = 28 marks)

C 5820 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER P.G. DEGREE (SUPPLEMENTARY) EXAMINATION SEPTEMBER 2021

(CUCSS)

Physics

PHY 4E 20—MICROPROCESSORS AND APPLICATIONS

(2012 Syllabus)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Explain the instruction format of 8085 microprocessor.
2. Draw the schematic of the timing and control unit of 8085 microprocessor.
3. What are the different addressing modes in 8085 microprocessor ?
4. What is the role of READY signal in the timing and control circuit of 8085 microprocessor ?
5. What are the important features of the Shift instruction in microprocessor ?
6. Explain concept of address space partition and its implementation in 8085 microprocessor.
7. Explain the working of 8253 interface.
8. What is the special use of HL register pair in of 8085 microprocessor ?
9. Explain the use of microprocessor for measurement of (i) Voltage ; and (ii) Current.
10. Explain the use of POP in 8051 microcontroller.
11. What is use of stack in 8085 microprocessor ?
12. What is the functions of the controller 8257 in 8085 microprocessor ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 6.

13. Explain the data transfer schemes of 8085 based on DMA.

14. With suitable examples discuss the various addressing modes and interrupts of 8085 microprocessor.

15. Show how to implement an AD converter using D/A converter in the 8085 microprocessor system.

16. Draw the block diagram and explain the architecture of 8051 microcontroller and explain its various registers.

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

17. Write an assembly language program to get 2's complement of a 16-bit numbers.

18. What is meant by data transfer group of the Intel 8085 instruction set ? Explain with suitable instructions.

19. Explain how 8251 programmable communication is used for serial communication.

20. Draw a 4 to 16 decoder-based circuit for address space partitioning in 8085.

21. Write an assembly language program for 8-bit division, product being a 16-bit.

22. Describe the interfacing of 7 segment display, which can display alphabets as well as digits.

(4 × 3 = 12 weightage)

C 5819 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER P.G. DEGREE (SUPPLEMENTARY) EXAMINATION SEPTEMBER 2021

(CUCSS)

Physics

PHY 4E 13—LASER AND FIBRE OPTICS

(2012 Syllabus)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*

Each question carries a weightage of 1.

1. What is meant by Q Switching ?
2. What is a confocal resonator ?
3. Draw the energy level diagram of Ruby laser and mark the important transitions ?
4. Explain briefly second harmonic generation.
5. What is a Dye laser ?
6. Distinguish step index and graded index fibre.
7. What is meant by the acceptance angle of a fibre ?
8. Explain Evanescent wave.
9. What are the different absorption losses in fibre ?
10. Explain what is OTDR ?
11. What is the function of WDM device ?
12. Mention the different types of fibre misalignment which contribute to insertion loss in a fibre.

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries a weightage of 6.

13. Explain the different line broadening mechanisms.

14. Describe the working of an NdiYAG laser.

15. What are single mode fibres ? What are its advantages ? Explain what is cut off wavelength.

16. Explain the different attenuation mechanisms in fibre communication ?

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries a weightage of 3.

17. Determine the loss factor due to mirrors if the reflectivity of two mirrors are 100 % and 99 % respectively and the length of the laser cavity is 50 cms.

18. Determine the cut-off wavelength for a step index fibre to exhibit single mode operation when the core refractive index and radius are 1.46 and 4.5 μm respectively with the relative index difference being 0.25 %

19. When an optical power of 120 μw is launched into an 8 km length of fibre, the mean optical power at the fibre output is 3 μw. Determine the overall signal loss in decibels through the fibre. Also calculate the overall signal attenuation for a 10 km optical link using the same fibre.

20. An optical fibre has a core refractive index of 1.5. Two lengths of the fibre with smooth and perpendicular (to the core axis) end faces are butted together. Assuming the fibre axes are perfectly aligned, calculate the optical loss in decibels at the joint due to Fresnel reflection when there is a small air gap between the fibre end faces.

21. Find out the number of longitudinal modes in a He-Ne laser of length L = 0.5 m. Natural line width of the laser is 1500 MHz.

22. Determine the cut-off wavelength for a step index fibre to exhibit single mode operation when the core refractive index and radius are 1.46 and 4.5 μm respectively with the relative index difference being 0.25 %.

(4 × 3 = 12 weightage)

C 5817 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER P.G. DEGREE (SUPPLEMENTARY) EXAMINATION SEPTEMBER 2021

(CUCSS)

Physics

PHY 4E 18—MODERN OPTICS

(2010 Syllabus)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions, weightage* 1 *each.*

1. Discuss the propagation of em wave in free space.
2. Discuss the theory of partial coherence.
3. What do you mean by Fourier transform hologram ?
4. What is the significance of Hanbury-Brown-Twiss experiment ?
5. Define resolving power of an interferometer and explain its dependent parameters.
6. Distinguish between Fresnel and Fraunhofer diffraction.
7. Compare and contrast between zone plate and convex lens.
8. Explain the phenomenon of Faraday rotation in solids.
9. Explain apodization and gives its significance.
10. Discuss Pockel's effect and explain its application.
11. Describe in detail phase matching conditions.
12. Discuss in detail with suitable example the physical origin of non-linearity.

(12 × 1 = 12 weightage)

Section B

Answer any **two**, *weightage 6 each.*

13. Derive Sellmeier's formula. Explain its advantages over Cauchy's equation.

14. Describe in detail the phenomenon observed in the Fraunhofer diffraction due to single slit. Explain the observed spectrum.

15. Deduce Poynting theorem for the flow of energy in em field.

16. Discuss the propagation of em wave in anisotropic media. Obtain the relation between D and E.

(2 × 6 = 12 weightage)

Section C

Answer any **four**, *weightage* 3 *each.*

17. Show that a photographic negative of a hologram made with unit magnification will give the same observable image as the original hologram.

18. Discuss with theory the Gaussian beams in homogeneous media.

19. Prove that the velocity of em wave in the vacuum is given by $c = \frac{1}{\sqrt{\mu_o \varepsilon_o}}$.

20. A soap film of refractive index 1.34 appear bright red for $\lambda = 633$ nm for normally reflected light. Calculate its thickness.

21. Explain second harmonic generation and obtain an expression for Coherence length.

(4 × 3 = 12 weightage)

C 5816 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER P.G. DEGREE (SUPPLEMENTARY) EXAMINATION SEPTEMBER 2021

(CUCSS)

Physics

PHYE411—MATERIALS SCIENCE

(2010 Syllabus)

Time : Three Hours Maximum : 36 Weightage

Part A

Answer **all** *questions.*
Each question carries 1 *weightage.*

1. Distinguish between Schottky and Frenkel defects.
2. Explain what is Frank Read mechanism.
3. Define Edge and Screw dislocations.
4. What is Hume Rothery electron compounds ?
5. What is polymorphism ?
6. What are solid solutions ? Explain the Vegards law.
7. What is copolymerisation ?
8. Distinguish between thermoplastics and thermosetting plastics.
9. Explain what is quasi crystals.
10. Explain what is meant by strong confinement.
11. Explain the mechanism of electrical conductivity in ceramics
12. State and explain Gibb's phase rule.

(12 × 1 = 12 weightage)

Part B

Answer any **two** *questions.*
Each question carries 6 *weightage.*

13. Explain the Fizeau fringe method for thickness measurement ? What is the maximum thickness that can be measured by this technique ?
14. Discuss with example the important electrical properties of ceramics.

Turn over

15. Explain the concept of Atomic force microscopy and scanning tunnelling microscopy.

16. Discuss how the fullerenes are grown and characterised.

(2 × 6 = 12 weightage)

Part C

Answer any **four** *questions.*

Each question carries 3 *weightage.*

17. Alpha brass contains 65 wt % copper and 35 wt % zinc Calculate the atomic percentage.

18. What is a phase diagram ? Illustrate its importance with one example.

19. The energy required to move an atom from its site to surface is 1 ev at 1000 K. Find the concentration of vacant site. What is the energy required to move an atom from its site to surface if number of occupied states equal to number of unoccupied states ?

20. The average molecular weight of polypropylene is 33040 g/mol. What is the degree of polymerisation ?

21. Explain with an example how carbon nanotubes are used in electronic devices.

22. What are elastomers ? Give some of its applications.

(4 × 3 = 12 weightage)

C 5815 (Pages : 2) Name.....

Reg, No.....

FOURTH SEMESTER P.G. DEGREE (SUPPLEMENTARY) EXAMINATION SEPTEMBER 2021

(CUCSS)

Physics

PHY 4C 12—ATOMIC AND MOLECULAR SPECTROSCOPY

(2010 Syllabus)

Time : Three Hours Maximum : 36 Weightage

Section A

Answer **all** *questions.*
Each question carries weightage 1.

1. Distinguish between Zeeman effect and Paschen back effect.
2. Why oxygen molecules do not show IR absorption or emission ?
3. Explain briefly the information one can get from vibrational analysis of electronic spectra.
4. What are singlet and triplet state ?
5. Explain the principle of IR Spectroscopy.
6. Distinguish between Anti-Stokes Raman scattering and inverse Anti-stokes Raman Scattering. Give the condition for them to occur.
7. Write a note on Franck-Condon principle.
8. Briefly explain recoilless emission and absorption of gamma rays.
9. What is Mossbauer spectroscopy ?
10. Why stokes lines are more intense than anti stokes lines.
11. Explain the hyperfine structure in ESR spectra.
12. How do you represent the electronic states of a many electron diatomic molecule ?

(12 × 1 = 12 weightage)

Section B

Answer any **two** *questions.*
Each question carries weightage 6.

13. What are equivalent and non-equivalent electrons ? Using JJ coupling scheme obtain the term symbols of a LS configuration.

14. Describe with necessary theory hoy structure of diatomic and triatomic molecules can be determined by combining Raman and Infrared spectroscopy.

15. (a) Discuss in detail the rotational fine structure of electronic vibrational transitions.

    (b) Explain conditions under which the band heads are degraded towards violet and red in the electronic spectra.

16. Discuss in detail the principle of ESR. What is the effect of hyperfine interactions ? What is its effect on the spectrum ?

(2 × 6 = 12 weightage)

Section C

Answer any **four** *questions.*
Each question carries weightage 3.

17. Calculate the wavelength separation between the two component lines which observed in the normal Zeeman effect. The magnetic field used is 0.4 weber/m^2 specific charge = 1.76×10^{11} Ckg^{-1} and λ = 6000Å.

18. The first line in the rotational spectrum of carbon monoxide has a frequency of 3.8424 cm^{-1}. Calculate the rotational constant and hence the C-O bond length in carbon monoxide. Avogadro number is 6.022×10^{23} /mol.

19. Calculate the recoil velocity of a free Mossbauer nucleus of mass 1.67×10^{-25} kg (equivalent at wt.100) when emitting a γ-ray of wavelength 0.1 nm. What is the Doppler shift of the γ-ray frequency to an outside observer ?

20. The vibrational structure of the absorption spectrum of O_2 becomes a continuum at 56876 cm^{-1}. If the upper electronic state dissociates into one ground state atom and one excited atom with excitation energy 15875 cm^{-1}, estimate the dissociation energy of the ground state of O_2 in cm^{-1} and in $KJmol^{-1}$.

21. The first Stokes line in the rotational Raman Spectrum of $N^{14}N^{15}$ is observed at 11.5416 cm^{-1}. What is its B value ? Calculate its bond length.

22. In the NMR spectrum of N^{14} with I = 1, how many spectral lines will be observed ? Calculate the frequency required for the NMR line at an external field of 1.4T (g = 0.403).

(4 × 3 = 12 weightage)

C 1769 (Pages : 2) Name.....

Reg. No.....

FOURTH SEMESTER M.Sc. DEGREE (SUPPLEMENTARY/IMPROVEMENT) EXAMINATION, MARCH 2021

(CUCSS)

Physics

PHY 4E 17—ADVANCED CONDENSED MATTER PHYSICS

(2017 Admissions)

Time : Three Hours Maximum : 36 Weightage

Section A

Twelve Short Questions, Each answerable within 5 *minutes.*
Answer **all** *questions.*
Each question carries weightage 1.

1. Explain the photographic process.
2. Differentiate phonon and Magnon.
3. Note down the Pauli spin matrices with commutation relations.
4. Explain acoustic branch and optical branch.
5. Illustrate the variation of diffusion coefficient with temperature.
6. List any four optoelectronic and microelectronic applications of thin films ?
7. Write short note on steps of thin film deposition process.
8. Write any two applications of carbon nanotubes.
9. Explain single electron tunneling.
10. Define Debye frequency.
11. Note down the expression for ionic conductivity.
12. Explain Type 1 and Type 2 Quantum wells.

(12 × 1 = 12 weightage)

Section B

Four Essay Questions, Each answerable within 30 *minutes.*
Answer any **two** *questions.*
Each question carries weightage 6.

13. Write a note on Debye temperature and Debye approximations leading to specific heat.
14. Explain different diffusion mechanisms in solids.

Turn over

15. Explain PVD and CVD in detail.

16. Explain quantum wells, wires and dots.

(2 × 6 = 12 weightage)

Section C

Six Problems Questions, Each answerable within 15 *minutes.*
Answer any **four** *questions.*
Each question carries weightage 3.

17. What is sputtering and how it is different from thermal evaporation ?

18. Show how the number of vacancies or vacancy concentration varies with temperature.

19. Write down the diffusion equation and plot the graph showing the variation of diffusion co-efficient with the temperature ?

20. Estimate the emission wavelength of a 15nm GaAs quantum well laser at 300K. [Assume Ehkl = 3meV and Eel = 25meV}.

21. Derive an expression for Curie Weiss law.

22. Describe Superlattices.

(4 × 3 = 12 weightage)