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ItemNo. _____

UNIVERSITY OF MUMBAI



Syllabus
for the
PET Examination
in
Physics

(With effect from the Academic year 2019-2020)

AC _____
Item No. _____

UNIVERSITY OF MUMBAI



Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	PET in Physics
2	Eligibility for Admission	As per Minimum Standards and Procedure for Award of M.Phil and Ph,D Degrees, Mumbai University VCD dated 15.06.2018
3	Passing Marks	40%
4	Ordinances / Regulations (if any)	VCD/947 of 2018
5	No. of Years / Semesters	Minimum of 3 years and maximum of 6 years
6	Level	Certificate/Diploma/UG/PG (Strike out which is not applicable)
7	Pattern	Semester/Yearly (Strike out which is not applicable)
8	Status	Revised/New / (Strike out which is not applicable)
9	To be implemented from Academic Year	From Academic Year:2019-2020

Date: 6.07.2020

Signature:

Name: Anuradha Misra

Chairman of BoS of Physics

Dr. Anuradha Majumdar

Dean, Science and Technology

PET Syllabus for Physics student 2019-20 onwards

Paper I: Research Methodology

There will be 10 sections in the paper with 5 questions from each section to test the general research aptitude, cognitive abilities like comprehension, analysis, evaluation, understanding the structure of arguments, deductive and inductive reasoning, general awareness about environment issues as well as their awareness about research ethics.

- 1. Error Analysis:** Experimental Error measurement of factual data, True value and error, Precision and accuracy, Random and systematic errors, Random errors, Uncertainty in measurement, Combining uncertainties, Expanded uncertainty
- 2. Research Aptitude :** Research: Meaning, characteristic and types, Methods of research, Research Ethics: IPR, Copyrights in scientific work, patents. Plagiarism: Meaning, checks and consequences. General terminology: Paper, article, workshop, seminar, conference and symposium. Thesis writing: format and characteristic.
- 3. Reading Comprehension:** Questions based on a given passage to evaluate reading comprehension
- 4. Communication:** Nature, Characteristics, Effective communication
- 5. Mathematical Reasoning:** Numbers series, letter series, codes, relationships, classification
- 6. Logical Reasoning:** Understanding the structure of arguments, Evaluating and distinguishing deductive and inductive reasoning, Verbal analogies: Word analogy, Applied Analogy, Verbal classifications, Reasoning Logical Diagrams: Simple diagrammatic relationships, Venn diagram, Analytical reasoning
- 7. Data Interpretation:** Sources, Acquisition and Interpretation of data, Quantitative and qualitative data, Graphical Representation and mapping of data
- 8. Information and Communication Technology (ICT):** ICT—Meaning, advantages, disadvantages and uses, General abbreviations and terminology, Basics of e-mail and emailing
- 9. People and environment:** People and environment interaction, Sources of pollution, Pollutants and their impact on human life, exploitation of natural and energy resources, Natural hazards and mitigation
- 10. Higher Education System :** Structure of institutions of higher learning and research in India, formal and distance education, professional/technical and general education, value education, governance, polity and administration, concept, institutions and their interactions

Paper II Core Subject: Physics

1. Mathematical Methods: Matrices, Eigenvalues and Eigen vectors, orthogonal, unitary and hermitian matrices, Diagonalization of Matrices, Tensor Analysis, Addition and Subtraction of Tensors, summation convention, Contraction, Direct Product, Levi-Civita Symbol, Complex Analysis basics, Cauchy-Riemann Equations, Analytic functions, Harmonic functions, Elementary functions, Residue theorem, Contour Integration, Second order linear differential equations with non-constant coefficients, Power series solutions, Frobenius method, Fourier and Laplace transforms with application to solving differential equations.
2. Classical Mechanics: D'Alembert's principle and Lagrange's equations, Velocity-dependent potentials and the dissipation function, Simple applications of the Lagrangian formulation. Hamilton's principle, Calculus of variations, Derivation of Lagrange's equations from Hamilton's principle, Conservation theorems and symmetry properties, Two-Body Central Force Problem, The Kepler problem, Scattering in a central force field, Legendre transformations and the Hamilton equation of motion, Cyclic coordinates and conservation theorems, Canonical Transformations, Poisson brackets
3. Quantum Mechanics: Formalism : Postulates of quantum mechanics, observables and operators, measurements, state function and expectation values, the time-dependent Schrodinger equation, time development of state functions, solution to the initial value problem. The Superposition principle, commutator relations, their connection to the uncertainty principle, complete set of commuting observables. Time development of expectation values, conservation theorems and parity, Matrix mechanics, Schrodinger, Heisenberg and interaction pictures, One dimensional problems, Hydrogen atom: eigenvalues and radial eigenfunctions, degeneracy, probability distribution, Angular Momentum algebra, Time independent perturbation theory, time dependent perturbation theory, variation method, scattering theory.
4. Classical Electrodynamics : Maxwell's equations, The Poynting vector, The Maxwellian stress tensor, Lorentz Transformations, Four Vectors and

Tensors, The field equations and the field tensor, Maxwell equations in covariant notation, Electromagnetic waves in vacuum, Electromagnetic waves in matter, Waveguides, Moving charges in vacuum, gauge transformation, The time dependent Green function, The Lienard-Wiechert potentials, Lienard-Wiechert fields, Relativistic covariant Lagrangian formalism: Covariant Lagrangian formalism for relativistic point charges. The energy-momentum tensor, Conservation laws.

5. Solid State Physics : The crystalline state, Basic definitions of crystal lattice, basis vectors, unit cell, primitive and non-primitive cells, The fourteen Bravais lattices and these seven crystal systems, elements of symmetry, nomenclature of crystal directions and crystal planes, Miller Indices, spacing between the planes of the same Miller indices, examples of simple crystal structures, The reciprocal lattice and X-ray diffraction.

Classical free electron theory of metals, Quantum theory of free electrons, Fermi-Dirac statistics and electronic distribution in solids, Density of energy states and Fermi energy, The Fermi distribution function, Heat capacity of the electron gas, Mean energy of electron gas at 0K, Band Theory of Solids and Conduction in Semiconductors, Band theory of solids, The Kronig-Penney model, Brillouin zones,

Diffraction of Waves by Crystals and Reciprocal Lattice, Lattice Vibrations and thermal properties, Diamagnetism and paramagnetism, Magnetic ordering, Superconductivity

6. Electronics : Field effect transistors: JFET: Basic ideas, Drain curve, The transconductance curve, Biasing in the ohmic region and the active region, Transconductance, JFET common source amplifier, JFET analog switch, multiplexer, voltage controlled resistor, Current sourcing, MOSFET: Depletion and enhancement mode, MOSFET operation and characteristics, digital switching, SCR – construction, static characteristics, Analysis of the operation of SCR, Gate Triggering Characteristics, Variable half wave rectifier and Variable full wave rectifier, Current ratings of SCR, UJT: Construction, Operation, characteristics and application as a relaxation oscillator.

Differential Amplifier using transistor: The Differential Amplifier, DC and AC analysis of a differential amplifier, Input characteristic-effect of input bias, offset current and input offset voltage on output, common mode gain, CMRR

OpAmp Applications: Log amplifier, Instrumentation amplifiers, Voltage controlled current sources (grounded load), First order Active filters, Astable using OPAMP, square wave and triangular wave generator using OPAMP, Wein-bridge oscillator using OPAMP, Comparators with Hysteresis, Window Comparator, Transistor Multivibrators, 555 Timer: Review Block diagram, Monostable and Astable operation Voltage Controlled Oscillator, Pulse Width modulator, Pulse Position Modulator, Triggered linear ramp generator

Microprocessors and Microcontrollers, Analog and Data Acquisition Systems, Data Transmissions, Instrumentation Circuits & Designs, Instrumentation Circuits and Designs, Regulated DC power supply: Supply characteristics, series voltage regulator, Short circuit protection (current limit and fold back) Monolithic linear IC voltage regulators, Digital Communication Techniques: Digital Transmission of Data, Benefits of Digital Communication, Disadvantages of Digital Communication, Parallel and Serial Transmission, Pulse Modulation, Comparing Pulse-Modulation Methods

7. Solid State Devices : Semiconductor Physics: Classification of Semiconductors; Crystal structure, Energy band structure of Si, Ge & GaAs; Extrinsic and compensated Semiconductors; Temperature dependence of Fermi-energy and carrier concentration. Drift, diffusion and injection of carriers; Carrier generation and recombination processes- Direct recombination, Indirect recombination, Surface recombination, Auger recombination; Applications of continuity equation- Steady state injection from one side, Minority carriers at surface, Haynes Shockley experiment, High field effects. Hall Effect; Four-point probe resistivity measurement; Carrier lifetime measurement by light pulse technique

Semiconductor Devices: p-n junction, p-i-n diode, tunneling diode, Metal-Semiconductor Contacts, Bipolar Junction Transistor (BJT), Metal-semiconductor field effect transistor, MESFET, Modulation doped field effect transistor, MODFET, MOSFET fundamentals

8. Statistical Mechanics: Elements of Ensemble Theory- Phase space of a classical system, Liouville's theorem and its consequences, The microcanonical ensemble, The Canonical Ensemble, The Grand Canonical Ensemble, Formulation of Quantum Statistics- Quantum-mechanical ensemble theory: the density matrix, Statistics of the various ensembles, Examples, systems composed of indistinguishable particles, the density matrix and the partition function of a system of free particles.

9. Nuclear Physics : All static properties of nuclei (charge, mass, binding energy, size, shape, angular momentum, magnetic dipole moment, electric quadrupole moment, statistics, parity, isospin), Measurement of Nuclear size and estimation of R_0 , mirror nuclei and meson atom method Q -value equation, energy release in fusion and fission reaction, Deuteron Problem and its ground state properties, Estimate the depth and size of (assuming) square well potential, Tensor force as an example of non-central force, nucleon-nucleon scattering- qualitative discussion on results, Spin-orbit strong interaction between nucleon, double scattering experiment, Alpha decay, Beta decay, Gamma decay, Gamma ray interaction with matter, and Charge-particle interaction with matter,

Introduction to the elementary particle Physics : The Eight fold way, the Quark Model, the November revolution and aftermath, The standard Model, Revision of the four forces, Properties of Neutrino, helicity of Neutrino, Parity.

10. Atomic and Molecular Physics: Fine structure of hydrogenic atoms, Lamb shift. Hyperfine structure and isotope shift, Linear and quadratic Stark effect in spherical polar coordinates. Zeeman effect in strong and weak fields, Paschen-Back effect, Schrodinger equation for two electron atoms: Identical particles, The Exclusion Principle. Exchange forces and the helium atom (ER), independent particle model, ground and excited states of two electron atoms, The central field, Thomas-Fermi potential, The Hartree theory, ground state of multi-electron atoms and the periodic table, The L-S coupling approximation, allowed terms in L-S coupling, fine structure in L-S coupling, relative intensities in L-S coupling, j-j coupling approximation and other types of coupling

Interaction of one electron atom with electromagnetic radiation, Einstein coefficients, selection rules. Line intensities and lifetimes of excited state,

lineshapes and linewidths. X-ray spectra, Born-Oppenheimer approximation-rotational, vibrational and electronic energy levels of diatomic molecules, Linear combination of atomic orbitals (LCAO) and Valence bond (VB) approximations, comparison of valence bond and molecular orbital theories

11. Experimental Physics: Vacuum techniques, Fundamental processes at low pressures, Mean Free Path, Time to form monolayer, Number density, Materials used at low pressure, vapor pressure Impingement rate, Flow of gases, Laminar and turbulent flow, Production of flow pressures, Types of Pumps, High Vacuum Pumps and systems, Ultra High Vacuum Pumps and System, Nuclear Detectors: Gamma ray spectrometer using Na scintillation detector, High Purity Germanium detector, Multi-wire Proportional counter Accelerators: Cockroft Walton Generator, Van de Graaf Generator, Sloan and Lawrence type Linear Accelerator, Proton Linear Accelerator, Cyclotron and Synchrotron. Characterization techniques for materials analysis: Spectroscopy: XRD, XRF, XPS, EDAX, Raman, UV Visible spectroscopy, FTIR spectroscopy, Microscopy: SEM, TEM, AFM

References: As prescribed by University of Mumbai

Sample Question Paper Pattern for PET in Physics

SAMPLEQUESTIONS

(Source: <https://www.ugc.ac.in/net/syllabuspdf/00.pdf>)

I. Error Analysis

1. Not a type of Errors:

- (A) Gross Errors
- (B) Systematic Errors
- © Random Errors
- (D) All above are types of Errors

Key : (D)

2. Not a characteristic of Gross Errors:

- (A) Occurs because of the human mistakes.
- (B) Person using the instrument took the wrong reading
- © Record the incorrect data.
- (D) All the above are Gross Errors.

Key : (D)

3. Not a type of Systematic Errors

- (A) Instrumental Errors
- (B) Environmental Errors
- © Observational Errors
- (D) All above are Systematic Errors

Key : (D)

4. Not correct about the Random Errors:

- (A) Caused by the sudden change in the atmospheric condition.
- (B) Remains even after the removal of the systematic error.
- © Also called residual error.
- (D) All the above are correct

Key: (D)

5. Find the % Error in the Volume of a Sphere, if % error in the measurement of radius is 10 %. (A) 10%

- (B) 30 %
- © 33.1%
- (D) None

Key: (C)

II. Research Aptitude

1. A researcher is generally expected to:
(A) Study the existing literature in a field
(B) Generate new principles and theories
(C) Synthesize the ideas given by others
(D) Evaluate the findings of a study.
Key: (B)

2. One of the essential characteristics of research is:
(A) Replicability
(B) Generalizability
(C) Usability
(D) Objectivity
Key: (D)

3. The Government of India conducts Census after every 10 years. The method of research used in this process is :
(A) Case study
(B) Developmental
(C) Survey
(D) Experimental
Key: (C)

4. An academic association assembled at one place to discuss the progress of its work and future plans. Such an assembly is known as a
(A) Conference
(B) Seminar
(C) Workshop
(D) Symposium
Key: (A)

5. An investigator studied the census data for a given area and prepared a write-up based on them. Such a write-up is called:
(A) Research paper
(B) Article
(C) Thesis
(D) Research report
Key: (B)

III. Reading Comprehension

Read the following passage and answer the question Nos. 1 to 5

The Constitution guarantees every citizen the fundamental right to equality. Yet after 50 years of independence, just one perusal of the female infant mortality figures, the literacy rates and the employment opportunities for women is sufficient evidence that discrimination exists. Almost predictably, this gender bias is evident in our political system as well. In the 13th Lok Sabha, there were only 43 women MPs out of a total of 543; it is not a surprising figure, for never has women's representation in Parliament been more than 10 percent.

Historically, the manifestos of major political parties have always encouraged women's participation. It has been merely a charade. So, women's organizations, denied a place on merit, opted for the last resort: a reservation of seats for women in Parliament and State Assemblies. Parties, which look at everything with a vote bank in mind, seemed to endorse this. Alas, this too was a mirage.

But there is another aspect also. At a time when caste is the trump card, some politicians want the bill to include further quotas for women from among minorities and backward castes. There is more to it. A survey shows that there is a general antipathy towards the bill. It is actually a classic case of double speak: in public, politicians were endorsing women's reservation but in the backroom of Parliament, they were busy sabotaging it. The reasons are clear: Men just don't want to vacate their seats of power.

1. The problem raised in the passage reflects badly on our
(A) Political system
(B) Social behaviour
(C) Individual behaviour
(D) Behaviour of a group of people

Key: (B)

2. According to the passage, political parties have mostly in mind
(A) Economic prosperity
(B) Vote bank
(C) People's welfare
(D) Patriotism

Key: (B)

3. "Trump Card" means
(A) Trying to move a dead horse
(B) Playing the card cautiously
(C) Sabotaging all the moves by others
(D) Making the final jolt for success

Key: (D)

4. The sentence "Men just don't want to vacate their seats of power" implies
- (B) Lust for power
 - (C) Desire to serve the nation
 - (D) Conviction in one's own political abilities
 - (E) Political corruption

Key:(A)

5. What is the percentage of women in the Lok Sabha
- (A) 10
 - (B) 7.91
 - (C) 43
 - (D) 9.1

Key:(B)

IV. Communication

1. Informal communication network within the organization is known as
- (A) Interpersonal communication
 - (B) Intrapersonal Communication
 - (C) Mass Communication
 - (D) Grapevine Communication

Key:(D)

2. TV Channel launched for covering only Engineering and Technology subjects is known as
- (A) Gyan Darshan
 - (B) Vyas
 - (C) Eklavya
 - (D) Kisan

Key:(C)

3. In which state the maximum number of periodicals are brought out for public information:
- (A) Uttar Pradesh
 - (B) Tamil Nadu
 - (C) Kerala
 - (D) Punjab

Key:(C)

4. The main objective of public broadcasting system, i.e. Prasar Bharti is
- (A) Inform, Entertainment & Education
 - (B) Entertain, Information & Interaction
 - (C) Educate, Interact & entertain
 - (D) Entertainment only

Key:(A)

5. The competency of an effective communicator can be judged on the basis

- (A) Personality of communicator
- (B) Experience in the field
- (C) Interactivity with target audience
- (D) Meeting the needs of target audience.

Key:(D)

v. **Reasoning(IncludingMathematical)**

1. Which one of the following belongs to the category of homogeneous data:

- (A) Multi-storeyed houses in a colony.
- (B) Trees in a garden
- (C) Vehicular traffic on a highway
- (D) Student population in a class.

Key : (A)

2. In which of the following ways a theory is not different from a belief?

- (A) Antecedent—consequent
- (B) Acceptability
- (C) Verifiability
- (D) Demonstrability

Key : (B)

3. The state—“Honesty is the best policy” is

- (A) A fact
- (B) An value
- (C) An opinion
- (D) A value judgement

Key:(D)

4. Which one is like pillar, pole and standard?

- (A) Beam
- (B) Plank
- (C) Shaft
- (D) Timber

Key:(A)

5. Following incomplete series is presented. Find out the number which should come at the place of question mark which will complete the series:

4, 16, 36, 64?

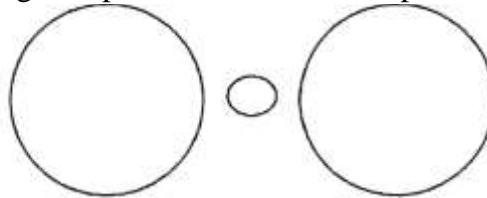
- (A) 300
- (B) 200
- (C) 100
- (D) 150

Key:(A)

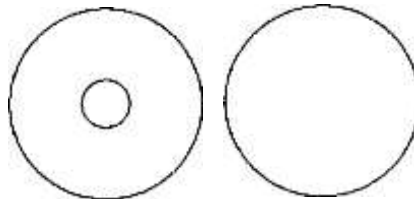
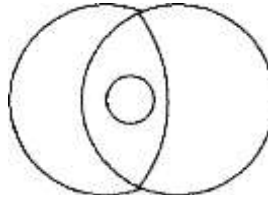
VI. Logical Reasoning

1) The following question is based on the diagram given below. If the two big circles represent animals living on soil and those living in water, and the small circle stands for the animals who both live on soil and in water, which figure represents the relationships among them.

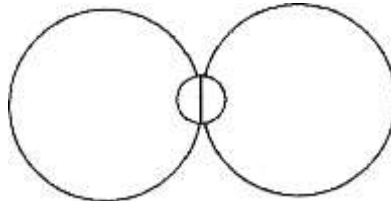
A)



B)



D)



Key : (D)

2. Of the following statements, there are two statements both of which cannot be true but both can be false. Which are these two statements?

- i) All machines make noise
- ii) Some machines are noisy
- iii) No machine makes noise
- iv) Some machines are not noisy

- (A) (i) and (ii)
- (B) (iii) and (iv)
- (C) (i) and (iii)
- (D) (ii) and (iv)

Key: (C)

3. In the following question a statement is followed by two assumptions (i) and (ii). An assumption is something supposed or taken for granted. Consider the statement and the following assumptions and decide which of the following assumptions is implicit in the statement.

Statement: We need not worry about errors but must try to learn from our errors.

Assumptions: i) Errors may take place when we are carrying out certain work.

ii) We are capable of benefiting from the past and improve our chances of error-free work.

- A) Only assumption (i) is implicit
- B) Only assumption (ii) is implicit
- C) Either assumption (i) or (ii) is implicit
- D) Both the assumptions are implicit

Key: (D)

4. The question below is followed by two arguments numbered (i) and (ii). Decide which of the arguments is 'strong' and which is 'weak'. Choose the correct answer from the given below:

(A) (B) (C) (D)

Should the press exercise some self-restraint?

i) Yes, they should not publish news items which may incite the readers to indulge in wrong practices.

ii) No, it is the responsibility of the press to present the truth irrespective of the consequences.

- A) Only the argument (i) is strong.
- B) Only the argument (ii) is strong.
- C) Neither argument (i) nor argument (ii) is strong.
- D) Both the arguments (i) and (ii) are strong.

Key: (A)

5. Study the argument and the inference drawn from that argument, given below carefully.

Argument: Anything that goes up definitely falls down. Helicopter goes up.

Inference: So the helicopter will definitely fall down.

What is your opinion on the inference drawn from the argument?

- A) Valid
- B) Invalid
- C) Doubtful
- D) Long drawn none

Key: (D)

VII. Data Interpretation

Four students W, X, Y, Z appeared in four papers, I, II, III and IV in a test. Their scores out of 100 are given below:

Students	Papers			
	I	II	III	IV
W	60	81	45	55
X	59	43	51	A
Y	74	A	71	65
Z	72	76	A	68

Where 'A' stands for absent

Read the above table and answer below mentioned questions i-v.

1. Which candidate has secured between 60-65% marks in aggregate

- A) W
- B) X
- C) Y
- D) Z

Key : (A)

2. Who has obtained the lowest average in aggregate

- A) W
- B) X
- C) Y
- D) Z

Key : (B)

3. Who has obtained the highest average

- A) W
- B) X
- C) Y
- D) Z

Key : (A)

4. In which paper the lowest marks were obtained by the candidates

- A) I
- B) II
- C) III
- D) IV

Key : (B)

5. Which candidate has secured the highest percentage in the papers appeared

- A) W
- B) X
- C) Y
- D) Z

Key : (D)

VIII. Information and Communication Technology (ICT)

1. ICT stands for
(A) Information commontechonology
(B) Information and communication technology
(C) Information and computer technology
(D) Interconnected technology

Key: (B)

2. Computer can
(A) Process both quantitative and qualitative information. (B) Store huge information
(C) Process information and fast accurately
(D) All the above.

Key: (D)

3. Satellite Communication work through
(A) Radar
(B) Transponder
(C) Receptor
(D) Transmitter

Key : (B)

4. A computer is that machine which works more like a human brain. This definition of computer is
(A) Correct
(B) Incorrect
(C) Partially correct
(D) None of the above.

Key: (A)

5. Informal ion and communication technology includes
(A) E-mail
(B) Internet
(C) Educational television
(D) All the above.

Key: (D)

m. People and Environment

1. It is believed that our globe is warming progressively. This global warming will eventually result in.
(A) increase in availability of usable land.
(B) uniformity of climate at equator and poles.
(C) Fall in the sea level
(D) melting of polar ice.

Key: (D)

2. In which part of India groundwater is affected with arsenic contamination?
 (A) Haryana
 (B) Andhra Pradesh
 (C) Sikkim
 (D) West Bengal
 Key: (D)
3. Sunderban in Hooghly delta is known for
 (A) Grasslands
 (B) Conifers
 (C) Mangroves
 (D) Arid forests
 Key: (C)
4. Sardar Sarovar dam is located on the river
 (A) Ganga
 (B) Godavari
 (C) Mahanadi
 (D) Narmada
 Key: (D)
5. Which one of the following trees has medicinal value?
 (A) Pine
 (B) Teak
 (C) Neem
 (D) Oak
 Key: (C)

x. Digheer Education System: Governance, Polity And Administration

1. Which one of the following is not considered a part of technical education in India:
 (A) Medical
 (B) Management
 (C) Pharmaceutical
 (D) Aeronautical
 Key: (A)
2. Which of the following is a Central university
 (A) Mumbai University
 (B) Calcutta University
 (C) Delhi University
 (D) Madras University
 Key: (C)

3. Identify the main principle on which the Parliamentary System operates.

- (A) Responsibility of Executive to Legislature
- (B) Supremacy of Parliament
- (C) Supremacy of Judiciary
- (D) Theory of Separation of Power

Key:(A)

4. The reservation of seats for women in the Panchayat Raj Institutions is:

- A) 30% of the total seats
- B) 33% of the total seats
- C) 33% of the total population
- D) In proportion to their population.

Key:(B)

5. Match list I with list II and select the correct answer from the code given below:

- | LIST I (Institutions) | LIST II (LOCATIONS) |
|--|---------------------|
| 1) Indian Veterinary Research Institute | i) Pune |
| 2) Institute of Armament Technology | ii) Izat Nagar |
| 3) Indian Institute of Science | iii) Delhi |
| 4) National Institute for Educational Pannesi Administrators | iv) Bangalore And |
- A) 1(iü), 2(i)3(iv), 4(iü)
 - B) 1(ii), 2(iv)3(ii),4(iü)
 - C) 1(iü), 2(iü)3(i),4(iv)
 - D) 1(iv),2(iii)3(iü),4(i)

Key:(A)