No.03-03/2025-PSC(R-II)   **Dated: 27-01-2026**

Syllabus for Paper-II i.e. Descriptive type Subject Aptitude Test (SAT) for recruitment to post of Assistant Director (Voice Analysis), Group-A (Job Trainee) in the Directorate of Forensic Services, Home Department, H.P. The SAT paper shall be of 03 hours duration having 120 marks. The SAT paper shall have two parts, i.e. Part-I and Part-II and shall cover following topics of Master Degree in Forensic Science/ Physics/ Mathematics/ Multimedia Forensics level.

Part-I (60 Marks)

1. General Forensic Science:-

- **Introduction to Forensic Science:** Definition, nature and scope of forensic Science in the crime investigation.

- **History and Development of Forensic Science-** The evolution of scientific investigation methods and techniques, Forensic science set-ups in the national and international forum, FBI, GEQD etc. Modern instrumental methods viz. LVA (Layered Voice analysis), audio comparison and video comparison, BEOS (Brain Oscillation Electrical Signature) DNA Profiling and Digital Forensics etc.

- **Principles of Forensic Science -** Locard's Exchange Principle, Law of natural variation, law of comparison, law of probability, law of individualisation etc.

- **Scope of Forensic Science-** Multidisciplinary and multi professional nature, need of forensic Science.

- **Crime Scene Management-** Systematic approach in crime scene investigation including securing the scene, identifying evidence, collection, packaging and forwarding of evidence, chain of custody etc. photography, videography, 3D recording, sketching and notes preparation, various search methods. The reconstruction of crime scene, hypothesis formulation, testing of Hypothesis.

- **Type of Evidences-** Physical, digital and trace evidence, location and identifying evidence. The significance of evidence in linking perpetrator to the crime, d-linking innocent. Standard Operating instructions for collection of Physical, Digital and trace evidence from scene of crime.

- **Chemometrics:** Introduction to chemometrics; application of statistical tools in interpretation of data, multivariate analysis (PCA, PLS, cluster analysis,discriminant analysis); calibration models; pattern recognition; and their applications.

- **Reportwriting-** Preparation of scientific test report, essentials of reportadmissibility of test reports.Writing of scene of crime reports. Expert testimony, Examination-in-chief, cross-examination, re-examination. Related Laws -BNS, BNSS, BSA 2023, IT Act 2000, POCSO Act, NDPS Act, MVA Act etc.

- **Concept of Quality Management System-** ISO/IEC 17025, ISO 9001 standard, accreditation,certification, Calibration, proficiency testing, blind testing, inter and intra laboratory comparison, internal audit, uncertainty measurement, Z score,limitofdetection (LOD), limit of quantification (LOQ) Verification and validation methods.

- **Laboratory Information Management Systems –** The management of laboratory information, protection of data, traceability of record andtransparency in laboratory operations.

- **Research Methodology -** Research design, hypothesis formulation, sampling, data collection techniques, statistical interpretation, literature review, and scientific paper writing skills. Plagiarism - types of plagiarism, plagiarism detection tools, and ethical responsibilities in research and report preparation. Citation index and impact factor.

- **Ethics -** Impartiality, honesty, confidentiality and adherence to professional conduct throughout forensic practice.

Part-II (60 Marks)

1. ## Physics of Sound and Speech Science:

- **Fundamentals of Sound** -Voltage and intensity of sound signals and their relation, Concept of sound pressure levels (SPL) and Decibels (dB);Key acoustic parameters and their significance, and application in forensic audio analysis; Vibrating systems and sound generation; Doppler Effect, use of Doppler effect for forensic timestamp verification,micro doppler effect-the tiny frequency shift caused by the micro-motion; Frequency measurements and pitch perception.

- **Acoustic Environment & Audio Characteristics** - Reverberation and echo patterns, Room acoustics, effect on environmental factors on audio recording, noise characteristics, Factors of harmonic distortion, importance of harmonic distortion in forensic investigation, dynamic rangeand its evaluation, Signal-to-noise ratio (SNR) and its role in clarity assessment.

- **Audio Spectrum & Signal Analysis**- Spectrum analysis fundamentals, Fourier Analysis and Fourier Transform, Spectral representation used in audio and speech processing, Understanding frequency domain vs time domain, Types and characteristics of speech signals.

- **Audio Recording Technologies** - Basic electric circuits related to audio systems, Analog recorders: types, working principles, Digital recorders: formats, advantages, limitations, Analog vs digital sound recording methods, Microphones: types, working principles, forensic significance,Sampling theories (Nyquist theorem), Methods of Analog-to-Digital Conversion (ADC).

- **Audio Enhancement & Processing** - Audio enhancement techniques, Noise reduction and filtering, Echo cancellation and reverberation control, Equalization, compression, and dynamic processing, Type and applications of signal processing (linear, nonlinear, digital, adaptive), Computer-based representations of speech used in forensic examination.

- **Speech Science & Production Mechanisms** - Organs of speech production, Mechanismof human speech production, Acoustic features of speech, Phonetic and linguistic aspects relevant to forensic speech analysis, Variability in speech due to physiology, accent, and environment.

- **Forensic Applications of Audio & Speech Analysis** - Examination of disputed recordings, Enhancement of audio and video, Identification and comparison of speakers, Analysis of background noises and environmental cues, Authenticity and verification of audio recordings.

2. <u>Voice Identification and Authentication:</u>

- **Fundamentals of Voice Identification**- Principles of voice identification, importance of voice comparison, History and evolution of voice analysis, Scope of voice identification in forensic science.

- **Voice Production & Speaker Characteristics**- Theory of human voice production, Role of articulators and vocal tract in speech generation, Relationship between physiology and speaker characteristics, Acoustic and phonetic foundations of voice signals.

- **Components & Features of Voice Identification**- Feature extraction techniques : MFCC (Mel Frequency Cepstral Coefficients), PLP (Perceptual Linear Prediction),

- **GFCC (Gammatone Frequency Cepstral Coefficients), Prosodic features:** Pitch, intensity, rhythm, Formant mapping and resonance characteristics, Pitchsynchronous analysis, Voice quality measures: jitter, shimmer, HNR (Harmonic-to-Noise Ratio), Speaker profiling approaches, Normalization techniques to reduce variability.

- **Speech Signal Processing & Enhancement-** Noise reduction techniques, Enhancement of speech/ audio recordings, Pre-processing methods for forensic analysis, Methods to isolate, segment, and clean speech samples, Time-domain and frequency-domain representation of

speech signals, Fourier Analysis and its applications, Analog-to-digital conversion principles (ADC).

- **Approaches to Voice Identification**- Segregation and preparation of speech samples, Listener's/auditory analysis approach, Spectrographic approach (visual comparison), Automatic voice identification systems (machine-based), Pattern recognition algorithms for matching and comparison Acoustic parameters used: Formant frequencies, Pitch and intensity, Duration and temporal patterns, Harmonic structure.

- **Phonetic & Linguistic Analysis-** Phonetic transcription techniques, Linguistic markers relevant to forensic voice comparison, Prosodic and segmental analysis, Temporal measurements and speech rhythm studies.

- **Authenticity Examination of Audio Samples**- Types of audio alterations, Detection of tampering and splicing, Compression tampering detection, Error Level Analysis (ELA), Waveform anomalies and micro-pauses, Electrical Network Frequency (ENF) analysis, Metadata analysis for authenticity verification.

- **Challenges, Reliability & Legal Aspects-** Present scenario of voice identification techniques, Challenges faced in forensic laboratories, Accuracy and reliability concerns, Sources of error and variability, Legal acceptability and admissibility issues, Standardsand guidelines for forensic voice examination.

3. **<u>Introduction to Artificial Intelligence (AI) and Machine Learning (ML):</u>**

- **Foundations of AI & Data Processing-**Basics of data processing, Feature extraction and feature engineering, Data cleaning, normalization, and transformation, Dataset preparation for audio and video signal.

- **Machine Learning Techniques for Forensics**- Supervised learning techniques (classification, regression), Unsupervised learning techniques (clustering, dimensionality reduction), Anomaly detection approaches, Model evaluation, accuracy, precision, recall, F1-score.

- **Intrusion & Threat Detection Systems**- Concepts of intrusion detection, Signature-based and anomaly-based IDS, ML-based intrusion detection frameworks and their Applications.

- **AI/ML Applications in Multimedia Forensics-**AI in image forensics (forgery detection, object tampering), ML applications in video forensics (frame duplication, manipulation), AI-based audio forensics (voice alteration, noise pattern analysis), Cross- modal analysis combining image, audio, text, and metadata.

- **Ethical, Legal & Reliability Issues in AI-**AI in crime scene analysis and reconstruction, Bias & Fairness in AI data analysis, Accountability and Reliability of AI data, Falsepositives and false negatives in AI systems, Ethical considerations and privacy concerns.

- **Deepfake & Synthetic Media-**Deepfake technology: GANs and AI-driven face swapping, Synthetic media generation (audio, video, images), AI-based manipulation techniques and emerging threats, Challenges and Limitations of synthetic content on investigations.

- **AI-Based Tampering & Manipulation Detection-** AI techniques for detecting manipulated digital content, Deepfake detection methods, Audio-video integrity verification, Metadata-based and signal-level authentication, Hybrid approachescombining ML, forensic tools, and manual review. Merits and shortcomings of hybrid approaches.

<div align="center">

Sd/
Secretary
H. P. Public Service Commission

</div>