Roll No. .....

Question Booklet Number

O. M. R. Serial No.

M. A./M. Sc. (Fourth Semester)
(NEP) EXAMINATION, 2025-26
MATHEMATICS
(Cosmology) (Elective)

Paper Code							
B	0	3	1	0	1	1	T

Questions Booklet Series
A

Time : 1:30 Hours] [*Maximum Marks : 75*

Instructions to the Examinee :

1. Do not open the booklet unless you are asked to do so.

2. The booklet contains 100 questions. Examinee is required to answer 75 questions in the OMR Answer-Sheet provided and not in the question booklet. All questions carry equal marks.

3. Examine the Booklet and the OMR Answer-Sheet very carefully before you proceed. Faulty question booklet due to missing or duplicate pages/questions or having any other discrepancy should be got immediately replaced.

परीक्षार्थियों के लिए निर्देश :

1. प्रश्न-पुस्तिका को तब तक न खोलें जब तक आपसे कहा न जाए।

2. प्रश्न-पुस्तिका में 100 प्रश्न हैं। परीक्षार्थी को 75 प्रश्नों को केवल दी गई OMR आन्सर-शीट पर ही हल करना है, प्रश्न-पुस्तिका पर नहीं। सभी प्रश्नों के अंक समान हैं।

3. प्रश्नों के उत्तर अंकित करने से पूर्व प्रश्न-पुस्तिका तथा OMR आन्सर-शीट को सावधानीपूर्वक देख लें। दोषपूर्ण प्रश्न-पुस्तिका जिसमें कुछ भाग छपने से छूट गए हों या प्रश्न एक से अधिक बार छप गए हों या उसमें किसी अन्य प्रकार की कमी हो, तो उसे तुरन्त बदल लें।

(Remaining instructions on the last page) **(शेष निर्देश अन्तिम पृष्ठ पर)**

(Only for Rough Work)

1. According to Mach's principle, what determines the local inertial frame of reference ?

(A) The geometry of empty space.

(B) The local gravitational field of the Earth.

(C) The large-scale distribution of matter in the universe.

(D) The velocity of light

2. Which force appears due to the acceleration of a non-inertial frame ?

(A) Centripetal force

(B) Centrifugal force

(C) Gravitational force

(D) Pseudo force

3. What is suitable for inertial reference frame ?

(A) Steady state of motion

(B) Simple harmonic motion

(C) Changing state of motion

(D) None of the above

4. Who gave the term "Mach's Principle" ?

(A) Ernst Mach

(B) Isaac Newton

(C) Albert Einstein

(D) Hendrik Lorentz

5. Who introduced cosmological constant ?

(A) Isaac Newton

(B) Albert Einstein

(C) Edwin Hubble

(D) Ernst Mach

6. What defines to Einstein tensor $G_{\mu\nu}$?

(A) $R_{\mu\nu} + \frac{1}{2} R g_{\mu\nu}$

(B) $R_{\mu\nu} - R g_{\mu\nu}$

(C) $R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu}$

(D) $R_{\mu\nu} + R g_{\mu\nu}$

7. Which is Einstein modified field equation ?

(A) $R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \frac{8\pi G}{C^4} T_{\mu\nu}$

(B) $R_{\mu\nu} + \wedge g_{\mu\nu} = \frac{8\pi G}{C^4} T_{\mu\nu}$

(C) $R_{\mu\nu} - \wedge g_{\mu\nu} = \frac{8\pi G}{C^4} T_{\mu\nu}$

(D) $R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \wedge g_{\mu\nu} = \frac{8\pi G}{C^4} T_{\mu\nu}$

8. What does $\wedge g_{\mu\nu}$ represent in the field equation ?

(A) Vacuum energy density

(B) Curvature of space

(C) Energy-momentum tensor

(D) None of the above

9. Why Einstein introduced cosmological constant ?

(A) To explain galaxy rotation

(B) To obtain a static universe

(C) To explain black holes

(D) To describe gravitational wave

10. If cosmological constant $\wedge = 0$, then equation is :

(A) Maxwell equation

(B) Original Einstein field equation

(C) Newton's law of gravity

(D) Schrodinger equation

11. When the cosmological constant $\wedge$ is positive, it behaves as ..... .

(A) Attractive force

(B) A variable speed of light

(C) A zero point energy

(D) A repulsive force or anti-gravity

12. What denotes stress-Energy tensor ?

(A) $T_{\alpha\beta}$

(B) $\tau_{\alpha\beta}$

(C) $t_{\alpha\beta}$

(D) None of the above

13. Stress-Energy tensor is also called ..... .

(A) Repulsive tensor

(B) Asymmetrical tensor

(C) Symmetrical tensor

(D) None of the above

14. Einstein tensor is also called :

(A) Ricci tensor

(B) Metric tensor

(C) Symmetrical tensor

(D) None of the above

15. Einstein field equations describe gravity as .....

(A) A zero-point energy

(B) Curvature of space time

(C) Attractive force

(D) Repulsive force

16. What does cosmological constant ($\wedge$) represent ?

(A) The intrinsic energy density of space.

(B) The external energy density of space.

(C) The intrinsic energy density of earth.

(D) The external energy density of earth.

17. What represents matter and energy content of space time ?

(A) $\wedge$

(B) $G_{\mu\nu}$

(C) $T_{\mu\nu}$

(D) None of the above

18. What fundamentally Einstein field equation states ?

(A) $G_{\mu\nu} = T_{\mu\nu}$

(B) $G_{\mu\nu} \neq T_{\mu\nu}$

(C) $G_{\mu\nu} \propto \frac{1}{T_{\mu\nu}}$

(D) $G_{\mu\nu} \propto T_{\mu\nu}$

19. What is Einstein static universe ?

(A) Stable

(B) Unstable

(C) Periodic

(D) Chaotic

20. Which is correct for Einstein static universe ?

(A) The universe expands with time

(B) The scale factor is constant

(C) The scale factor decreases

(D) The universe oscillates

21. What is spatial geometry of the universe according to Einstein static universe ?

(A) Flat

(B) Closed and positively curved

(C) Hyperbolic

(D) Infinite

22. What is the expansion of space in a De-Sitter universe ?

(A) Accelerating

(B) Decelerating

(C) Linear

(D) Zero

23. The De-Sitter universe is a maximally symmetric space with ..... .

(A) Varying curvature

(B) Zero curvature

(C) Constant negative curvature

(D) Constant positive curvature

24. In De-Sitter model, what is the main reason of the expansion of the universe ?

(A) Radiation pressure

(B) Magnetic fields

(C) Cosmological constant

(D) Matter density

25. Which component makes the majority of the total mass-energy density of the universe ?

(A) Ordinary matter

(B) Dark matter

(C) Dark energy

(D) Light

26. How does the actual universe behave according to modern cosmology ?

(A) It is expanding at an accelerating rate.

(B) It is static and unchanging.

(C) It has a well defined center.

(D) It is contracting

27. Which of the following equations represents Hubbles' law ?

(A) $v = H_0 \times d$

(B) $v = \frac{H_0}{d}$

(C) $v = \frac{d}{H_0}$

(D) $v = H_0 + d$

28. What is the commonly used unit for the Hubble constant (H_0)?

(A) M_{pc}/km

(B) M_{pc}/km/s

(C) km/M_{pc}/s

(D) km/s/M_{pc}

29. What is the relative velocity of two stars, according to Hubble's law ?

(A) It is directly proportional to the square of their separation.

(B) It is inversely proportional to the square of their separation.

(C) It is directly proportional to their separation.

(D) It is inversely proportional to their separation.

30. What phenomenon in galactic light spectra supports Hubble's law ?

(A) Polarization

(B) Diffraction

(C) Blueshift

(D) Redshift

31. What cosmological principle states about the universe ?

(A) Only isotropic

(B) Homogeneous and isotropic on large scales

(C) Different in every direction

(D) Static and infinite

32. What is term isotropic means in cosmology ?

(A) Same in all directions

(B) Same at every location

(C) Same density everywhere

(D) Same temperature everywhere

33. According to the cosmological principle, the large-scale, distribution of matter in the universe is .....

(A) Infinite only in one direction

(B) Concentrated only near galaxies

(C) Uniform

(D) Completely irregular

34. According to Weyl's postulate, the world lines of galaxies form :

(A) Random curves

(B) Parallel geodesics

(C) Intersecting paths

(D) Circular paths

35. Weyl's postulate assumes that galaxies move in such a way that their world lines .....

(A) Intersect frequently
(B) Never intersect
(C) Move in closed loops
(D) Are completely random

36. How galaxies are treated in Weyl's postulate ?

(A) Test particles in the universe
(B) Electromagnetic waves
(C) Black holes
(D) Quantum particles

37. What Weyl's postulate assumes about the behaviour of galaxies ?

(A) A continuous distribution of dust
(B) Solid rigid bodies
(C) Charged particles
(D) Independent stars

38. On which two fundamental pillars of physical cosmology derivation of Robertson-Walker metric is based ?

(A) Static and anisotropic
(B) Inhomogeneous and anisotropic
(C) Homogeneous and isotropic
(D) Static and homogeneous

39. Which co-ordinates are generally used in Robertson-Walker metric ?

(A) Cartesian
(B) Polar
(C) Cylindrical
(D) Spherical

40. What denotes the scale factor in the Robertson-Walker metric ?

(A) H (t)
(B) $k(t)$
(C) $\rho(t)$
(D) $a(t)$

41. Which one denotes Hubble parameter ?

(A) $\frac{a}{\dot{a}}$
(B) $\frac{\dot{a}}{a}$
(C) $\frac{a}{\ddot{a}}$
(D) $\frac{\ddot{a}}{a}$

42. Which one defines deceleration parameter q ?

(A) $-\frac{a\,\ddot{a}}{\dot{a}^2}$
(B) $-\frac{\ddot{a}}{\dot{a}^2}$
(C) $-\frac{\dot{a}}{a}$
(D) $-\frac{a}{\dot{a}}$

43. If $q > 0$, then the universe is ..... .

(A) Decelerating
(B) Accelerating
(C) Static
(D) Contracting

44. What is the deceleration parameter for a matter-dominated universe ?

(A) 1

(B) 0

(C) $\frac{1}{2}$

(D) – 1

45. Which of the following is not a type of redshift ?

(A) Doppler

(B) Gravitational

(C) Cosmological

(D) Thermal

46. Redshift in galaxies was first systematically observed by whom ?

(A) Albert Einstein

(B) Edwin Hubble

(C) Isaac Newton

(D) None of the above

47. The graph between redshift and distance for nearly galaxies is .....

(A) Parabolic

(B) Hyperbolic

(C) Straight line

(D) Circular

48. In a standard Friedmann – Lemaitre – Robertson – Walker universe, which formula relates angular diameter distance (d_A) to the luminosity distance (d_L) and redshift (z) ?

(A) $d_A = d_L(1+z)$

(B) $d_A = \frac{d_L}{(1+z)}$

(C) $d_A = d_L(1+z)^2$

(D) $d_A = \frac{d_L}{(1+z)^2}$

49. In Robertson-Walker spacetime, for a constant co-moving number density of sources, the differential number count $\left(\frac{d_N}{d_Z}\right)$ is proportional to ..... .

(A) $\frac{r^2 dr}{dz}$

(B) $\frac{r dr}{dz}$

(C) $(1+r)\frac{dr}{dz}$

(D) $(1+r)^2\frac{dr}{dz}$

50. As redshift (z) increases, the angular size (θ) of an object of fixed physical size in an expanding universe generally .....

(A) Decreases monotonically

(B) Increases monotonically

(C) Decrease, hits a minimum, and then increases

(D) Remains constant

51. In an expanding FLRW universe, what affects the number of sources observed within a redshift shell *dz* ?

(A) Time dilation

(B) Volume change

(C) Redshifting of luminosity

(D) All of the above

52. What is the approximate value of the redshift at which the angular size of a standard rod becomes minimum in a flat matter-dominated universe ?

(A) $z \approx 0.1$

(B) $z \approx 1.25$

(C) $z \approx 5$

(D) $z \approx 10$

53. Which one belongs for the number of sources brighter than flux S, in a static Euclidean universe with uniform source density ?

(A) $N(>S) \propto S^{3/2}$

(B) $N(>S) \propto S^{-3/2}$

(C) $N(>S) \propto S^{2/3}$

(D) $N(>S) \propto S^{-2/3}$

54. Upon what the Comoving volume element depends, in Robertson – Walker cosmology ?

(A) Redshift and cosmological parameters

(B) Only flux

(C) Only angular size

(D) Only time

55. What is the main function of the Friedmann equation in the context of modern cosmology ?

(A) To model the expansion of the universe

(B) To describe the behavior of black holes

(C) To track planetary orbits

(D) To calculate the mass of stars

56. The Friedmann equations are obtained by applying Einstein's field equations to which spacetime metric ?

(A) Einstein metric

(B) Newton metric

(C) Robertson – Walker metric

(D) None of the above

57. What is represented by the parameter *k* in Friedmann models ?

(A) Density of radiation

(B) Spatial curvature of the universe

(C) Hubble constant

(D) Cosmological constant

58. The density parameter is defined as $\Omega = \frac{\rho}{\rho_c}$. If $\Omega > 1$, the universe is .....

(A) Open

(B) Closed

(C) Flat

(D) Static

59. How the scale factor evolves in a matter-dominated Friedmann universe with $k = 0$?

(A) $a(t) \propto t^{3/2}$

(B) $a(t) \propto t^{2/3}$

(C) $a(t) \propto t^{1/2}$

(D) $a(t) \propto t$

60. Why did matter eventually dominate over radiation in the Friedmann model ?

(A) Radiation density diluted faster during expansion

(B) Matter was created later

(C) Radiation turned into dark

(D) Matter is heavier than light

61. The fundamental equation of dynamical cosmology is commonly known as .....

(A) Friedmann equation

(B) Maxwell equation

(C) Poisson equation

(D) None of the above

62. The Friedmann equation are derived from .....

(A) Planck radiation law

(B) Newton's law of gravitation

(C) Maxwell equations

(D) Einstein field equations

63. Which one is related to the first Friedmann equation ?

(A) Temperature and density

(B) Pressure and entropy

(C) Expansion rate and energy density

(D) Luminosity and distance

64. What values can the curvature parameter k take in cosmology ?

(A) 0 only

(B) $\pm$ 1 only

(C) 0, + 1, – 1

(D) Any real number

65. The critical density of the universe is proportional to :

(A) H^2

(B) $\sqrt{H}$

(C) H

(D) $\frac{1}{H^2}$

66. What will be the geometry of the universe, if the average density of the universe is greater than the critical density ?

(A) Open

(B) Closed

(C) Flat

(D) Hyperbolic

67. The critical density of the universe is the density required for the universe to be ..... .

(A) Expanding forever

(B) Contracting

(C) Closed

(D) Statically flat

68. From which equation the concept of critical density arises ?

(A) Friedmann equation

(B) Einstein equation

(C) Maxwell equation

(D) Boltzmann equation

69. What is the approximate age of the universe ?

(A) 1 billion years

(B) 4.5 billion years

(C) 13.8 billion years

(D) 20 billion years

70. By which observation the age of the universe is estimated ?

(A) Expansion of the universe

(B) Rotation of the stars

(C) Rotation of the earth

(D) Number of stars

71. The universe began with a massive explosion known as ..... .

(A) Solar Burst

(B) Cosmic Bang

(C) Big Bang

(D) Stellar Blast

72. What crucial event marked the beginning of the matter-dominated era ?

(A) Big Bang Nucleosynthesis

(B) Recombination

(C) Inflation

(D) The first supernovas

73. How did the density of matter change as the universe expanded during this era ?

(A) It remained constant

(B) It decreased proportional to $\frac{1}{a^2}$

(C) It decreased proportional to $\frac{1}{a^3}$

(D) It increased

74. What was the state of matter during the early part of matter dominated era ?

(A) Neutral Hydrogen and Helium gas

(B) Solid rocks

(C) Ionized plasma

(D) Supermassive black holes

75. According to the Einstein-De-Sitter model, what does the universe mainly contain ?

(A) Radiation

(B) Dark energy

(C) Matter

(D) None of the above

76. In Einstein-De-Sitter model, the universe expands but the rate of expansion ..... .

(A) Gradually slows down due to gravity

(B) Increases due to dark energy

(C) Remains constant

(D) Stops immediately

77. What is meant by "dust", in Einstein-De-Sitter model.

(A) Cosmic rays

(B) Non-relativistic matter

(C) Dark energy

(D) Relativistic radiation

78. The particle horizon increases with time because ..... .

(A) The universe expands and light travels longer distances.

(B) Stars produce more light

(C) Dark matter disappears

(D) Galaxies collide

79. Which of the following horizon depends strongly on the future expansion of the universe ?

(A) Particle horizon

(B) Stellar horizon

(C) Galactic horizon

(D) Event horizon

80. Why the concept of particle and event horizons arises ?

(A) Magnetic fields in space

(B) Nuclear reactions in State

(C) Rotation of galaxies

(D) Expansion of the universe

81. The particle horizon limits ..... .

(A) Past observations of the universe

(B) Future observations

(C) Stellar evolution

(D) Planet formation

82. Who proposed Big Bang theory ?

(A) Georges Lemaitre

(B) Arthur Eddingtion

(C) Fred Hoyle

(D) Sir Hermann Bondi

83. What cosmological constant represents in the Eddingtion – Lemaitre model ?

(A) Dark Matter

(B) Matter creation

(C) Vacuum energy causing repulsive gravity

(D) Radiation pressure

84. How the universe initially remains in the Eddington – Lemaitre model ?

(A) Nearly static for a long time
(B) Rapidly expanding
(C) Contracting
(D) Completely empty

85. Who first pointed out the instability of Einstein static universe ?

(A) Edwin Hubble
(B) Arthur Eddington
(C) Georges Lemaitre
(D) Albert Einstein

86. The perfect cosmological principle is the basis for which cosmological theory ?

(A) The Big Bang theory
(B) The Oscillating Universe theory
(C) The steady state theory
(D) All of the above

87. Discovery of what strongly supported the perfect cosmological principle ?

(A) Cosmic Microwave Background
(B) Cosmic Matter Background
(C) Cosmic Microwave Black hole
(D) None of the above

88. How is universe according to the perfect cosmological principle ?

(A) Homogeneous only in space
(B) Isotropic only in space
(C) Same in both space and time
(D) Different in different epochs

89. Which observation contradicts the perfect cosmological principle ?

(A) Large scale structure of galaxies
(B) The expansion of the universe
(C) The inflationary model
(D) The evolution of quasars and galaxies over time

90. According to the perfect cosmological principle, what happens to the density of the universe as it expands ?

(A) It remains constant
(B) It decreases
(C) It increases
(D) It fluctuates randomly

91. The steady state theory is based on the perfect cosmological principle, which states that the universe is ..... .

(A) Homogeneous and isotropic in space only.
(B) Homogeneous and isotropic in space and time.
(C) Changing its physical state over time.
(D) Finite in size but infinite in age.

92. Who proposed the steady state theory of the universe ?

(A) Edwin Hubble and Albert Einstein
(B) Georges Lemaitre and Alexander Friedmann
(C) Fred Hoyle, Hermann Bondi and Thomas Gold
(D) Einstein and De-Sitter

93. According to the steady state theory, as the universe expands, what happens to maintain its density ?

(A) Matter is continuously created

(B) Matter is converted into energy

(C) The expansion rate slows down

(D) Black holes consume excess space

94. According to the steady state cosmology, the universe ..... .

(A) has a definite beginning

(B) is expanding but its large-scale properties remain constant

(C) will eventually collapse

(D) is static and non-expanding

95. Which field is introduced by Fred Hoyle to explain matter creation ?

(A) $\wedge$-field

(B) H-field

(C) G-field

(D) C-field

96. The Eddington-Lsemaitre model helped to explain which observational evidence ?

(A) Black hole evaporation

(B) Hubble's law of galaxy recession

(C) Stellar nucleosynthesis

(D) None of the above

97. The Matter-Dominated era followed which era of the universe ?

(A) Inflationary epoch

(B) Dark energy era

(C) Radiation-Dominated era

(D) Planck epoch

98. Redshift is measured by observing the shift in ..... .

(A) Brightness

(B) Spectral lines

(C) Temperature

(D) Luminosity

99. The cosmological principle is most valid when the universe is observed on ..... .

(A) Planetary scales

(B) Stellar scales

(C) Galactic scales

(D) Very large cosmic scales

100. Weyl's postulate is important for constructing the standard models of ..... .

(A) Relativistic cosmology

(B) Minkowski space

(C) Circular paths

(D) None of the above

(Only for Rough Work)

4. Four alternative answers are mentioned for each question as—A, B, C & D in the booklet. The candidate has to choose the correct answer and mark the same in the OMR Answer-Sheet as per the direction :

Example :

Question :

Q. 1 (A) ● (C) (D)
Q. 2 (A) (B) ● (D)
Q. 3 (A) ● (C) (D)

Illegible answers with cutting and over-writing or half filled circle will be cancelled.

5. Each question carries equal marks. Marks will be awarded according to the number of correct answers you have.
6. All answers are to be given on OMR Answer Sheet only. Answers given anywhere other than the place specified in the answer sheet will not be considered valid.
7. Before writing anything on the OMR Answer Sheet, all the instructions given in it should be read carefully.
8. After the completion of the examination candidates should leave the examination hall only after providing their OMR Answer Sheet to the invigilator. Candidate can carry their Question Booklet.
9. There will be no negative marking.
10. Rough work, if any, should be done on the blank pages provided for the purpose in the booklet.
11. To bring and use of log-book, calculator, pager and cellular phone in examination hall is prohibited.
12. In case of any difference found in English and Hindi version of the question, the English version of the question will be held authentic.

Impt. : On opening the question booklet, first check that all the pages of the question booklet are printed properly. If there is any discrepancy in the question Booklet, then after showing it to the invigilator, get another question Booklet of the same series.

4. प्रश्न-पुस्तिका में प्रत्येक प्रश्न के चार सम्भावित उत्तर—A, B, C एवं D हैं। परीक्षार्थी को उन चारों विकल्पों में से सही उत्तर छाँटना है। उत्तर को OMR आन्सर-शीट में सम्बन्धित प्रश्न संख्या में निम्न प्रकार भरना है :

उदाहरण :

प्रश्न :

प्रश्न 1 (A) ● (C) (D)
प्रश्न 2 (A) (B) ● (D)
प्रश्न 3 (A) ● (C) (D)

अपठनीय उत्तर या ऐसे उत्तर जिन्हें काटा या बदला गया है, या गोले में आधा भरकर दिया गया, उन्हें निरस्त कर दिया जाएगा।

5. प्रत्येक प्रश्न के अंक समान हैं। आपके जितने उत्तर सही होंगे, उन्हीं के अनुसार अंक प्रदान किये जायेंगे।
6. सभी उत्तर केवल ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर ही दिये जाने हैं। उत्तर-पत्रक में निर्धारित स्थान के अलावा अन्यत्र कहीं पर दिया गया उत्तर मान्य नहीं होगा।
7. ओ. एम. आर. उत्तर-पत्रक (OMR Answer Sheet) पर कुछ भी लिखने से पूर्व उसमें दिये गये सभी अनुदेशों को सावधानीपूर्वक पढ़ लिया जाये।
8. परीक्षा समाप्ति के उपरान्त परीक्षार्थी कक्ष निरीक्षक को अपनी OMR Answer Sheet उपलब्ध कराने के बाद ही परीक्षा कक्ष से प्रस्थान करें। परीक्षार्थी अपने साथ प्रश्न-पुस्तिका ले जा सकते हैं।
9. निगेटिव मार्किंग नहीं है।
10. कोई भी रफ कार्य, प्रश्न-पुस्तिका के अन्त में, रफ-कार्य के लिए दिए खाली पेज पर ही किया जाना चाहिए।
11. परीक्षा-कक्ष में लॉग-बुक, कैलकुलेटर, पेजर तथा सेल्युलर फोन ले जाना तथा उसका उपयोग करना वर्जित है।
12. प्रश्न के हिन्दी एवं अंग्रेजी रूपान्तरण में भिन्नता होने की दशा में प्रश्न का अंग्रेजी रूपान्तरण ही मान्य होगा।

महत्वपूर्ण : प्रश्नपुस्तिका खोलने पर प्रथमतः जाँच कर देख लें कि प्रश्न-पुस्तिका के सभी पृष्ठ भलीभाँति छपे हुए हैं। यदि प्रश्नपुस्तिका में कोई कमी हो, तो कक्षनिरीक्षक को दिखाकर उसी सिरीज की दूसरी प्रश्न-पुस्तिका प्राप्त कर लें।