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
C

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. 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

2. 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

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

(A) Brightness

(B) Spectral lines

(C) Temperature

(D) Luminosity

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

(A) Inflationary epoch

(B) Dark energy era

(C) Radiation-Dominated era

(D) Planck epoch

5. 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

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

(A) $\wedge$-field

(B) H-field

(C) G-field

(D) C-field

7. 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

8. 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

9. 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

10. 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.

11. 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

12. 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

13. 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

14. 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

15. 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

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

(A) Edwin Hubble

(B) Arthur Eddington

(C) Georges Lemaitre

(D) Albert Einstein

17. 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

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

(A) Dark Matter
(B) Matter creation
(C) Vacuum energy causing repulsive gravity
(D) Radiation pressure

19. Who proposed Big Bang theory ?

(A) Georges Lemaitre
(B) Arthur Eddingtion
(C) Fred Hoyle
(D) Sir Hermann Bondi

20. The particle horizon limits ..... .

(A) Past observations of the universe
(B) Future observations
(C) Stellar evolution
(D) Planet formation

21. 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

22. 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

23. 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

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

(A) Cosmic rays
(B) Non-relativistic matter
(C) Dark energy
(D) Relativistic radiation

25. 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

26. 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

27. 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

28. 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

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

(A) Big Bang Nucleosynthesis

(B) Recombination

(C) Inflation

(D) The first supernovas

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

(A) Solar Burst

(B) Cosmic Bang

(C) Big Bang

(D) Stellar Blast

31. 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

32. 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

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

(A) Friedmann equation

(B) Einstein equation

(C) Maxwell equation

(D) Boltzmann equation

34. 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

35. 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

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

(A) H^2

(B) $\sqrt{H}$

(C) H

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

37. 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

38. 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

39. The Friedmann equation are derived from .....

(A) Planck radiation law

(B) Newton's law of gravitation

(C) Maxwell equations

(D) Einstein field equations

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

(A) Friedmann equation

(B) Maxwell equation

(C) Poisson equation

(D) None of the above

41. 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

42. 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) $a(t) \propto t$

43. 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

44. 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

45. 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

46. 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

47. 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

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

49. 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) $z \approx 10$

50. 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

51. 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

52. 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) $(1+r)^2 \frac{dr}{dz}$

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

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

(A) Parabolic

(B) Hyperbolic

(C) Straight line

(D) Circular

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

(A) Albert Einstein

(B) Edwin Hubble

(C) Isaac Newton

(D) None of the above

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

(A) Doppler

(B) Gravitational

(C) Cosmological

(D) Thermal

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

(A) 1

(B) 0

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

(D) – 1

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

(A) Decelerating

(B) Accelerating

(C) Static

(D) Contracting

59. 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) $-\frac{a}{\dot{a}}$

60. Which one denotes Hubble parameter ?

(A) $\frac{a}{\dot{a}}$

(B) $\frac{\dot{a}}{a}$

(C) $\frac{a}{\ddot{a}}$

(D) $\frac{\ddot{a}}{a}$

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

(A) H (t)

(B) $k(t)$

(C) $\rho(t)$

(D) $a(t)$

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

(A) Cartesian

(B) Polar

(C) Cylindrical

(D) Spherical

63. 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

64. 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

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

(A) Test particles in the universe

(B) Electromagnetic waves

(C) Black holes

(D) Quantum particles

66. 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

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

(A) Random curves

(B) Parallel geodesics

(C) Intersecting paths

(D) Circular paths

68. 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

69. 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

70. 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

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

(A) Polarization

(B) Diffraction

(C) Blueshift

(D) Redshift

72. 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.

73. 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}

74. 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) $v = H_0 + d$

75. 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

76. 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

77. 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

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

(A) Varying curvature

(B) Zero curvature

(C) Constant negative curvature

(D) Constant positive curvature

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

(A) Accelerating

(B) Decelerating

(C) Linear

(D) Zero

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

(A) Flat

(B) Closed and positively curved

(C) Hyperbolic

(D) Infinite

81. 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

82. What is Einstein static universe ?

(A) Stable

(B) Unstable

(C) Periodic

(D) Chaotic

83. 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) $G_{\mu\nu} \propto T_{\mu\nu}$

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

(A) $\wedge$

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

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

(D) None of the above

85. 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.

86. Einstein field equations describe gravity as .....

(A) A zero-point energy

(B) Curvature of space time

(C) Attractive force

(D) Repulsive force

87. Einstein tensor is also called :

(A) Ricci tensor

(B) Metric tensor

(C) Symmetrical tensor

(D) None of the above

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

(A) Repulsive tensor

(B) Asymmetrical tensor

(C) Symmetrical tensor

(D) None of the above

89. What denotes stress-Energy tensor ?

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

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

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

(D) None of the above

90. 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

91. 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

92. 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

93. 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

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

95. 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) $R_{\mu\nu} + R g_{\mu\nu}$

96. Who introduced cosmological constant ?

(A) Isaac Newton

(B) Albert Einstein

(C) Edwin Hubble

(D) Ernst Mach

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

(A) Ernst Mach

(B) Isaac Newton

(C) Albert Einstein

(D) Hendrik Lorentz

98. 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

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

(A) Centripetal force

(B) Centrifugal force

(C) Gravitational force

(D) Pseudo force

100. 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

(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।