# M.Sc. 4$^{th}$ Semester Examination, 2021

## PHYSICS

## (Relativity & Astrophysics)

## Paper: 402C

## Course ID: 42452

**Time: 2 Hours**                                    **Full Marks:  40**

*Candidates are required to give their answers in their own words*
*as far as practicable.*
*The questions are of values indicated in the margin.*

### Unit-I

**1.  Answer *any three* of the following questions:**                    **2x3=6**

a)  Define Minkowski's Four Dimensional Space-time.

b)  What do you mean by affine connection?

c)  What do you mean by Geodesics?

d)  Explain briefly about principle of equivalence.

e)  Show that the trace of an anti-symmetric tensor of rank two is zero.

**2.  Answer *any two* of the following questions:**                    **4x2=8**

a)  State and prove Hubble's law.

b)  Calculate age of the Universe and radius of the Universe from Hubble's Law.

c)  Define Christoffel symbols of 1$^{st}$ and 2$^{nd}$ kind.

   Show that, $\Gamma^p_{mn} = \frac{1}{2} g^{pq} [g_{mq,n} + g_{nq,m} - g_{mn,q}]$.                    2+2=4

d)  Define the Ricci identity. How does it give the idea of the curvature of a space?

                                                       2+2=4

**3.  Answer *any one* of the following questions:**                    **6x1=6**

a)  What are the important crucial tests in verifying the Einstein's theory of gravity?
   Write a short note on the gravitational red shift.                    4+2=6

b)  What do you mean by event horizon?  Discuss the concept of black hole from
   Schwarzschild's exterior solution.                    2+4=6

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## Unit-II

**4.  Answer *any three* of the following questions:**  2x3=6

a)  Give an idea of the Neutron star.

b)  State the Virial theorem.

c)  What do you mean by the main sequence stars?

d)  How do you know the existence of dark matter from galaxy rotation curve?

e)  How do you know the fusion reaction is still going on inside the core of the sun?

**5.  Answer *any two* of the following questions:**  4x2=8

a)  Discuss about limitation of Big Bang theory. How Inflation theory overcomes that problems?

b)  What is missing neutrino problem? Discuss how it has been solved.

c)  Discuss how do you detect the solar neutrinos.

d)  What do you mean by last scattering surface in the context of CMBR? Explain briefly.

6. **Answer *any one* of the following questions:**  6x1=6

a)  Identify important stellar objects in the H-R diagram including the Sun. What is the Chandrasekhar mass limit?  Discuss the ultimate fate of our Sun?

<div align="right">3+1+2=6</div>

b)  Write down Friedmann equations and show that,

(i)  For $k = 0$, scale factor $a = a_0 \left(\frac{t}{t_0}\right)^{\frac{2}{3}}$ and the present value of time $t_0 = \frac{2}{3H_0}$.

(ii)  Closed model ($k = 1$), has a density exceeding the closer density $\rho_c$.

(iii)  For $k = -1$, universe is expanding.

(iv)  Draw a curve of scale factor vs cosmic time of three types of Friedmann models together.  2+1+1+2=6

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