St. Philomena's College (Autonomous), Mysore

Question Bank

Programme: M. Sc. Physics

III Semester

Course Title: Riemannian Geometry and Gravitational Field

Course Type: Soft Core

Q.P Code : 88335

Sl. No.	Module	Question	Marks
1.	1	Show that the covariant differentiation of the contravariant metric tensor g^{jk} with respect to x^l is zero.	5
2.	1	Show that the covariant differentiation of the covariant metric tensor g_{jk} with respect to x^l is zero.	5
3.	1	Prove that $g_{j,l}{}^{k} = 0$	5
4.	1	Show that the covariant differentiation for products, sumand differences obeys the same rule in the case of ordinary differentiation.	5
5.	1	Discuss the antisymmetric and cyclic properties of Riemann christoffel tensor properties	5
6.	1	Prove that $[ik,j]+[jk,i]=dg_{ij}/ dx^k$.	5
7.	1	Prove that $[ij, m]=gkm\{{}^{\ k}_{i\ j}\}$.	5
8.	1	Define a metric tensor with an example,	5
9.	1	Show that $R_{\rho\mu\nu\sigma} + R_{\mu\rho\nu\sigma} =0$	5
10.	1	Prove that $R_{\rho\mu\nu\sigma} + R_{\rho\nu\sigma\mu} + R_{\rho\sigma\mu\nu} = 0$.	5
11.	1	Prove that $\Gamma_{m,jk} - \Gamma_{m,kj} = 0$.	5
12.	1	Justify that the number of algebraically independent components of curvature tensor in 4d space it is 20.	5
13.	2	Write a brief note on the nature of singularities at r=0 and $r=2GM/c^2$ of the Schwarzchild line element.	5

14.	2	Write a note on the relativistic units.	5
15.	2	Discuss the relationship between the attracting mass M and the constant m occuring in Schwarzchild line element.	5
16.	2	Give the expression for Schwarzchild's line element and hence obtain the Schwarzchild's metric	5
17.	2	Calculate the determinant of Schwarzchild mertic.	5
18.	2	Calculate the perihelion shift of the Earth per century given T= 1 earth year.	5
19.	2	Calculate the perihelion shift of the Mercury per century given T= 0.24 earth years.	5
20.	2	Calculate the perihelion shift of the Mercury per century given T= 0.62 earth years.	5
21.	2	Calculate the Schwarzchild radius of the earth given that the mass of the Earth is 6×10^{24} kg.	5
22.	2	Calculate the Schwarzchild radius of the earth given that the mass of the Sun is 2×10^{30} kg.	5
23.	2	Calculate the Schwarzchild radius of the earth given that the mass of the Mercury is 3.3×10^{23} kg.	5
24.	2	Explain black hole as a region of strong gravitational field.	5
25.	2	List and explain the types of black holes.	5
26.	2	Write a short note on gravitational collapse.	5
27.	1	Discuss the covariant differentiation of a contravariant vector and show that it is a tensor.	10
28.	1	Discuss the covariant differentiation of a covariant vector and show that it is a tensor.	10
29.	1	Discuss the covariant differentiation of a mixed tensor of rank two and show that it is a tensor.	10

30.	1	Arrive at an expression for parallel transport of a contravariant vector A^{μ} along the curve x^{i} (s). in Riemannian space.	10
31.	1	state and prove the necessary and sufficient conditions that a system of coordinates be geodesic with an arbitrary pole.	10
32.	1	Obtain the differential equations of a geodesic in a given space.	10
33.	1	Define Riemann Christoffel curvature tensor and and obtain an expression for it.	10
34.	1	Deduce an expression for covariant curvature tensor and discuss its properties.	10
35.	1	Arrive at an expression for the variation of the metric in general relativity.	10
36.	1	Enumerate the number of independent non-zero components of $R_{\rho\mu\nu\sigma}$ in a Riemannian space V_n.	10
37.	1	Prove the Bianchi identity satisfied by $R_{\rho\mu\nu\sigma}$. Contracting the Bianchi identity, Show that the vector divergence of Einstein tensor vanishes identically.	10
38.	1	Show that the curvature tensor may be contracted in two ways which leads to zero tensor and Richi tensor and hence define scalar curvature.	10
39.	1	Define Christoffel symbols of first and second kind. Calculate the Christoffel symbol of first kind corresponding to $dS^2=dr^2+r^2d\theta^2+r^2\sin^2\theta d\phi^2$.	10
40.	1	Calculate the Christoffel symbol of first and second kind corresponding to $dS^2=dr^2+r^2d\theta^2+r^2\sin^2\theta d\phi^2$.	10
41.	2	Write a note on the equivalene principle. Discuss the Eotvos experiment in support of the equivalence principle	10
42.	2	Derive an expression for the stress energy tensor for a perfect fluid distribution.	10
43.	2	Deduce the Einstein's field equations in general theory of relativity.	10
44.	2	Obtain the Schwarzchild's exterior solution for the gravitational field of an isolated particle.	10

45.	2	Write a note on the equivalene principle. Discuss the Eotvos experiment in support of the equivalence principle	10
46.	2	Discuss the perihelion shift of mercury as a test of general relativity.	10
47.	2	Discuss the bending of light in gravitational field due to a static spherically symmetric mass distribution	10
48.	2	Explain in detail the isotropic polar coordinates and hence obtain an expression for Schwarzchild's isotropic line element	10
49.	2	Obtain an expression for the bendding of light passing close to a heavy gravitational mass.	10
50.	2	Show that the deflection of light rays as calculated on the assumption of Einstein's theory of gravitation is double that might have been predicted in Newtonian theory.	10
51.	2	obtain the formula for the gravitational red shift in general relativity.	10

For 2 credit soft core courses

St. Philomena's College(Autonomous), Mysuru		
I/II/III/IV Semester M.Sc. Examination Month – Year		
Subject:		
Title:		
Time: 3 hours		**Max. Marks:70**
Instruction: Answer any four full question from Section – A and any of the five questions from Section – B.		
Section - A		
1.	Question to be asked from unit I	**05**
2.	Question to be asked from unit I	**05**
3.	Question to be asked from unit I	**05**
4.	Question to be asked from unit II	**05**
5.	Question to be asked from unit II	**05**
6.	Question to be asked from unit II	**05**
Section - B		
7.	Question to be asked from unit I	**10**
8.	Question to be asked from unit I	**10**
9.	Question to be asked from unit I	**10**
10.	Question to be asked from unit II	**10**
11.	Question to be asked from unit II	**10**
12.	Question to be asked from unit II	**10**

Note : Marks of Section A and B can be any combinations of 5 and 10 respectively. For example in section – A we may have (3+2). In section-B we may have (6+4) and (5+5).