**ST MARY’S UNIVERSITY**

**TWICKENHAM, LONDON**

BSc Degree Examination students registered for

Level **SIX**

Title**: Mathematical Methods 3 – Special and General Relativity**

Code: **APH6001**

Semester: **One**

Date: **16th January, 2020**

Time: **9:30 am – 11:30 am**

TIME ALLOWED: **TWO** HOURS

Answer **SECTION A** and **ONE** of the other two sections (B or C).

**STUDENTS CAN USE A NON PROGRAMMABLE CALCULATOR**

**Section A: [60 marks]**

1. Describe Galileo’s hypothesis of inertia. **[1 mark]**
2. Explain the concept of lightcone in terms of events. **[2 marks]**
3. Describe the basic principle of a Michelson-Morley interferometer. **[1 mark]**
4. Explain why Lorentz transformations must be linear. **[2 marks]**
5. State in words Einstein velocity relationship. What is the main difficulty encountered when applying Einstein’s relationship to problems involving more than two objects? **[2 marks]**
6. In your own words, describe Lorentz transformations and explain why they must be linear. **[2 marks]**
7. Explain which description of spacetime the postulates of relativity lead to. **[3 marks]**
8. What is a Taylor expansion? Write down the Taylor expansion of the exponential **[2 marks]**
9. What is a Laurent series? **[1 mark]**
10. When are Laurent series used? **[1 mark]**
11. What is a Laplace transform? **[1 mark]**
12. What are the properties of a Laplace transform? **[3 marks]**
13. Define “inertial observer” **[4 marks]**
14. Calculate the integral:

The curves and are given by the parametric expressions:

where

where .

**[20 marks]**

1. Find the Laurent series about x = 0 and which is valid in the annulus of the function:

**[15 marks]**

**Section B: [40 marks]**

1. Write a short essay (1 page) on “Transformations in Special Relativity: Principles and applications”. In particular your essay should contain:
* Description of Galileian and Lorentz transformations
* Explanation of time dilation and length contraction, and their relation with Galileian transformations
* Examples of applications and/or effects of Lorentz transformations

**[20 marks]**

1. Consider the 4-vectors ,, and . Given two arbitrary scalar λ and μ show that:
2. **[3 marks]**
3. **[4 marks]**
4. **[7 marks]**
5. **[6 marks]**

**Section C: [40 marks]**

1. Write a short essay (1 page) on “Tensor calculus and its applications in Relativity Theory”. In particular your essay should contain:
* Description of tensors, vectors and covectors
* Description of the different types of tensors and the main tensor calculations
* Examples of the use of tensor calculus in Special and General Relativity **[20 marks]**
1. Consider the function:

where . Calculate:

1. The Fourier transform of the function fn(x) **[15 marks]**
2. **[5 marks]**

**END OF EXAMINATION**