Test 3 – Standard model & Special Relativity, 2024

Question/Answer booklet

PHYSICS UNIT 4

DRAFT

Student number: In figures | | | | | | | | |

In words _____

Your name _____

Time allowed for this test

Reading time before commencing work: five minutes
Working time: forty minutes

Materials required/recommended for this section

To be provided by the supervisor

This Question/Answer booklet
Formula sheet

To be provided by the candidate

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: up to 3 non programmable scientific calculators

Instructions to candidates

1. The rules for the conduct of examinations are detailed in the school handbook. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet.

3. You must be careful to confine your response to the specific question asked and to follow any instructions that are specified to a particular question.

4. Supplementary pages for the use of planning/continuing your answer to a question have been provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

5. Show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning. Incorrect answers given without supporting reasoning cannot be allocated any marks. For any question or part question worth more than two marks, valid working or justification is required to receive full marks. If you repeat any question, ensure that you cancel the answer you do not wish to have marked.

6. It is recommended that you do not use pencil, except in diagrams.

7. The Formula sheet is not to be handed in with your Question/Answer booklet.

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Question 1 **(7 marks)**

A physics student is conducting an experiment involving two magnets and a wooden table. The student observes that a magnet on top of the table is able to attract a magnet below the table.

(a) Name the force of attraction between the two magnets. (1 mark)

(b) Explain how photons are able to carry the force through the table, but the table appears opaque to the human eye. (6 mark)

See next page

Question 2 **(8 marks)**

(a) Fermions are particles with half integer spin. Explain what is half-integer spin and how it differs from integer spin with regard to the motion of the particle. (3 marks)

(b) Mesons are composed of a quark and antiquark, both of which are fermions. Would this make mesons a type of fermion? Justify your answer. (2 marks)

(c) Explain why the quark and antiquark in a meson do not annihilate each other. (3 marks)

See next page

Question 3 **(8 marks)**

Two spaceships A and B are flying towards each other with a velocity of $0.95C$ and $0.98C$ respectively. In as the two spaceships pass each other, observer A on spaceship A sees a crewmate on spaceship B shine a laser from the back of the ship towards the front of the ship.

(a) Given observer A measured spaceship B to be $100m$ long, calculate how long it takes for the laser to hit the front of spaceship B as measured by observer A (4 marks)

(b) Assuming both spaceships to be points, if the crewmate on spaceship B wished to shine the laser on spaceship A when the ships are side by side with a separation of $10km$, at what angle should he aim? (4 marks)

(c) The laser on spaceship B has a wavelength of $650nm$, determine the wavelength of the light as observed by observer A on spaceship A. (3 marks)

Question 4 **(4 marks)**

A spaceship with a powerful electromagnet is stationary relative to a space station 420 million kilometres away. If the spaceship turns on the electromagnet, after how long will the space station experience an electromagnetic force?

Question 5 **(7 marks)**

A physics student builds a particle accelerator to conduct some experiments in their backyard.

(a) A proton in the particle accelerator is given an energy of $10\ GeV$. Using the equation for mass-energy equivalence, calculate the speed of the proton in terms of c. Give your answer to five significant figures. (3 marks)

Answer _____c

(b) If the particle accelerator is circular, with the proton travelling in uniform circular motion with a radius of $40km$ determine the strength and direction of the magnetic field keeping the proton in its circular path. (4 marks)
Hint: gravity is acting on the proton

Question 6 **(6 marks)**

The standard model of particle physics is not a perfect model. Suggest some improvements that could be made to the standard model.

End of questions

Supplementary page

Question number: _____