# SOUTH EASTERN KENYA UNIVERSITY

## UNIVERSITY EXAMINATIONS 2016/2017

### FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS

#### SPH 414: ELEMENTARY PARTICLE PHYSICS

**8TH DECEMBER, 2016** **TIME: 8.00-10.00 A.M**

## INSTRUCTIONS TO CANDIDATES

- This paper consists of FIVE questions.
- Answer questions **ONE** and any other **TWO** questions.
- Question **ONE** carries 30 mark while the other **TWO** questions carry 20 marks each
- Use the following constants where necessary

  Proton mass $m_p = 938.3 MeV/c^2$

  Electron mass $m_e = 0.511 MeV/c^2$

  Electron mass $m_n = 939.6 MeV/c^2$

**QUESTION ONE (COMPULSORY) (30 MARKS)**

a) Explain how the elementary particles are classified in the standard model (2 marks)

b) Indicate with an explanation which interaction is involved in the following decay process and indicate whether they are allowed or forbidden.

(i). $\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$. (2 marks)

(ii). $p \rightarrow n + e^+ + \nu_e$.(3 marks)

(iii). $e^+ + e^- \rightarrow \mu^+ + \mu^-$.(2 marks)

c) Show that the relativistic energy-momentum relation is given as $E = \sqrt{(mc^2)^2 + (pc)^2}$. (5 marks).

d) Draw and explain the Feynman diagram of the reaction $e^+ + e^- \rightarrow \mu^+ + \mu^-$. (4 marks)

e) Differentiate between pseudoscalar and vector mesons. Give two examples of each (4 marks)

f) Explain how particles are detected in calorimeters. (5 marks)

**QUESTION TWO (20 MARKS)**

a) Explain forces involved in the elementary particle interactions. State the particle involved in each case. (6 marks)

b) Describe the classification and characteristics of leptons. (6 marks)

c) A particle X decays at rest weakly as follows $X \rightarrow \pi^0 + \mu^+ + \nu_\mu$. Determine the following properties of X

(i). Charge. (1 mark)

(ii). Baryon number. (1 mark)

(iii). Lepton number. (1 mark)

(iv). Spin. (2 marks)

(d). Use cabibbo theory to explain the difference in decay $D^+ \rightarrow \overline{K}^0 \mu^+ \nu_\mu$ and $D^+ \rightarrow \pi^0 \mu^+ \nu_\mu$, given that $D^+$ consists of $c$ quark and $\bar{d}$ anti-quark. (3 marks)

**QUESTION THREE (20 MARKS)**

a) Briefly explain the following terms giving two examples of each:

(i). Hadron (2 marks)

(ii). Baryon (2 marks)

(iii). Meson (2 marks)

b) Pions can be used as a beam to study the structure of nucleons. Write the equations of production and decay of $\Delta$-multiplets particles. (8 marks)

c) A closer investigation of the $J = \frac{3}{2}$ baryons shows an interesting problem when we consider the symmetry under exchange of labels of the three quarks in the $uuu$, $ddd$ and $sss$ baryons. Using the concept of "*color*" charge explain how this problems can be resolved. (6 marks)

**QUESTION FOUR (20 MARKS)**

(a) What is a Feynman diagram? (2 marks)

(b) Explain the rules that must be followed in drawing a Feynman diagram. (6 marks)

(c) Draw the lowest Feynman diagram of the electromagnetic vertex with particle and antiparticle in the final state. (2 marks)

(d) Consider scattering of an electron with four momentum vector $p$ off a particle with four momentum vector $P$ in the lab frame. Show that the energy $E'$ of the scattered electron is $E' = \frac{E}{1 + E/Mc^2 .(1 - Cos\theta)}$ where $\theta$ is the scattering angle and E is the initial energy of the electron. (10 marks)

**QUESTION FIVE (20 MARKS)**

(a) Describe the following types of accelerators

(i). Linear accelerator, (5 marks)

(ii). Cyclotrons accelerator. (5 marks)

(b) Describe the working principle of the following detectors.

(i). Wire chambers, (5 marks)

(ii). Scintillation counters. (5 marks)