RONGO
UNIVERSITY COLLEGE

Goldmine of Knowledge and Innovation

(A Constituent College of Moi University)

OFFICE OF THE DEPUTY PRINCIPAL- ACADEMICS AND STUDENTS AFFAIRS

UNIVERSITY EXAMINATIONS

2013/2014 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER EXAMINATION

FOR

THE DEGREE

IN

BACHELOR OF SCIENCE

COURSE CODE: ESP 122/112

COURSE TITLE: MODERN PHYSICS

DATE: 25/6/2014 **TIME: 2.00PM-5.00PM**

INSTRUCTIONS TO CANDIDATES

- Answer questions **ONE** and any other **TWO** questions
- Show workings in the answer booklet for award of full marks
- Do not write on the question paper.
- Switch off your mobile phones.
- Each question should begin on a fresh page
- Marks are shown at the end of each question
- Duration is 3 hours

THIS PAPER CONSISTS (3) PRINTED PAGES **PLEASE TURN OVER**

Physical constants

Speed of light, c 3×10^{8} m/s

Planck's constant, h 6.63×10^{-34} J. S = $4.14\text{x }10^{-15}$ eV. s

Mass of an electron, m $9.11 \text{ X } 10^{31}$ kg

QUESTION ONE:

(a) Explain the difference between general relativity and special relativity **(2marks)**

(b) Sea waves are approaching the beach at 20 m/s. A boat heading out to sea travels at 5 m/s. How fast are the waves moving in the boat's reference frame? **(3marks)**

(c) Using time dilation, prove that nothing can travel faster than the speed of light. **(3marks)**

(d) An 8.0-m-long school bus drives past at 30 m/s. By how much is its length contracted? **(4marks)**

(e) An atom has stationary states E_1= 0.0 eV, E_2= 2.0 eV, and E_3= 5.0 eV. What wavelengths are observed in the absorption spectrum and in the emission spectrum of this atom? **(4marks)**

(f) Explain Wien's displacement law. **(2 marks)**

(g) What is the rest energy of a 100 g orange? **(3marks)**

(h) Explain the Law of conservation of total energy **(2 marks)**

(i) Explain the difference between binding energy and ionization energy. **(2 marks)**

(j) A rear molar from a mammoth skeleton is dated using a measurement of its ^{14}C content. Carbon from the tooth is chemically extracted and formed into benzene. The benzene sample is placed in a shielded chamber. Decays from the sample come at an average rate of 11 .5 counts per minute. A modern benzene sample of the exact same size gives 54.9 counts per minute. What is the age of the skeleton? **(4 marks)**

(k) What is the difference between ground state and excited state? **(1 mark)**

QUESTION TWO:

(a) State the Galilean principle of relativity. **(1 mark)**

(b) An airplane is flying at speed 150 m/s with respect to the ground. Sound wave 1 is approaching the plane from the front, while sound wave 2 is catching up from behind. Both waves travel at 340 m/s relative to the ground.

(i) What is the velocity of wave 1 relative to the plane? **(3marks)**

(ii) What is the velocity of wave 2 relative to the plane? **(3marks)**

(c) Using the equation involving time dilation and proper time, show that the time interval between two ticks of a light clock is the shortest in the reference frame in which the clock is at rest. **(4marks)**

(d) A planet is 1.3×10^{12} m from the sun. A rocket travels along a line from the sun to the planet at a constant speed of exactly 0.7c relative to the solar system. How long does the journey take

(i) As measured by an experimenter on earth? **(3marks)**

(ii) As measured by an astronaut on the rocket? **(3 marks)**

(e)Dan holds a 5.0-m-long ladder parallel to the ground. He then gets up to a good sprint, eventually reaching 98% of the speed of light.

How long is the ladder according to Dan, once he is running, and according to Cannen, who is standing on the ground as Dan goes by? **(3 marks)**

QUESTION THREE

a. A rocket flies past the earth at precisely 0.95c. As it goes by, the rocket fires a bullet in the forward direction at precisely 0.95c with respect to the rocket.
   i. What is the bullet's speed with respect to the earth? **(4 marks)**
   ii. Suppose the rocket above fired a laser beam in the forward directionas it traveled past the earth at velocity v. The laser beam would travel away fromthe rocket at speed $u' = c$ in the rocket's reference frame S'. What is the laser beam's speed in the earth 's frame S? **(4 marks)**

(b) Calculate the rest energy and the kinetic energy of
(i) a 100 g ball moving with a speed of 100 mls **(4marks)**
(ii)an electron with a speed of 0.99c. (4 marks)

(c) Using a well labeled diagrams, show the equivalence of mass and energy. **(4 marks)**

QUESTION FOUR:

(a) Explain Stefan's- Boltzman law. **(2 marks)**
(b) What are the wavelengths of peak intensity and the corresponding spectral regions for radiating objects at
(i) normal human body temperature of 37°C, **(2marks)**
(ii) the temperature of the filament in an incandescent lamp, 1500°C, **(2marks)**
(iii) the temperature of the surface of the sun, 5800 K? (2 marks)
(iv) Explain the results in (b) i, ii and iii using thermal emission spectrum. **(3marks)**
(c) Using a well labeled diagram, explain Compton scattering. **(4marks)**
d) The separation between adjacent energy levels is typically a few eV for atomic energy levels, on the orderof 0.1 eV for vibrational levels, and on the order of 10^{-3} eV for rotational levels. Find the wavelength of thephoton emitted during a transition in which the energy of the molecule decreases by 5.00 eV, by 0.500 eV,and by 5.00×10^{-3} eV. In each case, in what region of the electromagnetic spectrum does the photon lie? **(5 marks)**

QUESTION FIVE:

(a) What is the De Broglie wavelength of an electron with a kinetic energy of 1.0 eV?**(5 marks)**
(b) An electron is confined to a region of space of length 0. 19 nmcomparable in size to an atom. What are the first three allowed energies of the electron? **(4 marks)**
(c) An electron in a quantum system has allowed energies E_1=1.0 eV, E_2 = 4.0 eV, and E_3 = 6.0 eV. What wavelengths are observed in the emission spectrum of this system? **(4 marks)**
(d) What range of velocities might an electron have if confined to a 0.1 nmwide region, about the size of an atom? **(4 marks)**
(e) State the **three** Einstein postulates about light quanta and their interaction with matter. **(3 marks)**