GLASGOW COLLEGE UESTC

Final Exam Paper

Physics II (UESTC 2010)

Date: 29th Dec. 2019

Time: 09:30-11:30am

Attempt all PARTS. Total 100 marks
Use one answer sheet for each of the questions in this exam.
Show all work on the answer sheet.
Make sure that your University of Glasgow and UESTC Student Identification Numbers are on all answer sheets.
An electronic calculator may be used provided that it does not allow text storage or display, or graphical display.
All graphs should be clearly labelled and sufficiently large so that all elements are easy to read.
The numbers in square brackets in the right-hand margin indicate the marks allotted to the part of the question against which the mark is shown. These marks are for guidance only.

Useful constants

Speed of light c=2.998× $\mathbf{10^8}$m/s

Permittivity of free space $\boldsymbol{\varepsilon_0 = 8.85 \times 10^{-12} C^2/N \cdot m^2}$

Permeability of free space $\boldsymbol{\mu_0 = 4\pi \times 10^{-7} T \cdot m/A}$

Elementary mass $\boldsymbol{1u = 1.66 \times 10^{-27} kg}$

Elementary charge $\boldsymbol{e = 1.60 \times 10^{-19} C}$

Continued overleaf

Q1 Multiple choice.

Choose the one alternative that best complete the statement or answers the questions.

( ) (i) In an *RC* circuit, the capacitor begins to discharge. During the discharge, in the region of space between the plates of the capacitor, there is_____. [2]

(A) conduction current but no displacement current.

(B) displacement current but no conduction current.

(C) both conduction and displacement current.

(D) no current of any type but electromagnetic field.

(E) no current of any type and no electric field.

( ) (ii) The Fig. Q1(b) shows a circular loop of wire falling toward a wire carrying a current to the right. What is the direction of the induced current in the loop of wire? [2]

(A) Counterclockwise.

(B) Clockwise.

(C) Zero.

(D) Impossible to determine.

(E) The direction depends on the falling speed.

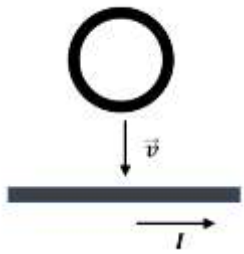

Figure Q1(b)

( ) (iii) For any given scattering angle θ, equation $\lambda' - \lambda_0 = \frac{h}{m_e c}(1 - \cos\theta)$ gives the same value for the **Compton shift** for any wavelength. Keeping that in mind, for which of the following types of radiation is the fractional shift in wavelength at a given scattering angle the largest? [2]

(A) Radio waves.

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(B) Microwaves.

(C) Visible light.

(D) X-rays.

(E) Infrared light.

( ) (iv) Which of the following changes would ***not*** increase the probability of transmission of a particle through a potential barrier? [2]

(A) Decreasing the width of the barrier.

(B) Increasing the width of the barrier.

(C) Increasing the temperature.

(D) Decreasing the height of the barrier.

(E) Increasing the kinetic energy of the incident particle.

( ) (v) Two spacecraft A and B are moving in opposite directions. An observer on the Earth measures the speed of spacecraft A to be **0.750*c*** and the speed of spacecraft B to be **0.850*c***. The velocity of spacecraft B as observed by the crew on spacecraft A is_____. [2]

(A) 0.750c

(B) 0.850c

(C) 1.600c

(D) 0.996c

(E) 1.000c

Q2 Please fill-in the missing parts.

(a) Write out Maxwell's equations and provide a brief explanation (about each equation)

(i) _____

_____ [1]

(ii) _____

_____ [1]

(iii) _____

_____ [1]

Continued overleaf

(iv) _____

_____ [1]

(b) X-rays of wavelength $\lambda_0 = 0.200000\text{nm}$ are scattered from a block of material. The scattered x-rays are observed at an angle of 45.0° to the incident beam. Thus, the wavelength should be _____. [4]

(c) The following *pairs* of energies represent the rest and total energy of three different particles:

particle ①: *E*, 2*E*;

particle ②: *E*, 3*E*;

particle ③: 2*E*, 4*E*

(i) Rank the particles with "=" or ">" according to their masses.

_____ [1]

(ii) Rank the particles with "=" or ">" according to their kinetic energy.

_____ [1]

(iii) Rank the particles with "=" or ">" according to their speed.

_____ [2]

(d) A painting (1.0m×1.5m) is hanging on a spaceship with v = 0.9c relative to Earth.

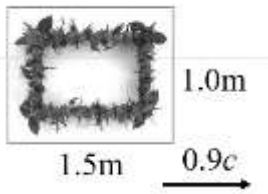

Figure Q2 (d)

(i) What are the dimensions as seen from a spaceship? _____ [2]

(ii) What are the dimensions as seen on Earth? _____ [2]

(e) (i) How many sets of quantum numbers are possible for a hydrogen atom for n=3?

_____. [1]

(ii) List all possible sets of quantum numbers for the hydrogen atom associated with the ***3p*** subshell. [3]

Continued overleaf

Q3 A loop of wire enclosing an area A is placed in a region where the magnetic field is perpendicular to the plane of the loop. The magnitude of $\vec{B}$ varies in time according to the expression $B = B_{max}e^{-2at}$, where a is a constant. That is, at $t = 0$, the field is B_{max}, and for $t > 0$, the field decreases exponentially (Fig. Q3).

(a) Find the induced ***emf*** in the loop as a function of time.

[7]

(b) Draw the *emf* in the loop as a function of time (in the right rectangle of Fig. Q3). [5]

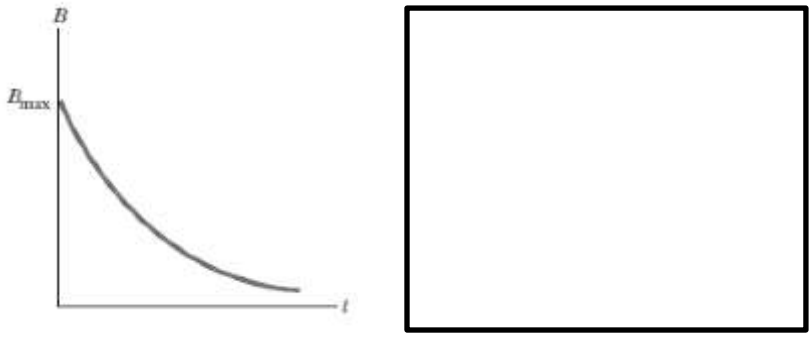

Figure Q3

Q4 Fig. Q4 shows a solenoid (N loops, length L, μ_0). The current in a solenoid changes as $dI/dt = C > 0$. A triangle coil (OA=OB=AB=***l***) is placed at the center of the solenoid.

(a) Determine the ***emf*** in the straight wire OA; [4]

(b) Determine the ***emf*** in the coil AOB; [6]

(c) Determine the ***emf*** in the straight wire AB; [4]

(d) Determine the mutual inductance ***M*** of the solenoid and the triangle coil. [2]

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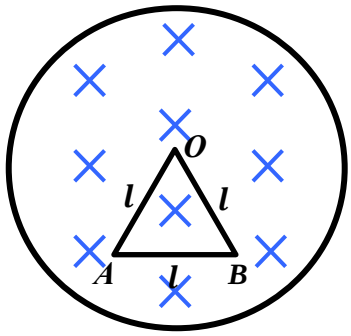

Figure Q4

Q5 A Speedy Proton (^{1}H, the mass is 1.007u).

(a) Find the rest energy of a proton in units of electron volts (eV). [5]

(b) If the total energy of a proton is three times its rest energy, what is the speed of the proton? [5]

(c) Determine the kinetic energy of the proton in units of electron volts (eV). [3]

(d) What is the proton's momentum? [5]

Q6 In a photoelectric effect experiment it is observed that no current flows unless the wavelength is less than 570nm.

(a) What is the work function $\boldsymbol{W_0}$ of this material? [6]

(b) What is the stopping voltage required if light of wavelength 400nm is used? [6]

Q7. An electron is trapped in an infinitely deep potential well of width $\boldsymbol{L}$.

(a) Determine the probability of finding the electron within L/4 of either wall if it is in the ground state. [6]

(b) Determine the probability of finding the electron within $\boldsymbol{L/4}$ of either wall if it is in the n=4 state. [Hint: Evaluate $\int_0^{L/4}|\psi|^2dx + \int_{3L/4}^{L}|\psi|^2dx$] [3]

(c) What is the classical prediction? [3]

End of question paper