GLASGOW COLLEGE UESTC

Final Exam paper

Physics II (UESTC2010)

Date: 4th Jan. 2021
Time: 19:00pm-21:00pm

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.
For Multiple Choice Questions, use the dedicated answer sheet provided.

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.

DATA/FORMULAE SHEET IS PROVIDED AT THE END OF PAPER

Useful constants

Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} C^2/N \cdot m^2$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} T \cdot m/A$
Elementary mass	$1u = 1.66 \times 10^{-27}\text{kg}$
Electron rest mass	$m_e = 9.11 \times 10^{-31}\text{kg} = 0.511\text{MeV/c}^2$
Elementary charge	$e = 1.60 \times 10^{-19} C$
Compton wavelength	$\lambda_C = 2.43 \times 10^{-12} m$
Planck's constant	$h = 6.63 \times 10^{-34} J \cdot s$

Continued overleaf

Q1 Multiple choice.
Choose the ONE alternative that best complete the statement or answer the questions.

( ) (1) Which of the equations about the electrostatic field E_0 and induced electric field E_i is correct? [3]

(A) $\oint_S \vec{E}_i \cdot \mathrm{d}\vec{S} = 0$

(B) $\oint_S \vec{E}_0 \cdot \mathrm{d}\vec{S} = Q_{in}$

(C) $\oint_l \vec{E}_i \cdot \mathrm{d}\vec{l} = -\mathrm{d}B/\mathrm{d}t$

(D) $\oint_s (\vec{E}_0 + \vec{E}_s) \cdot \mathrm{d}\vec{S} = 0$

(E) $\oint_l (\vec{E}_0 + \vec{E}_s) \cdot \mathrm{d}\vec{l} = 0$

( ) (2) An electromagnetic wave with a peak magnetic field magnitude of $1.50 \times 10^{-7}\ T$ has an associated peak electric field of what magnitude? [3]

(A) 0.50×10^{-15} N/C (B) $2.00 \times 10^{-5}\ N/\mathrm{C}$ (C) 2.20×10^{4} N/C

(D) 45.0 N/C (E) 22.0 N/C

( ) (3) At an instant of time during the oscillations of an LC circuit, the current is at its maximum value. At this instant, what happens to the capacitor? [3]

(A) The voltage across the capacitor is different from that across the inductor.
(B) The voltage across the capacitor is zero.
(C) The voltage across the capacitor has its maximum value.
(D) The voltage across the capacitor is impossible to determine.
(E) The energy stored in the capacitor has its maximum value.

( ) (4) At what speed $\boldsymbol{v}$ will an object's relativistic mass $\boldsymbol{m}$ is twice its rest mass $\boldsymbol{m_0}$? [3]

(A) 0.5c (B) 0.6c (C) 1.0c (D) 0.866c (E) 0

( ) (5) Two spaceships leave Earth in opposite directions, each with a speed of **0.50c** with respect to Earth. What is the velocity of spaceship 2 relative to spaceship 1? [3]

(A) 0.5c (B) 0.42c (C) 1.00c (D) 0 (E) 0.8c

Continued overleaf

( ) (6) In Compton Effect, X-rays of wavelength $\lambda_0 = 0.2\text{nm}$ are scattered from a block of material. The scattered X-rays are observed at an angle of 90.0° to the incident beam. What is the scattered wavelength? [3]

(A) 0.00243 nm (B) 0.00486nm (C) 0.20243nm
(D) 0.20486nm (E) 0.19757nm

( ) (7) A particle in a rigid box of length L is in the first excited state for which $n = 2$ (Fig. Q1). Where is the particle most likely to be found? [3]

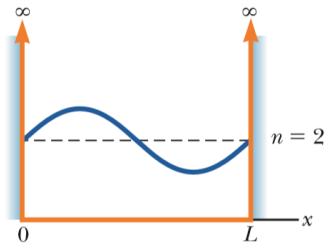

Figure Q1

(A) At the center of the box.
(B) At either end of the box.
(C) All points in the box are equally likely.
(D) One-fourth of the way from either end of the box.
(E) None of those answers is correct.

( ) (8) An electron and a proton (^{1}H) both moving at nonrelativistic speeds have the same de Broglie wavelength. Which of the following quantities are also the same for the two particles? [2]

(A) mass (B) speed (C) total energy (D) kinetic energy (E) momentum

( ) (9) Which electron configuration is forbidden? [2]

(A) $1s^2 2s^3 2p^3$ (B) $1s^2 2s^2 2p^5 3s^2$ (C) $1s^2 2s^2 2p^6 2d^2$

(D) $1s^2 2s^3 2p^6 3s^1$ (E) $1s^2 2s^2 2p^6 3s^2$

Continued overleaf

Q2 (a) Determine the magnetic flux through a square loop (shown in Fig.*Q2-1*) of side a if one side is parallel to, and a distance a from a straight wire that carries a current I. [5]

(b) In Fig. *Q2-1*, if the current *I* increase slowly, what is the direction of the current induced inside the loop? Explain. [4]

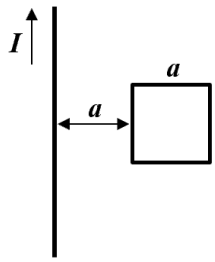

Figure Q2-1

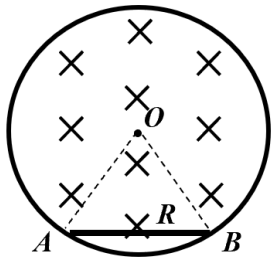

Figure Q2-2

(c) Uniform magnetic field exists only in a cylindrical space with radius R, and it changes as $\mathrm{d}B/\mathrm{d}t = C > 0$, where C is a constant. Determine the induced electric field $\vec{E}_i$ inside and outside the volume enclosed by the cylinder. [8]

(d) If a straight wire *AB* (length *R*) lays in Fig. *Q2-2*, where *O* is the center of the cylinder, A, B points are at the cylinder surface. What is the EMF $\boldsymbol{\varepsilon}$ in the wire? [8]

Q3 (a) Toroid (Fig. *Q3*) is often used in transformers and other devices. Consider a toroid (N loops, current I) with rectangular cross-section. Determine the magnetic energy U_m stored in the toroid. [8]

(b) Determine the self-inductance *L* of the toroid. [9]

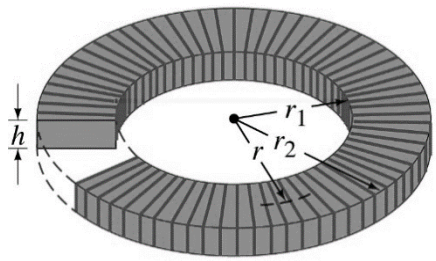

Figure Q3

(c) Determine the mutual inductance M per unit length between two long solenoids, one inside the other, whose radii are r_1 and r_2 ($r_2 < r_1$) and whose turns per unit length are n_1 and n_2. [8]

Continued overleaf

Q4 (a) What is the principle of uncertainty by Heisenberg? How accurately can the position of a 25.0 keV electron be measured assuming its energy is known to be 1.00 percent? [8]

(b) A particle trapped in a special potential well has a wave function $\psi = Cx(L - x)$, where $0 < x < L$. What is the constant C ? What is the probability p to find the particle in the region $0 < x < L/2$? [9]

(c) Show that the number of different states possible for a given value of l is equal to $2(2l + 1)$. What is this number for $l = 0,\ 1,\ 2,\ 3,\ 4,\ 5$ and 6? [8]

End of question paper