GLASGOW COLLEGE UESTC

Final Exam paper

Physics II (UESTC2010)

Date: Dec.23rd, 2021
Time: 7:00-9:00pm

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.

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 START OF PAPER

Useful constants

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

Mass of electron $\boldsymbol{m_e = 9.11 \times 10^{-31} kg}$

Compton wavelength $\boldsymbol{\lambda_C = 2.43 \times 10^{-12} m}$

Planck's constant $\boldsymbol{h = 6.626 \times 10^{-34} J \cdot s}$

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Q1 Multiple choice

Choose the ONE alternative that best completes the statement or answer the question.

1. ( ) A conducting rod in a uniform magnetic field rotates about its end as shown in the figure. How much is the induced EMF? [3]

(A) $\varepsilon = BL^2\omega$

(B) $\varepsilon = \frac{1}{2}BL^2\omega$

(C) $\varepsilon = \frac{1}{3}BL^2\omega$

(D) $\varepsilon = 0$

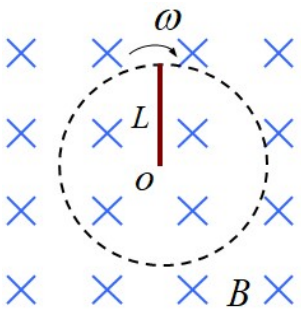

Figure Q1-1.

2. ( ) In an LC circuit, the current changes as $I = I_0 \sin\omega t$. What is the energy stored in the Capacitor? [3]

(A) $U = \frac{1}{2}CI_0^2 \cos^2 \omega t$

(B) $U = \frac{1}{2}CI_0^2 \sin^2 \omega t$

(C) $U = \frac{1}{2}LI_0^2 \cos^2 \omega t$

(D) $U = \frac{1}{2}LI_0^2 \sin^2 \omega t$

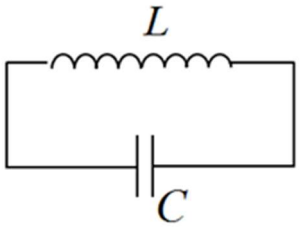

Figure Q1-2.

3. ( ) There are some statements about an electromagnetic wave. Which of them is CORRECT? [3]

(A) The electric field and magnetic field caused by the wave is always parallel to each other.

(B) The electric field and magnetic field at the same point oscillates in phase.

(C) The energy is transported along the direction of electric field.

(D) The wave speed is independent of the medium in which it travels.

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4. ( ) Someone measures the volume of a cube at rest to be V_0. He then measures the volume V of the same cube, when it passes him at speed v=0.980c in a direction parallel to one side of the cube. How much is V_0 / V? [3]

(A) 0.04 (B) 0.20

(C) 5.0 (D) 25.3

5. ( ) Two spaceships leave Earth in the same direction, with a speed of **0.50c** and **0.80c** relative to the Earth respectively. What is the speed v of spaceship 2 relative to spaceship 1? [3]

(A) 0.50c (B) 0.80c

(C) 0.93c (D) 1.30c

6. ( ) Photons may be emitted when a hydrogen atom initially at the 4th excited state jumps to other energy level. What is the maximum possible wavelength λ of the photons? [3]

(A) $4.05\times10^{-6}\,m$

(B) $1.88\times10^{-6}\,m$

(C) $3.27\times10^{-7}\,m$

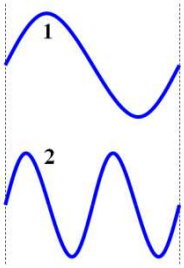
(D) $9.50\times10^{-8}\,m$

7. ( ) The following figure shows the de Broglie wave of two nonrelativistic electrons. Then what is the relationship about their kinetic energy? [3]

(A) $E_{k1}=2E_{k2}$

(B) $E_{k1}=E_{k2}$

(C) $E_{k2}=2E_{k1}$



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(D) $E_{k2} = 4E_{k1}$

Figure Q1-7.

8. ( ) A particle trapped in an infinitely deep square potential well of length L, has a wave functions $\psi(x) = \sqrt{\frac{2}{L}} \sin(\frac{2\pi}{L} x)$. What is the probability to find the particle in region $0 < x < \frac{L}{3}$? [2]

(A) 0.264

(B) 0.303

(C) 0.333

(D) 0.402

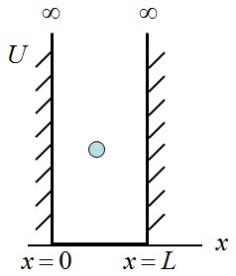

Figure Q1-8.

9. ( ) Considering all possible values of quantum numbers (n, l, m_l, m_s), What is the maximum number of electrons in the shell for n=3 ? [2]

(A) 2

(B) 8

(C) 18

(D) 32

Q2 A straight wire lies on a conducting rail in nonuniform magnetic field $B = bx$ (b is a constant) as figure. The wire moves along x axis with constant speed v, passing origin O when $t = 0$.

(a) Determine the magnetic flux Φ_B through the triangular loop at moment t. [7]

(b) Determine the induced EMF $\mathcal{E}$ in the triangular loop. [6]

(c) If the magnetic field changes as $B = bx \sin t$, what is the induced EMF $\mathcal{E}$? [6]

(d) Write out the definition formula of self-inductance L, how does L of the triangular loop change when the wire moves? [6]

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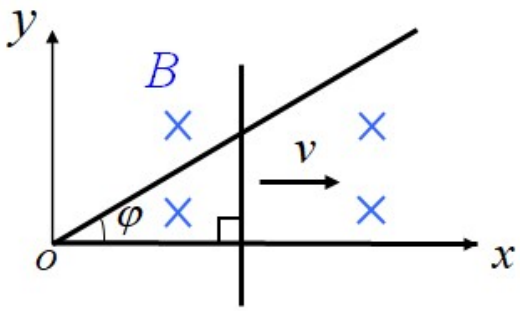

Figure Q2.

Q3 Wireless power transmission technology can transfer energy by electromagnetic waves. Suppose the electromagnetic wave has a frequency of 6.0MHz, and it transfers 5.0W average power through an effective area 30cm^2.

(a) Write out the Maxwell's equations, and use them to explain the production of electromagnetic waves. [8]

(b) What is the maximum value of electric field $E_{\max}$ and magnetic field $B_{\max}$ due to the electromagnetic wave? [7]

(c) How many photons pass through the 30cm^2 area in 1 second? [5]

(d) If this electromagnetic wave shines onto a metallic surface, can we observe the Photoelectric Effect, why? [5]

Q4 In a Compton scattering experiment, an X-ray photon collides with a resting electron, the wavelength of photon changes from 0.01nm to 0.011nm after the collision.

(a) Draw a figure to show the collision process, and determine the kinetic energy ΔE_k transferred from the photon to the electron. [5]

(b) About the electron after collision, how much is the total energy E, speed v and momentum p? [10]

(c) What is the de Broglie wavelength λ of electron? [5]

(d) If the relative uncertainty in momentum of the electron is 0.1%, what is the minimum uncertainty in position Δx , by Heisenberg uncertainty principle? [5]

End of question paper