Beijing-Dublin International College

SEMESTER I FINAL EXAMINATION - 2023/2024

Beijing-Dublin International College

《UNIVERSITY PHYSICS 2》 BDIC2008J

Dr. Hao Zhu

Time Allowed: 95 minutes

Instructions for Candidates

Full marks will be awarded for complete answer to All questions.

BJUT Student ID: _____ **UCD Student ID: _____**

I have read and clearly understand the Examination Rules of both Beijing University of Technology and University College Dublin. I am aware of the Punishment for Violating the Rules of Beijing University of Technology and/or University College Dublin. I hereby promise to abide by the relevant rules and regulations by not giving or receiving any help during the exam. If caught violating the rules, I accept the punishment thereof.

Honesty Pledge：_____ (Signature)

Instructions for Invigilators

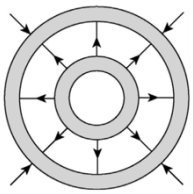
Non-programmable calculators are permitted.
No rough-work paper is to be provided for candidates.

Part 1: Multiple Choice (3 marks each question, 30 marks altogether)

1. Which of the following statements is NOT true?

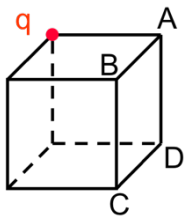
(A) Millikan oil-drop experiment is the first direct measurement of single electron's charge.
(B) Electric field lines start at positive charges or infinity.
(C) The electric dipole moment is directed from the positive charge to the negative charge.
(D) Proton carries positive charge and neutron carries no charge.

2. Sketch qualitatively the electric field lines both between and outside two concentric conducting spherical shells when a uniform positive charge q_1 is on the inner shell and a uniform negative charge $-q_2$ is on the outer. What is the relationship of the magnitudes between q_1 and q_2?



(A) $q_1 > q_2$
(B) $q_1 < q_2$
(C) $q_1 = q_2$
(D) It is hard to tell.

3. What is the electric flux through the surface ABCD?



(A) $^{q}/_{12\varepsilon_0}$
(B) $^{q}/_{18\varepsilon_0}$
(C) $^{q}/_{24\varepsilon_0}$
(D) $^{q}/_{30\varepsilon_0}$

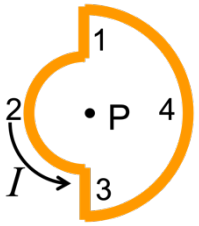
4. What is the electric energy density for the parallel-plate capacitor? (Suppose D is electric displacement vector and E is electric field)

(A) $\frac{1}{2}DE$
(B) DE
(C) DE^2
(D) $\frac{1}{2}DE^2$

5. Which of the following statement is NOT true?

(A) Polarization density P is the vector sum of the electric dipole moment per unit volume in dielectric.
(B) The electric susceptibility χ of the dielectric just depends on its property.
(C) The electric susceptibility χ has unit.
(D) The unit of electric displacement vector D is C/m^2.

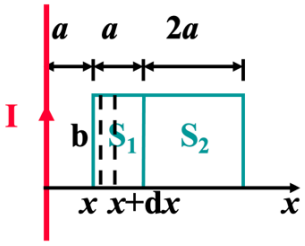
6. Consider a coil made of semi-circles of radii R and $2R$ and carrying a current I. What is the magnetic field B at point P?



(A) $3\mu_0 I/8R$
(B) $5\mu_0 I/6R$
(C) $5\mu_0 I/7R$
(D) $\mu_0 I/2R$

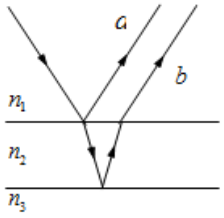
7. Φ_{m1} and Φ_{m2} are the magnetic flux through S_1 and S_2 as shown in the figure, then what is the value of Φ_{m1}: Φ_{m2}?

(A) 1:1
(B) 1:2
(C) 2:1
(D) 1:3



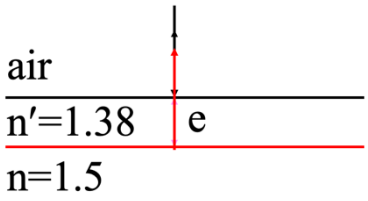
8. A ray of light is incident on a thin film. Two of the reflected rays are shown. Assume that rays *a* and *b* undergo a phase change because of differences in the indices of refraction. Which would be the proper ordering of the indices?

(A) $n_1 > n_2 > n_3$
(B) $n_2 > n_3 > n_1$
(C) $n_3 > n_2 > n_1$
(D) None of these; the specified phase changes cannot occur.



9. Lenses are often coated with thin film of transparent substance such as MgF_2 to reduce the reflection from the glass surface. How thick a coating *e* is needed at least to produce a minimum reflection at the center of the visible spectrum? ($\lambda = 550$ nm)

(A) 130.8 nm
(B) 116.5 nm
(C) 107.3 nm
(D) 99.6 nm



10. The wave function of a particle is $\psi(x) = \cos(3\pi x/2a)/\sqrt{a}$, where $-a \le x \le a$. What is the distribution probability of the particle at point $x = 5a/6$?

(A) $1/\sqrt{2a}$
(B) $1/2a$
(C) $1/\sqrt{4a}$
(D) $1/4a$

Part 2: Blank Filling (20 marks altogether)

1. (4 points) The differential form of Maxwell's equations is

$\nabla \cdot \vec{D} = \rho_f$ (A)

$\nabla \cdot \vec{B} = 0$ (B)

$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ (C)

$\nabla \times \vec{B} = \mu_0 \left(\vec{j} + \frac{\partial \vec{D}}{\partial t}\right)$ (D)

Determine which equation in the following descriptions is related to.

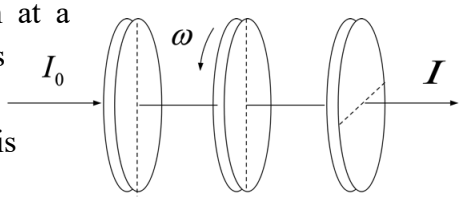
(1) There is no magnetic monopole. _____

(2) It describes how electric fields are induced by charges. _____

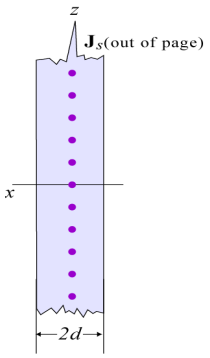
(3) It illustrates the generation of magnetic fields by electric currents and the induction of magnetic fields by changing electric fields. _____

(4) It describes the induction of electric fields by changing magnetic fields. _____

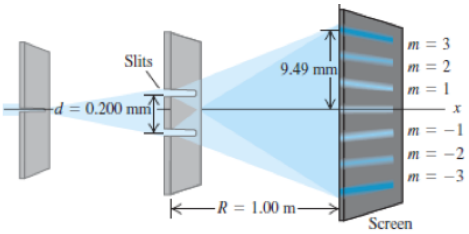
2. (4 marks) There are three polarizing sheets. The polarizing directions of the first and the third are perpendicular and the second rotates about the incident light beam at a constant angular speed ω. If the unpolarized incident light has intensity I_0 and the polarizing direction of the second is parallel to that of the first at $t = 0$, the transmitted intensity through the device is _____.



3. (4 marks) A sheet of current (infinite in the y & z directions, of thickness $2d$ in the x direction) carries a uniform current density $\vec{j} = j\hat{k}$. For $x > d$, the magnetic field strength is _____.



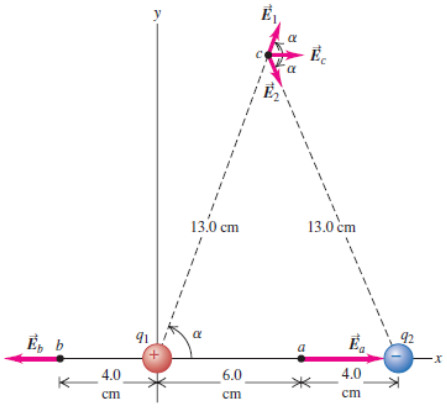
4. (4 marks) The figure illustrates a two-slit interference experiment in which the slits are 0.200 mm apart and the screen is 1.00 m from the slits. The $m = 3$ bright fringe in the figure is 9.49 mm from the central fringe. The wavelength of the light is _____ nm.



5. (4 marks) In atom, the maximum number of electrons in Shell M (n = 3) is _____. In Shell K (n = 1), the four quantum numbers (n, l, m_l, m_s) of electrons are (__,__,__,__) and (__,__,__,__).

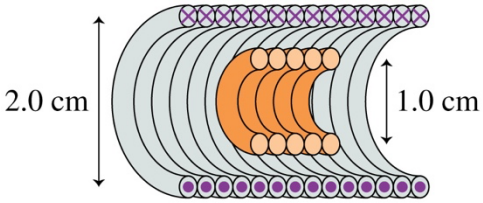
Part 3: Calculation (10 marks each question, 50 marks altogether)

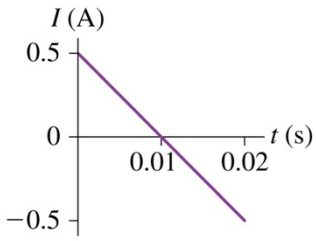
1. Point charges $q_1 = 12$nC and $q_2 = -q_1$ are 0.10m apart. Such pairs of point charges with equal magnitude and opposite sign are called electric dipoles. Please calculate the total field at points a, b and c. (Hint: $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/(N \cdot m^2)}$)



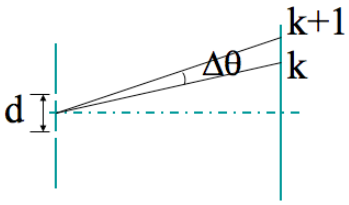
2. A parallel-plate capacitor has plates of area 0.12 $\mathrm{m^2}$ and a separation of 1.2 m. A battery charges the plates to a potential difference of 120 V and is then disconnected. A dielectric slab of thickness 4.0 mm and relative permittivity $\varepsilon_r = 4.8$ is then placed symmetrically between the plates. (a) What is the capacitance before the slab is inserted? (b) What is the capacitance with the slab in place? What is the free charge q (c) before and (d) after the slab is inserted? What is the magnitude of the electric field (e) in the space between the plates and dielectric and (f) in the dielectric itself? (Hint: $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/(N \cdot m^2)}$)

3. The figure shows a 5-turn 1.0-cm diameter coil with $R = 0.10\Omega$ inside a 2.0-cm solenoid. The solenoid is 8.0cm long, has 120 turns and carries the current shown in the graph. A positive current is counter-clockwise when seeing from the left. What is the direction and magnitude of the current in the coil? (Hint: $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{N/A^2}$)





4. In a two-slit interference experiment, $\lambda = 589.3$ nm, the angular distance $\Delta\theta$ between two adjacent fringes is 0.20°. (a) For what wavelength λ, the angular distance will increase by 10%? (b) If the device is put into water ($n = 1.33$), what is the angular distance? (Hint: $\sin\theta \approx \theta$ if $\theta \to 0$)



5. Light of wavelength 600nm normally falls on a diffraction grating. The 2nd-order bright fringe occurs at angle given by $\sin\theta = 0.20$, and the $\pm$4th-order maxima are missing firstly. (a) What is grating spacing? (b) What is the slit-width of this grating? (c) How many orders of principal maxima can be observed by this grating? Please list all of them.