**Beijing-Dublin International College**

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**SEMESTER I FINAL EXAMINATION - 2021/2022**

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**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**

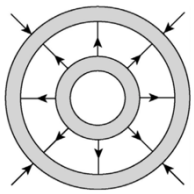
Non-programmable calculators are permitted.
No rough-work paper is to be provided for candidates.

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

1. An electron is released from rest in a region of space with nonzero electric field. Which of the following statements is true?

(A) The electron will move towards the region with lower potential.
(B) The electron will move towards the region with higher potential.
(C) The electron will move along a line of constant potential.
(D) Nothing can be concluded unless the direction of the electric field is known.

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 $q_2$?

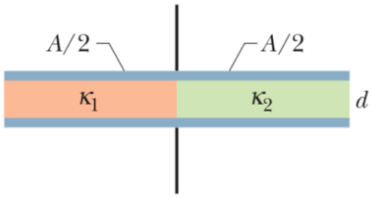


(A) $q_1 > q_2$
(B) $q_1 < q_2$
(C) $q_1 = q_2$
(D) It is hard to tell.

3. In which of the following problems would Gauss' law be useful?

(A) Finding the electric field at various points on the surface of a uniformly charged cylinder of finite length.
(B) Finding the electric flux through the end surface of a uniformly charged cylinder.
(C) Finding the electric field at various points on the surface of a uniformly charged plane of finite area.
(D) Finding the electric flux through one side of a uniformly charged cube.

4. The right figure shows a parallel-plate capacitor with a plate area $A = 5.56\ \text{cm}^2$ and separation $d = 5.56$ mm. The left half of the gap is filled with material of relative permittivity $\varepsilon_1 = 5.00$; the right half is filled with material of relative permittivity $\varepsilon_2 = 10.00$. What is the capacitance? (Hint: $\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2/(\text{N}\cdot\text{m}^2)$)

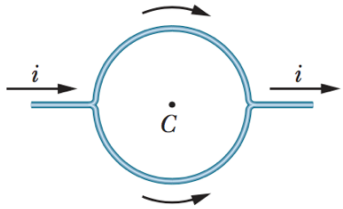



(A) 3.72 pF
(B) 6.64 pF
(C) 9.26 pF
(D) 16.11 pF

5. A proton traveling at $23.0^\circ$ with respect to the direction of a magnetic field of strength 2.6 mT experiences a magnetic force of $6.50 \times 10^{-17}$ N. What is the proton's speed and its kinetic energy in electron-volts? (Hint: $e = 1.60 \times 10^{-19}$ C, $m_p = 1.67 \times 10^{-27}$ Kg)

(A) $4.00 \times 10^5$ m/s; 835 eV
(B) $6.00 \times 10^5$ m/s; 976 eV
(C) $4.00 \times 10^5$ m/s; 1670 eV
(D) $6.00 \times 10^5$ m/s; 1464 eV

6. A straight conductor carrying current $i = 5.0$ A splits into identical semi-circular arcs with the radius 1 m as shown below. What is the magnetic field at the center *C* of the resulting circular loop? (Hint: $\mu_0 = 4\pi \times 10^{-7}$ N/A$^2$)

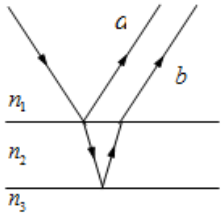



(A) $1.00 \times 10^{-6}$ T
(B) 0
(C) $-1.00 \times 10^{-6}$ T
(D) None of these and Happy New Year!

7. A certain elastic conducting material is stretched into a circular loop of 12.0 cm radius. It is placed with its plane perpendicular to a uniform 0.80 T magnetic field. When released, the radius of the loop starts to shrink at an instantaneous rate of 75 cm/s. What emf is induced in the loop at that instant?

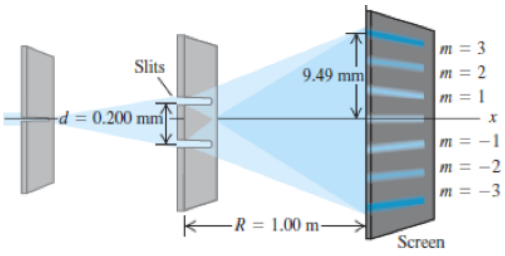
(A) 0.23 V
(B) 0.45 V
(C) 0.97 V
(D) 1.14 V

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. 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. What is the wavelength of the light?




(A) 633 nm
(B) 658 nm
(C) 666 nm
(D) 686 nm

10. What is the De Broglie wavelength of Dr. Hao Zhu, assuming his body weight is 75 kg, and is running at 5 m/s? (Hint: $h = 6.63 \times 10^{-34}$ J · s)

(A) $1.77 \times 10^{-36}$ m
(B) $2.75 \times 10^{-36}$ m
(C) $4.27 \times 10^{-36}$ m
(D) $6.73 \times 10^{-36}$ m

**Part 2:** Blank Filling (20 marks altogether)

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

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

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

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

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

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) In a single slit diffraction experiment, $\lambda = 600$ nm, a $= 0.60$mm, f $= 60$cm. The linear width of the central bright fringe is _____. The distance between the two third diffraction minima on both side of central diffraction maximum is _____.

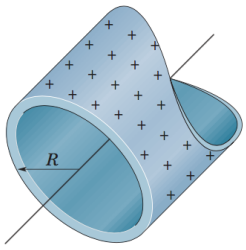
3. (4 marks) The two surfaces are parallel to each other. The incident light is unpolarized light. If the reflected light from the upper surface is totally polarized, the incident angle is _____ (in degree). The refraction angle is _____ (in degree). ($n_{glass} = 1.60$)

4. (4 marks) The wave function of a particle is $\psi(x) = \frac{1}{\sqrt{a}} \cos \frac{3\pi x}{2a}$ $(-a \le x \le a)$. The distribution probability of the particle at point $x$=5$a$/6 is _____. At points $x$= _____ the distribution probability of the particle is maximum.

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 (__,__,__,__).

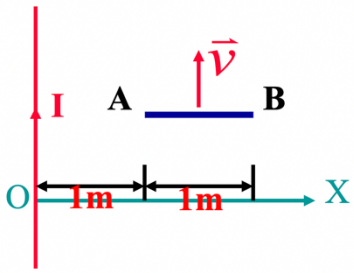
**Part 3:** Calculation (10 marks each question, 50 marks altogether)

1. The figure shows a section of a long, thin-walled metal tube of radius $R = 3.00$ cm, with a charge per unit length of $\lambda = 2.00 \times 10^{-8}$ C/m. What is the magnitude $E$ of the electric field at radial distance (a) $r = R/2.00$ and (b) $r = 2.00R$? (c) Graph $E$ versus $r$ for the range $r = 0$ to $2.00R$. (d) What is the maximum value of the electric field in this system? (Hint: $\varepsilon_0 = 8.85 \times 10^{-12}$ 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: $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C}^2/(\mathrm{N}\cdot\mathrm{m}^2)$)

3. Given $I = 40$ A, and $v = 2$ m/s. (a) What is the motional electromotive force of bar AB? (b) Which end has the higher electric potential? Please explain the reason. (Hint: $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{N/A}^2$)




4. A double-slit arrangement produces interference fringes for sodium light ($\lambda = 589$ nm) that have an angular separation of $3.50 \times 10^{-3}$ rad. (a) For what wavelength would the angular separation be 10.0% greater? (b) If the device is in the 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$3rd-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.