北京郵電大學

Queen Mary University of London

For examiners' use only

1	
2	
3	
4	
5	
6	
7	
8	
Total	

BBC5210 A

Joint Programme Examinations 2022/23

BBC5210 Electric & Magnetic Fields

Paper A

Time allowed 2 hours

Answer ALL questions

Complete the information below about yourself very carefully.

QM student number										
BUPT student number										
Class number										

ALLOWED **: electronic calculators and electronic dictionaries.**

INSTRUCTIONS

1. **You must NOT take answer books, used or unused, from the examination room.**
2. Write only with a black or blue pen **and in English**.
3. Do all rough work in the answer book – **do not tear out any pages**.
4. If you use Supplementary Answer Books, tie them to the end of this book.
5. Write clearly and legibly.
6. **Read the instructions on the inside cover.**

Examiners

Dr Yong Zuo, Dr Shaohua Liu

Instructions

Before the start of the examination

1) Place your BUPT and QM student cards on the corner of your desk so that your picture is visible.

2) Put all bags, coats and other belongings at the back/front of the room. All small items in your pockets, including wallets, mobile phones and other electronic devices must be **placed in your bag in advance**. **Possession of mobile phones, electronic devices and unauthorised materials is an offence.**

3) Please ensure your mobile phone is switched off and that no alarm will sound during the exam. **A mobile phone causing a disruption is also an assessment offence.**

4) Do not turn over your question paper or begin writing until told to do.

During the examination

1) You must not communicate with or copy from another student.

2) If you require any assistance or wish to leave the examination room for any reason, please raise your hand to attract the attention of the invigilator.

3) If you finish the examination early you may leave, but not in the first 30 minutes or the last 10 minutes.

4) For 2 hour examinations you may **not** leave temporarily.

5) For examinations longer than 2 hours you **may** leave temporarily but not in the first 2 hours or the last 30 minutes.

At the end of the examination

1) You must stop writing immediately – **if you continue writing after being told to stop, that is an assessment offence.**

2) Remain in your seat until you are told you may leave.

Question 1 Single Choice, Choose A, B, C or D in the blank area below every problem.

1） With respect to the alternating electromagnetic fields ($\vec{E}$, $\vec{D}$, $\vec{H}$, $\vec{B}$, ω) in a source-free conductive medium (ε, μ, σ), the displacement current density in Maxwell's first equation is ____. [2 marks]

A. $\nabla \times \vec{H}$ **;** **B.** $\frac{\partial \vec{D}}{\partial t}$ **;** **C. 0;** **D .** $\sigma \vec{E}$

	Do not write in this column
	2 marks

2）In the absence of any surface currents and charges at the interface between perfect dielectrics, the normal components and the tangential components of $\vec{E}$ should be respectively ____. [2 marks]

A. continuous, continuous; **B**. discontinuous, continuous;
C. continuous, discontinuous; **D**. discontinuous, discontinuous.

	Do not write in this column
	2 marks

3）If there exist surface currents ($\vec{J}_s$) and charges (ρ_s) at the interface of a perfect conductor, the difference between the normal components of $\vec{D}$ and the difference of tangential components of $\vec{H}$ should be respectively _____ . [2 marks]

A. ρ_s, $\left|\vec{J}_s\right|$; **B.** ρ_s, ρ_s; **C.** $\left|\vec{J}_s\right|$, ρ_s; **D.** $\left|\vec{J}_s\right|$, $\left|\vec{J}_s\right|$

	Do not write in this column
	2 marks

4） The polarization of wave if the electric field intensity in a region is given by $\vec{E} = (\vec{e}_x + j\vec{e}_y)\ E_0 e^{j(\omega t - kz)}$ is____ . [2 marks]

A. elliptically polarized B. right-hand circularly polarized
C. left-hand circularly polarized D. linearly polarized

	Do not write in this column
	2 marks

5）As for the oblique incidence on surface of perfect conductor, the total wave whose electric field lies in the incidence plane will be a ____wave. [2 marks]

A. TE B. TM C. TEM D. no correct answers

	Do not write in this column
	2

	marks

6）When a homogenous plane wave (HPW) propagates in boundaryless region of source-free, lossless, isotropic homogenous medium, the phase difference between electrical field intensity and magnetic field intensity is____. [2 marks]

A. 0^0 B. 45^0 C. 90^0 D. -45^0

	Do not write in this column
	2 marks

7）In conducting medium, the phase velocity is related with frequency. The shape of a wave comprising many different frequencies will keep on changing as it progresses. The signal is distorted by the time it reaches its destination. This phenomenon is called_____ . [2 marks]

A. attenuation B. loss C. polarization D. dispersion .

	Do not write in this column
	2 marks

8）If an uniform plane wave is normally incident from air upon the surface of a perfect conductor and the magnitude of incidence electric wave is 377 V/m, the magnitude of the surface current density on conductor is____. [2 marks]

A. 1A/m B. $1A/m^2$ C. 2A/m D. $2A/m^2$

	Do not write in this column
	2 marks

9）If an uniform plane wave is obliquely incident from a perfect dielectric (ε_r μ_0) on air and the incidence angle is 26.57^o. If the total refraction occurs, then the possible ε_r is____. [2 marks]

A. 1 B. 4 C. 9 D. 16

	Do not write in this column
	2 marks

10) The rectangular waveguide’s lowest-order mode in all TEmn modes is _____. [2 marks]

A. 10 B. 11 C. 20 D. 22

	Do not write in this column
	2 marks

Question marking: $\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}=\frac{}{20}$

Question 2 Choose True (T) or False (F) in the blank area below every problem.

[2 marks for each, 10 marks in total]

1) For time-varying electromagnetic fields, the divergence of $\vec{E}$ must be zero.

	Do not write in this column
	2 marks

2) For time-varying electromagnetic fields, the line of electric flux density can be closed itself.

	Do not write in this column
	2 marks

3) The Poynting vector represents the transmission direction of a time-varying electromagnetic field.

	Do not write in this column
	2 marks

4) The electromagnetic waves with different frequencies will have the same phase velocity when they propagate in sea water.

	Do not write in this column
	2 marks

5) For a uniform plane wave propagating in a perfect dielectric in boundaryless region, the electric field leads the magnetic field.

	Do not write in this column
	2 marks

6) The displacement current can be produced by static and time-varying electric fields.

	Do not write in this column
	2 marks

7) The loss tangent greater than 100 means good conductor.

	Do not write in this column
	2 marks

8) Total refraction is possible for a parallel polarized wave when oblique incidence from the glass to air.

	Do not write in this column	
		2 marks

9) In a rectangular waveguide with $a > b$, TE_{10} and TE_{01} modes have the different cut-off frequency.

	Do not write in this column	
		2 marks

10) Electromagnetic waves with any wavelength can enter a given rectangular waveguide and be transmitted.

	Do not write in this column	
		2 marks

Question marking: $\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}+\frac{}{2}=\frac{}{20}$

Question 3 Simple Answer**.**

a) Prove that an elliptically polarized wave, $\vec{E} = \vec{e}_x 6E_0 \cos(\omega t - kz) + \vec{e}_y 8E_0 \sin(\omega t - kz)$, can be expressed as a sum of left- and right-handed circularly polarized waves of unequal amplitude.

[6 marks]

	Do not write in this column	
		6 marks

b) Give two wave equations (in time domain) about $\vec{E}$ and $\vec{H}$ in an isotropic homogeneous source-free and lossless medium region.

[4 marks]

	Do not write in this column	
		4 marks

Question marking: $\frac{}{6}+\frac{}{4}=\frac{}{10}$

Question 4

A uniform plane wave propagates in perfect dielectric ($\varepsilon_r = 9$, $\mu_r = 1$) with electric field intensity is: $\vec{E} = \vec{e}_x 36\cos(\omega t - kz) - \vec{e}_y 25\sin(\omega t - kz)$ (V/m), where $\omega = 9\times10^8$ rad/s. Determine:

a) The wavelength λ, phase velocity v_p, phase shift constant and wave impedance.

b) The frequency-domain expression of magnetic field intensity $\dot{\vec{H}}$.

c) The average Poynting vector $\vec{S}_{av}$.

[10 marks]

	Do not write in this column
	10 marks

Question 5

An antenna just beneath the surface of a conducting medium ($\varepsilon_r = 1$, $\mu_r = 1$ and $\sigma = 4\times10^7$ S/m) is transmitting a signal at 100 Hz. Assuming that the signal propagate as a homogeneous plane wave, a receiver buried in the medium receives the signal which phase exactly changes $\pi/2$. Determine:

a) Whether the medium acts like a good conductor? Give the reason;

b) The phase constant, and the distance between the receiver and the transmitter.

[10 marks]

	Do not write in this column
	10 marks

Question 6

A uniform plane wave is normally incident on the surface of a perfect dielectric ($\mu_r = 1$) from air at x=0. Given the electric field of incident wave can be expressed as $\dot{\vec{E}}^+ = E_0^+ \vec{e}_y e^{j(\omega t - kx)}$ (V/m) .

a) If $E_0^+ = 3\times10^{-3}$ V/m and the amplitude of the reflected magnetic field is $H_0^- = 2.653\times10^{-6}$ A/m, find ε_r of the perfect dielectric.

b) Find the complex form of reflected electric field intensity $\dot{\vec{E}}^-$.

c) Find the complex form of refracted magnetic field intensity $\dot{\vec{H}}^T$.

[10 marks]

	Do not write in this column
	10 marks

Question 7

A uniform plane wave is incident from air upon the surface of perfect conductor at z=0 (XOY plane). Given the incident field is $\vec{E}^+ = \vec{e}_x 10 e^{j(\omega t - 6y - 8z)}$ (V/m). Determine:

a) The angle of incidence.

b) The expression of magnetic field of reflected wave.

[10 marks]

	Do not write in this column
	10 marks

Question 8

Consider a rectangular waveguide with cross section a×b＝30cm×20cm is filled with a perfect dielectric ($\varepsilon_r = 4$, $\mu_r = 1$). If a uniform plane wave in the air inputs to the rectangular waveguide. Determine the frequency ranges of input plane wave in the air when it is transmitted in the single mode in the waveguide.

[10 marks]

	Do not write in this column
	10 marks

Appendix: $\varepsilon_0 = \frac{1}{36\pi} \times 10^{-9}$ (F/m), $\mu_0 = 4\pi \times 10^{-7}$ (H/m).

For a good conductor, $\alpha = \beta = \sqrt{\frac{\omega\mu\sigma}{2}}$; for a good dielectric $\alpha = \frac{\sigma}{2}\sqrt{\frac{\mu}{\varepsilon}}$, $\beta = \omega\sqrt{\mu\varepsilon}$.

Do not write in this column

2022-2023 Rough Working

Do not write in this

2022-2023 Rough Working

Do not write in this

2022-2023 Rough Working

Do not write in this

2022-2023 Rough Working

	Do not write in this

2022-2023
Rough Working
Page 14 of 14