北京郵電大學

Queen Mary University of London

For examiners' use only

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BBC5210

Joint Programme Examinations 2019/20

BBC5210 Electric & Magnetic Fields

Paper B

Time allowed 2 hours

Answer ALL questions

Complete the information below about yourself very carefully.

QM student number										
BUPT student number										
Class number										

NOT allowed: electronic dictionaries.

INSTRUCTIONS

1. **You must not take answer books, used or unused, from the examination room.**
2. Write only in 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 Qiao Yaojun, Dr Liu Shaohua, Dr Shen Yuanmao

Filename: 1920_BBC5210_B No answerbook required

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.

a) As for the alternating electromagnetic fields ($\vec{E}, \vec{D}, \vec{H}, \vec{B}, \omega$) in a source-free dielectric medium (ε, μ), the displacement current density in complex format is ____.

[2 marks]

A. $\nabla \times \vec{E}$ **;** **B.** $j\omega\vec{D}$ **;** **C.** $j\omega\vec{B}$ **;** **D.** $\partial\vec{D}/\partial t$

	Do not write in this column
	2 marks

b) In the absence of any surface currents and charges at the interface between two different kinds of perfect dielectrics, the normal components of $\vec{D}$ should be ____.

[2 marks]

A.equal; **B**. half; **C**. 0; **D**. double

	Do not write in this column
	2 marks

c) Constitutive relations of fields indicate the dependencies between fields ($\vec{E}, \vec{D}$, $\vec{H}, \vec{B}$) and the media (ε, μ, σ). The equation ___ does NOT belong to the constitutive equations.

[2 marks]

A. $\vec{D} = \varepsilon\vec{E}$; **B**. $\vec{B} = \mu\vec{H}$; **C**. $\vec{J} = \sigma\vec{E}$; **D**. $p = \vec{J} \cdot \vec{E}$

	Do not write in this column
	2 marks

d) The expression of average power density $\vec{S}_{av}$ for time varying EM field is____ .

[2 marks]

A. $\mathrm{Re}(\vec{D} \times \vec{B}^*)/2$ **B**. $\mathrm{Re}(\vec{D} \times \vec{B}^*)$ **C**. $\mathrm{Re}(\vec{E} \times \vec{H}^*)/2$ **D**. $\mathrm{Re}(\vec{E} \times \vec{H}^*)$

	Do not write in this column
	2 marks

e) Both electrical field and magnetic field perpendicular to the propagation direction, without any longitudinal field components, then the wave is also called ____wave.

[2 marks]

A. EM **B**. TEM **C**. TE **D**. TM

	Do not write in this column
	2 marks

f) When an uniform plane wave propagates in a limitless region which filled with perfect dielectric medium, the phase difference between $\vec{E}$ and $\vec{H}$ is_____.

[2 marks]

A. 90^0 **B**. 45^0 **C**.15^0 **D**. 0^0

	Do not write in this column
	2 marks

g) One of characteristics of an EM wave in a conducting medium is transmission attenuation. So the energy is always confined to the region near the conducting medium surface. This phenomenon is called_____ .

[2 marks]

A. skin effect **B**. loss **C**. polarization **D**. dispersion

	Do not write in this column
	2 marks

h) If an uniform plane wave is normally incident on a perfect dielectric board and 36% of the incidence power is reflected, the magnitude of the reflection coefficient is____.

[2 marks]

A. 0.1 **B**. 0.3 **C**. 0.6 **D**. 0.9

	Do not write in this column
	2 marks

i) If the cutoff frequency of TE_{mn} in a rectangular wave guide is 1GHz, then that mode can propagate in the wave guide when the working frequency is ___.

[2 marks]

A. 0.1GHz **B**. 0.5GHz **C**. 1GHz **D**. 1.5GHz

	Do not write in this column
	2 marks

j) The significant feature of the near field of the electric dipole is that there has a ____ phase difference between the electric field strength and the magnetic field strength.

[2 marks]

A. 0^0 **B**. 15^0 **C**.45^0 **D**. 90^0

	Do not write in this column
	2 marks

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

Question 2 Choose True or False in the blank area below every problem.

a) As for EM field, the divergence of $\vec{B}$ must be zero.

	Do not write in this column
	2 marks

b) At the boundary of two different dielectric mediums, the tangential component of $\vec{D}$ must be equal.

	Do not write in this column
	2 marks

c) The unit of Poynting Vector is W/m^2, and this parameter represents the power density.

	Do not write in this column
	2 marks

d) EM waves with different frequencies will have the same phase velocity when they propagate in limitless region filled with perfect dielectric medium.

	Do not write in this column
	2 marks

e) As for EM plane wave propagating in a conducting medium, the magnetic field leads the electric field by an angle, and the wave impedance is a complex quantity.

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	2 marks

f) In the space filled with uniform, ideal and isotropic dielectric medium, the source-free wave equation in terms of electric field is $\nabla^2\vec{E} + \mu\varepsilon\frac{\partial^2\vec{E}}{\partial t^2} = 0$.

	Do not write in this column
	2 marks

g) The incidence wave and the reflected wave have the same phase constant.

	Do not write in this column
	2 marks

h) Total reflection is impossible for EM wave oblique incidence from air to other dielectric.

	Do not write in this column
	2 marks

i) The lowest-order mode in all TM_{mn} modes is TM_{10}.

	Do not write in this column
	2 marks

j） In the far field of the free space electric dipole, the ratio of the electric field and magnetic field must be 377Ω.

	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 short answer

a) In uniform dielectric, please give Maxwell's equations in **integral** form in **source free** region.

[4 marks]

	Do not write in this column
	4 marks

b) Point out the polarization of the following **three** plane waves

A. $\vec{E}=(\vec{e}_x-j\vec{e}_y)e^{-jkz}$ **B**. $\vec{H}=4\vec{e}_x\cos(\omega t-ky)$ **C**. $\vec{E}=4(\vec{e}_x+\vec{e}_y e^{-j\frac{\pi}{4}})e^{jkz}$

[4 marks]

	Do not write in this column
	6 marks

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

Question 4

Given the electric field intensity in a dielectric ($\varepsilon_r = 4, \mu_r = 1$) as $\vec{E} = \vec{e}_z A\pi \cos(\omega t + \pi y)$. Determine:

a) The wavelength and frequency. [4 marks]

b) The impedance and magnetic field intensity $\vec{H}$. [4 marks]

c) The average power density $\vec{S}_{avg}$. [2 marks]

[10 marks]

	Do not write in this column
	10 marks

Question 5

A uniform plane wave propagates in seawater ($\varepsilon_r = 64, \mu_r = 1, \sigma = 4$). Determine:

a) If the loss tangent is 0.01 (i.e. $\tan\delta << 1$), calculate the frequency and phase velocity. [4 marks]

b) If the loss tangent is 100 (i.e. $\tan\delta >> 1$), calculate the skin depth, wave length and impedance. [6 marks]

[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 conductor from air at z=0. Given the electric field of reflected wave can be expressed as $\vec{E}^- = \vec{e}_y E_0 e^{j(\omega t - \beta z)}$.

a) Try to find the expression of electric field ($\vec{E}^+$) of the incidence wave. [3 marks]

b) If the conductor is modified to a perfect dielectrics ($\varepsilon_r = 4 \quad \mu_r = 1$), try to find the electric reflection coefficient R and the expression of electric field of the transmitted wave. [6marks]

[9 marks]

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	9 marks

Question 7

A uniform plane wave propagating in free space strikes the surface of a perfect conductor (z=0). Given the incidence E filed as $\vec{E}^{+} = \vec{e}_x 120\pi e^{j(6\pi\times10^8 t-\pi z+Ay)}(V/m)$. Please determine:

a) the phase constant and A (A>0); [4 marks]

b) the incidence angle and reflected wave propagation direction ($\vec{e}^{-}$); [4 marks]

c) if the conductor are changed to a perfect dielectric ($\mu_r = 1$), and then the total reflection occurs. Please calculate the relative dielectric constant (permitivity) ε_r of that dielectric. [3 marks]

[11 marks]

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	11 marks

Question 8

Consider a rectangular waveguide with cross section a×b＝12cm×6cm is filled with air. Given the longitudinal electric field for a TM mode in that waveguide as following,

$$E_z = E_0 \sin\frac{\pi}{3}x \sin\frac{\pi}{3}y \cos\left(\omega t - \frac{\sqrt{2}}{3}\pi z\right)$$

where the unit of x, y, z is in cm. Please determine:

a) The phase constant and the waveguide wavelength;[4 marks]
a) The working frequency;[3 marks]
b) If the TE_{m2} mode can't propagate in that waveguide, please calculate the minimum m.[3marks]

[10 marks]

	Do not write in this column
	10 marks

Appendix

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

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

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