注意：考試開始鈴響前，不得翻閱試題，
並不得書寫、畫記、作答。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：聯合招生

科 目 代 碼 ：9803

考 試 科 目 ：電磁學

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 110 學年度碩士班考試入學試題

系所班組別：聯合招生 (0598)

考試科目（代碼）：電磁學 (9803)

 *請在【答案卡】作答

全部題目皆為多選題。每題十分，共五個選項，每個選項二分，每個選項答錯倒扣二分之一(倒扣一分)，扣至該考科零分為止。該題無作答則不予計分。

1. A static charge distribution produces a radial electrical field

$$\vec{E} = A\frac{e^{-br}}{r^2}\hat{r}$$

where *A* and *b* are constants. Which are possible total charges *Q*?

(a) $4\pi\epsilon_0 A$

(b) $2\pi\epsilon_0 A$

(c) 0

(d) $-2\pi\epsilon_0 A$

(e) $-4\pi\epsilon_0 A$

2. If P is the polarization vector and E is the electric field, then in the equation $\vec{P} = \alpha\vec{E}$, α in general are

(a) Scalar

(b) Vector

(c) Tensor

(d) Number

(e) Matrix

3. Given that $\nabla \cdot \mathrm{F} = \mathrm{D}$ and $\nabla \times \mathrm{F} = \mathrm{C}$, which are true?

(a) $\nabla \cdot \mathrm{C} = 0$

(b) $\nabla \cdot \mathrm{D} = 0$

(c) $\nabla\mathrm{C} = 0$

(d) $\nabla\mathrm{D} = 0$

(e) $\mathrm{F} = \nabla\mathrm{U} + \nabla \times \mathrm{W}$

4. Suppose a point charge *q* is held a distance d above an infinite grounded conducting plane. Given that the conducting plane is the x-y plane and the point charge *q* is at (0, 0, *d*).

(a) The potential on the conducting plane is constant.

(b) The potential far away from the charge is 0.

(c) An image charge *q* can be set at (0, 0, -*d*) to remove the conducting plane while still satisfying the same boundary conditions.

(d) The induced charge on the conducting plane is 0

(e) The induced charge on the conducting plane is $\frac{qd}{2\pi(x^2+y^2+d^2)^{3/2}}$

5. An uncharged metal sphere of radius R is placed in an otherwise uniform electric filed $\vec{E} = E_0\hat{z}$. The field will push positive charge to the northern (i.e., $z > 0$) surface of the sphere, leaving a negative charge on the southern surface.
   (a) The potential at $r \to \infty$ is 0.
   (b) The potential when $r \gg R$ (the radius of the sphere) is $-E_0 r cos\theta$.
   (c) The potential inside the sphere is $E_0 r cos\theta$.
   (d) The potential on the surface of the sphere is $E_0 R cos\theta$.
   (e) The induced charge density is $-3\epsilon_0 E_0 cos\theta$.

6. Given that dipole moment $\vec{p}$ and polarization $\vec{P}$.
   (a) The energy $U = \vec{p} \cdot \vec{E}$
   (b) The force $\vec{F} = (\vec{p} \cdot \nabla)\vec{E}$
   (c) The torque $\vec{N} = \vec{p} \times \vec{E}$
   (d) $\vec{P} = \vec{p} d\tau$ ($d\tau$ is a volume element)
   (e) $\vec{P} = \int \vec{p} d\tau$

7. Which are correct with the Poynting vector $\vec{S}$?
   (a) $\vec{S}$ is the energy per unit area and per unit time, transported by the electromagnetic fields.
   (b) $\vec{S}$ is the electromagnetic force per unit area acting on a surface.
   (c) $\vec{S}/c^2$ is the momentum current density transported by the fields.
   (d) $\vec{S}/c^2$ is the momentum per unit volume stored in the electromagnetic fields.
   (e) $\vec{S}/c^2$ is the work done on the charges by the electromagnetic force.

8. Assume the wave guide is a perfect conductor, so that the boundary conditions $\begin{cases} \boldsymbol{E}_{\parallel} = 0 \\ \boldsymbol{B}_{\perp} = 0 \end{cases}$. Given the general form $\begin{cases} \boldsymbol{E}(x,y,z,t) = (E_x\hat{\imath} + E_y\hat{\jmath} + E_z\hat{k})e^{i(kx-\omega t)} \\ \boldsymbol{B}(x,y,z,t) = (B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k})e^{i(kx-\omega t)} \end{cases}$, determine which expressions are true?

   (a) $\frac{\partial E_z}{\partial y} - \frac{\partial E_y}{\partial z} = i\omega B_x$

(b) $\frac{\partial E_x}{\partial z} - \frac{\partial E_z}{\partial x} = i\omega B_y$

(c) $\frac{\partial E_x}{\partial y} - ikE_y = -i\omega B_z$

(d) $\frac{\partial E_x}{\partial z} - ikE_z = -i\omega B_y$

(e) $\frac{\partial E_y}{\partial x} - ikE_x = -i\omega B_z$

9. A spherical shell of radius R, carrying a uniform surface charge σ, is set spinning at angular velocity $\vec{\omega}$.

(a) The vector potential $\vec{A} = \frac{2\mu_0 R^4 \omega\sigma}{3}\frac{sin\theta}{r^2}\hat{\phi}$ for $r \leq R$

(b) The vector potential $\vec{A} = \frac{2\mu_0 R\omega\sigma}{3} r sin\theta \hat{\phi}$ for $r \leq R$

(c) The vector potential $\vec{A} = \frac{2\mu_0 R^4 \omega\sigma}{3}\frac{sin\theta}{r^2}\hat{\phi}$ for $r \geq R$

(d) The magnetic field $\vec{B} = \frac{2\mu_0 R\omega\sigma}{3}(cos\theta\hat{r} - sin\theta\hat{\theta})$ for $r \leq R$

(e) The magnetic field $\vec{B} = \frac{2\mu_0 R\omega\sigma}{3}(cos\theta\hat{\phi} - sin\theta\hat{\theta})$ for $r \leq R$

10. Suppose a normal incidence occurred between tow linear media $(n_1 \rightarrow n_2)$

(a) The reflection coefficient $\mathrm{R} = \frac{n_1}{n_2}\left(\frac{2n_1}{n_1+n_2}\right)^2$

(b) The reflection coefficient $\mathrm{R} = \frac{n_2}{n_1}\left(\frac{2n_2}{n_1+n_2}\right)^2$

(c) The reflection coefficient $\mathrm{R} = \frac{n_1}{n_2}\left(\frac{n_1-n_2}{n_1+n_2}\right)^2$

(d) The transmission coefficient $\mathrm{T} = \frac{n_1}{n_2}\left(\frac{2n_2}{n_1+n_2}\right)^2$

(e) The transmission coefficient $\mathrm{T} = \frac{n_2}{n_1}\left(\frac{2n_1}{n_1+n_2}\right)^2$