

系所組別 物理學系

考試科目：電磁學

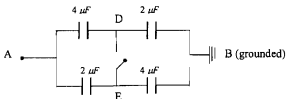
考試日期：0306，節次：2

※ 考生請注意：本試題 可 不可 使用計算機

Part I: 選擇題 (每題五分，題目可能是單選或複選，答錯不倒扣。複選題全對才給分。)

1. The capacitors shown in the accompanying figure are all uncharged when 30 V is applied between points A and B with the switch open. What is the potential difference between points E and D,  $V_E - V_D$ ?

(a) 30 V (b) 20 V (c) 10 V (d) 5 V (e) 3 V



2. A time-dependent voltage source  $V(t) = 2 + \pi^3$  Volt is connected across a parallel-plate capacitor with a separation  $d = 3$  mm and each surface area  $S = 1$  m<sup>2</sup>. What is the displacement current between the plates at  $t = 6$  sec?

(a)  $10^{-5}$  A (b)  $10^{-6}$  A (c)  $10^{-7}$  A (d)  $10^{-8}$  A (e)  $10^{-9}$  A.

3. A total positive charge  $Q$  is uniformly distributed on a ring of radius  $R$ . An electron with charge  $e$  and mass  $m$  is released from the point  $z \ll R$  along the axis of the ring. The motion of the electron can be described as a simple harmonic oscillation with an angular frequency  $\omega$ . What is the correct expression of  $\omega$ ?

(a)  $\sqrt{Qe/2\pi\epsilon_0 R^3}$  (b)  $\sqrt{Qe/4\pi\epsilon_0 R^3}$  (c)  $\sqrt{Qe/8\pi\epsilon_0 R^3}$  (d)  $\sqrt{Qe/2\pi\epsilon_0 R^2}$  (e)  $\sqrt{Qe/4\pi\epsilon_0 R^2}$ 

4. The  $x$ -polarized uniform plane wave with angular frequency  $\omega = 6 \times 10^8$  rad/s propagates in air along the  $z$ -direction and impinges on a perfectly conducting plane at  $z = 0$ . Assuming the amplitude of the  $\vec{E}$  field for the incident wave is  $0.12\pi$  (V/m), what is the expression for the reflected  $\vec{H}(t, z)$  field in  $10^{-4}$  A/m? (a)  $10\cos(1.5 \times 10^7 t - 2\pi z)\hat{y}$  (b)  $\cos(1.5 \times 10^7 t + 2z)\hat{y}$  (c)  $10\cos(6 \times 10^8 t + 2z)\hat{y}$  (d)  $\cos(6 \times 10^8 t - 2z)\hat{y}$  (e)  $10\cos(6 \times 10^8 t + 2z)\hat{y}$
5. In an air-filled rectangular cavity resonator has dimensions  $a = b = 1.5$  cm and  $d = 3$  cm. The  $z$ -component  $H$ -field for the **TE modes** in a Cartesian coordinate is

$$H_z(x, y, z) = H_0 \cos\left(\frac{m\pi}{a}x\right) \cos\left(\frac{n\pi}{b}y\right) \sin\left(\frac{p\pi}{d}z\right),$$

where  $m, n,$  and  $p$  are integrals. The resonant frequency is given as  $f_{\text{res}} = \frac{1}{2\sqrt{\mu\epsilon}} \sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + \left(\frac{p}{d}\right)^2}$  What is the lowest resonant

(背面仍有題目,請繼續作答)

系所組別：物理學系

考試科目：電磁學

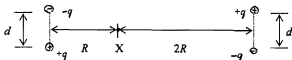
考試日期：0306·節次：2

※ 考生請注意：本試題 可 不可 使用計算機

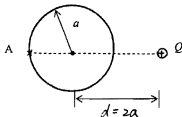
6. Three resistors are connected together (It could be connected in series or in parallel or in the combination of both cases.). Which answer is not possible for the total resistance?  
 (a)  $R_1+R_2+R_3$  (b)  $R_1+(R_2R_3)/(R_2+R_3)$  (c)  $R_1R_2R_3/(R_1R_2+R_2R_3+R_3R_1)$  (d)  $R_1R_2R_3/(R_1+R_2+R_3)$
7. In the following, which answers have the same unit as the *Poynting vector*?  
 (a) Tesla  $\cdot$  Volt (b) Watt/m<sup>3</sup> (c) Joule/(sec  $\cdot$  m<sup>2</sup>) (d) Amp  $\cdot$  Volt/m<sup>2</sup> (e) Watt/(sec  $\cdot$  m<sup>2</sup>)
8. In the following, which answers are possible for the magnetic flux density  $\vec{B}$ ? (Here  $\vec{\mu}$ ,  $i$ ,  $E$ , and  $v$  represent the magnetic dipole moment, electric current, electric field, and velocity, respectively.  $R$ ,  $r$ , and  $z$  have the dimension of length.)  
 (a)  $\mu_0 i/8r$  (b)  $\mu_0 \vec{\mu}/2\pi r^2$  (c)  $\mu_0 i r/2\pi R^2$  (d)  $\mu_0 i R/2(R^2+z^2)^{3/2}$  (e)  $E/v$

## Part II: 計算題

9. (15 Points) (a) Evaluate the electrostatic energy for the configuration of four charged particles shown below. (b) Compute the electric potential at point X.  
 (c) Calculate the electric field  $\vec{E}$  (magnitude and direction) at point X.  
 (d) If a charged particle  $-Q$  is placed at point X, what is the electric force experienced by that particle? You should provide the magnitude and direction for the force in your answer.  
 (e) Compute the electric field intensity  $\vec{E}$  at point A as  $R \gg d$ . Express your answer in terms of the definition of electric dipole  $\vec{p}$ .



10. (15 Points) A positive point charge  $Q$  is located at a distant  $d = 2a$  outside a grounded conducting sphere of radius  $a$ , as shown below.  
 (a) Determine the magnitude and location of the image charge inside the sphere.  
 (b) Evaluate the electric field  $\vec{E}$  and surface charge density induced on point A.



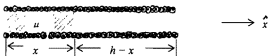
系所組別 物理學系

考試科目 電磁學

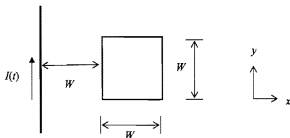
考試日期：0306，節次：2

※ 考生請注意：本試題 可 不可 使用計算機

11. (15 Points) A constant current  $i$  flows in a long solenoid of length  $h$  with  $n$  closely wound coil-turns per unit length. The cross sectional area of its iron core, which has permeability  $\mu$ , is  $S$ . (a) Determine the total magnetic energy stored in this solenoid. (b) Calculate the self-inductance of this case. (c) Find the force (magnitude and direction) acting on the iron core.



12. (15 Points) A very long, fixed straight wire with a time-dependent current  $I$  points to  $+y$  direction. The current  $I$  varies with time as  $I(t) = 3t^2 + 2$  Amp. (a) Find the total magnetic flux on the square loop with side  $W$  located at the right hand side of the straight wire, as shown below. Express your answer in terms of  $\mu_0$ ,  $I$ , and  $W$ . (b) If the square loop has the side  $W = 2$  m and a total resistance  $R = 2.4 \Omega$ , calculate the induced current on the loop at  $t = 1$  sec. You should provide the magnitude and direction (clockwise or counterclockwise) for the induced current in your answer. (c) Determine the net magnetic force (magnitude and direction) experienced by the loop at this instantaneous time  $t = 1$  sec. (d) Calculate the magnetic dipole moment  $\vec{m}$  of the loop (magnitude and direction) at  $t = 1$  sec. (e) Roughly plot the direction of the corresponding Poynting vector on each side of the loop.



\*Useful values:

$$\epsilon_0 = 1/(36\pi \times 10^9) \text{ F/m}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$