107 學年第二學期 普通物理 B 第一次段考試題

[Wolfson Ch. 20-24] 2019/04/02, ***8:20am – 09:50am***

B

(i)答案卷第一張正面為封面。第一張正、反兩面**不要寫任何答案。**

(ii)依空格號碼順序在第二張**正面**寫下所有填充題答案，不要寫計算過程。

(iii)依計算題之題號順序在第二張**反面**以後寫下演算過程與答案，**每題從新的一頁寫起**。

(iv)根據題目給的參數，**注意答案有效數位。(Please express your answer in significant figures.)**

Constants: $k = 1/4\pi\varepsilon_0 = 8.99\times10^9\ \mathrm{N\cdot m^2/C^2}$, Permittivity constant $\varepsilon_0 = 8.85\times10^{-12}\ \mathrm{C^2\cdot N^{-1}\cdot m^{-2}}$, electron mass $= 9.11\times10^{-31}$ kg, proton mass $= 1.67\times10^{-27}$ kg, 1 eV $= 1.60\times10^{-19}$ J ; Resistivity Copper: 1.68×10^{-8} (Ω·m)

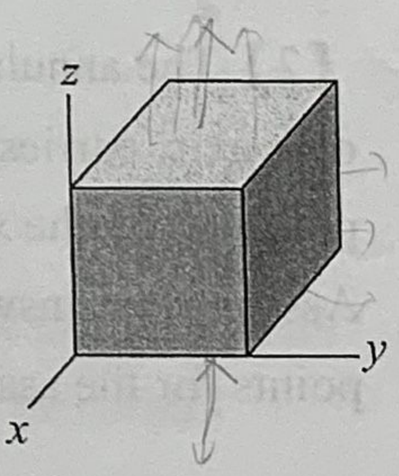
Part I. Filling the blank (5 points per blank)

• Two identical point charges are at $x = a$ and $x = -a$. The position on the y-axis where an electron will experience the greatest force is $y =$ 【1】.

• A 1.8-mm diameter copper wire carries 15 A to a household appliance. Find the magnitude of the electric field in the wire. $E =$【2】 mV/m

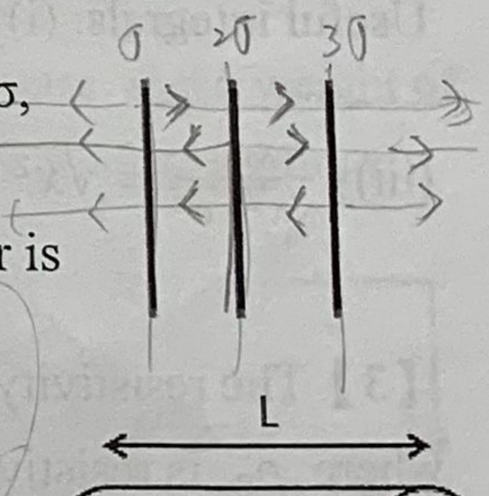
• An infinitely long rod of radius R carries a uniform volume charge density ρ. The electric field strength inside the rod $E(r)$ is 【3】, where r is the distance from the rod axis.

• A spherical conductor A of radius a carrying charge Q. Another conducting sphere B of radius b, initially, is neutral. After connecting spheres A and B with a thin conducting wire (the charge on the wire is negligible), the surface potential of B sphere is 【4】

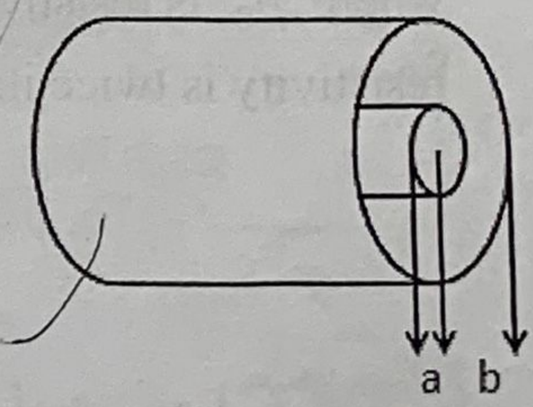


• The right figure shows a closed Gaussian surface in the shape of a cube of edge length of 2.00 m. It lies in a region where the electric field is given by $\boldsymbol{E} = (3.00x + 4.00)\,\boldsymbol{i} + 5.00\,\boldsymbol{j} + 6.00\,\boldsymbol{k}$ N/C, with x in meters. The net charge contained by the cube is 【5】 C.

• Three infinite non-conducting sheets, with uniform positive surface charge densities σ, 2σ, and 3σ, are arranged to be parallel like the right figure. If the electric field produced by the arrangement has magnitude $E = 0$ in one region and $E = 2\sigma/\varepsilon_0$ in another region, their order is 【6】. (from left to right)

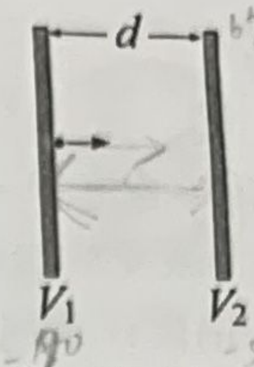


• A capacitor consists of two long concentric metal cylinders, as shown in the right figure. Find an expression for its capacitance in terms of the dimension shown. Note that $L >> b$, a and $b > a$, $C =$【7】.



• An implanted pacemaker supplies the heart with 72 pulses per minute, each pulse providing 6.8 V for 0.68 ms. The resistance of the heart muscle between the pacemaker's electrodes is 550 Ω. Find the current that flows during a pulse, and the energy delivered in one pulse. $I =$【8】 mA; $\Delta E =$【9】 μJ

• In right figure a charged particle (either an electron or a proton) is moving rightward between two parallel charged plates separated by distance $d = 2.00$ mm. The plate potentials are $V_1 = -70.0$ V and $V_2 = -50.0$ V. The particle is slowing down from an initial speed of 90.0 km/s at the left plate. Just as it reaches the right plate, its speed is 【10】 km/s.



• A sphere of radius R_1 carries charge Q distributed uniformly over its surface. How much work does it take to compress the sphere to a smaller radius R_2 ? U= 【11】

• A positive charge $+8Q$ is located at the origin, and a negative charge $-2Q$ is at $x = a$. The point (other than infinite far away) for a proton to have zero net force is $x =$ 【12】.

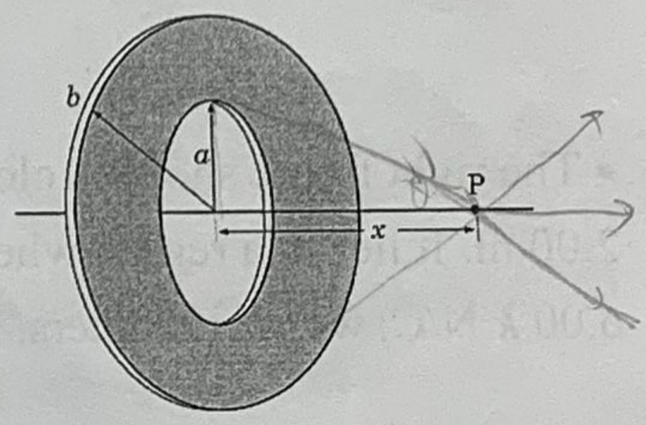
• A capacitor consists of two circular metal plates of radius $R = 12$ cm, separated by $d = 5.0$ cm. Find its capacitance $C =$【13】pF ; Find the charge on the plates $Q =$【14】pC ; and the stored energy when the capacitor is connected to a 12-V battery $U =$【15】pJ.

Part II Problems (10 points per problem)

【1】(a) A positive charge q and a negative charge $-q$ are located at $x = a$ and $x = -a$, respectively. Find the potential $V(x)$ on the positive x-axis at large distances $x >> a$ in terms of dipole moment $p = 2aq$.
(b) A rod of length $2a$ lies on the x-axis, centered at the origin, and carries line charge density $\lambda = \lambda_0(x/a)$, where λ_0 is a constant. Find the potential $V(x)$ at $x >> a$ and determine the dipole moment of the rod.

[The logarithmic approximation $ln(1+x) \cong x - \frac{x^2}{2} + \frac{x^3}{3}$ when $|x| \ll 1$ is useful in (b).] (5, 3, 2 points)

【2】The annulus shown in the figure, centered at origin and x-axis along its disk axis, carries a charge Q distributed uniformly over its surface. (a) Find the potential on the x-axis for $x > 0$, (b) find the electric field on the x-axis for $x > 0$. Assess your answers for $x >> b$ by $(1+x)^p \approx 1 + px$ when $|x| << 1$. (Extra 4 points for the assessing of V and E.)



Useful integrals: (i)$\int \frac{dx}{x^2+a^2} = \frac{1}{a}tan^{-1}(\frac{x}{a})$, (ii)$\int \frac{xdx}{\sqrt{a^2-x^2}} = -\sqrt{a^2-x^2}$,

(iii)$\int \frac{xdx}{\sqrt{x^2+a^2}} = \sqrt{x^2+a^2}$, (iv)$\int \frac{dx}{(x^2+a^2)^{3/2}} = \frac{x}{a^2\sqrt{x^2+a^2}}$.

【3】The resistivity of copper as a function of temperature is given approximately by $\rho = \rho_0[1 + \alpha(T - T_0)]$, where ρ_0 is resistivity of copper at T_0=20°C, and $\alpha = 4.3 \times 10^{-3}\ °C^{-1}$. Find the temperature at which copper's resistivity is twice its T_0 value.