物理电子学院2004年研究生招生复试试题

适用科目：电磁场与电磁波 / 电动力学
共5道题，任选4题，每题25分，满分100分。
闭卷考试，可带英汉词典和计算器。
考试时间120分钟，可用英文或中文答题。

Problem 1. Field under dc transmission line. Two long parallel conductors of a dc transmission line separated by 2*m* have linear charge densities of $\rho_L = 5\mu C\, m^{-1}$ of opposite sign. Both lines are 22*m* above ground. What is the magnitude of the electric field 4*m* directly below one of the wires? $\varepsilon_r = 1$ and $\varepsilon_0 = 8.85\times 10^{-12}\, C(Vm)^{-1}$.

Problem 2. Sandwich capacitor. Referring to Fig. 2, the capacitor is a sandwich of two dielectric media of the same thickness (*d*=1cm). Plate area $A = 100cm^2$. Neglect the field outside the capacitor, called fringing field. Find: (a) electric fields E_1 and E_2, voltages V_1 and V_2, and electric flux densities D_1 and D_2; (b) capacitance.

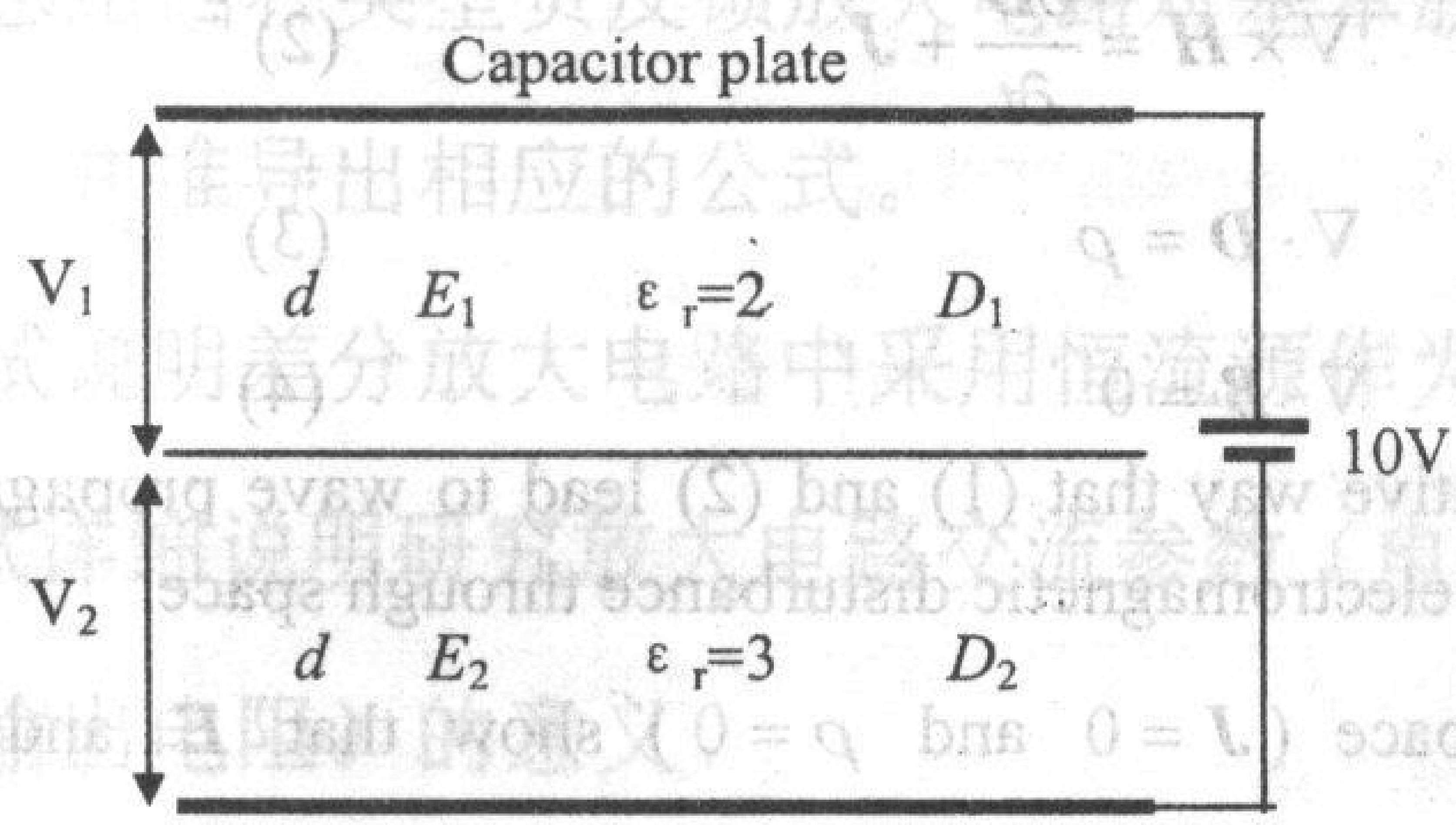

Fig.2

Problem 3. Ocean penetration. Calculate the ocean depths at which a 10^{-6}Vm^{-1} field will be obtained with *E* at the surface equal to 1Vm^{-1} at frequencies of 1, 10, 100, and 1000 kHz. $\sigma = 4(\Omega\, m)^{-1}$ and $\varepsilon_r = 80$ for sea water. What is the most suitable frequency for communication by wireless with undersea craft?

Hint. Let $x = 0$ at the surface of the ocean, with *x* increasing positively into the sea water. The wave equation for the sea water is

$$\frac{\partial^2 E}{\partial x^2} - \gamma^2 E = 0$$

where $\gamma^2 = j\omega\mu\sigma - \omega^2\mu\varepsilon$, and $\mu = 4\pi\times 10^{-7}\, Hm^{-1}$.

Problem 4. Multiple images. For a charge in the vicinity of the intersection of two conducting planes, such as q in the region of AOB of Fig. 4, find the potential in the region of AOB. The angle AOB is 45-degree.

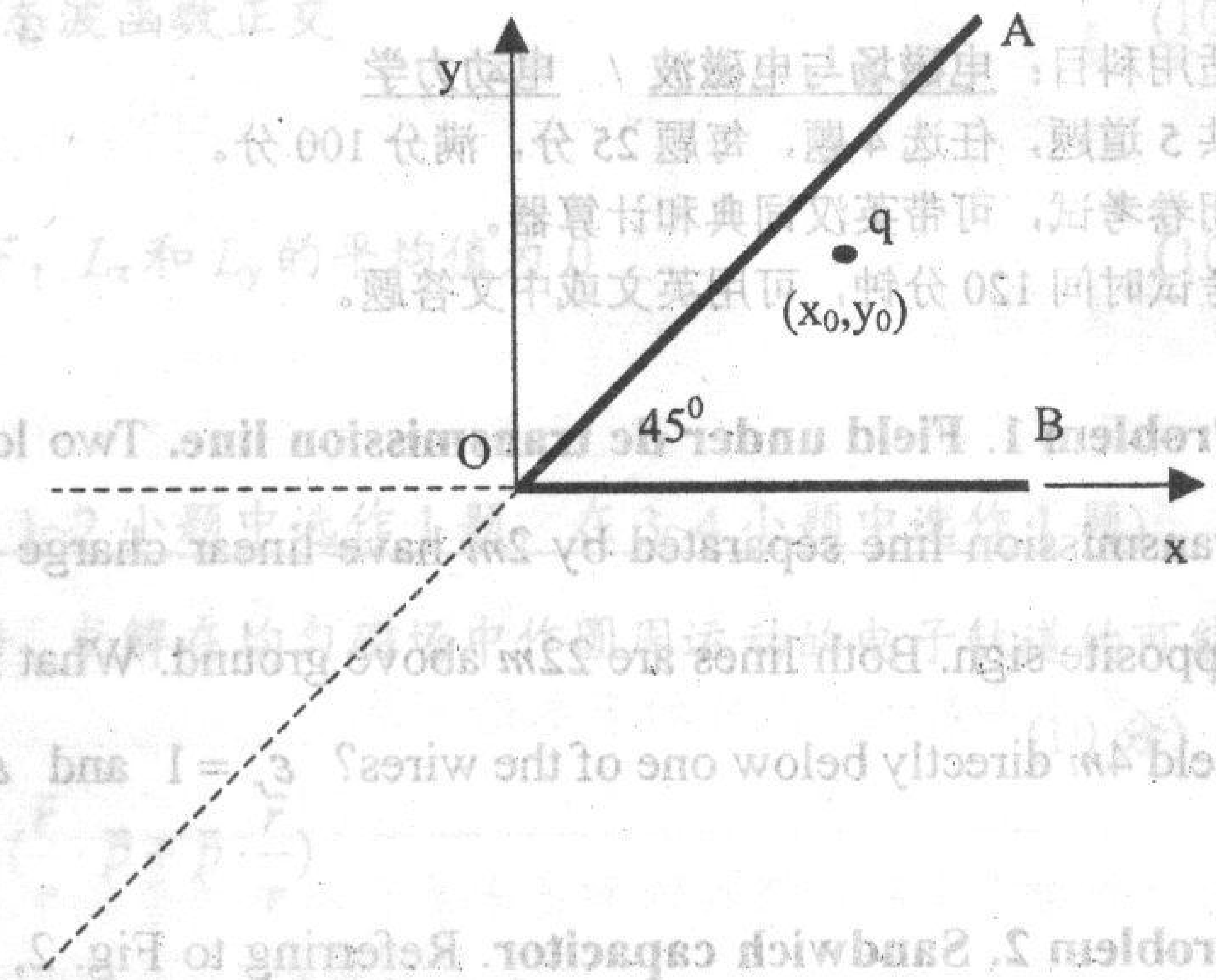

Fig.4

Problem 5. Maxwell's equations and wave equations. Maxwell's equations that describe electromagnetic phenomena in vacuum are

$$\nabla \times \boldsymbol{E} = -\frac{\partial \boldsymbol{B}}{\partial t} \qquad (1)$$

$$\nabla \times \boldsymbol{H} = \frac{\partial \boldsymbol{D}}{\partial t} + \boldsymbol{J} \qquad (2)$$

$$\nabla \cdot \boldsymbol{D} = \rho \qquad (3)$$

$$\nabla \cdot \boldsymbol{B} = 0 \qquad (4)$$

[1] Show in a qualitative way that (1) and (2) lead to wave propagation, i.e., to the propagation of an electromagnetic disturbance through space.

[2] In source-free space ($\boldsymbol{J} = 0$ and $\rho = 0$) show that $\boldsymbol{E}$ and $\boldsymbol{H}$ satisfy the following wave equations

$$\nabla^2 \boldsymbol{E} - \mu_0 \varepsilon_0 \frac{\partial^2 \boldsymbol{E}}{\partial t^2} = 0 \qquad (5)$$

$$\nabla^2 \boldsymbol{H} - \mu_0 \varepsilon_0 \frac{\partial^2 \boldsymbol{H}}{\partial t^2} = 0 \qquad (6)$$

Hint. $\nabla \times \nabla \times \boldsymbol{A} = \nabla \nabla \cdot \boldsymbol{A} - \nabla^2 \boldsymbol{A}$.