**TEST 1 PS250 MAKEUP Fall 1998 Show work to ensure credit. Put letter of the best answer in the answer sheet blank.**

(1) Find the electric force between two protons in a helium atom, if the proton centers are 2E-15 meters away from each other. (A) 17.9 N (B) 23.5 N (C) 32.8 N (D) 57.6 N (E) none of these

$$F = \frac{ke^2}{r^2} = \frac{9 \times 10^9 \cdot (1.6 \times 10^{-19})^2}{(2 \times 10^{-15})^2} = 5.76\ N$$

(2) A charge of 1 coulomb is placed at the origin and another of 3 coulombs is placed at x= 4 m. Where is the electric field equal to zero? Answer in meters. $k = 9x10^9\ N - m^2/C^2$ (A) 1.46 (B) 1.05 (C) 2.31 (D) 3.20 (E) 1.82 (F) none of the above

$$E = E_a + E_b = \frac{k}{x^2}\hat{x} + \frac{3k}{(4-x)^2}(-\hat{x}) = 0$$

Do the algebra.

(3) Calculate the electric field at (0,1) due to a line segment of charge, -1<x<1, with linear charge density of 1 nanocoulomb per unit length.
(A) 5.40 N/C (B) 12.7 N/C (C) 4.25 N/C (D) 8.12 N/C (E) 2.05 N/C (F) none of these

$$E = \int_{-1}^{1} \frac{k\lambda dx}{(x^2+1)^{3/2}}(-x, 1)$$

(4) Find the magnitude of the electric field at (0,2) due to a 5 nanocoulomb charge at the origin and a -10 nanocoulomb charge at (2,0).
(A) 4.5 N/C (B) 7.8 N/C (C) 8.6 N/C (D) 12.5 N/C (E) none of these

$$\vec{E} = \frac{5k}{4}(0,1) + \frac{-10k}{8}\frac{(-2,2)}{\sqrt{8}} \rightarrow 8.6\ N/C$$

Don't forget to multiply by $1\times10^{-9}$ (the charges are actually in nanocoulombs).

(5) A conducting ball, region A, carries a charge of 3Q. Some distance out from the surface of A is a thick conducting shell, called region C, which is concentric with the Ball and carries -4Q. B is empty space between A and C, and D is outside regions A , B, and C. Find the electric field in region A.
(A) $kQ/r^2$ (B) $-2kQ/r^2$ (C) $-3kQ/r^2$ (D) $3kQ/r^2$ (E) 0 (F) none of these

$$E(4\pi r^2) = 4\pi k Q_i n = 4\pi k(0) = 0 \rightarrow E_A = 0$$

(6) Same question as 4, in region B.
(A) 0 (B) 2kQ/r$^2$
(C) -3kQ/r$^2$ (D) 3kQ/r$^2$ (E) none of these

$$E(4\pi r^2) = 4\pi k Q_i n = 4\pi k(3) \rightarrow E_B = \frac{3k}{r^2}$$

(7) Same as before, in region D.
(A) $-kQ/r^2$ (B) $2kQ/r^2$ (C) $-2kQ/r^2$ (D) $3kQ/r^2$ (E) $4kQ/r^2$ (F) none of these

$$E(4\pi r^2) = 4\pi k Q_{in} = 4\pi k(3-4) \rightarrow E_D = \frac{-k}{r^2}$$

(8) Find the distribution of charge on the inner and outer surfaces of conductor C.
(A) 2Q inner, -2 Q outer (B) -2Q inner, -2Q outer (C) -3Q inner, -Q outer (D) cannot be determined (E) none of these

The answer is C.

(9) A ball of mass 1 kg and charge 2 coulombs falls ten meters from rest. What horizontal electric field will deflect it by five meters? use g=10m/ s$^2$.)
(A) 2.5 N/C (B) 3.5 N/C (C) 4.5 N/C (D) 5 N/C (E) 8.5 N/C (F) 15 N/C (G) none of these

For this one, first find the time of flight and then plug that into the horizontal force equation, which uses the electric field.

(10) A long, thick-walled cylinder with a bore hole inside has charge density $\rho = \alpha/r \quad a < r < b$. Find the electric field for a<r<b, using Gauss's law.(A) $2k\pi\alpha br^2/a$ (B) $2k\pi\alpha(r - a^{2/r})$ (C) $4k\pi\alpha(1 - a/r)$ (D) $2k\pi\alpha\, r(b-a)$ (E) cannot be determined (F) none of these

This is no sweat. Use Gauss's law, but you'll have to calculate the integral to get the charge inside. That's going to be:

$$Q_{in} = \int_a^r \rho 2\pi L r dr = \int_a^r \frac{\alpha}{r} 2\pi L r dr = \int_a^r 2\alpha\pi L dr = 2\alpha\pi L(r-a)$$

etc.

$$EA = E(2\pi r L) = 4\pi k Q_{in}$$

etc I believe the answer is C.

(11) A tetrahedron, composed of four triangular sides with equal area, contains charges of 2, -4, and 7 coulombs each. Find the total electric flux

through the surface, in MKS units. (A) 0 (B) 5.7E11 (C) 2.5E10 (D) 7.5E11 (E) 5.2E12 (F) 1.3E11 (G) cannot be determined (H) none of these

Use Gauss's law on this one.

$$\oint \vec{E} \cdot d\vec{A} = 4\pi k Q_i n = 4\pi k(2 - 4 + 7)$$

(12) Suppose the second minimum in a single slit experiment is displaced 4 cm from the central maximum. If the width of the slit is 0.02 mm, and the distance to the screen is 1 m., what is the wavelength of the light? (A) 300 nm (B) 200 nm (C) 400 nm (D) 600nm (E) 800 nm (F) none of these

(13) A diffraction grating 30 cm long is such that light at 500 nm has a third principal maximum at an angle of 0.01 radians. How many lines are etched in the grating? (A) 500 (B) 1000 (C) 2000 (D) 3000 (E) 4000 (F) none of these

(14) A thin piece of paper creates a thin film of air between two glass slides, each 30 cm long, with n=1.3. The gap is filled with goop with index of refraction n=1.2. If the paper is 1E-5 meters thick, and the slides are illuminated with 500 nm light, how many dark fringes are observed per centimeter? (A) 3.2 (B) 6.5 (C) 5 (D) 1.6 (E) 9 (F) none of these

(15) Light is incident on glass, n=1.5, which has a top surface coating with index n=1.25. If 500 nm is taken out of the reflected light, what is the minimum thickness of the coating?
(A) 400 nm (B) 500 nm (C) 300 nm (D) 700 nm (E) 100 nm (F) none of these