Week 11

21-1, 2, 3, 5, 6, 18, 20, 22, 24, 29, 31

21-1 : No, electric field lines cannot cross. If they did, then the $\vec{E}$ vector would point in two different directions at the same place

21-2 The particle at point B would experience a greater force than at A, because the E-lines are denser at B

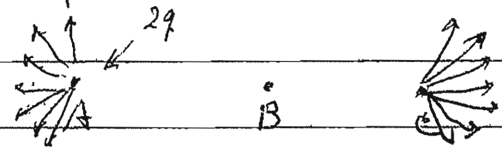
21-3 If the same number of field lines enter the closed surface than leave, the flux is zero but the $\vec{E}$ field is not zero.
Example two equal charges but opposite sign produce such a field

21-5 Flux = EA only when $\vec{E}$ direction is parallel to the vector normal to the surface A

21-6 : Closed surface, 8 field lines emerge.
If a second charge is placed outside the closed surface still 8 field lines emerge, but they will come out of the surface at different places, because the total $\vec{E}$ field will changes.

21-18 : The net charge is 2q

Proof



∴ $q_A = 14$ lines.

7 lines go out to space to the left of A, 7 other lines leave A to the right of A, and converge on to B. 7 more lines converge on B from the right. So $q_B = -2q = -14$ lines

7 lines leave C to the left and converge on B

7 more lines " " " " right and go out to space

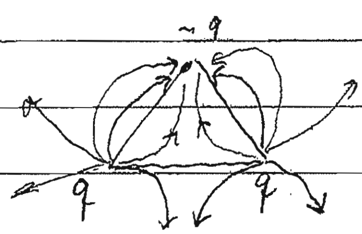
So $q_C = +2q = +14$ lines.

So, the net charge $= q_A + q_B + q_C = 2q = 3\mu C$

$q_A \uparrow 2q$, $q_B \uparrow -2q$, $q_C \uparrow +2q$

$-2q \uparrow -3\mu C$

21-20



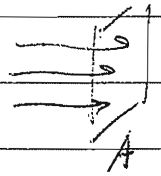
Only half of the field lines (three) that come out of each +q can converge on −q, the rest goes out to space.

The total charge is q

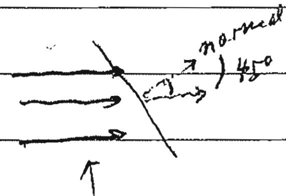
21-22 :

area A of flat surface = 2.0 m^2

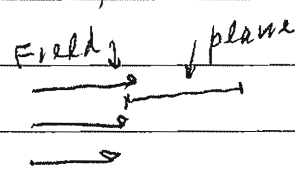
strength of E = 850 N/C



⇐ this case ϕ = flux = E * A = ~~2*~~ 850 * 2 = 1700 N/C * m^2

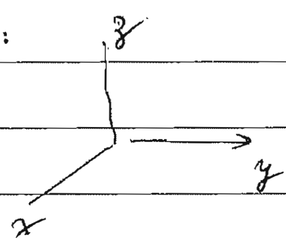


$\phi = E * A * \cos(45°) = \frac{1700}{\sqrt{2}}$ N/C * m^2



$\phi = E * A * \cos(90°) = 0$

21-24 :



Surface A = 0.14 m^2 lies in x y plane

$\vec{E} = 5.1\hat{i} + 2.1\hat{j} + 3.5\hat{k}$

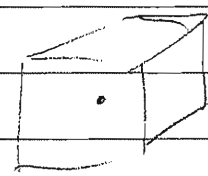
The normal to the plane = $\hat{k}$

∴ $\vec{A}$ = area = $A \cdot \hat{k}$

$\vec{E} \cdot \vec{A} = E_x A_x + E_y A_y + E_z A_z =$

zero zero 3.5 × 0.14 = 0.49 $(N/C)m^2$

21-29 :



charge q at center of a cube

cube has 6 faces, the flux through each face is the same = ϕ_s

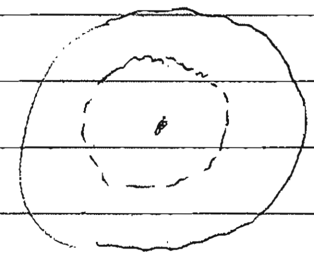
$6 * \phi_s$ = flux through a sphere surrounding charge = $4\pi kq$

∴ ϕ_s = flux through each side = $\frac{1}{6} \times 4\pi kq$

$= \frac{4}{6} \times 3.1416 \times 9 \times 10^{+9} \times 2.6 \times 10^{-6}$

$= 49 \times 10^3 (N/C)m^2$

~~29~~ 21. 31



sphere, radius 0.25 m, carries $Q = 14 \mu C$; Find $\vec{E}$ at various radii 0.15 ~~m~~, 0.25m, 0.50m

$$\text{charge/volume} = \rho = \frac{Q}{\frac{4}{3}\pi R^3} = \frac{14 \times 10^{-6}\, C}{\frac{4}{3} \times \pi \times (0.25)^3} = \cancel{21}$$

$$= 2.14 \times 10^{-4}\ C/m^3$$

Charge contained inside a imaginary sphere of radius r = vol. of sphere x charge/vol

$$q(r) = \frac{4}{3}\pi r^3 \times \frac{Q}{\frac{4}{3}\pi R^3} = \left(\frac{r}{R}\right)^3 * Q$$

Flux through that sphere = E x area of sphere

$$= E * 4\pi r^2$$

$$= 4\pi k \cdot q(r)$$

$$E = \frac{1}{4\pi r^2} \times (4\pi k) \times \left(\frac{r}{R}\right)^3 * Q$$

if r = 0.15 $\quad E = \frac{1}{8.85 \times 10^{-12}} \times \left(\frac{0.15}{0.25}\right)^3 \times \frac{14 \times 10^{-6}\, C}{4\pi (0.15)^2}$

$= \cancel{3.42 \times 10^5}$ ~~(N/C)~~ $\boxed{1.21 \times 10^6\ N/C}$

if r = 0.25 $\quad E = \frac{1}{8.85 \times 10^{-12}} \times (1)^3 \times 14 \times 10^{-6}\, C\ \frac{1}{4\pi \times (0.25)^2}$

$= \cancel{1.58 \times 10^6\ N/C} = \boxed{2.01 \times 10^6\ N/C}$

if r = 0.5 $\quad E = \frac{4\pi k Q}{4\pi r^2} = \frac{9 \times 10^9 \times 14 \times 10^{-6}}{(0.5)^2} = \boxed{5.04 \times 10^5\ N/C}$