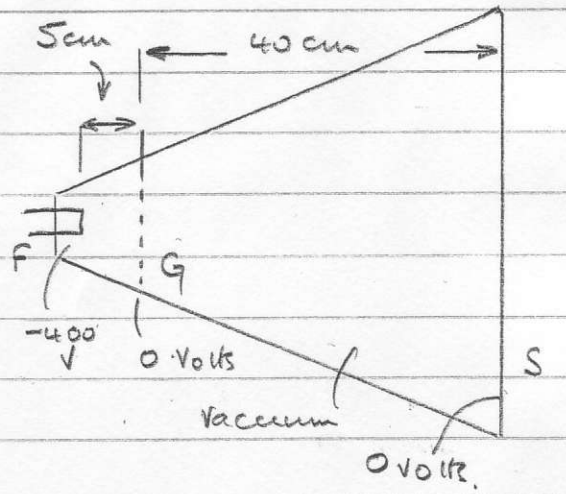
Electric Fields (1) — A-level Physics

1. Two electrons are "held" 10^{-12} m apart in a vacuum.
   (a) Calculate the force on each. (2)
   (b) Calculate the initial acceleration of each when released. (2)
   (c) Where does the energy come from to set the electrons moving? (2)
   (d) Draw a diagram to show the field and equipotential lines round the 2 electrons (4) [10]

data....
ε_0 – permittivity of vacuum $= 8.9 \times 10^{-12}$ Farads/m
ε_r paraffin = 5
ε_r water = 81
ε_r Caffreys = 77.
m_e : electron rest mass $= 9.1 \times 10^{-31}$ kg
m_p : proton rest mass $= 1.7 \times 10^{-27}$ kg
e = electron charge $= -1.6 \times 10^{-19}$ C

2. The diagram shows the latest 48" flat screen TV with Dolby-pro cinema sound. Electrons from the filament F are accelerated between F and G, and they then carry on without any further acceleration to the screen S. F and G can be regarded as flat plates.



(a) Why are electrons accelerated between F and G, and not between G and S.? (2)

Calculate... (b) the field strength between F and G (2) (c) the force on an electron... (2) (d)... its acceleration... (2) (e)... and maximum velocity at G (2). (f) Now... use the idea of converting electrical PE to electron KE to calculate electron velocity at G in 1 step.. (2)

(f) Calculate the time taken for the electron to reach S (2)

(g) Why must the TV tube be evacuated? (2)

(h) For filament F: current in = 50 mA; current out = 49 mA. Why are the values different? How many electrons are released each second by the filament? ..... (3) [19]

TW 7.98

Electric Fields (1) — Answers

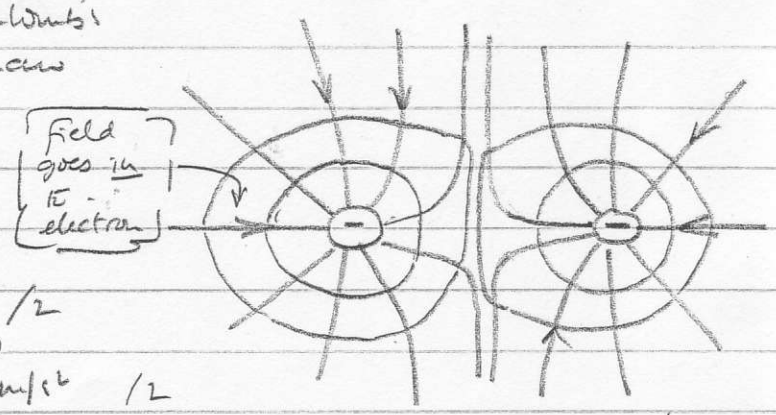
A Physics — Electric Fields

1. (a) $F_{elec} = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{d^2}$ ① Coulomb's Law

vacuum

$= \frac{1}{4\pi\, 8.9\times10^{-12}} \times \frac{1.6\times10^{-19}}{(10^{-12})^2}$

$= 2.3\times10^{-4}$ N ①



/2

(b) $a = F_E/m_e$ ① $= 2.5\times10^{26}$ m/s² ① /2

faster than an ×R3i !

(c) Energy from the potential energy ① stored in the field from the work ① done in pushing the electrons together /2

(d) See diagram. field lines – shape ① – direction ① equipots – shapes ①

(10)

2. (a) Electric field ① between F and Q; force ① on electron /2

no field between Q and S.

(b) Field strength $E = V/d$ ① $= 400/5\times10^{-2} = 8000$ ① V/m (= N/C) /2

(c) Force $F_E = QE$ ① $= 1.28\times10^{-15}$ ① N /2

(d) $a = F_E/m_e$ ① $= 1.4\times10^{15}$ ① m/s² (1.4066 ×10¹⁵ {funny!} /2

(e) $v^2 = u^2 + 2as$ ① → $v = 11.86\times10^6$ ① m/s. /2

(f) P.E. in field = KE of electron ⊖

$QV = \frac{1}{2} m_e v^2$ ① → $v_{electron} = 11.86\times10^6$ ① m/s /2

{identical if you don't round off intermediate answers}

(f) time Q → S no field ∴ constant velocity

so $v = s/t$ ① → time $t = s/v = 40\times10^{-2}/11.86\times10^6 = 3.4\times10^{-8}$ ① sec /2

(g) evacuated .... air molecules (O_2, N_2) much bigger ① than electrons, and would stop or deflect ① them. /2

(h) 1 mA = 1 milli Coulomb of electrons /sec

leaving the filament ① to be accelerated in the beam to the screen.

49 mA, 50 mA → 1 mA → beam

1 milliC = $\frac{1}{1000}$ C = $\frac{1}{1000\times1.6\times10^{-19}}$ ⊖ = 6.25×10^{15} ① electrons released/sec.

(19)

Q.1 /10 Q.2 /19

TLN 9.98.