Lecture 2 Chapter 25 Electric charge and Coulomb's Law Coulomb's law; To Study boice loctween elec vic doar ged \ , -| to measure electncal _y Cx perments wete done ly clhavled Agua Covlomb (1436 Pob) m~ attrachoms and xepulsiong and deduced Coulomb's law > Small changed pavttcles denoted ot a? and bh. — Noedle did nok move if aA and b 14 not chav ged — Spneve 'le' 74 yemoyed and Charged ond plaud lack =>'a'ond lb repels on they attain eapal charge. —_~ Ayre y angle ig weaguy ed 'Ys 48 OGM Ye rove dh and Patod iy Contact with anothey C prove * A =? Chovged ig veduced 0 hall: >| ia placed black =7 eled Ac vepulsion was Loto - ' . (.) | . Fonally a - DYkioN ovngle . > Hone Called og *tovSim balance' . APGURE 23-8. Coulomb's torsion balance, from his 1785 Aya wewadie'to the Paris Academy of Sciences. / U dedrvc fore OW Loge ' a? . th ~?7 Covlombs expe vient s showed that elect wc Kove exerted by one chovged ody OM AnoThey depends divert y on the Product of magn tudes Of 2 Chavgts am 1 Vey Gly on the £Qyrarve % thet y Bepayaneo = ey bq loyal L footy Magnitude Ok mutual duran berpeen theiy Centers - ove hatracks on each of the 2 Chovges Q, and > —7 Required by Nastoos thvd law | fovuL enevted oy Yi Or a> 18 eaual in magnitude but Op posite 'nv divecrion 1D the KOM exovted by WON Oy, attrough the magnitudes of Charges MGs loe dierent: 2 Converting proportionality Wn 1D Qguation , "entyoduang Congtont Of proportionality kx called couloml Constant => Fz k [illaa) y* 0 \ Covlombs lav —_ Holds only Koy Changed oyyects Whose SiTUs ave mudn 8m =7 Molds only koy point Charges - aley than the distanw hetweon them. —y7 Coulomb's law Yelemblee Newton, inverse % Guone law yrawtah Ww) Simila ity: ees m8 of q ° 4 fF = 2 i —) Covlombs Low > Charge ployg OM 'rnportont vole — Newby Law of gfaviTation —») Mase plays Ow) tmportont yoe - Ditleven W Gvawbi onal Koy Leg Electypstattc Lov Ces Vy Com be atkvachve oY ve pul sive dopen d v ing on Whethe Alooys otty ack ve the two Chavges habe game / opp. qn ST Suctems (ot. K- + —@ - y k= @ - -\2 €, =< electyic Constant Cpa mittivity) = @.eS4 X10 c* | Nom po IQ q | + = 849,10 Nim" ye ~ - KK coke " | a Lx 1b x SE CU Cm yy 1S 12-5 = 8.9X%10 - §:9 x10! Ung ob Fo N eT Covlombs Law in Qpantom Physic § Describes — oo (Elecrvital force that lands the ef of om atom to Tt Nucleus - @ Yoru that hind atom together' +o fp molecules (3) Fovur that lind atoms amd molecules LOgethey +o form Solide of Uquids - =7 Most of guy daily experianced OYA that ore not grovitak onal in naruve Ove elecr AC at- ° SAMPLE PROBLEM 28-2. In Sample Problem 25-1 we ea that ae Copper penny contains both positive and negative charges; each of a magnitude 1.37 x 10°C. Suppose that these . Charges could be concentrated into two separate bundles, held 100 m apart. What attractive force would act on cach bundle? _ Solution From Eq. 25-4 we have pe JAP. (8.99 & 10° Nm AC2K1.37 x 10°C on (100m)? yr a4e™ = 1.69 x 10! N, This is soul 10" tons of force! Even if the charges were sep- arated by one Earth diameter, the attractive force would still be Coulomb repulsion forces. The lesson of this sample problern is that you cannot disturb the electrical neutrality of ordinary matter very much. If you try to pull out any sizable fraction of the charge contained in a body, a large Coulomb force appears automatically, tending to pull it back, . ioe tx 10! tore TKN 1o4 — 1b etKIOo N 1-649 x10' N | tonne AFOb LEN IN —_ Lol xo ttonn SAMPLE PROBLEM 25-3, The average distance r be- tweea the electron and the Proton in the hydrogen atom is 5.3 x 10°" m. (a) What is the magnitude of the average electrostatic force that acts between these two particles? (b) What is the magni- tude of the average gravitational force that acts between these par- ticles? Solution (a) From Eq. 25-4 we have, for the electrostatic force, (5.3 X 107" m)? = 8.2 x [0°* N, Although this force may seem small (it is about equal to the weight of a speck of dust), it produces an enormous acceleration of the electron within the atom, about 107* mj/g?, (5) For the gravitational force, we have F. = Ge 8 rp? . £6.67 X 10°"! N-mifkg?\9.1 1X 10" kgy(1.67 x 10-27 kg) (5.3 % 107!' my? = 36 X 107" N. L , 8.99 X IP N- mC 1.60 x 10-9 CP _ : = 23416 74 -~-)?2 28:04 Vip~? -& =§,2x\0 N 4 We see that the gravitational force is weaker than the elec.' trostatic force by a factor of about 10" Although the gravitas, tional force is weak, it is always attractive. Thus it can act to, Balaxies, so that large gravitational forces cen develop. The? electrostatic force, on the other hand, is repulsive for charges of' the same sign, so that it is not possible 10 accumulate large con-— centrations of either positive or negative charge. We must el-+ ways have the two types of charge together, so that they largely * compensate for each other. The charges that we are accustomed.) to in our daily experiences are slight disturbances of this over- ; riding balance. : SAMPLE PROBLEM 25-4. The nucleus of an iron atom has a radius of about 4 x 10-'5 m and Contains 26 protons. What < repulsive electrostatic force acts between two protons in such g nucleus if they are separated by a distance of one radius? Solution From Eq. 25-4 we have Roman> Word Libya? T fale?

_ (899 xX 10°N-m4C2\1.60 x lo-"CPe 4 Ub(pond) = 0'4Sic¢ (re (4X 10-8 my. IN = 0.22 Ibs = 14N. The large repulsive electrostatic force. mor than 3 Ib and acting on a single proton, must be balanced by the attractive nuclear force that binds the nucleus together. This force, whose range is SO short that its effecin cannot be felt very far outside the nu- cleus, is known as the “strong nuclear force” and is very well named.