Physics 303 L

Instructor
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Topic for Term
Electricity, Magnetism,
Light

(they are connected)

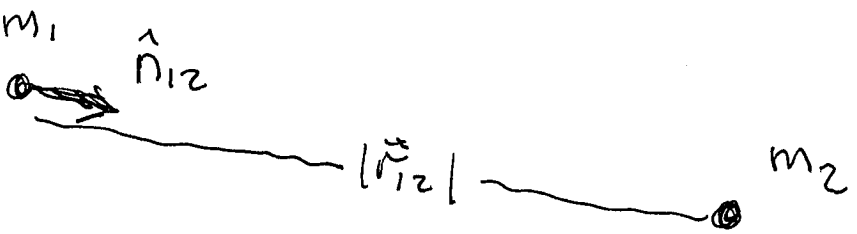
How have you experienced electrical phenomena in your life

1. lightning
2. outlet — shocked bad
   \ get energy
3. electric fence
4. static electricity
5. neurons

Recall Newton's Law of Gravitation

$$\vec{F}_{12} = \frac{G m_1 m_2}{|\vec{r}_{12}|^2} \hat{n}_{12}, \quad G = 6.67 \times 10^{-11} \ N m^2/kg^2$$

Force on "body" 1, from body 2, is an inverse square law, with force directed from body 1 to body 2



In nature there are electric charges that produces electrical forces.

The building blocks of matter, electrons with mass

$m_e = 9.11 \times 10^{-31}$ kg and protons

$m_p = 1.67 \times 10^{-27}$ kg have

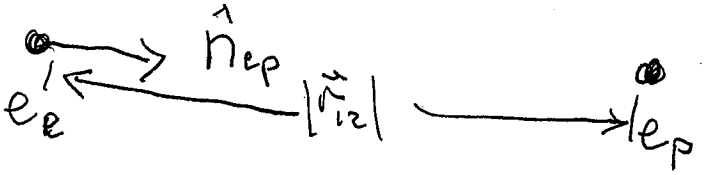
charges

-1.6×10^{-19} Coulombs (C)

and $+1.6 \times 10^{-19}$ C respectively.

The electrical force between an electron and a proton is also is also an inverse square law

$$\vec{F}_{elec} = \frac{k\, e_e\, e_p}{|\vec{r}_{ep}|^2} \hat{n}_{ep}, \quad k = 9.0 \times 10^9 \ N m^2/C^2$$



Estimate (guess, intuit) the ratio of gravitational to electrical force is between an electron and a proton

$|\vec{F}_g| / |\vec{F}_{elec}| \approx$ ← (approximate symbol)

(a) 1

(b) 10^{-39}

(c) 10^{+10}

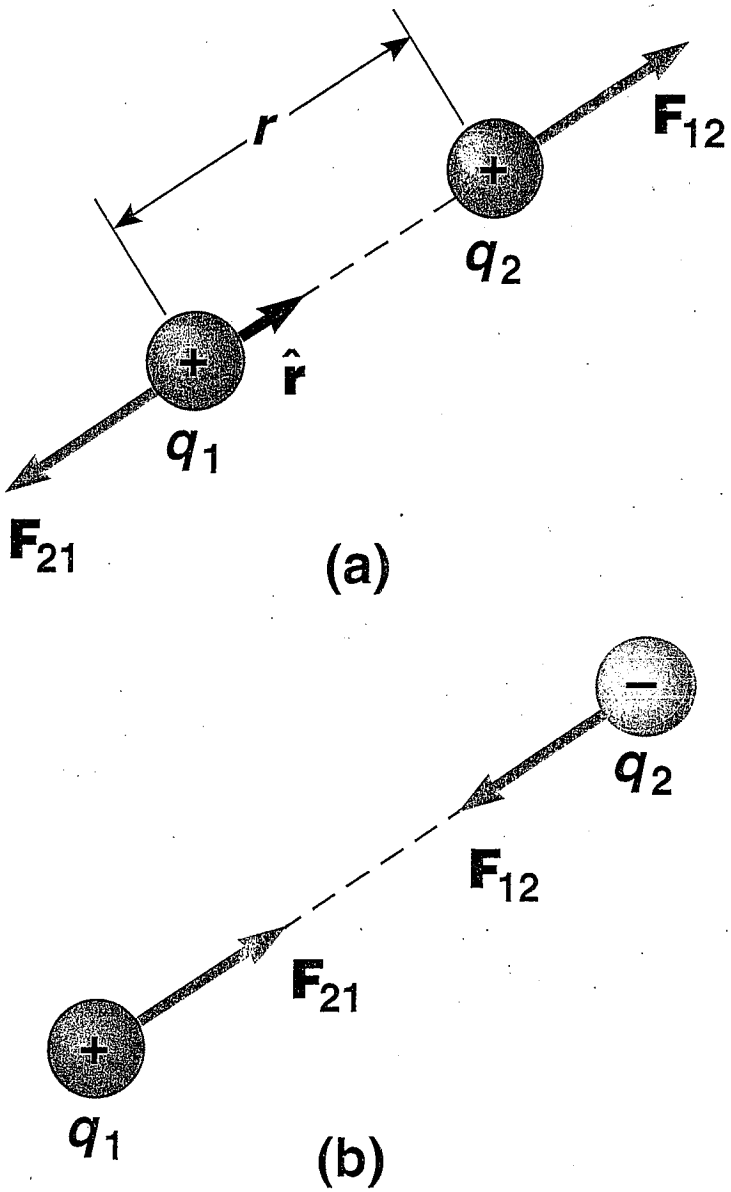
(d) $1/137$

On an atomic level gravitational forces are insignificant. Why is it that the most obvious external force we are conscious of is the force of gravity?

(a) atomic forces do not affect macroscopic forces

(b) A human being, is electrically neutral, so that electrical forces have no importance to their senses.

(c) As protons and electrons have opposite charges, equal amounts of electrons and protons, cancel the forces out to first approximation

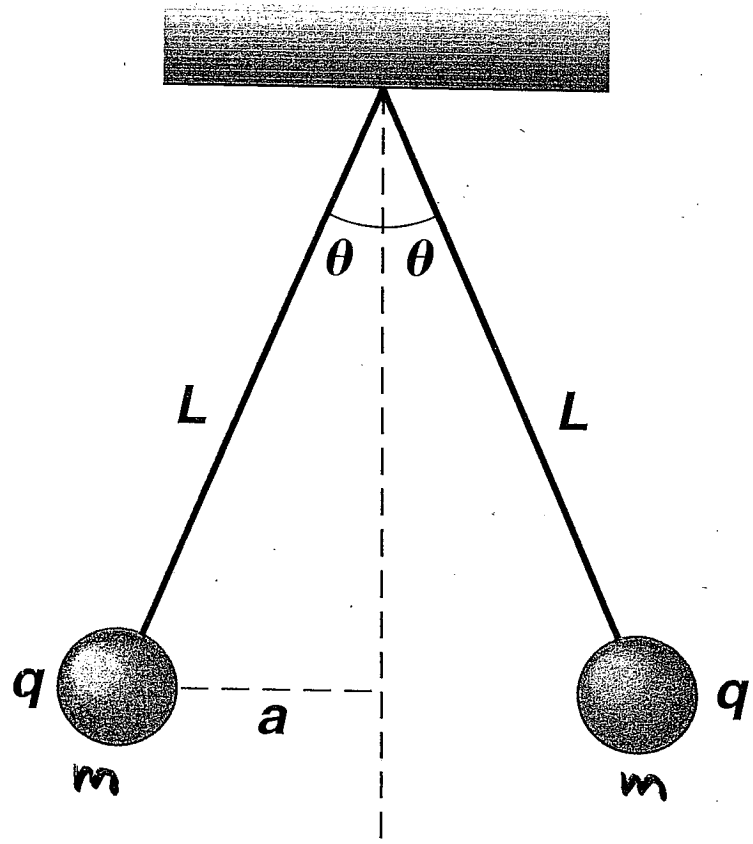


Serway and Jewett, Physics for Scientists and Engineers, 6/e
Figure 23.7

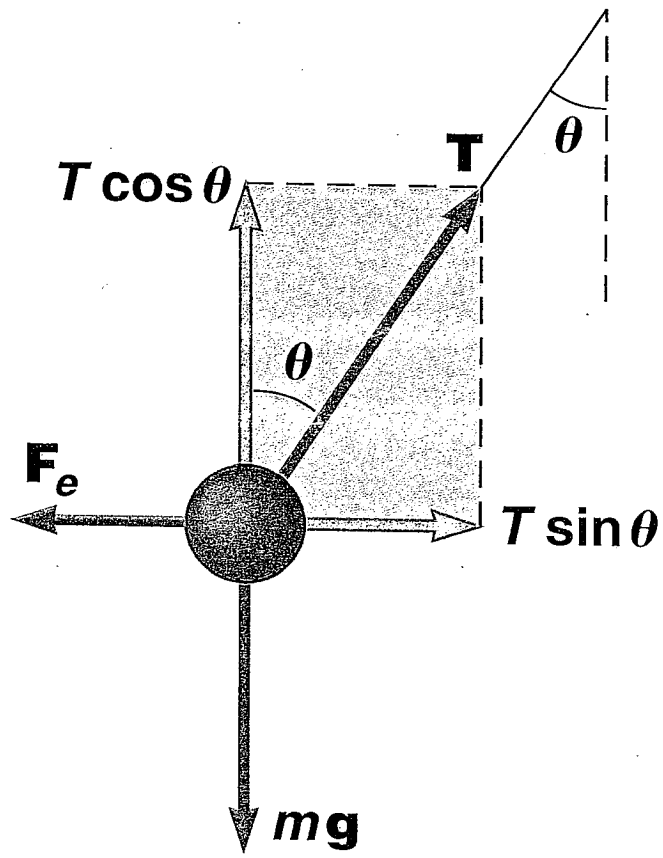
Figure 23.7

Two point charges separated by a distance r exert a force on each other that is given by Coulomb's law. The force $\mathbf{F}_{21}$ exerted by q_2 on q_1 is equal in magnitude and opposite in direction to the force $\mathbf{F}_{12}$ exerted by q_1 on q_2. (a) When the charges are of the same sign, the force is repulsive. (b) When the charges are of opposite signs, the force is attractive.

Combining Gravitational & Electrical Forces



(a)



(b)

What is charge q, given m, θ, L?

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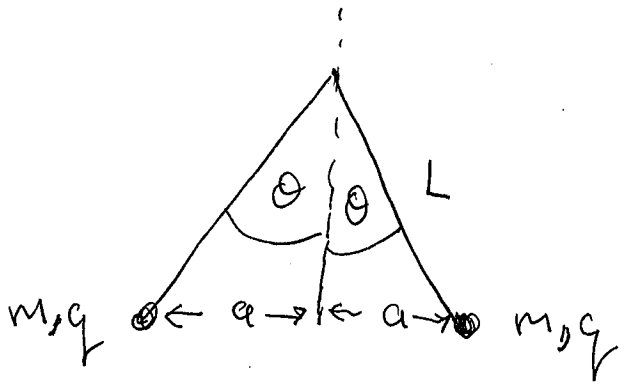
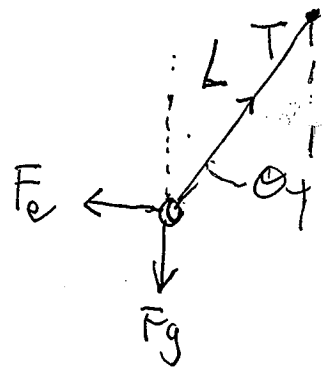
Figure 23.10

Figure 23.10

(Example 23.4) (a) Two identical spheres, each carrying the same charge q, suspended in equilibrium. (b) The free-body diagram for the sphere on the left.





$$F_g = T\cos\theta$$

$$F_e = T\sin\theta$$

eliminate T:

$$\frac{T\sin\theta}{T\cos\theta} = \frac{F_e}{F_g} = \tan\theta$$

$$F_e = \frac{kq^2}{(2a)^2}, \quad F_g = mg$$

$$\tan\theta = \frac{kq^2}{(2a)^2 mg}; \quad a = L\sin\theta$$

$$= \frac{kq^2}{(2L\sin\theta)^2 mg}, \quad \text{solve for } q^2$$

$$q^2 = \frac{4mg}{k}\frac{\sin^3\theta}{\cos\theta}L^2; \quad q = 2\sin\theta L\left(\frac{mg\tan\theta}{k}\right)^{1/2}$$