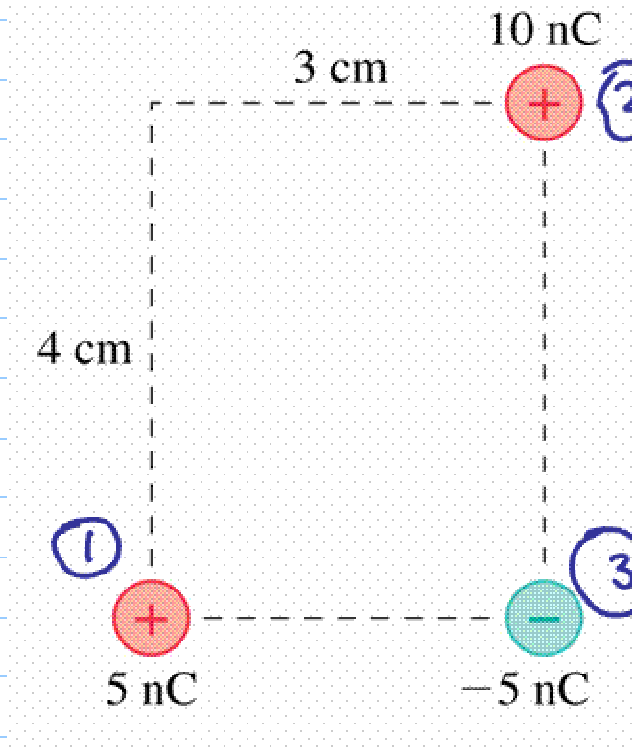
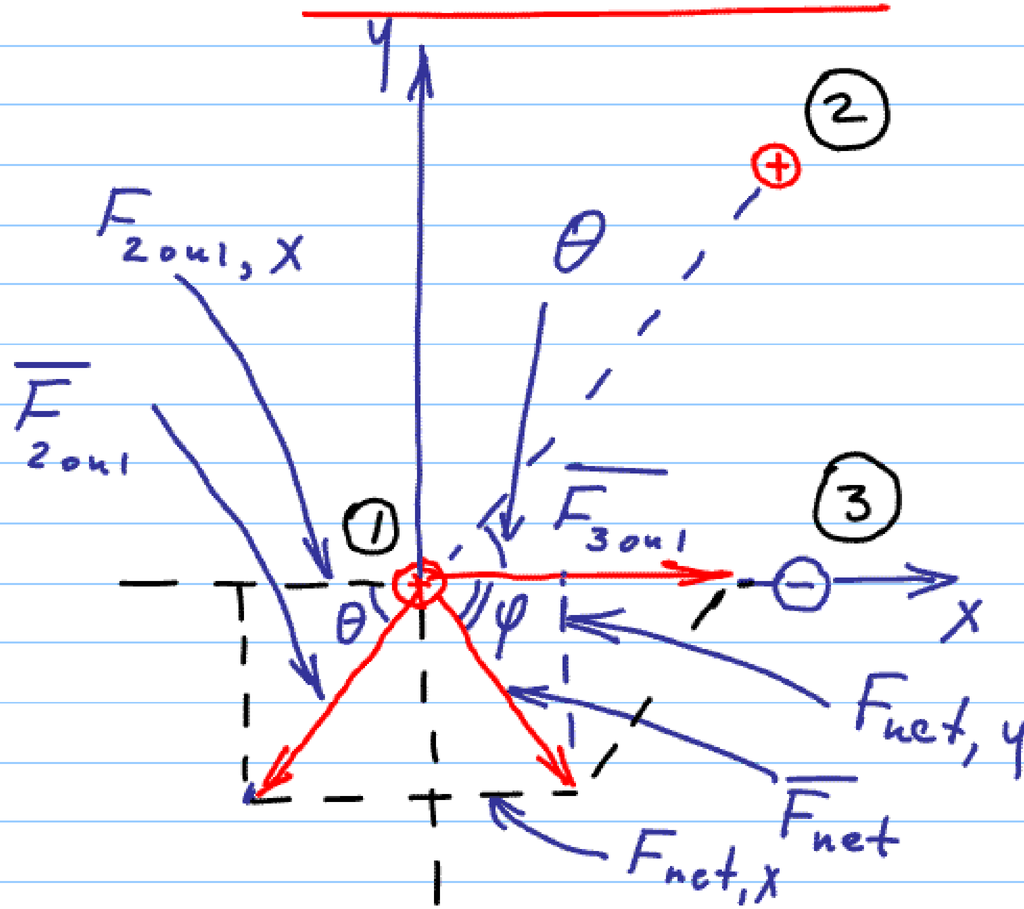
Note Title 8/30/2005

a) $|\vec{F}_{net}|$ - ?   b) φ - ?

Visualize

Problem 42, Chapter 25





Solve

General Solution

$$\bar{F}_{net} = \bar{F}_{2 on 1} + \bar{F}_{3 on 1}$$

$$\begin{cases} F_{net,x} = F_{2on1,x} + F_{3on1,x} \\ F_{net,y} = F_{2on1,y} + F_{3on1,y} \end{cases}$$

Signs can be determined from the geometry!

$$\begin{cases} |\bar{F}_{net}| = \sqrt{F_{net,x}^2 + F_{net,y}^2} \\ \varphi = \tan^{-1} \dfrac{F_{net,y}}{F_{net,x}} \end{cases}$$

φ is below x axis, in this case we can take $F_{net,y} > 0$ and $F_{net,x} > 0$

Substituting numbers, angles, etc. ...

$$|\bar{F}_{2on1}| = K\frac{q_1 \cdot q_2}{r_{12}^2} = 9 \cdot \cancel{10^9}\,\frac{5 \cdot \cancel{10^{-9}} \cdot 10 \cdot 10^{-9}}{(5 \cdot 10^{-2})^2} =$$

$$\boxed{r_{12} = \sqrt{3^2 + 4^2} = \sqrt{9 + 16} = \sqrt{25} = 5\ \text{cm}}$$

$$= \frac{45 \cdot 10^{-8}}{25 \cdot 10^{-4}} = 1.8 \cdot 10^{-4}\ N$$

Taken from the geometry

$$\bar{F}_{2on1}\ (\text{as a full vector}) = |\bar{F}_{2on1}| \cdot (-\cos\theta) \cdot \bar{i} +$$

$$+ |\bar{F}_{2on1}| \cdot (-\sin\theta) \cdot \bar{j} = (1.8 \cdot 10^{-4}\,N) \cdot \left[\left(-\frac{3}{5}\right) \cdot \bar{i} + \left(-\frac{4}{5}\right) \cdot \bar{j}\right]$$

$$= (-1.08 \cdot 10^{-4}\,N) \cdot \bar{i} + (-1.44 \cdot 10^{-4}\,N) \cdot \bar{j}$$

Not using sign "–" here since our signs come from the geometry

$$\overline{F}_{3on1} = |\overline{F}_{3on1}| \cdot \overline{i}$$

$$|\overline{F}_{3on1}| = K \frac{q_1 \cdot q_3}{r_{13}^2} = 9 \cdot \cancel{10^{9}} \frac{5 \cdot \cancel{10^{-9}} \cdot 5 \cdot 10^{-9}}{(3 \cdot 10^{-2})^2} =$$

$$= \frac{\cancel{9} \cdot 25 \cdot 10^{-9}}{\cancel{9} \cdot 10^{-4}} = 25 \cdot 10^{-5} = 2.5 \cdot 10^{-4}\ N$$

$$\overline{F}_{3on1} = (2.5 \cdot 10^{-4} N) \cdot \overline{i}$$

$$\overline{F}_{net} = \overline{F}_{2on1} + \overline{F}_{3on1} = (-1.08 \cdot 10^{-4} N) \cdot \overline{i} +$$

$$+ (2.5 \cdot 10^{-4} N) \cdot \overline{i} + (-1.44 \cdot 10^{-4} N) \cdot \overline{j} =$$

$$= \underbrace{(1.42 \cdot 10^{-4} N)}_{F_{net,x}} \cdot \overline{i} - \underbrace{(1.44 \cdot 10^{-4} N)}_{F_{net,y}} \cdot \overline{j}$$

$$|F_{net}| = \sqrt{(1.42 \cdot 10^{-4})^2 + (1.44 \cdot 10^{-4})^2} =$$

$$= \sqrt{1.42^2 \cdot 10^{-8} + 1.44^2 \cdot 10^{-8}} = 10^{-4} \cdot \sqrt{1.42^2 + 1.44^2} =$$

$$= 2.02 \cdot 10^{-4} \, N$$

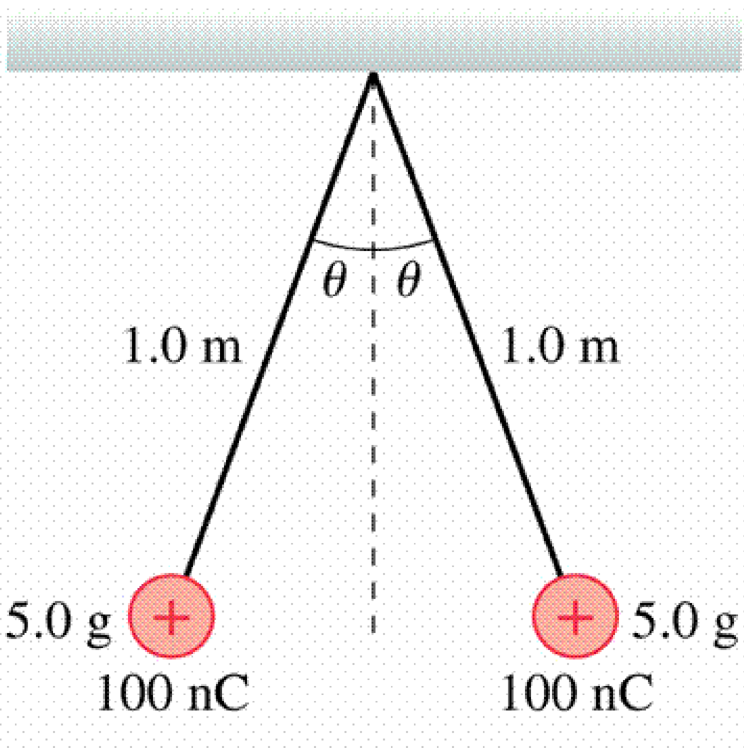
$$\varphi = \tan^{-1} \frac{1.44}{1.42} = 45.4^\circ$$

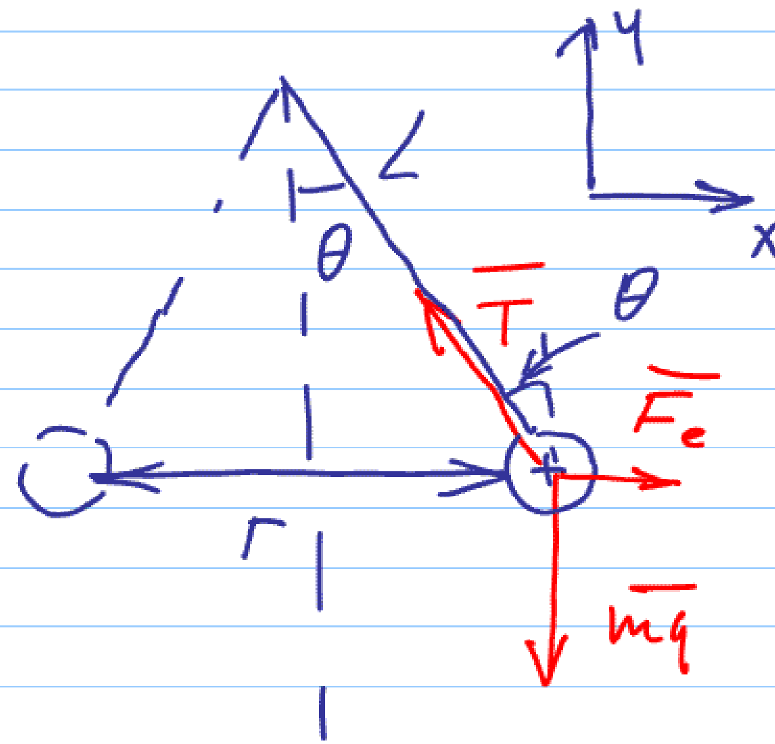
Below +X axis

θ – ?

Visualize

Problem 59, Chapter 25





1st Newton's Law: $\bar{v} = 0 \Rightarrow$

$$\bar{F}_{net} = 0$$

$$\begin{cases} F_{net,x} = 0 \\ F_{net,y} = 0 \end{cases} \qquad F_{net,x} = F_e - T \cdot \sin\theta = 0$$

$$F_{net,y} = T \cdot \cos\theta - mg = 0$$

$$\begin{cases} T \cdot \sin\theta = F_e \\ T \cdot \cos\theta = mg \end{cases}$$

Dividing...

$$\tan\theta = \frac{F_e}{mg}$$

$$F_e = K \frac{q^2}{r^2}, \qquad r = 2L\sin\theta$$

$$\tan\theta = K \frac{q^2}{(2L\sin\theta)^2 \cdot mg}$$

$$\tan\theta \cdot \sin^2\theta = K \frac{q^2}{4L^2 \cdot mg}$$

For small angles ($\theta << 10^\circ$):

$$\tan\theta \simeq \sin\theta$$

$$\sin^3\theta = 9 \cdot 10^9 \frac{(100 \cdot 10^{-9})^2}{4 \cdot 1^2 \cdot 5 \cdot 10^{-3} \cdot 9.8} = 4.6 \cdot 10^{-4}$$

$$\sin\theta \simeq 0.077 \Rightarrow \theta \simeq 4.4^\circ$$