Electric Field

- Like gravity, field strength is weaker when farther away $\frac{1}{r^2}$
- Electric fields interact with electric charges only
- Consider the same analysis for Electric field as done for gravitational field
- The idea of the field is to determine the amount of force [N] that a unit of charge [C] would experience

$$\vec{g} = \frac{\vec{F}_g}{m_o} \qquad \boxed{\vec{E} = \frac{\vec{F}_e}{q_o}} \longrightarrow \boxed{E = \frac{kq_s}{r^2}} \qquad F_e = \frac{kq_s q_o}{r^2}$$

Vector

- E has units of [N/C] --> unlike the gravitational field, this is not equivalent to an acceleration ← related to direction of motion
  > E measures how strong the Electric field is at a certain distance from the source
- F_e is electric force the charge experiences
- q_o is the charge of the object experiencing the field
- q_s is the source charge, what is causing the field

Direction of E

- Unlike gravity, electric field can be either attractive or repulsive
- The direction of E is not necessarily the same as the direction of F_e

- **The direction of E is determined by considering what direction a positive test charge would want to move in the presence of the given field created by a particular charge**

- Different charge combinations can make different setups

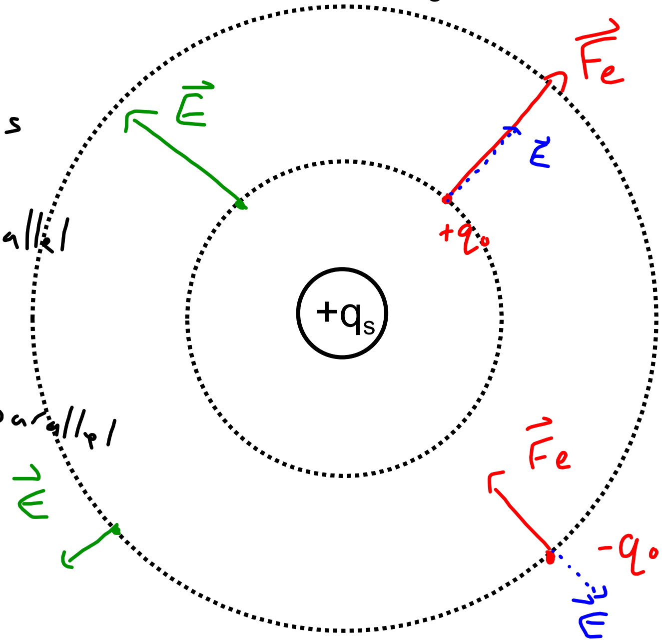
Electric Field Direction

Positive source charge

$\vec{E}$ away from $+q_s$

$\vec{F}_e$ & $\vec{E}$ parallel for $+q_0$

$\vec{F}_e$ & $\vec{E}$ antiparallel for $-q_0$

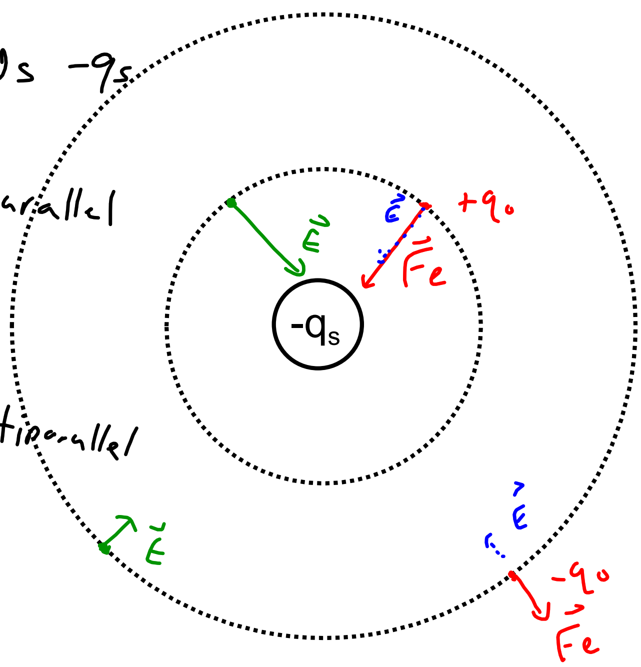


Negative source charge

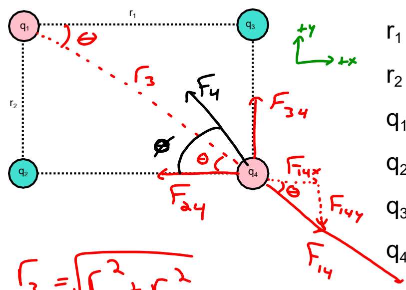
$\vec{E}$ towards $-q_s$

$\vec{F}_e$ & $\vec{E}$ parallel for $+q_0$

$\vec{F}_e$ & $\vec{E}$ antiparallel for $-q_0$



Do Practice Problems 11-14 on page 646



$r_1 = 0.16$ m

$r_2 = 0.12$ m

$q_1 = 1.0$ μC

$q_2 = -2.0$ μC

$q_3 = -3.0$ μC

$q_4 = 4.0$ μC

$\vec{F}_4 = ?$

$$r_3 = \sqrt{r_1^2 + r_2^2}$$

$$= \sqrt{(0.16\,m)^2 + (0.12\,m)^2} = 0.20\,m$$

$$\theta = \tan^{-1}\left(\frac{r_2}{r_1}\right) = \tan^{-1}\left(\frac{0.12\,m}{0.16\,m}\right) = 36.87°$$

$$F_{24} = \frac{kq_2q_4}{r_1^2} = \frac{(9 \times 10^9\,Nm^2/c^2)(2.0\,\mu C)(4.0\,\mu C)}{(0.16\,m)^2} \quad \times 10^{-6}$$

$$= 2.8125\,N$$

$$F_{34} = \frac{kq_3q_4}{r_2^2} = \frac{(9.0 \times 10^9\,Nm^2/c^2)(3.0\,\mu C)(4\,\mu C)}{(0.12\,m)^2}$$

$$= 7.5\,N$$

$$F_{14} = \frac{kq_1q_4}{r_3^2} = \frac{(9.0 \times 10^9\,Nm^2/c^2)(1.0\,\mu C)(4.0\,\mu C)}{(0.20\,m)^2}$$

$$= 0.90\,N$$

$$F_{4x} = F_{14x} - F_{24} = F_{14}\cos\theta - F_{24}$$

$$= 0.90\,N\cos(36.87°) - 2.8125\,N$$

$$= -2.0925\,N$$

$$F_{4y} = F_{34} - F_{14y} = F_{34} - F_{14}\sin\theta$$

$$= 7.5\,N - (0.90\,N)\sin(36.87°)$$

$$= 6.96\,N$$

$$F_4 = \sqrt{F_{4x}^2 + F_{4y}^2} = 7.2677\,N$$

$$\theta = \tan^{-1}\left(\frac{|F_{4y}|}{|F_{4x}|}\right) = 73.267°$$

$$\boxed{\vec{F}_4 = 7.3\,N\ [W\ 73°\ N]}$$

PHY 621 **Comparing Fields: Gravitation, Electric, and Magnetic**

	Gravitational Fields	Electric Fields	Magnetic Fields
surround...	objects of mass	objects with an electric charge	objects with magnetic poles
exert...	attractive forces only	attractive and repulsive forces	attractive and repulsive forces
strength is directly proportional to...	size of the source mass	amount of electric charge on the source	size of the magnetic poles
strength is inversely proportional to ...	distance of separation squared	distance of separation squared	distance of separation squared