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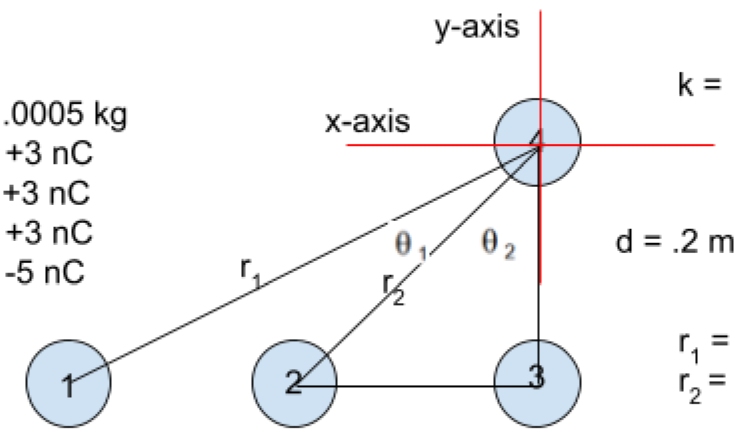
PH 213

HIP 1

We have three 0.5gram Styrofoam peanuts each with a charge of +3nC each separated by 0.1 meters. A 4th peanut is placed .2 m above the right hand side peanut—it has a charge of -5nC.

a) **Using analytical problem solving, what is the initial acceleration of the 4th peanut?**

m = .0005 kg
q_1 = +3 nC
q_2 = +3 nC
q_3 = +3 nC
q_4 = -5 nC



k = $\dfrac{1}{4\pi\varepsilon_o}$

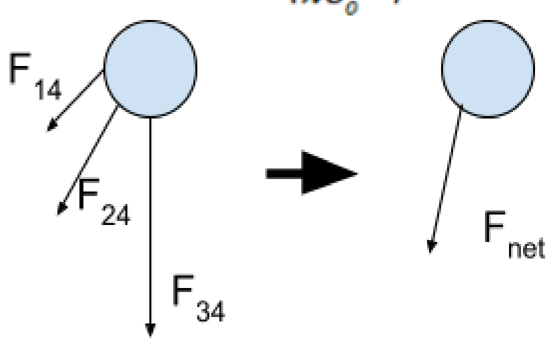
$r_1 = (d^2+(2s)^2)^{.5}$
$r_2 = (d^2+s^2)^{.5}$

θ_1 = arctan ((2s)/(d))
θ_2 = arctan (s/d)

s = .1 m

FBD of peanut 4

$$\vec{F} = \frac{1}{4\pi\varepsilon_o}\frac{q_1 q_2}{r^2}\hat{r}$$



$\mathbf{F}_{net} = \mathbf{F}_{14} + \mathbf{F}_{24} + \mathbf{F}_{34} = \mathbf{m}\mathbf{a}$

x - direction	y - direction
$F_{14x} = \frac{kq_1q_4}{d^2+4s^2} \sin\left(\tan^{-1}\frac{2s}{d}\right)$	$F_{14y} = \frac{kq_1q_4}{d^2+4s^2} \cos\left(\tan^{-1}\frac{2s}{d}\right)$
$F_{24x} = \frac{kq_2q_4}{d^2+s^2} \sin\left(\tan^{-1}\frac{s}{d}\right)$	$F_{24y} = \frac{kq_2q_4}{d^2+s^2} \cos\left(\tan^{-1}\frac{2s}{d}\right)$
$F_{34x} = \varnothing$	$F_{34y} = \frac{kq_3q_4}{d^2}$

$$F_{netx} = F_{14x} + F_{24x} + F_{34x} \qquad F_{nety} = F_{14y} + F_{24y} + F_{34y}$$

$$F_{netx} = -2.4 \times 10^{-6}\ N \qquad F_{nety} = -6.98 \times 10^{-6}\ N$$

$$F_{net} = \langle -2.4 \times 10^{-6}, -6.98 \times 10^{-6} \rangle\ N$$

$$a_x = \frac{F_{netx}}{m} \qquad a_y = \frac{F_{nety}}{m}$$

$$a_x = -4.8 \times 10^{-3}\ \frac{m}{s^2} \qquad a_y = -0.014\ \frac{m}{s^2}$$

$$a = \langle -4.8 \times 10^{-3}, -0.014 \rangle\ \frac{m}{s^2}$$

b) Create a program using vpython that calculates the initial acceleration of the 4th peanut

The initial acceleration of the 4th peanut at t=0 is:
a = < -4.7961e-3, -0.0139509, 0 > m/s^2
Magnitude of acceleration = 0.0147523 m/s^2

See code below

c) **What is the E-field due to the 4 peanuts at a place 10 cm above the left-hand side peanut?**

The electric field at the point of interest is:

E = < -631.897, 4293.81, 0 > N/C

See code below

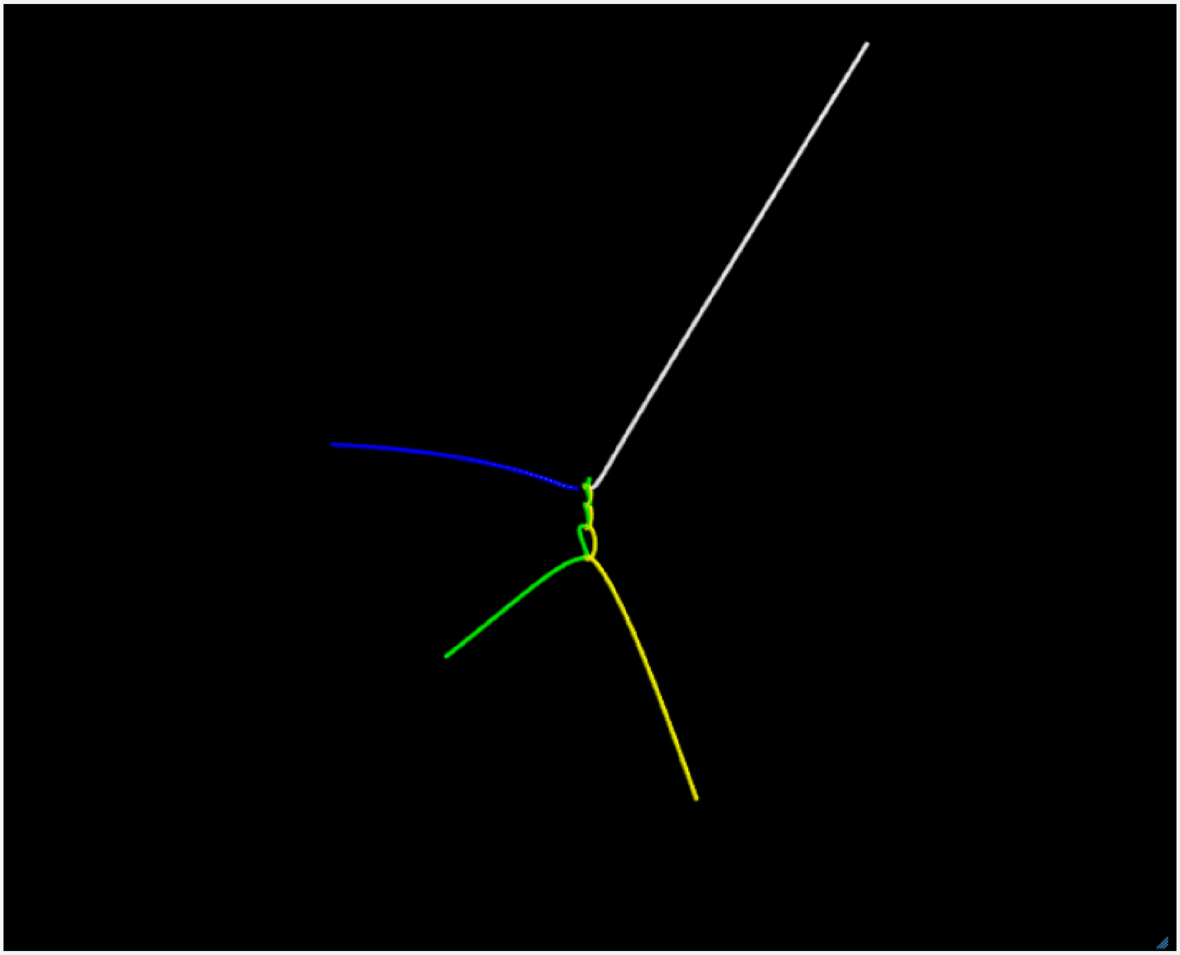
```
GlowScript 3.0 VPython

## Constants


m=.0005 ##kg

q1=-5*10**-9 ##C

q2=3*10**-9 ##C

k=8.99*10**9 ##Nm**2/C**2

t=0 ##s

dt=.1 ##s


## Vector positions

s1=vector(-.2,-.2,0) #m

v1=vector(0,0,0) #m/s

s2=vector(-.1,-.2,0) #m

v2=vector(0,0,0) #m/s

s3=vector(0,-.2,0) #m

v3=vector(0,0,0) #m/s

s4=vector(0,0,0) #m
```

```
v4=vector(0,0,0) #m/s

i=vector(-.2,-.1,0) ##m ##probe position for electric field


## Force calculations in Newtons

F_14=(k*q1*q2)/mag(s4-s1)**2*norm(s4-s1) ##Force of peanut 1 on peanut 4

F_24=(k*q1*q2)/mag(s4-s2)**2*norm(s4-s2) ##Force of peanut 2 on peanut 4

F_34=(k*q1*q2)/mag(s4-s3)**2*norm(s4-s3) ##Force of peanut 3 on peanut 4


F_net4=F_14+F_24+F_34 ##Net force on peanut 4


a4=F_net4/m #m/s^2


## Electric Field calculations in N/C

E_1=(k*q2)/mag(i-s1)**2*norm(i-s1) ##Electric field of peanut 1

E_2=(k*q2)/mag(i-s2)**2*norm(i-s2) ##Electric field of peanut 2

E_3=(k*q2)/mag(i-s3)**2*norm(i-s3) ##Electric field of peanut 3

E_4=(k*q1)/mag(i-s4)**2*norm(i-s4) ##Electric field of peanut 4


E_net=E_1+E_2+E_3+E_4 ##Net Electric Field at position i


print("Force vector: ",F_net4, "N")

print("Magnitude of Force 4: ",mag(F_net4), "N")

print("Acceleration vector of 4: ",a4,"m/s^2")

print("Magnitude of Acceleration 4: ",mag(a4), "m/s^2")

print("Electric Field Vector at Position i: ",E_net, "N/C")

print("Magnitude of Electric Field at Position i: ", mag(E_net),"N/C")
```

```
p4 = sphere(radius = .01, color = color.green, make_trail=True) #Peanut 4

p1 = sphere(radius = .01, color = color.blue, make_trail=True) #Peanut 3

p2 = sphere(radius = .01, color = color.yellow, make_trail=True) #Peanut 2

p3 = sphere(radius = .01, color = color.white, make_trail=True) #Peanut 1




while t<500:

    rate(50)

    ## Force calculations in Newtons

    F_14=(k*q1*q2)/mag(s4-s1)**2*norm(s4-s1) ##Force of peanut 1 on peanut 4

    F_24=(k*q1*q2)/mag(s4-s2)**2*norm(s4-s2) ##Force of peanut 2 on peanut 4

    F_34=(k*q1*q2)/mag(s4-s3)**2*norm(s4-s3) ##Force of peanut 3 on peanut 4


    F_net4=F_14+F_24+F_34 ##Net force on peanut 4



    F_13=(k*q2*q2)/mag(s3-s1)**2*norm(s3-s1) ##Force of peanut 1 on peanut 3

    F_23=(k*q2*q2)/mag(s3-s2)**2*norm(s3-s2) ##Force of peanut 2 on peanut 3

    F_43=(k*q1*q2)/mag(s3-s4)**2*norm(s3-s4) ##Force of peanut 3 on peanut 3


    F_net3=F_13+F_23+F_43 ##Net force on peanut 3



    F_12=(k*q2*q2)/mag(s2-s1)**2*norm(s2-s1) ##Force of peanut 1 on peanut 2
```

```
F_32=(k*q2*q2)/mag(s2-s3)**2*norm(s2-s3) ##Force of peanut 2 on peanut 2

F_42=(k*q1*q2)/mag(s2-s4)**2*norm(s2-s4) ##Force of peanut 3 on peanut 2


F_net2=F_12+F_32+F_42 ##Net force on peanut 2



F_41=(k*q1*q2)/mag(s1-s4)**2*norm(s1-s4)  ##Force of peanut 1 on peanut 1

F_31=(k*q2*q2)/mag(s1-s3)**2*norm(s1-s3) ##Force of peanut 2 on peanut 1

F_21=(k*q2*q2)/mag(s1-s2)**2*norm(s1-s2) ##Force of peanut 3 on peanut 1


F_net1=F_41+F_31+F_21 ##Net force on peanut 1


# Calculate the acceleration of each peanut at current position

a4=F_net4/m #m/s^2

a3=F_net3/m #m/s^2

a2=F_net2/m #m/s^2

a1=F_net1/m #m/s^2

# Calculate the velocity of each peanut at current position and acceleration

v4=v4+a4*dt #m/s

v3=v3+a3*dt #m/s

v2=v2+a2*dt #m/s

v1=v1+a1*dt #m/s

# Calculate the updated position of each peanut at current position, velocity and
acceleration

s4=s4+v4*dt #m

s3=s3+v3*dt #m

s2=s2+v2*dt #m
```

```
s1=s1+v1*dt #m

# Update time value

t=t+dt #s

# Update graphical position

p4.pos=s4

p3.pos=s3

p2.pos=s2

p1.pos=s1
```



Force vector: < -2.39805e-6, -6.97544e-6, 0 > N
Magnitude of Force 4: 7.37614e-6 N
Acceleration vector of 4: < -4.7961e-3, -0.0139509, 0 > m/s^2
Magnitude of Acceleration 4: 0.0147523 m/s^2
Electric Field Vector at Position i: < -631.897, 4293.81, 0 > N/C
Magnitude of Electric Field at Position i: 4340.05 N/C

GORY	PLARY (1.5)	MPLISHED (1)	LOPING (0.5)	GENT (0)
Statement and tion	earning tool for our class is written	blem is clearly presented for reader in n words.	blem is directly copied or is hard .	p into some calculation
	etch could be dropped into a novel as it stands.	a clear sketch, larger than a credit the problem set up with important and data noted	some sketch of the problem	etch?
s Tools	iate physics tools are correlated xercise in textbook quality and	iate physics tools are correlated to the . Appropriate tools include: pictures, onservational laws utilized, etc…	hysics tools are correlated to the .	re a few equations written.
n Solution tation	is very clearly presented with g asides or annotations	is complete and clearly presented no significant intuitive demands on the	solution I have to read between	es version of solution with only nts present
	ution can serve as solution	g is larger than a credit card, tion is fluid, notation used is clear.	gure the path of your solution with	read it.
		correctly given	ions & quantities are presented s	nits at the results
n			close	ot reasonable
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nableness	s more than one type of ableness check.	he clear rationale for appropriateness of tion in the setting	that the answer is reasonable but sn't given any evidence	ussion
Graded			e	ut your self-assessment is from mine by at least two steps.