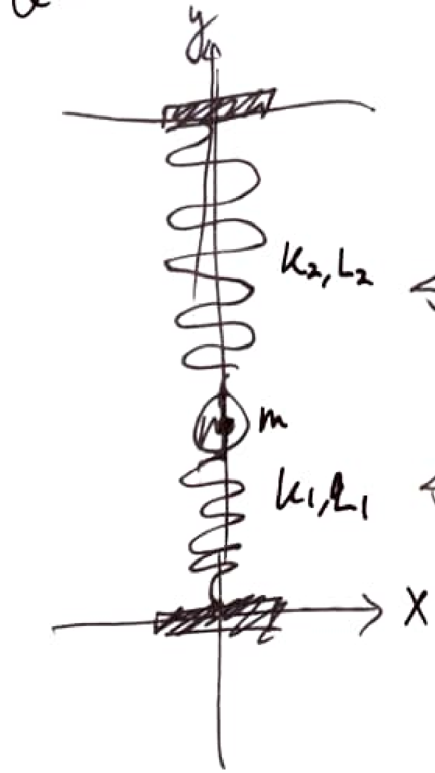
Q3



$m = 5kg$ $\quad$ $L_1 + L_2 = 7m$

$F_{net}(0) = 0$ $\quad$ $L_0 = 3m$

time 0s

$k_1 = 300\ N/m$ $\quad$ $L_1(0) = 2.5m$.

time 0s.

$k_2 = 100\ N/m$ $\quad$ $L_2(0) = 4.5m$

time 0s.

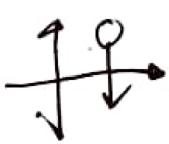
Q ~~3~~ 1

According to the data given, we know the mass of the ball is 5kg. Since the gravitational constant near the earth's space is 9.8 m/s^2, $|\vec{F_g}| = (m)(g) = (5kg)(9.8\ m/s^2) = 49N$.

typically g.

~~Answer: 49N~~

And, the direction is -y. Thus, $\vec{F_g} = \langle 0, -49N, 0 \rangle$



$\langle 0, -49, 0 \rangle N$

$\boxed{\text{Answer: } \vec{F_g} = \text{~~⟨0, -49, 0⟩~~ N}}$

$\boxed{\text{Approx. } \vec{F_g} = \langle 0, -50, 0 \rangle N}$

Q 3.2

The bottom spring is now "compressed". Thus the direction of the force is $+y$. The magnitude is gained as follows.

$$|\vec{F}_1| = k_1 |L_1 - L_0| = (300 \text{ N/m})(0.5 \text{ m}) = 150 \text{ N}$$

Thus, $\vec{F}_1 = \langle 0, 150\text{N}, 0 \rangle$

$$\boxed{\text{Answer: } \vec{F}_1 = \cancel{\langle 0\text{N}, 150\text{N}, 0\text{N} \rangle}\ \langle 0, 150, 0 \rangle \text{N}}$$

Q 3.3

The top spring is now "streched". Thus the direction of the force is $+y$. The magnitude is given as follows.

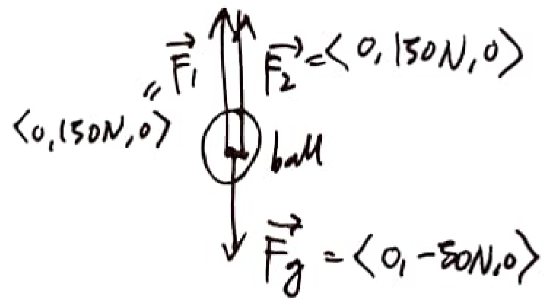
$$|\vec{F_2}| = k_2 \, |L_2 - L_0| = (100 \, N/m)(1.5 \, m) = 150 \, N$$

Thus, $\vec{F_2} = \langle 0, 150\,N, 0 \rangle$

$$\boxed{\text{Answer} : \vec{F_2} = \langle 0, 150, 0 \rangle \, N}$$

Q 3.4

Now we can draw a free-force diagram as follows.



The $\vec{F}_{net} = \vec{F_1} + \vec{F_2} + \vec{F_g} = \langle 0, 250N, 0\rangle$. By the momentum principle (Newton's 2nd Law), we know

$$\vec{F}_{net} = m \cdot \vec{a}$$

$$\Leftrightarrow \langle 0, 250N, 0\rangle = (5kg)\cdot \vec{a}$$

, ~~that~~ is, $\vec{a} = \langle 0, 50\ m/s^2, 0\rangle$.

Now we use "velocity update formula". Since we know the ball is initially motionless, ~~the~~ initial velocity, v_i, is 0.

$$\vec{v}_f = \vec{a}\cdot\Delta t + \cancel{\vec{v}_i}^{\,0} \quad \text{where } \Delta t = 0.1s$$

$\langle 0, 5, 0\rangle$ m/s

Thus, $\vec{v}_f = \langle 0, 5\ m/s, 0\rangle$

Answer: $\vec{V} = \cancel{\langle 0, 5\ m/s, 0\rangle}$

Q 3.5

In the ~~question~~ question 3.4, we gained the velocity of the ball.
Based on the kinematics formula, we know

$$\vec{r}_f = \frac{1}{2}\vec{a}(\Delta t)^2 + \vec{v}_i(\Delta t) + \vec{r}_i \quad \text{where } \Delta t = 0.1s$$

The initial velocity is 0, and initial position is $\langle 0, 2.5\,m, 0\rangle$,

$$\vec{r}_f = \frac{1}{2}(\Delta t)(\vec{a}\cdot\Delta t) + 0(\Delta t) + \langle 0, 2.5\,m, 0\rangle$$

$$= \frac{1}{2}(0.1[s])\langle 0, 5[m/s], 0\rangle + \langle 0, 2.5[m], 0\rangle$$

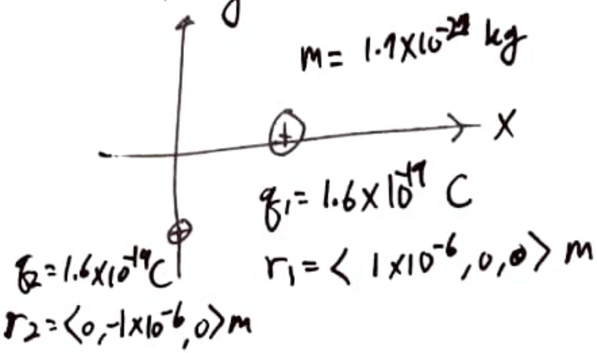
$$= \langle 0, 0.25\,(m), 0\rangle + \langle 0, 2.5(m), 0\rangle$$

$$= \langle 0, 2.75\,(m), 0\rangle$$

Thus $\vec{r} = \langle 0, 2.75\,m, 0\rangle$

$$\boxed{\text{Answer: } \vec{r} = \cancel{\langle 0, 2.75\,m, 0\rangle} = \langle 0, 2.75, 0\rangle\, m}$$

Q.4



Definition of Electric Force.

$$\vec{F}_e = \left(9\times10^{9}\ \frac{Nm^2}{C^2}\right)\frac{q_1 q_2}{r^2}\,(\hat{r}).$$

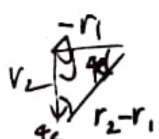
" Gravitational force

$$\vec{F}_g = -\left(6.7\times10^{-11}\ \frac{N\cdot m^2}{kg^2}\right)\frac{m_1 m_2}{r^2}\,(\hat{r})$$

Q 4.1

$$\vec{r} = \vec{r_2} - \vec{r_1}$$
$$= \langle 0, -1\times10^{-6}, 0\rangle\ m - \langle 1\times10^{-6}, 0, 0\rangle\ m$$
$$= \langle -1\times10^{-6}, -1\times10^{-6}, 0\rangle\ m$$

Thus, we can get the form of $|\vec{r}|\hat{r}$ as follows,



$$|\vec{r}| = \frac{|\vec{r_1}|}{\sin 45°} = \sqrt{2}\cdot|\vec{r_1}| = \underline{(\sqrt{2})(1\times10^{-6})\ m}$$

$$\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \left\langle -\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}, 0\right\rangle\ m$$

$$\boxed{\text{Answer: } \vec{r} = |\vec{r}|\,\hat{r} = (\sqrt{2}\times10^{-6})\cdot\left\langle -\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}, 0\right\rangle\ m}$$

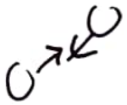
Q 4.2

$$\left|\vec{F}_g\right| = \left(6.7\times10^{-11}\ \frac{N\cdot m^2}{kg^2}\right)\cdot\frac{\left(1.7\times10^{-27}\ kg\right)^2}{\left(\sqrt{2}\times10^{-6}\ m\right)^2} = 9.68\times10^{-53}\ N$$

~~Thus $\vec{F}_g =$~~

(Attraction!)

Since the gravitational force towards each other,

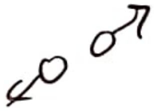


we know the direction is $\left\langle +\frac{1}{\sqrt{2}}, +\frac{1}{\sqrt{2}}, 0\right\rangle$

$$\boxed{\text{Answer: } \vec{F}_{g,2} \approx \left(9.68\times10^{-53}\right)\left\langle \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0\right\rangle\ N}$$

Q 4.3

$$|\vec{F_e}| = \left(9\times10^{9}\ \frac{N.m^2}{C^2}\right)\cdot\frac{(1.6\times10^{-19}\,C)^2}{(\sqrt{2}\times10^{-6}m)^2} = 1.15\times10^{-16}\ N$$

Since the electrical force is repulsion when the sign of each charge is the same,  we know the direction is

$\langle -\frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}}, 0\rangle$

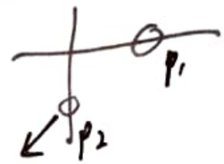
$$\boxed{\text{Answer: } \vec{F}_{e,2} \approx (1.15\times10^{-16})\langle -\tfrac{1}{\sqrt{2}}, -\tfrac{1}{\sqrt{2}}, 0\rangle\ N}$$

Q 4.4

(Newton's 2nd Law)

Now, it's time to use the "momentum principle" !!

$$\vec{F}_{net,2} = \vec{F}_{g,2} + \vec{F}_{e,2} = (-1.15\times10^{-16})\left\langle \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0 \right\rangle N$$



Based on the answers in Q 4.2 & Q 4.3,

we know the proton 2 will move to "bottom left"

Moreover, due to "reciprocity (Newton's 3rd Law)", we know their net force will have "the same magnitude, but opposite direction".

Since the universal gravitational force & electrical force follow the Newton's 3rd Rule, we know proton 1 will move to the "top right".

Answer: p_1 will go "bottom left" with 45°; p_2 go "top right" with 45°