

# PHSX 343: Assignment 13

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## +4 Problem 1

$$v_x = \frac{E}{B}$$

Checking to see if this is relativistic first:

$$K = \frac{1}{2}m_e v^2 \rightarrow v = \sqrt{\frac{2K}{m_e}} = 0.44c$$

So this is definitely relativistic

$$\frac{u}{c} = \frac{Pc}{E} = \frac{\sqrt{E^2 - (m_e c^2)^2}}{m_e c^2 + k} = 0.413c$$

Now using this value in the first equation:

$$B = \frac{E}{v_x} = 0.00162T = \boxed{1.6mT}$$

## +3 Problem 2

In order to solve this one I followed example 4.3 in the book pretty closely and wrote a quick python script to make my life a lot easier.

```

#Modern hw 13 problem 2

#Enter the values
mill = [25.41e-19, 20.64e-19, 19.06e-19, 17.47e-19, 14.29e-19, 12.70e-19]
milldif = []

#Divide by the range that we assume the energy to be in. This was provided
#in the example
for i in range(len(mill)):
    milldif.append((mill[i]/1.5e-19, mill[i]/2.0e-19))

#Find the average between these two values (the two extremes) and take
#the ceiling. This way we get a reliable bias and always have an integer
#multiple of e
for i in range(len(milldif)):
    milldif[i] = math.ceil((milldif[i][0]+milldif[i][1])/2)

#Divide by the above integer to get your approx of e
for i in range(len(mill)):
    mill[i]=mill[i]/milldif[i]

#printing to make it pretty
string = "{:.3e}".format(mill[0])
for i in range(1,len(mill)):
    string += ", {:.3e}".format(mill[i])
print(string)

```

1.694e-19, 1.588e-19, 1.588e-19, 1.588e-19, 1.588e-19, 1.587e-19

```

#getting the average
sm=0
for i in range(len(mill)):
    sm += mill[i]
avg = sm/len(mill)
print("{:.3e}".format(avg))

```

~~1.606e-19~~

1.588

This method mis-estimates the integer value for  $q_1$ . A more rigorous approach is to find the smallest difference between  $q$  values, then see if all the  $q$  values are whole multiples.

All the math is laid out there, but for the answer, what was wanted was a little confusing. What I have settled on is to give the format of both ways we understood the question. If the question just wanted us to pull out the largest value out of the array, the charge is  $e = 1.694 \times 10^{-19}C$ . In the example they took the average, and I can see the question asking that in a very odd way, so the average is  $e = 1.606 \times 10^{-19}C$ .

### +4 Problem 3

Pulling the equation from class:

$$d_{min} = \frac{kq_{\alpha}Q}{K_{\alpha}}$$

$$K_{\alpha} = \frac{kq_{\alpha}Q}{r_{al}} = \frac{8.988^9 \cdot 2e \cdot 13e}{3.6 \times 10^{-15}} = 1.666 \times 10^{-12} J = 10.4 MeV$$

Now to check that this resulting equation isn't relativistic:

$$m = 3.727 \frac{GeV}{c^2}$$

$$\frac{u}{c} = \frac{Pc}{mc^2} = \frac{\sqrt{(mc^2 + K)^2 - (mc^2)^2}}{mc^2 + K} = 0.0745$$

Since  $0.0745 < 0.1$  the speed is not relativistic.

### +4 Problem 4

$$\frac{\Delta n}{\Delta t} = \left( \frac{\frac{dn_{inc}}{dt} NA}{R^2} \right) \left( \frac{kZe^2}{2K} \right)^2 \frac{1}{\sin^4(\frac{\phi}{2})}$$

Now, using all the values:

$A = 0.5 \times 10^{-4} m$ ,  $z = 47$ ,  $\frac{dn_{inc}}{dt} = \frac{1 \times 10^{-9}}{2e}$ ,  $R = 0.1 m$ ,  $e = 1.602 \times 10^{-19} C$ ,  $k = 8.988 \times 10^9$ ,  $K = 9.613 \times 10^{-13} J$ ,  $D = 1 \times 10^{-6} m$ . To get N, we can just use  $\frac{atoms}{vol} = \frac{\rho N_a}{M}$ . Then if we multiply by the height, we get the number of atoms in that resulting cut-out.

With values:  $M = 107.8682 \frac{g}{mol}$ ,  $\rho = 10.49 \times 10^6 \frac{g}{m^3}$ ,  $N_a = 6.022 \times 10^{23} \frac{atoms}{mol}$

$$N = \frac{\rho D N_a}{M} = 5.856 \times 10^{22}$$

Now, plugging in all these values into an online calculator:

$\theta = 60^\circ$ :

$$\frac{\Delta n}{\Delta t} = 460 \frac{atoms}{s}$$

$\theta = 120^\circ$ :

$$\frac{\Delta n}{\Delta t} = 52 \frac{atoms}{s}$$

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If not feasible, hand-sanitizer is  
an acceptable substitute.