PHY 1120
Exam 1
07/02/2020

Name Alex Yeoh Table #_____

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Total _____ / 100 pts

Useful Information:	$k = 9.0 \times 10^9\ N \cdot m^2/C^2$ $c = 3.0 \times 10^8\ m/s$	$\epsilon_o = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$ $G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$
	$n = nano = 10^{-9}$	$p = pico = 10^{-12}$

Tables are located at the END of the exam.

Multiple Choice: Select the BEST answer from the options provided. Clearly check or fill in the box in front of the answer you are selecting. (2 pts each)

1) What is the net charge of a Sodium (Na) atom? **Explain**

- ☐ +1
- ☒ 0 an atom is neutral, if it was charged, it would be an ion
- ☐ -1
- ☐ More information needed

2) What is magnitude and direction of the electric field caused by a +75 μC at a distance of 25 cm?

- ☐ 1.08×10^3 N/C away from the charge
- ☒ 1.08×10^7 N/C away from the charge
- ☐ 1.08×10^3 N/C towards the charge
- ☐ 1.08×10^7 N/C towards the charge

$E = k\frac{Q}{r^2} = 9 \cdot 10^9 \cdot \frac{75 \cdot 10^{-6}}{0.25^2} = 1.08 \cdot 10^7$

the source is positive

3) A glass rod is rubbed with wool and a steel rod is rubbed with hair. Both rods are then brought close to each other without touching. Which of the following is true?

- ☐ The steel rod is more positive and the rods will attract
- ☒ The steel rod is more negative and the rods will attract
- ☐ The steel rod is more positive and the rods will repel
- ☐ The steel rod is more negative and the rods will repel

glass would lose e^-

steel would gain e^-

because glass is higher and steel is lower on the triboelectric scale than their respective materials

4) Two charges q_1 = -1.33 μC and q_2 = +81.5 μC are separated by 0.27 m. Which charge is the test charge and what is the magnitude of the force on the test charge?

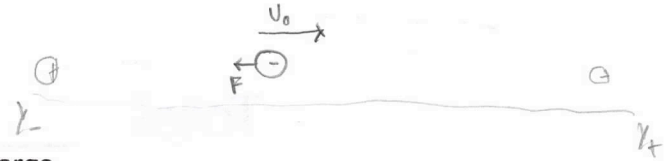
- ☒ q_1, 1.34×10^1 N
- ~~☐ q_2, 1.34×10^1 N~~
- ☐ q_1, -1.34×10^1 N
- ~~☐ q_2, -1.34×10^1 N~~

test charge is much smaller

$F = k\frac{|q_1 q_2|}{r^2} = q_{e1} \cdot \frac{81.5e^{-6} \cdot 1.33e^{-6}}{0.27^2} = 13.38$

5) An electron is traveling in the +Y direction and is slowing down. What is the direction of the E-field in this situation?

- ☒ +Y direction
- ☐ Zero
- ☐ -Y direction
- ☐ Depends on the size of the base charge



slowing down implies a force is pulling/pushing it in a -y direction. since it is negative, the E-field would be anti-parallel to the force.

Tables are located at the END of the exam.

6) A parallel plate capacitor has an electric field with a magnitude of 300,000 N/C. What is the magnitude of the potential difference if the spacing between the plates is 1.5 cm.

- [x] 4,500 V
- [ ] 200,000 V
- [ ] 450,000 V
- [ ] 20,000,000 V

$E = k\frac{q}{d^2}$

$V = K\frac{q}{d} = k\frac{q}{d^2}\cdot d = E\cdot d = 300000 \cdot 0.015 = 4500$

7) A parallel plate capacitor is made with two square plates with sides of 25.0 cm. If the plates are 0.015 m apart, what is the capacitance?

- [ ] 0.008 pF
- [ ] 0.531 pF
- [x] 36.9 pF
- [ ] 147 pF

$C = \frac{e_0 \cdot A}{d} = \frac{8.85e^{-12} \cdot 0.0625}{0.015} = 3.6875e^{-11}\,F \left| \frac{1e^{12}\,pF}{1F} \right. = 36.9\,pF$

$A = 0.25 \cdot 0.25 = 0.0625$

8) A capacitor is made with two circular plates (radius = r) that are separated by 1.00cm. If another capacitor is made with circular plates (radius = 2*r) and a separation of 2.00 cm, what is the new capacitance compared to the initial capacitance (C_o)?

- [ ] $C = 4*C_o$
- [x] $C = 2*C_o$
- [ ] $C = C_o$
- [ ] $C = (1/2)*C_o$

$C_0 = \frac{e_0 \cdot \pi r^2}{0.01}$ $\quad C = \frac{e_0 \cdot \pi (2r)^2}{0.02}$

$\frac{0.01}{e_0\pi} = \frac{r^2}{C_0}$ $\quad \frac{0.01}{e_0\pi} = \frac{4r^2}{2C}$

$\frac{r^2}{C_0} = \frac{2r^2}{C}$, $Cr^2 = 2r^2C_0$, $C = 2C_0$

9) A capacitor (C = 200 pF) has a sheet of plastic placed in between the plates. If the dielectric constant of plastic is 3.5, what is the new capacitance of the capacitor?

- [ ] 5.71 pF
- [ ] 200 pF
- [x] 700 pF
- [ ] More information required

$C = \frac{e_0 A}{d} = 200\,pF$

$C' = K \cdot \frac{e_0 A}{d} = 3.5 \cdot 200 = 700\,pF$

10) A 660 μF capacitor is charged with 330 V, how much energy is stored in that capacitor?

- [ ] 72 J
- [x] 36 J
- [ ] 0.22 J
- [ ] 0.11 J

$PE = \frac{1}{2}CV^2 = \frac{1}{2}660e^{-6} \cdot 330^2 = 35.937\,J$

Tables are located at the END of the exam.

PSP Style: Solve the problem. Make sure to show your work in **detail**. (25 pts each)

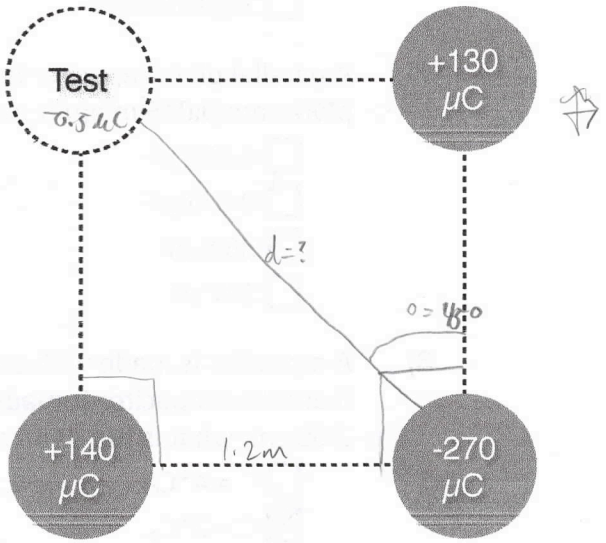
11) Three charges are located at the corners of a square with sides that are 120.0 cm as shown below. If a -0.5 μC test charge is placed at the open corner, what is the magnitude and direction of the electric field at the open corner? Determine the magnitude and direction of the Force on the test charge.

$\tan^{-1}\frac{y}{x}$

-52.2009352

1a) what is the net force and direction on the test charge? what is the net e-field and direction on the test charge?

1d) Force = ?
E-field = ?



1b)
1c)
3c)

2a) distance (to +140 μC & +130 μC) = 1.2 m
Angles = 90°, 45°
Charges = +140 μC, +130 μC, -270 μC, -0.5 μC

2b) distance to -270 μC = $\sqrt{1.2^2+1.2^2} = 1.697$ m

3a) trig (SOH-CAH-TOA)
Force calc ($k\frac{Qq}{r^2}$)
E-field calc ($k\frac{q}{r^2}$)

3b) Force calc: calculate net force
trig: calculate direction
E-field calc: calculate net E-field
trig: calculate direction

$\tan(\frac{x}{y})+90 = 37.793$
$+90$
$= 127.8$

4a) $F_{140} = 9e9\cdot\frac{.5e^{-6}\,140e^{-6}}{1.2^2} = 0.4375$ N

$F_{130} = 9e9\cdot\frac{.5e^{-6}\,130e^{-6}}{1.2^2} = 0.40625$ N

$F_{-270} = 9e9\cdot\frac{.5e^{-6}\,270e^{-6}}{1.697^2} = 0.421875$ N

$F_{-270x} = 0.421875\cos(45) = 0.29831$

$F_{-270y} = 0.421875\sin(45) = 0.29831$

$F_{Net\,x} = F_{130} - F_{-270y} = 0.1079$ N to pos x

$F_{Net\,y} = F_{140} - F = 0.1392$ N to neg y

$E_{140} = 9e9\cdot\frac{140e^{-6}}{1.2^2} = 875000\ N/C$

$E_{130} = 9e9\cdot\frac{130e^{-6}}{1.2^2} = 812500\ N/C$

$E_{-270} = 9e9\cdot\frac{270e^{-6}}{1.697^2} = 843750\ N/C$

$E_{-270x} = E_{-270}\cos(45) = 596621.3468\ N/C$

$E_{-270y} = E_{-270}\sin(45) = 596621.3468\ N/C$

$E_{net\,x} = E_{130} - E_{-270y} = 215978.6534\ N/C$ to -x

$E_{net\,y} = E_{140} - E_{-270y} = 278378.6534\ N/C$ to +y

4b) $F_{net} = \sqrt{0.1079^2+0.1392^2} = 0.176$ N

Direction $F = \tan^{-1}(\frac{y}{x}) = -52.2°$

$E_{net} = \sqrt{215978.6534^2+278378.6534^2} = 352275.8403\ N/C$

Direction = $\tan(\frac{x}{y})+90 = 37.793+90 = 127.8°$

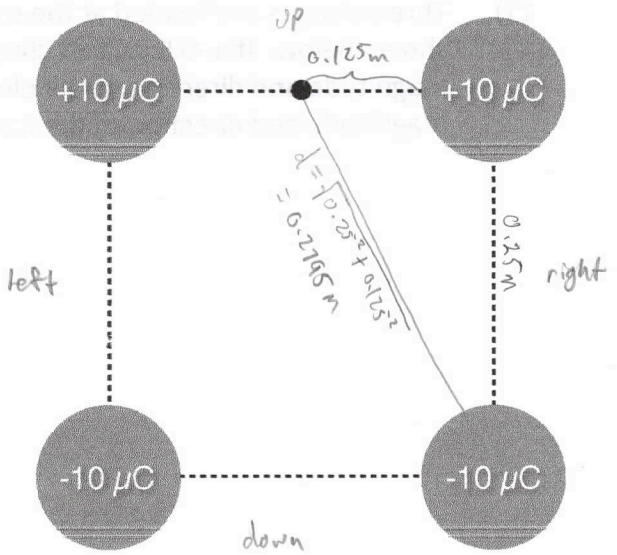
4c) J

4d) J

4e) There will be a net force of 0.176 N at -52.2° on the test charge and the net e-force would have a magnitude of 352275.8403 N/C at 127.8° on the test charge.

Tables are located at the END of the exam.

12a) Given the following charge distributions determine the potential at the CENTER of one edge of the square as shown below. Assume the square is 0.25 m on each side. (15 pts)



$V = K\frac{q}{r}$

2x +10uC charge $= 2 \cdot 9e9 \cdot \frac{10e^{-6}}{0.125} = 1440000V$

2x -10uC charges $= 2 \cdot 9e9 \cdot \frac{-10e^{-6}}{0.2795} = -643987.5775V$

Net potential $= 1440000 - 643987.5775 = 796012.4225V$

12b) If a -0.5 μC test charge is placed at the center of one edge of the square, what will be the **direction** of the force on that test charge? What will be the **direction** of the Electric Field at the center of the square. (10 pts)

The force would depend on the side, but assuming the same side as 12a)

F from both +10uC would cancel, the F_x from both -10uC would cancel (because they are both equal and in opposite directions). The remaining forces acting on the -0.5uC test charge are the F_y from both -10uC charges which would repel the test charge pushing it in the UP direction.

The x-components of both the +10uC charges and -10uC charges would cancel out (the +10uC would cancel the +10uC, similar situation for the -10uC) since positive is a source of E-fields and negative is a sink for e-fields, the e-fields would all be towards down because positive is above the test charge and negative is below the test charge.

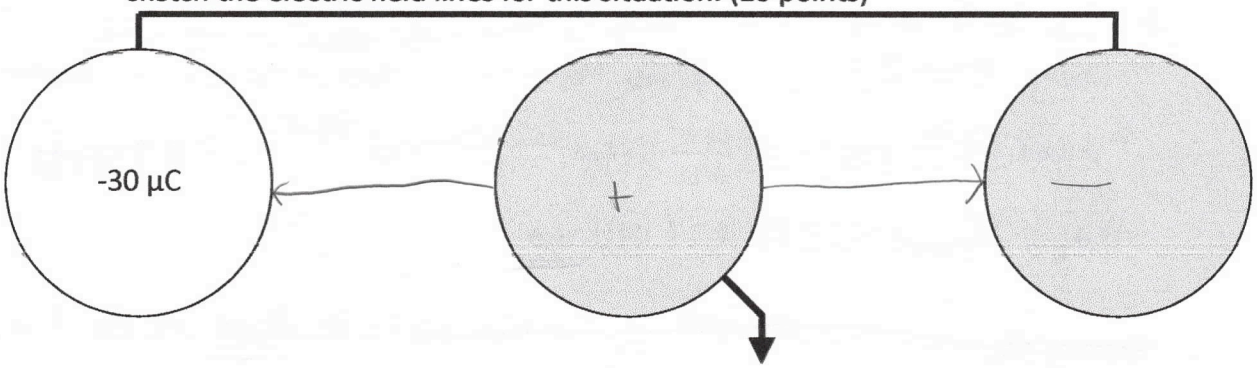
Tables are located at the END of the exam.

Complete the short-answer question below. Be aware the question may have multiple parts. You must answer all parts to receive full credit. Show all work. Partial credit may be given for partially correct or complete answers.

13) An amber comb is rubbed with silk and then brought next to a stream of water. What is the charge on the amber comb and what effect will it have on the thin steam of water when brought in close proximity?

The comb is negative. The water would bend towards the comb amber is lower on the triboelectric scale ∴ it would gain electrons. the comb would pull on the positive H+ bending the stream towards the comb.

14) Three metal shares are arranged as shown below. One spheres has a net charge of -30 μC. The other two have zero net charge. What will the charge look like on all of the spheres once the left and right spheres are connected with a conducting wire? NOTE: the center sphere is "grounded" Once you've found the induced charge, sketch the electric field lines for this situation. (10 points)



when the -30μC is connected to the neutral sphere on the far right, the charge will spread out making the far right sphere negatively charged.

Tables are located at the END of the exam. the middle sphere will have all its electrons pushed away, but because it's grounded, the earth acts as an electron sink and takes electrons away, leaving it positively charged

Positive acts as E-field source, negative acts as E-field sink.

15) As you go across the periods (rows) of the periodic table the radius of the atoms increase. Each time you add a proton in the nucleus you also add an electron in the outer shell. Using concepts from Chapter 18 explain why this is the case.

the radius actually decreases as you go across the period.

$F = \frac{qq}{r^2} \cdot k$, the force increases as the nucleus "gains" more protons making the radius smaller

Tables are located at the END of the exam.

[1]

Tend to lose electrons	(+)
	human hands (dry)
	glass
	human hair
	nylon
	cat fur
	silk
	cotton
	steel
	wood
	amber
	ebonite
	plastic wrap
Tend to gain electrons	Teflon®
	(–)

[1] https://extension.tennessee.edu/publications/Documents/W460.pdf

Tables are located at the END of the exam.