PHYS 223 University Physics III
Exam 1

January 29, 2020

Name J. C. Daly

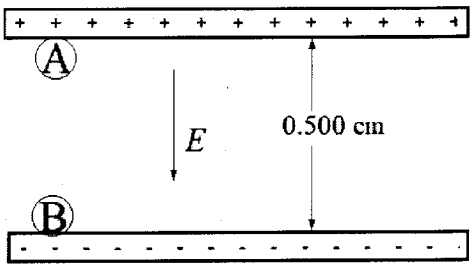

Figure 1

1. A 3.00 N/C electric field exists between two charged conducting plates as shown in Figure 1. A proton is released from rest at point A at the positive charged plate and travels 0.500 cm and strikes the negatively charged plate at point B.

   What is the speed of the proton when it strikes the negative plate? 1.69×10^3 m/s

Grades	
100	100
	96
90	89
	87
	86
80	80

$F = qE = ma$

$a = \frac{qE}{m}$

$v_f^2 - v_i^2 = 2a(x_f - x_i)$

$v^2 = 2ad = \frac{2qEd}{m}$

USING ENERGY

$KE = \frac{1}{2}mv^2 = Fd = qEd$

$v^2 = \frac{2qEd}{m}$

$v^2 = \frac{2 \times 1.6 \times 10^{-19} \times 3 \times 0.5 \times 10^{-2}}{1.673 \times 10^{-27}}$

$v^2 = 2.87 \times 10^6$

$v = 1.69 \times 10^3$ m/s

$a = \frac{qE}{m}$

$a = 2.86 \times 10^8$ m/s^2

$F = qE = 4.8 \times 10^{-19}$ N

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2. A conducting sphere of radius *a* of 5.00 cm caries a charge of Q_1 C. A concentric spherical conducting conducting shell with an inner radius *b* of 10.00 cm and an outer radius *c* of 15.00 cm carries a charge of Q_2 C.

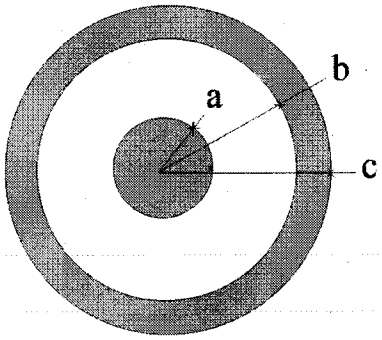

Figure 2

a = 5 cm
b = 10 cm
c = 15 cm

What is the Electric field for values of r from 0 to 20 cm?

a. r < 5 cm $Q_{enc} = 0 \therefore E = 0$

b. 5 cm < r < 10 cm $Q_{enc} = Q_1 \therefore \vec{E} = \frac{Q_1}{4\pi\epsilon_0 r^2}\hat{r}$

c. 10 cm < r < 15 cm $E = 0$ INSIDE THE CONDUCTOR

d. r > 15 cm $\vec{E} = \frac{Q_1 + Q_2}{4\pi\epsilon_0 r^2}\hat{r}$

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3. There are three charges, Q located at the origin (0,0), a second charge Q located on the y axis at y = a m, and a third charge 2Q is located on the x axis at x = a m, as shown in Figure 3.

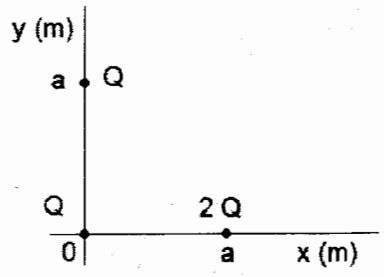


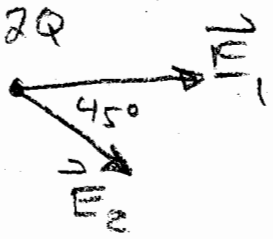
Figure 3

What is the force exerted on the charge 2Q located at x = a? _____

$$\vec{E} = \vec{E}_1 + \vec{E}_2$$

$$\vec{F} = 2Q\vec{E}$$

$$\vec{E}_1 = \frac{Q}{4\pi\epsilon_0 a^2}\hat{x}$$



$$\vec{E}_2 = \frac{Q}{4\pi\epsilon_0 2a^2}\left(\frac{\hat{x}-\hat{y}}{\sqrt{2}}\right)$$

$$\hat{r}_2 = \frac{a\hat{x}-a\hat{y}}{\sqrt{2}a}$$

$$\vec{E}_1 + \vec{E}_2 = \frac{Q}{4\pi\epsilon_0 a^2}\left[\left(1+\frac{1}{2\sqrt{2}}\right)\hat{x} - \frac{\hat{y}}{2\sqrt{2}}\right] = \frac{\hat{x}-\hat{y}}{\sqrt{2}}$$

$$\vec{F} = 2QE = \frac{2Q^2}{4\pi\epsilon_0 a^2}\left[\left(1+\frac{1}{2\sqrt{2}}\right)\hat{x} - \frac{\hat{y}}{2\sqrt{2}}\right]$$

$$= \frac{2Q^2}{4\pi\epsilon_0 a^2}\left(1.35\hat{x} - 0.353\hat{y}\right)$$

$$\vec{F} = \frac{2kQ^2}{a^2}\left(1.35\hat{x} - 0.353\hat{y}\right)$$

where $k = \frac{1}{4\pi\epsilon_0}$

Physical Constants

Constant	Symbol	Magnitude
Avogadro's Number	N_A	6.022×10^{23} molecules/mole
Boltzmann's constant	k	1.38×10^{-23} J/K = 8.62×10^{-5} eV/K
Stefan-Boltzmann constant	σ	5.67×10^{-8} J/(s*m^2*K^4)
Electronic charge	q	1.6×10^{-19} C
Electronvolt	eV	1.6×10^{-19} J
Planks constant	h	6.625×10^{-34} J-s
Thermal voltage, kT, at 300 ^oK	V_t	25.8 mV
Velocity of light	c	3×10^8 m/s
Permeability of free space	u_o	1.257×10^{-6} H/m
Permittivity of free space	ε_o	8.854×10^{-12} F/m
Electron mass	m_e	9.1×10^{-31} kg
Proton mass	m_p	1.673×10^{-27} kg

Atomic Masses

Element	Symbol	Atomic Mass	Atomic Number
Hydrogen	H	1.00794 u	1
Helium	He	4.00260 u	2
Lithium	Li	6.941 u	3
Beryllium	Be	9.0122 u	4
Boron	B	10.811 u	5
Carbon	C	12.0107 u	6
Nitrogen	N	14.0067 u	7
Oxygen	O	15.9994 u	8
Fluorine	F	18.9984 u	9
Neon	N	20.1797 u	10
Sodium	Na	22.9897 u	11
Magnesium	Mg	24.305 u	12
Aluminum	Al	26.9815 u	13
Silicon	Si	28.0855 u	14
Phosphorus	P	30.9738 u	15