STUDENT NUMBER:

NAME:

SECTION NUMBER:

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KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

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COURSE: PH102

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EXAM: PHYS102 2ND MAJOR EXAM - 011

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TEST CODE NUMBER: XXX

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INSTRUCTIONS:

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1. PRINT YOUR STUDENT NUMBER, NAME, AND SECTION NUMBER ON THE EXAM.

2. PRINT YOUR STUDENT NUMBER, SECTION NUMBER, AND YOUR NAME ON THE EXAM ANSWER FORM. PRINT THE TEST CODE NUMBER, OR CHECK IT IF IT HAS ALREADY BEEN PRINTED ON YOUR ANSWER FORM.

3. CODE YOUR STUDENT NUMBER AND SECTION NUMBER ON THE EXAM ANSWER FORM. CODE THE TEST CODE NUMBER, OR CHECK IT IF IT IS ALREADY CODED.

4. CODE YOUR ANSWERS ON THE EXAM ANSWER FORM. YOU MUST NOT GIVE MORE THAN ONE ANSWER PER QUESTION.

5. RETURN THE EXAM AND ANSWER FORM TO THE INSTRUCTOR WHEN YOU HAVE FINISHED.

****
QUESTION NO: 1
****

What is the electric potential energy of an electron at a distance r = 2.40*10**(-10) m from the nucleus of a hydrogen atom? (the nucleus consists of a single proton)

A. 6.0 eV.
B. 6.8 eV.
C. - 8.5 eV.
D. - 6.0 eV.
E. - 6.8 eV.

****
QUESTION NO: 2
****

Not required for second major 032

An electric dipole consists of charges +2e and -2e separated by 0.78*10**(-9) m. It is in an electric field of strength 3.0*10**6 N/C. Calculate the magnitude of the torque on the dipole when the dipole is perpendicular to the field. [e is the magnitude of the charge on the electron.]

A. 0 N.m.
B. 8.5*10**(-22) N.m.
C. 7.5*10**(-22) N.m.
D. 3.5*10**(-22) N.m.
E. 6.5*10**(-22) N.m.

****
QUESTION NO: 3
****

A charge of + 3.2*10**(-6) C is placed at the origin. A second charge (q2) is placed at x = 3.0 m. If a charge of 1.0*10**(-6) C experiences no force if placed at x = 4.0 m, then q2 is:

A. - 3.3*10**(-6) C.
B. - 2.1*10**(-6) C.
C. + 0.2*10**(-6) C.
D. - 0.2*10**(-6) C.
E. + 2.1*10**(-6) C.

****
QUESTION NO: 4
****

An ideal engine, whose low-temperature reservoir is at 27 degrees Celsius, has an efficiency of 20%. By how much should the temperature of the high-temperature reservoir be increased to increase the efficiency to 50%?

A. 225 K.
B. 300 K.
C. 88 K.
D. 20 K.
E. 975 K.

****
QUESTION NO: 5
****

Consider a metallic sphere carrying a charge of 4.0*10**(-8) C and having a potential of 400 V. Find the diameter of the sphere.

A. 3.6 m.
B. 6.0 m.
C. 1.2 m.
D. 4.2 m.
E. 1.8 m.

****
QUESTION NO: 6
****

Not required for second major 032

Consider the circuit shown in figure (5). If C1 = 1 micro F, C2 = 6 micro F and C3 = 3 micro F, what is the charge on C3?

A. 2 micro C.
B. 9 micro C.
C. 3 micro C.
D. 6 micro C.
E. 5 micro C.

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QUESTION NO: 7

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Calculate the electric flux (phi) through the curved surface of a cone of base radius R and height h. The electric field E is uniform and perpendicular to the base of the cone, and the field lines enter through the base. The cone has no charge enclosed inside it, as seen in figure (2).

A. Pi*(R**2)*E.
B. -2*Pi*R*E.
C. 2*Pi*R*E.
D. Pi*R*h*E.
E. -Pi*(R**2)*E.

****

QUESTION NO: 8

****

Two equal charges, each of 0.12 C, are separated by a distance of 1.8 m. What is the work done, by an external agent, to bring a charge of 0.15 C from infinity to the midpoint between the two charges?

A. 2.0*10**8 J.
B. 1.7*10**7 J.
C. 2.1*10**8 J.
D. 3.6*10**8 J.
E. 0.6*10**8 J.

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QUESTION NO: 9

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Not required for second major 032

At 20 degree C, a 100-W light bulb has a resistance of 12 ohms. To increase the resistance of the light bulb to 48 ohms, the temperature of the filament should be:
[Assume the temperature coefficient of resistivity of the filament is constant and = 0.006 (degree C)**(-1)].

A. 654 degree C.
B. 520 degree C.
C. 150 degree C.
D. 500 degree C.
E. 576 degree C.

****
QUESTION NO: 10
****

Not required for second major 032

A solid piece made of copper has the shape and dimensions shown in figure (6). Determine the resistance for the current that flows through the solid in the z-direction. (resistivity of copper = 1.69*10**(-8) ohm-meter).

A. 2.1*10**(-7) ohms.
B. 8.5*10**(-7) ohms.
C. 3.4*10**(-6) ohms.
D. 2.9*10**(-5) ohms.
E. 8.5*10**(-6) ohms.

****
QUESTION NO: 11
****

Not required for second major 032

Consider an isolated capacitor of capacitance C0 and charge Q0. Which of the following statements is true when a dielectric slab is inserted between the plates of the capacitor?

A. The charge on the capacitor does not change.
B. The potential difference across the capacitor does not change.
C. The capacitance goes to zero.
D. The capacitance of the capacitor does not change.
E. The energy stored in the capacitor does not change.

****
QUESTION NO: 12
****

Which of the following statements is WRONG:

A. Electric field lines extend away from a positive charge.
B. The magnitude of the charge on a positive ion is an integer multiple of the electron charge.
C. A shell of uniform charge density exerts a constant force on a charge inside it.
D. A shell of uniform charge density exerts a constant force on a charge outside it.
E. Electric field can exert a torque on an electric dipole.

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QUESTION NO: 13
****

A point charge of -50e lies at the center of a hollow spherical metal shell that has a net charge of -100e, as seen in figure (4). Calculate the charge on the
(a) shell's inner surface, and (b) on its outer surface.
[e is the magnitude of the charge on the electron.]

A. (a) 50e (b) -150e.
B. (a) 50e (b) -100e.
C. (a) -50e (b) -100e.
D. (a) Zero (b) -150e.
E. (a) -50e (b) 150e.

****
QUESTION NO: 14
****

An ideal monatomic gas is confined to a cylinder by a piston. The piston is slowly pushed in so that the gas temperature remains at 27 degree C. During the compression, 750 J of work is done on the gas. The change in the entropy of the gas is:

A. Zero.
B. - 3.0 J/K.
C. - 2.5 J/K.
D. 3.0 J/K.
E. 2.5 J/K.

****
QUESTION NO: 15
****

Which of the following statements are WRONG:

1. The efficiency of the ideal engine is greater than one.
2. The change in entropy is zero for reversible isothermal processes.
3. In cyclic processes, the change in entropy is zero.
4. If steam is condensed, its entropy will decrease.
5. If ice is melted, its entropy will decrease.

A. 1, 2 and 3.
B. 1, 3 and 5.
C. 2, 3 and 4.
D. 1, 2 and 5.
E. 1, 2 and 4.

****

QUESTION NO: 16

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A proton is shot out along the +x-axis from the origin with a speed of 1.0*10**6 m/s. In this region a uniform electric field of 2500 N/C exits in the negative x-direction. Find the distance traveled by the proton before it momentarily comes to rest.

A. 8.9 m.
B. 2.9 m.
C. 2.1 m.
D. 4.2 m.
E. 1.0 m.

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QUESTION NO: 17

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As shown in figure (3), a small, nonconducting ball of mass m = 1.0*10**(-6) kg and charge q = 2.0*10**(-8) C, distributed uniformly through its volume, hangs from an insulating thread that makes an angle theta = 20 degrees with a vertical, uniformly charged nonconducting sheet (shown in cross section). Considering the weight of the ball and assuming that the sheet extends far vertically and into and out of the page, calculate the surface charge density of the sheet.

A. 2.5*10**(-9) C/m**2.
B. 4.0*10**(-9) C/m**2.
C. 8.7*10**(-9) C/m**2.
D. 5.0*10**(-9) C/m**2.
E. 3.2*10**(-9) C/m**2.

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QUESTION NO: 18

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For the arrangement of charges shown in figure (1), the electric field at the point P is:

A. 1.3*k*q/(d**2) in the negative y-direction.
B. 1.3*k*q/(d**2) in the positive y-direction.
C. 2.0*k*q/(d**2) in the negative y-direction.
D. Zero.
E. 2.0*k*q/(d**2) in the positive y-direction.

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QUESTION NO: 19
****

An infinite nonconducting sheet has a surface charge density 0.10*10**(-6) C/m**2 on one side. How far apart are equipotential surfaces whose potentials differ by 90 V?

A. 1.6 cm.
B. 2.0 cm.
C. 0.88 cm.
D. 2.5 cm.
E. 1.8 cm.

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QUESTION NO: 20
****

Not required for second major 032

A 2.5 micro F capacitor, C1, is charged to a potential difference V1 = 10 V, using a 10 V battery. The battery is then removed and the capacitor is connected to an uncharged capacitor, C2, with capacitance of 10 micro F. What is the potential difference across C1 and C2, respectively?

A. 5 V, 5 V.
B. 2 V, 2 V.
C. 2 V, 8 V.
D. 1 V, 9 V.
E. 6 V, 6 V.

Physics 102
Formula Sheet for 2nd Major Exam
Second Semester 2001-2002 (Term 011)

$Q = mc\Delta T, \quad Q = mL$

$Q = nc_p\Delta T, \quad Q = nc_v\Delta T$

$W = Q_h - Q_c$

$\varepsilon = \frac{W}{Q_h} = 1 - \frac{Q_c}{Q_h}$

$K = \frac{Q_c}{W}$

$\frac{Q_c}{Q_h} = \frac{T_c}{T_h}, \quad \Delta S = \int \frac{dQ}{T}$

$F = k\frac{q_1 q_2}{r^2}, \quad \Phi = \int_{\text{Surface}} \vec{E}.d\vec{A}$

$E = \sigma/2\varepsilon_0, \quad E = \sigma/\varepsilon_0$

$E = k\frac{q}{r^2}, \quad E = k\frac{q}{R^3}r, \quad E = \frac{2k\lambda}{r}$

$U = -\vec{P}.\vec{E}$

$\vec{\tau} = \vec{P}\times\vec{E}$

$\Phi_c = \oint \vec{E}.d\vec{A} = \frac{q_{in}}{\varepsilon_0}$

$E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}$

$\Delta V = V_B - V_A = -\int_A^B \vec{E}.d\vec{S} = \frac{\Delta U}{q_0}$

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

$U = k\frac{q_1 q_2}{r_{12}}$

$C = \frac{q}{V}, \quad C = \kappa C_0$

$I = J A,$

$P = I V, \quad U = \frac{1}{2}CV^2$

$I = \frac{dq}{dt}; \; I = \frac{\Delta q}{\Delta t}$

$R = \frac{V}{I} = \rho\frac{L}{A}$

$\rho = \rho_0 [1 + \alpha(T - T_0)]$

$v = v_0 + at$

$x - x_0 = v_0 t + \frac{1}{2}a t^2$

$v^2 = v_0^2 + 2a(x - x_0)$

Constants:

Pi = π

k = 9.0×10^9 N.m^2/C^2

ε_0 = 8.85×10^{-12} C^2/N.m^2

e = -1.6×10^{-19} C

m_e = 9.11×10^{-31} kg

m_p = 1.67×10^{-27} kg

k_B = 1.38×10^{-23} J/K

N_A = 6.022×10^{23} molecules/mole

R = 8.314 J/mol. K

1 atm = 1.013×10^5 N/m^2

g = 9.8 m/s^2

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micro = 10^{-6}

nano = 10^{-9}

pico = 10^{-12}

a*b**c = ab^c

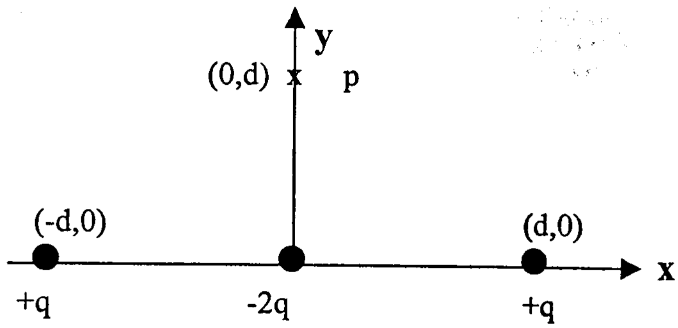


Figure 1

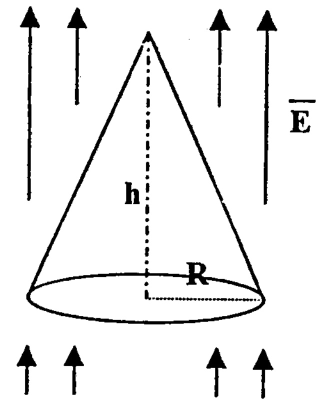


Figure 2

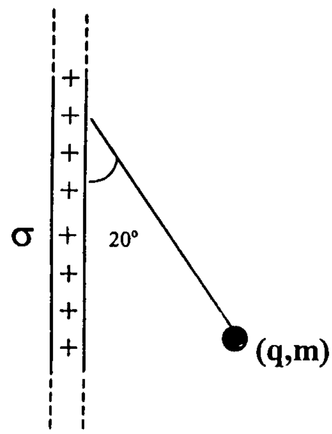


Figure 3

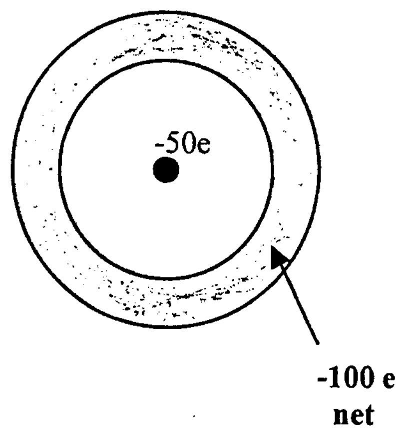


Figure 4

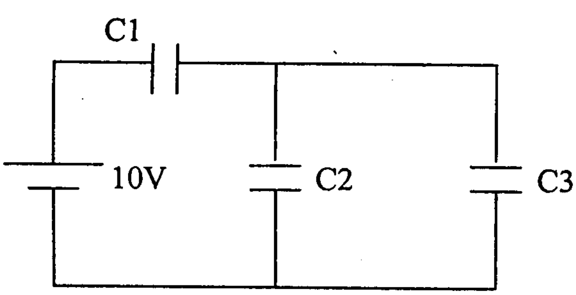


Figure 5

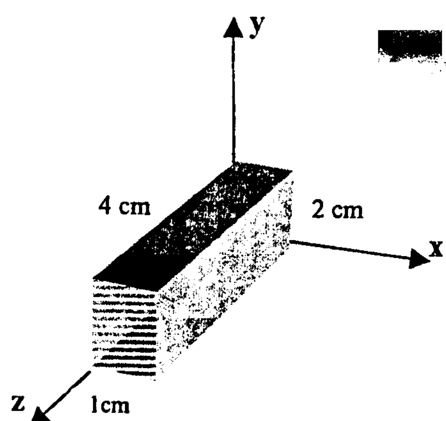
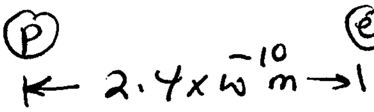


Figure 6

Apr 25, 02

Phys 102 - major 2 - 011 - p1

$q_p = 1.6\times10^{-19}C \qquad q_e = -1.6\times10^{-19}C$



Q1

$$U = k\frac{q_p q_e}{r}$$

$$= 8.99\times10^{9}\,\frac{(\cancel{1.6\times10^{-19}})(-1.6\times10^{-19})}{2.4\times10^{-10}}\left(\frac{1\,eV}{\cancel{1.6\times10^{-19}J}}\right)$$

answer is given in eV
this term convert from Joules to eV

$$= -8.99\times10^{9}\,\frac{1.6\times10^{-19}}{2.4\times10^{-10}}\,eV$$

$$= -5.99\,eV$$

Q2

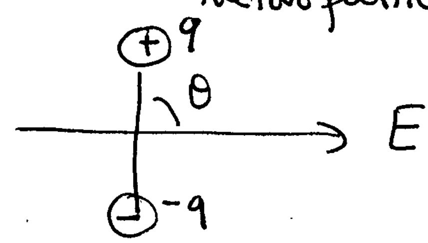
$p = qd$ ← distance between the two particles

absolute charge on one particle

$$\vec{\tau} = \vec{p}\times\vec{E}$$

$$\tau = pE\sin\theta$$

$$= qdE\sin\theta$$

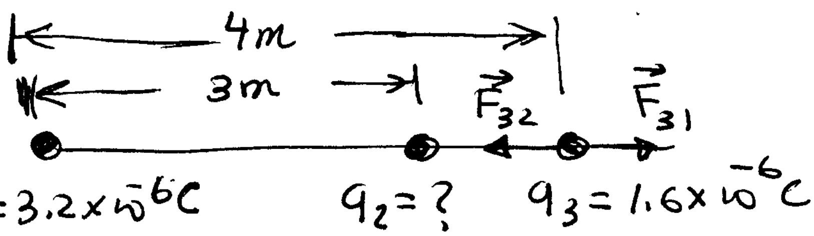


$$= 2(1.6\times10^{-19})(0.78\times10^{-9})(3\times10^{6})\sin 90^\circ$$

$$= 7.5\ N.m$$

Q3

Force on particle 3 due to charge on 1



$$F_{32} = F_{31}$$

$$\cancel{k}\frac{\cancel{|q_3|}|q_2|}{r_{32}^2} = \cancel{k}\frac{\cancel{|q_3|}|q_1|}{r_{31}^2}$$

distance between charge 3 and 1.

$$|q_2| = |q_1|\left(\frac{r_{32}}{r_{31}}\right)^2$$

$$= 3.2\times10^{-6}\left(\frac{1}{4}\right)^2 = 0.2\times10^{-6}\,C$$

$$q_2 = -0.2\times10^{-6}\,C.$$

Q4

$$\varepsilon = 1 - \frac{T_L}{T_H} \Longrightarrow T_H = \frac{T_L}{1-\varepsilon}$$

$$T_{H,old} = \frac{273+27}{1-0.2} = \frac{300}{0.8}$$

Temperature in Kelvins

$\varepsilon = 0.2$ not 20.

$$T_{H,new} = \frac{273+27}{1-0.5} = \frac{300}{0.5}$$

$$T_{H,new} - T_{H,old} = \frac{300}{0.8} - \frac{300}{0.5} = 227\ K$$

Q5

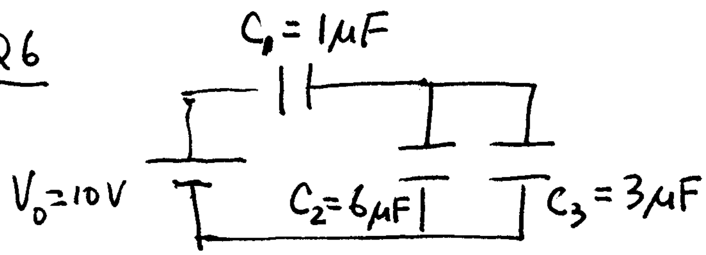
$$V = K\frac{Q}{R} \Rightarrow R = \frac{KQ}{V}$$

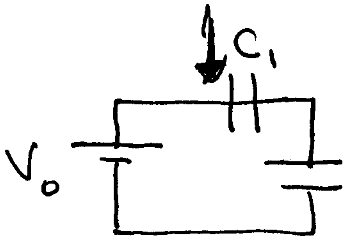
$$D = 2R = \frac{2KQ}{V} = 2\,\frac{8.99\times10^{9}(4.8\times10^{-8})}{400}$$

diameter

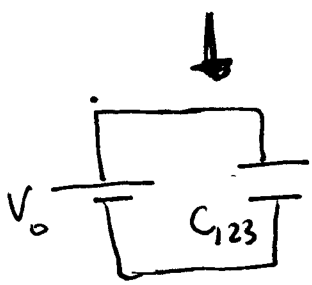
$$= 1.8\ m$$

Q6





$$C_{23} = C_2 + C_3 = 9\mu F$$



$$\frac{1}{C_{123}} = \frac{1}{C_1} + \frac{1}{C_{23}}$$

$$C_{123} = \frac{C_1 C_{23}}{C_1 + C_{23}}$$

$$C_{123} = \frac{(1)(9)}{1+9} = 0.9\mu F$$

$$Q_{123} = C_{123} V_0 = (0.9\mu)(10) = 9\mu C$$

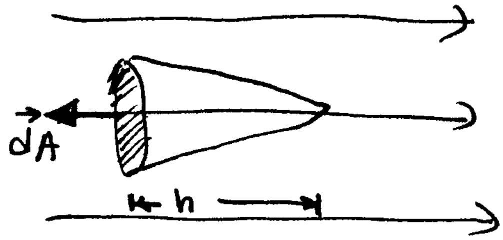
C_{123} is the equivalent of C_1 and C_{23} in series $\Rightarrow Q_{123} = Q_{23}$

$$V_{23} = \frac{Q_{23}}{C_{23}} = \frac{9\mu C}{9\mu F} = 1\ V$$

C_{23} is the equivalent of C_2 and C_3 in parallel $\Rightarrow V_3 = V_{23}$

$$Q_3 = C_3 V_3 = (3\mu F)(1\ V) = 3\mu C$$

Q7



$\phi = 0$ (Gauss' Law; not charge inside)

↑ flux through closed surface

$\phi_c + \phi_b = 0 \Longrightarrow \phi_c = -\phi_b = -\int \vec{E} \cdot d\vec{A}$

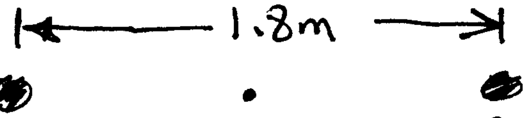
↑ flux through the cone; ↖ flux through the base

$= -EA\cos\theta$

$= -E\pi r^2 \cos 180°$

$\boxed{\phi_c = E\pi r^2}$

Q8



$W = U$

$= U_{13} + U_{23}$

$= K\frac{q_1 q_3}{R_{13}} + K\frac{q_2 q_3}{R_{23}}$ ← distance between 2 and 3

$= \frac{8.99\times10^9}{0.9}(0.15)[0.12+0.12] = 3.6\times10^8\,J$

Q9

$\rho - \rho_0 = \rho_0 \alpha (T - T_0)$ multiply this equation by $\frac{l}{A}$ to get (ignore thermal expansion, its effect is very small)

OR

$\rho\frac{l}{A} - \rho_0\frac{l}{A} = \rho_0\frac{l}{A}\alpha(T - T_0)$

$R - R_0 = R_0\alpha(T - T_0) \Rightarrow T = T_0 + \frac{R - R_0}{\alpha R_0}$

$T = 20 + \frac{48 - 12}{12(0.006)} = 520°C$

Q10 $R = \rho \frac{l}{A} = 1.69 \times 10^{-8} \frac{4 \times 10^{-2}}{(1 \times 10^{-2})(2 \times 10^{-2})}$

$= 3.4 \times 10^{-6}\ \Omega$

Q11 The charge on the capacitor does not change

Q12 A shell of uniform charge density exerts a constant force on a charge inside it

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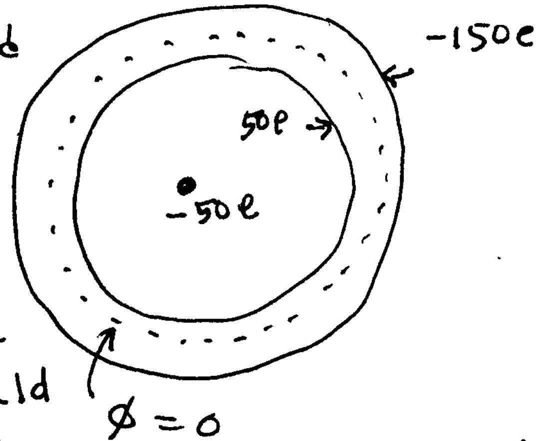
Q13 (a) 50e (b) −150e

there is no electric field inside the metal (electrostatic case).
flux through the shell shown in the figure = 0
⇒ net charge inside the shell = 0 ⇒ there should be +50e on the inner surface. Since the metall has net charge of −100e the outer surface should have −100e − 50e = −150e.



Q14 Reversible isothermal process ⇒ $\Delta S = \int \frac{dQ}{T} = \frac{Q}{T}$

$dE_{int} = dQ - dW$ ⇒ $Q = W$

dE_{int} = 0. for an ideal gas, E_{int} depends only on T. Since T does not change $dE_{int} = 0$

W: work done by the gas

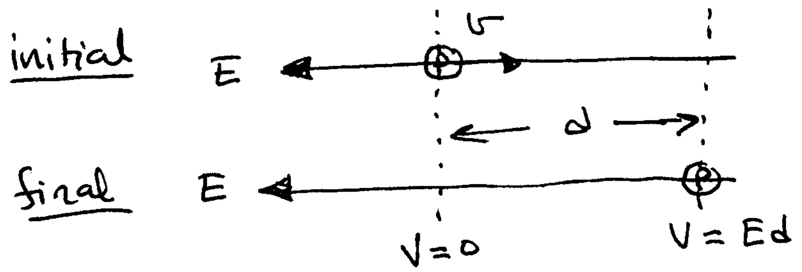
$W_{by} = -W_{on}$

W_{on}: work done on the gas

$\Delta S = -\frac{750}{27+273} = -\frac{750}{300} = -2.5\ J/K$

Q15 1, 2 and 5 are wrong

Q16



Mechanical Energy is conserved

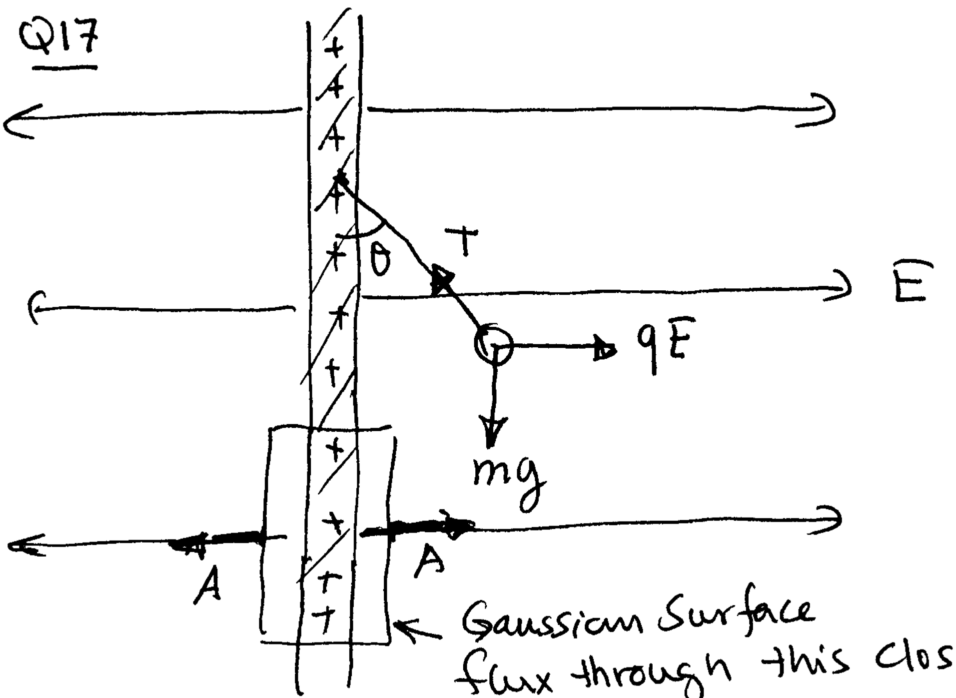
$$K_f + U_f = K_i + U_i$$

$$0 + eV = \frac{1}{2}mv^2 + 0$$

$$eEd = \frac{1}{2}mv^2 \Rightarrow d = \frac{mv^2}{2eE} = \frac{1.67\times10^{-27}(1.0\times10^{6})^2}{2(1.6\times10^{-19})(2500)}$$

$$= 2.1\ \text{m}.$$

Q17



← Gaussian Surface

flux through this closed Gaussian surface = charge inside / ε_0

$$EA + EA = \frac{Q_{in}}{\varepsilon_0} = \frac{\sigma A}{\varepsilon_0} \Rightarrow E = \frac{\sigma}{2\varepsilon_0}$$

Newton's Second law along-y : $T\cos\theta = mg$

along-x : $T\sin\theta = qE$

divide

$$\frac{\sin\theta}{\cos\theta} = \frac{qE}{mg}$$

$$\tan\theta = \frac{q\left(\frac{\sigma}{2\varepsilon_0}\right)}{mg} \Rightarrow \sigma = \frac{2mg\varepsilon_0\tan\theta}{q} = \frac{2(1.67\times10^{-31})(9.8)(8.85\times10^{-12})\tan 20}{2\times10^{-8}}$$

$$= 3.2\times10^{-9}\ \text{C/m}^2$$

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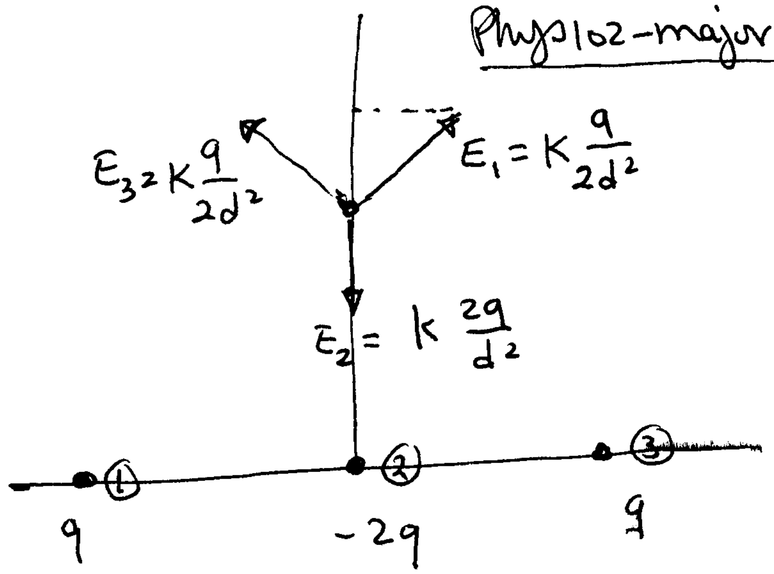
Phys102-major2-011-p6

Q18



Along y-axis $\quad E_1\cos 45 + E_3 \cos 45 - E_2$

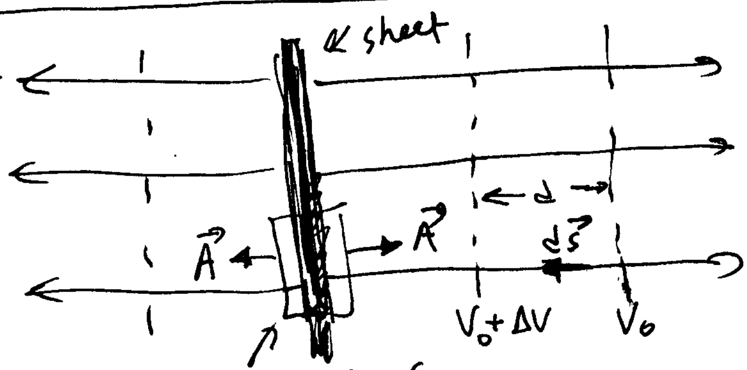
$$= K\frac{q}{2d^2}\frac{1}{\sqrt{2}} + K\frac{q}{2d^2}\frac{1}{\sqrt{2}} - K\frac{2q}{d^2}$$

$$= \left(\frac{1}{2}\frac{1}{\sqrt{2}} + \frac{1}{2\sqrt{2}} - 2\right) K\frac{q}{d^2} = -1.3\ K\frac{q}{d^2}$$

Along x-axis $\quad E_1 \sin 45 - E_2 \sin 45 = 0$

E is $1.3 \frac{Kq}{d^2}$ along negative y-axis

Q19



Gaussian Surface

$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{in}}{\varepsilon_0} \Rightarrow EA + EA = \frac{\sigma A}{\varepsilon_0}$

$\Rightarrow E = \frac{\sigma}{2\varepsilon_0}$

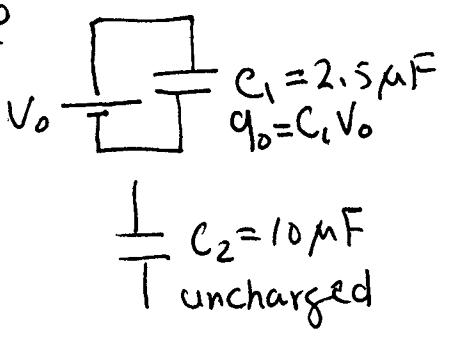
$$\Delta V = -\int \vec{E}\cdot d\vec{s}$$

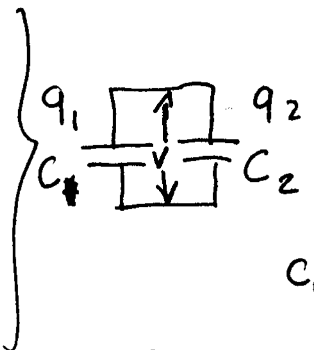
$$\Delta V = E d$$

$$\Delta V = \frac{\sigma}{2\varepsilon_0} d$$

$$d = \frac{2\varepsilon_0 \Delta V}{\sigma} = \frac{2(8.85\times 10^{-12})(90)}{0.1\times 10^{-6}} = 0.0159\ \text{m} = 1.6\ \text{cm}$$

Q20





$q_1 = C_1 V$

$q_2 = q_0 - q_1 = C_2 V$

Eliminate q_1

$q_0 - C_1 V = C_2 V$

$C_1 V_0$

$C_1 V_0 - C_1 V = C_2 V$

$V = \frac{C_1 V_0}{C_1 + C_2} = \frac{2.5}{2.5+10}\ 10 = 2\ V$ on both of them

~~on both C_1 and C_2, $V = 2$ V~~