Last Name:________________First Name_________________Network-ID__________

Discussion Section:________Discussion TA Name:_____________________________

Turn off your cell phone and put it out of sight.
Keep your calculator on your own desk. Calculators cannot be shared.
This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil. Do not use a mechanical pencil or pen. Darken each circle completely, but stay within the boundary. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner. Be especially careful that your mark covers the **center** of its circle.

2. You may find the version of **this Exam Booklet at the top of page 2**. Mark the version circle in the TEST FORM box near the middle of your answer sheet. **DO THIS NOW!**

3. Print your **NETWORK ID** in the designated spaces at the *right* side of the answer sheet, starting in the left most column, then **mark the corresponding circle** below each character. If there is a letter "o" in your NetID, be sure to mark the "o" circle and not the circle for the digit zero. If and only if there is a hyphen "-" in your NetID, mark the hyphen circle at the bottom of the column. When you have finished marking the circles corresponding to your NetID, check particularly that you have not marked two circles in any one of the columns.

4. Print **YOUR LAST NAME** in the designated spaces at the *left* side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.

5. Print your UIN# in the STUDENT NUMBER designated spaces and mark the corresponding circles. You need not write in or mark the circles in the SECTION box.

6. Sign your name **(DO NOT PRINT)** on the **STUDENT SIGNATURE** *line*.

7. On the **SECTION** *line*, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

Before starting work, check to make sure that your test booklet is complete. You should have 9 ***numbered pages*** *plus three (3) Formula Sheets following these instructions.*

Academic Integrity—**Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including dismissal from the University.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box near the middle of your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of **99** points, composed of three types of questions.

MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *three* answers, one of which is the correct answer,
you earn **2** points.
(d) If you mark no answers, or more than *three*, you earn 0 points.

MC3: *multiple-choice-three-answer questions, each worth 3 points.*
No partial credit.

(a) If you mark only one answer and it is the correct answer,
you earn **3** points.
(b) If you mark a wrong answer or no answers, you earn **0** points.

MC2: *multiple-choice-two-answer questions, each worth 2 points.*
No partial credit.

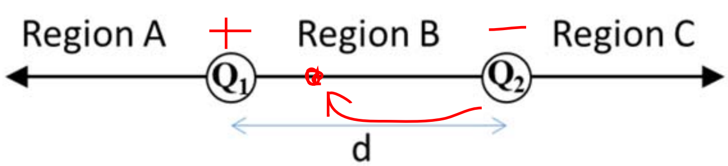
(a) If you mark only one answer and it is the correct answer,
you earn **2** points.
(b) If you mark the wrong answer or neither answer, you earn **0** points.

Some helpful information:

- A reminder about prefixes: p (pico) = 10^{-12}; n (nano) = 10^{-9}; μ (micro) = 10^{-6}; m (milli) = 10^{-3}; k (kilo) = 10^{+3}; M or Meg (mega) = 10^{+6}; G or Gig (giga) = 10^{+9}.

The next three questions pertain to the situation described below.

A positive and a negative charge have mass 0.4 kg and are fixed in position along the x-axis separated by a distance d=0.2 m as shown in below.



$Q1=8.2 \times 10^{-6}$ Coulombs
$Q2=-1.64 \times 10^{-5}$ Coulombs
d =0.2 m
m =0.4 kg

1) If charge Q2 is released from rest, how fast will it be moving when it is a distance d/4 from charge Q1?

This is an energy conservation problem.

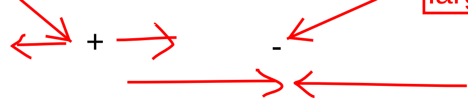
a. 11 m/s
b. 12.3 m/s
c. 5.5 m/s
d. 9.53 m/s
e. 0 m/s

Initial potential energy: U0 = kQ1Q2/d, initial kinetic energy: K0 = 0.
Final potential: U1= kQ1Q2/(d/4), K1 = mv^2/2.
The conservation of energy implies
kQ1Q2/d = mv^2/2 + 4kQ1Q2/d
so mv^2/2 = -3kQ1Q2/d -> v^2 = 2x3(9x10^9)(8.2x10^{-6})(1.64x10^{-5})/(0.2 x 0.4)
= 9077 x 10^{9-11} = (9.527)^2

2) In which region(s) is there a point on the x-axis where the electric field due to the two charges is zero?

possible 0 here.

larger |charge|



a. Region A only
b. Region A and B.
c. Region B only.

3) In which region(s) is there a point on the x-axis where the electric potential due to the two charges is zero?

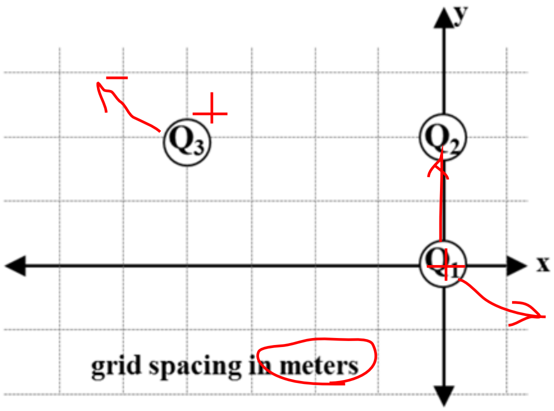
Potential is like a landscape: + makes a peak, and - a pit.

a. Region B only.
b. Region A only.
c. Regions A and B.

In the present case the pit is `much deeper', so the peak is inside the dip.
Therefore there is a zero equipotential contour around the + charge.

The next three questions pertain to the situation described below.

Three charges are fixed in position as shown in below. Note, charges Q1 and Q3 are positive, charge Q2 is negative.



$Q1 = 2.4 \times 10^{-6}$ Coulombs
$Q2 = -4.8 \times 10^{-6}$ Coulombs
$Q3 = 2.4 \times 10^{-6}$ Coulombs

Recall superposition principle.
You can consider each charge separately.

I strongly recommend you to draw forces in the figure.

4) What is the x component of the force on charge Q1 due to the other two charges?

a. $F_{1x} = -0.0236$ N
b. $F_{1x} = 0.00116$ N
c. $F_{1x} = 0.00232$ N
d. $F_{1x} = 0.00259$ N
e. $F_{1x} = -0.0259$ N

This is only due to Q3.
x comp of F13 = [kQ3Q1/(2^2 + 4^2)] x (4/¥sqrt{2^2+4^2})
= [(9x10^9)(2.4x10^{-6})(2.4x10^{-6})/20] x (2/¥sqrt{5})
= 2.318 x 10^{9-12} N

Here, Q1-Q3 in the formula are absolute values.

5) What is the y component of the force on charge Q1 due to the other two charges?

The sign is best determined by the figure.

a. $F_{1y} = 0.0233$ N
b. $F_{1y} = -0.0233$ N
c. $F_{1y} = 0.0224$ N
d. $F_{1y} = -0.0282$ N
e. $F_{1y} = 0.0248$ N

Q3 and Q2 may be considered separately.
y comp of F13 = -[kQ3Q1/20] x (2/¥sqrt{20}) = -2.318x10^{-3} x (1/2)
y comp of F12 = [kQ2Q1/2^2] = (9x10^9)(4.8x10^{-6})(2.4x10^{-6})/4
= 25.9 x 10^{9-12} = 25.9 x10^{-3}
Adding these F1y = 24.75 x 10^{-3} N

that is, when the configuration is constructed

6) How much work does the **electric field** do,when the charges are brought from infinitely far away, to their location in the figure.

I recommend you to obtain the work YOU must do (and then flip the sign).

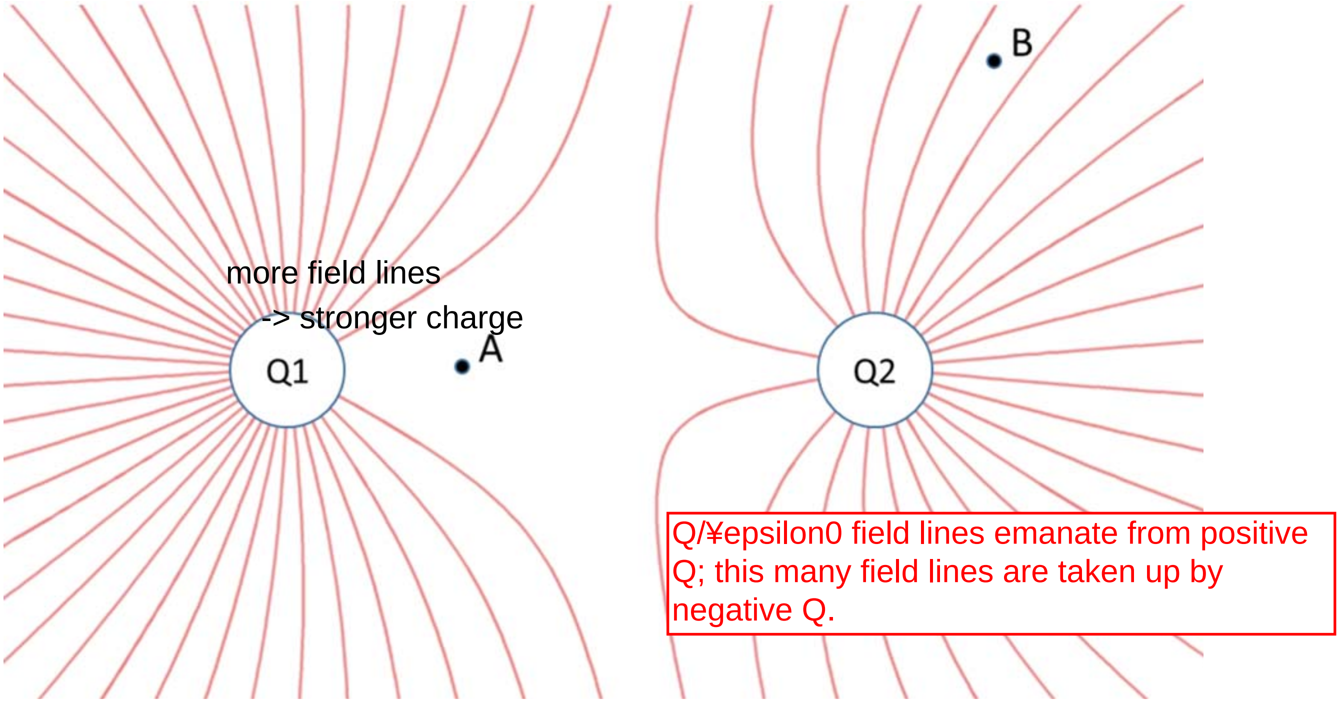
a. $W_E = -0.0143$ J
b. $W_E = -0.0662$ J
c. $W_E = 0.0662$ J
d. $W_E = 0.0143$ J
e. $W_E = 0$ J

The potential energy stored in the configuration is
kQ1Q2/2 + kQ2Q3/4 + kQ3Q1/¥sqrt{20}
= (9x10^9)(10^{-12})(-2.4x4.8/2 -4.8x2.4/4 + 2.4x2.4/¥sqrt{20})
= 9x10^{-3}(-5.76 - 2.88 +1.31) = -66 x 10^{-3} J
Thus, we must get 0.066 J by assembling the charges. That is, our work expenditure is -0.066 J. Therefore, the field does + 0.066 J (by convention).

not a good question

The next two questions pertain to the situation described below.

The figure below shows the field lines due to two unknown point charges.



Line density indicates the intensity of E

7) Compare the magnitude of the two charges.

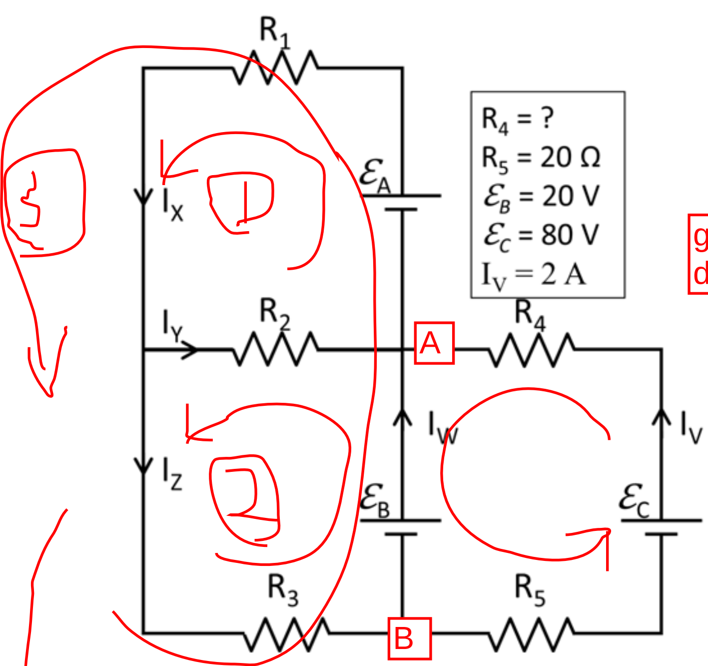
a. |Q1| < |Q2|
b. |Q1| > |Q2|
c. |Q1| = |Q2|

8) Compare the magnitude of the electric field at points **A** and **B**.

a. $|E_A| > |E_B|$
b. $|E_A| = |E_B|$
c. $|E_A| < |E_B|$

The next three questions pertain to the situation described below.

Consider the circuit shown below.



Kirchhoff's current law:
in current = out current
Kirchhoff's voltage law:
no voltage change around a loop

going down | going down | going up | going down | <- signs can be understood in this fashion.

The best method is to use the loop current approach.
If we go around the loop we come back to the same potential.

Kirchhoff's voltag law

Let us start from A along the loop:
-E_B - R5 Iv + 80 - R4 Iv = 0
or
-20 -40 + 80 -2R4 =0   20 = 2R4 -> R4 = 10 ohm.
Another approach:
60 = (R4 + R5) Iv = 2R4 + 40.

9) What is the resistance of resistor R_4?

a. $R_4 = 5\ \Omega$
b. $R_4 = 10\ \Omega$
c. There is no value of R_4 for which $I_V = 2$ A.
d. $R_4 = 20\ \Omega$
e. $R_4 = 2\ \Omega$

This is ultimately due to the conservation of charge.

10) Which of the following equations is a valid application of Kirchhoff's current law?

a. $I_x + I_y = I_z$
b. $I_z = I_w - I_v$
c. $I_y + I_w + I_v - I_x = 0$

Ix = Iy + Iz according to the figure.
At A: in Iy+Iv + Iw out Ix -> Ix = Iy + Iv + Iw
At B: Iz = Iv + Iw.

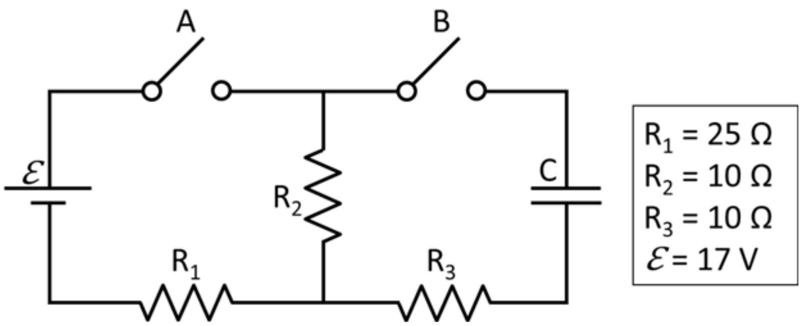
11) Which of the following equations is **NOT** a valid application of Kirchhoff's voltage law?

a. $\varepsilon_A + \varepsilon_B - I_xR_1 - I_zR_3 = 0$
b. $\varepsilon_B - I_yR_2 - I_zR_3 = 0$
c. $\varepsilon_A - I_xR_1 - I_yR_2 = 0$

For loop 1 EA - R1Ix - R2Iy = 0
For loop 2 EB + R2Iy - R3Iz = 0
For loop 3 EB + EA - R1Ix - R3Iz = 0

The next four questions pertain to the situation described below.

Consider the circuit shown below. Initially, both switches are open and the capacitor has been charged to 10 Volts.



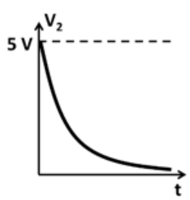
At time t=0 switch B is closed (switch A remains open).

12) What is the current through resister R_3 just after the switch B is closed?

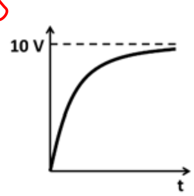
a. I_3 = 1.5 A.
b. I_3 = 0.5 A.
c. I_3 = 2.5 A.

Initially C provides 10 V across R2 + R3 = 20 omega

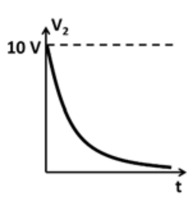
13) Which of the following plots best represents the voltage V_2 across resistor 2 starting just after switch B is closed? (Be careful image is above answer choice)



a.



b.

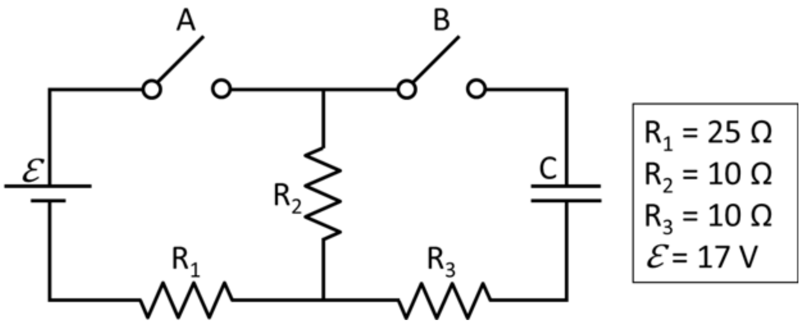


c.

Initially, 5 V across R2.
Eventually, zero V.

14) **Figure repeated from previous page**

Consider the circuit shown below. Initially, both switches are open and the capacitor has been charged to 10 Volts. At time t=0 switch B is closed (switch A remains open).



If it takes 12 μs for the charge on the capacitor to drop the 1/2 of its initial value, what is the capacitance of the capacitor C?

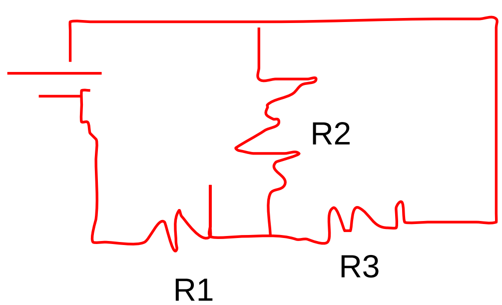
a. C = 1631 nF
b. C = 493 nF
c. C = 3370 nF
d. C = 866 nF
e. C = 215 nF

The half time is ln2 RC = 0.693 RC, where R = 20, so
12 x10^{-6} = 0.693 x 20 x C.
Therefore, C = 0.866 x 10^{-6} F

15) After a very long time, switch A is closed. Switch B remains closed. What is the magnitude of the current I_1 through resistor R_1 immediately after switch A is closed?

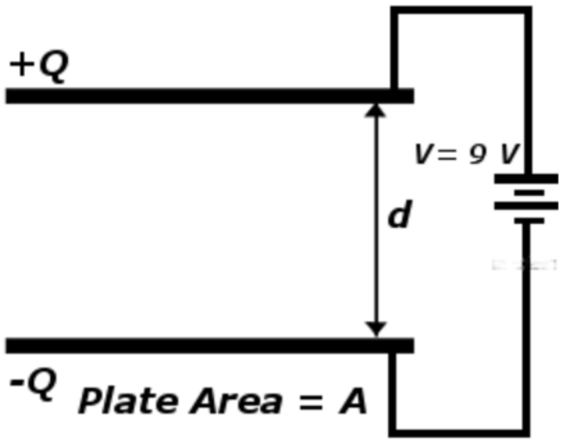
a. I_1 = 0.567 A
b. I_1 = 0.165 A
c. I_1 = 0.202 A
d. I_1 = 0.446 A
e. I_1 = 0.930 A

Immediately after t = 0, the voltage across C = 0, so the equivalent circuit looks as



The total resistance = 25 + 100/(10+10) = 30 ¥ohm. Thus, I = 17/30 = 0.567 A

The next three questions pertain to the situation described below.



This should not be read as m.m^2,

A parallel plate capacitor consists of two metal plates with an area $A = 542\ mm^2$ separated by a distance $d = 0.36\ mm$. The capacitor is connected to a 9 volt battery as shown above.

16) What is the charge Q on the capacitor?

a. $Q = 0.539\ nC$
b. $Q = 1.08\ nC$
c. $Q = 120\ nC$
d. $Q = 0.12\ nC$
e. $Q = 1.2 \times 10^{-4}\ nC$

C = ¥epsilon0 A/d
= (8.85 x 10^{-12}) (542 x 10^{-6})/(0.36 x 10^{-3})
= 13324 x 10^{-12 -6 +3} =1.33 x 10^{-11} F
Q = CV = 1.20 x 10^{-10} C

17) If the plates are pulled slightly further apart (increasing *d*) the magnitude of the *electric field* between the plates

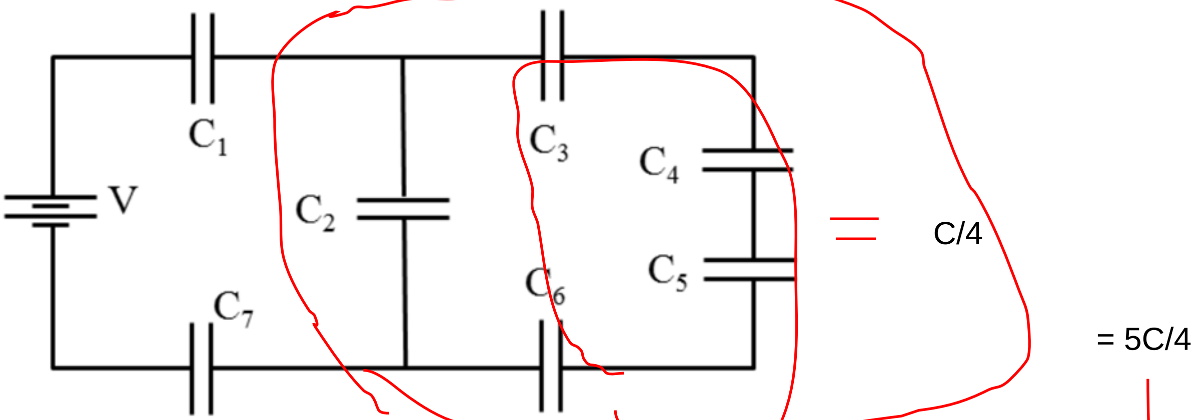
a. decreases.
b. remains the same.
c. increases.

E = V/d, V is constant, and d is increased, so E must go down.
In this case Q decreases, and Q/e_0 A =E decreases.

18) If a dielectric of dielectric strength κ is placed between the plates, how will the charge on the capacitor change?

a. *decrease by a factor of κ.*
b. *Stay the same.*
c. *Increase by a factor of κ.*

The next four questions pertain to the situation described below.



Seven identical capacitors with capacitance C = 8.5 nF are connected to a 12 Volt battery as shown in the figure above.

19) Capacitors C_3 and C_6 are connected

a. in parallel.
b. in series.
c. neither in series nor in parallel.

20) Compare the magnitude of the voltage across capacitor C_1 with the magnitude of the voltage across capacitor C_7

a. $V_1 = V_7$
b. $V_1 > V_7$
c. $V_1 < V_7$

21) What is the equivalent capacitance of the network of seven capacitors?

a. $C_{eq} = 9.92$ nF
b. $C_{eq} = 9.07$ nF
c. $C_{eq} = 23.8$ nF
d. $C_{eq} = 3.04$ nF
e. $C_{eq} = 1.21$ nF

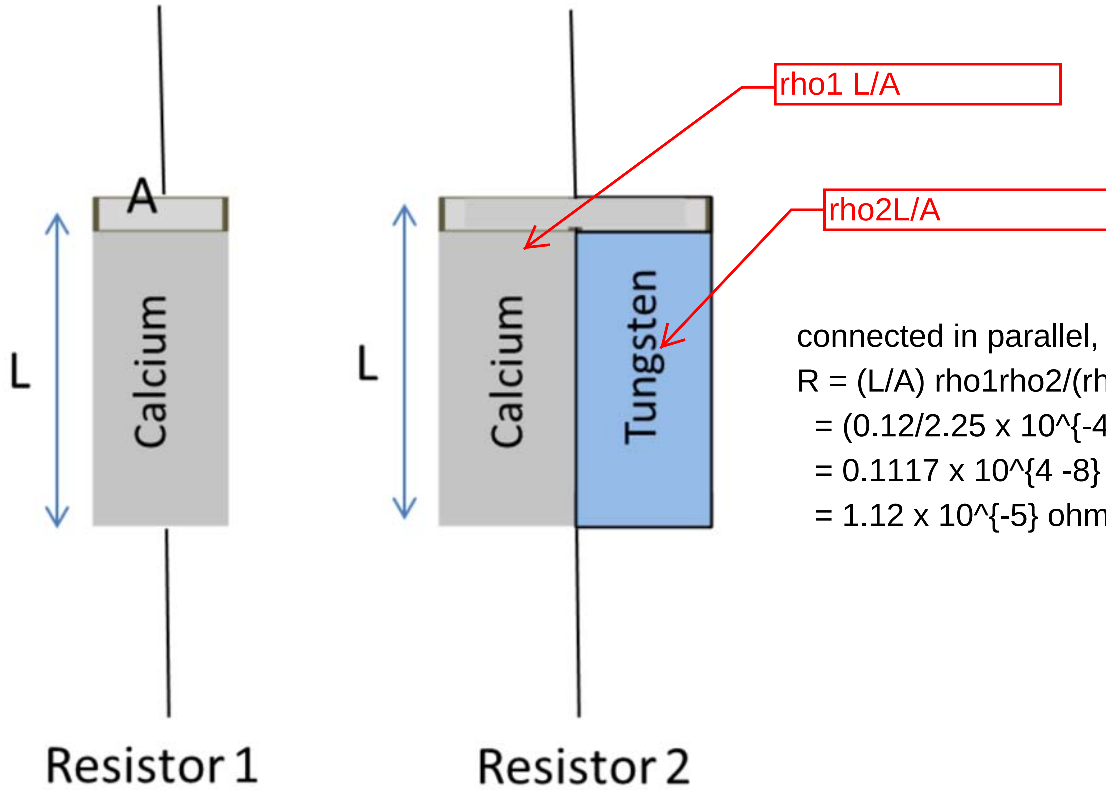
$1/(2/C + 4/5C) = 0.357C = 3.0357$ nF

22) What is the voltage across capacitor C_2?

a. $V_2 = 3.4$ Volts
b. $V_2 = 4$ Volts
c. $V_2 = 0.85$ Volts

Charges on the plates must be identical for C1, C7 and the effective capacitor C/4.
V1 C = V7C = V2(5C/4)
V1 + V2 + V7 = 12 -> (14/4) V2= 12
V2 = 3.4 V

The next two questions pertain to the situation described below.



connected in parallel, so
R = (L/A) rho1rho2/(rho1 + rho2)
= (0.12/2.25 x 10^{-4}) (5.6x3.35)10^{-8}/8.96
= 0.1117 x 10^{4 -8}
= 1.12 x 10^{-5} ohm.

A student decides to build some resistors using rectangular blocks of calcium (ρ =3.36 × 10^{-8} Ω m) and tungsten (ρ =5.6 × 10^{-8} Ω m). The dimensions of the blocks are identical with a length L = 0.12 m, and cross section A = 2.25 × 10^{-4} m^2. Resistor 1 is created from a single block of calcium. Resistor 2 is created by attaching a block of calcium to a block of tungsten as shown in the figure above.

23) Compare the resistance of the two resistors.

If you have more paths, R is smaller.

a. $R_1 = R_2$
b. $R_1 > R_2$
c. $R_1 < R_2$

24) What is the resistance of resistor 2?

a. $R_2 = 1.12 \times 10^{-5}$ Ω
b. $R_2 = 4.78 \times 10^{-5}$ Ω
c. $R_2 = 2.39 \times 10^{-5}$ Ω

Mechanics:

$x = x_0 + v_0 t + \frac{1}{2}at^2$ $v = v_0 + at$ $F = ma$ $a_c = \frac{v^2}{r}$

$E_{tot} = K.E. + P.E.$ $K.E. = \frac{1}{2}mv^2 = \frac{p^2}{2m}$ $p = mv$ $W_F = Fd\cos\theta$

Electrostatics:

$F_{12} = \frac{kq_1q_2}{r^2}$ $E \equiv \frac{F}{q_0}$ $V \equiv \frac{U}{q_0}$ Point charge: $E = \frac{kq}{r^2}$, $V = \frac{kq}{r}$

$U_{12} = \frac{kq_1q_2}{r}$ $W_E = -\Delta U = -W_{you}$

Capacitance:

$C \equiv \frac{Q}{V}$ Parallel plate capacitor: $C = \frac{\kappa\varepsilon_0 A}{d}$, $V = Ed$

$U_C = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ $C_P = C_1 + C_2 + \cdots$ $\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$

Resistance:

$R \equiv \frac{V}{I}$ $I = \frac{\Delta q}{\Delta t}$ Physical resistance: $R = \rho\frac{L}{A}$

$P = IV = I^2R = \frac{V^2}{R}$ $R_S = R_1 + R_2 + \cdots$ $\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

Circuits:

$\sum \Delta V = 0$ $\sum I_{in} = \sum I_{out}$

$q(t) = q_\infty(1 - e^{-t/\tau})$ $q(t) = q_0 e^{-t/\tau}$ $I(t) = I_0 e^{-t/\tau}$ $\tau = RC$

Magnetism:

$F = qvB\sin\theta$ $r = \frac{mv}{qB}$ $F = ILB\sin\theta$ $\tau = NIAB\sin\varphi$

$B_{wire} = \frac{\mu_0 I}{2\pi r}$ $B_{sol} = \mu_0 nI$

Induction and inductance:

$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ $\Phi = BA\cos\varphi$

$\varepsilon_{bar} = BLv$ $\varepsilon_{gen} = \varepsilon_{max}\sin\omega t = \omega NAB\sin\omega t$ $\omega = 2\pi f$

$L \equiv \frac{N\Phi}{I}$ $\varepsilon = -L\frac{\Delta I}{\Delta t}$ Solenoid inductor: $L = \mu_0 n^2 A\ell$ $U_L = \frac{1}{2}LI^2$

AC circuits and transformers:

$V_{rms} = \frac{V_{max}}{\sqrt{2}}$ $I_{rms} = \frac{I_{max}}{\sqrt{2}}$ $\frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{N_p}{N_s}$

$V_R(t) = V_{R,max}\sin(\omega t) = I_{max}R\sin(\omega t)$ $\omega = 2\pi f$

$V_C(t) = V_{C,max}\sin(\omega t - \pi/2) = I_{max}X_C\sin(\omega t - \pi/2)$ $X_C \equiv \frac{1}{\omega C}$

$V_L(t) = V_{L,max}\sin(\omega t + \pi/2) = I_{max}X_L\sin(\omega t + \pi/2)$ $X_L \equiv \omega L$

$V_{gen}(t) = V_{gen,max}\sin(\omega t + \varphi) = I_{max}Z\sin(\omega t + \varphi)$ $Z \equiv \sqrt{R^2 + (X_L - X_C)^2}$ $\tan\varphi = \frac{X_L - X_C}{R}$

$\overline{P} = I_{rms}V_{R,rms} = I_{rms}V_{gen,rms}\cos\varphi$ $f_0 = \frac{1}{2\pi\sqrt{LC}}$

Electromagnetic waves:

$\lambda = \frac{c}{f}$ $E = cB$

$u_E = \frac{1}{2}\varepsilon_0 E^2$ $u_B = \frac{1}{2\mu_0}B^2$ $\overline{u} = \frac{1}{2}\varepsilon_0 E_{rms}^2 + \frac{1}{2\mu_0}B_{rms}^2 = \varepsilon_0 E_{rms}^2 = \frac{B_{rms}^2}{\mu_0}$ $S = I = \overline{u}c$

$f' = f\left(1 \pm \frac{u}{c}\right)$ $I = I_0\cos^2\theta$

Reflection and refraction:

$\theta_r = \theta_i$ $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$ $f = \pm\frac{R}{2}$ $m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$

$n_1\sin\theta_1 = n_2\sin\theta_2$ $v = \frac{c}{n}$ $\sin\theta_c = \frac{n_2}{n_1}$ $M = \frac{\theta'}{\theta} \approx \frac{d_{near}}{f}$

Interference and diffraction:

Double slit interference: $d\sin\theta = m\lambda$ $d\sin\theta = (m + \frac{1}{2})\lambda$ $m = 0, \pm 1, \pm 2\ldots$

Single-slit diffraction: $w\sin\theta = m\lambda$ $m = \pm 1, \pm 2\ldots$

Circular aperture: $D\sin\theta \approx 1.22\lambda$

Thin film: $\delta_1 = (0 \text{ or } \frac{1}{2})$ $\delta_2 = (0 \text{ or } \frac{1}{2}) + 2t\frac{n_{film}}{\lambda_0}$ $|\delta_2 - \delta_1| = (m \text{ or } m + \frac{1}{2})$ $m = 0, 1, 2\ldots$

Quantum mechanics:

$E = hf = \frac{hc}{\lambda}$ $\lambda = \frac{h}{p}$

Blackbody radiation: $\lambda_{max}T = 2.898 \times 10^{-3}\, m \cdot K$ Photoelectric effect: $K.E. = hf - W_0$

$\Delta p_x \Delta x \geq \frac{\hbar}{2}$ $\hbar \equiv \frac{h}{2\pi}$

Bohr atom: $2\pi r_n = n\lambda$ $n = 1, 2, 3\ldots$ $L_n = mv_n r_n = n\hbar$

$$r_n = \left(\frac{\hbar^2}{mke^2}\right)\frac{n^2}{Z} \approx (5.29\times10^{-11}m)\frac{n^2}{Z}$$

$$E_n = -\left(\frac{mk^2e^4}{2\hbar^2}\right)\frac{Z^2}{n^2} \approx -(13.6\,eV)\frac{Z^2}{n^2}$$

$$\frac{1}{\lambda} \approx (1.097\times10^{7}m^{-1})Z^2\left(\frac{1}{n_f^2}-\frac{1}{n_i^2}\right)$$

Quantum atom: $L = \sqrt{\ell(\ell+1)}\hbar$ $\quad L_z = m_\ell \hbar$

Nuclear physics and radioactive decay:

$A = Z + N$ $\quad r \approx (1.2\times10^{-15}m)A^{1/3}$ $\quad E_0 = mc^2$

$\frac{\Delta N}{\Delta t} = -\lambda N$ $\quad N(t) = N_0 e^{-\lambda t} = N_0 2^{-t/T_{1/2}}$ $\quad T_{1/2} \equiv \frac{\ln 2}{\lambda} \approx \frac{0.693}{\lambda}$

Special relativity:

$\Delta t = \gamma \Delta t_0$ $\quad L = \frac{L_0}{\gamma}$ $\quad \gamma \equiv \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

Constants and unit conversions:

$g = 9.8\,m/s^2$ $\quad e = 1.60\times10^{-19}\,C$

$\varepsilon_0 = 8.85\times10^{-12}\,C^2/Nm^2$ $\quad k \equiv \frac{1}{4\pi\varepsilon_0} = 8.99\times10^{9}\,Nm^2/C^2$ $\quad \mu_0 = 4\pi\times10^{-7}\,T\cdot m/A$

$c = \frac{1}{\sqrt{\varepsilon_0\mu_0}} = 3\times10^{8}\,m/s$ $\quad h = 6.626\times10^{-34}\,J\cdot s$ $\quad hc = 1240\,nm\cdot eV$

$1\,eV = 1.60\times10^{-19}\,J$ $\quad m_{proton} = 1.67\times10^{-27}\,kg = 938\,MeV$ $\quad m_{electron} = 9.11\times10^{-31}\,kg = 511\,keV$

SI Prefixes

Power	**Prefix**	**Symbol**
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{0}	—	—
10^{-3}	milli	m
10^{-6}	micro	µ
10^{-9}	nano	n
10^{-12}	pico	p

Physics 102 Exam 1 --
Spring 2014

1. d
2. a
3. c
4. c
5. e
6. c
7. b
8. c
9. b
10. c
11. b
12. b
13. a
14. d
15. a
16. cd
17. a
18. c
19. b
20. a
21. d
22. a
23. b
24. a