Physics 2306 Exam 2 (Arsenault) Spring 2006

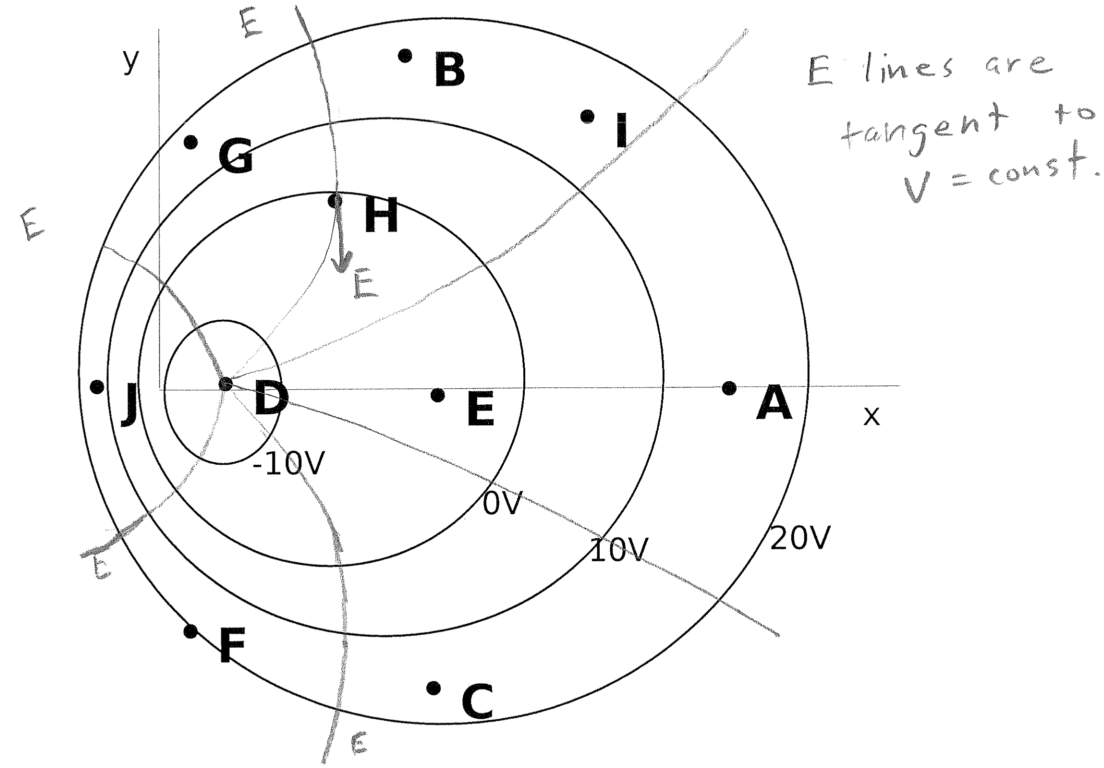
Name KEY **Student ID** ________________

Check your (CRN) section number (- 2 points if not checked):

	14291	**8:00 – 8:50**
	14288	**9:05 – 9:55**
	14296	**10:10 – 11:00**
	14295	**11:15 – 12:05**

Students may also use their own two sided 8.5″ x 11″ formula sheet in addition to the formula sheet that is on the last page of this.

For problems 1-4. The figure below shows equipotential lines with the corresponding potentials labeled (-10V to 20V). The corresponding electric field vectors lie in the plane of the paper. You are to assume that the potential is varying smoothly in the x-y plane.



1. Out of all the labeled points, which point has the electric field with the largest magnitude.

1	A	6	F
2	B	7	G
3	C	8	H
4	D	9	I
5	E	10	J

$\frac{\Delta V}{\Delta x}$ is large

2. Out of all the labeled points, which point has the electric field with the smallest magnitude.

1	A	6	F
2	B	7	G
3	C	8	H
4	D	9	I
5	E	10	J

D is at a minimum $\frac{\Delta V}{\Delta x} = \frac{\Delta V}{\Delta y} = 0$

3. If the equipotential lines with potentials 10V and 20V intersect the positive x-axis at positions that are 25mm apart, what is the magnitude of the electric field at the point labeled **A**?

$$E_x \cong -\frac{\Delta V}{\Delta x} = -\frac{10\,V}{25\,mm} = -\frac{10\,V}{.25 \times 10^{-1}\,m}$$

$$= -\frac{(40\,V)(10)}{m} = -400\,\frac{V}{m}$$

$$E_y = -\frac{\Delta V}{\Delta y} = 0 \qquad |\vec{E}| = |E_x| = \boxed{400\,\frac{V}{m}}$$

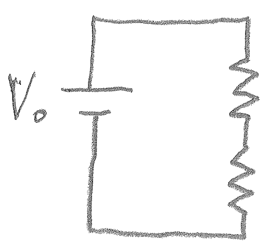
1	0.25 V/m	6	25 V/m
2	0.4 V/m	7	40 V/m
3	2.5 V/m	8	250 V/m
4	4 V/m	9	400 V/m
5	20 V/m	10	2000 V/m

4. What is the direction of the electric field at the point labeled **H**?

$-\hat{j}$

1	x direction	6	45° up from -x
2	-x direction	7	out of the paper
3	y direction	8	into the paper
4	-y direction	9	cannot be determined
5	45° up from +x	10	45° down from +x

5. A copper and an iron wire with the same length, L/2, and cross-sectional area, A, are joined in series to form one long wire of total length L. The resistivity of the copper is 1.6×10^{-8} Ωm, and the resistivity of the iron is 9.6×10^{-8} Ωm. If the potential difference of $V_0 = 2.8$V is imposed across the opposite ends, then the potential difference between the ends of the copper is:



$$R_{Fe} = \rho_{Fe}\frac{L}{A}$$

$$R_{cu} = \rho_{cu}\frac{L}{A}$$

$$V_{cu} = I R_{cu} = \left(\frac{V_0}{R_{Fe} + R_{cu}}\right) R_{cu}$$

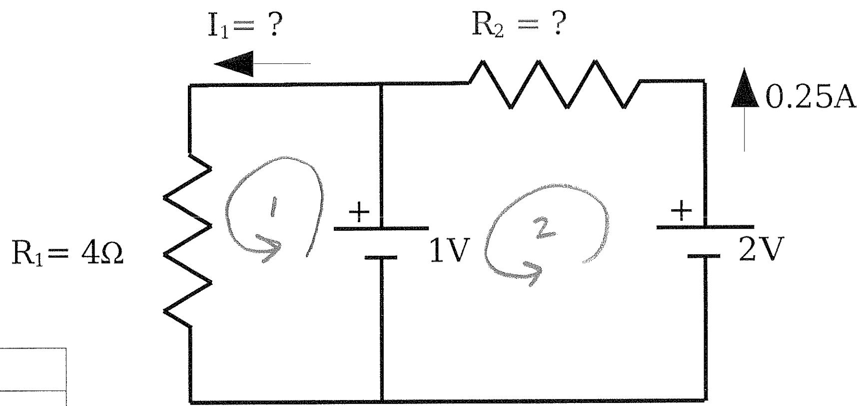
$$= V_0 \frac{R_{cu}}{R_{Fe} + R_{cu}} = V_0 \frac{\rho_{cu}}{\rho_{Fe} + \rho_{cu}}$$

$$= (2.8\,V)\frac{1.6 \times 10^{-8}\,\Omega m}{9.6 \times 10^{-8}\,\Omega m + 1.6 \times 10^{-8}\,\Omega m}$$

$$= 0.4\,V$$

1	0.2 V	6	1 V
2	0.4 V	7	1.2 V
3	0.6 V	8	1.4 V
4	0.65 V	9	2 V
5	0.7 V	10	2.8 V

6,7 Consider the following circuit.



6. Find I_1:

1	0.02 A	6	-0.02 A
2	0.05 A	7	-0.05 A
3	0.25 A	8	-0.25 A
4	0.5 A	9	-0.5 A
5	4 A	10	-4 A

KVL ① ⇒ $1V - I_1 R_1 = 0$

$\Rightarrow I_1 = \frac{1V}{R_1} = \frac{1V}{4\Omega} = 0.25A$

7. Find R_2:

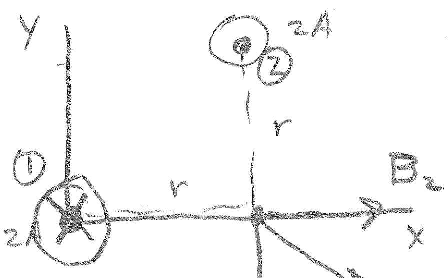
1	0.4 Ω	6	5 Ω
2	1 Ω	7	20 Ω
3	2 Ω	8	100 Ω
4	3 Ω	9	200 Ω
5	4 Ω	10	400 Ω

KVL ② ⇒ $2V - (0.25A)R_2 - 1V = 0$

$\Rightarrow (0.25A) R_2 = 1V$

$\Rightarrow R_2 = \frac{1V}{0.25A} = 4\Omega$

8. A steady current, of 2 amps, flows through a long wire in the z-direction at the x-y position x= 10 cm, y= 10 cm (10 cm, 10 cm). Another steady current, of 2 amps, flows through a long wire in the negative z-direction at the x-y position x= 0 cm, y= 0 cm (0,0). What is the magnitude of the magnetic field from these two currents at position x= 10 cm, y= 0 cm (10 cm, 0)? $\mu_0 = 4\pi \times 10^{-7}$ T m/A



$|B_1| = |B_2|$

1	0	6	1.4 x 10^5 T
2	2 x 10^{-6} T	7	1.77 x 10^5 T
3	4 x 10^{-6} T	8	2.3 x 10^5 T
4	5.66x 10^{-6} T	9	2 x 10^5 T
5	7.3 x 10^{-6} T	10	2 x 10^7 T

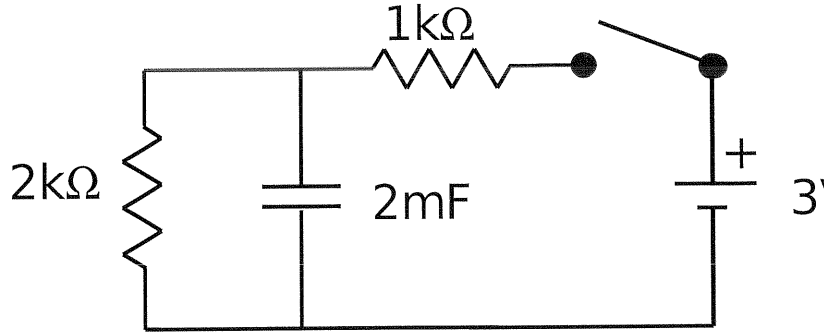
$B_{net} = \sqrt{2} B_1$

$B_1 = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \frac{Tm}{A} (2A)}{2\pi (0.10m)}$

$= 4 \times 10^{-6} T$

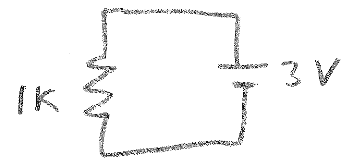
$B_{net} = \sqrt{2}\, 4 \times 10^{-6} T \simeq 5.656 \times 10^{-6} T$

9,10



9. The 2mF capacitor has no charge on it before the switch is closed. What is the current through the 1kΩ resistor at the instant the switch is closed?

Acts like this

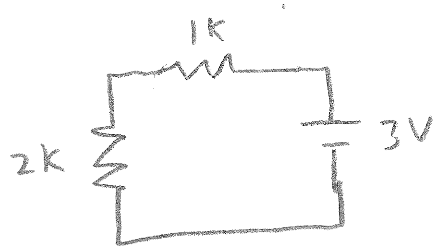


$I = \frac{3V}{1k\Omega} = 3mA$

1	1 mA	6	3 mA
2	10 mA	7	30 mA
3	1 A	8	3 A
4	10 A	9	30 A
5	1 kA	10	3 kA

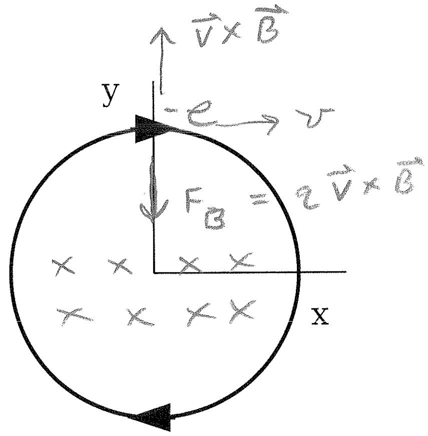
10. What is the current through the 1kΩ resistor a long time after the switch is thrown?

Acts like



$I = \frac{3V}{3k\Omega} = 1mA$

1	1 mA	6	3 mA
2	10 mA	7	30 mA
3	1 A	8	3 A
4	10 A	9	30 A
5	1 kA	10	3 kA



11,12. An electron has a speed of 1.4×10^{6} m/s, interacting with a uniform magnetic field, moves in a circular orbit with a diameter of 10 cm, as shown above. The z-direction is out of the paper.
$m_e = 9.11 \times 10^{-31}$ kg $e = 1.6 \times 10^{-19}$ C

11. What is the direction of the uniform magnetic field?

1	x direction	6	-z direction
2	y direction	7	
3	-x direction	8	
4	-y direction	9	
5	z direction	10	

12. What is the magnitude of this uniform magnetic field?

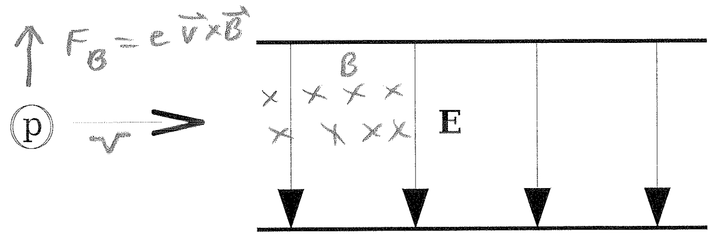
$$F = m_e \frac{v^2}{r} = evB \Rightarrow m_e v = eBr$$

$$\Rightarrow B = \frac{m_e v}{re} = \frac{9.11 \times 10^{-31}\,\text{kg}\,(1.4 \times 10^{6}\,\text{m/s})}{(.05\,\text{m})\ 1.6 \times 10^{-19}\,\text{C}}$$

$$\simeq 1.59425 \times 10^{-4}\,\text{T}$$

1	8×10^{-5} T	6	0
2	1.6×10^{-4} T	7	3.0×10^{-5} T
3	8×10^{-3} T	8	2.0×10^{-5} T
4	8×10^{-2} T	9	3140 T
5	0.8 T	10	6270 T

13.



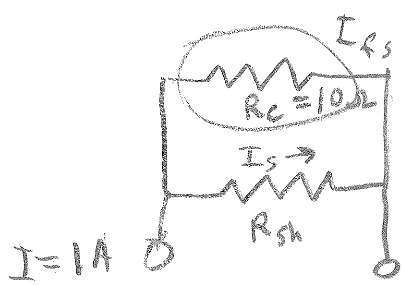
A proton is moving to the right at a speed of 5 x 10^5 m/s. An electric field, **E**, is directed down and has a magnitude of 10^6 V/m. The magnitude and direction of a the magnetic field that will allow the proton to pass through the field region without deflection is:

$F_E = F_B \Rightarrow eE = evB \Rightarrow B = \frac{E}{v} = \frac{10^6 \frac{V}{m}}{5\times10^5 \frac{m}{s}} = \frac{10}{5}\frac{Vs}{m^2}$

$= 2\ T$

1	0.5 T into the paper	6	2 T into the paper
2	0.5 T out of the paper	7	2 T out of the paper
3	0.5 T upward	8	2 T upward
4	0.5 T down	9	2 T down
5	0.2 T out of the paper	10	3 T upward

14. The resistance of a galvanometer coil is 10Ω, and the current required for full-scale deflection is 0.05A. What shunt resistor can we use to make this into an ammeter that can measure 1A with a full scale deflection?



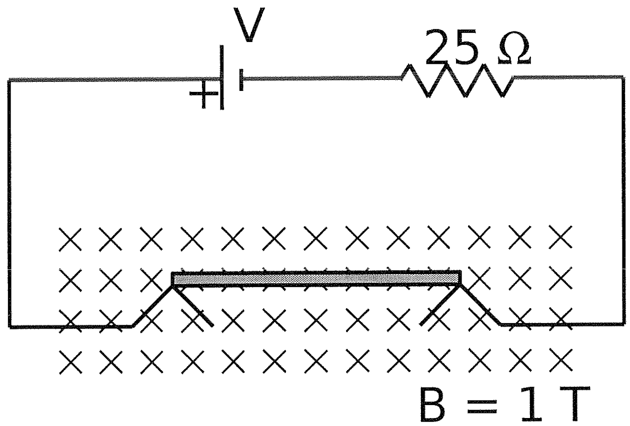
$I_s = 1A - 0.05A = .95A$

$R_{sh} = \frac{V_s}{I_s} = \frac{(10\Omega)(0.05A)}{.95A}$

$= \frac{50}{95}\Omega \simeq 0.526316\Omega$

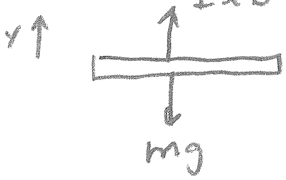
1	0.1 Ω	6	0.83 Ω
2	0.5 Ω	7	0.95 Ω
3	0.53 Ω	8	1 Ω
4	0.62 Ω	9	20 Ω
5	0.72 Ω	10	100 Ω

15.



A thin, 50 cm long conducting bar with mass 750g rests on two conducting supports in a uniform 1Tesla magnetic field, as shown above. A battery and a 25Ω resistor are in series with the supports. The conducting bar completes the circuit, so long as it touches the two conducting supports.
What is the largest voltage that the battery can have without having the conducting bar lift off its contacts?

1	3.68 V	6	100 V
2	37.5 V	7	184 V
3	46 V	8	368 V
4	75 V	9	817 V
5	92 V	10	1470 V



$\Sigma F_y = 0 = I\ell B - mg$

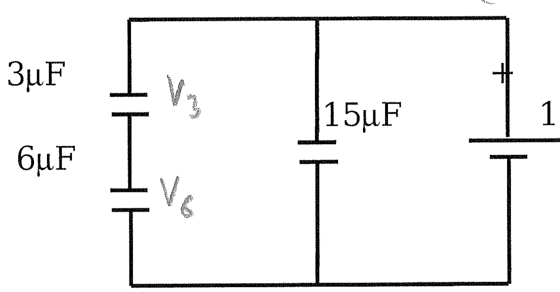
$\Rightarrow I\ell B = mg \qquad I = \frac{V}{R}$

$\Rightarrow \left(\frac{V}{R}\right)\ell B = mg \Rightarrow V = \frac{Rmg}{\ell B}$

$= \frac{25\Omega(.75\,kg)(9.8\,m/s^2)}{(.5\,m)\,1\,T}$

$= 367.5\,V$

16.



The circuit shown is in steady state. What is the voltage across the 6μF capacitor?

$C = \frac{Q}{V} \qquad C_{eq} = \frac{3(6)\,\mu F}{3+6} = 2\,\mu F$

$Q = (2\,\mu F)(12\,V)$

$V_6 = \frac{Q}{C} = \frac{(2\,\mu F)(12\,V)}{6\,\mu F} = 4\,V$

1	0	6	6 V
2	2 V	7	8 V
3	3 V	8	9 V
4	4 V	9	12 V
5	5 V	10	15 V

17-19 A parallel plate capacitor (with no dielectric) is charged to $V_1=12$ volts and has a charge of 3 nC (3×10^{-9} C) on it.

17. What is the capacitance, C, of this capacitor?

$$C = \frac{Q}{V} = \frac{3\times10^{-9}\,C}{12\,V} = 0.25\times10^{-9}\,\frac{C}{V}$$

$$= 2.5\times10^{-10}\,F$$

1	1×10^{-10} F	6	1×10^{-8} F
2	2.5×10^{-10} F	7	2.5×10^{-8} F
3	1×10^{-9} F	8	3.6×10^{-8} F
4	2.5×10^{-9} F	9	4.0×10^{-8} F
5	3.6×10^{-9} F	10	6×10^{-8} F

18. With no source attached the plates of the capacitor are changed to twice their original separation. In this process no charge is transfered to or from the capacitor. What is the potential, V_2, on the capacitor after this is done?

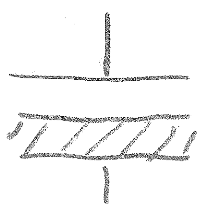
$$C = \epsilon_0 \frac{A}{d} \Rightarrow C \propto \frac{1}{d} \qquad V = \frac{Q}{C}$$

$$\frac{V_2}{V_1} = \frac{Q}{C_2}\left(\frac{C_1}{Q}\right) = \frac{C_1}{C_2} = \frac{d_2}{d_1}$$

$$\Rightarrow V_2 = V_1 \frac{d_2}{d_1} = (12\,V)\,2 = 24\,V$$

1	0	6	8 V
2	1 V	7	12 V
3	2 V	8	18 V
4	3 V	9	24 V
5	4 V	10	48 V

19. A mica dielectric, with K=5, is inserted between the plates of the capacitor. This dielectric only fills half of the space of the gap of the capacitor and has the same surface area as the parallel plates. What is the potential, V_3, on the capacitor now?



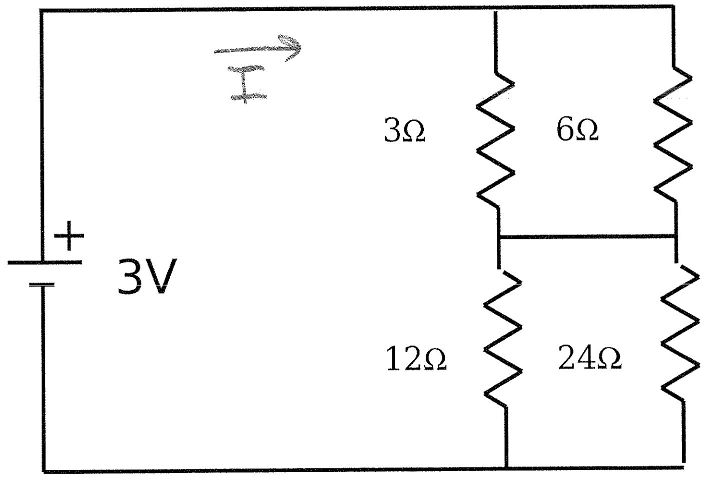
$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2} = \frac{C_1 (5C_1)}{C_1 + (5C_1)} = C_1 \frac{5}{6}$$

$$V = \frac{Q}{C} = \frac{Q}{C_1 \frac{5}{6}} = \frac{Q}{\left(\frac{Q}{V}\right)\frac{5}{6}} = V\,\frac{6}{5}$$

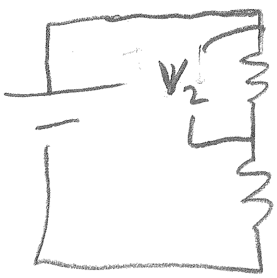
$$= (12\,V)\left(\frac{6}{5}\right) = 14.4\,V$$

1	0	6	24 V
2	1.2 V	7	36 V
3	10 V	8	40 V
4	12 V	9	72 V
5	14.4 V	10	120 V

20.



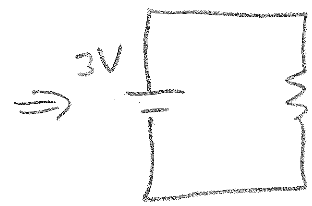
Find the current that is going through the 3Ω resistor.



$R_{eq_1} = \frac{3 \cdot 6}{3+6}\,\Omega = 2\Omega$

$R_{eq_2} = \frac{12(24)}{12+24}\,\Omega = 8\Omega$

$\Rightarrow$



$R_{eq_T} = 2\Omega + 8\Omega = 10\Omega$

$I = \frac{3V}{10\Omega} = 0.3\ A$

$V_2 = I(2\Omega) = 0.3A(2\Omega) = 0.6\ V$

$I_{3\Omega} = \frac{V_2}{3\Omega} = \frac{0.6V}{3\Omega} = \boxed{0.2\ A}$

1	0	6	6 A
2	0.2 A	7	7.2A
3	0.33 A	8	10 A
4	0.6 A	9	20 A
5	5 A	10	24 A

Forula Sheet

Chapter 15

$v = f\lambda$ $\quad k = \frac{2\pi}{\lambda}$ $\quad \omega = 2\pi f = \frac{2\pi}{T}$ $\quad \frac{\partial^2 y(x,t)}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y(x,t)}{\partial t^2}$

$\frac{\partial y(x,t)}{\partial t} = \mp v \frac{\partial y(x,t)}{\partial x}$ $\quad v = \sqrt{\frac{F}{\mu}}$ $\quad \text{Power} = F_y(x,t)v_y(x,t)$ $\quad P_{\text{av}} = \frac{1}{2}\sqrt{\mu F}\omega^2 A^2$

$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$ $\quad y(x,t) = A_{\text{sw}}\sin(kx)\cos(\omega t)$

Chapter 16

$p(x,t) = -B\frac{\partial y(x,t)}{\partial x}$ $\quad p_{\max} = BkA$ $\quad v = \sqrt{\frac{B}{\rho}}$ $\quad v = \sqrt{\frac{\gamma RT}{M}}$

$T_{\text{kelvin}} = T_C + 273.15$ $\quad v = \sqrt{\frac{Y}{\rho}}$ $\quad I = \langle p(x,t)v_y(x,t)\rangle_t$ $\quad I = \frac{1}{2}\sqrt{\rho B}\omega^2 A^2$

$\beta = (10\text{dB})\log\frac{I}{I_0}$ $\quad I_0 = 10^{-12}\frac{W}{m^2}$ $\quad f_{\text{beat}} = f_a - f_b$ $\quad f_L = \frac{v+v_L}{v+v_S}f_S$

Chapter 21

$F = k\frac{|q_1q_2|}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{|q_1q_2|}{r^2}$ $\quad \epsilon_0 = 8.85\times10^{-12}\frac{\text{C}^2}{\text{Nm}^2}$ $\quad k = 8.988\times10^9\frac{\text{Nm}^2}{\text{C}^2}$ $\quad \vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$

$p = dq$ $\quad \vec{\tau} = \vec{p}\times\vec{E}$ $\quad U = -\vec{p}\cdot\vec{E}$

Chapter 22

$\Phi_E \equiv \int \vec{E}\cdot \mathrm{d}\vec{A}$ $\quad \oint \vec{E}\cdot\mathrm{d}\vec{A} = \frac{Q_{\text{encl}}}{\epsilon_0}$

Chapter 23

$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$ $\quad -\Delta V = V_a - V_b = \int_a^b \vec{E}\cdot\mathrm{d}\vec{l}$ $\quad \vec{E} = -\left(\hat{\imath}\frac{\partial V}{\partial x} + \hat{\jmath}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$

Chapter 24

$C = \frac{Q}{V_{ab}}$ $\quad \frac{1}{C_{\text{series}}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$ $\quad C_{\text{parallel}} = C_1 + C_2 + C_3 + \ldots$ $\quad U = \frac{1}{2}CV^2 = \frac{1}{2}QV$

$u = \frac{1}{2}\epsilon_0 E^2$ $\quad C = KC_0$ $\quad u = \frac{1}{2}K\epsilon_0E^2$ $\quad \oint K\vec{E}\cdot\mathrm{d}\vec{A} = \frac{Q_{\text{encl-free}}}{\epsilon_0}$

Chapter 25

$I = \frac{\mathrm{d}Q}{\mathrm{d}t} = n|q|v_{\mathrm{d}}A$ $\quad \vec{J} = nq\vec{v}_{\mathrm{d}}$ $\quad \rho = \frac{E}{J}$ $\quad \rho(T) = \rho_0\left[1 + \alpha(T - T_0)\right]$

$V = IR$ $\quad R = \frac{\rho L}{A}$ $\quad V_{ab} = \mathcal{E} - Ir$ $\quad P = V_{ab}I$

$P_{\text{resistor}} = V_{ab}I = I^2R$

Chapter 26

$R_{\text{eq}} = R_1 + R_2 + R_3 + \ldots$ $\quad \frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$ $\quad \text{KCR } \sum I = 0$ $\quad \text{KVR } \sum V = 0$

$V_C = \frac{q}{C}$ $\quad q_C(t) = C\mathcal{E}\left(1 - e^{-t/RC}\right)$ $\quad i = \frac{\mathrm{d}q}{\mathrm{d}t}$

Chapter 27

$\vec{F} = q\vec{v}\times\vec{B}$ $\quad \Phi_B = \int\vec{B}\cdot\mathrm{d}\vec{A}$ $\quad \oint\vec{B}\cdot\mathrm{d}\vec{A} = 0$ $\quad R = \frac{mv}{|q|B}$ $\quad \vec{F} = I\vec{l}\times\vec{B}$

$\mathrm{d}\vec{F} = I\mathrm{d}\vec{l}\times\vec{B}$ $\quad \mu = IA$ $\quad \vec{\tau} = \vec{\mu}\times\vec{B}$ $\quad U = -\vec{\mu}\cdot\vec{B}$

Chapter 28

$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$ $\quad \mathrm{d}\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,\mathrm{d}\vec{l}\times\hat{r}}{r^2}$ $\quad B_{\text{straight wire}} = \frac{\mu_0 I}{2\pi r}$