Q1.
Two sinusoidal waves have the same angular frequency, the same amplitude y_m, and travel in the same direction in the same medium. If the two waves differ in phase by 50°, then find the amplitude of the resultant wave.

A) 1.8 y_m
B) 0.35 y_m
C) 0.91 y_m
D) 1.3 y_m
E) 0.64 y_m

Q2.
You are standing at a distance *D* from an isotropic point source of sound. You walk 50.0 m toward the source and observe that the intensity of the sound has doubled. Find the distance *D*.

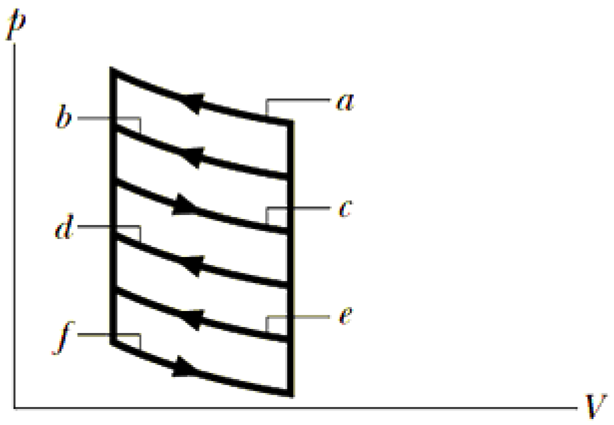
A) 171 m
B) 50.0 m
C) 127 m
D) 154 m
E) 201 m

Q3.
Suppose that on a linear temperature scale X, water boils at −53.5°X and freezes at −170°X. Find the temperature of 335 K on the X scale? (Approximate water's boiling point as 373 K.)

A) −97.8 °X
B) −82.9 °X
C) −73.8 °X
D) −121 °X
E) −102 °X

Q4.
The *p*-*V* diagram in **FIGURE 1** shows six curved paths (connected by vertical paths) that can be followed by a gas. Which two of the curved paths should be part of a closed cycle (those curved paths plus connecting vertical paths) if the net work done by the gas during the cycle is to be at its minimum positive value?

Fig#



A) *c* and *d*
B) *c* and *e*
C) *e* and *f*
D) *c* and *f*
E) *b* and *c*

Q5.
A quantity of an ideal gas is compressed to half its initial volume. The process may be adiabatic, isothermal, or isobaric. Rank those three processes in order of the work done on the gas by an external force, **LEAST to GREATEST**.

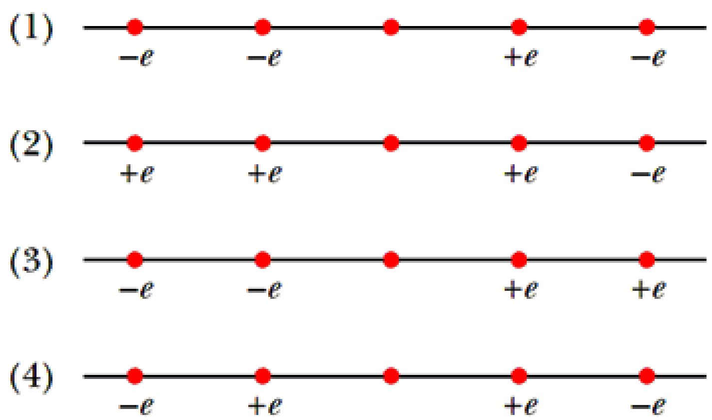
A) isobaric, isothermal, adiabatic
B) adiabatic, isothermal, isobaric
C) adiabatic, isobaric, isothermal
D) isothermal, adiabatic, isobaric
E) isobaric, adiabatic, isothermal

Q6.
The temperature of 1.00 mol of a monatomic ideal gas is raised reversibly from 300 K to 400 K, with its volume kept constant. Find the entropy change of the gas.

A) +3.59 J/K
B) +2.75 J/K
C) −2.75 J/K
D) +5.21 J/K
E) +2.32 J/K

Q7.
FIGURE 2 shows four situations in which five charged particles are evenly spaced along an axis. The charge values are indicated except for the central particle, which has the same charge in all four situations. Rank the situations according to the magnitude of the net electrostatic force on the central particle, **GREATEST** first.

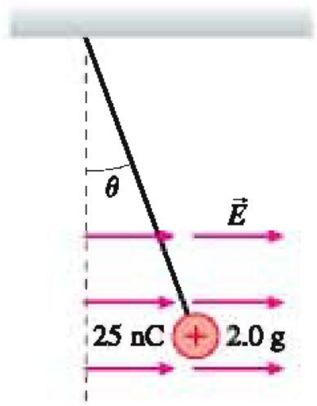
Fig#



A) 3, 1, 2, 4
B) 1, 2, 4, 3
C) 1, 3, 4, 2
D) 3, 4, 1, 2
E) 2, 4, 1, 3

Q8.
FIGURE 3 shows a horizontal electric field of magnitude 2.00×10^5 N/C that causes a small ball of mass 2.00 g and charge 25.0 nC attached to an insulating massless string to hang in air. Ignoring air friction, find the angle θ.

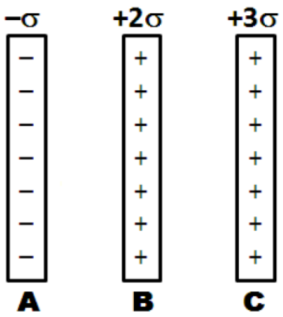
Fig#



A) 14.3°
B) 10.9°
C) 18.2°
D) 19.1°
E) 22.5°

Q9.
Consider three infinite non-conducting sheets with uniform charge densities (−σ, +2σ, +3σ), as shown in cross sectional view in **FIGURE 4**. If $\sigma = 8.85\times10^{-12}$ C/m^2, then find the electric field between sheets B and C.

Fig#



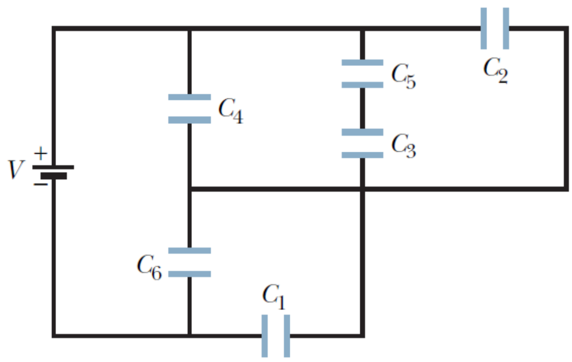
A) $-\hat{i}$ N/C
B) $-2\hat{i}$ N/C
C) $+\hat{i}$ N/C
D) $+2\hat{i}$ N/C
E) 0

Q10.
Find the electric field at the point $(x, y, z) = (3.00\text{ m}, -2.00\text{ m}, 4.00\text{ m})$, if the electric potential is given by $V = 2.00xyz^2$, where V is in volts and x, y, and z are in meters.

A) $(+64.0\hat{i} - 96.0\hat{j} + 96.0\hat{k})$ N/C
B) $(-64.0\hat{i} + 96.0\hat{j} + 96.0\hat{k})$ N/C
C) $(+64.0\hat{i} - 64.0\hat{j} - 96.0\hat{k})$ N/C
D) $(+96.0\hat{i} - 96.0\hat{j} + 96.0\hat{k})$ N/C
E) $(+64.0\hat{i} - 64.0\hat{j} + 96.0\hat{k})$ N/C

Q11.
In **FIGURE 5**, a 10.0 V battery is connected across capacitors of capacitances $C_1 = C_6 = 3.00$ μF, $C_3 = C_5 = 4.00$ μF and $C_2 = C_4 = 2.00$ μF. Find the charge stored by the equivalent capacitance of the capacitors.

Fig#



A) 3.00×10^{-5} C
B) 6.00×10^{-5} C
C) 4.00×10^{-5} C
D) 9.00×10^{-5} C

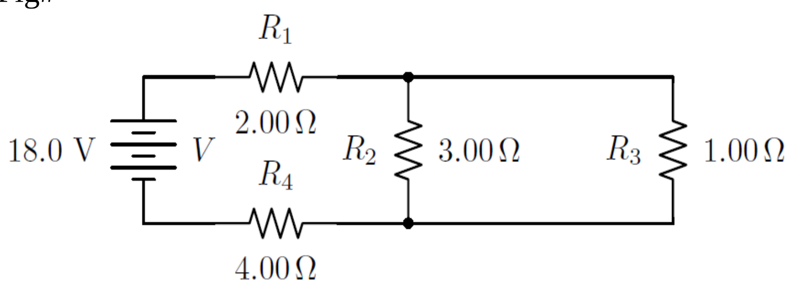
E) 2.00×10^{-5} C

Q12.
Two cylindrical wires, 1 and 2 are made of the same material. The resistance of wire 1 is three times the resistance of wire 2. If the length of wire 2 is four times the length of wire 1, then find the ratio of their cross-sectional areas, A_2/A_1.

A) 12
B) 6.0
C) 3.0
D) 0.17
E) 4.0

Q13.
In **FIGURE 6**, if the battery shown is an ideal electromotive force of 18.0 V, then calculate the power delivered to resistor R_2 = 3.00 **Ω** in the circuit.

Fig#



A) 1.33 W
B) 4.00 W
C) 3.20 W
D) 2.67 W
E) 2.00 W

Q14.
Two resistors R_1 and R_2, with $R_1>R_2$, are connected to a battery, first individually, then in series and then in parallel. Rank those arrangements according to the amount of current through the battery, **LEAST** first.

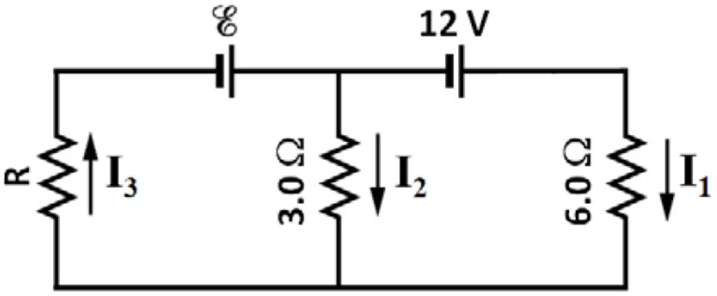
A) Series, R_1, R_2, parallel
B) Parallel, R_2, R_1, series
C) Series, Parallel, R_2, R_1
D) Series, R_2, R_1, parallel
E) R_2, series, R_1, parallel

Q15.
A capacitor with an initial potential difference of 100 V is discharged through a resistor when a switch between them is closed at $t = 0$. If at $t = 10.0$ s, the potential difference across the capacitor is 1.00 V, then find the potential difference across the capacitor at $t = 13.0$ s

A) 0.250 V
B) 0.725 V
C) 0.114 V
D) 0.395 V
E) 0.042 V

Q16.
In the circuit of **FIGURE 7**, the current $I_1 = 4.0$ A. Find the value of current I_3.

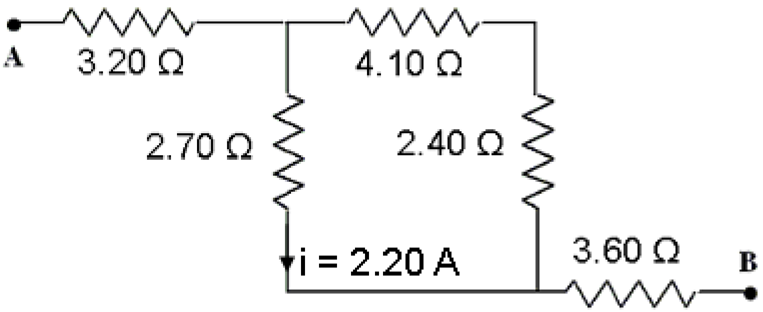
Fig#



A) 8.0 A
B) 6.0 A
C) 5.0 A
D) 9.0 A
E) 7.0 A

Q17.
Five resistors are connected as shown in **FIGURE 8**. Find the potential difference $V_A - V_B$, if the current through the 2.70 Ω resistor is 2.20 A?

Fig#



A) 27.1 V
B) 19.1 V
C) 21.6 V
D) 15.0 V
E) 33.7 V

Q18.
Copper has $8.50 \times 10^{+28}$ free electrons per cubic meter. A 84.9 cm-long copper wire that is 2.05 mm in diameter, carries 4.85 A of current. How much time does it take an electron to travel the length of the wire?

A) 131 min
B) 110 min
C) 120 min
D) 149 min
E) 172 min

Q19.
At one instant, an electron is moving in the *xy* plane, the components of its velocity being $v_x = 5.00\times10^5$ m/s and $v_y = 3.00\times10^5$ m/s. A magnetic field of 0.800 T is in the positive *x* direction. At that instant, find the acceleration of the electron. [Ignore gravity]

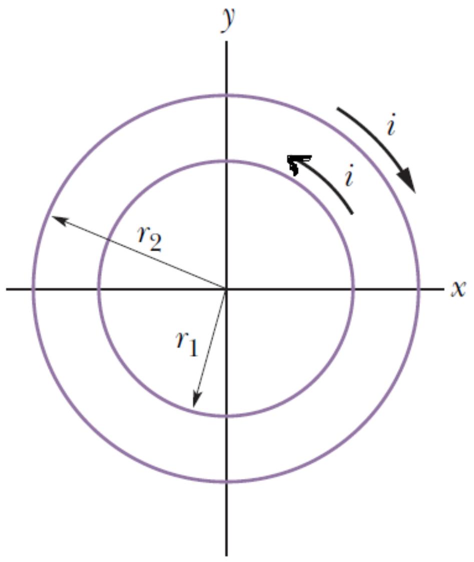
A) $+4.22 \times10^{16}\ \hat{k}$ m/s^2
B) $+2.32 \times10^{16}\ \hat{i}$ m/s^2
C) $+2.22 \times10^{16}\ \hat{j}$ m/s^2
D) $-2.22 \times10^{16}\ \hat{j}$ m/s^2
E) $-4.22 \times10^{15}\ \hat{k}$ m/s^2

Q20.
A particle ($m = 3.30 \times 10^{-27}$ kg, $q = 1.60 \times 10^{-19}$ C) is accelerated from rest through a 10 kV potential difference and then moves in a direction perpendicular to a uniform magnetic field of magnitude $B = 1.00$ T. Find the radius of the resulting circular path.

A) 20.3 mm
B) 17.0 mm
C) 9.00 mm
D) 10.0 mm
E) 15.0 mm

Q21.
FIGURE 9 shows two concentric circular wire loops, of radii $r_1 = 20.0$ cm and $r_2 = 30.0$ cm. Both loops located in the *xy* plane and each loop carries a current of 8.00 A but in opposite current directions. Find the magnitude of the net magnetic dipole moment of the system.

Fig#



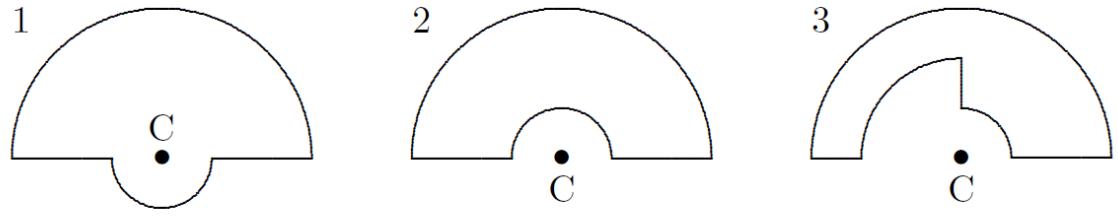
A) 1.26 A.m^2
B) 3.27 A.m^2
C) 1.05 A.m^2
D) 3.11 A.m^2
E) 2.33 A.m^2

Q22.
A wire 50.0 cm long carries a 0.500 A current in the positive direction of an *x* axis through a magnetic field of $\vec{B} = (3.00\ mT)\,\hat{j} + (10.0\ mT)\hat{k}$. Find the magnitude of the magnetic force on the wire.

A) 2.61 mN
B) 1.31 mN
C) 9.00 mN
D) 10.0 mN
E) 15.0 mN

Q23.
FIGURE 10 shows three circuits consisting of concentric circular arcs (either half or quarter circles of radii *r*, 2*r*, and 3*r*) and radial lengths. The circuits carry the same current. Rank them according to the magnitudes of the magnetic fields they produce at C, **GREATEST** first.

Fig#

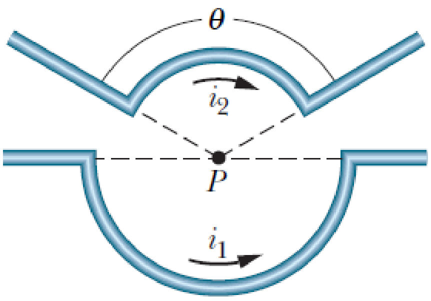


A) 1, 2, 3
B) 3, 2, 1

C) 1, 3, 2
D) 2, 3, 1
E) 2, 1, 3

Q24.
FIGURE 11 shows two current segments. The lower segment carries a current of i_1= 0.40 A and includes a semicircular arc with radius 5.0 cm, angle 180°, and center point *P*. The upper segment carries current i_2= 0.80 A and includes a circular arc with radius 4.0 cm, angle 120°, and the same center point *P*. Find the magnitude and direction of the net magnetic field at *P*.

Fig#



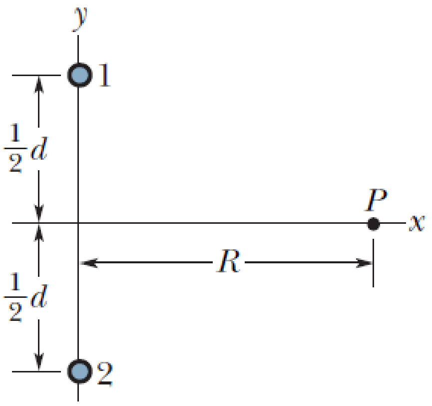
A) 1.7 µT , into the page
B) 6.7 µT, into the page
C) 6.7 µT, out of the page
D) 1.7 µT , out of the page
E) 3.2 µT , into the page

Q25.
A long solenoid has 100 turns/cm and carries current *i*. An electron moves within the solenoid in a circle of radius 2.50 cm perpendicular to the solenoid axis. If the speed of the electron is 7.50×10^5 m/s, then Find the current *i* in the solenoid.

A) 13.6 mA
B) 11.1 mA
C) 17.5 mA
D) 10.7 mA
E) 22.9 mA

Q26.
FIGURE 12 shows a cross sectional view of two long parallel wires that are separated by distance *d* = 18.6 cm. Each wire carries 4.23 A, out of the page in wire 1 and into the page in wire 2. In vector notation, find the net magnetic field at point *P* at distance *R* = 34.2 cm, due to the two currents.

Fig#



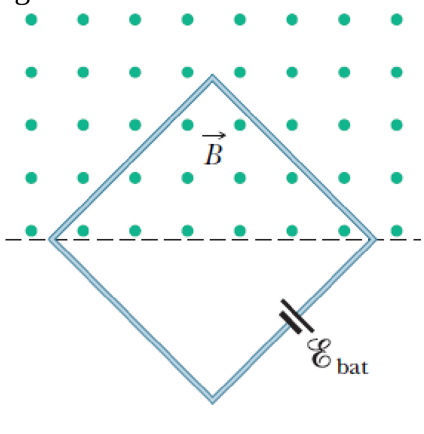
A) $\vec{B} = +1.25\times10^{-6}\hat{i}$ T
B) $\vec{B} = +1.25\times10^{-6}\hat{j}$ T
C) $\vec{B} = +1.25\times10^{-6}\hat{k}$ T
D) $\vec{B} = -1.25\times10^{-6}\hat{j}$ T
E) $\vec{B} = -1.25\times10^{-6}\hat{i}$ T

Q27.
A long cylindrical conductor of radius of 3.0 cm carrying a uniform current of 1.0×10^{2} A. Find the magnitude of the magnetic field inside the conductor at a radial distance of 2.0 cm from the wire center.

A) 4.44×10^{-4} T
B) 6.66×10^{-4} T
C) 5.54×10^{-4} T
D) 2.96×10^{-4} T
E) 3.12×10^{-4} T

Q28.
FIGURE 13 shows a square wire loop with 2.000 m sides is perpendicular to a uniform magnetic field, with half the area of the loop in the field. The loop contains an ideal battery with emf of 15.00 V. If the magnitude of the field varies with time according to $B = 0.04200 - 0.8700t$, with B in teslas and t in seconds, find the net emf in the circuit.

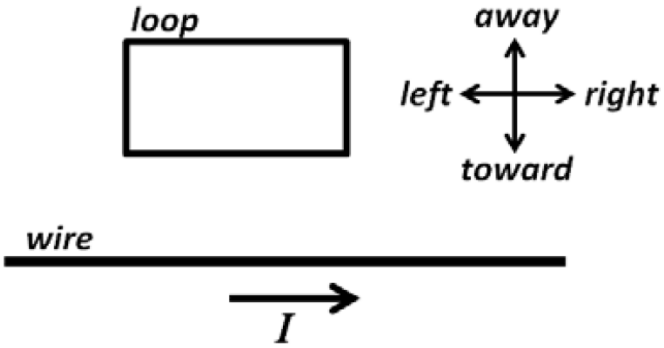
Fig#



A) 16.74 V
B) 13.26 V
C) 1.740 V
D) 15.00 V
E) 23.48 V

Q29.
A conducting loop is placed near a long straight wire carrying a constant current I, as shown in **FIGURE 14**. Find the action that will induce a clockwise current in the loop.

Fig#



A) Moving the loop towards the wire.
B) Moving the loop away from the wire.
C) Moving the loop to the left.
D) Moving the loop to the right.
E) Not moving the loop.

Q30.
A copper wire of length 10.0 m and a resistance of 2.50 Ω, is formed into a square loop and then placed with its plane perpendicular to an external uniform magnetic field that is increasing at the constant rate of 25.0 mT/s, at what rate is thermal energy generated in the loop?

A) 9.77 mW
B) 7.72 mW
C) 5.55 mW
D) 2.96 mW
E) 5.12 mW

$v = \sqrt{\tau / \mu}$

$y = y_m \sin(kx - \omega t)$

$v = \sqrt{B / \rho}$

$s = s_m \cos(kx - \omega t)$

$I = \dfrac{P_s}{4\pi r^2}$

$P_{avg} = \dfrac{1}{2}\mu\omega^2 v y_m^2$

$\Delta P = \Delta P_m \sin(kx - \omega t)$

$\Delta P_m = \rho v \omega S_m$

$I = \dfrac{1}{2}\rho(\omega S_m)^2 v$

$\beta = 10 \log \dfrac{I}{I_0}$, $I_0 = 10^{-12} W/m^2$

$f' = f\left(\dfrac{v \pm v_D}{v \mp v_s}\right)$

$y = \left(2y_m \cos\dfrac{\phi}{2}\right)\sin\left(kx - \omega t - \dfrac{\phi}{2}\right)$

$\Delta L = \dfrac{\lambda}{2\pi}\varphi$

$\Delta L = m\lambda, \quad m = 0, 1, 2, 3, ...$

$\Delta L = \left(m + \dfrac{1}{2}\right)\lambda, \; m = 0, 1, 2, 3, ...$

$y = 2y_m(\sin kx)(\cos \omega t)$

$f_n = \dfrac{nv}{2L}, \quad n = 1,2,3,...$

$f_n = \dfrac{nv}{4L}, \quad n = 1,3,5,...$

$\alpha = \dfrac{\Delta L}{L}\dfrac{1}{\Delta T}, \quad \beta = \dfrac{\Delta V}{V}\dfrac{1}{\Delta T}$

$PV = nRT = NkT$

$W = \int P\, dV$

$W = n R T \ln (V_f / V_i)$

$v_{rms} = \sqrt{\dfrac{3RT}{M}}$, $\dfrac{1}{2}mv^2 = \dfrac{3}{2}kT$

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

$\Delta E_{int} = Q - W, \quad \Delta E_{int} = n C_v \Delta T$

$Q = nC_p\Delta T$, $Q = nC_v\Delta T$

$C_p - C_v = R, \quad \gamma = Cp/Cv$

$P_{cond} = \dfrac{Q}{t} = \kappa A \dfrac{T_H - T_C}{L}$

$PV^\gamma = \text{constant}$, $TV^{\gamma\text{-}1} = \text{constant}$

$T_F = \dfrac{9}{5}T_C + 32, \qquad T_K = T_C + 273$

$W = Q_H - Q_L$, $\varepsilon = \dfrac{W}{Q_H} = 1 - \dfrac{Q_L}{Q_H}$

$\varepsilon_c = 1 - \dfrac{T_L}{T_H}$, $K_{\text{Ref}} = \dfrac{Q_L}{W}$, $K_{HP} = \dfrac{Q_H}{W}$,

$\Delta S = \int \dfrac{dQ}{T}$,

$\Delta S = nR\ln\dfrac{V_f}{V_i} + nC_V \ln\dfrac{T_f}{T_i}$

$F = \dfrac{kq_1q_2}{r^2}$, $F = qE$

$U = -\vec{p}.\vec{E}$, $\vec{\tau} = \vec{p}\times\vec{E}$

$\phi_c = \oint \vec{E}.d\vec{A} = \dfrac{q_{in}}{\varepsilon_0}$

$\phi = \int_{Surface} \vec{E} \,.\, d\vec{A}$, $E = \dfrac{kq}{r^2}$

$E = \dfrac{kQ}{R^3}r, \quad E = \dfrac{2k\lambda}{r}$

$E = \dfrac{\sigma}{2\varepsilon_o}, \quad E = \dfrac{\sigma}{\varepsilon_o}$

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

$V = \dfrac{kQ}{r}$, $U_{12} = \dfrac{kq_1q_2}{r_{12}}$

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

$C = \dfrac{Q}{V}$, $C = \dfrac{\varepsilon_0 A}{d}$

$C = \dfrac{2\pi\varepsilon_0 L}{\ln(b/a)}, \quad C = \dfrac{4\pi\varepsilon_0 ab}{b-a}$

$U = \dfrac{1}{2}CV^2, \quad C_\kappa = \kappa C_{air}$

$I = \dfrac{dQ}{dt}, \; I = JA, \; J = nev_d$

$R = \dfrac{V}{I} = \rho\dfrac{L}{A}, \quad J = \sigma E = E/\rho$

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

$q(t) = C\varepsilon[1 - e^{-t/RC}]$,

$i(t) = \dfrac{\varepsilon}{R}e^{-t/RC}$

$q(t) = q_o e^{-t/RC}$, $i(t) = \dfrac{q_o}{RC}e^{-t/RC}$

$\vec{F} = q(\vec{v}\times\vec{B})$, $\vec{F} = i(\vec{L}\times\vec{B})$

$\vec{\tau} = \vec{\mu}\times\vec{B}, \quad \vec{\mu} = Ni\vec{A}$

$U = -\vec{\mu}.\vec{B}$

$d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{i\, d\vec{s} \times \vec{r}}{r^3}$

$\oint \vec{B}.d\vec{s} = \mu_0 i_{enc}$

$B = \dfrac{\mu_0 i}{4\pi R}\varphi$, $B = \dfrac{\mu_0 i}{2\pi r}$

$F_{ba} = \dfrac{\mu_o L i_a i_b}{2\pi d}$,

$B = \dfrac{\mu_0 i}{2\pi R^2} r$

$B_s = \mu_0 n i$

$\vec{B}(z) = \dfrac{\mu_0}{2\pi}\dfrac{\vec{\mu}}{z^3}$,

$\Phi_B = \int \vec{B}\cdot d\vec{A}$

$\varepsilon_{ind} = -\dfrac{d\Phi_B}{dt}, \quad \varepsilon_{ind} = BLv$

....

$\varepsilon_o = 8.85 \times 10^{-12}\ C^2/N.m^2$
$k = 9.00 \times 10^9\ N.m^2/C^2$
$q_e = -e = -1.60 \times 10^{-19}\ C$
$q_p = +e = +1.60 \times 10^{-19}\ C$
$m_e = 9.11 \times 10^{-31}$ kg
$m_p = 1.67 \times 10^{-27}$ kg
μ = micro = 10^{-6}, n = nano = 10^{-9}
p = pico = 10^{-12}
$\mu_0 = 4\pi \times 10^{-7}$ Wb/A. m
$k_B = 1.38 \times 10^{-23}$ J/K
$N_A = 6.02 \times 10^{23}$ molecules/mole
1 atm = $1.01 \times 10^5\ N/m^2$
R = 8.31 J/mol. K
g = 9.8 m/s^2
1L = $10^{-3}\ m^3$

For water:
L_F = 333 kJ/kg
L_V = 2256 kJ/kg
c = 4190 J/kg.K

$\int x^n dx = \dfrac{x^{n+1}}{n+1}$

$\int \dfrac{dx}{x} = \ln x$

$v = v_o + at$

$v^2 = v_o^2 + 2a(x - x_o)$

$\Delta K = -\Delta U$

$\Delta U_g = mg\Delta y$