Q1.
The displacement (y) of a vibrating string versus position (x) along the string is shown in Figure 1. The wave has a speed of 0.10 m/s. What is the maximum transverse speed of a particle on the string?
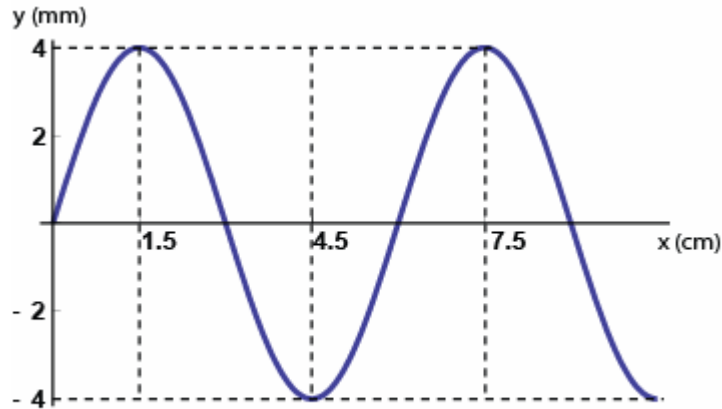
Fig#

Figure 1

A) 4.2 cm/s
B) 2.1 cm/s
C) 2.8 cm/s
D) 6.3 cm/s
E) 1.1 cm/s

Q2.
The frequencies of two consecutive harmonics of a pipe, closed at one end and open at the other, are 929 Hz and 1300 Hz. The length of the pipe is 0.450 m. What is the speed of sound waves in the pipe?

A) 334 m/s
B) 343 m/s
C) 340 m/s
D) 330 m/s
E) 410 m/s

Q3.
Two different materials A and B have the same mass and are at the same initial temperature. They both absorb equal amounts of heat energy. The final temperature of A is higher than that of B because

A) The specific heat of A is less than that of B.
B) They have the same coefficient of thermal expansion.
C) The specific heat of B is less than that of A.
D) Both materials have the same specific heat.
E) Both materials have the same thermal conductivity.

Q4.
A block of 200 g of copper is dropped into a container that has 500 g. Both are at a temperature T = 90 °C. The system is left to cool down slowly. What is the temperature of the system when the heat lost by the water and the copper is 2.0×10^4 J? (Neglect any heat gained or lost by the container. The specific heat of water and copper are 4180 J/kg K and 386 J/kg K, respectively).

A) 81 °C
B) 75 °C
C) 45 °C
D) 25 °C
E) 0 °C

Q5.
A cylinder contains 4.00 moles of a monatomic ideal gas at a temperature of 30.0 °C and a pressure of 1.50 atm. The gas is heated under constant pressure until its temperature reaches 150 °C. How much work is done by the gas in this process?

A) 953 cal
B) 389 cal
C) 645 cal
D) 760 cal
E) 540 cal

Q6.
A heat engine takes 0.200 moles of an ideal monatomic gas through the cyclic process shown in the PV diagram (see Figure 2), where AB is an adiabatic process, T_A = 600 K, T_B = 455 K and T_C = 300 K. The heat gained by the gas is
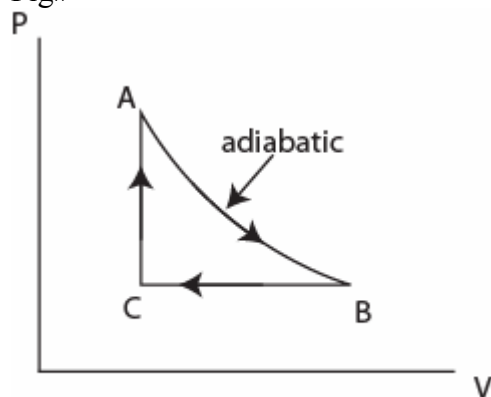
Fig#

Figure 2

A) 748 J.
B) 296 J.
C) 345 J.
D) 983 J.
E) 104 J.

Q7.
Two positive charges (+8.00 C and +2.00 C) are separated by 300 m. A third charge is placed a distance r from the +8.00 C charge so that the resultant electric force on the third charge due to the other two charges is zero. The distance r is

A) 200 m.
B) 500 m.
C) 300 m.
D) 100 m.
E) 400 m.

Q8.
A point charge q = + 4.00 nC is located at a point having coordinates (30.0 cm, 40.0 cm). At what point will the electric field due to this charge be 72.0 N/C and pointing in the negative x-direction?

A) – 40.7 cm,   40   cm
B) 40.7 cm,   40   cm
C) 70.7 cm,   40   cm
D) −70.7 cm,   40   cm
E) 12.5 cm, −12.5 cm

Q9.
Figure 3 shows two large, parallel, non-conducting sheets, each with fixed uniform surface charge density: $\sigma_1 = + 2.2 \times 10^{-6}$ C/m^2 and $\sigma_2 = - 4.3 \times 10^{-6}$ C/m^2. The ratio of the magnitude of the electric field at point A to that at point B is
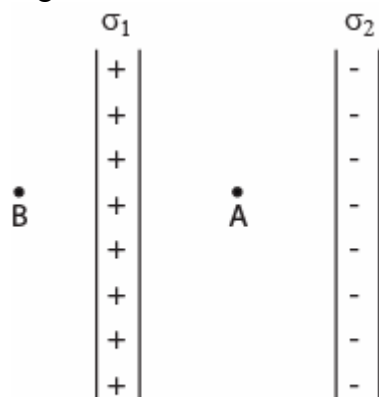
Fig#

Figure 3

A) 3.1
B) 4.4
C) 2.2
D) 1.5
E) 0.6

Q10.
What is the external work required to bring four 2.0×10^{-9} C point charges from infinity and place them at the corners of a square of side 0.14 m?

A) 1.4×10^{-6} J
B) 1.8×10^{-6} J
C) 0.30×10^{-6} J
D) 0.60×10^{-6} J
E) 1.0×10^{-6} J

Q11.
Three capacitors $C_1 = 5.0$ μF, $C_2 = 10$ μF and $C_3 = 3.0$ μF are connected to a 20 V battery as shown in Figure 4. Find the stored electric energy in C_2.
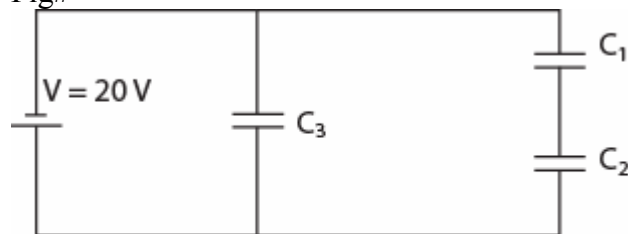
Fig#

Figure 4

A) 2.2×10^{-4} J
B) 0.35×10^{-4} J
C) 1.3×10^{-4} J
D) 1.9×10^{-5} J
E) 4.0×10^{-6} J

Q12.
An isolated conducting sphere whose radius R is 2.0 cm has a charge $q = +16 \times 10^{-9}$ C. What is the energy density at the surface of the sphere?

A) 0.57 J/m^3
B) 0.93 J/m^3
C) 2.3 J/m^3
D) 3.7 J/m^3
E) 4.1 J/m^3

Q13.
A copper wire of cylindrical shape has resistance R. What is the resistance of a second wire, made of the same material, that is twice as long and has twice the diameter?

A) R/2
B) 2R
C) 4R

D) R/4
E) R

Q14.
The four resistors shown in Figure 5 are identical, and each has a resistance of 6.0 Ω. The battery is ideal and has emf $\mathcal{E}$= 12 V. What is the value of the current i_2 passing through R_2?
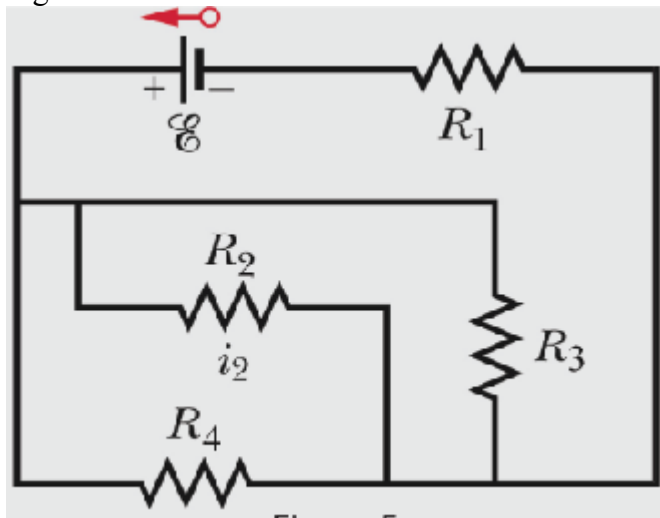
Fig#

Figure 5

A) 0.50 A
B) 1.0 A
C) 1.5 A
D) 2.0 A
E) 2.5 A

Q15.
In the circuit shown in Figure 6, $\mathcal{E}_1$ = 6.00 V, $\mathcal{E}_2$ = 12.0 V, R_1 = 200 Ω, and R_2 = 100 Ω. What is the power supplied by $\mathcal{E}_1$? (Consider the two emf to be ideal).

Fig#
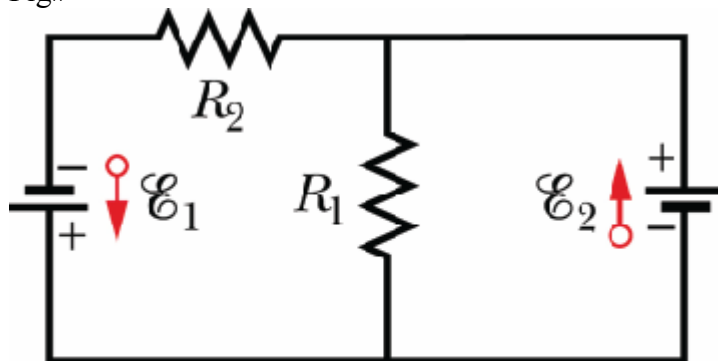

Figure 6

A) 1.08 W
B) 0.720 W

C) 3.24 W
D) 2.88 W
E) 1.80 W

Q16.
Consider the circuit shown in Figure 7. When the capacitor is fully charged the current I is 3.00 A. What is the charge on the capacitor if its capacitance is 10.0 µF?

Fig#

Figure 7
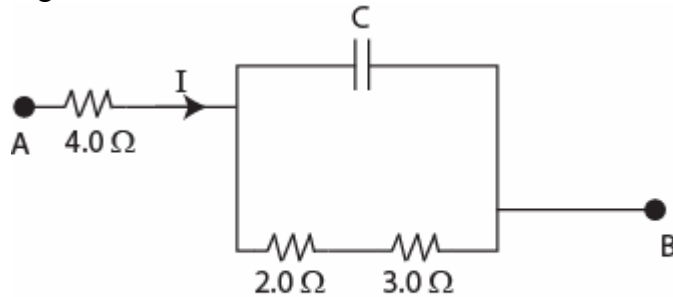
A) 150 µC
B) 60.0 µC
C) 90.0 µC
D) 270 µC
E) zero

Q17.
A power supply charges a 6.00-µF capacitor to a potential difference of 100 V. The power supply is removed and the capacitor is connected to a 1.50 kΩ resistor at time t = 0. What is the potential energy stored in the capacitor at t = 2.00 ms?

A) 19.2 mJ
B) 27.4 mJ
C) 15.6 mJ
D) 23.8 mJ
E) 21.3 mJ

Q18.
A single resistor R_1 is connected to a battery. A second resistor R_2 is then connected to R_1 in parallel. Which of the following statements is CORRECT?

A) The current through R_1 will not change.
B) The current through R_1 will increase.
C) The current through R_1 will decrease.
D) The current through the battery will decrease.
E) The current through the battery will not change.

Q19.
At one instant, an electron is moving in the xy plane. The components of its velocity are $v_x = 5.0 \times 10^5$ m/s and $v_y = 3.0 \times 10^5$ m/s. A magnetic field of 0.80 T is in the positive y direction. At that instant, what is the magnetic force on the electron?

A) 6.4×10^{-14} N in the negative z direction
B) 6.4×10^{-14} N in the positive z direction
C) 3.2×10^{-14} N in the negative z direction
D) 3.2×10^{-14} N in the positive z direction
E) 1.8×10^{-14} N in the negative z direction

Q20.
A proton is moving with velocity of $v = (1.5\,i + 1.5\,j) \times 10^6$ m/s. It enters a region of a uniform magnetic field pointing in the negative z direction. What is the direction of a uniform electric field in the xy plane that will make the proton move un-deflected?

A) At an angle of 315° form the positive x axis
B) At an angle of 45° form the positive x axis
C) At an angle of 225° form the positive x axis
D) At an angle of 135° form the positive x axis
E) No electric field in the xy plane can prevent the deflection of the proton

Q21.
A particle, with charge $q = + 1.6 \times 10^{-16}$ C and mass $m = 3.2 \times 10^{-27}$ kg, is travelling in the positive y direction at speed $v = 5.0 \times 10^6$ m/s as shown in Figure 8. It enters a region of uniform magnetic field where it is deflected to follow a circular path of radius $R = 0.50$ m. What is the magnetic field in this region?
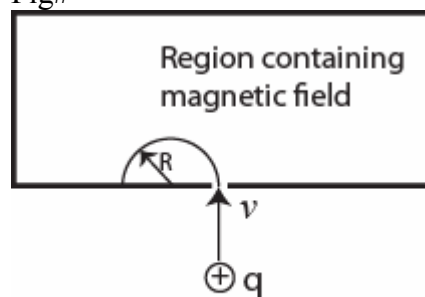
Fig#

Figure 8

A) 0.20 mT into the page
B) 0.20 mT out of the page
C) 0.10 mT into the page
D) 0.10 mT out of the page
E) 0.35 mT into the page

Q22.

In Figure 9, a square loop of wire of side 0.50 m lies in the xy plane. The current in the loop is 0.25 A. There is a uniform magnetic field B in the positive y direction of magnitude 0.75 T. What is the toque on the loop?
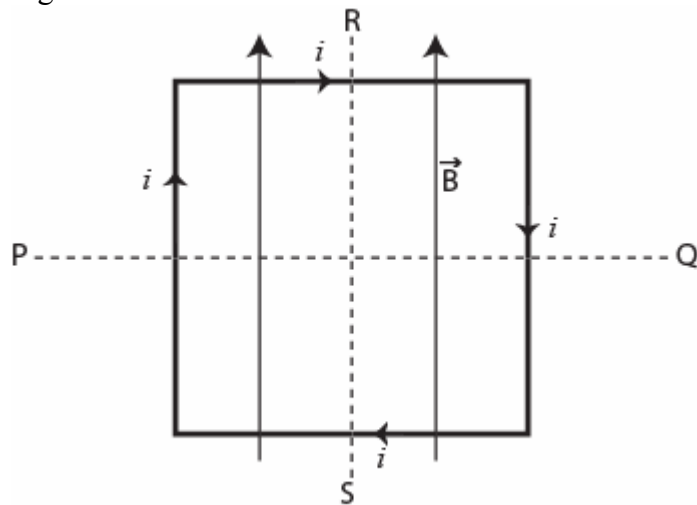
Fig#

Figure 9

A) 0.047 N.m causing rotation about the line PQ
B) 0.047 N.m causing rotation about the line RS
C) zero
D) 0.094 N.m causing rotation about the line PQ
E) 0.094 N.m causing rotation about the line RS

Q23.
In Figure 10, a copper wire AB is hanging between the poles of a magnet. As a result of closing the switch (S), there will be
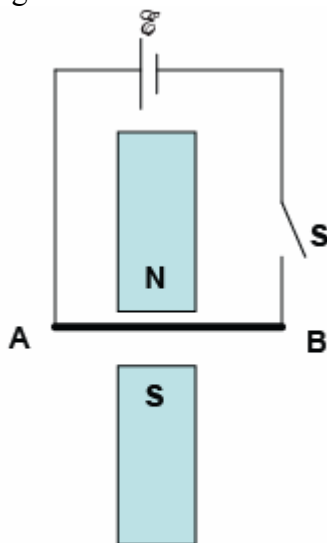
Fig#

Figure 10

A) A magnetic force on the wire AB into the page.

B) A magnetic force on the wire AB out of the page.
C) A magnetic force on the wire AB towards the left.
D) A magnetic force on the wire AB towards the right.
E) No magnetic force on the wire AB.

Q24.
In Figure 11, the current in both very long wires is $i = 5.00$ A and R = 2.00 cm. The magnitude of the magnetic field at point P, at the center of the semicircle shown, is

Fig#
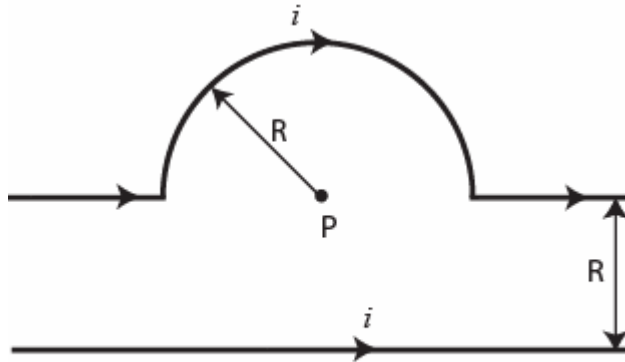
Figure 11

A) 29 µT into the page.
B) 29 µT out of the page.
C) 15 µT out of the page.
D) 15 µT into the page.
E) zero

Q25.
Figure 12 shows the cross section of two long wires A and B each carrying a current I = 12 A (out of the page). Calculate the magnitude of the net magnetic field due to these two currents at point C.
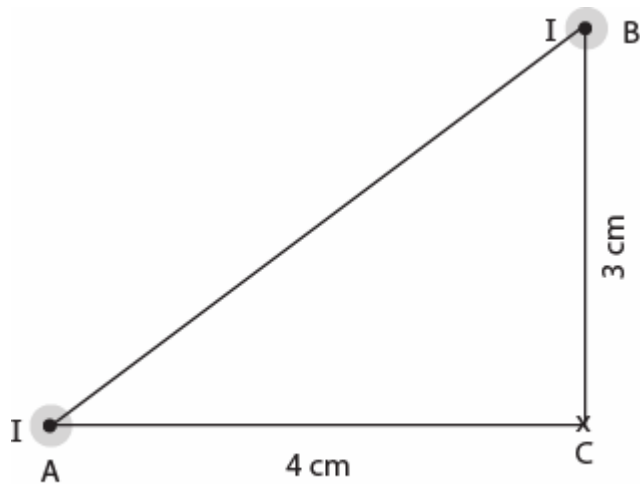
Fig#

Figure 12

A) 0.10 mT
B) 0.20 mT
C) 0.30 mT
D) 0.40 mT
E) 0.50 mT

Q26.
An ideal solenoid has length L = 0.80 m and inner diameter d = 3.6 cm. It carries a current I = 5.6 A. It consists of 10 layers each with 900 turns along its length. The magnitude of the magnetic field at the center is

A) 0.079 T.
B) 1.9   T.
C) 0.50 T.
D) 2.3   T.
E) 0.20 T.

Q27.
A long solid cylindrical conductor of radius R = 4.0 mm carries a current I parallel to its axis. The current density in the wire is 2.0×10^4 A/m^2. Determine the magnitude of the magnetic field at a point that is 3.0 mm from the axis of the conductor.

A) 38 μT
B) 52 μT
C) 12 μT
D) 24 μT
E) 48 μT

Q28.
A circuit is pulled to the right at a constant speed v = 9.0 m/s in a uniform magnetic field with a 16-N force as shown in Figure 13. As the circuit moves, a current flows through the 4.0 Ω resistor (R). What is the magnitude and direction of the current in the circuit?
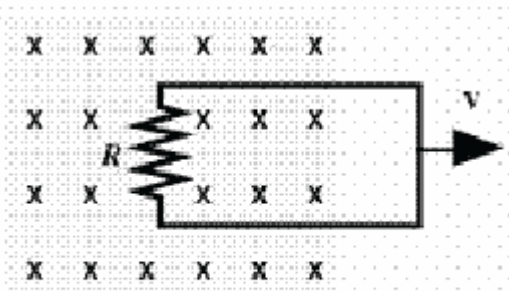
Fig#

Figure 13

A) 6.0 A, clockwise
B) 4.0 A, clockwise
C) 6.0 A, counterclockwise
D) 4.0 A, counterclockwise
E) 10 A, clockwise

Q29.
A small circular loop of area 0.50 cm^2 is placed in the plane of, and concentric with, a large circular loop of radius 2.0 m. The current in the large loop is changed uniformly from +100 A to −100 A in a time interval of 0.50 s. Find the magnitude of the emf induced in the small loop in this time interval (Assume the field is uniform through the smaller loop).

A) 6.3×10^{-9} V
B) 3.1×10^{-8} V
C) 5.0×10^{-8} V
D) 7.5×10^{-6} V
E) 9.2×10^{-9} V

Q30.
A 2.0 m long copper wire, with a resistance of 5.0 Ω, is formed into a square loop and placed perpendicular to a uniform magnetic field that is increasing at the constant rate of 10 mT/s. At what rate is thermal energy generated in the loop?

A) 1.3×10^{-6} W
B) 4.5×10^{-6} W
C) 3.2×10^{-3} W
D) 2.1×10^{-4} W
E) 0.10×10^{-6} W

Physics 102
Formula sheet for Final Exam

$v = \sqrt{\dfrac{\tau}{\mu}}$, $v = \lambda f$ $v = \sqrt{\dfrac{B}{\rho}}$

$S = S_m \cos(kx - \omega t)$

$I = \dfrac{\text{Power}}{\text{Area}}$

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

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

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

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

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

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

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

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

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

$\Delta L = n\dfrac{\lambda}{2}$ $n = 0,1,2,3,..$ ...

$\Delta L = m\lambda$

$\Delta L = \left(m + \dfrac{1}{2}\right)\lambda$

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

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

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

$\alpha = \dfrac{\Delta L}{L}\dfrac{1}{\Delta T}$, $PV = nRT = NkT$

$n = \dfrac{m}{M} = \dfrac{N}{N_A}$, $\beta = \dfrac{1}{V}\dfrac{\Delta V}{\Delta T}$

$Q = mL$, $W = \int PdV$,

$P = \dfrac{2}{3}\dfrac{N}{V}\left(\dfrac{1}{2}m\vec{v}^2\right)$, $C_p - C_v = R$

$Q = mc\Delta T$,

$\Delta E_{int} = Q - W$, $\Delta E_{int} = nc_v \Delta T$

$v_{rms} = \sqrt{\dfrac{3RT}{M}}$, $\dfrac{1}{2}m\vec{v}^2 = \dfrac{3}{2}k_B T$,

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

$Q = n c_p \Delta T$, $Q = n c_v \Delta T$

$P V^\gamma = \text{constant}$, $T V^{\gamma-1} = \text{constant}$

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

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

$\dfrac{Q_L}{Q_H} = \dfrac{T_L}{T_H}$, $K = \dfrac{Q_L}{W}$, $\Delta S = \int \dfrac{dQ_r}{T}$

$F = \dfrac{kq_1 q_2}{r^2}$, $F = q_0 E$, $\vec{\tau} = \vec{p} \times \vec{E}$

$\varphi = \int\limits_{Surface} \vec{E} . d\vec{A}$, $E = \dfrac{kq}{r^2}$, $U = \vec{p} \cdot \vec{E}$

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

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

$E = \dfrac{\sigma}{2\varepsilon_o}$, $E = \dfrac{\sigma}{\varepsilon_o}$, $V = \dfrac{kQ}{r}$,

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

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

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

$U = \dfrac{kq_1 q_2}{r_{12}}$, $C = \dfrac{Q}{V}$, $C_o = \dfrac{\varepsilon_0 A}{d}$

$C = 4\pi\varepsilon_o \dfrac{ab}{b-a}$, $U = \dfrac{1}{2}CV^2$

$u = \dfrac{1}{2}\varepsilon_o E^2$, $C = \kappa C_0$,

$E = \dfrac{E_0}{\kappa}$, $V = \dfrac{V_o}{\kappa}$, $I = \dfrac{dQ}{dt}$,

---

$I = JA$, $R = \dfrac{V}{I} = \rho\dfrac{L}{A}$

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

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

$q(t) = q_o e^{-t/RC}$

$\tau = N i A B \sin\theta$, $\vec{\tau} = \vec{\mu} \times \vec{B}$

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

$F_{ba} = \dfrac{\mu_o L i_a i_b}{2\pi d}$, $d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{i\,d\vec{s} \times \vec{r}}{r^3}$,

$\oint \vec{B}.d\vec{s} = \mu_0 i_{enc}$, $U = -\vec{\mu} \cdot \vec{B}$

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

$B_s = \mu_0 n i$, $\varphi_B = \int\limits_{Surface} \vec{B}.d\vec{A}$

$\varepsilon = -\dfrac{d\varphi_B}{dt}$, $\varepsilon = BLv$

$v = v_o + at$

$x - x_o = v_o t + \dfrac{1}{2}at^2$

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

$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N.m}^2$
$k = 9.0 \times 10^9 \text{ N.m}^2/\text{C}^2$
$q_e = -1.6 \times 10^{-19} \text{ C}$
$m_e = 9.11 \times 10^{-31} \text{ kg}$
$m_p = 1.67 \times 10^{-27} \text{ kg}$
$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$
$\mu_0 = 4\pi \times 10^{-7} \text{ Wb/A. m}$
$k_B = 1.38 \times 10^{-23} \text{ J/K}$
$N_A = 6.02 \times 10^{23} \text{ molecues/mole}$
$1 \text{ atm} = 1.013 \times 10^5 \text{ N/m}^2$
$R = 8.31 \text{ J/mol. K}$
$g = 9.8 \text{ m/s}^2$, $1 \text{ cal} = 4.186 \text{ J}$,
for water:

$c = 4180 \dfrac{\text{J}}{\text{kg.K}}$

$L_F = 333 \dfrac{\text{kJ}}{\text{kg}}$, $L_V = 2256 \dfrac{\text{kJ}}{\text{kg}}$