$g \approx 9.8\ \mathrm{m/s^2}$ $\rho_{\mathrm{water}} \approx 1000\ \mathrm{kg/m^3} = 1\ \mathrm{gram/cc} = 1\ \mathrm{kg/liter}$ $\rho_{\mathrm{air}} = 1.29\ \mathrm{kg/m^3}$

Atmospheric Pressure $\approx$ 101.3 kPa

$\eta_{\mathrm{water}} \approx 10^{-3}$ Pa s $\eta_{\mathrm{blood}} \approx 3\ 10^{-3}$ Pa s $V_{\mathrm{cube}} = L^3$

Circle: $A = \pi r^2$ Sphere: $V = \frac{4}{3}\pi r^3$ 1 liter = 1000 cc = $10^{-3}\ \mathrm{m^3}$

Density = Mass/Volume Pressure = Force/Area weight = mg

Work = Force x Distance Power = Force x Velocity

pressure = $P_{ATM} + \rho g h$ BF=weight of water displaced

Flow rate $= A_1 v_1 = A_2 v_2$ $P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$

$$\text{Flow rate} = \frac{\Delta V}{\Delta t} = \frac{\pi R^4}{8\eta L}\Delta P$$

$$T_C = \frac{5}{9}(T_F - 32) \qquad T_F = \frac{9}{5}T_C + 32 \qquad T = (T_C + 273.15\ )K$$

$$\Delta L = \alpha L_0 \Delta T \qquad \Delta V = \beta V_0 \Delta T \qquad \beta \approx 3\alpha$$

1 calorie = 4.186 J 1 Calorie = 1000 calories

$$C = \frac{Q}{\Delta T} \qquad c = \frac{Q}{m\Delta T}$$

$$c_{\mathrm{water}} = 4186\ \mathrm{J/(kg\ K)} = 1\ \mathrm{calorie/(gm\ K)}$$

$$P = e\sigma A T^4, \quad P_{NET} = e\sigma A\left(T^4 - T_s^4\right) \quad \sigma = 5.67 \text{ x } 10^{-8}\ \mathrm{W/(m^2K^4)}$$

Copper conductivity $k_{Cu} = 395\ \ (\mathrm{W/m \cdot K})$ Fusion/melting: $\Delta Q = mL$

$$Q = kA\frac{\Delta T}{L}t$$

$PV = NkT$ $k = 1.38\ 10^{-23}$ J/K N = number of molecules

$PV = nRT$ $R = 8.31$ J/(mol K) n = number of moles

$N_A = 6.022\ 10^{23}$ molecules per mole

Water: heat of fusion: $33.5\ 10^4$ J/kg = 80 calories/gm

Water: heat of vaporization: $22.6\ 10^5$ J/kg = 540 calories/gm

$$\left(\frac{1}{2}mv^2\right)_{\mathrm{ave}} = \frac{3}{2}kT \qquad U = \frac{3}{2}NkT = \frac{3}{2}nRT$$

1^{st} Law $\Delta U = Q - W$

2^{nd} Law For a closed system $\Delta S > 0$ or $= 0$

Constant P process Work = $P \Delta V$

Isothermal process Work = $nRT \ln (V_f/V_i)$

Ideal Gas $PV = nRT = NkT$ $U = 3/2nRT = 3/2NkT$

$k_B = 1.38 \times 10^{-23}$ J/K $R = 8.31$

Latent Heat $L_{steam} = 2.26 \times 10^6$ J/kg $Q = mL$

For reversible heat engines (Carnot) efficiency = $1 - Q_c/ Q_h = 1 - T_c/ T_h$

$Q_h = Q_c + W$

COP for Heat Pump = Q_h / W

COP for Refrigerator = Q_c / W

Entropy $\Delta S = \Delta Q/T$ at constant T

Electron charge 1.6×10^{-19} C Electron mass 9.11×10^{-31} kg

Permittivity of Vacuum $\varepsilon_0 = 8.85 \times 10^{-12}$ $k=1/(4\pi\varepsilon_0)$ $F_{12}=kQ_1Q_2/R^2$

Energy density in the Electric field is $u = \varepsilon_0 E^2 / 2$ J/m^3

Capacitance for a parallel plate capacitor with vacuum $\varepsilon_0 A/d$ Farads

Electric flux $\Phi = E A \cos\theta$

Gauss's Law Total Electric Flux through closed surface = Q / ε_0

Electric field $E = - \Delta V/ \Delta s$ Capacitor Law: $Q = CV$

Electric field due to point charge $E = k Q/ R^2$, $k = 8.99 \times 10^9$

Electric Potential due to point charge $V = kQ/R$

Work done on charge $= - Q \Delta V$

Electric Current $I = \Delta Q/\Delta t$ = Rate of flow of electric charge

Ohm's Law $V = IR$

$R = \rho L/A$, ρ resistivity

Series $R = R_1 + R_2 + \ldots\ldots\ldots$ Parallel $R^{-1} = R_1^{-1} + R_2^{-1} + \ldots\ldots\ldots$

$Q = CV$

Series $C^{-1} = C_1^{-1} + C_2^{-1} + \ldots\ldots$ Parallel $C = C_1 + C_2 + \ldots\ldots\ldots$

Charging a capacitor in an RC circuit

$Q(t) = Q_{max}(1 - e^{-t/\tau})$ $\tau = RC$, Q_{max} = max charge on C (at t=infinity)=$C\mathcal{E}$

$F_B = q v B \sin(\theta)$ [use RHR], $F_E = q E$ (on a charge q)

Work = $q V$

Kinetic energy for mass m, speed v = $\frac{1}{2} mv^2$

$F_B = I l B \sin(\theta)$ (on wire with length l)

Torque on coil of N loops = $N I B A \sin(\theta)$

Force per unit length between parallel currents = $\mu_0 I_1 I_2 / 2\pi D$

D is distance between wires

Magnetic Permeability of Vacuum $\mu_0 = 4 \pi \times 10^{-7}$

Power = $V I$

Loop Rule Sum of Voltage Drops around any Loop = Zero

Junction Rule Sum of Currents In = Sum of Currents Out at any junction

Magnetic field at distance R from a long straight wire with current I

$B = 2 \times 10^{-7} I/R$

Cyclotron formula for charged particle moving perpendicular to uniform field B

$R = mv/(qB)$, R radius of the circular trajectory

Solenoid field $B = \mu_0 N I / l$ (N turns over length l)
Energy in inductor $U=LI^2 / 2$, field energy density $u_B = B^2/ (2 \mu_0)$,
Transformers: $(V_2 / V_1) = (N_2 / N_1) = (I_1 / I_2)$
Inductance $L = \Delta\Phi_m / \Delta I$ Inductance of solenoid (N turns, length l): $L= \mu_0 N^2 A / l$
$\tau = L/ R$
$V = V_{max} \sin(\omega t)$, $V_{RMS} = V_{max} / \sqrt{2}$, $I_{RMS} = V_{RMS} / X$, $X_C = 1 /(\omega C)$, $X_L= \omega L$
$Z= \sqrt{[R^2 + (X_L - X_C)^2]}$, resonant freq $\omega_0 = 1 /\sqrt{[LC]}$

<u>scratch paper</u>