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November 21, 2023

Abstract

Deakin Uni Physics for the Life Sciences Notes

1 Constants

$$
\begin{aligned}
c &= 3.00 \times 10^{9}\ m/sec \\
e &= 1.80 \times 10^{-19}\ C \\
g &= 9.8\ m/sec^{2} \\
1\ \text{atm} &= 1.01 \times 10^{5} Pa = 760\ mmHg \\
\text{Coulomb's } K &= 9 \times 10^{9}\ Nm^{2}C^{-2} \\
\text{Speed of Sound} &= 343\ m/sec \\
1\text{Cal} &= 4.186\ J \\
1\text{eV} &= 1.60 \times 10^{-}19\ J \\
\text{Electron Mass} &= 9.11 \times 10^{-31}\ Kg \\
\text{Proton Mass} &= 1.67 \times 10^{-17}\ Kg \\
\text{Atomic Mass Unit} &= 1.67 \times 10^{-17}\ Kg \\
\epsilon_0 &= 8.85 \times 10^{-12}\ C^{2}/Nm^{2} \\
R &= 6.31\ J/Mol - K \\
\text{Threshold of hearing} &= l_0 = 1.0 \times 10^{-12}\ W/m^{2} \\
1\ \text{curie} &= 3.7 \times 10^{10}\ Bq \\
k_g &= 1.38 \times 10^{-23}\ J/K \\
R &= 8.31\ J/mol - K \\
\text{Speed of Light} &= 3.0 \times 10^{8}\ m/sec \\
\hbar &= 1.05 \times 10^{-34}\ J * s = 6.58 \times 10^{-18}\ eV * s \\
\text{Density of Water} &= 1000\ kg/m^{3}
\end{aligned}
$$

2 Conversion Formulae

$$T = T_c + 273$$
$$T(^\circ C) = \frac{5}{9}[T(^\circ F) - 32^\circ]$$
$$n = \frac{M \text{ (in grams)}}{M_{mol}} = \frac{N}{N_A}$$

2.1 Trigonometry

$$cosine = \frac{adjacent}{hypotenuse}$$
$$sine = \frac{opposite}{hypotenuse}$$
$$tangent = \frac{opposite}{adjacent}$$

2.2 Pythagorean Theorem

$$a^2 = b^2 + c^2$$

3 Formulae

3.1 Area and Volume Formulae

Circle	$A = 2\pi r$	$V = \pi r^2$
Cylinder	$A = 2\pi r h$	$V = \pi r^2 h$
Sphere	$A = 4\pi r^2$	$V = \frac{4}{3}\pi r^3$
Cube	$A = 6h^2$	$V = h^2$

3.2 Length of a vector

Length of a Vector $\quad |V| = \sqrt{V_x^2 + V_y^2}$

4 Kinematics

Equations of Motion

$$\Delta x = x_j = x_j$$
$$\nu = \frac{\Delta x}{\Delta t}$$
$$a = \frac{\Delta v}{\Delta T}$$
$$v_f^2 = v_i^2 + 2a\Delta X$$
$$v_f = v_i + a\Delta t$$
$$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$$

Net Force $F_{net} = F_1 + F_2 + ... + F_N$

Newton's Second Law $F = ma$

Drag Force $D = \frac{1}{2}C_d\rho v^2 A$

Friction Force $f_{s,max} = \mu_s n$ $f_k = \mu_k n$

Spring Force (Hook's Law) $F = -kx$

Conservation of Energy (without transfer) $\Delta K + \Delta U + \Delta E_{th} + = 0$

Conservation of Energy (with transfer) $\Delta K + \Delta U + \Delta E_{th} + = w + q$

Kinetic Energy: $K = \frac{1}{2}mv^2$

Gravitational Potential Energy: $U_g = mgy$

Spring Potential Energy: $U_x = \frac{1}{2}kx^2$

Work: $W = Fd(cos\theta)$

Power: $P = \frac{\Delta E}{\Delta t}$

Mechanical Power: $P = \frac{W}{\Delta t} = F\nu$

Energy Efficiency: $e = \frac{E_{out}}{E_{in}}$

4.1 Thermal Properties

$$T = \frac{2}{3}\frac{K_{avg}}{k_b}$$

Thermal expansion (volume): $\Delta V = \beta V, \Delta T$

Thermal expansion (linear): $\Delta L = \alpha L, \Delta T$

Gas Pressure $p = \frac{2}{3}\frac{N}{V}K_{avg}$

Ideal Gas Law (multiple forms) $pV = NK_bT \qquad = nN_Ak_bT = nRT$

Mass of a Substance $m = \rho V$

Work Done by a Gas $W_{gas} = p\Delta V$

Energy Conservation for Interacting Systems $Q_{net} = Q_1 + Q_2 + \ldots = 0$

Heat Equations for Solids and Liquids $Q = mC\Delta T$

Heat Equations for Gasses

Constant Volume $Q = nC_v\Delta T$

Constant Pressure $Q = mC_p\Delta T$

Heat Required for a Phase Change

Fusion (melting.freezing) $Q = \pm ML_f$

Vapourization (boiling/conmdensing) $Q = \pm ML_v$

Rate of Conduction Across a Temperature Gradient $Q = \frac{kA}{L}\Delta T$

Rate of Radiative Heat Transfer $\frac{Q}{\Delta T} = e\ \sigma AT^4$

5 Fluids

Fluid Pressure	$p = \frac{F}{A}$
Hydrostatic Pressure	$p = p_0 + \rho g d$
Gauge Pressure	$p_g = p - p_{atm}$
Pressure Gradiaent in a Viscous Fluid	$\Delta p = 8\pi\nu\frac{LV_{avg}}{A}$
Buoyancy Force	$F_b = \rho_f V_f g$

6 Oscillations

Frequency-period relationship	$f = \frac{1}{T}$
Frequency of mass-spring oscillator	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$
Frequency of pendulum oscillator (small angle of displacement)	$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$

7 Waves

Wave speed of a stretched string $\quad v_{string} = \sqrt{\frac{T_s}{\mu}}$

Wave speed in a gas $\quad v_{sound} = \sqrt{\frac{\gamma RT}{M}}$

Wave speed $\quad v = f\lambda = \frac{\lambda}{T}$

Sound intensity $\quad \beta = (10dB)log_{10}(\frac{I}{I_0})I = \frac{P_{source}}{4\pi r^2}$

8 Doppler Effect

Observed frequency (source approaching at v_s)	$f_+ = \dfrac{f_0}{1 - v_a/v}$
Observed frequency (source receding at v_s)	$f_- = \dfrac{f_0}{1 + v_a/v}$
Observed frequency (observer approaching source at v_o)	$f_+ = \dfrac{1 + v_o}{v} f_0$
Observed frequency (observer receding from source at v_0)	$f_- = \dfrac{1 - v_o}{v} f_0$

9 Optics

Speed of light in a transparent mediun $\quad v = \frac{c}{n}$

Snall's Law $\quad n_1 sin\ \theta_1 = n_2 sin\ \theta_2$

Critical angle (total internal reflection) $\quad \theta_c = sin^{-1}\left(\frac{n_2}{n_1}\right)$

Optical magnification $\quad m = \frac{s^{'}}{s} = \frac{h^{'}}{h}$

Len power $\quad P = \frac{1}{f}$

Thin lens equation $\quad \frac{1}{s} + \frac{1}{s^{'}} = \frac{1}{f}$

Light gathering ability $\quad f - \text{number} = \frac{f}{d}$

Simple magnifier $\quad M = \frac{25\ \text{cm}}{f}$

10 Electric Fields and Forces

Coulomb's law $F_{1on2} = F_{2on1} = \frac{K\,|q_1|\,|q_2|}{r^2}$

Electric field at point defined by charge q $E(x,y,z) = \frac{F_{on\ q}(x,y,z)}{q}$

Electric field at distance r from charge q $E = \left(\frac{K|q|}{r^2}, \begin{bmatrix} \text{away from } q \text{ if } q > 0 \\ \text{toward } q \text{ if } q < 0 \end{bmatrix}\right)$

Electric field in parallel plate capacity $E_{capacitor} = \frac{Q}{\epsilon_0 A}$

Force on charge q $F_{on\ q} = qE$

Electric potential energy $U_{elec} = qV$

Conservation of energy in charge interactions $\Delta K + q\Delta V = 0$

Electric potential energy of two charges $U_{elec} = K\frac{qq^{'}}{r} = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$

Electric potential at distance r from charge q $V = K\frac{q}{r} = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$

Electric potential at distance r from center of sphere (charge Q, radius R)

$$V = K\frac{Q}{r} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}, r > R$$

Electric field strength $E = \frac{\Delta V}{d}$

Charge on a capacitor $Q = C\Delta V_C$

Capacitance of parallel plate capacitor $C = \frac{\epsilon_0 A}{d}$

Capacitance of parallel plate capacitor with dielectric

$$C = \frac{\kappa\epsilon_0 A}{d}$$

Electric potential of capacitor with charge Q and potential difference ΔV

$$U_C = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}C(\Delta V_c)^2$$

Conservation of energy for a charge moving in a potential field

$$K_f + u_f = K_i + u_i$$

11 Quantum Numbers

Bohr energy of an hydrogen atom	$E_n = \frac{13.6\ eV}{n^2}$ where $n = 1$, 2, 3, 4, ...
Angular momentum of an electron's orbit	$L = \sqrt{\ell(\ell+1)}\hbar$ where $\ell = 0$, 1, 2, 3, ..., n-1
Magnetic quantum number	$m = -\ell, -\ell_{+1}, ...0, \ell_{-1}, \ell$
Spin quantim number	$m_s = -\frac{1}{2}$ or $+\frac{1}{2}$

12 Nuclear Physics

Half life	$N = N_0 \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$
Exponential decay	$N = N_0 \; e^{-\frac{t}{\tau}}$
Activity	$R = \frac{N}{\tau} = \frac{0.693 \; N}{t_{1/2}}$
Binding energy	$B = (Zm_H + Nm_n - m_{atom}) \times (931.49 \; MeV/u)$

13 Periodic Tables

14 Examples

$$\left\{\begin{matrix}\text{morphisms from } V \text{ to } W\\ \text{as algebraic sets}\end{matrix}\right\} \longleftrightarrow \left\{\begin{matrix}k\text{-algebra homomorphisms}\\ \text{from } k[W] \text{ to } k[V]\end{matrix}\right\}$$