
Math, Science, and Engineering Handbook

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1 Math

1.1 Integrals

- 1 $\int x^n dx = \frac{x^{n+1}}{n+1}$
- 2 $\int \frac{dx}{x} = \ln x$
- 3 $\int e^x dx = e^x$
- 4 $\int \cos(x) dx = \sin(x)$
- 5 $\int \sin(x) dx = -\cos(x)$
- 6 $\int \sec^2(x) dx = \tan(x)$
- 7 $\int \csc^2(x) dx = -\cot(x)$
- 8 $\int \sec(x) \cdot \tan(x) dx = \sec(x)$
- 9 $\int \csc(x) \cdot \cot(x) dx = -\csc(x)$
- 10 $\int \frac{dx}{\sqrt{a^2-x^2}} = \sin^{-1}\left(\frac{x}{a}\right)$
- 11 $\int \frac{dx}{a^2+x^2} = \frac{1}{a}\tan^{-1}\left(\frac{x}{a}\right)$
- 12 $\int \tan(x) dx = -\ln(\cos(x))$
- 13 $\int \cot(x) dx = \ln(\sin(x))$
- 14 $\int \sec(x) dx = \ln(\sec(x) + \tan(x))$
- 15 $\int \csc(x) dx = -\ln(\csc(x) + \cot(x))$

1.2 Formulas

Quadratic Approximation	$f(u + x) = f(u) + f'(u) \cdot x + f''(u) \cdot x^2 / 2$
FTC2	$d/dx \int_0^x f(t)dt = f(x)$
FTC2 Chain Rule	$d/dx \int_0^{g(x)} f(t)dt = g'(x) \cdot f(g(x))$
Weighted Average	$\int_a^b f(x)w(x)dx / \int_a^b w(x)dx$

1.3 L'Hôpital's Rule

$$\lim_{x \rightarrow a} f(x)/g(x) = \lim_{x \rightarrow a} f'(x)/g'(x)$$

0/0	Straight up
∞/∞	Straight up
$0 \cdot \infty$	Rewrite as quotient
0^0	Rewrite as $e^{\ln(f)}$
∞^0	Rewrite as $e^{\ln(f)}$
1^∞	Rewrite as $e^{\ln(f)}$
$\infty - \infty$	Good luck
Otherwise	Forget it.

1.4 Parametric Vector Calculus

Position	$\vec{r}(t) = x(t)\hat{i} + y(t)\hat{j}$	$\int \vec{v}(t)dt$
Velocity	$d\vec{r}(t)/dt$	$\vec{v}(t) = x'(t)\hat{i} + y'(t)\hat{j}$
Acceleration	$d\vec{v}(t)/dt$	$d^2\vec{r}(t)/dt^2$
Arc Length	$\frac{ds}{dt} = \sqrt{x'(t)^2 + y'(t)^2}$	$\int \vec{a}(t)dt$
Unit Tangent	$\vec{T} = \vec{v}/ \vec{v} $	$\frac{ds}{dt}\vec{T}$

1.5 Partial Differentiation

Approximation	$f(x, y) = z_0 + \frac{\partial f}{\partial x}(x - x_0) + \frac{\partial f}{\partial y}(y - y_0)$
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2 Science

2.1 Units

Quantity	MKS	Name	Abbrev.
Angle		radian	rad
Solid Angle		steradian	sr
Area	m^2		
Volume	m^3		
Frequency	s^{-1}	Hertz	Hz
Velocity	$m \cdot s^{-1}$		
Acceleration	$m \cdot s^{-2}$		
Angular Velocity	$rad \cdot s^{-1}$		
Angular Acceleration	$rad \cdot s^{-2}$		
Density	$kg \cdot m^{-3}$		
Momentum	$kg \cdot m \cdot s^{-1}$		
Angular Momentum	$kg \cdot m^2 \cdot s^{-1}$		
Force	$kg \cdot m \cdot s^{-2}$	Newton	N
Work, Energy	$kg \cdot m^2 \cdot s^{-2}$	Joule	J
Power	$kg \cdot m^2 \cdot s^{-3}$	Watt	W
Torque	$kg \cdot m^2 \cdot s^{-2}$		
Pressure	$kg \cdot m^{-1} \cdot s^{-2}$	Pascal	Pa

2.2 Laws

Newton's 1st Law	$\sum \mathbf{F} = 0 \Leftrightarrow \dot{\mathbf{v}}$
Newton's 2nd Law	$\mathbf{F} = m\mathbf{a} = \dot{\mathbf{p}}$
Newton's 3rd Law	$\mathbf{F}_a = -\mathbf{F}_b$
Gravity	$\mathbf{F} = m\mathbf{g}; \mathbf{g} = 9.81 \text{ m/s}^2$
Hooke's Law	$F_x = -k\Delta x; k = \text{spring constant}$
Force	$N = kg \cdot m \cdot s^{-2}$
Energy	$J = N \cdot m$
Power	$W = J \cdot s^{-1}$
Momentum	$\mathbf{p} = m \cdot \mathbf{v}$
Kinetic Energy	$K = \frac{1}{2}m\mathbf{v}^2 = \frac{\mathbf{p}^2}{2m}$
Momentum is conserved	
Energy is conserved	

2.3 Mechanics Problem Workflow

- Draw a good picture.
- Decorate with forces with a *free body diagram for each body*.
- Choose a suitable coordinate system.
- Decompose forces on each body.
- Determine acceleration for each body.
- Determine 1d equations of motion for each body, including necessary constraints.
- Reconstruct multidimensional motion vectors.
- Algebraically determine kinematics as needed.

3 Engineering

3.1 DC Ohm's Law

$$\begin{aligned} I &= \frac{E}{R} = \frac{P}{E} = \sqrt{\frac{P}{R}} \\ R &= \frac{E}{I} = \frac{E^2}{P} = \frac{P}{I^2} \\ E &= IR = \frac{P}{I} = \sqrt{PR} \\ P &= EI = I^2 R = \frac{E^2}{R} \end{aligned}$$

3.2 AC Ohm's Law

$$\begin{aligned} I &= \frac{E}{Z} = \frac{P}{E \cos(\theta)} = \sqrt{\frac{P}{Z \cos(\theta)}} \\ Z &= \frac{E}{I} = \frac{E^2 \cos(\theta)}{P} = \frac{P}{I^2 \cos(\theta)} \\ E &= IZ = \frac{P}{I \cos(\theta)} = \sqrt{\frac{PZ}{\cos(\theta)}} \\ P &= EI \cos(\theta) = I^2 Z \cos(\theta) = \frac{E^2 \cos(\theta)}{Z} \end{aligned}$$

Bibliography

- [1] Robert G. Brown, *Introductory Physics I*. <http://web-home.phy.duke.edu/rgb/Class/intro-physics-1/intro-physics-1.pdf>
- [2] Allied Radio Corporation, *Allied's Electronics Data Handbook*. <https://archive.org/details/AlliedsElectronicsDataHandbook>