$$\text{scal}_{\mathbf{w}}\mathbf{u} = |\mathbf{u}| \cdot \cos\theta = \frac{\mathbf{w}\cdot\mathbf{u}}{|\mathbf{w}|}$$

$$\text{proj}_{\mathbf{w}}\mathbf{u} = \left(\frac{\mathbf{w}\cdot\mathbf{u}}{\mathbf{w}\cdot\mathbf{w}}\right)\mathbf{w}$$

$$\text{V}_{\text{parallelepiped}} = \vec{u}\cdot(\vec{v}\times\vec{w})$$

$$S(t) = \int_a^t \left|\vec{r}\,'(s)\right| ds$$

$$\kappa(t) = \frac{|\vec{T}'(t)|}{|\vec{r}\,'(t)|}$$

$$\kappa(t) = \frac{|\vec{a}\times\vec{v}|}{|\vec{v}|^3}, \quad \kappa(t) = \frac{1}{|\vec{v}|}\left|\frac{d\vec{T}}{dt}\right|, \quad \kappa(t) = \left|\frac{d\vec{T}}{ds}\right|$$

$$|\vec{a}_\perp(t)| = \frac{|\vec{v}(t)\times\vec{a}(t)|}{|\vec{v}(t)|} = |\vec{v}(t)|^2\cdot\kappa(t)$$

$$|\vec{a}_\parallel(t)| = \frac{d}{dt}|\vec{v}(t)| = \frac{d^2}{dt^2}\int_0^t |\vec{v}(p)|dp = \frac{d^2}{dt^2}s(t)$$

$$\vec{a}(t) = |\vec{a}_\perp(t)|\cdot\frac{\vec{T}'(t)}{|\vec{T}'(t)|} + |\vec{a}_\parallel(t)|\cdot\frac{\vec{r}\,'(t)}{|\vec{r}\,'(t)|}$$

$$\vec{B} = \vec{T}\times\vec{N} = \frac{\vec{v}\times\vec{a}}{|\vec{v}\times\vec{a}|}$$

$$\vec{T} = \frac{\vec{r}\,'(t)}{|\vec{r}\,'(t)|}$$

$$\vec{N} = \frac{\vec{T}'(t)}{|\vec{T}'(t)|}$$

$$\frac{d\vec{B}}{dt} = -\tau\vec{N}$$

$$\tau = \frac{\vec{B}'(t)\cdot\vec{N}(t)}{|\vec{r}\,'(t)|}$$

$$\tau = \frac{(\vec{v}\times\vec{a})\cdot\vec{a}\,'}{|\vec{v}\times\vec{a}|^2}$$

$$H(x,y) = \begin{bmatrix} f_{xx}(x,y) & f_{xy}(x,y) \\ f_{yx}(x,y) & f_{yy}(x,y)\end{bmatrix}$$

1. If $\det(H) > 0$ and $f_{xx}(a,b) > 0$, then $f(a,b)$ is a *local minimum.*
2. If $\det(H) > 0$ and $f_{xx}(a,b) < 0$, then $f(a,b)$ is a *local maximum.*
3. If $\det(H) < 0$, then (a,b) is a *saddle point.*
4. If $\det(H) = 0$, the test is *inconclusive.*

Curve/Surface	**Equation**
$y = f(x)$	$y = f'(a)(x-a) + f(a)$
$z = f(x,y)$	$z = c + \nabla f(a,b)\cdot\langle x-a, y-b\rangle$
$F(x,y,z) = D$	$\nabla F(a,b,c)\cdot\langle x-a, y-b, z-c\rangle = 0$

$$D_{\mathbf{u}}f(a,b) = \langle f_x(a,b), f_y(a,b)\rangle\cdot\mathbf{u}$$

$$\frac{\frac{dy}{d\theta}}{\frac{dx}{d\theta}} = \frac{dy}{dx} = \frac{f'(\theta)\sin\theta + f(\theta)\cos\theta}{f'(\theta)\cos\theta - f(\theta)\sin\theta}$$

$$A = \int_\alpha^\beta \frac{1}{2}f(\theta)^2\,d\theta$$

$$S_r = \int_{\theta_1}^{\theta_2}\sqrt{\left(f'(\theta)\right)^2 + \left(f(\theta)\right)^2}\,d\theta$$

$$\det(J) = \begin{vmatrix} \frac{\partial g}{\partial u} & \frac{\partial g}{\partial v} \\ \frac{\partial h}{\partial u} & \frac{\partial h}{\partial v}\end{vmatrix} = \frac{\partial g}{\partial u}\cdot\frac{\partial h}{\partial v} - \frac{\partial g}{\partial v}\cdot\frac{\partial h}{\partial u}$$

$$\int_C f(x,y)\,ds = \int_a^b f(\mathbf{r}(t))|\mathbf{r}'(t)|\,dt$$

$$\int_C \mathbf{F}\cdot d\mathbf{r} = \int_a^b \mathbf{F}(\mathbf{r}(t))\cdot\mathbf{r}'(t)\,dt =$$

$$\int_a^b \left[P(x(t),y(t))\frac{dx}{dt} + Q(x(t),y(t))\frac{dy}{dt}\right]dt =$$

$$\iint_R \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right)dA$$

To determine whether a vector field $\mathbf{F} = (P(x,y), Q(x,y))$ is a gradient field: $\frac{\partial P}{\partial y} = \frac{\partial Q}{\partial x}$.

$$\phi(x,y) = \int P(x,y)\,dx + h(y)$$

$$\text{curl}(\mathbf{F}) = \frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}$$

$$\text{Area}(R) = \int_C x\,dy = -\int_C y\,dx = \frac{1}{2}\int_C (x\,dy - y\,dx)$$

$$\int_C \mathbf{F}\cdot\mathbf{n}\,ds = \int_a^b \left[f(x(t),y(t))y'(t) - g(x(t),y(t))x'(t)\right]dt =$$

$$\int_C f\,dy - g\,dx$$

$$\int_C \mathbf{F}\cdot\mathbf{n}\,ds = \iint_R \text{div}(\mathbf{F})\,dA$$

$$\text{div}(\mathbf{F}) = \frac{\partial f}{\partial x} + \frac{\partial g}{\partial y}$$

$$\sin^2\theta + \cos^2\theta = 1$$
$$1 + \tan^2\theta = \sec^2\theta, \quad 1 + \cot^2\theta = \csc^2\theta$$
$$\sin(-\theta) = -\sin\theta, \quad \cos(-\theta) = \cos\theta$$
$$\tan(-\theta) = -\tan\theta, \quad \csc(-\theta) = -\csc\theta$$

$$\sin(a \pm b) = \sin a \cos b \pm \cos a \sin b$$
$$\cos(a \pm b) = \cos a \cos b \mp \sin a \sin b$$
$$\tan(a \pm b) = \frac{\tan a \pm \tan b}{1 \mp \tan a \tan b}$$

$$\sin(2\theta) = 2\sin\theta\cos\theta$$
$$\cos(2\theta) = \cos^2\theta - \sin^2\theta = 2\cos^2\theta - 1 = 1 - 2\sin^2\theta$$
$$\tan(2\theta) = \frac{2\tan\theta}{1 - \tan^2\theta}$$
$$\sin^2\theta = \frac{1 - \cos(2\theta)}{2}, \quad \cos^2\theta = \frac{1 + \cos(2\theta)}{2}$$

$$\sin a \sin b = \frac{1}{2}[\cos(a-b) - \cos(a+b)]$$
$$\cos a \cos b = \frac{1}{2}[\cos(a-b) + \cos(a+b)]$$
$$\sin a \cos b = \frac{1}{2}[\sin(a+b) + \sin(a-b)]$$

$$\sin a + \sin b = 2\sin\left(\frac{a+b}{2}\right)\cos\left(\frac{a-b}{2}\right)$$
$$\sin a - \sin b = 2\cos\left(\frac{a+b}{2}\right)\sin\left(\frac{a-b}{2}\right)$$
$$\cos a + \cos b = 2\cos\left(\frac{a+b}{2}\right)\cos\left(\frac{a-b}{2}\right)$$
$$\cos a - \cos b = -2\sin\left(\frac{a+b}{2}\right)\sin\left(\frac{a-b}{2}\right)$$

$$\int \sin x \, dx = -\cos x + C$$
$$\int \cos x \, dx = \sin x + C$$
$$\int \sec^2 x \, dx = \tan x + C$$

$$\int \csc^2 x \, dx = -\cot x + C$$
$$\int \sec x \tan x \, dx = \sec x + C$$
$$\int \csc x \cot x \, dx = -\csc x + C$$

$$\int \frac{1}{\sqrt{1-x^2}} \, dx = \arcsin x + C$$
$$\int \frac{-1}{\sqrt{1-x^2}} \, dx = \arccos x + C$$
$$\int \frac{1}{1+x^2} \, dx = \arctan x + C$$
$$\int \frac{-1}{1+x^2} \, dx = \operatorname{arccot} x + C$$
$$\int \sin^2 x \, dx = \frac{x}{2} - \frac{\sin(2x)}{4} + C$$
$$\int \cos^2 x \, dx = \frac{x}{2} + \frac{\sin(2x)}{4} + C$$
$$\int \sin^n x \cos^m x \, dx$$

(Use reduction formulas)

$$\int \sin^2 x \, dx = \int \frac{1 - \cos(2x)}{2} \, dx$$
$$\int \cos^2 x \, dx = \int \frac{1 + \cos(2x)}{2} \, dx$$

$$\int \tan x \, dx = \ln|\sec x| + C$$
$$\int \cot x \, dx = \ln|\sin x| + C$$
$$\int \sec x \, dx = \ln|\sec x + \tan x| + C$$
$$\int \csc x \, dx = \ln|\csc x - \cot x| + C$$

$$\int \sqrt{a^2 - x^2} \, dx \quad (x = a\sin\theta)$$
$$\int \sqrt{x^2 + a^2} \, dx \quad (x = a\tan\theta)$$
$$\int \sqrt{x^2 - a^2} \, dx \quad (x = a\sec\theta)$$