$$\overline{v}\cdot\overline{w} = |\overline{v}||\overline{w}|\cos(\theta) = \overline{v}_1\overline{w}_1 + \dots \overline{v}_n\overline{w}_n$$

$$\text{Proj}_{\overline{v}}(\overline{F}) = \left(\frac{\overline{F}\cdot\overline{v}}{|\overline{v}|^2}\right)\overline{v}$$

$$\text{Eq } \perp \overline{n} \to \overline{n}\cdot\langle x - x_o, y - y_o, \dots\rangle = 0$$

$$|\overline{v}\times\overline{w}| = |\overline{v}||\overline{w}|\sin(\theta)$$

Parametrization: $\overline{r}(t) = \overline{r}_o + t\overline{v}$

Or: $\overline{r}(t) = \overline{r}(p) + t\overline{r}_u(p) + s\overline{r}_v(p)$

Point to point: $\overline{r}(t) = (1-t)\overline{p} + t\overline{q}, 0 \xrightarrow{t} 1$

$$L_f(x,y) \approx f(a,b) + f_x(a,b)(x-a) + f_y(a,b)(y-b)$$

$$\frac{df}{dt} = \frac{\delta f}{\delta x}\frac{dx}{dt} + \frac{\delta f}{\delta y}\frac{dy}{dt} + \dots = \nabla f\cdot\frac{d\overline{x}}{dt}$$

$$D_{\overline{u}}f(p) = \nabla f(p)\cdot\overline{u}$$

Max. magnitude: $\dfrac{\nabla f(p)}{|\nabla f(p)|}$

Min. magnitude: $-\dfrac{\nabla f(p)}{|\nabla f(p)|}$

Max/Min Rate of Change: $\pm|\nabla f(p)|$

Lagrange Multipliers: $\overline{\nabla} f = \lambda\overline{\nabla} g$

$$D = f_{xx}(p)f_{yy}(p) - f_{xy}^2(p)$$

Degenerate if $D = 0$

If $D > 0$, and $f_{xx}(p) > 0$, min

If $D > 0$, and $f_{xx}(p) < 0$, max

If $D < 0$, saddle point

$$V = \iiint_S dV$$

$$= \iiint_S r\,dr\,d\theta\,dz \begin{cases} x = r\cos(\theta) \\ y = r\sin(\theta) \\ z = z \\ x^2 + y^2 = r^2 \end{cases}$$

$$= \iiint_S \rho^2\sin(\phi)\,d\rho\,d\phi\,d\theta \begin{cases} x = \rho\sin(\phi)\cos(\theta) \\ y = \rho\sin(\phi)\sin(\theta) \\ z = \rho\cos(\phi) \\ x^2 + y^2 + z^2 = \rho^2 \end{cases}$$

Surface Area: $\displaystyle\iint_D |\overline{r}_u\times\overline{r}_v|\,du\,dv$

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

Gradient: ∇f

Divergence: $\nabla\cdot f$

Curl: $\nabla\times f$

$$\int_C P\,dx + Q\,dy + R\,dz =$$

$$\int_C (P\cdot x'(t) + Q\cdot y'(t) + R\cdot z'(t))\,dt$$

If conservative: $\displaystyle\int_C \overline{F}\cdot d\overline{r} = f(B) - f(A)$

Where $\overline{F} = \nabla f$

Cons. if: $\text{curl}(\overline{F}) = 0$

Green's Theorem:

$$\int_{\delta R} \overline{F}\,d\overline{r} = \iint_R Q_x - P_y\,dA$$

Flux: $\displaystyle\iint_{D(u,v)} V(\overline{r}(u,v))\cdot(\overline{r}_u\times\overline{r}_v)\,du\,dv$

Stokes' Theorem:

$$\int_{\delta M} \overline{F}\,d\overline{r} = \iint_M (\text{curl}(\overline{F})\cdot\overline{n})\,dS$$

$$= \iint_M (Q_x - P_y)\,dA$$

Divergence Theorem:

$$\iint_{\delta E} (\overline{F}\cdot\overline{n})\,dS = \iiint_E \text{div}(\overline{F})\,dV$$