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

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

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

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

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

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

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

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

Max/Min Direction: $\pm \dfrac{\nabla f(p)}{|\nabla f(p)|}$

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

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

$$V = \iiint_S dV$$

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

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

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

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

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:

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

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

Divergence Theorem:

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

Stokes' Theorem:

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