

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

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

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

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

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

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

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

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

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

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

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

$$\text{Degenerate if } D = 0$$

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

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

$$\text{If } D < 0, \text{ saddle point}$$

$$\begin{aligned} V &= \iiint_S dV \\ &= \iiint_S r \, dr \, d\theta \, dz \\ &= \iiint_S \rho^2 \sin(\phi) \, d\rho \, d\phi \, d\theta \end{aligned}$$

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

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

$$\text{Gradient: } \nabla f$$

$$\text{Divergence: } \nabla \cdot f$$

$$\text{Curl: } \nabla \times f$$

$$\begin{aligned} \int_C P \, dx + Q \, dy + R \, dz &= \\ \int_C (P \cdot x'(t) + Q \cdot y'(t) + R \cdot z'(t)) \, dt \end{aligned}$$

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

$$\text{Where } \bar{F} = \nabla f$$

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

$$\text{Green's Theorem:}$$

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

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

$$\bar{n} = \frac{\bar{r}_u \times \bar{r}_v}{|\bar{r}_u \times \bar{r}_v|}$$

$$\text{Divergence Theorem:}$$

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

$$\text{Stokes' Theorem:}$$

$$\begin{aligned} \int_{\delta M} \bar{F} \, d\bar{r} &= \iint_M (\text{curl}(\bar{F}) \cdot \bar{n}) \, dS \\ &= \iint_M (Q_x - P_y) \, dA \end{aligned}$$