# Derivatives

$D_x e^x = e^x$
$D_x \sin(x) = \cos(x)$
$D_x \cos(x) = -\sin(x)$
$D_x \tan(x) = \sec^2(x)$
$D_x \cot(x) = -\csc^2(x)$
$D_x \sec(x) = \sec(x)\tan(x)$
$D_x \csc(x) = -\csc(x)\cot(x)$
$D_x \sin^{-1} = \frac{1}{\sqrt{1-x^2}}, x \in [-1,1]$
$D_x \cos^{-1} = \frac{-1}{\sqrt{1-x^2}}, x \in [-1,1]$
$D_x \tan^{-1} = \frac{1}{1+x^2}, \frac{-\pi}{2} \leq x \leq \frac{\pi}{2}$
$D_x \sec^{-1} = \frac{1}{|x|\sqrt{x^2-1}}, |x| > 1$
$D_x \sinh(x) = \cosh(x)$
$D_x \cosh(x) = \sinh(x)$
$D_x \tanh(x) = sech^2(x)$
$D_x \coth(x) = -csch^2(x)$
$D_x sech(x) = -sech(x)\tanh(x)$
$D_x csch(x) = -csch(x)\coth(x)$
$D_x \sinh^{-1} = \frac{1}{\sqrt{x^2+1}}$
$D_x \cosh^{-1} = \frac{-1}{\sqrt{x^2-1}}, x > 1$
$D_x \tanh^{-1} = \frac{1}{1-x^2} - 1 < x < 1$
$D_x sech^{-1} = \frac{-1}{x\sqrt{1-x^2}}, 0 < x < 1$
$D_x \ln(x) = \frac{1}{x}$

# Integrals

$\int \frac{1}{x} dx = \ln|x| + c$
$\int e^x dx = e^x + c$
$\int a^x dx = \frac{1}{\ln a} a^x + c$
$\int e^{ax} dx = \frac{1}{a} e^{ax} + c$
$\int \frac{1}{\sqrt{1-x^2}} dx = \sin^{-1}(x) + c$
$\int \frac{1}{1+x^2} dx = \tan^{-1}(x) + c$
$\int \frac{1}{x\sqrt{x^2-1}} dx = \sec^{-1}(x) + c$
$\int \sinh(x) dx = \cosh(x) + c$
$\int \cosh(x) dx = \sinh(x) + c$
$\int \tanh(x) dx = \ln|\cosh(x)| + c$
$\int \tanh(x) sech(x) dx = -sech(x) + c$
$\int sech^2(x) dx = \tanh(x) + c$
$\int csch(x)\coth(x) dx = -csch(x) + c$
$\int \tan(x) dx = -\ln|\cos(x)| + c$
$\int \cot(x) dx = \ln|\sin(x)| + c$
$\int \cos(x) dx = \sin(x) + c$
$\int \sin(x) dx = -\cos(x) + c$
$\int \frac{1}{\sqrt{a^2-u^2}} dx = \sin^{-1}(\frac{u}{a}) + c$
$\int \frac{1}{a^2+u^2} dx = \frac{1}{a}\tan^{-1}\frac{u}{a} + c$
$\int ln(x) dx = (xln(x)) - x + c$

**U-Substitution**
Let $u = f(x)$ (can be more than one variable).
Determine: $du = \frac{f(x)}{dx} dx$ and solve for dx.
Then, if a definite integral, substitute the bounds for $u = f(x)$ at each bounds
Solve the integral using u.

**Integration by Parts**
$\int udv = uv - \int vdu$

# Fns and Identities

$\sin(\cos^{-1}(x)) = \sqrt{1-x^2}$
$\cos(\sin^{-1}(x)) = \sqrt{1-x^2}$
$\sec(\tan^{-1}(x)) = \sqrt{1+x^2}$
$\tan(\sec^{-1}(x))$
$= (\sqrt{x^2-1} \text{ if } x \geq 1)$
$= (-\sqrt{x^2-1}\ if\ x \leq -1)$
$\sinh^{-1}(x) = \ln x + \sqrt{x^2+1}$
$\sinh^{-1}(x) = \ln x + \sqrt{x^2-1},\ x \geq -1$
$\tanh^{-1}(x) = \frac{1}{2}\ln x + \frac{1+x}{1-x},\ 1 < x < -1$
$sech^{-1}(x) = \ln[\frac{1+\sqrt{1-x^2}}{x}],\ 0 < x \leq -1$
$\sinh(x) = \frac{e^x - e^{-x}}{2}$
$\cosh(x) = \frac{e^x + e^{-x}}{2}$

# Trig Identities

$\sin^2(x) + \cos^2(x) = 1$
$1 + \tan^2(x) = \sec^2(x)$
$1 + \cot^2(x) = \csc^2(x)$
$\sin(x \pm y) = \sin(x)\cos(y) \pm \cos(x)\sin(y)$
$\cos(x \pm y) = \cos(x)\cos(y) \pm \sin(x)\sin(y)$
$\tan(x \pm y) = \frac{\tan(x) \pm \tan(y)}{1 \mp \tan(x)\tan(y)}$
$\sin(2x) = 2\sin(x)\cos(x)$
$\cos(2x) = \cos^2(x) - \sin^2(x)$
$\cosh(n^2x) - \sinh^2 x = 1$
$1 + \tan^2(x) = \sec^2(x)$
$1 + \cot^2(x) = \csc^2(x)$
$\sin^2(x) = \frac{1-\cos(2x)}{2}$
$\cos^2(x) = \frac{1+\cos(2x)}{2}$
$\tan^2(x) = \frac{1-\cos(2x)}{1+\cos(2x)}$
$\sin(-x) = -\sin(x)$
$\cos(-x) = \cos(x)$
$\tan(-x) = -\tan(x)$

# Calculus 3 Concepts

## Cartesian coords in 3D

given two points:
$(x_1, y_1, z_1)$ and $(x_2, y_2, z_2)$,
Distance between them:
$\sqrt{(x_1-x_2)^2 + (y_1-y_2)^2 + (z_1-z_2)^2}$
Midpoint:
$(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}, \frac{z_1+z_2}{2})$
Sphere with center (h,k,l) and radius r:
$(x-h)^2 + (y-k)^2 + (z-l)^2 = r^2$

## Vectors

Vector: $\vec{u}$
Unit Vector: $\hat{u}$
Magnitude: $||\vec{u}|| = \sqrt{u_1^2 + u_2^2 + u_3^2}$
Unit Vector: $\hat{u} = \frac{\vec{u}}{||\vec{u}||}$

**Dot Product**
$\vec{u} \cdot \vec{v}$
Produces a Scalar
(Geometrically, the dot product is a vector projection)
$\vec{u} = < u_1, u_2, u_3 >$
$\vec{v} = < v_1, v_2, v_3 >$
$\vec{u} \cdot \vec{v} = \vec{0}$ means the two vectors are Perpendicular $\theta$ is the angle between them.
$\vec{u} \cdot \vec{v} = ||\vec{u}||\ ||\vec{v}|| \cos(\theta)$
$\vec{u} \cdot \vec{v} = u_1v_1 + u_2v_2 + u_3v_3$
NOTE:
$\hat{u} \cdot \hat{v} = \cos(\theta)$
$||\vec{u}||^2 = \vec{u} \cdot \vec{u}$
$\vec{u} \cdot \vec{v} = 0$ when $\perp$
Angle Between $\vec{u}$ and $\vec{v}$:
$\theta = \cos^{-1}(\frac{\vec{u} \cdot \vec{v}}{||\vec{u}||\ ||\vec{v}||})$

Projection of $\vec{u}$ onto $\vec{v}$:
$pr_{\vec{v}}\vec{u} = (\frac{\vec{u} \cdot \vec{v}}{||\vec{v}||^2})\vec{v}$

**Cross Product**
$\vec{u} \times \vec{v}$
Produces a Vector
(Geometrically, the cross product is the area of a paralellogram with sides $||\vec{u}||$ and $||\vec{v}||$)
$\vec{u} = < u_1, u_2, u_3 >$
$\vec{v} = < v_1, v_2, v_3 >$

$$\vec{u} \times \vec{v} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ u_1 & u_2 & u_3 \\ v_1 & v_2 & v_3 \end{vmatrix}$$

$\vec{u} \times \vec{v} = \vec{0}$ means the vectors are paralell

## Lines and Planes

**Equation of a Plane**
$(x_0, y_0, z_0)$ is a point on the plane and $< A, B, C >$ is a normal vector

$A(x - x_0) + B(y - y_0) + C(z - z_0) = 0$
$< A, B, C > \cdot < x - x_0, y - y_0, z - z_0 > = 0$
$Ax + By + Cz = D$ where
$D = Ax_0 + By_0 + Cz_0$

**Equation of a line**
A line requires a Direction Vector $\vec{u} = < u_1, u_2, u_3 >$ and a point $(x_1, y_1, z_1)$
then,
a parameterization of a line could be:
$x = u_1t + x_1$
$y = u_2t + y_1$
$z = u_3t + z_1$

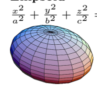
**Distance from a Point to a Plane**
The distance from a point $(x_0, y_0, z_0)$ to a plane Ax+By+Cz=D can be expressed by the formula:
$d = \frac{|Ax_0 + By_0 + Cz_0 - D|}{\sqrt{A^2+B^2+C^2}}$

## Coord Sys Conv

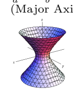
**Cylindrical to Rectangular**
$x = r\cos(\theta)$
$y = r\sin(\theta)$
$z = z$
**Rectangular to Cylindrical**
$r = \sqrt{x^2 + y^2}$
$\tan(\theta) = \frac{y}{x}$
$z = z$
**Spherical to Rectangular**
$x = \rho\sin(\phi)\cos(\theta)$
$y = \rho\sin(\phi)\sin(\theta)$
$z = \rho\cos(\phi)$
**Rectangular to Spherical**
$\rho = \sqrt{x^2 + y^2 + z^2}$
$\tan(\theta) = \frac{y}{x}$
$\cos(\phi) = \frac{z}{\sqrt{x^2+y^2+z^2}}$
**Spherical to Cylindrical**
$r = \rho\sin(\phi)$
$\theta = \theta$
$z = \rho\cos(\phi)$
**Cylindrical to Spherical**
$\rho = \sqrt{r^2 + z^2}$
$\theta = \theta$
$\cos(\phi) = \frac{z}{\sqrt{r^2+z^2}}$

# Surfaces

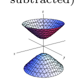
**Ellipsoid**
$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$



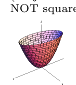
**Hyperboloid of One Sheet**
$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = 1$
(Major Axis: z because it follows - )



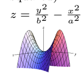
**Hyperboloid of Two Sheets**
$\frac{z^2}{c^2} - \frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$
(Major Axis: Z because it is the one not subtracted)



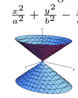
**Elliptic Paraboloid**
$z = \frac{x^2}{a^2} + \frac{y^2}{b^2}$
(Major Axis: z because it is the variable NOT squared)



**Hyperbolic Paraboloid**
(Major Axis: Z axis because it is not squared)
$z = \frac{y^2}{b^2} - \frac{x^2}{a^2}$



**Elliptic Cone**
(Major Axis: Z axis because it's the only one being subtracted)
$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = 0$



**Cylinder**
1 of the variables is missing
OR
$(x - a)^2 + (y - b^2) = c$
(Major Axis is missing variable)

## Partial Derivatives

Partial Derivatives are simply holding all other variables constant (and act like constants for the derivative) and only taking the derivative with respect to a given variable.

Given z=f(x,y), the partial derivative of z with respect to x is:
$f_x(x, y) = z_x = \frac{\partial z}{\partial x} = \frac{\partial f(x,y)}{\partial x}$
likewise for partial with respect to y:
$f_y(x, y) = z_y = \frac{\partial z}{\partial y} = \frac{\partial f(x,y)}{\partial y}$
**Notation**
For $f_{xyy}$, work "inside to outside" $f_x$ then $f_{xy}$, then $f_{xyy}$
$f_{xyy} = \frac{\partial^3 f}{\partial^2 y \partial x}$,
For $\frac{\partial^3 f}{\partial^2 y \partial x}$, work right to left in the denominator

## Gradients

The Gradient of a function in 2 variables is $\nabla f = < f_x, f_y >$
The Gradient of a function in 3 variables is $\nabla f = < f_x, f_y, f_z >$

## Chain Rule(s)

Take the Partial derivative with respect to the first-order variables of the function times the partial (or normal) derivative of the first-order variable to the ultimate variable you are looking for summed with the same process for other first-order variables this makes sense for.
Example:
let x = x(s,t), y = y(t) and z = z(x,y).
z then has first partial derivative:
$\frac{\partial z}{\partial x}$ and $\frac{\partial z}{\partial y}$
x has the partial derivatives:
$\frac{\partial x}{\partial s}$ and $\frac{\partial x}{\partial t}$
and y has the derivative:
$\frac{dy}{dt}$
In this case (with z containing x and y as well as x and y both containing s and t), the chain rule for $\frac{\partial z}{\partial s}$ is $\frac{\partial z}{\partial s} = \frac{\partial z}{\partial x}\frac{\partial x}{\partial s}$
The chain rule for $\frac{\partial z}{\partial t}$ is
$\frac{\partial z}{\partial t} = \frac{\partial z}{\partial x}\frac{\partial x}{\partial t} + \frac{\partial z}{\partial y}\frac{dy}{dt}$
Note: the use of "d" instead of "$\partial$" with the function of only one independent variable

## Limits and Continuity

**Limits in 2 or more variables**
Limits taken over a vectorized limit just evaluate separately for each component of the limit.
**Strategies to show limit exists**
1. Plug in Numbers, Everything is Fine
2. Algebraic Manipulation
-factoring/dividing out
-use trig identites
3. Change to polar coords
$if(x, y) \to (0, 0) \Leftrightarrow r \to 0$
**Strategies to show limit DNE**
1. Show limit is different if approached from different paths
(x=y, $x = y^2$, etc.)
2. Switch to Polar coords and show the limit DNE.
**Continuity**
A fn, $z = f(x, y)$, is continuous at (a,b) if
$f(a, b) = \lim_{(x,y)\to(a,b)} f(x, y)$
Which means:
1. The limit exists
2. The fn value is defined
3. They are the same value

## Directional Derivatives

Let z=f(x,y) be a fuction, (a,b) ap point in the domain (a valid input point) and $\hat{u}$ a unit vector (2D).
The Directional Derivative is then the derivative at the point (a,b) in the direction of $\hat{u}$ or:
$D_{\vec{u}} f(a, b) = \hat{u} \cdot \nabla f(a, b)$
This will return a *scalar*. 4-D version:
$D_{\vec{u}} f(a, b, c) = \hat{u} \cdot \nabla f(a, b, c)$

## Tangent Planes

let F(x,y,z) = k be a surface and P = $(x_0, y_0, z_0)$ be a point on that surface.
Equation of a Tangent Plane:
$\nabla F(x_0, y_0, z_0) \cdot < x - x_0, y - y_0, z - z_0 >$

## Approximations

let $z = f(x, y)$ be a differentiable function total differential of f = dz
$dz = \nabla f \cdot < dx, dy >$
This is the *approximate* change in z
The actual change in z is the difference in z values:
$\Delta z = z - z_1$

## Maxima and Minima

**Internal Points**
1. Take the Partial Derivatives with respect to X and Y ($f_x$ and $f_y$) (Can use gradient)
2. Set derivatives equal to 0 and use to solve system of equations for x and y
3. Plug back into original equation for z. Use Second Derivative Test for whether points are local max, min, or saddle

**Second Partial Derivative Test**
1. Find all (x,y) points such that $\nabla f(x, y) = \vec{0}$
2. Let $D = f_{xx}(x, y)f_{yy}(x, y) - f_{xy}^2(x, y)$
IF (a) D > 0 AND $f_{xx} < 0$, f(x,y) is local max value
(b) D > 0 AND $f_{xx}(x, y) > 0$ f(x,y) is local min value
(c) D < 0, (x,y,f(x,y)) is a saddle point
(d) D = 0, test is inconclusive
3. Determine if any boundary point gives min or max. Typically, we have to parametrize boundary and then reduce to a Calc 1 type of min/max problem to solve.
**The following only apply only if a boundary is given**
1. check the corner points
2. Check each line (0 ≤ x ≤ 5 would give x=0 and x=5 )
On Bounded Equations, this is the global min and max...second derivative test is not needed.

## Lagrange Multipliers

Given a function f(x,y) with a constraint g(x,y), solve the following system of equations to find the max and min points on the constraint (NOTE: may need to also find internal points.):
$\nabla f = \lambda \nabla g$
$g(x, y) = 0 (orkifgiven)$

## Double Integrals

With Respect to the xy-axis, if taking an integral,
$\int\int dydx$ is cutting in vertical rectangles,
$\int\int dxdy$ is cutting in horizontal rectangles

**Polar Coordinates**
When using polar coordinates,
$dA = rdrd\theta$

## Surface Area of a Curve

let z = f(x,y) be continuous over S (a closed Region in 2D domain)
Then the surface area of z = f(x,y) over S is:
$SA = \int\int_S \sqrt{f_x^2 + f_y^2 + 1} dA$

## Triple Integrals

$\int\int\int_s f(x, y, z) dv =$
$\int_{a_1}^{a_2} \int_{\phi_1(x)}^{\phi_2(x)} \int_{\psi_1(x,y)}^{\psi_2(x,y)} f(x, y, z) dzdydx$
Note: $dv$ can be exchanged for $dxdydz$ in any order, but you must then choose your limits of integration according to that order

## Jacobian Method

$\int\int_G f(g(u, v), h(u, v))|J(u, v)| dudv =$
$\int\int_R f(x, y) dxdy$

$$J(u, v) = \begin{vmatrix} \frac{\partial x}{\partial u} & \frac{\partial x}{\partial v} \\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v} \end{vmatrix}$$

Common Jacobians:
Rect. to Cylindrical: $r$
Rect. to Spherical: $\rho^2\sin(\phi)$

## Vector Fields

let $f(x, y, z)$ be a scalar field and
$\vec{F}(x, y, z) =$
$M(x, y, z)\hat{i} + N(x, y, z)\hat{j} + P(x, y, z)\hat{k}$ be a vector field,
Grandient of f = $\nabla f = < \frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z} >$
Divergence of $\vec{F}$:
$\nabla \cdot \vec{F} = \frac{\partial M}{\partial x} + \frac{\partial N}{\partial y} + \frac{\partial P}{\partial z}$
Curl of $\vec{F}$:

$$\nabla \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ M & N & P \end{vmatrix}$$

## Line Integrals

C given by $x = x(t), y = y(t), t \in [a, b]$
$\int_c f(x, y) ds = \int_a^b f(x(t), y(t)) ds$
where $ds = \sqrt{(\frac{dx}{dt})^2 + (\frac{dy}{dt})^2} dt$
or $\sqrt{1 + (\frac{dy}{dx})^2} dx$
or $\sqrt{1 + (\frac{dx}{dy})^2} dy$
To evaluate a Line Integral,
· get a paramaterized version of the line (usually in terms of t, though in exclusive terms of x or y is ok)
· evaluate for the derivatives needed (usually dy, dx, and/or dt)
· plug in to original equation to get in terms of the independant variable
· solve integral

**Work**
Let $\vec{F} = M\hat{i} + \hat{j} + \hat{k}$ (force)
$M = M(x, y, z), N = N(x, y, z), P = P(x, y, z)$
(Literally)$d\vec{r} = dx\hat{i} + dy\hat{j} + dz\hat{k}$
Work $w = \int_c \vec{F} \cdot d\vec{r}$
(Work done by moving a particle over curve C with force $\vec{F}$)

## Independence of Path

**Fund Thm of Line Integrals**
C is curve given by $\vec{r}(t), t \in [a, b]$;
$\vec{r}'(t)$ exists. If $f(\vec{r})$ is continuously differentiable on an open set containing C, then $\int_c \nabla f(\vec{r}) \cdot d\vec{r} = f(\vec{b}) - f(\vec{a})$
**Equivalent Conditions**
$\vec{F}(\vec{r})$ continuous on open connected set D. Then,
$(a)\vec{F} = \nabla f$ for some fn f. (if $\vec{F}$ is conservative)
$\Leftrightarrow (b) \int_c \vec{F}(\vec{r}) \cdot d\vec{r} isindep.ofpathinD$
$\Leftrightarrow (c) \int_c \vec{F}(\vec{r}) \cdot d\vec{r} = 0$ for all closed paths in D.
**Conservation Theorem**
$\vec{F} = M\hat{i} + N\hat{j} + P\hat{k}$ continuously differentiable on open, simply connected set D.
$\vec{F}$ conservative $\Leftrightarrow \nabla \times \vec{F} = \vec{0}$
(in 2D $\nabla \times \vec{F} = \vec{0}$ iff $M_y = N_x$)

## Green's Theorem

(method of changing line integral for double integral - Use for Flux and Circulation across 2D curve and line integrals over a closed boundary)
$\oint Mdy - Ndx = \int\int_R (M_x + N_y) dxdy$
$\oint Mdx + Ndy = \int\int_R (N_x - M_y) dxdy$
Let:
·R be a region in xy-plane
·C is simple, closed curve enclosing R (w/ paramerization $\vec{r}(t)$)
$\cdot\vec{F}(x, y) = M(x, y)\hat{i} + N(x, y)\hat{j}$ be continuously differentiable over R∪C.
**Form 1: Flux Across Boundary**
$\vec{n}$ = unit normal vector to C
$\oint_c \vec{F} \cdot \vec{n} = \int\int_R \nabla \cdot \vec{F} dA$
$\Leftrightarrow \oint Mdy - Ndx = \int\int_R (M_x + N_y) dxdy$
**Form 2: Circulation Along Boundary**
$\oint_c \vec{F} \cdot d\vec{r} = \int\int_R \nabla \times \vec{F} \cdot \hat{u} dA$
$\Leftrightarrow \oint Mdx + Ndy = \int\int_R (N_x - M_y) dxdy$
**Area of R**
$A = \oint(\frac{-1}{2} ydx + \frac{1}{2} xdy)$

## Gauss' Divergence Thm

(3D Analog of Green's Theorem - Use for Flux over a 3D surface) Let:
$\cdot\vec{F}(x, y, z)$ be vector field continuously differentiable in solid S
·S is a 3D solid $\cdot\partial S$ boundary of S (A Surface)
$\cdot\hat{n}$unit outer normal to $\partial S$
Then,
$\int\int_{\partial S} \vec{F}(x, y, z) \cdot \hat{n} dS = \int\int\int_S \nabla \cdot \vec{F} dV$
(dV = dxdydz)

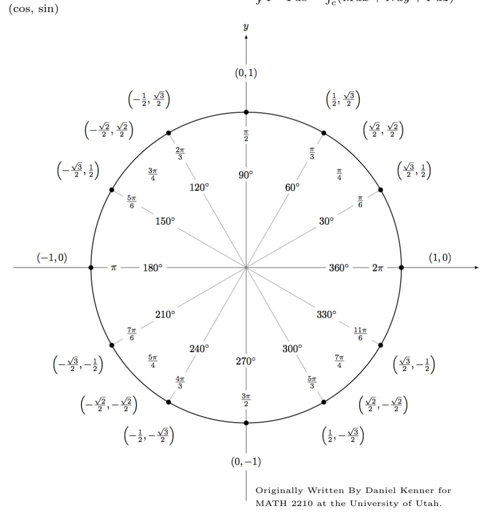
## Surface Integrals

Let
·R be closed, bounded region in xy-plane
·f be a fn with first order partial derivatives on R
·G be a surface over R given by
$z = f(x, y)$
$\cdot g(x, y, z) = g(x, y, f(x, y))$ is cont. on R
Then,
$\int\int_G g(x, y, z) dS =$
$\int\int_R g(x, y, f(x, y)) dS$
where $dS = \sqrt{f_x^2 + f_y^2 + 1} dydx$

**Flux of $\vec{F}$ across G**
$\int\int_G \vec{F} \cdot ndS =$
$\int\int_R [-Mf_x - Nf_y + P] dxdy$
where:
$\cdot\vec{F}(x, y, z) =$
$M(x, y, z)\hat{i} + N(x, y, z)\hat{j} + P(x, y, z)\hat{k}$
·G is surface f(x,y)=z
$\cdot\vec{n}$ is upward unit normal on G.
·f(x,y) has continuous $1^{st}$ order partial derivatives

## Unit Circle

(cos, sin)




## Other Information

$\frac{\sqrt{a}}{\sqrt{b}} = \sqrt{\frac{a}{b}}$
Where a Cone is defined as
$z = \sqrt{a(x^2 + y^2)}$,
In Spherical Coordinates,
$\phi = \cos^{-1}(\sqrt{\frac{a}{1+a}})$

Right Circular Cylinder:
$V = \pi r^2 h, SA = \pi r^2 + 2\pi rh$
$\lim_{n\to\inf}(1 + \frac{m}{n})^{pn} = e^{mp}$
Law of Cosines:
$a^2 = b^2 + c^2 - 2bc(\cos(\theta))$

## Stokes Theorem

Let:
·S be a 3D surface
$\cdot\vec{F}(x, y, z) =$
$M(x, y, z)\hat{i} + N(x, y, z)\hat{j} + P(x, y, z)\hat{l}$
·M,N,P have continuous $1^{st}$ order partial derivatives
·C is piece-wise smooth, simple, closed, curve, positively oriented
$\cdot\hat{T}$ is unit tangent vector to C.
Then,
$\oint \vec{F}_c \cdot \hat{T} dS = \int\int_s (\nabla \times \vec{F}) \cdot \hat{n} dS =$
$\int\int_R (\nabla \times \vec{F}) \cdot \vec{n} dxdy$
Remember:
$\oint \vec{F} \cdot \vec{T} ds = \int_c (Mdx + Ndy + Pdz)$

Originally Written By Daniel Kenner for MATH 2210 at the University of Utah.
Source code available at
https://github.com/keytotime/Calc3_CheatSheet
Thanks to Kelly Macarthur for Teaching and Providing Notes.