

**Projections and distances**      $\text{proj}_{\mathbf{A}} \mathbf{B} = \left( \frac{\mathbf{A} \cdot \mathbf{B}}{\mathbf{A} \cdot \mathbf{A}} \right) \mathbf{A}$       $d = \frac{|\overrightarrow{PS} \times \mathbf{v}|}{|\mathbf{v}|}$       $d = \left| \overrightarrow{PS} \cdot \frac{\mathbf{n}}{|\mathbf{n}|} \right|$

**Arc length, frenet formulas, and tangential and normal acceleration components**

$ds = |\mathbf{v}| dt$       $\mathbf{T} = \frac{d\mathbf{r}}{ds} = \frac{\mathbf{v}}{|\mathbf{v}|}$       $\mathbf{N} = \frac{d\mathbf{T}/ds}{|d\mathbf{T}/ds|} = \frac{d\mathbf{T}/dt}{|d\mathbf{T}/dt|}$       $\mathbf{B} = \mathbf{T} \times \mathbf{N}$

$\frac{d\mathbf{T}}{ds} = \kappa \mathbf{N}$       $\frac{d\mathbf{B}}{ds} = -\tau \mathbf{N}$       $\kappa = \left| \frac{d\mathbf{T}}{ds} \right| = \frac{|\mathbf{v} \times \mathbf{a}|}{|\mathbf{v}|^3} = \frac{|f''(x)|}{|1 + (f'(x))^2|^{3/2}} = \frac{|\dot{x}\ddot{y} - \dot{y}\ddot{x}|}{|\dot{x}^2 + \dot{y}^2|^{3/2}}$       $\tau = -\frac{d\mathbf{B}}{ds} \cdot \mathbf{N}$

$\mathbf{a} = a_N \mathbf{N} + a_T \mathbf{T}$       $a_T = \frac{d|\mathbf{v}|}{dt}$       $a_N = \kappa |\mathbf{v}|^2 = \sqrt{|\mathbf{a}|^2 - a_T^2}$

**Directional derivative, discriminant, and Lagrange multipliers**

$\frac{df}{ds} = (\nabla f) \cdot \mathbf{u}$       $f_{xx}f_{yy} - (f_{xy})^2$       $\nabla f = \lambda \nabla g, \quad g = 0$

**Polar coordinates**      $x = r \cos \theta$       $y = r \sin \theta$       $r^2 = x^2 + y^2$       $dA = dx dy = r dr d\theta$

**Cylindrical and spherical coordinates**

Cylindrical to Rectangular	Spherical to Cylindrical	Spherical to Rectangular
$x = r \cos \theta$	$r = \rho \sin \phi$	$x = \rho \sin \phi \cos \theta$
$y = r \sin \theta$	$z = \rho \cos \phi$	$y = \rho \sin \phi \sin \theta$
$z = z$	$\theta = \theta$	$z = \rho \cos \phi$

$dV = dx dy dz = dz r d\theta dr = \rho^2 \sin \phi d\rho d\phi d\theta$

**Substitutions in multiple integrals**

$\iint_R f(x, y) dx dy = \iint_G f(x(u, v), y(u, v)) |J(u, v)| du dv$      where      $J(u, v) = \frac{\partial x}{\partial u} \frac{\partial y}{\partial v} - \frac{\partial y}{\partial u} \frac{\partial x}{\partial v}$

**Mass, moments, and center of mass**     Mass      $M = \iint_R \delta dA$

Moments      $M_x = \iint_R y \delta dA$       $M_y = \iint_R x \delta dA$      Center of mass      $\bar{x} = M_y/M$       $\bar{y} = M_x/M$

**Flow and flux**     Flux =  $\int_C \mathbf{F} \cdot \mathbf{n} ds$      Flow =  $\int_C \mathbf{F} \cdot \mathbf{T} ds$