Table A-1. Vector: A C++ Class for 3-Dimensional Vector Algebra—Reference Sheet

Operation	Mathematical notation	Vector class
Definition	Let $\boldsymbol{v}$ be an unspecified vector.	`Vector v;`
	Let $\boldsymbol{a}$ be the cartesian vector (1,2,3).	`Vector a(1,2,3);` *or* `Vector a(1,2,3,CART);`
	Let $\boldsymbol{b}$ be the polar vector (r,θ,ϕ).[a]	`Vector b(r,th,ph,POLAR);`
Input vector $\boldsymbol{a}$	*n/a*	`cin >> a;`
Output vector $\boldsymbol{a}$	*n/a*	`cout << a;`
Cartesian representation	Let $\boldsymbol{a} = x\hat{\boldsymbol{\imath}} + y\hat{\boldsymbol{\jmath}} + z\hat{\boldsymbol{k}}$.[b]	`Vector a(x,y,z);` *or* `Vector a(x,y,z,CART);`
Polar representation	Let $\boldsymbol{a} = (r, \theta, \phi)$.[a]	`Vector a(r,th,ph,POLAR);`
Assign one vector to another	Let $\boldsymbol{b} = \boldsymbol{a}$ *or* $\boldsymbol{b} \Leftarrow \boldsymbol{a}$	`b = a;` *or* `b(a);`
Components of vector $\boldsymbol{a}$	a_x, a_y, a_z	`a.x(), a.y(), a.z()` *or* `x(a), y(a), z(a)` *or* `a[X], a[Y], a[Z]`
	r, θ, ϕ	`a.r(), a.theta(), a.phi()` *or* `r(a), theta(a), phi(a)`
Direction cosines	$\boldsymbol{v}\cdot\hat{\boldsymbol{\imath}}/\Vert\boldsymbol{v}\Vert$, $\boldsymbol{v}\cdot\hat{\boldsymbol{\jmath}}/\Vert\boldsymbol{v}\Vert$, $\boldsymbol{v}\cdot\hat{\boldsymbol{k}}/\Vert\boldsymbol{v}\Vert$	`v.dircos(X);` ... *or* `dircos(v,X);` ...
Vector addition	$\boldsymbol{c} = \boldsymbol{a} + \boldsymbol{b}$	`c = a + b;`
Addition assignment	$\boldsymbol{b} \Leftarrow \boldsymbol{b} + \boldsymbol{a}$	`b += a;`
Vector subtraction	$\boldsymbol{c} = \boldsymbol{a} - \boldsymbol{b}$	`c = a - b;`
Subtraction assignment	$\boldsymbol{b} \Leftarrow \boldsymbol{b} - \boldsymbol{a}$	`b -= a;`
Multiplication by a scalar s	$\boldsymbol{b} = s\,\boldsymbol{a}$ *or* $\boldsymbol{b} = \boldsymbol{a}\,s$	`b = s * a;` *or* `b = a * s;`
Multiplication assignment	$\boldsymbol{a} \Leftarrow s\,\boldsymbol{a}$ *or* $\boldsymbol{a} \Leftarrow \boldsymbol{a}\,s$	`a *= s;`
Dot (scalar) product	$\mathrm{c} = \boldsymbol{a}\cdot\boldsymbol{b}$	`c = a * b;`
Cross (vector) product	$\boldsymbol{c} = \boldsymbol{a}\times\boldsymbol{b}$	`c = a ^ b;`
Negative of a vector	$-\boldsymbol{v}$	`-v;`
Norm, or magnitude, of a vector	$\Vert\boldsymbol{v}\Vert$	`v.norm();` *or* `norm(v);` *or* `v.mag();` *or* `mag(v);` *or* `v.r();` *or* `v.scalar();`
Angle between two vectors	$\theta = \cos^{-1}\left(\dfrac{\boldsymbol{a}\cdot\boldsymbol{b}}{\Vert\boldsymbol{a}\Vert\,\Vert\boldsymbol{b}\Vert}\right)$	`angle(a, b);`
Normalize a vector	$\hat{\boldsymbol{u}} = \boldsymbol{v}/\Vert\boldsymbol{v}\Vert$	`u = v.normalize();`[c] *or* `u = normalize(v);` *or* `u = v.unit();` *or* `u = unit(v);`
Projection of $\boldsymbol{a}$ along $\boldsymbol{b}$	$\left(\boldsymbol{a}\cdot\dfrac{\boldsymbol{b}}{\Vert\boldsymbol{b}\Vert}\right)\dfrac{\boldsymbol{b}}{\Vert\boldsymbol{b}\Vert}$	`proj(a, b);` *or* `a.proj(b);`
Rotate vector $\boldsymbol{a}$ about the axial vector $\hat{\boldsymbol{u}}$ through the angle θ	$\boldsymbol{a} + \hat{\boldsymbol{u}}\times\boldsymbol{a}\sin\theta + \hat{\boldsymbol{u}}\times(\hat{\boldsymbol{u}}\times\boldsymbol{a})(1-\cos\theta)$	`a.rotate(u, theta);` *or* `a.rot(u, theta);`

[a] r is the magnitude, θ is the polar angle measured from the z-axis, and ϕ is the azimuthal angle measured from the x-axis to the plane that contains the vector and the z-axis. The angle θ and ϕ are in radians. Use `rad(deg)` to convert degrees to radians and `deg(rad)` to convert radians to degrees.

[b] $\hat{\boldsymbol{\imath}}$, $\hat{\boldsymbol{\jmath}}$, and $\hat{\boldsymbol{k}}$ are unit vectors along the x-axis, y-axis, and z-axis, respectively.

[c] `normalize` does not change the vector it is invoked on; it merely returns the vector divided by its norm.