# Vector: A C++ Class for 3D Vector Algebra
# Reference Sheet

| *Operation* | *Mathematical Notation* | *Computer Code* |
|---|---|---|
| Definition | Let **v** be an unspecified vector. | `Vector v;` |
| | Let **a** be the cartesian vector (1, 2, 3). | `Vector a( 1., 2., 3. );` *or*<br>`Vector a( 1., 2., 3., CART );` |
| | Let **b** be the polar vector $(r, \theta, \phi)$.[a] | `Vector b( r, th, ph, POLAR );` |
| Input vector **a** | *n/a* | `cin >> a;` |
| Output vector **a** | *n/a* | `cout << a;` |
| Cartesian representation | Let $\mathbf{a} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$. | `Vector a( x, y, z );` *or*<br>`Vector a( x, y, z, CART );` |
| Polar representation | $\mathbf{a} = (r, \theta, \phi)$[a] | `Vector a( r, th, ph, POLAR );` |
| Assign one vector to another | Let $\mathbf{b} = \mathbf{a}$ *or*<br>$\mathbf{b} \Leftarrow \mathbf{a}$ | `b = a;` *or*<br>`b( a );` |
| Components of vector **a** | $a_x, a_y, a_z$ | `a.x(), a.y(), a.z()` *or*<br>`x( a ), y( a ), z( a )` *or*<br>`a[ X ], a[ Y ], a[ Z ]` |
| | $r, \theta, \phi$ | `a.r(), a.theta(), a.phi()` *or*<br>`r( a ), theta( a ), phi( a )` |
| Vector addition | $\mathbf{c} = \mathbf{a} + \mathbf{b}$ | `c = a + b;` |
| Addition assignment | $\mathbf{b} \Leftarrow \mathbf{b} + \mathbf{a}$ | `b += a;` |
| Vector subtraction | $\mathbf{c} = \mathbf{a} - \mathbf{b}$ | `c = a - b;` |
| Subtraction assignment | $\mathbf{b} \Leftarrow \mathbf{b} - \mathbf{a}$ | `b -= a;` |
| Multiplication by a scalar *s* | $\mathbf{b} = s\,\mathbf{a}$ *or*<br>$\mathbf{b} = \mathbf{a}\,s$ | `b = s * a;` *or*<br>`b = a * s;` |
| Multiplication assignment | $\mathbf{a} \Leftarrow s\,\mathbf{a}$ *or*<br>$\mathbf{a} \Leftarrow \mathbf{a}\,s$ | `a *= s;` |
| Dot (scalar) product | $c = \mathbf{a} \cdot \mathbf{b}$ | `c = a * b;` |
| Cross (vector) product | $\mathbf{c} = \mathbf{a} \times \mathbf{b}$ | `c = a ^ b;` |
| Negative of a vector | $-\mathbf{a}$ | `-a;` |
| Magnitude of a vector | $\lvert\mathbf{a}\rvert$ | `a.r();` *or* `a.mag();` *or*<br>`mag( a );` *or* `scalar( a );` |
| Angle between two vectors | $\theta = \cos^{-1}\left(\frac{\mathbf{a}\cdot\mathbf{b}}{\lvert\mathbf{a}\rvert\,\lvert\mathbf{b}\rvert}\right)$ | `angle( a, b );` |
| Unit vector | $\mathbf{u} = \frac{\mathbf{v}}{\lvert\mathbf{v}\rvert}$ | `Vector u = v.unit();` *or*<br>`Vector u = unit( v );` *or*<br>`Vector u = v.normalize();` *or*<br>`Vector u = normalize( v );` |
| Perpendicular vector | $(r, \theta - \pi/2, \phi)$ | `a.perp();` *or*<br>`perp( a );` |
| Projection of **a** along **b** | $\left(\mathbf{a}\cdot\frac{\mathbf{b}}{\lvert\mathbf{b}\rvert}\right)\frac{\mathbf{b}}{\lvert\mathbf{b}\rvert}$ | `proj( a, b );` *or*<br>`a.proj( b );` |
| Rotate vector **a** about the axial vector **b** through the angle $\alpha$ | $\mathbf{a} + \mathbf{b}\times\mathbf{a}\sin\alpha + \mathbf{b}\times(\mathbf{b}\times\mathbf{a})(1-\cos\alpha)$ | `a.rotate( b, alpha );` *or*<br>`a.rot( b, alpha );` |
| Check for equality | Is it true that $\mathbf{a} = \mathbf{b}$? | `a == b;` |
| Check for inequality | Is it true that $\mathbf{a} \neq \mathbf{b}$? | `a != b;` |

a $\theta$ is the polar angle measured from the $z$-axis and $\phi$ is the azimuthal angle measured from the $x$-axis to the plane that contains the vector and the $z$-axis. The angles $\theta$ and $\phi$ are in radians; use `rad(deg)` to convert degrees to radians and `deg(rad)` to convert radians to degrees.