Concept	**Definition(s)**	**Applications**	**Examples**
Dot product	$\vec{a} \cdot \vec{b} = \lvert\vec{a}\rvert\lvert\vec{b}\rvert \cos\theta$ $\vec{a} \cdot \vec{b} = a_1b_1 + a_2b_2 + a_3b_3$	Angle between vectors Component of vector in direction: $\text{comp}_{\vec{v}}\vec{w} = \frac{\vec{v}\cdot\vec{w}}{\lvert\vec{v}\rvert}$	1B-6, 1B-11
Cross product	$\lvert\vec{a} \times \vec{b}\rvert = \lvert\vec{a}\rvert\lvert\vec{b}\rvert \sin\theta$ Direction determined by right-hand rule $\vec{a} \times \vec{b} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix}$	Area of triangles and parallelograms Finding normal vectors to planes	1D-2, 1D-5
Determinant	$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc$ 3×3 determinant: (sum of downward diagonals) − (sum of upward diagonals)	Inverting matrices Find area of parallelogram, volume of parallelpiped	1C-1, 1C-4
Scalar triple product	$\vec{a} \cdot (\vec{b} \times \vec{c}) = \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}$	Volume of parallelpiped	1D-9, 1D-8
Matrix inverse	$\begin{pmatrix} a & b \\ c & d \end{pmatrix}^{-1} = \frac{1}{ad-bc}\begin{pmatrix} d & -b \\ -c & a \end{pmatrix}$ 3×3 inverse: see handout	Solving linear systems	1G-2, 1G-1
Matrix · vector	$\begin{pmatrix} a & b \\ c & d \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} ax+by \\ cx+dy \end{pmatrix}$	Solving linear systems, transformations of the plane If $A\vec{x} = \vec{b}$, then $\vec{x} = A^{-1}\vec{b}$	1F-8b)
Matrix multiplication	$\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}\begin{pmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{pmatrix}$ Sizes must match! $= \begin{pmatrix} a_{11}b_{11}+a_{12}b_{21} & a_{11}b_{12}+a_{12}b_{22} \\ a_{21}b_{11}+a_{22}b_{21} & a_{21}b_{12}+a_{22}b_{22} \end{pmatrix}$, etc.	Do one transformation, then another	1F-1, 1F-11
Normal vector to plane	$ax + by + cz = d$ normal to $\langle a, b, c\rangle$	Finding equation of plane, angle between planes, intersection of planes, ...	1E-1, 1E-6
Parametrized line	$\ell(t) = \vec{x}_0 + \vec{v}t$	Describe line in space	1E-3, 1E-4
Equation of plane	$a(x - x_0) + b(y - y_0) + c(z - z_0) = 0$ $(\vec{x} - \vec{x}_0) \cdot \vec{n} = 0$	Describe plane in space Describe plane via point and normal vector	1E-2
Parametrizing a path	$x(t) = \cdot$, $y(t) = \cdot$	Describe path in plane/space (e.g. cycloid)	1I-6, 1I-7
Velocity, speed, etc.	$\vec{v}(t) = \frac{d}{dt}\vec{x}(t)$, $\vec{a}(t) = \frac{d}{dt}\vec{v}(t)$ (differentiate each component), $\frac{ds}{dt} = \lvert\vec{v}(t)\rvert$, $T = \frac{\vec{v}(t)}{\lvert\vec{v}(t)\rvert}$	Physics (Kepler's laws)	1J-4, 1J-5
Geometry problems via vectors	all of the above!		1A-9, 1B-11, 1E-7