

# Quick Review of High School Mathematics

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## 1 Book 1

### 1.1 Distance of a Point From a Line

$$\frac{|ax_0 + by_0 + c|}{\sqrt{a^2 + b^2}}$$

### 1.2 Distance Between Two Parallel Lines

$$\frac{|c_1 - c_2|}{\sqrt{a^2 + b^2}}$$

### 1.3 Equation of a Circle Given The Endpoints of a Diameter

$$(x - x_1)(x - x_2) + (y - y_1)(y - y_2) = 0$$

## 1.4 Equations of a Tangent Line or a Chord of Contact on A Circle

$$(x - h)(x_0 - h) + (y - k)(y_0 - k) = r^2$$

$$x_0x + y_0y + d\frac{x + x_0}{2} + e\frac{y + y_0}{2} + f = 0$$

## 1.5 Lagrange Interpolation

$$\sum_{j=0}^n f(x_j) \left( \prod_{\substack{i=0 \\ i \neq j}}^n \frac{x - x_i}{x_j - x_i} \right)$$

## 2 Book 2

### 2.1 Series

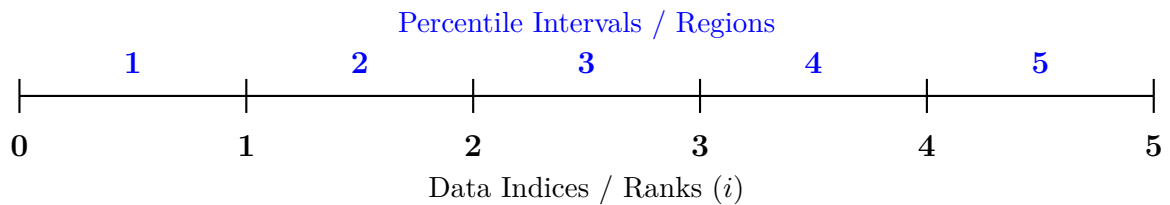
$$\sum_{k=1}^n ar^{k-1} = \frac{a(1 - r^n)}{1 - r}$$

$$\sum_{k=1}^n k = \frac{n(n+1)}{2}$$

$$\sum_{k=1}^n k^2 = \frac{n(n+1)(2n+1)}{6}$$

$$\sum_{k=1}^n k^3 = \left[ \frac{n(n+1)}{2} \right]^2$$

### 2.2 Percentiles



### 2.3 Variance and Standard Deviation

$$\sigma^2 = \frac{1}{n} \sum_{i=1}^n (x_i - \mu)^2 = \frac{1}{n} \sum_{i=1}^n x_i^2 - \mu^2$$

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (x_i - \mu)^2} = \sqrt{\frac{1}{n} \sum_{i=1}^n x_i^2 - \mu^2}$$

## 2.4 Correlation Coefficient

$$r = \frac{1}{n} \sum_{i=1}^n x'_i y'_i = \frac{S_{xy}}{\sqrt{S_{xx}} \sqrt{S_{yy}}}$$

Note: The numerator is proportional to  $n$ , and the denominator is proportional to  $\sqrt{n} \times \sqrt{n} = n$ , so no extra multiplication or division by  $n$  is required.

## 2.5 Line of Best Fit

$$y - \mu_y = r \times \frac{\sigma_y}{\sigma_x} (x - \mu_x) = \frac{S_{xy}}{S_{xx}} (x - \mu_x)$$

## 2.6 Pascal's Principle

$$C_k^n = C_{k-1}^{n-1} + C_k^{n-1}$$

## 2.7 Combination With Repetition

$$H_k^n = C_{n-1}^{n+k-1}$$

## 2.8 Derangement

$$D_n = n! \sum_{k=0}^n \frac{(-1)^k}{k!}$$

## 2.9 Sine Rule

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = 2R$$

## 2.10 Cosine Rule

$$a^2 = b^2 + c^2 - 2ab \cos A$$

### 3 Book 3

#### 3.1 Projection Vector And Its Length

Projection Vector:

$$\frac{\vec{a} \cdot \vec{b}}{|\vec{b}|} \cdot \frac{\vec{b}}{|\vec{b}|}$$

Length of Projection Vector:

$$\frac{|\vec{a} \cdot \vec{b}|}{|\vec{b}|}$$

#### 3.2 Triangle Inequality

$$|x + y| \leq |x| + |y|$$

$$||x| - |y|| \leq |x - y|$$

#### 3.3 Cauchy-Schwarz Inequality

$$(a_1^2 + a_2^2)(b_1^2 + b_2^2) \geq (a_1b_1 + a_2b_2)^2$$

The equality holds if and only if  $a_1b_2 = a_2b_1$

#### 3.4 Two-Dimensional Determinant

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = - \begin{vmatrix} b & a \\ d & c \end{vmatrix}; \quad \begin{vmatrix} a & b \\ c & d \end{vmatrix} = - \begin{vmatrix} c & d \\ a & b \end{vmatrix}$$

$$\begin{vmatrix} ra & a \\ rc & c \end{vmatrix} = 0; \quad \begin{vmatrix} ra & rb \\ a & b \end{vmatrix} = 0$$

$$\begin{vmatrix} ra & b \\ rc & d \end{vmatrix} = r \begin{vmatrix} a & b \\ c & d \end{vmatrix}; \quad \begin{vmatrix} ra & rb \\ c & d \end{vmatrix} = r \begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

$$\begin{vmatrix} a & ka + b \\ c & kc + d \end{vmatrix} = \begin{vmatrix} a & b \\ c & d \end{vmatrix}; \quad \begin{vmatrix} a & b \\ ka + c & kb + d \end{vmatrix} = \begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

$$\begin{vmatrix} a + x & b \\ c + y & d \end{vmatrix} = \begin{vmatrix} a & b \\ c & d \end{vmatrix} + \begin{vmatrix} x & b \\ y & d \end{vmatrix}; \quad \begin{vmatrix} a + x & b + y \\ c & d \end{vmatrix} = \begin{vmatrix} a & b \\ c & d \end{vmatrix} + \begin{vmatrix} x & y \\ c & d \end{vmatrix}$$

#### 3.5 Cramer's Rule ( $2 \times 2$ )

$$\begin{cases} a_1x + b_1y = c_1 \\ a_2x + b_2y = c_2 \end{cases}$$

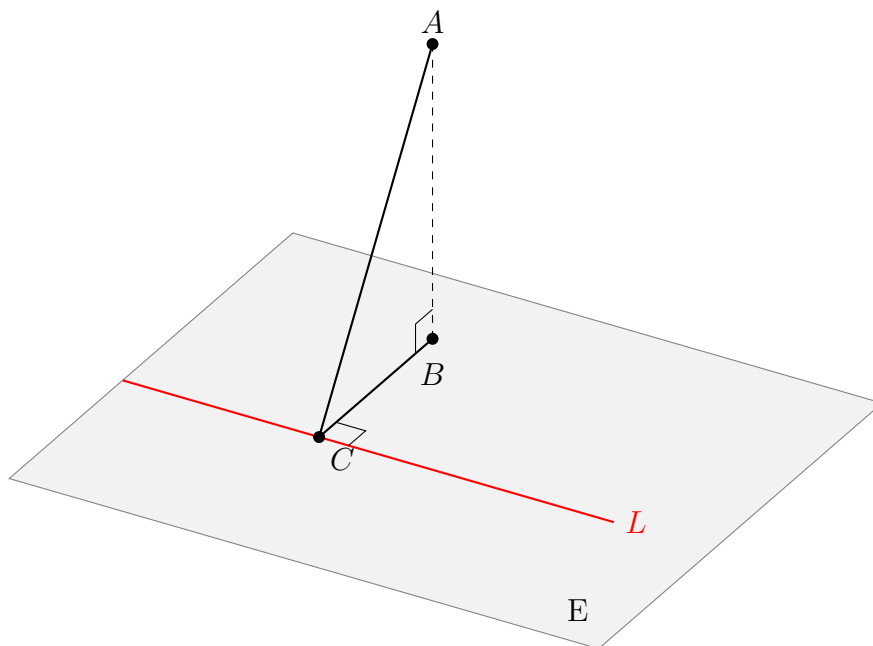
$$\Delta = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}, \quad \Delta_x = \begin{vmatrix} c_1 & b_1 \\ c_2 & b_2 \end{vmatrix}, \quad \Delta_y = \begin{vmatrix} a_1 & c_1 \\ a_2 & c_2 \end{vmatrix}$$

Condition	Solution	Geometric Meaning
$\Delta \neq 0$	Unique $(x = \frac{\Delta_x}{\Delta}, y = \frac{\Delta_y}{\Delta})$	Intersecting lines
$\Delta = 0, (\Delta_x \neq 0 \vee \Delta_y \neq 0)$	None	Parallel distinct lines
$\Delta = \Delta_x = \Delta_y = 0$	Infinite	Coincident lines

## 4 Book 4

### 4.1 Theorem of Three Perpendiculars

Let line  $AB$  be perpendicular to plane  $E$  at point  $B$ . If on plane  $E$  the line  $BC$  is perpendicular to line  $L$  at  $C$ , then line  $AC$  is perpendicular to line  $L$  at point  $C$ .



### 4.2 Cross Product

$$(a_1, a_2, a_3) \times (b_1, b_2, b_3) = \left( \begin{vmatrix} a_2 & a_3 \\ b_2 & b_3 \end{vmatrix}, \begin{vmatrix} a_3 & a_1 \\ b_3 & b_1 \end{vmatrix}, \begin{vmatrix} a_1 & a_2 \\ b_1 & b_2 \end{vmatrix} \right)$$

### 4.3 Volume of Parallelepipeds

$$|\vec{a} \cdot \vec{b} \times \vec{c}| = \begin{vmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{vmatrix}$$

### 4.4 Laplace Expansion

$$\begin{vmatrix} + & - & + \\ - & + & - \\ + & - & + \end{vmatrix}$$

## 4.5 Point-Normal Form

$$a(x - x_0) + b(y - y_0) + c(z - z_0) = 0$$

## 4.6 Distance of a Point From a Plane

$$\frac{|ax_0 + by_0 + cz_0 + d|}{\sqrt{a^2 + b^2 + c^2}}$$

## 4.7 Distance Between Two Parallel Planes

$$\frac{|d_1 - d_2|}{\sqrt{a^2 + b^2 + c^2}}$$

## 4.8 Lines in Space

$$\begin{cases} x = x_0 + at \\ y = y_0 + bt \\ z = z_0 + ct \end{cases}$$
$$\frac{x - x_0}{a} = \frac{y - y_0}{b} = \frac{z - z_0}{c}$$

## 4.9 Conditional Probability

$$P(B|A) = \frac{n(A \cap B)}{n(A)} = \frac{P(A \cap B)}{P(A)}$$

$$P(A \cap B) = P(B)P(A|B) = P(A)P(A|B)$$

$$P(B) = P(A' \cap B) + P(A \cap B)$$

## 4.10 Independent Events

$$P(A \cap B) = P(A)P(B)$$

If the events  $A, B$  are independent, then  $A', B$  are independent;  $A, B'$  are independent; and  $A', B'$  are independent.

## 4.11 Bayes' Theorem

$$P(A|B) = \frac{P(A)P(B|A)}{P(B)} = \frac{P(A)P(B|A)}{P(A)P(B|A) + P(A')P(B|A')}$$

## 4.12 Operational Properties of Matrices

$$(AB)C = A(BC)$$

$$A(B + C) = AB + AC$$

$$(A + B)C = AC + BC$$

## 4.13 Inverse Matrix

$$A^{-1} = \begin{bmatrix} a & b \\ c & d \end{bmatrix}^{-1} = \frac{1}{\det(A)} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

## 4.14 Scaling Matrix

$$\begin{bmatrix} h & 0 \\ 0 & k \end{bmatrix}$$

## 4.15 Shear Matrix

$$\begin{bmatrix} 1 & h \\ 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 1 & 0 \\ k & 1 \end{bmatrix}$$

## 4.16 Rotation Matrix

$$\begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix}$$

## 4.17 Reflection Matrix

$$\begin{bmatrix} \cos 2\theta & \sin 2\theta \\ \sin 2\theta & -\cos 2\theta \end{bmatrix}$$

## 4.18 Transition Matrix

$$\begin{bmatrix} a & b \\ 1-a & 1-b \end{bmatrix}$$

where  $0 \leq a, b \leq 1$

# 5 Additional Tricks

## 5.1 Centroids of Triangles

$$\overrightarrow{DG} = \frac{1}{3}\overrightarrow{DA} + \frac{1}{3}\overrightarrow{DB} + \frac{1}{3}\overrightarrow{DC}$$



## 5.2 Circumcenters of Triangles

$$\overrightarrow{AB} \cdot \overrightarrow{AO} = \frac{1}{2} \overline{AB}^2$$

## 5.3 Incenters of Triangles

$$\overrightarrow{DI} = \frac{\overline{BC}}{\overline{AB} + \overline{BC} + \overline{CA}} \overrightarrow{DA} + \frac{\overline{CA}}{\overline{AB} + \overline{BC} + \overline{CA}} \overrightarrow{DB} + \frac{\overline{AB}}{\overline{AB} + \overline{BC} + \overline{CA}} \overrightarrow{DC}$$

## 5.4 Orthocenters of Triangles

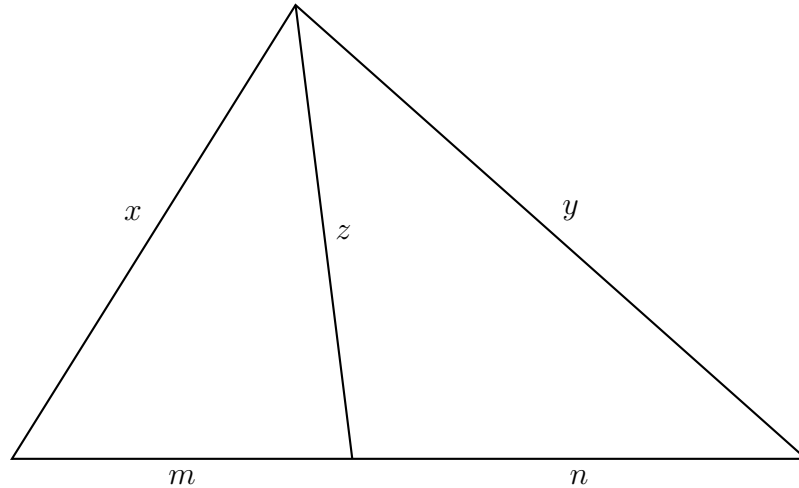
$$\overrightarrow{AB} \cdot \overrightarrow{AC} = \overrightarrow{AB} \cdot \overrightarrow{AH} = \overrightarrow{AC} \cdot \overrightarrow{AH}$$

## 5.5 The Pairing Method

While dividing some labeled items into groups of two, pick the partners for the unpaired items. For example, the numbers of ways to pair 5 people and one people left is  $C_1^5 \times 3 \times 1 = 15$ .

## 5.6 Stewart's Theorem

$$z^2 = \frac{n}{m+n} x^2 + \frac{m}{m+n} y^2 - mn$$

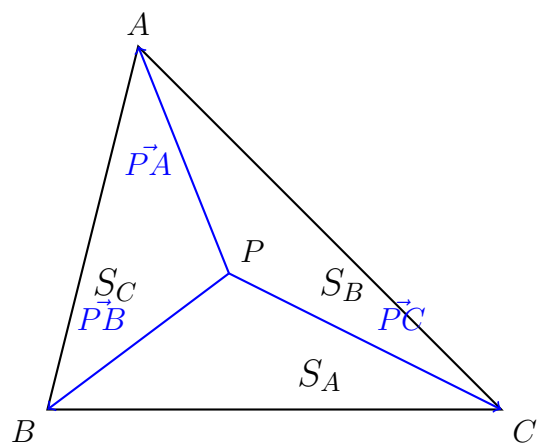


When the dividing line is a bisector,  $z^2 = xy - mn$ .

When it is a median,  $2(z^2 + n^2) = x^2 + y^2$ .

## 5.7 Vectors And Areas about a Point inside a Triangle

$$S_A \vec{PA} + S_B \vec{PB} + S_C \vec{PC} = \vec{0}$$



## 5.8 Areas of Triangles in Terms of Circumradius

$$Area = \frac{abc}{4R}$$

## 5.9 Shoelace Formula

$$Area = \frac{1}{2} \left| \begin{vmatrix} x_1 & x_2 & \dots & x_k & x_1 \\ y_1 & y_2 & \dots & y_k & y_1 \end{vmatrix} \right|$$