CDS Elementary Maths | PYQ Formula Sheet

2021 – 2026

1. Algebra — 231 Qs

Algebraic Identities — 72

Square of a sum/difference

$$(a \pm b)^2 = a^2 \pm 2ab + b^2$$

Difference of two squares

$$a^2 - b^2 = (a+b)(a-b)$$

Square of a trinomial

$$(a+b+c)^2 = a^2 + b^2 + c^2 + 2(ab+bc+ca)$$

Cube of a sum/difference

$$(a \pm b)^3 = a^3 \pm b^3 \pm 3ab(a \pm b)$$

Sum/difference of cubes

$$a^3 \pm b^3 = (a \pm b)(a^2 \mp ab + b^2)$$

Three-cube identity

$$a^3 + b^3 + c^3 - 3abc = (a+b+c)(a^2 + b^2 + c^2 - ab - bc - ca)$$

Special case when the sum is zero

$$a+b+c=0 \;\Rightarrow\; a^3 + b^3 + c^3 = 3abc$$

Quadratic Equations — 56

Roots of $ax^2 + bx + c = 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Sum of the two roots

$$\alpha + \beta = -\frac{b}{a}$$

Product of the two roots

$$\alpha\beta = \frac{c}{a}$$

Discriminant

$$D = b^2 - 4ac$$

Roots real & equal

$$D = 0 \quad (\text{so } b^2 = 4ac)$$

Roots real & distinct

$$D > 0$$

Roots imaginary

$$D < 0$$

Polynomials — 41

Remainder theorem — dividing by $(x-a)$

$$\text{Remainder} = p(a)$$

Factor theorem — test if $(x-a)$ divides $p(x)$

$$(x-a) \text{ is a factor} \iff p(a) = 0$$

Common root p of $a_1x^2+b_1x+c_1 = 0$ and $a_2x^2+b_2x+c_2 = 0$

$$p = \frac{a_1c_2 - a_2c_1}{a_2b_1 - a_1b_2}$$

Linear Equations — 25

The pair of equations

$$a_1x + b_1y = c_1 \quad \text{and} \quad a_2x + b_2y = c_2$$

Exactly one solution (lines meet)

$$\frac{a_1}{a_2} \neq \frac{b_1}{b_2}$$

Infinitely many (same line)

$$\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$$

No solution (parallel lines)

$$\frac{a_1}{a_2} = \frac{b_1}{b_2} \neq \frac{c_1}{c_2}$$

Sequences & Series — 10

AP — nth term

$$T_n = a + (n-1)d$$

AP — sum of n terms

$$S_n = \frac{n}{2}\left[2a + (n-1)d\right]$$

AP — sum when the last term l is known

$$S_n = \frac{n}{2}(a+l)$$

GP — nth term

$$T_n = ar^{n-1}$$

GP — sum of n terms ($r \neq 1$; if $r = 1$, $S_n = na$)

$$S_n = \frac{a(r^n - 1)}{r - 1}$$

GP — sum to infinity, $|r| < 1$

$$S_\infty = \frac{a}{1-r}$$

Logarithms — 9

Product becomes a sum

$$\log mn = \log m + \log n$$

Quotient becomes a difference

$$\log \frac{m}{n} = \log m - \log n$$

Power comes down in front

$$\log m^n = n \log m$$

Change of base

$$\log_b a = \frac{\log a}{\log b}$$

Log of the base itself

$$\log_a a = 1$$

Sets, Relations & Functions — 8

Two sets — count the union

$$n(A \cup B) = n(A) + n(B) - n(A \cap B)$$

Three sets — count the union

$$n(A\cup B\cup C)=\Sigma n-\Sigma n(\text{pairs})+n(A\cap B\cap C)$$

Inequalities 8

Order of the three means (positive numbers only)

$\text{AM}\geq\text{GM}\geq\text{HM}$ (equal iff all terms equal)

Number + its reciprocal

$$x>0\Rightarrow x+\frac{1}{x}\geq 2;\quad x<0\Rightarrow x+\frac{1}{x}\leq -2$$

Reciprocals — both same sign, the sign flips

$$x>y>0\ \Rightarrow\ \frac{1}{x}<\frac{1}{y}$$

Reciprocals — opposite signs, the sign stays

$$x>0>y\ \Rightarrow\ \frac{1}{x}>\frac{1}{y}$$

Simplification 2

Order of operations

Bracket → Of → Divide → Multiply → Add → Subtract

Telescoping — split the fraction, middles cancel

$$\frac{1}{a(a+d)}=\frac{1}{d}\left(\frac{1}{a}-\frac{1}{a+d}\right)$$

2. Mensuration 177 Qs

3D Mensuration 89

Cube — volume

$V=a^3$

Cube — total surface area

$\text{TSA}=6a^2$

Cube — space diagonal

$d=a\sqrt{3}$

Cuboid — volume

$V=lbh$

Cuboid — total surface area

$\text{TSA}=2(lb+bh+hl)$

Cuboid — space diagonal

$d=\sqrt{l^2+b^2+h^2}$

Cylinder — volume

$V=\pi r^2h$

Cylinder — curved surface

$\text{CSA}=2\pi rh$

Cylinder — total surface

$\text{TSA}=2\pi r(r+h)$

3D Mensuration (cont.) 89

Cone — volume

$V=\frac{1}{3}\pi r^2h$

Cone — slant height

$l=\sqrt{r^2+h^2}$

Cone — curved surface

$\text{CSA}=\pi rl$

Cone — total surface

$\text{TSA}=\pi r(r+l)$

Sphere — volume

$V=\frac{4}{3}\pi r^3$

Sphere — surface area

$\text{SA}=4\pi r^2$

Hemisphere — volume

$V=\frac{2}{3}\pi r^3$

Hemisphere — total surface (curved + flat)

$\text{TSA}=3\pi r^2$

2D Mensuration 88

Square — area

$A=a^2$

Square — diagonal

$d=a\sqrt{2}$

Rectangle — area

$A=lb$

Triangle — area from base & height

$A=\frac{1}{2}bh$

Equilateral triangle — area

$A=\frac{\sqrt{3}}{4}a^2$

Heron — area from three sides

$A=\sqrt{s(s-a)(s-b)(s-c)}$

Heron — semi-perimeter

$s=\frac{a+b+c}{2}$

2D Mensuration (cont.) 88

Circle — area

$A=\pi r^2$

Circle — circumference

$C=2\pi r$

Sector — area for angle θ°

$A=\frac{\theta}{360}\pi r^2$

Arc length (θ in radians)

$\ell=r\theta$

Parallelogram — area

$A=bh$

Rhombus — area from diagonals

$A=\frac{1}{2}d_1d_2$

Trapezium — area

$A=\frac{1}{2}(a+b)h$

3. Arithmetic 166 Qs

Time, Speed & Distance 39

Basic relation

$$S = \frac{D}{T}$$

Unit conversion km/h → m/s

Multiply by $\frac{5}{18}$

Relative speed — same direction

$$v_1 - v_2$$

Relative speed — opposite directions

$$v_1 + v_2$$

Time, Speed & Distance (cont.) 39

Average speed for equal distances

$$\bar{v} = \frac{2xy}{x+y}$$

Boat downstream (with the current)

$$u + v$$

Boat upstream (against the current)

$$u - v$$

Same distance, speed changes by Δt

$$D = \frac{S_1 S_2}{S_1 - S_2} \cdot \Delta t$$

Ratio & Proportion 30

Cross-multiplication

$$a : b = c : d \;\Rightarrow\; ad = bc$$

Mean proportional between a and c

$$b = \sqrt{ac}$$

Componendo–dividendo — only if $\frac{a}{b} = \frac{c}{d}$

$$\frac{a+b}{a-b} = \frac{c+d}{c-d}$$

Direct variation

$$a \propto b \;\Rightarrow\; a = kb$$

Time & Work 23

A alone in A days, B alone in B days — together

$$\frac{AB}{A+B} \text{ days} \quad \left(\text{rate} = \frac{1}{A} + \frac{1}{B}\right)$$

Unit method — take total work = LCM(A, B) units

$$\text{Efficiency} = \frac{\text{total work}}{\text{days}} \text{ units/day}$$

Men–days–work relation

$$\frac{M_1 D_1}{W_1} = \frac{M_2 D_2}{W_2}$$

Simple & Compound Interest 19

Simple interest

$$\text{SI} = \frac{PRT}{100}$$

Compound amount, n years, compounded annually

$$A = P\left(1 + \frac{r}{100}\right)^n$$

Compounded k times a year

$$A = P\left(1 + \frac{r}{100k}\right)^{kn}$$

Compound interest

$$\text{CI} = A - P$$

Gap between CI and SI over 2 years

$$\text{CI} - \text{SI} = P\left(\frac{r}{100}\right)^2$$

Simplification 18

Order of operations

Bracket → Of → Divide → Multiply → Add → Subtract

Rationalise a surd denominator (use the conjugate)

$$\frac{1}{\sqrt{a} + \sqrt{b}} = \frac{\sqrt{a} - \sqrt{b}}{a - b}$$

If $x + \frac{1}{x} = k$, then

$$x^2 + \frac{1}{x^2} = k^2 - 2$$

and

$$x^3 + \frac{1}{x^3} = k^3 - 3k$$

Percentage 10

Percent as a fraction

$$x\% = \frac{x}{100}$$

Percentage change

$$\frac{\text{new} - \text{old}}{\text{old}} \times 100$$

Two successive changes $a\%$ then $b\%$

$$\text{Net} = a + b + \frac{ab}{100}$$

Profit & Loss 10

Profit percentage (on cost price)

$$P\% = \frac{SP - CP}{CP} \times 100$$

Selling price from CP and profit/loss

$$SP = CP \cdot \frac{100 \pm P/L\%}{100}$$

Mixture & Alligation 8

Rule of alligation (m = mean price)

$$\frac{\text{Qty cheaper}}{\text{Qty dearer}} = \frac{d - m}{m - c}$$

Average 8

Average of n values

$$\bar{x} = \frac{\text{sum}}{n}$$

New member of value v joins n members

$$\bar{x}_{\text{new}} = \frac{n\bar{x} + v}{n+1}$$

Partnership 1

Profit is shared in the ratio of capital × time

$$P_1 : P_2 = C_1 t_1 : C_2 t_2$$

4. Geometry 166 Qs

Triangles 88

Angles of any triangle

$$\text{Sum} = 180^\circ$$

Pythagoras (right triangle)

$$a^2 + b^2 = c^2$$

Area from base & height

$$A = \tfrac{1}{2}bh$$

Triangles (cont.) 88

Similar triangles — areas

$$\frac{A_1}{A_2} = \left(\frac{s_1}{s_2}\right)^2$$

Similar triangles — perimeters

$$\frac{P_1}{P_2} = \frac{s_1}{s_2} = \sqrt{\frac{A_1}{A_2}}$$

Altitude drawn to the hypotenuse

$$h = \frac{\text{leg} \times \text{leg}}{\text{hyp}}$$

Median drawn to the hypotenuse

$$m = \tfrac{1}{2} \times \text{ hypotenuse}$$

Centroid divides each median (vertex side longer)

$$AG : GD = 2 : 1$$

Circles 50

Two tangents PA, PB from an external point P

$$PA = PB$$

Tangent ⊥ radius at the point of contact

$$\angle OAP = 90^\circ$$

Angle between the tangents and the central angle

$$\angle APB + \angle AOB = 180^\circ$$

Angle in a semicircle

$$\angle ACB = 90^\circ$$

Inscribed vs central angle on the same arc

$$\angle ACB = \tfrac{1}{2}\angle AOB$$

Cyclic quadrilateral $ABCD$ — opposite angles

$$\angle A + \angle C = \angle B + \angle D = 180^\circ$$

Quadrilaterals 19

Parallelogram — area

$$A = bh$$

Parallelogram — the diagonals bisect each other

$$AO = OC, \;\; BO = OD$$

Cyclic quadrilateral — opposite angles

$$\angle A + \angle C = 180^\circ$$

Lines & Angles 8

Linear pair (angles on a straight line)

$$\angle 1 + \angle 2 = 180^\circ$$

Vertically opposite angles

$$\angle 1 = \angle 3$$

Parallel lines + transversal — corresponding angles

$$\angle 1 = \angle 5$$

Parallel lines + transversal — alternate angles

$$\angle 3 = \angle 5$$

Co-interior (same-side) angles

$$\angle 3 + \angle 6 = 180^\circ$$

Coordinate Geometry 1

Distance between two points

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Midpoint of a segment

$$\left(\frac{x_1 + x_2}{2}, \frac{y_1 + y_2}{2}\right)$$

Slope of a line

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Section formula (ratio $m : n$)

$$\left(\frac{mx_2 + nx_1}{m+n}, \frac{my_2 + ny_1}{m+n}\right)$$

5. Trigonometry 151 Qs

Trigonometric Identities 74

Fundamental identity

$$\sin^2\theta + \cos^2\theta = 1$$

Secant identity

$$1 + \tan^2\theta = \sec^2\theta$$

Cosecant identity

$$1 + \cot^2\theta = \csc^2\theta$$

If $a\sin\theta + b\cos\theta = c$, then the partner is

$$a\cos\theta - b\sin\theta = \pm\sqrt{a^2 + b^2 - c^2}$$

A ratio + its reciprocal (needs $\cos\theta > 0$, i.e. $0^\circ < \theta < 90^\circ$)

$$\sec\theta + \cos\theta \geq 2$$

Trigonometric Ratios 54

Sine

$$\sin\theta = \frac{\text{perpendicular}}{\text{hypotenuse}}$$

Cosine

$$\cos\theta = \frac{\text{base}}{\text{hypotenuse}}$$

Tangent

$$\tan\theta = \frac{\text{perpendicular}}{\text{base}}$$

Complementary angles

$$\sin(90^\circ - \theta) = \cos\theta$$

Pythagorean triplets to memorise

$(3,4,5),\ (5,12,13),\ (7,24,25),\ (8,15,17)$

Heights & Distances 22

Angle of elevation

$$\tan\theta = \frac{\text{height}}{\text{base distance}}$$

Two poles — from the near foot

$$\tan x = \frac{h}{a}$$

Two poles — from the far foot

$$\tan y = \frac{h}{b}$$

The two feet distances add to the gap

$a + b =$ distance between the poles

6. Number System 130 Qs

HCF & LCM 27

For any two numbers a, b

$$\text{HCF} \times \text{LCM} = a \times b$$

Largest x leaving the *same* remainder on a, b, c

$$x = \text{HCF}(a-b,\ b-c,\ a-c)$$

Largest x leaving remainders r_1, r_2, r_3

$$x = \text{HCF}(a-r_1,\ b-r_2,\ c-r_3)$$

Remainders & Modular 25

Reduce the base first

$$a \equiv r \pmod m \ \Rightarrow\ a^n \equiv r^n \pmod m$$

Cyclicity — if $a^k \equiv 1 \pmod m$, powers repeat every k

$a^n \equiv a^{\,n \bmod k} \pmod m$ (the period k depends on m)

Fermat — p prime, $\gcd(a,p) = 1$

$$a^{p-1} \equiv 1 \pmod p$$

Unit Digit of a^n 25

Cycle length is 1, 2 or 4 — never longer

$0, 1, 5, 6$: length 1 (digit never changes)

Length 2

$4:\ 4,6 \qquad 9:\ 9,1$

Length 4

$2:\ 2,4,8,6 \qquad 3:\ 3,9,7,1$

$7:\ 7,9,3,1 \qquad 8:\ 8,4,2,6$

Shortcut — 4 is a multiple of every cycle length

Take n mod 4; if it is 0, use the *last* term of the cycle

Primes & Factors 20

Prime factorisation

$$N = p^a q^b r^c$$

How many factors N has

$$(a{+}1)(b{+}1)(c{+}1)$$

Sum of all factors

$$\prod \frac{p^{a+1}-1}{p-1}$$

Powers & Surds 19

Multiplying like bases — add the powers

$$a^m a^n = a^{m+n}$$

Power of a power — multiply them

$$(a^m)^n = a^{mn}$$

Negative index — flip it

$$a^{-n} = \frac{1}{a^n}$$

Rationalise a surd denominator (conjugate)

$$\frac{1}{\sqrt{a}+\sqrt{b}} = \frac{\sqrt{a}-\sqrt{b}}{a-b}$$

Infinite nested radical — set the whole thing $= x$

$$x = \sqrt{a+\sqrt{a+\cdots}} \ \Rightarrow\ x^2 = a + x$$

Solving that quadratic gives

$$x = \frac{1+\sqrt{1+4a}}{2}$$

Digits & Place Value 19

A two-digit number

$$= 10x + y$$

Interchanging the digits changes it by

$$9(x-y)$$

Divisibility 12

By 2

Last digit is even

By 3

Digit-sum divisible by 3

By 4

Last 2 digits divisible by 4

By 5

Last digit is 0 or 5

By 6

Passes the 2 and the 3 test

Divisibility (cont.) 12

By 8

Last 3 digits divisible by 8

By 9

Digit-sum divisible by 9

By 11

Alternating digit-sum divisible by 11

By 36

Passes the 4 and the 9 test

Number Properties (General) 8

Sum of the first n natural numbers

$$1+2+\cdots+n=\frac{n(n+1)}{2}$$

Sum of the first n odd numbers

$$1+3+\cdots+(2n-1)=n^2$$

Parity

even $\pm$ even = even; odd $\pm$ odd = even; even $\pm$ odd = odd

Trailing zeros in $n!$

$$\left\lfloor \tfrac{n}{5} \right\rfloor + \left\lfloor \tfrac{n}{25} \right\rfloor + \cdots$$

7. Statistics & Probability 79 Qs

Mean, Median & Mode 45

Mean of a frequency table

$$\bar{x}=\frac{\Sigma fx}{\Sigma f}$$

Median of grouped data

$$L+\frac{\frac{N}{2}-\mathrm{CF}}{f}\times h$$

Mode of grouped data

$$L+\frac{f_1-f_0}{2f_1-f_0-f_2}\times h$$

Empirical relation between the three

$$\text{Mode}=3\,\text{Median}-2\,\text{Mean}$$

Link between the means — *two* numbers only

$$\mathrm{GM}^2=\mathrm{AM}\times\mathrm{HM}$$

Data Interpretation 34

Pie chart — value of a sector

$$\%\times \text{ total}$$

Pie chart — angle of a sector

$$\%\times 360^\circ$$

Percentage change between two bars/rows

$$\frac{\text{new}-\text{old}}{\text{old}}\times 100$$

Share of one item in the total

$$\frac{\text{item}}{\text{total}}\times 100\%$$