IMPORTANT CHAPTER-WISE MATH FORMULAS

JEE MAINS

1. Algebra
2. Series
3. Circle
4. Complex Numbers
5. Conic Sections
6. Differential Calculus
7. Differential Equations
8. Geometry
9. Integral Calculus
10. Matrices and Determinants
11. Probability
12. Sets
13. Straight Line
14. 3-Dimensional Geometry
15. Triangle
16. Trigonometry
17. Vectors

BAAP OF ALL FORMULA LISTS

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ALGEBRA

SL#	FORMULA
1	$a^2-b^2=(a+b)(a-b)$
2	$a^3-b^3=(a-b)\left(a^2+ab+b^2\right)$
3	$a^3+b^3=(a+b)\left(a^2-ab+b^2\right)$
4	$a^4-b^4=\left(a^2-b^2\right)\left(a^2+b^2\right)=(a-b)(a+b)\left(a^2+b^2\right)$
5	$a^5-b^5=(a-b)\left(a^4+a^3b+a^2b^2+ab^3+b^4\right)$
6	$a^5+b^5=(a+b)\left(a^4-a^3b+a^2b^2-ab^3+b^4\right)$
7	**If n is odd, then** $a^n+b^n=(a+b)\left(a^{n-1}-a^{n-2}b+a^{n-3}b^2-\ldots-ab^{n-2}+b^{n-1}\right).$
8	**If n is even, then** $a^n-b^n=(a-b)\left(a^{n-1}+a^{n-2}b+a^{n-3}b^2+\ldots+ab^{n-2}+b^{n-1}\right),$ $a^n+b^n=(a+b)\left(a^{n-1}-a^{n-2}b+a^{n-3}b^2-\ldots+ab^{n-2}-b^{n-1}\right).$
9	$(a-b)^2=a^2-2ab+b^2$
10	$(a+b)^2=a^2+2ab+b^2$
11	$(a-b)^3=a^3-3a^2b+3ab^2-b^3$
12	$(a+b)^3=a^3+3a^2b+3ab^2+b^3$
13	$(a-b)^4=a^4-4a^3b+6a^2b^2-4ab^3+b^4$
14	$(a+b)^4=a^4+4a^3b+6a^2b^2+4ab^3+b^4$
15	**Binomial Formula** $(a+b)^n=\hat{}\ nC_0a^n+$ **^nC_1a^(n-1)b+** $\hat{}\ nC_2a^{n-2}b^2+\ldots+$ **^nC_(n-1)ab^(n-1)+** $\hat{}\ nC_nb^n,$
16	$(a+b+c)^2=a^2+b^2+c^2+2ab+2ac+2bc$
17	$(a+b+c+\ldots+u+v)^2=a^2+b^2+c^2+\ldots+u^2+v^2+2(ab+ac+\ldots+au+av+bc+\ldots+bu+bv+\ldots+uv)$
18	$a^ma^n=a^{m+n}$

19	$\frac{a^m}{a^n} = a^{m-n}$
20	$(ab)^m = a^m b^m$
21	$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$
22	$(a^m)^n = a^{mn}$
23	$a^0 = 1, a \neq 0$
24	$a^1 = 1$
25	$a^{-m} = \frac{1}{a^m}$
26	$a^{\frac{m}{n}} = \sqrt[n]{a^m}$
27	$\sqrt[n]{ab} = \sqrt[n]{a}\sqrt[n]{b}$
28	$\sqrt[n]{a}\sqrt[m]{b} = \sqrt[nm]{a^m b^n}$
29	$\sqrt[n]{\frac{a}{b}} = \frac{\sqrt[n]{a}}{\sqrt[n]{b}}, b \neq 0$
30	$\frac{\sqrt[n]{a}}{\sqrt[m]{b}} = \frac{\sqrt[nm]{a^m}}{\sqrt[nm]{b^n}} = \sqrt[nm]{\frac{a^m}{b^n}}, b \neq 0.$
31	$\left(\sqrt[n]{a^m}\right)^P = \sqrt[n]{a^{mp}}$
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32	$\left(\sqrt[n]{a}\right)^n = a$
33	$\sqrt[n]{a^m} = \sqrt[np]{a^{mp}}$
34	$\sqrt[n]{a^m} = a^{\frac{m}{n}}$
35	$\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a}$
36	$\left(\sqrt[n]{a}\right)^m = \sqrt[n]{a^m}$
37	$\frac{1}{\sqrt[n]{a}} = \frac{\sqrt[n]{a^{n-1}}}{a}, a \neq 0$
38	$\sqrt{a \pm \sqrt{b}} = \frac{\sqrt{a + \sqrt{a^2 - b}}}{2} \pm \frac{\sqrt{a - \sqrt{a^2 - b}}}{2}$
39	$\frac{1}{\sqrt{a} \pm \sqrt{b}} = \frac{\sqrt{a} \pm \sqrt{b}}{a - b}$
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40	**Definition of Logarithm**

	$y = \log_a x$ **if and only if** $x = a^y$ **where** $a > 0, a \neq 1.$
41	$\log_a 1 = 0$
42	$\log_a a = 1$
43	$\log_a 0 = \begin{cases} -\infty & \text{if} \quad a > 1 \\ +\infty & \text{if} \quad a < 1 \end{cases}$
44	$\log_a (xy) = \log_a x + \log_a y$
45	$\dfrac{\log_a x}{y} = \log_a x - \log_a y$
46	$\log_a (X^n) = n \log_a x$
47	$\log_a \sqrt[n]{x} = \dfrac{1}{n} \log_a x$

48	$\log_a x = \dfrac{\log_c x}{\log_c a} = \log_c a \cdot \log_a c, c > 0, c \neq 1.$
49	$\log_a c = \dfrac{1}{\log_c a}$
50	$x = a^{\log_a x}$
51	**Logarithm to Base 10** $\log_{10} x = \log x$
52	**Natural Logarithm** $\log_e x = \ln x$, **where** $e = \lim_{k \to \infty} \left(1 + \dfrac{1}{k}\right)^k = 2.718281828\ldots$
53	$\log x = \left(\dfrac{1}{\ln 10}\right) \ln x = 0.434294 \ln x$
54	$\ln x = \left(\dfrac{1}{\log e}\right) \log x = 2.302585 \log x$
55	**Linear Equation in One Variable** $ax + b = 0, x = -\dfrac{b}{a}$

56	**Quadratic Equation** $ax^2 + bx + c = 0, x_{1,2} = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
57	**Discriminant** $D = b^2 - 4ac$
58	**Viete\'s Formulas** **If** $x^2 + px + q = 0$, **then** $\begin{cases} x_1 + x_2 = -p \\ x_1 x_2 = q \end{cases}$

59	$ax^2 + bx = 0, x_1 = 0, x_2 = -\frac{b}{a}$
60	$ax^2 + c = 0, x_{1,2} = \pm\sqrt{-\frac{c}{a}}$
61	**Cubic Equation. Cardano\'s Formula.** $y^3 + py + q = 0,$ $y_1 = u + v, y_{2,3} = -\frac{1}{2}(u+v) \pm \frac{\sqrt{3}}{2}(u+v)i,$ where $u = \sqrt[3]{-\frac{q}{2} + \sqrt{\left(\frac{q}{2}\right)^2 + \left(\frac{p}{3}\right)^2}}, v = \sqrt[3]{-\frac{q}{2} - \sqrt{\left(\frac{q}{2}\right)^2 + \left(\frac{p}{3}\right)^2}}$
62	**Inequality Interval Notation** $a \le x \le b\ [a,b]$ $a < x \le b\ (a,b]$ $a \le x < b\ [a,b)$ $a < x < b\ (a,b)$ $-\infty < x \le b, x \le b\ (-\infty, b]$ $-\infty < x < b, x < b\ (-\infty, b)$ $a \le x < \infty, x \ge a\ [a, \infty)$ $a < x < \infty, x > a\ (a, \infty)$
63	If $a > b$, then $b < a$.
64	If $a > b$, then $a - b > 0$ or $b - a < 0$.
65	If $a > b$, then $a + c > b + c$
66	If $a > b$, then $a - c > b - c$
67	If $a > b$ and $c > d$, then $a + c > b + d$
68	If $a > b$ and $c > d$, then $a - d > b - c$
69	If $a > b$ and $m > 0$, then $ma > mb$
70	If $a > b$ and $m > 0$, then $\frac{a}{m} > \frac{b}{m}$
71	If $a > b$ and $m < 0$, then $ma < mb$
72	If $a > b$ and $m < 0$, then $\frac{a}{m} < \frac{b}{m}$
73	If $0 < a < b$ and $n > 0$, then $a^n < b^n$
74	If $0 < a < b$ and $n < 0$, then $a^n > b^n$
75	If $0 < a < b$, then $\sqrt[n]{a} < \sqrt[n]{b}$
76	$\sqrt{ab} \le \frac{a+b}{2}$, where $a > 0, b > 0$; an equality is valid only if $a = b$

77	$a + \frac{1}{a} \geq 2$, where $a > 0$; an equality takes place only at $a = 1$
78	$\sqrt[n]{a_1 a_2 \ldots a_n} \leq \frac{a_1 + a_2 + \ldots + a_n}{n}$, where $a_1, a_2, \ldots, a_n > 0$
79	If $ax + b > 0$ and $a > 0$, then $x > -\frac{b}{a}$
80	If $ax + b > 0$ and $a < 0$, then $x < -\frac{b}{a}$
81	$ax^2 + bx + c > 0$
82	$\lvert a + b \rvert \leq \lvert a \rvert + \lvert b \rvert$
83	If $\lvert x \rvert < a$, then $-a < x < a$, where $a > 0$.
84	If $\lvert x \rvert > a$, then $x < -a$ and $x > a$, where $a > 0$
85	If $x^2 < a$, then $\lvert x \rvert < \sqrt{a}$, where $a > 0$
86	If $x^2 > a$, then $\lvert x \rvert > \sqrt{a}$, where $a > 0$
87	If $\frac{f(x)}{g(x)} > 0$, then $\begin{cases} f(x) \cdot g(x) > 0 \\ g(x) \neq 0 \end{cases}$
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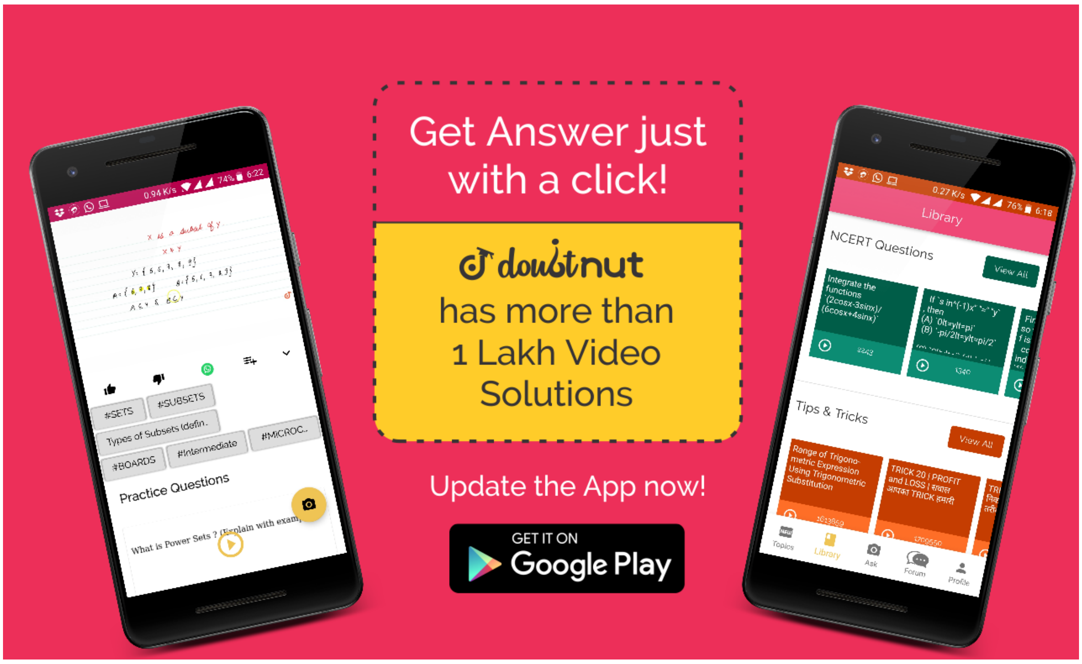
88	$\frac{f(x)}{g(x)} < 0$, then $\begin{cases} f(x) \cdot g(x) < 0 \\ g(x) \neq 0 \end{cases}$
89	**General Compound Interest Formula** $A = C\left(1 + \frac{r}{n}\right)^{nt}$
90	**Simplified Compound Interest Formula** If interest is compounded once per year, then the previous formula simplifies to: $A = C(1 + r)^t$
91	**Continuous Compound Interest** If Interest is compounded continually $(n \to \infty)$, then $A = Ce^{rt}$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#SETS
#SUBSETS
#BOARDS
#Intermediate
What is Power Sets ? (Explain with exam

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SERIES

SL#	FORMULA
1	$a_n = a_{n-1} + d = a_{n-2} + 2d = \ldots = a_1 + (n-1)d$
2	$a_1 + a_n = a_2 + a_{n-1} = \ldots = a_i + a_{n+1-i}$
3	$a_i = \frac{a_{i-1} + a_{i+1}}{2}$
4	$S_n = \frac{a_1 + a_n}{2} . n = \frac{2a_1 + (n-1)d}{2} . n$
5	$a_n = qa_{n-a} = a_1 q^{n-1}$
6	$a_1 . a_n = a_2 . a_{n-1} = \ldots = a_i . a_{n+1-i}$
7	$a_i = \sqrt{a_{i-1} . a_{i+1}} .$
8	$S_n = \frac{a_n q - a_1}{q - 1} = \frac{a_1(q^n - 1)}{q - 1}$
9	$S = \lim_{n \to \infty} S_n \Big\vert = \frac{a_1}{1-q} F \text{ or } \Big\vert q \mid < 1$, the sum S converges as $n \to \infty$.
10	$1 + 2 + 3 + \ldots\ldots\ldots\ldots + n = \frac{n(n+1)}{2}$
11	$2 + 4 + 6 + \ldots + 2n = n(n+1)$
12	$1 + 3 + 5 + \ldots + (2n-1) = n^2$
13	$k + (k+1) + (k+2) + \ldots + (k+n-1) = \frac{n(2k+n-1)}{2}$
14	$1^2 + 2^2 + 3^2 + \ldots + n^2 = \frac{n(n+1)(2n+1)}{6}$
15	$1^2 + 3^2 + 5^2 + \ldots + (2n-1)^2 = \frac{n(4n^2-1)}{3}$

16	$1^3 + 3^3 + 5^3 + \ldots + (2n-1)^3 = n^2(2n^2-1)$
17	$1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \ldots + \frac{1}{2^n} + \ldots = 2$
18	$\frac{1}{1.2} + \frac{1}{2.3} + \frac{1}{3.4} + \ldots + \frac{1}{n(n+1)} + \ldots = 1$
19	$1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \ldots + \frac{1}{(n-1)! + \ldots.} = e$
20	**Infinite Series** $\sum_{n=1}^{\infty} a_n = a_1 + a_2 + \ldots + a_n + \ldots$
21	**Nth Partial Sum** $S_n = \sum_{n=1}^{n} a_n = a_1 + a_2 + \ldots + a_n$
22	**Convergence of Infinite Series** $\sum_{n=1}^{\infty} a_n = L$, if $\lim_{n\to\infty} S_n = L$
23	**Nth Term Test** , If the series $\sum_{n=1}^{\infty} a_n$ is convergent, then $\lim_{n\to 00} a_n = 0$, If $\lim_{n\to\infty} a_n \neq 0$, then the series is divergent.

24	$\sum_{n=1}^{\infty} (a_n + b_n) = \sum_{n=1}^{\infty} a_n + \sum_{n=1}^{\infty} b_n = A + B$
25	$\sum_{n=1}^{\infty} ca_n = c\sum_{n=1}^{\infty} a_n = cA$
26	**The Comparison Test** Let $\sum_{n=1}^{\infty} a_n$ and $\sum_{n=1}^{\infty} b_n$ be series such that $0 < a_n \le b_n$ for all n. If $\sum_{n=1}^{\infty} b_n$ is convergetn then $\sum_{n=1}^{\infty} a_n$ is also convergent. If $\sum_{n=1}^{\infty} a_n$ is divergent then $\sum_{n=1}^{\infty} b_n$ is also divergent.
27	P-series $\sum_{n=1}^{\infty} \frac{1}{n^p}$ converges for $p > 1$ and diverges for $0 < p \le 1$
28	**The integral Test** Let $f(x)$ be a function which is continuous, positive, and decreasing for all $x \ge 1$. The series

	$\sum_{n=1}^{\infty} f(n) = f(1) + f(2) + f(3) + \ldots + f(n) + \ldots$ converges if $\int_1^{\infty} f(x)dx$ converges, and divrges if $\int_1^n f(x)dx \to \infty asn \to \infty$
29	**The ratio test** Let $\sum_{n=1}^{\infty} a_n$ be a series with positive terms. If $\lim_{n \to \infty} \frac{a_{n+1}}{a_n} < 1$ then $\sum_{n=1}^{\infty} a_n$ is convergent., If $\lim_{n \to \infty} \frac{a_{n+1}}{a_n} > 1$ then $\sum_{n=1}^{\infty} a_n$ is divergent., If $\lim_{n \to \infty} \left(\frac{a_{n+1}}{a_n} = 1 then \sum_{n=1}^{\infty} a_n\right.$ may converge or diverge and the ratio test is inconclusive, some other tests must be used.
30	**The Root Test** Let $\sum_{n=1}^{\infty} a_n$ be a series with positive terms. If $\lim_{n \to \infty} \sqrt[n]{a_n} < 1 then \sum_{n=1}^{\infty} a_n$ is convergent., If $\lim_{n \to \infty} \sqrt[n]{a_n} > 1 then \sum_{n=1}^{\infty} a_n$ is convergent., If $\lim_{n \to \infty} \sqrt[n]{a_n} = 1 then \sum_{n=1}^{\infty} a_n$ may converge or diverge, but no conclusion can be drawn from this test.
31	The Alternating Series Test (Leibniz\'s Theorem) Let $\{a_n\}$ be a sequence of positive numbers such that $a_{n+1} < a_n$ for all n. $\lim_{n \to \infty} a_n = 0.$, Then the alternating series $\sum_{n=1}^{\infty} (-1)^n a_n$ and $\sum_{n=1}^{\infty} (-1)^{n-1} a_n$ both converge.

32	**Absolute Convergence** A series $\sum_{n=1}^{\infty} a_n$ is absolutely convergetn if the series $\sum_{n=1}^{\infty} \lvert a_n \rvert$ is convergent., If the series $\sum_{n=1}^{\infty} a_n$ is absoluytely convergent then it is convergent.
33	**Conditional Convergence** A series $\sum_{n=1}^{\infty} a_n$ is conditionally convergent if the series is convergent but is not absolutely convergent.
34	**Power Series in x** $\sum_{n=0}^{\infty} a_n x^n = a_0 + a_1 x + a_2 x^2 + \ldots + a_n x^n + \ldots$
35	**Power Series** $\sum_{n=0}^{\infty} a_n (x - x_0)^n = a_0 + a_1 (x - x_0) + a_2 (x - x_0)^2 + \ldots + a_n (x - x_0)^n + \ldots$
36	**Interval of Convergence** The set of those values of x for which the function $f(x) = \sum_{n=0}^{\infty} a_n (x - x_0)^n$ is convergent is called the interval of conegence.
37	**Radius of Convergence**

	If the interval of convergence is $(x_0 - R, x_0 + R)$ for some $R \geq 0$ the R is called the radius of convergence. It is given as $R = \lim_{n \to \infty} \frac{1}{\sqrt[n]{a_n}}$ or $R = \lim_{n \to \infty} \left\lvert \frac{a_n}{a_{n+1}} \right\rvert$.
38	**Differentiation of Power Series** Let $f(x) = \sum_{n=0}^{\infty} a_n x^n = a_0 + a_1 x + a_2 x^2 + \ldots$ for $\lvert x \rvert < R$. Then, for $\lvert x \rvert < R$, $f(x)$ is contiuous, the derivative $f'(x)$ exists and $f'(x) = \frac{d}{dx} a_0 + \frac{d}{dx} a_1 x + \frac{d}{dx} a_2 x^2 \Big) \ldots = a_1 + 2a_2 x + 3a_3 x^2 + \ldots = \sum_{n=1}^{\infty} n a_n x^{n-1}$.
39	**Integration of Power Series** $Let f(x) = \sum_{n=0}^{\infty} a_n x^n = a_0 + a_1 x + a_2 x^2 + \ldots$ for $\lvert x \rvert < R$ Then for $\lvert x \rvert < R$, the indefinite integral $\int f(x) dx$ exists and $\int f(x) dx = \int a_0 dx + \int a_1 x dx + \int a_2 x^2 dx + \ldots = a_0 x + a_1 \frac{x^2}{2} + a_2 \frac{x^3}{3} + \ldots \sum_{n=0}^{\infty} a_n \frac{x^{n+1}}{n+1} + C$
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40	**Taylor Series** $f(x) = \sum_{n=0}^{\infty} f^n(a) \frac{I(x-a)^n}{n!} = f(a) + f'(a)(x-a) + \frac{f''(a)(x-a)^2}{2!} + \ldots = \frac{f^n(a)(x-a)^n}{n!} + R_n$.
41	**The Remainder After $n+1$ Terms is given by** $R_n = \frac{f^{n+1}(\xi)(x-a)^{n+1}}{(n+1)!}, a < \xi < x.$
42	**Maclaurin Series** $f(x) f^n(0) \frac{x^n}{n!} = f(0) + f'(0)x + \frac{f''(0)x^2}{2!} = \ldots + \frac{f^n(0)x^n}{n!} + R_n$
43	$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots + x^n(n!) + \ldots$
44	$a^x = 1 + \frac{x \ln a}{1!} + \frac{(x \ln a)^2}{2!} + \left(\frac{(x \ln a)^3}{3!} + \ldots + \frac{(x \ln a)^n}{n!} + \ldots \right.$
45	$\ln(1+x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^3}{4} + \ldots + \frac{(-1)^n x^{n+1}}{n+1} \pm \ldots, -1 < x \leq 1.$
46	$\frac{\ln(1+x)}{1-x} = 2\left(x + \frac{x^3}{3} + \frac{x^5}{5} + \frac{x^7}{7} + \ldots\right), \lvert x \rvert < 1.$
47	$\ln x = 2\left[\frac{x-1}{x+1} + \frac{1}{3}\left(\frac{x-1}{x+1}\right)^3 + \frac{1}{5}\left(\frac{x-1}{(x+1)^5} \ldots\right], x > 0.$

48	$\cos x = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} + \frac{x^6}{6!} + \ldots + \frac{(-1)^n x^{2n}}{(2n)!} \pm \ldots$
49	$\sin x = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \ldots + \frac{(-1)^n x^{2n+1}}{(2n+1)!} \pm \ldots$
50	$\tan x = x + \frac{x^3}{3} + \frac{2x^5}{15} + \frac{17x^7}{315} + \frac{62x^9}{2835} + \ldots, \|x\| < \frac{\pi}{2}$
51	$\cot x = \frac{1}{x} - \left(\frac{x}{3} + \frac{x^3}{45} + \frac{2x^5}{945} + \frac{2x^7}{4725}\right) + \ldots\Big), \|x\| < \pi.$
52	$\sin^{-1} x = x + \frac{x^3}{2.3} + \frac{1.3x^5}{2.4.5} + \ldots + \frac{1.3.5\ldots(2n-1)x^{2n+1}}{2.4.6\ldots(2n)(2n+1)} + \ldots, \|x\| < 1$
53	$\cos^{-1} x = \frac{\pi}{2} - \left(x + \frac{x^3}{2.3} + \frac{1.3x^5}{2.4.5} + \ldots + \frac{1.3.5.\,(2n-1)x^{2n+1}}{2.4.6\ldots(2n)(2n+1)} + \ldots\right), \|x\| < 1.$
54	$\tan^{-1} x = x - \frac{x^3}{3} + \frac{x^5}{5} - \frac{x^7}{7} + \ldots + \frac{(-1)^n x^{2n+1}}{2n+1} \pm \ldots, \|x\| \leq 1.$
55	$\cosh x = 1 + \frac{x^2}{2!} + \frac{x^4}{4!} + \frac{x^6}{6!} + \ldots + \frac{x^{2n}}{(2n)!} + \ldots$
56	$\sinh x = x + \frac{x^3}{3!} + \frac{x^5}{5!} + \frac{x^7}{7!} + \ldots + \frac{x^{2n+1}}{(2n+1)!} + \ldots$
57	$(1+x)^n = 1 +^n C_1 x +^n C_2 x^2 + \ldots +^m C_n x^m + \ldots + x^n$
58	$\hat{}\ nC_m = \frac{n(n-1)\ldots[n-(m-1)]}{m!}, \|x\| < 1$
59	$\frac{1}{1+x} = 1 - x + x^2 - x^3 + \ldots, \|x\| < 1.$
60	$\frac{1}{1-x} = 1 + x + x^2 + x^3 + \ldots, \|x\| < 1$
61	$\sqrt{1+x} = 1 + \frac{x}{2} - \frac{x^2}{2.4} + \frac{1.3x^3}{2.4.6} - \frac{1.3.5x^4}{2.4.6.8} + \ldots, \|x\| \leq 1$
62	$\sqrt[3]{1+x} = 1 + \frac{x}{3} - \frac{1.2x^2}{3.6} + \frac{1.2.5x^3}{3.6.9} - \frac{1.2.5.8x^4}{3.6.9.12} = \ldots, \|x\| \leq 1.$
63	$f(x) = \frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos nx + b_n \sin nx)$

64	$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx dx$
65	$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos nx dx$

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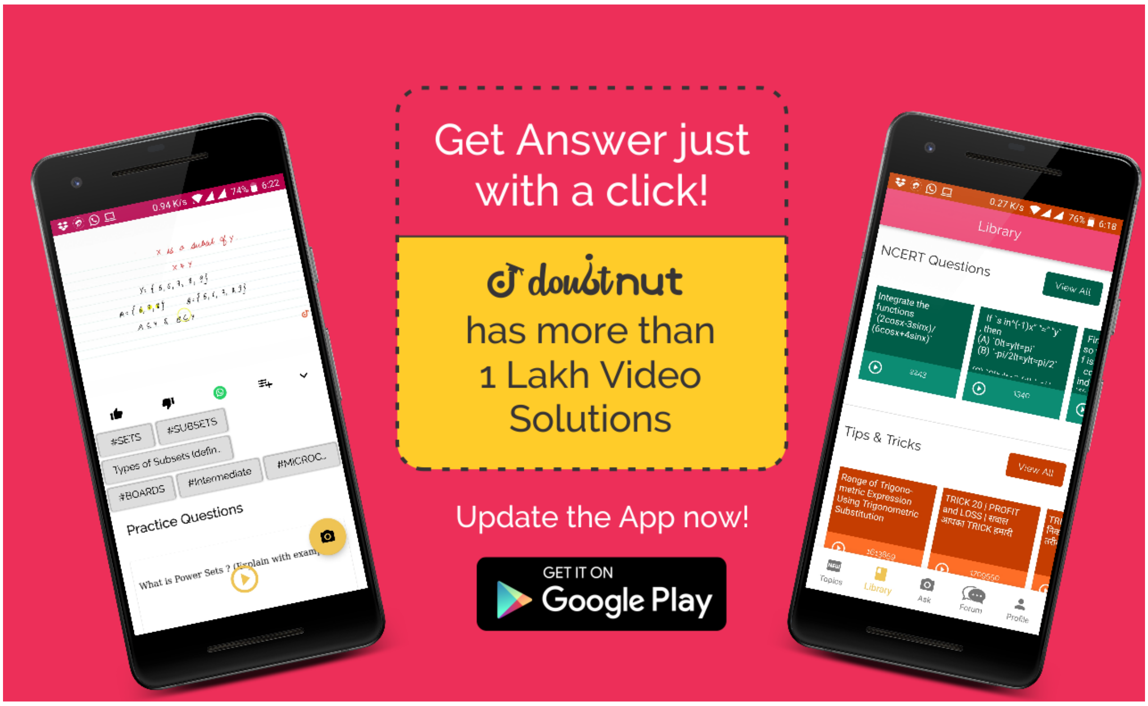
CIRCLE

SL#	FORMULA
1	**Equation of a Circle Centered at the Origin (Standard Form)** $x^2 + y^2 = R^2$
2	**Equation of a Circle Centered at Any Point** (a, b) ,$(x-a)^2 + (y-b)^2 = R^2$
3	**Three Point Form** $\begin{vmatrix} x^2+y^2 & x & y & 1 \\ x_1^2+y_1^2 & x_1 & y_1 & 1 \\ x_2^2+y_2^2 & x_2 & y_2 & 1 \\ x_3^2+y_3^2 & x_3 & y_3 & 1 \end{vmatrix} = 0$
4	**Parametric Form** $x = R\cos t, y = R\sin t, 0 \le t \le 2\pi$
5	**General Form** $Ax^2 + Ay^2 + Dx + Ey + F = 0$ ($A \neq 0, D^2 + E^2 > 4AF$). The center of the Circle has coordinates (a, b) where $a = -\dfrac{D}{2A}, b = -\dfrac{E}{2A}$. The radius of the circle is $R = \sqrt{\dfrac{D^2 + E^2 - 4AF}{2\|A\|}}$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COMPLEX NUMBERS

SL#	FORMULA
1	$i^1 = i$; $i^5 = i$; $i^{4n+1} = i$ $i^2 = -1$; $i^6 = -1$; $i^{4n+2} = -1$ $i^3 = -i$; $i^7 = -i$; $i^{4n+3} = -i$ $i^4 = 1$; $i^8 = 1$; $i^{4n} = 1$
2	$z = a + bi$
3	$(a+bi)+(c+di)=(a+c)+(b+d)i$
4	$(a+bi)-(c+di)=(a-c)+(b-d)i$
5	$(a+bi)(c+di)=(ac-bd)+(ad+bc)i$
6	$\frac{a+bi}{c+di}=\frac{ac+bd}{c^2+d^2}+i\cdot\frac{bc-ad}{c^2+d^2}$
7	**Conjugate Complex Numbers** $\overline{a+bi}=a-bi$
8	$a = r\cos\varphi, b = r\sin\varphi$
9	**Polar Presentation of Complex Numbers** $a+bi=r(\cos\varphi+i\sin\varphi)$
10	**Modulus and Argument of a Complex Number: If $a+bi$ is a complex number, then $r=\sqrt{a^2+b^2}$ (modulus),** $\varphi=\tan^{-1}\left(\frac{b}{a}\right)$ **(argument).**

11	**Product in Polar Representation** $z_1 \cdot z_2 = r_1(\cos\varphi_1 + i\sin\varphi_1) \cdot r_2(\cos\varphi_2 + i\sin\varphi_2) = r_1 r_2[\cos(\varphi_1 + \varphi_2) + i\sin(\varphi_1 + \varphi_2)]$
12	**Conjugate Numbers in Polar Representation** $\overline{r(\cos\varphi + i\sin\varphi)} = r[\cos(-\varphi) + i\sin(-\varphi)]$
13	**Inverse of a Complex Number in Polar Representation** $\frac{1}{r(\cos\varphi + i\sin\varphi)} = \frac{1}{r}[\cos(-\varphi) + i\sin(-\varphi)]$
14	**Quotient in Polar Representation** $\frac{z_1}{z_2} = \frac{r_1(\cos\varphi_1 + i\sin\varphi_1)}{r_2(\cos\varphi_2 + i\sin\varphi_2)} = \frac{r_1}{r_2}[\cos(\varphi_1 - \varphi_2) + i\sin(\varphi_1 - \varphi_2)]$
15	**Power of a Complex Number** $z^n = [r(\cos\varphi + i\sin\varphi)]^n = r^n[\cos(n\varphi) + i\sin(n\varphi)]$
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16	**De Moivre** $(\cos\varphi + i\sin\varphi)^n = \cos(n\varphi) + i\sin(n\varphi)$
17	**nth Root of a Complex Number** $\sqrt[n]{z} = \sqrt[n]{r(\cos\varphi + i\sin\varphi)} = \sqrt[n]{r}\left(\frac{\cos(\varphi + 2\pi k)}{n} + i\sin\left(\frac{\varphi + 2\pi k}{n}\right)\right),$
18	**Euler\'s Formula** $e^{ix} = \cos x + i\sin x$
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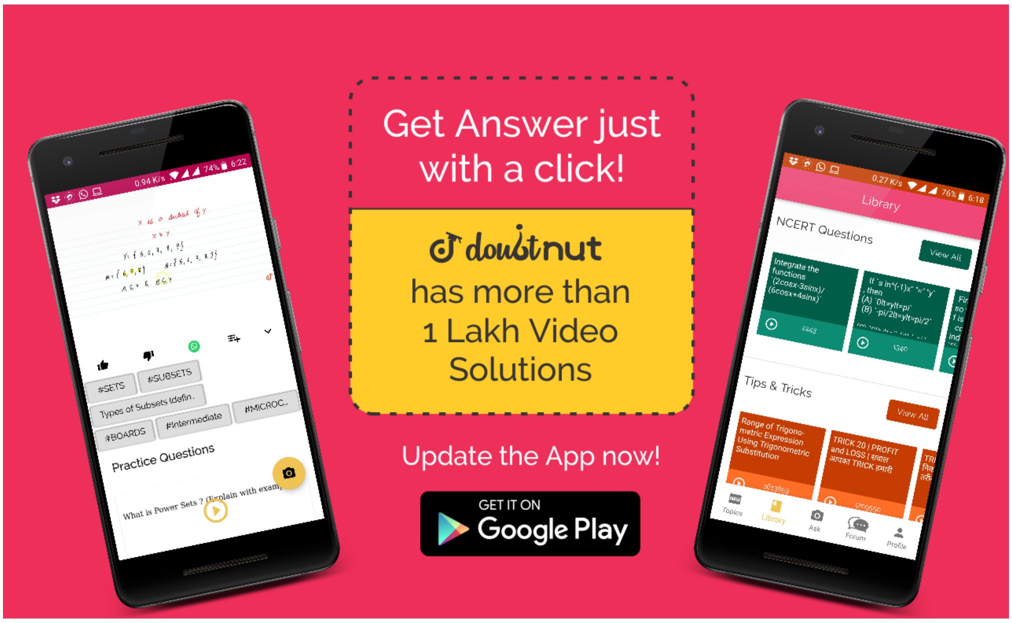
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CONIC SECTIONS

SL#	FORMULA
1	**Equation of an Ellipse (Standard Form)** $\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$
2	$r_1+r_2=2a, where r_1, r_2$ **are distances from any point** $P(x,y)$ **on the ellipse to the two foci.**
3	$a^2=b^2+c^2$
4	**Eccentricity** $e=\frac{c}{a}<1$
5	**Equations of Directrices** $x=\pm\frac{a}{e}=\pm\frac{a^2}{c}$
6	**Parametric Form** $\begin{cases} x=a\cos t \\ y=b\sin t \end{cases}$ **where** $(0\leq t\leq 2\pi)$
7	**General Form** $Ax^2+Bxy+Cy^2+Dx+Ey+F=0$, **where** $B^2-4AC<0$
8	**General Form with Axes Parallel to the Coordinate Axes** $Ax^2+Cy^2+Dx+Ey+F=0$, **where** $AC>0$
9	**Circumference** $L=4aE(e)$, **where the function E is the complete elliptic integral of the second kind.**
10	**Approximate Formulas of the Circumference** $L=\pi\left(1.5(a+b)-\sqrt{ab}\right), L=\pi\sqrt{2\left(a^2+b^2\right)}$.
11	$S=\pi ab$
12	**Equation of a Hyperbola (Standard Form)**

	$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$
13	$\|r_1 - r_2\| = 2a$, where r_1, r_2 are distances from any point $P(x, y)$ on the hyperbola to the two foci.
14	Equations of Asymptotes $y = \pm \frac{b}{a}x$
15	$c^2 = a^2 + b^2$
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16	Eccentricity $e = \frac{c}{a} > 1$
17	Equations of Directrices $x = \pm \frac{a}{e} = \pm \frac{a^2}{c}$
18	Parametric Equation of the Right Branch of a Hyperbola $\begin{cases} x = a\cosh t \\ y = b\sin ht \end{cases}$ where $0 \leq t \leq 2\pi$
19	General Form(0letle2pi $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$, where$B^2 - 4AC < 0$
20	Asymptotic Form $xy = \frac{e^2}{4}$ or $y = \frac{k}{x}$, where $k = \frac{e^2}{4}$. In this case, the asymptotes have equations $x = 0$ and $y = 0$
21	Equation of a Parabola (Standard Form) $y^2 = 2px$
22	General Form $Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$, where $B^2 - 4AC = 0$
23	$y = ax^2, p = (2a)$ Equation of the directrix $y = -\frac{p}{2}$ Coordinates of the focus$F\left(o, \frac{p}{2}\right)$ Coordinates of the vertex $M(0, 0)$
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24	General Form, Axis Parallel to the y-axis

$Ax^2 + Dx + Ey + F = 0$ **(A,E nonzero)**, $y = ax^2 + bx + c, p = \frac{1}{2a}$.

Equation of the directrix $y = y_0 - \frac{p}{2}$,

coordinates of the focus $F\left(x_0, y_0 + \frac{p}{2}\right)$,

Coordinates of the vertex $x_0 = -\frac{b}{2a}, y_0 = ax_2^2 + bx_0 + C = \frac{4ac - b^2}{4a}$

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DIFFERENTIAL CALCULUS

SL#	FORMULA
1	**Even Function** $F(-x) = f(x)$
2	**Odd Functin** $f(-x) = -f(x)$
3	**Periodic Function** $f(x+nT) = f(x)$
4	**Inverse Function** $y = f(x)$ **is any function** $x = g(y)$ **or** $y = f^{-1}(x)$ **is its inverse function.**
5	**Composite Functin** $y = f(u), u = g(x), y = f(g(x))$ **is a composite function.**
6	**Linear Function** $y = ax + b, x \in R, a = \tan\alpha$ **is the slope of the line, b is the y-intercept.**
7	**Quadratic Function** $y = x^2, x\varepsilon R.$ $y = ax^2 + bx + c, x\varepsilon R.$
8	**Cubic Function** $y = x^3, x\varepsilon R$ $y = ax^3 + bx^2 + cx + d, x\varepsilon R$
9	**Power Function** $y = x^n, n\varepsilon N.$
10	**Square Root function** $y = \sqrt{x}, x\varepsilon[0, \infty).$
11	**Exponential Functions** $y = a^x, a > 0, a \neq 1, y = e^x$ **if** $a = e, e = 2.71828182846.\dots\dots.$
12	**Logarithmic Functions** $y = \log_a x, x\varepsilon(0, \infty), a > 0, a \neq 1, y = \ln x$ **if** $a = e, x > 0$
13	**Hyperbolic Sine Function** $y = \sinh x, \sinh x = \dfrac{e^x - e^{-x}}{2}, x\varepsilon R.$
14	**Hyperbolic Cosine Function** $y = \cosh x, \cosh x = \dfrac{e^x + e^{-x}}{2}, x\varepsilon R.$
15	**Hyperbolic Tangent Function**

	$y = \tanh x, y = \tanh x = \frac{\sinh x}{\cosh x} = \frac{e^x - e^{-x}}{e^x + (e^{-x})}, x \varepsilon R.$
16	**Hyperbolic Cotangent Function** $y = \cot hx, y = \coth x = \frac{\cosh x}{\sinh x} = \frac{e^x + e^{-x}}{e^x - e^{-x}}, x \varepsilon R, x \neq 0$
17	**Hyperbola Secant Function** $y = \operatorname{sech} x, y = \operatorname{sech} x = \frac{1}{\cosh x} = \frac{2}{e^x + e^{-x}}, x \varepsilon R.$
18	**Hyperbolic Cosecant Function** $y = \cos echx, y = \cos echx = \frac{1}{\sinh x} = \frac{2}{e^x - e^{-x}}, x \varepsilon R, x \neq 0$
19	**Inverse Hyperbolic Sine Function** $y = \sin^{-1} hx, x \varepsilon R.$
20	**Inverse Hyperbolic cosine Function** $yi = \cos^{-1} hx, x \varepsilon [1, \infty).$
21	**Inverse Hyperbolic Tangent Function** $y = \tan^{-1} hx, x \varepsilon (-1, 1).$
22	**Inverse Hyperbolic Contagent Function** $y = \cot^{-1} hx, x \varepsilon (-\infty, -1) \cup (1, \infty).$
23	**Inverse Hyperbola Secant Function** $y = \sec^{-1} hx, x \varepsilon (0, 1].$
24	**Inverse Hyperbolic Cosecant Function** $y = \cos^{-1} echx, x \varepsilon R, x \neq 0$
25	$\lim_{x \to a} [f(x) + g(x)] = \lim_{x \to a} f(x) + \lim_{x \to a} g(x)$
26	$\lim_{x \to a} [f(x) - g(x)] = \lim_{x \to a} f(x) - \lim_{x \to a} g(x)$
27	$\lim_{x \to a} [f(x). g(x)] = \lim_{x \to a} f(x). \lim_{x \to a} g(x)$
28	$\lim_{x \to a} \left(\frac{f(x)}{g(x)}\right) = \frac{\lim_{x \to a} f(x)}{\lim_{x \to a} g(x)} \text{ if } \lim_{x \to a} g(x) \neq 0.$
29	$\lim_{x \to a} [kf(x)] = k \lim_{x \to a} f(x)$
30	$\lim_{x \to a} f(g(x)) = f\left(\lim_{x \to a} g(x)\right)$
31	$\lim_{x \to a} f(x) = f(a)$ **if the function** $f(x)$ **is continuous at x=a**
32	$\lim_{x \to 0} \frac{\sin x}{x} = 1$
33	$\lim_{x \to 0} \frac{\tan x}{x} = 1$

34	$\lim_{x \to 0} \frac{\sin^{-1} x}{x} = 1$
35	$\lim_{x \to 0} \frac{\tan^{-1} x}{x} = 1$
36	$\lim_{x \to 0} \frac{\ln(1+x)}{x} = 1$
37	$\lim_{x \to \infty} \left(1 + \frac{1}{x}\right)^x = e$
38	$\lim_{x \to \infty} \left(1 + \frac{k}{x}\right)^x = e^k$
39	$\lim_{x \to 0} a^x = 1$
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40	$y'(x) = \lim_{\triangle x \to 0} \frac{f(x + \triangle x) - f(x)}{\triangle x} = \lim_{\delta x \to 0} \frac{\triangle y}{\triangle x} = \frac{dy}{dx}$
41	$\frac{dy}{dx} = \tan \alpha$
42	$\frac{d(u+v)}{dx} = \frac{du}{dx} + \frac{dv}{dx}$
43	$\frac{d(u-v)}{dx} = \frac{du}{dx} + \frac{dv}{dx}$
44	$\frac{d(ku)}{dx} = k \frac{du}{dx}$
45	**Product Rule** $\frac{d(u.\,v)}{dx} = \frac{du}{dx}.\,v + u.\,\frac{dv}{dx}$
46	**Chain Rule** $y = f(g(x)), y = g(x), \frac{dy}{dx} = \frac{dy}{dg}.\,\frac{dg}{dx}$
47	**Derivative of Inverse function** $\frac{dy}{dx} = \frac{1}{\frac{dx}{dy}}$ **where $x(y)$ is the inverse function of $y(x)$.**
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48	**Reciprocal Rule** $\frac{d}{dx}\left(\frac{1}{y}\right) = -\frac{\frac{dy}{dx}}{y^2}$
49	**Logarithmic Differentiation** $y = f(x), \ln y = \ln f(x), \frac{dy}{dx} = f(x).\,\frac{d}{dx}[\ln f(x)]$
50	$\frac{d}{dx}(C) = 0$
51	$\frac{d}{dx}(x) = 1$
52	$\frac{d}{dx}(ax+b) = a$
53	$\frac{d}{dx}(ax^2 + bx + c) = 2ax + b$

54	$\frac{d}{dx}(x^n) = nx^{n-1}$
55	$\frac{d}{dx}x^{-n} = -\frac{n}{x^{n+1}}$

56	$\frac{d}{dx}\left(\frac{1}{x}\right) = -\frac{1}{x^2}$
57	$\frac{d}{dx}(\sqrt{x}) = \frac{1}{2\sqrt{x}}$
58	$\frac{d}{dx}(\sqrt[n]{x}) = \frac{1}{n\sqrt[n]{x^{n-1}}}$
59	$\frac{d}{dx}(\ln x) = \frac{1}{x}$
60	$\frac{d}{dx}(\log_a x) = \frac{1}{x1na}, a > 0, a \neq 1.$
61	$\frac{d}{dx}(e^x) = e^x$
62	$\frac{d}{dx}(\sin x) = \cos x$
63	$\frac{d}{dx}(\cos x) = -\sin x$

64	$\frac{d}{dx}(\tan x) = \frac{1}{\cos^2 x} = \sec^2 x$
65	$\frac{d}{dx}(\cot x) = \frac{1}{\sin^2 x} = \cos ec^2 x$
66	$\frac{d}{dx}(\sec x) = \tan x. \sec x$
67	$\frac{d}{dx}(\cos ecx) = -\cot x. \cos ecx$
68	$\frac{d}{dx}(\sin^{-1} x) = \frac{1}{\sqrt{1-x^2}}$
69	$\frac{d}{dx}(\cos^{-1} x) = -\frac{1}{\sqrt{1-x^2}}$
70	$\frac{d}{dx}(\tan^{-1} x) = \frac{1}{1+x^2}$
71	$\frac{d}{dx}(\cot^{-1} x) = -\frac{1}{1+x^2}$

72	$\frac{d}{dx}(\sec^{-1} x) = \frac{1}{\lvert x\rvert\sqrt{x^2-1}}$
73	$\frac{d}{dx}(\cos^{-1} ecx) = -\frac{1}{\lvert x\rvert\sqrt{x^2-1}}$
74	

	$\frac{d}{dx}(\sinh x) = \cos hx$
75	$\frac{d}{dx}(\cosh x) = \sinh x$
76	$\frac{d}{dx}(\tanh x) = \frac{1}{\cosh^2 x} = \text{sech}^2 x$
77	$\frac{d}{dx}(\coth x) = -\frac{1}{\sinh^2 x} = \text{sech}^2 x$
78	$\frac{d}{dx}(\text{sech}\, x) = -\text{sech}\, x.\tanh x$
79	$\frac{d}{dx}(\cos echx) = -\cos echx.\coth x$

80	$\frac{d}{dx}(\sin^{-1} hx) = \frac{1}{\sqrt{x^2+1}}$
81	$\frac{d}{dx}(\cos^{-1} hx) = \frac{1}{\sqrt{x^2-1}}$
82	$\frac{d}{dx}(\tan^{-1} x) = \frac{1}{1-x^2}, \lvert x \rvert < 1$
83	$\frac{d}{dx}(\cot^{-1} hx) = -\frac{1}{x^2-1}, \lvert x \rvert > 1$
84	$\frac{d}{dx}(u^v) = vu^{v-1}.\frac{du}{dx} + u^v \ln u.\frac{dv}{dx}$
85	**Second derivative** $f'' = (f')' = \frac{dy}{dx}' = \frac{d}{dx} = \frac{d^2y}{dx^2}$
86	**Higher-Order derivative** $f^n = \frac{d^ny}{dx^n} = y^n = \left(f^{n-1}\right)$
87	$(u+v)^n = u^n + v^n$

88	$(u-v)^n = u^n - v^n$
89	**Leibnitz\'s formulas** $(uv)'' = u''v + 2u'v' + uv'', (uv)''' + u'''v + 3u''v' + 3u'v'' + uv''', (uv)^n = u^nv + \nu^{n-1}v' + \frac{n(n-1)}{1.2}u^{n-2}v'' + \ldots + uv^n$
90	$(x^m)^n = \frac{m!}{m-n}!x^{m-n}$
91	$(x^n)^n = n!$
92	$(\log_a x)^a = \frac{(-1)^{n-1}(n-1)!}{x^n 1na}$
93	$(\ln x)^n = \frac{(-1)^{n-1}(n-1)!}{x^n}$
94	$(a^x)^n = a^x \ln^n a$
95	$(e^x)^n = e^x$

96	$\left(a^{mx}\right)^n = m^n a \cdot (mx)1n^n a$
97	$(\sin x)^n = \sin\left(x + \frac{n\pi}{2}\right)$
98	$(\cos x)^n = \cos\left(x + \frac{n\pi}{2}\right)$
99	**Velocity and Acceleration** $s = f(t)$ **is the position of an object relative to a fixed coordinate system at a time t,** $v = s' = f'(t)$ **is the instantaneous velocity of the object** $w = v' = s'' = f''(t)$ **is the intantaneous acceleration of the object.**
100	**Tangent Line** $y - y_0 = f'(x_0)(x - x_0)$
101	**Normal Line** $y - y_0 = -\frac{1}{f'(x_0)(x - x_0)}$
102	**Increasing and Decreasing Functions.** **If** $f'(x_0) > 0$, **then** $f(x)$ **is increasing at** x_0. **If** $f'(x_0) < 0,$ **then** $f(x)$ **is decreasing at** x_0.
103	**If** $f'(x_0)$ **does not exist or is zero, then the test fails.**
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104	**Local extrema** **A function** $f(x)$ **has as local maximum at** x_1 **if and only if there exists some interval containing** x_1 **such that** $f(x_1) \geq f(x)$ **for all** x **in the interval.** **A function** $f(x)$ **has a local minimum at** x_2 **if and only if there exists some interval contaiing** x_2 **such that** $f(x_2) \leq f(x)$ **for all** x **in the interval.**
105	**Cirtical Points** **A critical points on** $f(x)$ **occurs at** x_0 **if and only if either** $f'(x_0)$ **is zero or the derivative doesn\'t exist.**
106	**First Derivative Test for Local extrema** **If** $f(x)$ **is increasing** $(f'(x) > 0$ **for all** x **in some interval** $(a, x_1]$ and $f(x)$ **is decreasing** $(f'(x) < 0)$ **for all** x **in some interval** $[x_1, b)$, **then** $f(x)$ **has a local maximum at** x_1.
107	**If** $f(x)$ **is decreasing** $(f'(x) < 0)$ **for all x in some interval** $(a, x_{20}$ and $f(x)$ **is increasing** $(f'(x) > 0)$ **for all x in some interval** $[x_2, b)$, **then** $f(x)$ **has a local minimum at** x_2.
108	**Second Derivative Test for local Extrema** **If** $f'(x_1) = 0$ **and** $f''(x_1) < 0$, **then** $f(x)$ **has a local maximum at** x_1. **If** $f'(x_2) = 0$ **and** $f''(x_2) > 0$, **then** $f(x)$ **has a local minimum at** x_2.
109	**Concavity** $f(x)$ **is concave upward at** x_0 **if and only if** $f'(x)$ **is increasing at** $x_0 f(x)$ **is concave downward at** x_0 **if and only if** $f'(x)$ **is decreasing at** x_0.
110	**Second Derivative Test for Concavity** **If** $f''(x_0) > 0$, **then** $f(x)$ **is concave upward at** x_0, **If** $f''(x_0) < 0$, **then** $f(x)$ **is concave downward at** x_0, **If** $f''(x)$ **does not exist or is zero, then the test fails.**
111	**Inflection Points** **If** $f'(x_3)$ **exists and** $f''(x)$ **changes sign at** $x = x_3,$ **then the point** $(x_3, f(x_3))$ **is an inflection point of the graph of** $f(x)$ **If** $f''(x_3)$ **exists at the inflection point, then** $f''(x_3) = 0$
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112	**L\' Hopital\'s Rule**

	$\lim_{x \to c} \frac{f(x)}{g(x)} = \lim_{x \to c} \frac{f'(x)}{g'(x)} \quad \text{if} \quad \lim_{x \to c} f(x) = \lim_{x \to c} g(x) = \begin{cases} 0 \\ . \\ \infty \end{cases}$
113	$dy = y'dx$
114	$f(x + \triangle x) = f(x) + f'(x) \triangle x$
115	**Small Change in** $y \triangle y = f(x + \triangle x) - f(x)$
116	$d(u+v) = du + dv$
117	$d(u-v) = du - dv$
118	$d(Cu) = Cdu$
119	$d(uv) = vdu + udv$
120	$d\left(\frac{u}{v}\right) = \frac{vdu - udv}{v^2}$
121	**First Order Partial Derivatives** The partial derivative with respect to x $\frac{\partial f}{\partial x} = f_x\left(also \frac{\partial z}{\partial x} = z_x\right)$, The partial derivative with respect to y $\frac{\partial f}{\partial y} = f_y\left(also \frac{\partial z}{\partial y} = z_y\right)$.
122	**Second Order Partial Derivatives** $\frac{\partial}{\partial x}\frac{\partial f}{\partial x} = (\partial^2 f)(\partial x^2) = f_{\times}, \frac{\partial}{\partial y}\frac{\partial^2 f}{\partial y^2} = f_{yy}, patial\bigg(\partial y\bigg(\frac{\partial f}{\partial x} = \frac{\partial^2 f}{\partial y \partial x} = f_{xy}, \partial(\partial x)\bigg(\frac{\partial f}{\partial y} = \frac{\partial^2 f}{\partial x \partial y} = f_{yx}.$ If the derivatives are continuous, then $\frac{\partial f}{\partial y \partial x} = \frac{\partial^2 f}{\partial x \partial y}$.
123	**Chain Rules** If $f(x,y) = g(h(x,y))$(g is a function of one variable h), then $\frac{\partial f}{\partial x} = g'(h(x,y))\frac{\partial h}{\partial x}, \frac{\partial f}{\partial y} = g(h(x,y))\frac{\partial h}{\partial y}$. If $h(t) = f(x(t), y(t))$,then $h'(t) = \frac{\partial f}{\partial x}\frac{dx}{dt} + \frac{\partial f}{\partial y}\frac{dy}{dt}$. I $z = f(x(u,v), y(u,v)0$ then $\frac{\partial z}{\partial u} = \frac{\partial f}{\partial x}\frac{\partial x}{\partial u} + \frac{\partial f}{\partial y}\frac{\partial y}{\partial u}, \frac{\partial z}{\partial v} = \frac{\partial f}{\partial} x\bigg)\frac{\partial x}{\partial v} + \frac{\partial f}{\partial y}\frac{\partial y}{\partial v}$.
124	**Small Changes** $\triangle \approx \left(\frac{\partial f}{\partial x}\right)x + \left(\frac{\partial f}{\partial y}\right)y.$
125	**Local Maxima and Minima** $f(x,y)$ has a local maximum at (x_0, y_0) if $f(x,y) \leq f(x_0, y_0)$ for all (x,y) sufficiently close to $(x_0, y_0) f(x,y)$ has a local minimum at (x_0, y_0) if $f(x,y) \geq f(x_0, y_0) f \text{ or } all(x,y)$ sufficiently close (x_0, y_0).
126	**Saddle Point** A stationary point which is neither a local maximum nor a local minimum
127	**Stationary Points** $\frac{\partial f}{\partial x} = \frac{\partial f}{\partial y} = 0$ Local maxima and local minima occur at stationary points.
128	**Tangent Plane** The equation of the tangent plane to the surface $z = f(x,y) at (x_0, y_0, z_0)$ is $z - z_0 = f_x(x_0, y_0)(x - x_0) + f_y(x_0, y_0)(y - y_0)$

129	**Normal to Surface** The equationn of the normal to the surface $z = f(x, y)$ at (x_0, y_0, z_0) is $\frac{x - x_0}{f_x(x_0, y_0)} = \frac{y - y_0}{f_y(x_0, y_0)} = \frac{z - z_0}{-1}$
130	**Gradient of a Scalar Function** $\nabla f = \nabla f = \left(\frac{\partial f}{\partial x}, \frac{\partial f}{\partial y}, \frac{\partial f}{\partial z}\right)$ $\nabla u = \nabla u = \left(\frac{\partial u}{\partial x_1}, \frac{\partial u}{\partial x_2}, \ldots\ldots, \frac{\partial u}{\partial x_n}\right)$
131	**Directional Derivative** $\frac{\partial f}{\partial 1} = \frac{\partial f}{\partial x}\cos\alpha + \frac{\partial f}{\partial y}\cos\beta + \frac{\partial f}{\partial z}\cos\gamma,$ where the direction is defined by the vector $\vec{1}(\cos\alpha, \cos\beta, \cos\gamma), \cos^2\alpha + \cos^2\beta + \cos^2\gamma = 1.$
132	**Divergence of a Vector Field** $\div \vec{F} \equiv \nabla . \vec{F} = \frac{\partial P}{\partial x} + \frac{\partial Q}{\partial y} + \frac{\partial R}{\partial z}$
133	**Laplacian Operator** $\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2}$
134	$\div\left(curl\vec{F}\right) = \nabla . \left(\nabla \times \vec{F}\right) = 0$
135	$curl(\nabla f) = \nabla \times (v \nabla f) \equiv 0$
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136	$\div(\nabla f) = \nabla . (\nabla) = \nabla^2 f$
137	$curl\left(curl\vec{F}\right) \equiv \nabla\left(\div \vec{F}\right) - \nabla\vec{F} - \nabla\left(\nabla . \vec{F}\right) - \nabla^2\vec{F}.$

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DIFFERENTIAL EQUATIONS

SL#	FORMULA
1	Linear Equation $\frac{dy}{dx}+p(x)y=q(x)$. The general solutin is $y=\frac{\int u(x)q(x)dx+C}{u(x)}$, where $u(x)=\exp\left(\int p(x)dx\right)$.
2	Separable Equations $\frac{dy}{dx}=f(x,y)=g(x)h(y)$ The general solution is given by $\int\frac{dy}{h(y)}=\int g(x)dx+C$, or $H(y)=G(x)+C$
3	Homogeneous Equations The differential equation $\frac{dy}{dx}=f(x,y)$ is homogeneous, if the function $f(x,y)$ is homogeneous, that is $f(tx,ty)=f(x,y)$ The substitution $z=\frac{y}{x}(theny=zx)$ leads to the separable equation $x\frac{dz}{dx}+z=f(1,z)$.
4	Bernoulli Equation $\frac{dy}{dx}+p(x)y=q(x)y^n$. The substitution $z=y^{1-n}$ leads to the linear equation $\frac{dz}{dx}+(1-n)p(x)z=(1-n)q(x)$.
5	Riccati Equation $\frac{dy}{dx}=p(x)+q(x)y+r(x)y^2$ If a particular solution y_1 is known, then the general solution can be obtained with the help of substitutin $z=\frac{1}{y-y_1}$ which leads to the first order linear equation $\frac{dz}{dx}=-[q(x)+2y_1(x)]z-r(x)$.
6	Exact and Nonexact Equations The equation $M(x,y)dx+N(x,y)dy=0$ is called exact if $\frac{\partial M}{\partial Y}=\frac{\partial N}{\partial x}$, nd nonexact other wise. The general solution is $\int M(x,y)dx+\int N(x,y)dy=C$.
7	Radioactive Decay $\frac{dy}{dx}=-ky$, where y(t) is the amount of radioactive element at time t,k is the rate of decay. The solution is $y(t)=y_0e^{-kt}, wherey_0=y(0)$ is the initial amount.
8	

	Newton\'s Law of cooling $\frac{dT}{dt} = -k(T-S)$, where T(t) is the temperature of an object at time t,S is the temperature of the surrounding environement k, is a possitive constant.The Solution is $T(t) = S + (T_0 - S)e^{-kt}, where T_0 = T(0)$ is the initial temperature of the object at time t=0.
9	Population Dynamics (Logistic Model) $\frac{dP}{dt} = kP\left(1 - \frac{P}{M}\right)$, where P(t) is population at time t,k is a positive costant, M is a limiting size for the population . The solution of the differential equation is $P(t) = \frac{MP_0}{P_0 + (M - P_0)e^{-kt}}, where P_0 = P(0)$ is the initial population at time t=0.
10	Homogeneous Linear Equations with Constant Coefficients $y'' + py' + qy = 0$ The characteristic equatin is $\lambda^2 + p\lambda + q = 0$ If λ_1 and λ_2 are distinct real roots of the characteristc equation then the general solution is $y = C_1 e^{\lambda_1} + C_2 (e^{\lambda_2}, where C_1$ and C_2 integration constants. If $\lambda_1 = \lambda_2 = -\frac{p}{2}$ then the general solution is $y = (C_1 + C_2 x)e^{-\frac{p}{2}x}. If \lambda_1$ and λ_2 are complex numbers. $\lambda_1 = \alpha + \beta i, \lambda_2 = \alpha - \beta i, where \alpha = -\frac{p}{2}, \beta = \frac{\sqrt{4q - p^2}}{2}$, then the general solutin is $y = e^{\alpha x}(C_1 \cos \beta x + C_2 \sin \beta x)$.
11	Inhomogeneous Linear Equations with Constant Coefficietns $y'' + py' + qy = f(x)$. The general solution is given by $y = y_p + y_h, where y_p$ is a particular solution o fthe inhomogeneous equation and y_h is the general solution of the associated homogeneous equation. If the right side has the form $f(x) = e^{\alpha x}(P_1(x)\cos \beta x + P_1(x)\sin \beta x)$, then the particular solution y_p is given by $y_p = x^k e^{\alpha x}(R_1(x)\cos \beta x + R_2(x)\sin \beta x)$, where the polynomials $R_1(x)$ and $R_2(x)$ have to be found by using the method of undetermined coefficiets. If $\alpha + \beta i$ is a simle root, then $k = 1$, If $\alpha + \beta i$ is a double root, then $k = 2$.
12	Differential Equatins with y missing $y'' = f(x, y'). Set u = y'$. then the new equation satisfied by v is $u' = f(x, u)$ where is a first order differential equation.
13	Differential Equations with x missing $y'' = f(y, y')$. Since $y'' = \frac{du}{dx} = \frac{du}{dy}\frac{dy}{dx} = u\frac{du}{dy}$, we have $u\frac{du}{dy} = f(y, u)$, which is a first order differential equation.
14	Free Undamped Vibrations The motion of a Mass on a Spring is described by the equation $m\ddot{y} + ky = 0$, where m is the mass of the object, k is the stiffness of the spring, y is displacement of the mass from equilibrium. The general solution is $y = A\cos(\omega_0 t - \delta)$, where is the amplitude of the displacement, $om\eta_0$ is the fundamenta frequency, the perod is $T = \frac{2\pi}{\omega_0}, \delta$ is phase angle o the displacement. This is an example of simple harmonic motion.
15	Free Damped Vibrations $m\ddot{y} + \gamma\dot{y} + ky = 0$, where gamma is the damping coefficient. There are 3 cases for the general solution: Case 1. $\gamma^2 > 4km$(overdamped) $y(t) = Ae^{\lambda_1 t} + Be^{\lambda_2 t}$, where $\lambda_1 = \frac{-\gamma - \sqrt{\gamma^2 - 4km}}{2m}$, $\lambda_2 = \frac{-\gamma + \sqrt{\gamma^2 - 4km}}{2m}$. Case 2. $\gamma^2 = 4km$(critically damped)y(t)=(A+Bt)e^(lambdat), $where$lambda=- gamma/(2m) $. Case 3.$ gamma^2lt4km$(underdamed)\ y(t) = e^{-\frac{\gamma}{2m}}A\cos(\omega t - \delta)$, where, $\omega = \sqrt{4km - \gamma^2}$
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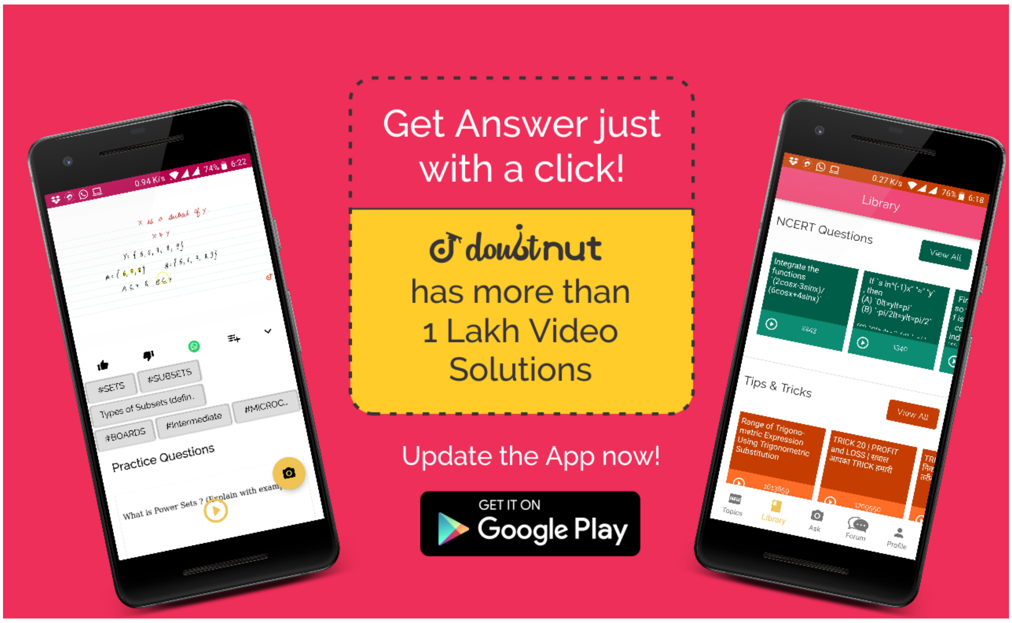
16	simple Pendulum $\frac{d^2\theta}{dt^2} + \frac{g}{L}\theta = 0,$ where theta is the angular displacement, L is the pendulum length, g is the acceleration of gravity. The general solution for small angles theta is $\theta(t) = \theta_{\max} \sin\left(\sqrt{\frac{g}{L}}t,\right.$ the period is $T = 2\pi\sqrt{\frac{L}{g}}$.
17	RLC circuit $L\frac{d^2I}{dt^2} + R\frac{dI}{dt} + \frac{1}{C}I = V'(t) = \omega E_0 \cos(\omega t)$, where I is the current is an RLC circuit with an ac voltage source $V(t) = E_0 \sin(\omega t)$. The general solution is $I(t) = C_1 e^{r_1 t} + C_2 e^{r_2 t} + A\sin(\omega t - \varphi)$, where $r_{1,2} = \frac{-R \pm \sqrt{R^2 - \frac{4L}{C}}}{2L}$, $A = \frac{\omega E_0}{\sqrt{L\omega^2 - \frac{1}{C}^{-2} + R^2\omega^2}}\Bigg)$, $\varphi = \tan^{-1}\left(\frac{L\omega}{R} - \frac{1}{RC\omega}\right)$, C_1, C_2 are constants depending on intial conditions.
18	The Lalace Equation $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ applies to potential energy function $u(x, y)$ for a conservative force field in the xy-plane. Partial differential equations of this type are called elliptic.
19	The Heat Equation $\frac{\partial^2 u}{\partial x^2 + \frac{\partial^2 u}{\partial y^2} = \frac{\partial u}{\partial t}}$ applies to the temperature distribution$u(x, y)$ in the xy-plane whenheat is allowed to flow from warm areas to cool ones. The equations of this type are called parabolic.
20	The Wave Equatin $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = \frac{\partial^2 u}{\partial t^2}$ applies to the displacement $u(x, y)$ of vibrating membrances and other wave functions. The equations of this type are caled hyperbolic.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1	$\alpha+\beta=90^\circ$
2	$\sin\alpha=\frac{a}{c}=\cos\beta$
3	$\cos\alpha=\frac{b}{c}=\sin\beta$
4	$\tan\alpha=\frac{a}{b}=\cot\beta$
5	$\cot\alpha=\frac{b}{a}=\tan\beta$
6	$\sec\alpha=\frac{c}{b}=\cos ec\beta$
7	$\cos ec\alpha=\frac{c}{a}=\sec\beta$
8	**Pythagorean Theorem** $a^2+b^2=c^2$
9	$a^2=fc, b^2=gc,$ **where f and c are projections of the legs a and b, respectively, onto the hypotenuse c.**
10	$h^2=fg,$ **where h is the altitude from the right angle.**
11	$m_a^2=b^2-\frac{a^2}{4}, m_b^2=a^2-\frac{b^2}{4},$ **where m_a and m_b are the medians to the legs a and b.**
12	$m_c=\frac{c}{2},$

	where m_c is the median to the hypotenuse c.
13	$R = \frac{c}{2} = m_c$
14	$r = \frac{a+b-c}{2} = \frac{ab}{a+b+c}$
15	$ab = ch$
16	$S = \frac{ab}{2} = \frac{ch}{2}$
17	$\beta = 90^\circ - \frac{\alpha}{2}$
18	$h^2 = b^2 - \frac{a^2}{4}$
19	$L = a + 2b$
20	$S = \frac{ah}{2} = \frac{b^2}{2} \sin \alpha$
21	$h = \frac{a\sqrt{3}}{2}$
22	$R = \frac{2}{3}h = \frac{a\sqrt{3}}{3}$
23	$r = \frac{1}{3}h = \frac{a\sqrt{3}}{6} = \frac{R}{2}$
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24	$L = 3a$
25	$S = \frac{ah}{2} = \frac{a^2\sqrt{3}}{4}$
26	$\alpha + \beta + \gamma = 180^\circ$
27	In a $\triangle ABC$ with sides a, b and c $a + b > c,$ $b + c > a,$ $a + c > b.$

28	In a $\triangle ABC$ with sides a, b and c $\|a-b\| < c$, $\|b-c\| < a$, $\|a-c\| < b$.
29	**Midline** $q = \frac{a}{2}, q \mid \mid a$.
30	**Law of Cosines** $a^2 = b^2 + c^2 - 2bc\cos\alpha$, $b^2 = a^2 + c^2 - 2ac\cos\beta$, $c^2 = a^2 + b^2 - 2ab\cos\gamma$
31	**Law of Sines** $\frac{a}{\sin\alpha} = \frac{b}{\sin\beta} = \frac{c}{\sin\gamma} = 2R$, where R is the radius of the circumscribed circle.
32	$R = \frac{a}{2\sin\alpha} = \frac{b}{2\sin\beta} = \frac{c}{2\sin\gamma} = \frac{bc}{2h_a} = \frac{ac}{2h_b} = \frac{ab}{2h_c} = \frac{abc}{4S}$
33	$R = \frac{bc}{2h_a} = \frac{ac}{2h_b} = \frac{ab}{2h_c} = \frac{abc}{4S}$
34	$r^2 = \frac{(p-a)(p-b)(p-c)}{p}$, $\frac{1}{r} = \frac{1}{h_a} + \frac{1}{h_b} + \frac{1}{h_c}$
35	$\sin\left(\frac{\alpha}{2}\right) = \sqrt{\frac{(p-b)(p-c)}{bc}}$, $\cos\left(\frac{\alpha}{2}\right) = \sqrt{\frac{p(p-a)}{bc}}$, $\tan\left(\frac{\alpha}{2}\right) = \sqrt{\frac{(p-b)(p-c)}{p(p-a)}}$.
36	$h_a = \frac{2}{a}\sqrt{p(p-a)(p-b)(p-c)}$, $h_b = \frac{2}{b}\sqrt{p(p-a)(p-b)(p-c)}$,

	$h_c = \frac{2}{c}\sqrt{p(p-a)(p-b)(p-c)}$.
37	$h_a = b\sin\gamma = c\sin\beta$, $h_b = a\sin\gamma = c\sin\alpha$, $h_c = a\sin\beta = b\sin\alpha$.
38	$m_a^2 = \frac{b^2+c^2}{2} - \frac{a^2}{4}$, $m_b^2 = \frac{a^2+c^2}{2} - \frac{b^2}{4}$ $m_c^2 = \frac{a^2+b^2}{2} - \frac{c^2}{4}$.
39	$AM = \frac{2}{3}m_a, BM = \frac{2}{3}m_b, CM = \frac{2}{3}m_c$
40	$t_a^2 = \frac{4bcp(p-a)}{(b+c)^2}$, $t_b^2 = \frac{4acp(p-b)}{(a+c)^2}$, $t_c^2 = \frac{4abp(p-c)}{(a+b)^2}$.
41	$S = \frac{ah_a}{2} = \frac{bh_b}{2} = \frac{ch_c}{2}$, $S = \frac{ab\sin\gamma}{2} = \frac{ac\sin\beta}{2} = \frac{bc\sin\alpha}{2}$, $S = \sqrt{p(p-a)(p-b)(p-c)}$ **(Heron\'s Formula),** $S = pr$, $S = \frac{abc}{4R}$, $S = 2R^2\sin\alpha\sin\beta\sin\gamma$, $S = p^2\tan\left(\frac{\alpha}{2}\right)\tan\left(\frac{\beta}{2}\right)\tan\left(\frac{\gamma}{2}\right)$.
42	$d = a\sqrt{2}$
43	$R = \frac{d}{2} = \frac{a\sqrt{2}}{2}$
44	

	$r=\frac{a}{2}$
45	$L=4a$
46	$S=a^2$
47	$d=\sqrt{a^2+b^2}$
48	$R=\frac{d}{2}$
49	$L=2(a+b)$
50	$S=ab$
51	$\alpha+\beta=180^\circ$
52	$d_1^2+d_2^2=2\left(a^2+b^2\right)$
53	$h=b\sin\alpha=b\sin\beta$
54	$L=2(a+b)$
55	$S=ah=ab\sin\alpha, S=\frac{1}{2}d_1d_2\sin\varphi$
56	$\alpha+\beta=180^\circ$
57	$d_1^2+d_2^2=4a^2$
58	$h=a\sin\alpha=\frac{d_1d_2}{2a}$
59	$r=\frac{h}{2}=\frac{d_1d_2}{4a}=\frac{a\sin\alpha}{2}$
60	$L=4a$
61	$S=ah=a^2\sin\alpha,$ $S=\frac{1}{2}d_1d_2$
62	$q=\frac{a+b}{2}$

63	$S = \frac{a+b}{2} \cdot h = qh$
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64	$q = \frac{a+b}{2}$
65	$d = \sqrt{ab + c^2}$
66	$h = \sqrt{c^2 - \frac{1}{4}(b-a)^2}$
67	$R = \frac{c\sqrt{ab+c^2}}{\sqrt{(2c-a+b)(2c+a-b)}}$
68	$S = \frac{a+b}{2} \cdot h = qh$
69	$a + b = 2c$
70	$q = \frac{a+b}{2} = c$
71	$d^2 = h^2 + c^2$
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72	$r = \frac{h}{2} = \frac{\sqrt{ab}}{2}$
73	$R = \frac{cd}{2h} = \frac{cd}{4r} = \frac{c}{2}\sqrt{1 + \frac{c^2}{ab}} = \frac{c}{2h}\sqrt{h^2 + c^2} = \frac{a+b}{8}\sqrt{\frac{a}{b} + 6 + \frac{b}{a}}$
74	$L = 2(a+b) = 4c$
75	$S = \frac{a+b}{2} \cdot h = \frac{(a+b)\sqrt{ab}}{2} = qh = ch = \frac{Lr}{2}$
76	$a + b = c + d$
77	$q = \frac{a+b}{2} = \frac{c+d}{2}$
78	$L = 2(a+b) = 2(c+d)$
79	$S = \frac{a+b}{2} \cdot h = \frac{c+d}{2} \cdot h = qh,$

	$S=\frac{1}{2}d_1d_2\sin\varphi$

80	$\alpha+\beta+2\gamma=360^\circ$
81	$L=2(a+b)$
82	$S=\frac{d_1d_2}{2}$
83	$\alpha+\gamma=\beta+\delta=180^\circ$
84	**Ptolemy\'s Theorem** $ac+bd=d_1d_2$
85	$L=a+b+c+d$
86	$R=\frac{1}{4}\sqrt{\frac{(ac+bd)(ad+bc)(ab+cd)}{(p-a)(p-b)(p-c)(p-d)}},$ **where** $p=\frac{L}{2}$
87	$S=\frac{1}{2}d_1d_2\sin\varphi,$ $S=\sqrt{(p-a)(p-b)(p-c)(p-d)},$ **where** $p=\frac{L}{2}$

88	$a+c=b+d$
89	$L=a+b+c+d=2(a+c)=2(b+d)$
90	$r=\frac{\sqrt{d_1^2d_2^2-(a-b)^2(a+b-p)^2}}{2p},$ **where** $p=\frac{L}{2}$
91	$S=pr=\frac{1}{2}d_1d_2\sin\varphi$
92	$\alpha+\beta+\gamma+\delta=360^\circ$

93	$L = a + b + c + d$
94	$S = \frac{1}{2} d_1 d_2 \sin \varphi$
95	$\alpha = 120^\circ$
96	$r = m = \frac{a\sqrt{3}}{2}$
97	$R = a$
98	$L = 6a$
99	$S = pr = \frac{a^2 3\sqrt{3}}{2}$, where $p = \frac{L}{2}$
100	$\alpha = \frac{n-2}{2} \cdot 180^\circ$
101	$R = \frac{a}{2\sin\left(\frac{\pi}{n}\right)}$
102	$r = m = \frac{a}{2\tan\left(\frac{\pi}{n}\right)} = \sqrt{R^2 - \frac{a^2}{4}}$
103	$L = na$
104	$S = \frac{nR^2}{2} \sin\left(\frac{2\pi}{n}\right)$, $S = pr = p\sqrt{R^2 - \frac{a^2}{4}}$, where $p = \frac{L}{2}$
105	$a = 2R\sin\left(\frac{\alpha}{2}\right)$
106	$a_1 a_2 = b_1 b_2$
107	$ee_1 = ff_1$
108	$g^2 = ff_1$
109	$\beta = \frac{\alpha}{2}$

110	$L = 2\pi R = \pi d$
111	$S = \pi R^2 = \frac{\pi d^2}{4} = \frac{LR}{2}$
112	$s = Rx$
113	$s = \frac{\pi R \alpha}{180^\circ}$
114	$L = s + 2R$
115	$S = \frac{Rs}{2} = \frac{R^2 x}{2} = \frac{\pi R^2 \alpha}{360^\circ}$
116	$a = 2\sqrt{2hR - h^2}$
117	$h = R - \frac{1}{2}\sqrt{4R^2 - a^2}, h < R$
118	$L = s + a$
119	$S = \frac{1}{2}[sR - a(R - h)] = \frac{R^2}{2}\left(\frac{\alpha\pi}{180^\circ} - \sin\alpha\right) = \frac{R^2}{2}(x - \sin x),$ $S \approx \frac{2}{3}ha$
120	$d = (a\sqrt{3})$
121	$r = \frac{a}{2}$
122	$R = \frac{a\sqrt{3}}{2}$
123	$S = 6a^2$
124	$V = a^3$
125	$d = \sqrt{a^2 + b^2 + c^2}$
126	$S = 2(ab + ac + bc)$
127	$V = abc$

128	$S = S_L + 2S_B$
129	**Lateral Area of a Right Prism** $S_L = (a_1 + a_2 + a_3 + \ldots + a_n)l$
130	**Lateral Area of an Oblique Prism** $S_L = pl,$ **where p is the perimeter of the cross section.**
131	$V = S_B h$
132	**Cavalieri\'s Principle** **Given two solids included between parallel planes. If every plane cross section parallel to the given planes has the same area in both solids, then the volumes of the solids are equal.**
133	$h = \sqrt{\frac{2}{3}}a$
134	$S_B = \frac{\sqrt{3}a^2}{4}$
135	$S = \sqrt{3}a^2$

136	$V = \frac{1}{3}S_B h = \frac{a^3}{6\sqrt{2}}$
137	$m = \sqrt{b^2 - \frac{a^2}{4}}$
138	$h = \frac{\sqrt{4b^2 \sin^2\left(\frac{\pi}{n}\right) - a^2}}{2\sin\left(\frac{\pi}{n}\right)}$
139	$S_L = \frac{1}{2}nam = \frac{1}{4}na\sqrt{4b^2 - a^2} = pm$
140	$S_B = pr$
141	$S = S_B + S_L$
142	$V = \frac{1}{3}S_B h = \frac{1}{3}prh$
143	$\frac{b_1}{a_1} = \frac{b_2}{a_2} = \frac{b_3}{a_3} = \ldots = \frac{b_n}{a_n} = \frac{b}{a} = k$

144	$\frac{S_2}{S_1} = k^2$
145	$S_L = \frac{m(P_1 + P_2)}{2}$
146	$S = S_L + S_1 + S_2$
147	$V = \frac{h}{3}\left(S_1 + \sqrt{S_1 S_2} + S_2\right)$
148	$V = \frac{hS_1}{3}\left[1 + \frac{b}{a} + \left(\frac{b}{a}\right)^2\right] = \frac{hS_1}{3}\left[1 + k + k^2\right]$
149	$S_L = \frac{1}{2}(a+c)\sqrt{4h^2 + b^2} + b\sqrt{h^2 + (a-c)^2}$
150	$S_B = ab$
151	$S = S_B + S_L$

152 $V = \frac{bh}{6}(2a + c)$

153 **Five Platonic Solids: The platonic solids are convex polyhedra with equivalent faces composed of congruent convex regular polygons.**

Solid	No. of Vertices	No. of Edges	No. of Faces	Section
Tetrahedron	4	6	4	3.25
Cube	8	12	6	3.22
Octahedron	6	12	8	3.27
Icosahedron	12	30	20	3.27
Dodecahedron	20	30	12	3.27

154	$r = \frac{a\sqrt{6}}{6}$
155	$R = \frac{a\sqrt{2}}{2}$
156	$S = 2a^2\sqrt{3}$

157	$V=\frac{a^3\sqrt{2}}{3}$
158	$r=\frac{a\sqrt{3}\left(3+\sqrt{5}\right)}{12}$
159	$R=\frac{a}{4}\sqrt{2\left(5+\sqrt{5}\right)}$
160	$S=5a^2\sqrt{3}$
161	$V=\frac{5a^3\left(3+\sqrt{5}\right)}{12}$
162	$r=\frac{a\sqrt{10\left(25+11\sqrt{5}\right)}}{2}$
163	$R=\frac{a\sqrt{3}\left(1+\sqrt{5}\right)}{4}$
164	$S=3a^2\sqrt{5\left(5+2\sqrt{5}\right)}$
165	$V=\frac{a^3\left(15+7\sqrt{5}\right)}{4}$
166	$S_L=2\pi RH$
167	$S=S_L+2S_B=2\pi R(H+R)=\pi d\left(H+\frac{d}{2}\right)$
168	$V=S_BH=\pi R^2H$
169	$S_L=\pi R(h_1+h_2)$
170	$S_B=\pi R^2+\pi R\sqrt{R^2+\left(\frac{h_1-h_2}{2}\right)^2}$
171	$S=S_L+S_B=\pi R\left[h_1+h_2+R+\sqrt{R^2+\left(\frac{h_1-h_2}{2}\right)^2}\right]$
172	

	$V=\frac{\pi R^2}{2}(h_1+h_2)$
173	$H=\sqrt{m^2-R^2}$
174	$S_L=\pi Rm=\frac{\pi md}{2}$
175	$S_B=\pi R^2$
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176	$S=S_L+S_B=\pi R(m+R)=\frac{1}{2}\pi d\left(m+\frac{d}{2}\right)$
177	$V=\frac{1}{3}S_BH=\frac{1}{3}\pi R^2H$
178	$H=\sqrt{m^2-(R-r)^2}$
179	$\frac{R}{r}=k$
180	$\frac{S_2}{S_1}=\frac{R^2}{r^2}=k^2$
181	$S_L=\pi m(R+r)$
182	$S=S_1+S_2+S_L=\pi\left[R^2+r^2+m(R+r)\right]$
183	$V=\frac{h}{3}\left(S_1+\sqrt{S_1S_2}+S_2\right)$
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184	$V=\frac{hS_1}{3}\left[1+\frac{R}{r}+\left(\frac{R}{r}\right)^2\right]=\frac{hS_1}{3}\left[1+k+k^2\right]$
185	$S=4\pi R^2$
186	$V=\frac{4}{3}\pi R^3H=\frac{1}{6}\pi d^3=\frac{1}{3}SR$
187	$R=\frac{r^2+h^2}{2h}$
188	$S_B=\pi r^2$
189	$S_C=\pi\left(h^2+r^2\right)$

190	$S = S_B + S_C = \pi\left(h^2 + 2r^2\right) = \pi\left(2Rh + r^2\right)$
191	$V = \frac{\pi}{6}h^2(3R - h) = \frac{\pi}{6}h\left(3r^2 + h^2\right)$
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192	$S = \pi R(2h + r)$
193	$V = \frac{2}{3}\pi R^2 h$
194	$S_S = 2\pi Rh$
195	$S = S_S + S_1 + S_2 = \pi\left(2Rh + r_1^2 + r_2^2\right)$
196	$V = \frac{1}{6}\pi h\left(3r_1^2 + 3r_2^2 + h^2\right)$
197	$S_L = \frac{\pi R^2}{90}\alpha = 2R^2 x$
198	$S = \pi R^2 + \frac{\pi R^2}{90}\alpha = \pi R^2 + 2R^2 x$
199	$V = \frac{\pi R^3}{270}\alpha = \frac{2}{3}R^3 x$
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200	$V = \frac{4}{3}\pi abc$
201	$S = 2\pi b\left(b + \frac{a\sin^{-1}e}{e}\right)$, where $e = \frac{\sqrt{a^2 - b^2}}{a}$.
202	$V = \frac{4}{3}\pi b^2 a$
203	$S = 2\pi b\left(b + \frac{a\sin^{-1}h\left(\frac{be}{a}\right)}{be/a}\right)$, where $e = \frac{\sqrt{b^2 - a^2}}{b}$
204	

	$V = \frac{4}{3}\pi b^2 a$
205	$S = 4\pi^2 Rr$
206	$V = 2\pi^2 Rr^2$

BAAP OF ALL FORMULA LISTS

FOR IIT JEE

INTEGRAL CALCULUS

SL#	FORMULA
1	$\int f(x)dx = F(x) + C \text{ if } F'(x) = f(x).$
2	$\left(\int f(x)dx\right)' = f(x)$
3	$\int kf(x)dx = k\int f(x)dx$
4	$\int [f(x) + g(x)]dx = \int f(x)dx + \int g(x)dx$
5	$\int [f(x) - g(x)]dx = \int f(x)dx - \int g(x)dx$
6	$\int f(ax)dx = \frac{1}{a}F(ax) + C$
7	$\int f(ax+b)dx = \frac{1}{a}F(ax+b) + C$
8	$\int f(x)df'(x)dx = \frac{1}{2}f^2(x) + C$
9	$\int \frac{f'(x)}{f(x)}dx \vert = \ln\vert f(x)\vert + C$
10	**Method of Substitution** $\int f(x)dx = \int f(u(t))u'(t)dt \text{ if } x = u(t).$
11	**Integration by Parts** $\int udv = uv - \int vdu, where u(x), v(x)$ **are differentiable functions.**
12	$\int adx = ax + C$
13	$\int xdx = \frac{x^2}{2} + C$
14	$\int x^2dx = \frac{x^3}{3} + C$
15	$\int x^p dx = \frac{x^{p+1}}{p+1} + C, p \neq -1$
16	$\int (ax+b)^n dx = \frac{(ax+b)^{n+1}}{a(n+1)} + C, n \neq -1.$
17	$\int \frac{dx}{x} = \ln\vert x\vert + C$
18	$\int \frac{dx}{ax+b} = \frac{1}{a}\ln\vert ax+b\vert + C$

19	$\int \frac{ax+b}{cx+d}dx = \frac{a}{c}x + (bc-ad)c^2 \ln\lvert cx+d\rvert + C$
20	$\int \frac{dx}{x+a}(x+b) = \frac{1}{a-b}\ln\left\lvert\frac{x+b}{x+a}\right\rvert + C, a \neq b.$
21	$\int \frac{xdx}{a+bx} = \frac{1}{b^2}(a+bx-\ln\lvert a+bx\rvert)+C$
22	$\int \frac{x^2dx}{a+bx} = \frac{1}{b^3}\left[\frac{1}{2}(a+bx)^2 + a^2\ln\lvert a+bx\rvert\right]+C$
23	$\int \frac{dx}{x(a+bx)} = \frac{1}{a}\ln\left\lvert\frac{a+bx}{x}\right\rvert + C$

24	$\int \frac{dx}{x^2(a+bx)} = -\frac{1}{ax} + \frac{b}{a^2}\ln\left\lvert\frac{a+bx}{x}\right\rvert + C$
25	$\int \frac{xdx}{a+bx} = \frac{1}{b^2}\left(\ln\lvert a+bx\rvert + \frac{a}{a+bx}\right)+C$
26	$\int \frac{x^2dx}{a+bx^2} = \frac{1}{b^3}\left(a+bx-2a\ln\lvert a+bx\rvert - \frac{a^2}{a+bx}\right)+C$
27	$\int \frac{dx}{x(a+bx)^2} = \frac{1}{a(a+bx)} + \frac{1}{a^2}\ln\left\lvert\frac{a+bx}{x}\right\rvert + C$
28	$\int \frac{dx}{x^2-1} = \frac{1}{2}\ln\left\lvert\frac{x-1}{x+1}\right\rvert + C$
29	$\int \frac{dx}{1-x^2} = \frac{1}{2}\ln\left\lvert\frac{1+x}{1-x}\right\rvert + C$
30	$\int \frac{dx}{a^2-x^2} = \frac{1}{2a}\ln\left\lvert\frac{a+x}{a-x}\right\rvert + C$
31	$\int \frac{dx}{x^2-a^2} = \frac{1}{2a}\ln\left\lvert\frac{x-a}{x+a}\right\rvert + C$

32	$\int \frac{dx}{1+x^2} = \tan^{-1}x + C$
33	$\int \frac{dx}{a^2+x^2} = \frac{1}{a}\frac{\tan^{-1}x}{a} + C$
34	$\int \frac{xdx}{x^2+a^2} = \frac{1}{2}\ln(x^2+a^2)+C$
35	$\int \frac{dx}{a+bx^2} = \frac{1}{\sqrt{ab}}\tan^{-1}\left(x\sqrt{\frac{b}{a}}\right) + C, ab > 0$
36	$\int \frac{xdx}{a+bx^2} = \frac{1}{2b}\ln\left\lvert x^2+\frac{a}{b}\right\rvert + C$
37	$\int \frac{dx}{x(a+bx^2)} = \frac{1}{2a}\ln\left\lvert\frac{x^2}{a+bx^2}\right\rvert + C$
38	$\int \frac{dx}{a^2-b^2x^2 = \frac{1}{2ab}\ln\left\lvert\frac{a+bx}{a-bx}\right\rvert + C}$
39	$\int \frac{dx}{ax^2+bx+c} = \frac{1}{\sqrt{b^2-4ac}}\ln\left\lvert\frac{2ax+b-\sqrt{b^2-4ac}}{2ax+b+\sqrt{b^2-4ac}}\right\rvert + C, b^2-4ax > 0$

40	$\int \frac{dx}{ax^2+bx+c} = \frac{2}{\sqrt{4ac-b^2}}\frac{\tan^{-1}(2ax+b)}{\sqrt{4ac-b^2}} + C, b^2-4ac < 0$

41	$\int \frac{dx}{\sqrt{ax+b}} = \frac{2}{a}\sqrt{ax+b} + C$
42	$\int \sqrt{ax+b}dx = \frac{2}{3a}(ax+b)^{\frac{3}{2}} + C$
43	$\int \frac{xdx}{\sqrt{ax+b}} = \frac{2(ax-2b)}{3a^2}\sqrt{ax+b} + C$
44	$\int x\sqrt{ax+b}dx = \frac{2(3ax-2b)}{15a^2}(ax+b)^{\frac{3}{2}} + C$
45	$\int \frac{dx}{(x+c)\sqrt{ax+b}} = \frac{1}{\sqrt{b-ac}}\ln\left\|\frac{\sqrt{ax+b}-\sqrt{b-ac}}{\sqrt{ax+b}+\sqrt{b-ac}}\right\| + C, b-ac>0.$
46	$\int \frac{dx}{(x+c)\sqrt{ax+b}} = \frac{1}{\sqrt{ac-b}}\tan^{-1}\sqrt{\frac{ax+b}{ac-b}} + C, b-ac<0.$
47	$\int x^2\sqrt{a+bx}dx = \frac{2\left(8a^2-12abx+15b^2x^2\right)}{105b^3}\sqrt{(a+bx)^3} + C$
48	$\int \frac{x^2dx}{\sqrt{a+bx}} = \frac{2\left(8a^2-4abx+3b^2x^2\right)}{15b^3}\sqrt{a+bx} + C$
49	$\int \frac{dx}{x\sqrt{a+bx}} = \frac{1}{\sqrt{a}}\ln\left\|\frac{\sqrt{a+bx}-\sqrt{a}}{\sqrt{a+bx}+\sqrt{a}}\right\| + C, a>0$
50	$\int \frac{dx}{x\sqrt{a+bx}} = \frac{2}{\sqrt{-a}}\tan^{-1}\left\|\frac{a+bx}{-a}\right\| + C, a<0.$
51	$\int \sqrt{\frac{a-x}{b+x}}dx = \sqrt{(a-x)(b+x)} + (a+b)\sin^{-1}\sqrt{\frac{x+b}{a+b}} + C$
52	$\int \sqrt{\frac{a+x}{b-x}}dx = -\sqrt{(a+x)(b-x)} - (a+b)\sin^{-1}\sqrt{\frac{b-x}{a+b}} + C$
53	$\int \frac{dx}{\sqrt{x-a}(b-a)} = 2\sin^{-1}\sqrt{\frac{x-a}{b-a}} + C$
54	$\int \sqrt{a+bx-cx^2}dx = \frac{2cx-b}{4c}\sqrt{a+bx-cx^2} + \frac{b^2-4ac}{8\sqrt{c^3}}\frac{\sin^{-1}(2cx-b)}{\sqrt{b^2+4ac}} + C$
55	$\int \frac{dx}{\sqrt{ax^2+bx+c}} = \frac{1}{\sqrt{a}}\ln\left\|2ax+b+2\sqrt{ax^2+bx+c}\right\| + C, a>0$
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56	$\int \frac{dx}{\sqrt{ax^2+bx+c}} = -\frac{1}{\sqrt{a}}\frac{\sin^{-1}(2ax+b)}{4a}\sqrt{b^2-4ac} + C, a<0$
57	$\int \sqrt{x^2+a^2}dx = \frac{x}{2}\sqrt{x^2+a^2} + \frac{a^2}{2}\ln\left\|x+\sqrt{x^2+a^2}\right\| + C$
58	$x\sqrt{x^2+a^2}dx = \frac{1}{3}\left(x^2+a^2\right)^{\frac{3}{2}} + C$
59	$\int x^2\sqrt{x^2+a^2}dx = \frac{x}{8}\left(2x^2+a^2\right)\sqrt{x^2+a^2} - \frac{a^4}{8}\ln\left\|x+\sqrt{x^2+a^2}\right\| + C$
60	$\int \frac{\sqrt{x^2+a^2}}{x^2}dx = -\frac{\sqrt{x^2+a^2}}{x} + \ln\left\|x+\sqrt{x^2+a^2}\right\| + C$
61	$\int \left(\frac{\sqrt{x^2+a^2}}{x}\right)dx = \sqrt{x^2+a^2} + a\ln\left\|\frac{x}{a+\sqrt{x^2+a^2}}\right\| + C$
62	$\int \frac{xdx}{\sqrt{x^2+a^2}} = \sqrt{x^2+a^2} + C$
63	

	$\int\frac{x^2dx}{\sqrt{x^2+a^2}}=\frac{x}{2}\sqrt{x^2+a^2}-\frac{a^2}{2}\ln\left\|x+\sqrt{x^2+a^2}\right\|+C$

64	$\int\frac{dx}{x\sqrt{x^2+a^2}}=\frac{1}{a}\ln\left\|\frac{x}{a+\sqrt{x^2+a^2}}\right\|+C$
65	$\int\sqrt{x^2-a^2}dx=\frac{x}{2}\sqrt{x^2-a^2}-\frac{a^2}{2}\ln\left\|x+\sqrt{x^2-a^2}\right\|+C$
66	$\int x\sqrt{x^2-a^2}dx=\frac{1}{3}(x^2-a^2)^{\frac{3}{2}}+C$
67	$\int\frac{\sqrt{x^2-a^2}}{x}dx=\sqrt{x^2-a^2}+a\sin^{-1}\left(\frac{a}{x}\right)+C$
68	$\int\frac{\sqrt{x^2-a^2}}{x^2}dx=-\frac{\sqrt{x^2-a^2}}{x}+\ln\left\|x+\sqrt{x^2-a^2}\right\|+C$
69	$\int\frac{dx}{\sqrt{x^2-a^2}}=\ln\left\|x+\sqrt{x^2-a^2}\right\|+C$
70	$\int\frac{xdx}{\sqrt{x^2-a^2}}=\sqrt{x^2-a^2}+C$
71	$\int\frac{x^2dx}{\sqrt{x^2-a^2}}=\frac{x}{2}\sqrt{x^2-a^2}+\frac{a^2}{2}\ln\left\|x+\sqrt{x^2-a^2}\right\|+C$

72	$\int\frac{dx}{x\sqrt{x^2-a^2}}=-\frac{1}{a}\sin^{-1}\left(\frac{a}{x}\right)+C$
73	$\int\frac{dx}{(x+a)\sqrt{x^2-a^2}}=\frac{1}{a}\sqrt{\frac{x-a}{x+a}}+C$
74	$\int\frac{dx}{(x-a)\sqrt{x^2-a^2}}=-\frac{1}{a}\sqrt{\frac{x+a}{x-a}}+C$
75	$\int\frac{dx}{x^2\sqrt{x^2-a^2}}=\left(\frac{\sqrt{x^2-a^2}}{a^2x}\right)+C$
76	$\int\frac{dx}{(x^2-a^2)^{\frac{3}{2}}}=-\frac{x}{a^2\sqrt{x^2-a^2}}+C$
77	$\int(x^2-a^2)^{\frac{3}{2}}dx=-\frac{x}{8}(2x^2-5a^2)\sqrt{x^2-a^2}++\frac{3a^4}{8}\ln\left\|x+\sqrt{x^2-a^2}\right\|+C$
78	$\int\sqrt{a^2-x^2}dx=\frac{x}{2}\sqrt{a^2-x^2}+\frac{a^2}{2}\sin^{-1}\left(\frac{x}{a}\right)+C$
79	$\int x\sqrt{a^2-x^2}dx=-\frac{1}{3}(a^2-x^2)^{\frac{3}{2}}+C$

80	$\int x^2\sqrt{a^2-x^2}dx=\frac{x}{8}(2x^2-a^2)\sqrt{a^2-x^2}+\frac{a^4}{8}\sin^{-1}\left(\frac{x}{a}\right)+C$
81	$\int\frac{\sqrt{a^2-x^2}}{x}dx=\sqrt{a^2-x^2}+a\ln\left\|\frac{x}{a+\sqrt{a^2-x^2}}\right\|+C$
82	$\int\frac{\sqrt{a^2-x^2}}{x^2}dx=-\frac{\sqrt{a^2-x^2}}{x}-\frac{\sin^{-1}x}{a}+C$
83	$\int\frac{dx}{\sqrt{1-x^2}}=\sin^{-1}x+C$
84	

	$\int \frac{dx}{\sqrt{a^2-x^2}} = \frac{\sin x}{a} + C$
85	$\int \frac{x dx}{\sqrt{a^2-x^2}} = -\sqrt{a^2-x^2} + C$
86	$\int \frac{x^2 dx}{\sqrt{a^2-x^2}} = -\frac{x}{2}\sqrt{a^2-x^2} + \frac{a^2}{2}\sin^{-1}\left(\frac{x}{a}\right) + C$
87	$\int \frac{dx}{(x+a)\sqrt{a^2-x^2}} = -\frac{1}{2}\sqrt{\frac{a-x}{a+x}} + C$

88	$\int \frac{dx}{(x-a)\sqrt{a^2-x^2}} = -\frac{1}{\sqrt{\frac{a+x}{a-x}}} + C$
89	$\int \frac{dx}{(x+b)\sqrt{a^2-x^2}} = \frac{1}{\sqrt{b^2-a^2}} \frac{\sin^{-1}(bx+a^2)}{a(x+b)} + C, b > a.$
90	$\int \frac{dx}{(x+b)\sqrt{a^2-x^2}} = \frac{1}{\sqrt{a^2-b^2}} \ln\left\lvert \frac{x+b}{\sqrt{a^2-b^2}\sqrt{a^2-x^2}+a^2+bx} \right\rvert + C, b < a.$
91	$\int \frac{dx}{x^2\sqrt{a^2-x^2}} = -\frac{\sqrt{a^2-x^2}}{a^2 x} + C$
92	$\int (a^2-x^2)^{\frac{3}{2}} dx = \frac{x}{8}(5a^2-2x^2)\sqrt{a^2-x^2} + \frac{3a^4}{8}\sin^{-1}\left(\frac{x}{a}\right) + C$
93	$\int \frac{dx}{(a^2-x^2)^{\frac{3}{2}}} = \frac{x}{a^2\sqrt{a^2-x^2}} + C$
94	$\int \sin x dx = -\cos x + C$
95	$\int \cos x dx = \sin x + C$

96	$\int \sin^2 x dx = \frac{x}{2} - \frac{1}{4}\sin 2x + C$
97	$\int \cos^2 x dx = \frac{x}{2} + \frac{1}{4}\sin 2x + C$
98	$\int \sin^3 x dx = \frac{1}{3}\cos^3 x - \cos x + C = \frac{1}{12}\cos 3x - \frac{3}{4}\cos x + C$
99	$\int \cos^3 x dx = \sin x - \frac{1}{3}\sin^3 x + C = \frac{1}{12}\sin 3x + \frac{3}{4}\sin x + C$
100	$\int \frac{dx}{\cos x} = \int \sec x dx = \ln\left\lvert \tan\left(\frac{x}{2}+\frac{\pi}{4}\right)\right\rvert + C$
101	$\int \frac{dx}{\sin x} = \int \cos ec x dx = \ln\left\lvert \frac{\tan x}{2} \right\rvert + C$
102	$\int \frac{dx}{\sin^2 x} = \int \cos c^2 x dx = -\cot x + C$
103	$\int \frac{dx}{\cos^2 x} = \int \sec^2 x dx = \tan x + C$

104	$\int \frac{dx}{\sin^3 x} = \int \cos ec^3 x dx = -\frac{\cos x}{2\sin^2 x} = \frac{1}{2}\ln\left\lvert \frac{\tan x}{2} \right\rvert + C$
105	$\int \frac{dx}{\cos^3 x} = \int \sec^3 x dx = \frac{\sin x}{2\cos^2 x} + \frac{1}{2}\ln\left\lvert \tan\left(\frac{x}{2}+\frac{\pi}{4}\right)\right\rvert + C$

106	$\int \sin x \cos x dx = -\frac{1}{4}\cos 2x + C$
107	$\int \sin^2 x \cos x dx = \frac{1}{3}\sin^3 x + C$
108	$\int \sin x \cos^2 x dx = -\frac{1}{3}\cos^3 x + C$
109	$\int \sin^2 x \cos^2 x dx = \frac{x}{8} - \frac{1}{32}\sin 4x + C$
110	$\int \tan x dx = -\ln\lvert\cos x\rvert + C$
111	$\int \frac{\sin x}{\cos^2 x} dx = \frac{1}{\cos x} + C = \sec x + C$
112	$\int \frac{\sin^2 x}{\cos x} dx = \ln\left\lvert\tan\left(\frac{x}{2} + \frac{\pi}{4}\right)\right\rvert - \sin x + C$
113	$\int \tan^2 x dx = \tan x - x + C$
114	$\int \cot x dx = \ln\lvert\sin x\rvert + C$
115	$\int \frac{\cos x}{\sin^2 x} dx = -\frac{1}{\sin x} + C = -\cos ecx + C$
116	$\int \frac{\cos^2 x}{\sin x} dx = \ln\left\lvert\frac{\tan x}{2}\right\rvert + \cos x + C$
117	$\int \cot^2 x dx = -\cot x - x + C$
118	$\int \frac{dx}{\cos x \sin x} = \ln\lvert\tan x\rvert + C$
119	$\int \frac{dx}{\sin^2 x \cos x} = -\frac{1}{\sin x} + \ln\left\lvert\tan\left(\frac{x}{2} + \frac{\pi}{4}\right)\right\rvert + C$
120	$\int \frac{dx}{\sin x \cos^2 x} = \frac{1}{\cos x} + \ln\left\lvert\frac{\tan x}{2}\right\rvert + C$
121	$\int \frac{dx}{\sin^2 x \cos^2 x} = \tan x - \cot x + C$
122	$\int \sin mx \sin nx dx = -\frac{\sin(m+n)x}{2(m+n)} + \frac{\sin(m-n)x}{2(m-n)} + C, m^2 \neq n^2,$
123	$\int \sin mx \cos nx dx = -\frac{\cos(m+n)x}{2(m+n)} - \frac{\cos(m-n)x}{2(m-n)} + C, m^2 \neq n^2.$
124	$\int \cos mx \cos nx dx = \frac{\sin(m+n)x}{2(m+n)} + \frac{\sin(m-n)x}{2(m-n)} + C, m^2 \neq n^2.$
125	$\int \sec x \tan x dx = \sec x + C$
126	$\int \cos ecx \cot x dx = -\cos ecx + C$
127	$\int \sin x \cos^n x dx = -\frac{\cos^{n+1} x}{n+1} + C$
128	

	$\int \sin x \cos^n x dx = -\frac{\sin^{n+1} x}{n+1} + C$
129	$\int \sin^{-1} x dx = x \sin^{-1} x + \sqrt{1-x^2} + C$
130	$\int \cos^{-1} x dx = x \cos^{-1} x - \sqrt{1-x^2} + C$
131	$\int \tan^{-1} x dx = x \tan^{-1} x - \frac{1}{2} 1n(x^2+1) + C$
132	$\int \cot^{-1} x dx = x \cot^{-1} x + \frac{1}{2} 1n(x^2+1) + C$
133	$\int \sinh x dx = \cosh x + C$
134	$\int \cosh x dx = \sinh x + C$
135	$\int \tanh x dx = 1n \cosh x + C$
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136	$\int \coth x dx = 1n \lvert \sinh x \rvert + C$
137	$\int \operatorname{sech}^2 x dx = \tanh x + C$
138	$\int \cos ech^2 dx dx = -\coth x + C$
139	$\int \operatorname{sech} x \tanh x dx = -\operatorname{sech} x + C$
140	$\int \cos echx \coth x dx = -cshx + C$
141	$\int e^x dx = e^x + C$
142	$\int a^x dx = \frac{a^x}{1na} + C$
143	$\int e^{ax} dx = \frac{e^{ax}}{a} + C$
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144	$\int x e^{ax} dx = \frac{e^{ax}}{a^2}(ax-1) + C$
145	$\int 1nxdx = x1nx - x + C$
146	$\int \frac{dx}{x1nx} = 1n \lvert 1nx \rvert + C$
147	$\int x^n 1nxdx = x^{n+1}\left[\frac{1nx}{n+1} - \frac{1}{(n+1)^2}\right] + C$
148	$\int e^{ax} \sin bx dx = \frac{a \sin bx - b \cos bx}{a^2+b^2} e^{ax} + C$
149	$\int e^{ax} \cos bx dx = \frac{a \cos bx + b \sin bx}{a^2+b^2} e^{ax} + C$
150	$\int x^m e^{mx} dx = \frac{1}{m} x^n e^{mx} - \frac{n}{m} \int x^{n-1} e^{mx} dx$
151	$\int \frac{e^{mx}}{x^n} dx = -\frac{e^{mx}}{(n-1)x^{n-1}} + \frac{m}{n-1} \int \frac{e^{mx}}{x^{n-1}} dx, n \neq 1,$

152	$\int \sinh^n x dx = \frac{1}{n} \sinh^{n-1} x \cosh x - \frac{n-1}{n} \int \sinh^{n-2} x dx$
153	$\int \frac{dx}{\sinh^n x} = \frac{\cosh x}{(n-1)\sinh^{n-1} x} - \frac{n-2}{n-1} \int \frac{dx}{\sinh^{n-2} x}, n! - 1.$
154	$\int \cosh^n x dx = \frac{1}{n} \sinh x \cosh^{n-1} x \cosh x \frac{n-1}{n} \int \cosh^{n-2} x dx$
155	$\int \frac{dx}{\cosh^n x} = \frac{\sinh x}{n - 1(\cos^{n-1} x) + \frac{n-2}{n-1}} \int \frac{dx}{\frac{\cosh^{n-2}}{x}}, n \neq 2.$
156	$\int \sinh^n x \cosh^m x dx = \frac{\sinh x}{n + 1 \frac{x \cosh^{m-1} x}{n+m} \frac{m-1}{n+m} \int \sinh^n x \cosh^{m-2} x dx}$
157	$\int \sinh nx \cosh^m x dx = \frac{\sinh^{n-1} x \cosh^{m+1} x}{n+m} - \frac{n-1}{n+m} \int \sin^{n-2} x \cosh^m x dx$
158	$\int \tanh^n x dx = -\frac{1}{n-1} \tanh^{n-1} x + \int \tanh^{n-2} x dx, n \neq 1.$
159	$\int \coth^n x dx = -\frac{1}{n-1} \coth^{n-1} x + \int \coth^{n-2} x dx, n \neq 1.$

160	$\int \text{sech}^n x dx = \frac{\text{sech}^{n-2} x \tanh x}{n-1} + \frac{n-2}{n-1} \int \text{sech}^{n-2} x dx, n \neq 1.$
161	$\int \sin^n x dx = -\frac{1}{n} \sin^{n-1} x \cos x + \frac{n-1}{n} \int \sin^{n-2} x dx$
162	$\int \frac{dx}{\sin^n x} = -\frac{\cos x}{(n-1)\sin^{n-1} x} + \frac{n-2}{n-1} \int \frac{dx}{\sin^{n-2} x}, n \neq 1.$
163	$\int \cos^n x dx = \frac{1}{n} \sin x \cos^{n-1} x + \frac{n-1}{n} \int \cos^{n-2} x dx$
164	$\int \frac{dx}{\cos^n x} = \frac{\sin x}{(n-1)\cos^{n-1} x} + \frac{n-2}{n-1} \int \frac{dx}{\cos^{n-2} x}, n \neq 1$
165	$\int \sin^n x \cos^m x dx = \frac{\sin^{n+1} x \cos^{m-1} x}{n+m} + \frac{m-1}{n+m} \int \sin^n x \cos^{m-2} x dx$
166	$\int \sin^n x \cos^m x dx = -\frac{\sin^{n-1} x \cos^{m+1} x}{n+m} + \frac{n-1}{n+m} \int \sin^{n-2} x \cos^m x dx$
167	$\int \tan^n x dx = \frac{1}{n-1} \tan^{n-1} x - \int \tan^{n-2} x dx, n \neq 1.$

168	$\int \cot^n x dx = -\frac{1}{n-1} \cot^{n-1} x - \int \cot^{n-2} x dx, n \neq 1.$
169	$\int \sec^n x dx = \frac{\sec^{n-2} x \tan x}{n-1} + \frac{n-2}{n-1} \int \sec^{n-2} x dx, n \neq 1.$
170	$\int \cos ec^n x dx = \frac{csn^{n-2} x \cot x}{n-1} + \frac{n-2}{n-1} \int \cos^{n-2} x dx, n \neq 1$
171	$\int x^n \ln^m x dx = \frac{x^{n+1} 1n^m x}{n+1} - \frac{m}{n+1} \int x^n 1n^{m-1} x dx$
172	$\int \frac{1n^m x}{x^n} dx = -\frac{\ln^m x}{(n-1)x^{n-1}} + \frac{m}{n-1} \int \frac{1n^{m-1} x}{x^n} dx, n \neq 1.$
173	$\int 1n^n x dx = x 1n^n x - n \int 1n^{n-1} x dx.$

174	$\int x^n \sinh x dx = x^n \cosh x - n \int x^{n-1} \cosh x dx.$
175	$\int x^n \cosh x dx = x^n \sinh x - n \int x^{n-1} \sin h x dx.$
176	$\int x^n \sin x dx = -x^n \cos x + n \int x^{n-1} \cos x dx$
177	$\int x^n \cos x dx = x^n \sin x - n \int x^{n-1} \sin x dx.$
178	$\int x^n \sin^{-1} x dx = \frac{x^{n+1}}{n+1} \sin^{-1} x - \frac{1}{n+1} \int \frac{x^{n+1}}{\sqrt{1-x^2}} dx$
179	$\int x^n \cos^{-1} x dx = \frac{x^{n+1}}{n+1} \cos^{-1} x + \frac{1}{n+1} \int \left(\frac{x^{n+1}}{\sqrt{1-x^2}} dx.\right.$
180	$\int x^n \tan^{-1} x dx = \frac{x^{n+1}}{n+1} \tan^{-1} x - \frac{1}{n+1} \int \frac{x^{n+1}}{1+x^2} dx.$
181	$\int \frac{x^n dx}{ax^n + b} = \frac{x}{a} - \frac{b}{a} \int \frac{dx}{ax^n + b}$
182	$\int \frac{dx}{(ax^2+bx+c)^n} = \frac{-2ax-b}{(n-1)(b^2-4ac)(ax^2bx+c)^{n-1}} - \frac{2(2n-3)a}{(n-1)(b^2-4ac)} \int \frac{dx}{(ax^2+bx+c)^{n-1}}, n \neq 1.$
183	$\int \frac{dx}{(x^2+a^2)^n} = \frac{x}{2(n-1)a^2(x^2+a^2)^{n-1}} + \frac{2n-3}{2(n-1)a^2} \int \frac{dx}{(x^2+a^2)^{n-1}, n \neq 1}.$
184	$\int \frac{dx}{(x^2-a^2)^n} = -\frac{x}{2(n-1)a^2(x^2-a^2)^{n-1}} - \frac{2n-3}{2(n-1)a^2} \int \frac{dx}{(x^2-a^2)^{n-1}}, n \neq 1.$
185	$\int_a^b f(x) dx = \lim_{x \to \infty} \sum_{i=1}^n f(\xi_i) \triangle x_i, where \triangle x_i = x_i - x_{i-1}, x_{i-1} \leq \xi_i \leq x_i.$
186	$\int_a^b 1 dx = b - a$
187	$\int_a^b k f(x) dx = k \int_a^b f(x) dx$
188	$\int_a^b [f(x) + g(x)] x = \int_a^b f(x) dx + \int_a^b g(x) dx$
189	$\int_a^b [f(x) - g(x)] x = \int_a^b f(x) dx - \int_a^b g(x) dx$
190	$\int_a^a f(x) dx = 0$
191	$\int_a^b f(x) dx = -\int_b^a f(x) dx$
192	$\int_a^b f(x) dx = \int_a^c f(x) dx + \int_c^b f(x) dx f \text{ or } a < c < b.$
193	$\int_a^b f(x) dx \geq 0 \text{ if } f(x) \geq 0 on [a, b]$
194	$\int_a^b f(x) dx \leq 0 \text{ if } f(x) \leq 0 on [a, b]$
195	**Fundamental Theorem of Calculus**

	$\int_a^b f(x)dx = F(x)\mid_a^b = F(b) - F(a)$ if $F(x) = f(x)$.
196	**Method of substitution** If $x = g(t)$, then $\int_a^b f(x)dx = \int_c^d f(g(t))g'(t)dt$, where $c = g^{-1}(a), d = g^{-1}(b)$.
197	**Integration by Parts** $\int_a^b udv(uv)\mid_a^b - \int_a^b vdu$
198	**Traezoidal Rule** $\int_a^b f(x)dx = \frac{b-a}{2n}\left[f(x_0) + f(x_n) + 2\sum_{i=1}^{n-1} f(x_i)\right]$
199	**Simpson\'s Rule** $\int_a^b f(x)dx = \frac{b-a}{3n}[f(x_0) + 4f(x_1) + 2f(x_2) + 4f(x_3) + \ + 2f(x_4) + \ldots + 4f(x_{n-1} + f(x_n)]$, where $x_i = a + \frac{b-a}{n}i, i, 0, 1, 2, ., , n$.

200	**Area Under a Curve** $S = \int_a^b f(x)dx = F(b) - F(a)$, where $F'(x) = f(x)$.
201	**Area Between Two Curves** $S = \int_a^b [f(x) - g(x)]dx = F(b) - G(b) - F(a) + G(a)$, where $F'(x) = (x), G'(x) = g(x)$.
202	The definite integral $\int_a^b f(x)dx$ is called an improper integral if , a or b is infinite, $f(x)$ has one or more points of discontinuity in the interval $[a, b]$.
203	If $f(x)$ is a continuous functn on $[a, \infty)$ then $\int_a^\infty f(x)dx = \lim_{n \to \infty} \int_a^n f(x)dx$.
204	If $f(x)$ is continuous function on $(-\infty, b)$, then $\int_{-\infty}^b f(x)dx = \lim_{n \to \infty} \int_n^b f(x)dx$.
205	$\int_{-\infty}^\infty f(x)dx = \int_{-\infty}^c f(x)dx + \int_c^\infty f(x)dx$
206	**Comparison Theorem:** Let $f(x)$ and $g(x)$ be continuous functions on the closed interval $[a, \infty)$. Suppose that $0 \le g(x) \le f(x)$ for all x in $[a, \infty)$., If $\int_a^\infty f(x)dx$ is convergent, then $\int_a^\infty g(x)dx)$ is also convergent, if $\int_a^\infty g(x)dx$ is divergent then $\int_a^\infty f(x)dx$ is also divergent.
207	**Absolute Convergence** If $\int_a^\infty \lvert f(x) \rvert dx$ is convergent then the integral $\int_a^\infty f(x)dx$ is absolutely convergent.

208	**Discontinuous Integrand** Let $f(x)$ be a function which is continuous on the interval $[a, b)$ but is continuous at $x = b$. Then $\int_a^b f(x)dx = \lim_{\xi \to 0+} \int_a^{b-\xi} f(x)dx$.
209	Let $f(x)$ be a continuous function for all real numbers x in the interval $[a, b]$ except for some point c in (a, b). Then $\int_a^b f(x)dx - \lim_{\xi \to 0+}^{c-\xi} f(x)dx + \lim_{\delta \to 0+} \int_{c+\delta}^b f(x)dx$
210	**Double Integral Functions of two variables** $f(x, y), (u, v)$ Double integrals: $\iint_r f(x, y)dxdy, \iint_r g(x, y)dxdy$ Riemann sum: $\sum_{i=1}^m \sum_{j=1}^n (f(u_i, v_j) \triangle x_i \triangle y_j,$

	Small changes: $\triangle x_i, \ \triangle y_j$ **Regions of integration :R,S** **Polar coordinates** $r\theta$ **Area:A, Surface area;** **Volume of a solid:V** **Mass of a lamina:m** **Density;**$\rho(x, y)$ **First moments :** M_x, M_y **Moments of inertial:** I_x, I_y, I_0 **Charge of a plate: Q** **Charge density:** $\sigma(x, y)$, **Coordinates of center of mass:** $\bar{x}, \bar{y}$ **Average of a function :**μ
211	$\iint_R [f(x, y) + g(x, y)]dA = \iint_R f(x, y)dA + \iint_R g(x, y)dA$
212	$\iint_R [f(x, y) - g(x, y)]dA = \iint_R f(x, y)dA - \iint_R g(x, y)dA$
213	$\iint_R kf(x, y)dA = k\iint_R (x, y)dA$ **where** k **is a constant.**
214	**If** $f(x, y) \leq g(x, y)$ **on** $\mathbb{R}$**, then** $\iint_R f(x, y)dA \leq \iint_R g(x, y)dA.$
215	**If** $f(x, y) \geq 0$**on** R **and** $S \subset \sec R$**, then** $\iint_S f(x, y)dA \leq \iint_R f(x, y)dA.$
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216	**If** $f(x, y) \geq 0$ **on** R **and** R **and** S **are non-overlapping regions, then** $\iint_{R \cup S} f(x, y)dA = \iint_R f(x, y)dA + \iint_S f(x, y)dA$ **Here** $R \cup S$ **is the union of the regions** R **and** S**.**
217	**Integrated Integrals and Fubini\'s Theorem** $\iint_R f(x, y)dA = \int_a^b \int_{p(x)}^{q(x)} f(x, y)dydx$ **for a region on type I,** $R - \{(x, y) \mid a \leq x \leq b, p(x) \leq y \leq (x)\}$
218	**Doubles Integrals over Rectangular Regions** **If R is the rectangular regin** $[a, b] \times [c, d]$**, then** $\iint_R f(x, y)dxdy = \int_a^b \left(\int_c^d (x, y)dy\right)dx = \int_c^d \left(\int_a^b f(x, y)dx\right)dy$**. In the special case whre the integrand** $f(x, y)$ **can be written as** $g(x)h(y)$ **we have** $\iint_R f(x, y)dxdy = \iint_R g(x)h(y)dxdy = \left(\int_a^b g(x)dx\right)\left(\int_c^d h(y)dy\right)$
219	**Change of Variables** $\iint_R f(x, y)dxdy \equiv \iint_S f[x(u, v), y(u, v)] \mid \frac{\partial(x, y)}{\partial(u, v)\|dudv, where\|\frac{\partial(x, y)}{\partial(u, v)\mid = \mid\left(\frac{\partial x}{\partial u}, \frac{\partial x}{\partial v}\right), \left(\frac{\partial y}{\partial u}, (\partial y), (\partial v)\right) \mid \neq 0}}$ **is the jacobian of the transformatons** $(x, y) \rightarrow (u, v)$ **and S is the pullbasck of R which can be computed by** $x = x(u, v), y = y(u, v)$ **into the definitins of R.**
220	**Polar Coordinates** **`x=rcostheta, y=rsintheta\`**
221	**Double Integrals in Polar Coordinats** **The diferential** $dxdy$ **for Polar Coordinate is** $dxdy = \left\|\frac{\partial(x, y)}{\partial(r, \theta)}\right\|drdth\eta = rdrdth\eta.$ **Let the region R is determined as follows:** $0 \leq g(\theta), \ = r \leq h(\theta), \alpha \leq \theta \leq \beta, where\beta - \alpha \leq 2\pi$**/ Then** $\iint_R f(x, y)dxdy = \int_\alpha^\beta \int_{g(\theta)}^{h(\theta)} f(r\cos\theta, r\sin\theta)rdrdth\eta.$
222	**Area of Region** $A = \int_a^b \int_{g(x)}^{f(x)} \Big) dydx$ **(for a type I region).**
223	**Volume of a Solid**

	$V = \iint_R f(x, y) dA$
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224	**Area and Volume in Polar Coodinates** If S is a region in the xy-plane bounded by $\theta = \alpha, \theta = \beta, r = h(\theta), r = g(\theta), then A = \iint_S dA = \int_\alpha^\beta \int_{h(\theta)}^{g(\theta)} r dr d\theta, V = \iint_S f(r, \theta) r dr d\theta.$
225	Surface Area $S = \iint_R \sqrt{1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial z}\right)^2} dx dy$
226	Mass of a Lamina $m = \iint_R \rho(x, y) dA,$ where the lamina occupies a regions R and its density at a point (x, y) is $\rho(x, y)$
227	**Moments** The moment of the lamna abut the x-axis is given by formula $M_x \iint_R y\rho(x, y) dA$. The moment of the lamina about the y=axis is $M_y \iint_R x\rho(x, y) dA$. The moment of inertia about the x-axis is $I_x \iint_R y^2 \rho(x, y) dA$. The moment of inertia about the y-axis is $I_x \iint_R x^2 \rho(x, y) dA$. The polar moment of inertia is $I_0 = \iint_R (x^2 + y^2) \rho(x, y) dA$
228	**Center of Mass** $\bar{x} = \frac{M_y}{m} = \frac{1}{m} \iint_R x\rho(x, y) dA = \frac{\iint_R x\rho(x, y) dA}{\iint_R \rho(x, y) dA},$ $\bar{y} = \frac{M_x}{m} = \frac{1}{m} \iint_R y\rho(x, y) dA = \frac{\iint_R y\rho(x, y) dA}{\iint_R \rho(x, y) dA},$
229	**Charge of a Plate** $Q = \iint_R \sigma(x, y) dA,$ where electrical charge is distributed over a region R and its charge density at a point (x, y) is $\sigma(x, y)$
230	**Average of Function** $\mu = \frac{1}{S} \iint_R f(x, y) dA$, where $S = \iint_R dA.$
231	**Definition of Triple Integral** The triple integral over as parallelopiped $[a, b] \times [c, d] \times [r, s]$ is defined to be $\iiint_{[a, b] \times [c, x] \times [r, s]} f(x, y, z) dV = \lim_{\substack{\max \triangle x_i \to 0 \\ \max \triangle y_j \to 0 \\ \max \triangle z_k \to 0}} \sum_{i=1}^m \sum_{j=1}^n \sum_{k=1}^p f(u_i, v_j, w_k) \triangle x_i \triangle y_j \triangle z_k, where (u_i, v_j, w_k)$ is some point in the paralleloiped $(x_{i-1}, x_i) \times (y_{j-1}, y_{j-}) \times (z_{k-1}, z_k)$ and $\triangle x_i = x_i - x_{i-1}, \triangle y_j = y_j - y_{j-1}, \triangle zk = z_k - z_{k-1}.$
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232	$\iiint_G [f(x, y, z) + g(x, y, z)] dV = \iiint_g f(x, y, z) dV + \iiint_G g(x, y, z) dV$
233	$\iiint_G [f(x, y, z) - g(x, y, z)] dV = \iiint_g f(x, y, z) dV - \iiint_G g(x, y, z) dV$
234	$\iiint_G k f(x, y, z) dV = k \iiint_g f(x, y, z) dV$ where k is a constant.
235	If $f(x, y, z) \geq 0$ and G and T are nonoverlapping basic regions then $\iiint_{G \cup T} f(x, y, z) dV - \iiint_G f(x, y, z) dV + \iiint_T f(x, y, z) dV.$ Here $G \cup T$ is the union of the regions G and T.
236	**Evaluation of Triple Integrals by Repeated Integrals** If the solid G is the set of points (x, y, z) such that $(x, y) \varepsilon R, \chi_1(x, y) \leq z \leq \chi_2(x, y)$ then $\iiint_G f(x, y, z) dx dy dz = \iint_R \left[\int_{\chi_1(x, y)}^{\chi_2(x, y)(x, y, z) dz}\right. dx dy,$ where R is projection of G onto the xy-plane. If the solid G is the set of points (x, y, z) such that $a \leq x \leq b, \varphi_1(x) \leq y \leq \varphi_2(x), \chi_1(x, y) \leq z \leq \chi_2(x, y)$, then $\iiint_G f(x, y, z) dx dy dz = \int_a^b \left[\left(\int_{\varphi_1(x)}^{\varphi_2(x)} \left(\int_{\chi_1(x, y)}^{\chi_2(x, y)} f(x, y, z) dz\right) dy\right] dx\right.$
237	**Triple Integrals over Parallelepiped**

	If G is a paraelepiped $[a,b]\times[c,d]\times[r,s]$ then $\iiint_G f(x,y,z)dxdydz=\int_a^b\left[\int_c^d\left(\int_r^{x,y,z}dz\right)dy\right]dx$. In the special case where in the integrand $f(x,y,z)$ can be written as $g(x)h(y)k(z)$ we have $\iiint_{f(x,y,z)}dxdydz=\left(\int_a^b g(x)dx\right)\left(\int_c^d h(y)dy\left(\int_r^s k(z)dz\right)\right.$.
238	Change of Variables $\iiint_G f(x,y,z)dxdydz=\iiint_S f[(u,v,w),y(u,v,w),z(u,v,w)]\left\lvert\frac{\partial(x,y,z)}{\partial(u,v,w)}\right\rvert dxdydz$, where $\left\lvert\frac{\partial(x,y,z)}{\partial(u,v,w)}\right\rvert=\frac{\frac{\partial x}{\partial u},\frac{\partial x}{\partial v},\frac{\partial x}{\partial w}}{\frac{\partial y}{\partial u},\frac{\partial y}{\partial v},\frac{\partial y}{\partial w}},\left(\frac{\partial z}{\partial}u\right),\frac{\partial z}{\partial v},\frac{\partial z}{\partial w}\Bigg)\neq 0$ is the jacobian of the transformation $(x,y,z)\to(u,v,w)$ and S is the pull back of G which canbe computed by $x=x(u,v,w), y=y(u,v,w)z=z(u,v,w)$ into the definition of G.
239	Triple Integrals in Spherical Coordinates The Differential dxdydz for Sphericla Coordinates is $dxdydz=\mid\frac{\partial(x,y,z)}{\partial(r,\theta,\varphi)}drdth\eta d\varphi=r^2\sin\theta drdtehtasd\varphi\iiint_R f(x,y,z)dxdydz=,=\iiint_S f(r\sin\theta\cos\varphi,r\sin\theta\sin\varphi,r\cos\theta)r^s\sin\theta drdth\eta d\varphi,$ where the solid S is the pullback of G is spherical coordinates. the angle θ ranges from 0 to 2π, the angle varphi ranges from $0\to\pi$.
240	Volume of a solid $V=\iiint_G dxdydz$
241	Volume of Cylindrical Coordinates $V=\iiint_{S(r,\theta,z)}rdrdth\eta dz$
242	Volume of Spherical Coordinates $V=\iiint_{S(r,\theta,\varphi)}r^2\sin\theta drdth\eta d\varphi$
243	Mass of a solid $m=\iiint_G\mu(x,y,z)dV,$ where the soid occupies a region G and its density at a point $(x,y,z)is\mu(x,y,z)$
244	Center of mass of a solid $\bar{x}=\left(\frac{M_{yz}}{m},\bar{y}=\frac{M_{xy}}{m},\bar{z}=\frac{M_{xy}}{m}\right.$, where $M_{yz}=\iiint_G x\mu(x,y,z)dV, M_{xz}=\iiint_G y\mu(x,y,z)dV, M_{xy}=\iiint_G z\mu(x,y,z)dV$ are the first moments about the coordinte planes $x=0,y=0,z=0$ respectively, $m(x,y,z)$ is the density function.
245	Moments of Inertia about the xy-plane (or $z=0$), yz-plane ($x=0$) and xz=plane ($y=0$) $I_{xy}=\iiint_G z^2\mu(x,y,z)dV, I_{yz}=\iiint_G x^2\mu(x,y,z)dV, I_{xz}=\iiint_G y^2\mu(x,y,z)dV.$
246	Moment of Inertial about the x-axis, y-axis, and z-zxis $I_x=I_{xy}+\left(I_{xz}=\iiint_G(z^2+y^2)\mu(x,y,z)dV\right.$ $I_y=I_{xy}+\left(I_{yz}=\iiint_G(z^2+x^2)\mu(x,y,z)dV, I_z=I_{xz}+\left(I_{yz}=\iiint_G(y^2+x^2)\mu(x,y,z)dV\right.\right.$
247	Polar Moment of Inertia $I_0=I_{xy}+I_{yz}+I_{xz}=\iiint_G(x^2+y^2+z^2)\mu(x,y,z)dV$
248	Line Integral of a Scalar Function Let a curve C be given by the vector function $\vec{r}=\vec{r}(s), 0\leq s<+S,$ and a scalar function F is defined over the curve C. Then $\int_0^s F\left(\vec{r}(s)\right)ds=\int_C F(x,y,z)ds=\int_C Fds,$ where ds is the arc length differential.
249	$\int_{C_1\cup C_2}Fds=\int_{C_1}Fds+\int_{C_2}Fds$
250	If the month smooth Curve C is parametrized by $\vec{r}=\vec{r}(t)\alpha,\ \leq t\leq\beta$, then $\int_C F(x,y,z)ds=\int_\alpha^\beta F(x(t),y(t),z(t))\sqrt{(x'(t))^2+(y'(t))^2+(z'(t))^2}dt.$
251	If C si a smooth curve in the xy-plane given by the equation $y=f(x), a\leq x\leq b,$ then $\int_F(x,y)ds=\int_a^b F(x,f(x))\sqrt{1+(f'(x))^2}dx.$
252	Line Integral of Scalar Function in Polar coordinates

	$\int_C F(x,y)ds = \int_\alpha^\beta F(r\cos\theta, r\sin\theta)\sqrt{r^2 - \left(\frac{dr}{d\theta}\right)^2}d\theta$, where the curve C is defined by the polar function $r(\theta)$.
253	**Line Integral of Vector Field** Let a curve C be defined by the vector function $\vec{r} = \vec{r}(s), 0 \le s \le S$. Then $\frac{dverr}{ds} = \vec{\tau} = (\cos\alpha, \cos\beta, \cos\gamma)$ is the unit vector of the tangent line to this crurve.
254	**Properties of Line Integrals of Vector fields** $\int_{-C}\left(\vec{F}.d\vec{r}\right) = -\int_C\left(\vec{F}.d\vec{r}\right)$, where -C denote the curve with the opposite orientation. $\int_C\left(\vec{F}.d\vec{r}\right) = \int_{C_1 \cup C_2}\left(\vec{F}.d\vec{r}\right) = \int_{C_1}\left(\vec{F}.d\vec{r}\right) + \int_{C_2}\left(\vec{F}.d\vec{r}\right)$, where C is the union of the curve $C_1 \text{ and } C_2$.
255	If the curve C is parameterized by $\vec{r}(t) = \{x(t), y(t), z(t)\}, \alpha \le t \le \beta, then \int_C Pdx + Qdy + Rdz = , = \int_\alpha^\beta\left(P(x(t),y(t),z(t))\frac{dx}{dt} + Q(x(t),y(t),z(t))\frac{dy}{dt} + R(x(t),y(t),z(t))\frac{dz}{dt}\right)dt$.

256	If C lis in the xy-plane and given by the equation $y = f(x)$, then $\int_C Pdx + Qdy = \int_a^b\left(P(x, f(x)) + Q(x, f(x))\frac{df}{dx}\right)dx$.
257	**Green\'s Theorem** $\iint_R\left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right)dxdy = \oint Pdx + Qdy$, where $\vec{F} = P(x,y)\vec{i} + Q(x,y)\vec{j}$ is a continuous vector function with continuous first partial derivatives $\frac{\partial P}{\partial y}, \frac{\partial Q}{\partial x}$ in a some domain R, which is bounded by a close, piecewise smooth curve C.
258	Area of a Region R bounded by the curve C $S = \iint_R dxdy = \frac{1}{2}\oint_C xdy - ydx$
259	**Path Independence of Line Integrals** The line integral of a vector function $\vec{F} = P\vec{i} + Q\vec{j} + R\vec{k}$ is said to be path independent, if and only if P,Q andR are continuous in a domain D, and if there exists some scalar function $u = u(x,y,z)$ (a scalar potential) in D such that $\vec{F} = \nabla u$, or $\frac{\partial u}{\partial x} = P, \frac{\partial u}{\partial y} = Q, \frac{\partial u}{p}artilz\Big) = R$ Then $\int_C \vec{F}\left(\vec{r}\right).d\vec{r}\int_C Pdx + Qdy + Rdz = u(B) - u(A)$.
260	**Test for a conservative field** A vector field of the form $\vec{F} = \nabla u$ is called a conservative fiedl. The line integral of a vector function $\vec{F} = P\vec{i} + Q\vec{j} + R\vec{k}$ is path independent if and only if $curl\vec{F} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ P & Q & R \end{vmatrix} = \vec{0}$. If the line integral is taken in xy-plane so that $\int_C Pdx + Qdy = (B) - u(A)$, then the test for determining if a vector field is conservative can be written in the form $\frac{\partial P}{\partial y} = \frac{\partial Q}{\partial x}$.
261	**Length of a Curve** $L = \int_C ds = \int_\alpha^\beta \left\lvert\frac{d\vec{r}}{dt}(t)\right\rvert dt = \int_\alpha^\beta\sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \frac{dz}{dt}\Big)^2}dt$, where C is a piecewie smooth curve described by the position vector $\vec{r}(t), \alpha \le t \le \beta$. If the curve C is two dimensional , then $L = \int_C ds = \int_\alpha^\beta\left\lvert\frac{d\vec{r}}{dt}(t)\right\rvert dt = \int_\alpha^\beta\sqrt{\frac{((dx))^2}{dt} + \left(\frac{dy}{dt}\right)^2}dt$. The curve C is the graph of a function $y = f(x)$ in the xy- plane $(a \le x \le b)$, then $L = \int_a^b\sqrt{1 + \left(\frac{dy}{dx}\right)^2}dx$
262	**Length of a curve in polar coordinates** $L = \int_\alpha^\beta\sqrt{\left(\frac{dr}{(d\theta)^2} + r^2\right)}d\theta$, where the curve C is given by the equationi $r = r(\theta)\alpha \le \theta \le \beta$ in polar coordinates.
263	**Mass of a wire** $m = \int_C \rho(x,y,z)ds$, where $\rho(x,y,z)$ is the mass per unt length of the wire. If C is a curve parametrized by the vector function $\vec{r}(t) = \{x(t), y(t), z(t)$, then the mass can be computed by the formula $m = \int \alpha^\beta \rho\left(x(t), y(t), (t)\sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2}dt\right.$. If C is a curve in xy-plane then the mass of the wire is given by $m = \int_C \rho(x,y,z)ds$, or $m = \int_\alpha^\beta \rho\left(x(t), y(t)\sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}dt\right.$ (in parametric form)

264	Center of mass of a wire $\bar{x} = \frac{M_{yz}}{m}, \bar{y} = \frac{M_{xz}}{m}, \bar{z} = \frac{M_{xy}}{m} where M_{yz} = \int_C x\rho x, y, z\Big)ds, M_{xz} = \int_C y\rho x, y, z\Big)ds, M_{xy} = \int_C z\rho x, y, z\Big)ds,$
265	Moments of Inertia The moments of inertia about the x-axis, y-axis, and z-axis are given by the formulas $I_x = \int_C (y^2 + z^2)\rho(x, y, z)ds, I_y = \int_C (x^2 + z^2)\rho(x, y, z)ds, I_z = \int_C (x^2 + y^2)\rho(x, y, z)ds$
266	Area of a Region Bounded by a closed curve $S = \oint_c xdy = -\oint_C ydx = \frac{1}{2}\oint_C xdy - ydx.$
267	Volume of a Solid Formed by Rotating a Closed Curve about the x-axis $V = -\pi\oint_c y^2dx = -2\pi\oint_C xydy = -\frac{\pi}{2}\oint_C 2xydy + y^2dx$
268	Work done by a force $\vec{F}$ on an object moving along a curve C is given by the line integral $W = \int_C \vec{F}.d\vec{r}$, where $\vec{F}$ is the vector force field acting on the object $d\vec{r}$ is the unit tangent vector.
269	Ampere\'s Law $\oint_C \vec{B}.d\vec{r} = \mu_o I$. The line integral of a magnetic field $\vec{B}$ around a closed path C is equal to the total current I flowing through the area bunded by the path.
270	Faraday\'s Law $\varepsilon = \oint C\vec{E}.d\vec{r} = -\frac{dy}{dt}$ Th electromotive force (emf) epsilon induced around a closed loop C is equal to the rate to the change of magnetic flux ψ passing through the loop.
271	Surface Integral of a scalar function Let a surface S be given by the positin vector $\vec{r}(u, v) = x(u, v)\vec{i} + y(u, v)\vec{j} + z(u, v)\vec{k}$, where (u, v) ranges over some domain $D(u, v)$ of the uv-plane. The surface integral of a scalar function $f(x, y, z)$ over the surface S is defined as $\iint_S f(x, y, z)dS = \iint_{D(u,v)} f(x(u, v), y(u, v))\left\lvert\frac{\partial\vec{r}}{\partial u}\times\frac{\partial\vec{r}}{\partial v}\right\rvert dudv,$ where the partia,l derivaties $\frac{\partial\vec{r}}{\partial u}$ and $\frac{\partial\vec{r}}{\partial v}$ are given by $\frac{\partial\vec{r}}{\partial u} = \frac{\partial x}{\partial u}(u, v)\vec{i} + \frac{\partial y}{\partial u}(u, v)\vec{j} + \frac{\partial z}{\partial u}(u, v)\vec{k}, \frac{\partial\vec{r}}{\partial v} = \frac{\partial x}{\partial v}(u, v)\vec{i} + \frac{\partial y}{\partial v}(u, v)\vec{j} + \frac{\partial z}{\partial z}(u, v)\vec{k}$ and $\frac{\partial\vec{r}}{\partial u}\times\frac{\partial\vec{r}}{\partial v}$ is the cross product.

272	If the surface S is given by the equation $z = z(x, y)$ where $z(x, y)$ is a differentiable function in the domain $D(x, y)$, then $\iint_S f(x, y, z)dS = \iint_{D(x,y)} f(x, y, z(x, y))\sqrt{1 + \frac{\partial z}{\partial x}^2 + \left(\frac{\partial z}{\partial y}\right)^2}\Bigg)dxdy.$
273	Surface integral of the vector field $\vec{F}$ over the surface S If S is oriented outward, then $\iint_S \vec{F}(x, y, z).d\vec{S} = \iint_S \vec{F}(x, y, z).\vec{n}dS = \iint_{D(u,v)} \vec{F}(x(u, v), y(u, v), z(u, v)).\left[\frac{\partial\vec{r}}{\partial u}\times\frac{\partial\vec{r}}{\partial v}\right]dudv.$
274	If S is oriented inward, then $\iint_S \vec{F}(x, y, z).d\vec{S} = \iint_S \vec{F}(x, y, z).\vec{n}dS = \iint_D (u, v)\vec{F}(x(u, v), y(u, v), z(u, v)).\left[\left(\frac{\partial\vec{r}}{\partial}v\right)\times\frac{\partial\vec{r}}{\partial u}\right]dudv. d\vec{S} = \vec{n}dS$ is called the vector element of the surface. Dot means the scalar product of the appropriate vecrtors. The partial derivatives $\frac{\partial\vec{r}}{\partial u}$ and $\frac{\partial\vec{r}}{\partial v}$ are given by $\frac{\partial\vec{r}}{\partial u} = \frac{\partial u}{\partial u}(u, v).\vec{i} + \frac{\partial y}{\partial u}(u, v).\vec{j} + \frac{partalz}{\partial u}(u, v).\vec{k}, \frac{\partial\vec{r}}{\partial v} = \frac{\partial x}{\partial v}(u, v).\vec{i} + \frac{\partial y}{\partial}v\Big)(u, v).\vec{j} + \frac{\partial z}{\partial v}(u, v).\vec{k}.$
275	If the surface S is given by the equation $z = z(x, y)$ where $z(x, y)$ is a differentiable function in the domain $D(x, y), then If S is$ or $iented upward, i.e. the k - th compo \ne nt of the \|a\|l \overrightarrow{\quad} r is positive, then$ int int_S vecF(x,y,z).dvecS=int int_S vecF(x,y,z).vecn dS= int int_(D(x,y)) vecF(x,y,z).(-(partialz)/(partialy)vecj+veck) dxdy, If S is oriented downward, i.e. the k-th component of the normal vector is negative, then $\iint_S \vec{F}(x, y, z).d\vec{S} = \iint_S \vec{F}(x, y, z).\vec{n}dS = \iint_d (x, y)\vec{F}(x, y, z).\left(\frac{\partial z}{\partial x}\vec{i} + \frac{\partial z}{\partial y}\vec{j} - \vec{k}\right)dxdxy.$
276	$\iint_S \left(\vec{F}.\vec{n}\right)dS = \iint_S Pdydz = Qdzdx + Rdxdy = \iint_S (P\cos\alpha + Q\cos\beta + R\cos\gamma)dS, where P(x, y, z), Q(x, y, z), R(x, y, z)$ are the components of the vector field $\vec{F}$., $\cos alph, \cos\beta, \cos\gamma$ are the angles between the outer unit normal vector $\vec{n}$ and the x-axis, y-axis, and z-axis, respectively.
277	

	If The surface S is given in parametric form by the vector $\vec{r}(x(u,v), y(u,v), z(u,v))$, then the latter formula can be written as $\iint_S \left(\vec{F}.\vec{n}\right)dS = \iint_S Pdydz + Qdzdx + Rdxdy = \iint_{D(u,v)} \begin{vmatrix} (P,Q,R), & \frac{\partial x}{\partial u}, \frac{\partial y}{\partial u}, \frac{\partial z}{\partial u} \\ & \frac{\partial x}{\partial v}, \frac{\partial y}{\partial v}, \frac{\partial z}{\partial v} \end{vmatrix} dudv, where(u,v)$ ranges over some domain $D(u,v)$ of the uv-plane.
278	**Divergence Theorem** $\oint\oint_S \vec{F}.d\vec{S} = \iiint_G \left(\nabla.\vec{F}\right)dV, where\vec{F}(x,y,z) = \{P(x,y,z), Q(x,y,z), R(x,y,z)\}$ is a vectro field whose components P,Q, and R have continuous partial derivatives, $\nabla.\vec{f} = \frac{\partial P}{\partial x} + \frac{\partial Q}{\partial y} + \frac{\partial R}{\partial z}$ is the divergence of $\vec{F}$ also denoted $\div \vec{F}$. The symbol $\oint\oint$indicates that the surface integral is taken over a closed surface.
279	**Divergence Theorem in Coordinate Form** $\oint\oint_S Pdydz + Qdxdz + Rdxdy = \iiint + G\left(\frac{\partial P}{\partial x} + \frac{\partial Q}{\partial y} + \frac{\partial R}{\partial z}\right)dxdydz.$
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280	**Stoke\'s Theorem** $\oint_C \vec{F}.d\vec{r} = \iint_S \left(\nabla \times \vec{F}\right).d\vec{S}, where\vec{F}(x,y,z) = \{P(x,y,z), Q(x,y,z), R(x,y,z)\}$ is a vector field whose components P,Q, and R have continuous partial derivatives $\nabla \times \vec{f} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial x} & \frac{\partial}{\partial x} \\ P & Q & R \end{vmatrix} = \left(\frac{\partial R}{\partial y} - \frac{\partial Q}{\partial z}\right)\vec{i} + \left(\frac{\partial P}{\partial z} - \frac{\partial R}{\partial x}\right)\vec{j} = \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right)\vec{k}$ is teh curl of $\vec{F}$, also denoted curl $\vec{F}$. The symbol, $\oint$ indicates that the line integral is taken over a closed curve.
281	**Stroke\'s Theorem in Coordinate Form** $\oint + CPdx + Qdy + Rdz = \iint + S\frac{\partial R}{\partial y} - \frac{\partial Q}{\partial z}\Big)dydz + \left(\frac{\partial P}{\partial z} - \frac{\partial R}{\partial x}\right)dzdx + \left(\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y}\right)dxdy$
282	Surface Area $A = \iint_S dS$
283	If the surface S is parametrized by the vector $\vec{r}(u,v) = x(u,v)\vec{i} + y(u,v)\vec{j} + z(u,v)\vec{k}$, then the surface area is $A = \iint_{D(u,v)\left\|\frac{\partial \vec{r}}{\partial u} \times \frac{\partial \vec{r}}{\partial v}\right\|dudv, whereD(u,v)}$ is the domain where the surfasce $\vec{r}(u,v)$ is defined.
284	If S given explicitly by the function $z(x,y)$ then the surface area is $A = \iint_{D(x,y)} \sqrt{1 + \left(\frac{\partial z}{(\partial x)^2} + \left(\frac{\partial z}{\partial y}\right)^2\right)}dxdy, whereD(x,y)$ is the projection of the surface S onto the xy-plane.
285	Mass of a surface $m = \iint_S \mu(x,y,z)dS, where\mu(x,y,z)$ is the mass per unit area (density function).
286	Center of Mass of a shell $\bar{x} = \frac{M_{yz}}{m}, \bar{y} = \frac{M_{xz}}{m}, \bar{z} = (M_{xy})m, whereM_{yz} = \iint_S x\mu(x,y,z)dS, M_{xz} = \iint_S y\mu(x,y,z)dS, M_{xy} = \iint_S z\mu(x,y,z)dS,$ are the first moments about the coordinate planes x=0, y=0, z=0, respectively. $\mu(x,y,z)$ is the density function.
287	Moment of lertia the xy-plane (or z=0), yz-plane $(x=0)$, and xz-plane $(y=0)I_{xy} = \iint Sz^2\mu(x,y,z)dS, I_{yz}\iint_S x^2\mu(x,y,z)dS, I_{xz} = \iint_S y^2\mu(x,y,z)dS.$
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288	Moments of Inertia about the x-axis, y-axis, and z-axis $I_x = \iint_S (y^2+z^2)\mu(x,y,z)dS, I_y = \iint_S (x^2+z^2)\mu(x,y,z)dS, I_z = \iint_S (x^2+y^2)\mu(x,y,z)dS,$
289	Volume of a solid Bounded by a closed surface $V = \frac{1}{3}\left\|\oint\oint_S dxydz + ydxdz + zdxdy\right\|$
290	Gravitational Force $\vec{F} = G\min t\int_S \mu(x,y,z)\frac{\vec{r}}{r^3}dS$, where m is a mass at a point (x_0, y_0, z_0) outside the surface, $\vec{r} = (x - x_2, y - y_0, z - z_0)$, $\mu(x,y,z)$ is the density function, and G is a gravitational constant.
291	Pressure Foreee $\vec{F} = \iint_S p\left(\vec{r}\right)d\vec{S}$, where the pressure $p\left(\vec{r}\right)$ acts on the surface S given by the position vector $\vec{r}$.
292	Fluid Flux (across the surface S) $\Phi = \oint\oint\vec{v}\left(\vec{r}\right).d\vec{S}, where\vec{v}\left(\vec{r}\right)$ is the fluid velocity.
293	

	Mass Flux (across the surface S) $\Phi = \iint_S \rho \vec{v}\left(\vec{r}\right). d\vec{S}, where \vec{F} = \rho \vec{v}$ is the vector field, rho is the fuid density,
294	Surface Charge $Q = \iint_S \sigma(x, y) dS, where \sigma(x, y)$ is the surface charge density.
295	Gauss\' law the electric flux through any closed surface is proportional to the charge Q enclosed by the surface $\Phi = \iint_S \vec{E}. d\vec{S} = \frac{Q}{\varepsilon_0}$ where Φ is the electric flux, $\vec{E}$ e is the magnitude of the electric field strength, $\varepsilon_0 = 8, 85 \times 10^{-12} \frac{F}{m}$ is permittivity of free space.

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MATRICES AND DETERMINANTS

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SL#	FORMULA
1	**Second Order Determinant** $\det A = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} = a_1b_2 - a_2b_1$
2	**Value of Determinant** $\det A = \begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} = a_{11}a_{22}a_{33} + a_{12}a_{23}a_{31} + a_{13}a_{21}a_{32} - a_{11}a_{23}a_{32} - a_{12}a_{21}a_{33} - a_{13}a_{22}a_{31}$
3	**N-th Order Determinant** $\det A = \begin{vmatrix} a_{11} & a_{12} & \dots & a_{1j} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2j} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{i1} & a_{i2} & \dots & a_{ij} & \dots & a_{in} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nj} & \dots & a_{nn} \end{vmatrix}$
4	**Minor** **The minor M_{ij} associated with the element a_{ij} of n-th order matrix A is the (n-1)-th order determinant derived from the matrix A by deletion of its i-th row and j-th column.**
5	**Cofactor** $C_{ij} = (-1)^{i+j}M_{ij}$
6	**Laplace Expansion of n-th Order Determinant** **Laplace expansion by elements of the i-th row** $\det A = \sum_{j=1}^{n} a_{ij}C_{ij}, i = 1, 2, \dots, n$ **Laplace expansion by elements of the j-th column** $\det A = \sum_{i=1}^{n} a_{ij}C_{ij}, j = 1, 2, \dots, n$
7	**The value of a determinant remains unchanged if rows are changed to columns and columns to rows.**

	$\begin{vmatrix} a_1 & a_2 \\ b_1 & b_2 \end{vmatrix} = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}$
8	**If two rows (or two columns) are interchanged, the sign of the determinant is changed.** $\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} = -\begin{vmatrix} a_2 & b_2 \\ a_1 & b_1 \end{vmatrix}$
9	**If two rows (or two columns) are identical, the value of the determinant is zero.** $\begin{vmatrix} a_1 & a_1 \\ a_2 & a_2 \end{vmatrix} = 0$
10	**If the elements of any row (or column) are multiplied by a common factor, the determinant is multiplied by that factor.** $\begin{vmatrix} ka_1 & kb_1 \\ a_2 & b_2 \end{vmatrix} = k\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}$
11	**If the elements of any row (or column) are increased (or decreased) by equal multiples of the corresponding elements of any other row (or column), the value of the determinant is unchanged.** $\begin{vmatrix} a_1 + kb_1 & b_1 \\ a_2 + kb_2 & b_2 \end{vmatrix} = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}$
12	**An $m \times n$ matrix A is a rectangular array of elements (numbers or functions) with m rows and n columns.** $A = [a_{ij}] = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix}$
13	**Square matrix is a matrix of order $n \times n$**
14	**A square matrix $\lfloor a_{ij} \rfloor$ is symmetric if $a_{ij} = a_{ji}$, i.e. it is symmetric about the leading diagonal.**
15	**A square matrix $\lfloor a_{ij} \rfloor$ is skew-symmetric if $a_{ij} = -a_{ji}$**
16	**Diagonal matrix is a square matrix with all elements zero except those on the leading diagonal.**
17	**Unit matrix is a diagonal matrix in which the elements on the leading diagonal are all unity. The unit matrix is denoted by I**
18	**A null matrix is one whose elements are all zero**
19	**Two matrices A and B are equal if, and only if, they are both of the same shape $m \times n$ and corresponding elements are equal.**
20	**Two matrices A and B can be added (or subtracted) of, and only if, they have the same shape $m \times n$. If**

	$$A = [a_{ij}] = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix},$$ $$B = [b_{ij}] = \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ \vdots & \vdots & & \vdots \\ b_{m1} & b_{m2} & \dots & b_{mn} \end{bmatrix},$$ **then,** $$A + B = \begin{bmatrix} a_{11}+b_{11} & a_{12}+b_{12} & \dots & a_{1n}+b_{1n} \\ a_{21}+b_{21} & a_{22}+b_{22} & \dots & a_{2n}+b_{2n} \\ \vdots & \vdots & & \vdots \\ a_{m1}+b_{m1} & a_{m2}+b_{m2} & \dots & a_{mn}+b_{mn} \end{bmatrix}$$
21	**If k is a scalar, and** $A = \lfloor a_{ij} \rfloor$ **is a matrix, then** $$kA = [ka_{ij}] = \begin{bmatrix} ka_{11} & ka_{12} & \dots & ka_{1n} \\ ka_{21} & ka_{22} & \dots & ka_{2n} \\ \vdots & \vdots & & \vdots \\ ka_{m1} & ka_{m2} & \dots & ka_{mn} \end{bmatrix}$$
22	**Multiplication of Two Matrices** **Two matrices can be multiplied together only when the number of columns in the first is equal to the number of rows in the second.** **If** $$A = [a_{ij}] = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix},$$ $$B = [b_{ij}] = \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1k} \\ b_{21} & b_{22} & \dots & b_{2k} \\ \vdots & \vdots & & \vdots \\ b_{n1} & b_{n2} & \dots & b_{nk} \end{bmatrix},$$ **then** $AB = C = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1k} \\ c_{21} & c_{22} & \dots & c_{2k} \\ \vdots & \vdots & & \vdots \\ b_{m1} & c_{m2} & \dots & c_{mk} \end{bmatrix}$, **where** $c_{ij} = a_{i1}b_{1j} + a_{i2}b_{2j} + \dots + a_{in}b_{nj} = \sum_{\lambda=1}^{n} a_{i\lambda}b_{\lambda j}$ $(i = 1, 2, \dots, m; j = 1, 2, \dots, k).$ **Thus if** $A = [a_{ij}] = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix}, B = [b_i] = \begin{bmatrix} b_i \\ b_2 \\ b_3 \end{bmatrix},$

	then, $AB = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix} \cdot \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} a_{11}b_1 & a_{12}b_2 & a_{13}b_3 \\ a_{21}b_1 & a_{22}b_2 & a_{23}b_3 \end{bmatrix}$
23	**Transpose of a Matrix** **If the rows and columns of matrix are interchanged, then the new matrix is called the transpose of the original matrix. If A is the original matrix, its transpose is denoted** A^T **or** $\tilde{A}$
24	**The matrix A is orthogonal if** $AA^T = I$
25	**If the matrix product AB is defined, then** $(AB)^T = B^T A^T$
26	**Adjoint of Matrix** **If A is a square** $n \times n$ **matrix, its adjoint, denoted by adj A, is the transpose of the matrix of cofactors** C_{ij} **of** A: $adjA = [C_{ij}]^T$.
27	**Trace of a Matrix** **If A is a square** $n \times n$ **matrix, its trace, denoted by tr A, is defined to be the sum of the terms on the leading diagonal:** $trA = a_{11} + a_{22} + \ldots + a_{nn}$.
28	**Inverse of a Matrix** **If A is a square** $n \times n$ **matrix with a nonsingular determinant det A, then its inverse** A^{-1} **is given by** $A^{-1} = \dfrac{adjA}{\det A}$
29	**If the matrix product AB is defined, then** $(AB)^{-1} = B^{-1}A^{-1}$
30	**If A is a square** $n \times n$ **matrix, the eigenvectors X satisfy the equation** $AX = \lambda X$, **while the eigenvalues** λ **satisfy the characteristic equation** $\lvert A - \lambda I \rvert = 0$
31	$\begin{cases} a_1x & + & b_1y & = & d_1 \\ a_2x & + & b_2y & = & d_2 \end{cases}$ $x = \dfrac{D_x}{D}, y = \dfrac{D_y}{D}$ **(Cramer\'s rule),** **where** $D = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} = a_1b_2 - a_2b_1,$ $D_x = \begin{vmatrix} d_1 & b_1 \\ d_2 & b_2 \end{vmatrix} = d_1b_2 - d_2b_1,$ $D_y = \begin{vmatrix} a_1 & d_1 \\ a_2 & d_2 \end{vmatrix} = a_1d_2 - a_2d_1$

32	If $D \neq 0$, then the system has a single solution: $$x=\frac{D_x}{D}, y=\frac{D_y}{D}.$$ If $D=0$ and $D_x \neq 0\left(\text{ or } D_y \neq 0\right)$, then the system has no solution. If $D=D_x=D_y=0$, then the system has infinitely many solutions.
33	$$\begin{cases} a_1x & + & b_1y & + & c_1z & = & d_1 \\ a_2x & + & b_2y & + & c_2z & = & d_2 \\ a_3x & + & b_3y & + & c_3z & = & d_3 \end{cases}$$ $x=\frac{D_x}{D}, y=\frac{D_y}{D}, z=\frac{D_z}{D}$ (Cramer\'s rule), where $$D=\begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}, D_x=\begin{vmatrix} d_1 & b_1 & c_1 \\ d_2 & b_2 & c_2 \\ d_3 & b_3 & c_3 \end{vmatrix},$$ $$D_y=\begin{vmatrix} a_1 & d_1 & c_1 \\ a_2 & d_2 & c_2 \\ a_3 & d_3 & c_3 \end{vmatrix}, D_z=\begin{vmatrix} a_1 & b_1 & d_1 \\ a_2 & b_2 & d_2 \\ a_3 & b_3 & d_3 \end{vmatrix}.$$
34	If $D \neq 0$, then the system has a single solution: $$x=\frac{D_x}{D}, y=\frac{D_y}{D}, z=\frac{D_z}{D}.$$ If $D=0$ and $D_x \neq 0\left(\text{ or } D_y \neq 0 \text{ or } D_z \neq 0\right)$, then the system has no solution. If $D=D_x=D_y=D_z=0$, then the system has infinitely many solutions.
35	Matrix Form of a System of n Linear Equations in n Unknowns The set of linear equations $$\begin{cases} a_{11}x_1 & + & a_{12}x_2 & + & \ldots & + & a_{1n}x_n & = & b_1 \\ a_{21}x_1 & + & a_{22}x_2 & + & \ldots & + & a_{2n}X_n & = & b_2 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \\ a_{n1}X_1 & + & a_{n2}X_2 & + & \ldots & + & a_{nn}X_n & = & b_n \end{cases}$$ can be written in matrix form $$\begin{pmatrix} a_{11} & a_{12} & \ldots & a_{1n} \\ a_{21} & a_{22} & \ldots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \ldots & a_{nn} \end{pmatrix} \cdot \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{pmatrix} = \begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{pmatrix},$$ i.e. $A \cdot X = B$,

	where, $A = \begin{pmatrix} a_{11} & a_{12} & \vdots & a_{1n} \\ a_{21} & a_{22} & \vdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix}, X = \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{pmatrix}, B = \begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{pmatrix}.$
36	**Solution of a Set of Linear Equations $n \times n$** $X = A^{-1} \cdot B,$ **where A^{-1} is the inverse of A.**

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PROBABILITY

SL#	FORMULA
1	**Factorial** $n \neq 1.2.3\ldots(n-2)(n-1)n0 \neq 1$
2	$\hat{}\ P_n = n!$
3	$\hat{}\ P_m = \dfrac{n!}{(n-m)!}$
4	**Binomial Coefficient** $\hat{}\ C_m = \binom{n}{m} = \dfrac{n!}{m!(n-m)!}$
5	$\hat{}\ nC_m =^n C_{n-m}$
6	$\hat{}\ nC_m +^n C_{m+1} =^{n+1} C_{m+1}$
7	$\hat{}\ nC_0 +^n C_1 +^n C_2 + \ldots +^n C_n = 2^n$
8	**Probability of an Event** $P(A) = \dfrac{m}{n}$, **where m is the number of possible positive outcomes n is the total number of possible outcomes.**
9	**Range of Probability Values** $0 \leq P(A) \leq 1$
10	**Certain Event** $P(A) = 1$
11	**Impossible Event** $P(A) = 0$
12	**Complement** $P(\overline{A}) = 1 - P(A)$
13	**Independent Events** $P\left(\dfrac{A}{B}\right) = P(A), P\left(\dfrac{B}{A}\right) = P(B)$
14	**Addition Rule for Independent Events** $P(A \cup B) = P(A) + P(B)$
15	**Multipication Rule of Independent Events** $P(AcpB) = P(A).\,P(B)$

16	**General Addition Rule** $P(A \cup B) = P(A) + P(B) - P(A \cap B), where A cub B$ **is the union of events A and B,** $A cab B$ **is the intersection of events A and B.**
17	**Conditional Probability** $P\left(\frac{A}{B}\right) = \frac{P(A \cap B)}{P(B)}$
18	$P(A \cap B) = P(B).\, P\left(\frac{A}{B}\right) = P(A).\, P\left(\frac{B}{A}\right)$
19	**Law of Total Probability** $P(A) = \sum_{i=1}^{m} P(B_i)P\left(\frac{A}{B_i}\right)$, **where** B_i **is a sequence of mutually exclusive events.**
20	**Bayes\' Theorem** $P\left(\frac{B}{A}\right) = \frac{P\left(\frac{A}{B}\right).\, P(B)}{P(A)}$
21	**Bayes\' Formula** $P\left(\frac{B_i}{A}\right) = \frac{P(B_i).\, P\left(\frac{A}{B_i}\right)}{\sum_{k=1}^{m} P(B_i).\, P\left(\frac{A}{B_i}\right)}$ **where** B_i **is a set of mutually exclusive events (hypotheses), A is the final event,** $P(B_i)$ **are the prior probabilities,** $P\left(\frac{B_i}{A}\right)$ **are the posterior probabilities.**
22	**Law of Large Numbers** $P(\lvert(S_n)n - \mu\rvert \geq \varepsilon) \to 0 as n \to \infty, P(\lvert(S_n)n - \mu\rvert < \varepsilon) \to 1 as n \to \infty$, **where** S_n **is the sum of random variables, n is the number of possible outcomes.**
23	**Chebyshev Inequality** $P(\lvert X - \mu\rvert \geq \varepsilon) \leq \frac{V(X)}{\varepsilon^2}, wehre V(X)$ **is the variace of X**

24	**Normal Density Function** $\varphi(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{(x-\mu)^2}{2\sigma^2}}$, **whre x is a particular outcome.**
25	**Standard Normal Density Function** $\varphi(z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}}$ **Average value** $\mu = 0$ **deviation** $\sigma = 1$
26	**Standard Z value** $Z = \frac{X - \mu}{\sigma}$
27	**Cumulative Normal Distribution Functon** $F(x) = \frac{1}{\sigma\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{(t-\mu)^2}{2\sigma^2}dt}$, **where x is a particular outcome, t is variable of integration.**
28	$P(\alpha < X < \beta) = F\left(\frac{\alpha - \mu}{\sigma}\right) - F\left(\frac{\beta - \mu}{\sigma}\right)$, **where X is normally distributed random variable, F is cumulative normal distribution function,** $P(\alpha < X < \beta)$ **is interval probability.**
29	$P(\lvert X - \mu\rvert < \varepsilon) = 2F\left(\frac{\varepsilon}{\sigma}\right)$, **where X is normally distributed random variable, F is cumulative normal distribution function.**
30	**Cumulative Distribution Function** $F(x) = P(X < x) = \int_{-\infty}^{x} f(t)dx$, **where t is a variable of integration.**

31	**Bernoulli Trails Process** $\mu = np, \sigma^2 = npq,$ **where n is a sequence of experimets, p is the probability of success of each experiments, q is the probability of failure,** $q = 1, 1 - p$
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32	**Binomial Distribution Function** $b(n, p, q) = \binom{n}{k} p^k q^{n-k}, \mu = np, \sigma^2 = npq, f(x) = (q + pe^x)^n,$ **where n is the number of trials of selections p is the pribabilityi of success, q is the probability of failure q=1-p.**
33	**Geometric Disrtribution** $P(T = j) - q^{i-j} p, , \mu = \frac{1}{p}, \sigma^2 = \frac{1}{p^2},$ **where T is the first successful event is the series, j is the event number, p is the probability that any one event is successful, q is the probability of failure** $q = 1 - p$**.**
34	**Poisson Distribution** $P(x = k) \approx \frac{\lambda^k}{k!} e^{-\lambda}, \lambda - np, \mu = \lambda, \sigma^2 = \lambda, where$ **lamds is the rate of occurrence, k is the number of positive outcomes.**
35	**Density Function** $P(a \leq X \leq b) = \int_a^b f(x) dx$
36	**Continuous Uniform Density** $f = \frac{1}{b - a}, \mu = \frac{a + b}{2},$ **where f is the density function.**
37	**Exponential Density Function** $f(t) = \lambda e^{-\lambda t}, \mu = \lambda, \sigma^2 = \lambda^2$ **where t is the lambda is the failure rate.**
38	**Exponential Distribution Function** $F(t) = 1 - e(-\lambda t),$ **where t is the lambda is the failure rate.**
39	**Expected Value of Discrete Radom Variables** $\mu = E(X) = \sum_{i=1}^{n} x_i p_i, where x_i$ **is a particular outcomes** p_i **is its probabilaty.**
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40	**Expected Value of Continuous Random Variables** $\mu = E(X) = \int_{-\infty}^{\infty} x f(x) dx$
41	**Propeties of Expectations** $E(X + Y) = E(X) + E(Y), E(X - Y) = E(X) - E(Y), E(cX) = CE(X), E(XY) = E(X). E(Y),$ **where c is a constant.**
42	$E(X^2) = V(X) + \mu^2, where \mu = E(X)$ **is the expected value,** $V(X)$ **is the variance.**
43	**Markov Inequality** $P(X > k) \leq \frac{E(X)}{K},$ **where k is some constant.**
44	**Variance of Discrete Random Variables** $\sigma^2 = V(X) = E\left[(X - \mu)^2\right] = \sum_{i=1}^{n} (x_i - \mu)^2 p_i,$ **where** x_i **is a particular outcome,** p_i **is its probability.**
45	**Variance of Continuous Random Variables** $\sigma^2 = V(X) = E\left[(X - \mu)^2 = \int_{-\infty}^{\infty} (x - \mu)^2 f(x) dx\right.$

46	**Properties of Variance** $V(X+Y)=V(X)+V(Y), V(X-Y)=V(X)+V(Y), V(X+c)=V(X), V(cX)=c^2V(X)$, **where c is a constant.**
47	**Standard Deviationn** $D(X)=\sqrt{V(X)}=\sqrt{E\left[(X-\mu)^2\right]}$
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48	**Covariance** $cov(X,Y)=E[(X-\mu(X))(Y-\mu))]=E(XY)-\mu(X)\mu(Y)$, **where X is random variable** $V(X)$ **is the variance of X, mu is the expected vlue of X or Y.**
49	**Correlation** $\rho(X<Y)+\frac{cov(X,Y)}{\sqrt{V(X)V(Y)}}$, **where** $V(X)$ **is the variasnce of X,** $V(Y)$ **is the variance of Y.**
50	**Standard Deviationn** $D(X)=\sqrt{V(X)}=\sqrt{E\left[(X-\mu)^2\right]}$
51	**Covariance** $cov(X,Y)=E[(X-\mu(X))(Y-\mu))]=E(XY)-\mu(X)\mu(Y)$, **where X is random variable** $V(X)$ **is the variance of X, mu is the expected vlue of X or Y.**
52	**Correlation** $\rho(X<Y)+\frac{cov(X,Y)}{\sqrt{V(X)V(Y)}}$, **where** $V(X)$ **is the variasnce of X,** $V(Y)$ **is the variance of Y**

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SETS

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SL#	FORMULA
1	$A \subset I$
2	$A \subset A$
3	$A = B$ **if** $A \subset B$ **and** $B \subset A$.
4	**Empty Set** $\emptyset \subset A$
5	**Union of Sets** $C = A \cup B = \{x \mid x \in A$ **or** $x \in B\}$
6	**Commutativity** $A \cup B = B \cup A$
7	**Associativity** $A \cup (B \cup C) = (A \cup B) \cup C$
8	**Intersection of Sets** $C = A \cap B = \{x \mid x \in A$ **and** $x \in B\}$
9	**Commutativity** $A \cap B = B \cap A$
10	**Associativity** $aA \cap (B \cap C) = (A \cap B) \cap C$
11	**Distributivity** $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$, $A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$.
12	**Idempotency** $A \cap A = A$, $A \cup A = A$
13	**Domination:** $A \cap O = O$, $A \cup I = I$
14	**Identity**

	$A \cup O = A$, $A \cap I = A$
15	**Complement** $A' = \{x \in I \mid x \notin A\}$
16	**Complement of Intersection and Union** $A \cup A' = I$, $A \cap A' = \emptyset$
17	**DeMorgan\'s Laws** $(A \cup B)' = A' \cap B'$, $(A \cap B)' = A' \cup B'$
18	**Difference of Sets** $C = B \backslash A = \{x \mid x \in B \text{ and } x \notin A\}$
19	$B \backslash A = B \backslash (A \cap B)$
20	$B \backslash A = B \cap A'$
21	$A \backslash A = \emptyset$
22	$A \backslash B = A$ **if** $A \cap B = \emptyset$
23	$(A \backslash B) \cap C = (A \cap C) \backslash (B \cap C)$
24	$A' = I \backslash A$
25	**Cartesian Product** $C = A \times B = \{(x, y) \mid x \in A$ **and** $y \in B\}$
26	**Natural numbers** **Counting numbers:** $N = \{1, 2, 3, \ldots\}$.
27	**Whole numbers** **Counting numbers and zero:** $N_0 = \{0, 1, 2, 3, \ldots\}$.
28	**Integers** **Whole numbers and their opposites and zero:**

	$Z^{+} = N = \{1, 2, 3, \ldots\}$, $Z^{\equiv}\{\ldots, -3, -2, -1\}$, $Z = Z^{-\cup}\{0\} \cup Z^{+} = \{\ldots, -3, -2, -1, 0, 1, 2, 3, \ldots.\}$.
29	**Rational numbers: Repeating or terminating decimals:** $Q = \left\{x \mid x = \frac{a}{b}\right.$ **and** $a \in Z$ **and** $b \in Z$ **and** $b \neq 0\}$.
30	**Irrational Numbers: Nonrepeating and nonterminating decimals.**
31	**Real Numbers: Union of rational and irrational numbers: R.**

32	**Complex Numbers:** $C = \{x + iy \mid x \in R$ **and** $y \in R\}$, **where** i **is the imaginary unit.**
33	$N \subset Z \subset Q \subset R \subset C$
34	**Additive Identity:** $a + 0 = a$
35	**Additive Inverse:** $a + (-a) = 0$
36	**Commutative of Addition:** $a + b = b + a$
37	**Associative of Addition:** $(a + b) + c = a + (b + c)$
38	**Definition of Subtraction:** $a - b = a + (-b)$
39	**Multiplicative Identity:** $a \cdot 1 = a$

40	**Multiplicative Inverse:** $a \cdot \frac{1}{a} = 1, a \neq 0$
41	**Multiplication Times 0** $a \cdot 0 = 0$
42	**Commutative of Multiplication** $a \cdot b = b \cdot a$
43	**Associative of Multiplication** $(a \cdot b) \cdot c = a \cdot (b \cdot c)$
44	**Distributive Law** $a(b + c) = ab + ac$

45	**Definition of Division** $\frac{a}{b} = a \cdot \frac{1}{b}$

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STRAIGHT LINE

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SL#	FORMULA
1	**Distance Between Two Points** $d = AB = \lvert x_2 - x_1 \rvert = \lvert x_1 - x_2 \rvert$
2	**Dividing a Line Segment in the Ratio** $\lambda x_0 = \frac{x_1 + \lambda x_2}{1 + \lambda}, \lambda \frac{AC}{CB}, \lambda \neq -1.$
3	**Midpoint of a Line Segment** $x_0 = \frac{x_1 + x_2}{2}, \lambda = 1.$
4	**Distance Between Two Points** $d = AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$
5	**Distance Between Two Points in Polar Coordinates** $d = AB = \sqrt{r_1^2 + r_2^2 - 2r_1 r_2 \cos(\phi_2 - \phi_1)}$
6	**Converting Rectangular Coordinates to Polar Coordinates** $x = r\cos\phi, y = r\sin\psi.$
7	**Converting Polar Coordinates to Rectangular Coordinates** $r = \sqrt{x^2 + y^2}, \tan\phi = \frac{y}{x}.$
8	**General Equation of a straight Line** $Ax + By + C = 0$
9	**Normal Vector to a Straight Line The Vector** $\overrightarrow{A, B}$ is noramal to the line $Ax + By + C = 0$

10	Explicit Equation of a straight Line (Slope -Intercept Form)$y = kx + b$.
11	Gradient of a Line $k = \tan\alpha = \frac{y_2 - y_1}{x_2 - x_1}$
12	Equation of a line given a point and the Gradient $y = y_0 + k(x - x_0)$, where k is the gradient, $P(x_0, y_0)$ is a point on the line.
13	Equation of a Line That Passes Through Two Points $\frac{y - y_1}{y_2 - y_1} = \frac{x - x_1}{x_2 - x_1}$ or $\begin{vmatrix} x & y & 1 \\ x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \end{vmatrix} = 0$
14	Intercept Form $\frac{x}{a} + \frac{y}{b} = 1$
15	Normal Form $x\cos\beta + y\sin\beta - p = 0$
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16	Point Direction Form $\frac{x - x_1}{X} = \frac{y - y_1}{Y}$, where (X, Y) is the direction of the ine and $P_1(x_1, y_1)$ lies on the line.
17	Vertical Line $x = a$
18	Horizontal Line $y = b$
19	Vector equation of a Straight Line $\vec{r} = \vec{a} + t\vec{b}$, where O is the origin of the coordinates, X is any variable point on the line, $\vec{a}$ is the position vector of a known point A on the line, $\vec{b}$ is a known vector of direction, parallel to the line, t is a parameter, $\vec{r} = \overrightarrow{OX}$ is the position vector of any pont X on the line.
20	Straight Line in Parametric Form $\begin{cases} x = a_1 + tb_1 \\ y = a_2 + tb_2 \end{cases}$ where (x, y) are the coordinates of any unknown point on the line,

	(a_1, a_2) **are the coordinates of a known point on the line,** (b_1, b_2) **are the coordinates of a vector parallel to the line,** **t is a parameter.**
21	**Distance From a Point To a Line** **The distance from the point** $P(a, b)$ **to line** $Ax + By + C = 0$ **is** $d = \frac{\lvert Aa + Bb + c\rvert}{\sqrt{A^2 + B^2}}$
22	**Parallel Lines Two lines** $y = k_1x + b_1 \text{ and } y = k_2x + b_2$ **are parallel if** $k_1 = k_2$. **Two lines** $A_1x + B_1y + C_1 = 0 \text{ and } A_2x + B_2y + C_2 = 0$ **are parallel if** $\frac{A_1}{A_2} = \frac{B_1}{B_2}$.
23	**Perpendicular Lines** **Two Lines** $y = k_1x + b_1 \text{ and } y = k_2x + b_2$ **are perpendicular if** $k_2 = -\frac{1}{k_1}$ **or, equivalently,** $k_1k_2 = -1$. **Two lines** $A_1x + B_1y + C_1 = 0 \text{ and } A_2x + B_2y + C_2 = 0$ **perpendicular if** $A_1A_2 + B_1B_2 = 0$
24	**Angle Between Two Lines** $\tan\phi = \frac{k_2 - k_1}{1 + k_1k_2}, \cos\phi = \frac{A_1A_2 + B_1B_2}{\sqrt{A_1^2 + B_1^2}.\sqrt{A_2^2 + B_2^2}}$
25	**Intersection of Two Lines** **If two lines** $A_1x + B_1y + C_1 = 0 \text{ and } A_2x + B_2y + C_2 = 0$ **intersect, the intersection point has coordinates** $x_0 = \frac{-C_1B_2 + C_2B_1}{A_1B_2 - A_2B_1}$, $y_0 = \frac{-A_1C_2 + A_2C_1}{A_1B_2 - A_2B_1}$

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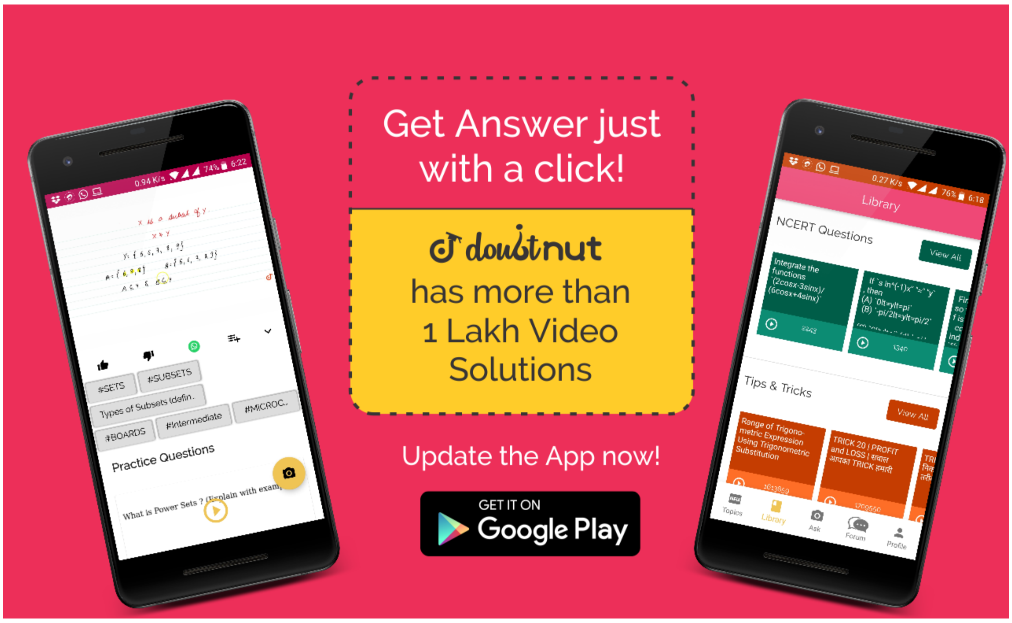

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3D GEOMETRY

SL#	FORMULA
1	**Distance Between two points** $d = AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$
2	**Dividing a Line Segment in the Ratio** $\lambda x_0 = \frac{x_1 + \lambda x_2}{1 + \lambda},$ $y_0 = \frac{y_1 + \lambda y_2}{1 + \lambda},$ $z_0 = \frac{z_1 + \lambda z_2}{1 + \lambda}, where \lambda = \frac{AC}{CB}, \lambda \neq -1.$
3	**Midpoint of a Line Segment** $x_0 = \frac{x_1 + x_2}{2},$ $y_0 = (y_1 + y_2)/2,$ $z_0 = \frac{z_1 + z_2}{2}, \lambda = 1.$
4	**Area of a Triangle The area of a triangle with vertices** $P_1(x_1, y_1, z_1), P_2(x_2, y_2, z_2)$, **and** $P_3(x_3, y_3, z_3)$ **is given by** $S = \frac{1}{2}\sqrt{\begin{vmatrix} y_1 & z_1 & 1 \\ y_2 & z_2 & 1 \\ y_3 & z_3 & 1 \end{vmatrix}^2 + \begin{vmatrix} z_1 & x_1 & 1 \\ z_2 & x_2 & 1 \\ z_3 & x_3 & 1 \end{vmatrix}^2 + \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}^2}.$
5	**Volume of a Tetrahedron** **The volume of a tetrahedron with vertices** $P_1(x_1, y_1, z_1), P_2(x_2, y_2, z_2), P_3(x_3, y_3, z_3)$ **and** $P_4(x_4, y_4, z_4)$ **is given by** $V = \pm\frac{1}{6}\begin{vmatrix} x_1 & y_1 & z_1 & 1 \\ x_2 & y_2 & z_2 & 1 \\ x_3 & y_3 & z_3 & 1 \\ x_4 & y_4 & z_4 & 1 \end{vmatrix}, \text{ or } V = \pm\frac{1}{6}\begin{vmatrix} x_1 - x_4 & y_1 - y_4 & z_1 - z_4 \\ x_2 - x_4 & y_2 - y_4 & z_2 - z_4 \\ x_3 - x_4 & y_3 - y_4 & z_3 - z_4 \end{vmatrix}.$ **Note: We choose the sign (+) or (-) so that to get a positive answer for volume.**

6	**General Equation of a Plane** $Ax + By + Cz + D = 0$
7	**Normal Vector to a plane** **The vector** $\overrightarrow{n}(A, B, C)$ **is normal to the plane** $Ax + By + Cz + D = 0$
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8	**Particular Cases of the Equation of a plane** $Ax + By + Cz + D = 0$ **If** $A = 0$**, the plane is parallel to the x-axis.** **If** $B = 0$**, the plane is parallel to the y-axis.** **If** $C = 0$ **the plane is parallel to the z-axis.** **If** $D = 0$**, the plane lies on the origin.** **If** $A = B = 0$**, the plane is paralle to the xy-plane,** **If** $B = C = 0$ **the plane is parallel to the yz-plane.** **If** $A = C = 0$ **the plane is parallel to the xz-plane.**
9	**Point Direction form** $A(x - x_0) + B(y - y_0) + C(z - z_0) = 0$ **where the point** $P(x_0, y_0, z_0)$ **lies in the plane, and the vector (A,B,C) is normal to the plane.**
10	**Intercept form** $\frac{x}{a} + \frac{y}{b} + \frac{z}{c} = 1$
11	**Three Point Form** $\begin{vmatrix} x - x_3 & y - y_3 & z - z_3 \\ x_1 - x_3 & y_1 - y_3 & z_1 - z_3 \\ x_2 - x_3 & y_2 - y_3 & z_2 - z_3 \end{vmatrix} = 0, \text{ or } \begin{vmatrix} x & y & z & 1 \\ x_1 & y_1 & z_1 & 1 \\ x_1 & y_1 & z_1 & 1 \\ x_2 & y_2 & z_2 & 1 \\ x_3 & y_3 & z_3 & 1 \end{vmatrix} = 0$
12	**Normal Form** $\cos\alpha + y\cos\beta + z\cos gama - p = 0$ **where p is the perpendicular distance from the origin to the plane, and** $\cos\alpha, \cos\beta, \cos\gamma$ **are the direction cosines of any line normal to the plane.**
13	**Parametric form** $\begin{cases} x = x_1 + a_1 s + a_2 t \\ y = y_1 + b_1 + b_2 t \\ z = z_1 + c_1 s + c_2 t \end{cases}$ **where** (x, y, z) **are the coordinates of any unknown point on the line the point** $P(x_1, y_1, z_1)$ **lies in the plane, the vectors** (a_1, b_1, c_1) **and** (a_2, b_2, c_2) **are parallel to the plane.**
14	**Dihedral Angle Between Two Planes**

	If the planes are given by $A_1x+B_1y+C_1z+D_1=0$, $A_2x+B_2y+C_2z+D_2=0$, then the dihedral angle between them is $\cos\phi=\frac{\vec{n}_1.\vec{n}_2}{\lvert\vec{n}_1\rvert.\lvert\vec{n}_2\rvert}=\frac{A_1A_2+B_1+B_2+C_1C_2}{\sqrt{A_1^2+B_1^2+C_1^2}.\sqrt{A_2^2+B_2^2+C_2^2}}$
15	**Parallel Planes Two planes** $A_1x+B_1y+C_1z+D_1=0$ **and** $A_2x+B_2y+C_2z+D_2=0$ **are parallel if** $\frac{A_1}{A_2}=\frac{B_1}{B_2}=\frac{C_1}{C_2}$

16	**Perpendicular planes** Two planes $A_1x+B_1y+C_1z+D_1=0$ and $A_2x+B_2y+C_2z+D_2=0$ are perpendicular if $A_1A_2+B_1B_2+C_1C_2=0$
17	**Equation of a Plane Through $P(x_1,y_1,z_1)$ and Parallel to the vectors (a_1,b_1,c_1) and (a_2,b_2,c_2)** $\begin{vmatrix} x-x_1 & y-y_1 & z-z_1 \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix}=0$
18	**Equation of a plane through** $P_1(x_1,y_1,z_1)$ **and** $P_2(x_2,y_2,z_2)$, **and Parallel to the vector** (a,b,c) **is** $\begin{vmatrix} x-x_1 & y-y_1 & z-z_1 \\ x_2-x_1 & y_2-y_1 & z_2-z_1 \\ a & b & c \end{vmatrix}=0$
19	**Distance From a point to a plane the distance from the point** $P_1(x_1,y_1,z_1)$ **to the plane** $Ax+By+Cz+D=0 isd=\left\lvert\frac{Ax_1+By_1+Cz_1+D}{\sqrt{A^2+B^2+C^2}}\right\rvert$.
20	**Point Direction Form of the Equation of a Line** $\frac{x-x_1}{a}=\frac{y-y_1}{b},\frac{z-z_1}{c}$, **where the point** $P_1(x_1,y_1,z_1)$ **lies on the lines and** (a,b,c) **is the direction vector of the line.**
21	**Two Point Form** $\frac{x-x_1}{x_2-x_1}=\frac{y-y_1}{y_2-y_1}=\frac{z-z_1}{z_2-z_1}$
22	**Parametric Form** $\begin{cases} x=x_1+t\cos\alpha \\ y=y_1+t\cos\beta \\ z=z_1+t\cos\gamma \end{cases},$ **where the point** $P_1(x_1,y_1,z_1)$ **lies on the straight lines,** $\cos\alpha,\cos\beta,\cos\gamma$ **are the direction cosines of the direction vector of the line, the parameter** t **is any real number.**
23	**Angle Between Two Straight Lines**

	$\cos\phi = \frac{\vec{s}_1 . \vec{s}_2}{\lvert\vec{s}_1\rvert . \lvert\vec{s}_2\rvert} = \frac{a_1a_2 + b_1b_2 + c_1c_2}{\sqrt{a_1^2 + b_1^2 + c_1^2} . \sqrt{a_2^2 + b_2^2 + c_2^2}}.$
24	**Parallel Lines** Two lines are parallel if $\vec{s}_1 \mid \mid \vec{s}_2$, or $\frac{a_1}{a_2} = \frac{b_1}{b_2} = \frac{c_1}{c_2}$.
25	**Perpendicular Lines** Two lines are perpendicular if $\vec{s}_1 . \vec{s}_2 = 0$, or $a_1a_2 + b_1b_2 + c_1c_2 = 0$
26	**Intersection of two lines Two Lines** $\frac{x - x_1}{a_1} = \frac{y - y_1}{b_1} = \frac{z - z_1}{c_1}$ and $\frac{x - x_2}{a_2} = \frac{y - y_2}{b_2} = \frac{z - z_2}{c_2}$ intersect at $\begin{vmatrix} x_2 - x_1 & y_2 - y_1 & z_2 - z_1 \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix} = 0$
27	**Parallel Line and Plane** The straight line $\frac{x - x_1}{a} = \frac{y - y_1}{b} = \frac{z - z_1}{c}$ and the plane $Ax + By + Cz + D = 0$ are parallel iif $\vec{n} . \vec{s} = 0$, or $Aa + Bb + Cc = 0$
28	**Perpendicular Line and Plane** The straight line $\frac{x - x_1}{a} = \frac{y - y_1}{b} = \frac{z - z_1}{c}$ and the plane $Ax + By + Cz + D = 0$ are perpendicular if $\vec{n} \mid \mid \vec{s}$ or $\frac{A}{a} = \frac{B}{b} = \frac{C}{c}$.
29	**General Quadratic Equation** $Ax^2 + By^2 + Cz^2 + 2Fyz + 2Gzx + 2Hxy + 2Px + 2Qy + 2Rz + D = 0$
30	**Real Ellipsoid (Case 1)** $\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$
31	**Imaginary Ellipsoid (Case 2)** $x^2 + a^2 + \frac{y^2}{b^2} + \frac{z^2}{c^2} = -1$
32	**Hyperboloid of 1 Sheet (Case 3)**

	$$\frac{x^2}{a^2}+\frac{y^2}{b^2}-\frac{z^2}{c^2}=1$$
33	**Hy-erboloid of 2 Sheets (case 4)** $$\frac{x^2}{a^2}+\frac{y^2}{b^2}-\frac{z^2}{c^2}=-1$$
34	**Real Quadric Cone (Case 5)** $$\frac{x^2}{a^2}+\frac{y^2}{b^2}-\frac{z^2}{c^2}=0$$
35	**Imaginary Quadric Cone (case 6)** $$\frac{x^2}{a^2}+\frac{y^2}{b^2}+\frac{z^2}{c^2}=0$$
36	**Elliptic Paraboloid (Case 7)** $$\frac{x^2}{a^2}+\frac{y^2}{b^2}-z=0$$
37	**Hyperbolic Paraboloid (Case 8)** $$\frac{x^2}{a^2}-\frac{y^2}{b^2}-z=0$$
38	**Real Ellipstic Cylinder (case 9)** $$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$
39	**Imaginary Elliptic Cylinder (case 10)** $$\frac{x^2}{a^2}+\frac{y^2}{b^2}=-1$$
40	**Hyperbolic Cylinder (Case 11)** $$\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$$
41	**Real Intersecting Planes (Case 12)** $$\frac{x^2}{a^2}-\frac{y^2}{b^2}=0$$
42	**Imaginary Intersecting Planeks (case 13)** $$\frac{x^2}{a^2}+\frac{y^2}{b^2}=0$$
43	**Parabolic Cylinder (Case 14)**

	$\frac{x^2}{a^2} - y = 0$
44	**Real Parallel Planes (case 15)** $\frac{x^2}{a^2} = 1$
45	**Imaginary Parallel Planes (case 16)** $\frac{x^2}{a^2} = -1$
46	**Coincident Planes (case 17)** $x^2 = 0$
47	**Equation of a sphere Centered at the origin (standard form)** $x^2 + y^2 + z^2 = R^2$
48	**Equation of a Circle Centered at Any point** $(a, b, c), (x-a)^2 + (y-b)^2 + (z-c)^2 = R^2$
49	**Diameter Form** $(x-x_1)(x-x_2)(y-y_1)(y-y_2) + (z-z_1)(z-z_2) = 0$ **where** $P_1(x_1, y_1, z_1), P_2(x_2, y_2, z_2)$ **are the ends of a diameter.**
50	**Four Point Form** $\begin{vmatrix} x^2+y^2+z^2 & x & y & z & 1 \\ x_1^2+y_1^2+x_1^2 & x_1 & y_1 & z_1 & 1 \\ x_2^2+y_2^2+x_2^2 & x_2 & y_2 & z_2 & 1 \\ x_3^2+y_3^2+x_3^2 & x_3 & y_3 & z_3 & 1 \\ x_4^2+y_4^2+x_4^2 & x_4 & y_4 & z_4 & 1 \end{vmatrix} = 0$
51	**General Form** $Ax^2 + Ay^2 + Az^2 + Dx + Ey + Fz + M = 0$ **(A is nonzero).** **The center of the sphere has coordinates (a,b,c) where** $a = -\frac{D}{2A}, b = -\frac{E}{2A}, c = -\frac{F}{2A}$ **The radius of the sphere is** $R = \frac{\sqrt{D^2 + E^2 + F^2 - 4A^2M}}{2A}$

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TRIANGLE

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SL#	FORMULA
1	**Centroid (Intersection of Medians) of a Triangle** $x_0 = \dfrac{x_1 + x_2 + x_3}{3}, y_0 = \dfrac{y_1 + y_2 + y_3}{3}, where A(x_1, y_1), (B(x_2, y_2), \text{ and } C(x_3, y_3)$ are vertices of the $\triangle ABC$
2	**Incenter (Intersection of Angle Bisectors) of a Triangle** $x_0 = \dfrac{ax_1 + bx_2 + cx_3}{a + b + c}, y_0 = \dfrac{ay_1 + by_2 + cy_3}{a + b + c}$ where $a = BC, b = CA, c = AB.$
3	**Circumcenter (Intersection of the side Perpendicular Bisectors) of a Triangle** $x_0 = \dfrac{\begin{vmatrix} x_1^2 + y_1^2 & y_1 & 1 \\ x_2^2 + y_2^2 & y_2 & 1 \\ x_3^2 + y_3^2 & y_3 & 1 \end{vmatrix}}{2\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}}, y_0 = \dfrac{\begin{vmatrix} x_1 & x_1^2 + y_1^2 & 1 \\ x_2 & x_2^2 + y_2^2 & 1 \\ x_3 & x_3^2 + y_3^2 & 1 \end{vmatrix}}{2\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}}$
4	**Orthocenter (Intersection of Altitudes) of a Triangle** $x_0 = \dfrac{\begin{vmatrix} y_1x_2 & x_3 + y_1^2 & 1 \\ y_2 & x_3x_1 + y_2^2 & 1 \\ y_3 & x_1x_2 + y_3^2 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}}, y_0 = \dfrac{\begin{vmatrix} x_1^2 + y_2y_3 & x_1 & 1 \\ x_2^2 + y_3y_1 & x_2 & 1 \\ x_3^2 + y_1y_2 & x_3 & 1 \end{vmatrix}}{\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}}$
5	**Area of a Triangle** $S = (\pm)\dfrac{1}{2}\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = (\pm)\dfrac{1}{2}\begin{vmatrix} x_2 - x_1 & y_2 - y_1 \\ x_3 - x_1 & y_3 - y_1 \end{vmatrix}$
6	**Area of a Quadrilateral** $S = (\pm)\dfrac{1}{2}[(x_1 - x_2)(y_1 + y_2) + (x_2 - x_3)(y_2 + y_3) + (x_3 - x_4)(y_3 + y_4) + (x_4 - x_1)(y_4 + y_1)]$

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TRIGONOMETRY

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SL#	FORMULA
1	$1 rad = \frac{180^\circ}{\pi} \approx 57^\circ 17' 45''$
2	$1^\circ = \frac{\pi}{180} rad \approx 0.017453 rad$
3	$1' = \frac{\pi}{180 \times 60} rad \approx 0.000291 rad$
4	$1'' = \frac{\pi}{180 \times 3600} rad \approx 0.000005 rad$
5	Angle(degrees): 0, 30, 45, 60, 90, 180, 270, 360 Angle (radians): 0, $\frac{\pi}{6}$, $\frac{\pi}{4}$, $\frac{\pi}{3}$, $\frac{\pi}{2}$, π, $\frac{3\pi}{2}$, 2π
6	$\sin\alpha = \frac{y}{r}$
7	$\cos\alpha = \frac{x}{r}$
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8	$\tan\alpha = \frac{y}{x}$
9	$\cot\alpha = \frac{x}{y}$
10	$\sec\alpha = \frac{r}{x}$
11	$\cos ec\alpha = \frac{r}{y}$
12	**Sine Function** $y = \sin x, \ -1 \le \sin x \le 1$
13	**Cosine Function** $y = \cos x, \ -1 \le \cos x \le 1$

Table for row 5:

Angle(degrees)	0	30	45	60	90	180	270	360
Angle (radians)	0	$\frac{\pi}{6}$	$\frac{\pi}{4}$	$\frac{\pi}{3}$	$\frac{\pi}{2}$	π	$\frac{3\pi}{2}$	2π

14	**Tangent Function** $y = \tan x, x \ne (2k+1)\frac{\pi}{2}, -\infty \le \tan x \le \infty$
15	**Cotangent Function** $y = \cot x, x \ne k\pi, -\infty \le \cot x \le \infty$

16	**Secant Function** $y = \sec x, x \ne (2k+1)\frac{\pi}{2}$
17	**Cosecant Function** $y = \cos ec x, x \ne k\pi$

18

Quadrant	I	II	III	IV
$\sin\alpha$	$+$	$+$	$-$	$-$
$\cos\alpha$	$+$	$-$	$-$	$+$
$\tan\alpha$	$+$	$-$	$+$	$-$
$\cot\alpha$	$+$	$-$	$+$	$-$
$\sec\alpha$	$+$	$-$	$-$	$+$
$\cos ec\alpha$	$+$	$+$	$-$	$-$

19

α°	αrad	$\sin\alpha$	$\cos\alpha$	$\tan\alpha$	$\cot\alpha$	$\sec\alpha$	$\cos ec\alpha$
0	0	0	1	0	∞	1	∞
30	$\frac{\pi}{6}$	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{3}}$	$\sqrt{3}$	$\frac{2}{\sqrt{3}}$	2
45	$\frac{\pi}{4}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	1	1	$\sqrt{2}$	$\sqrt{2}$
60	$\frac{\pi}{3}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$\sqrt{3}$	$\frac{1}{\sqrt{3}}$	2	$\frac{2}{\sqrt{3}}$
90	$\frac{\pi}{2}$	1	0	∞	0	∞	1
120	$\frac{2\pi}{3}$	$\frac{\sqrt{3}}{2}$	$-\frac{1}{2}$	$-\sqrt{3}$	$-\frac{1}{\sqrt{3}}$	-2	$\frac{2}{\sqrt{3}}$
180	π	0	-1	0	∞	-1	∞
270	$\frac{3\pi}{2}$	-1	0	∞	0	∞	-1

360	2π	0	1	0	∞	1	∞

20

15

α°	αrad	$\sin\alpha$	$\cos\alpha$	$\tan\alpha$	$\cot\alpha$
$\frac{\pi}{12}$	$\frac{\sqrt{6}-\sqrt{2}}{4}$	$\frac{\sqrt{6}+\sqrt{2}}{4}$	$2-\sqrt{3}$	$2+\sqrt{3}$	
18	$\frac{\pi}{10}$	$\frac{\sqrt{5}-1}{4}$	$\frac{\sqrt{10+2\sqrt{5}}}{4}$	$\sqrt{\frac{5-2\sqrt{5}}{5}}$	$\sqrt{5+2\sqrt{5}}$
36	$\frac{\pi}{5}$	$\frac{\sqrt{10-2\sqrt{5}}}{4}$	$\frac{\sqrt{5}+1}{4}$	$\frac{\sqrt{10-2\sqrt{5}}}{\sqrt{5}+1}$	$\frac{\sqrt{5}+1}{\sqrt{10-2\sqrt{5}}}$
54	$\frac{3\pi}{10}$	$\frac{\sqrt{5}+1}{4}$	$\frac{\sqrt{10-2\sqrt{5}}}{4}$	$\frac{\sqrt{5}+1}{\sqrt{10-2\sqrt{5}}}$	$\frac{\sqrt{10-2\sqrt{5}}}{\sqrt{5}+1}$
72	$\frac{2\pi}{5}$	$\frac{\sqrt{10+2\sqrt{5}}}{4}$	$\frac{\sqrt{5}-1}{4}$	$\sqrt{5+2\sqrt{5}}$	$\sqrt{\frac{5-2\sqrt{5}}{5}}$
75	$\frac{5\pi}{12}$	$\frac{\sqrt{6}+\sqrt{2}}{4}$	$\frac{\sqrt{6}-\sqrt{2}}{4}$	$2+\sqrt{3}$	$2-\sqrt{3}$

21	$\sin^2\alpha+\cos^2\alpha=1$
22	$\sec^2\alpha-\tan^2\alpha=1$
23	$\cos ec^2\alpha-\cot^2\alpha=1$

24	$\tan\alpha=\frac{\sin\alpha}{\cos\alpha}$
25	$\cot\alpha=\frac{\cos\alpha}{\sin\alpha}$
26	$\tan\alpha\cdot\cot\alpha=1$
27	$\sec\alpha=\frac{1}{\cos\alpha}$
28	$\cos ec\alpha=\frac{1}{\sin\alpha}$

29

β	$\sin\beta$	$\cos\beta$	$\tan\beta$	$\cot\beta$
$-\alpha$	$-\sin\alpha$	$+\cos\alpha$	$-\tan\alpha$	$-\cot\alpha$
$90^\circ-\alpha$	$+\cos\alpha$	$+\sin\alpha$	$+\cot\alpha$	$+\tan\alpha$

	$90^\circ + \alpha$	$+\cos\alpha$	$-\sin\alpha$	$-\cot\alpha$	$-\tan\alpha$
	$180^\circ - \alpha$	$+\sin\alpha$	$-\cos\alpha$	$-\tan\alpha$	$-\cot\alpha$
	$180^\circ + \alpha$	$-\sin\alpha$	$-\cos\alpha$	$+\tan\alpha$	$+\cot\alpha$
	$270^\circ - \alpha$	$-\cos\alpha$	$-\sin\alpha$	$+\cot\alpha$	$+\tan\alpha$
	$270^\circ + \alpha$	$-\cos\alpha$	$+\sin\alpha$	$-\cot\alpha$	$-\tan\alpha$
	$360^\circ - \alpha$	$-\sin\alpha$	$+\cos\alpha$	$-\tan\alpha$	$-\cot\alpha$
	$360^\circ + \alpha$	$+\sin\alpha$	$+\cos\alpha$	$+\tan\alpha$	$+\cot\alpha$

30	$\sin(\alpha \pm 2\pi n) = \sin\alpha$, **period** 2π **or** 360°
31	$\cos(\alpha \pm 2\pi n) = \cos\alpha$, **period** 2π **or** 360°
32	$\tan(\alpha \pm \pi n) = \tan\alpha$, **period** π **or** 180°
33	$\cot(\alpha \pm \pi n) = \cot\alpha$, **period** π **or** 180°
34	$\sin\alpha = \pm\sqrt{1-\cos^2 a} = \pm\sqrt{\frac{1}{2}(1-\cos 2\alpha)} = 2\cos^2\left(\frac{\alpha}{2}-\frac{\pi}{4}\right) - 1 = \frac{2\tan\left(\frac{\alpha}{2}\right)}{1+\tan^2\left(\frac{\alpha}{2}\right)}$
35	$\cos\alpha = \pm\sqrt{1-\sin^2 a} = \pm\sqrt{\frac{1}{2}(1+\cos 2\alpha)} = 2\cos^2\left(\frac{\alpha}{2}\right) - 1 = \frac{1-\tan^2\left(\frac{\alpha}{2}\right)}{1+\tan^2\left(\frac{\alpha}{2}\right)}$
36	$\tan\alpha = \frac{\sin\alpha}{\cos\alpha} = \pm\sqrt{\sec^2\alpha - 1} = \frac{\sin 2\alpha}{1+\cos 2\alpha} = \frac{1-\cos 2\alpha}{\sin 2\alpha} = \pm\sqrt{\frac{1-\cos 2\alpha}{1+\cos 2\alpha}} = \frac{2\tan\left(\frac{\alpha}{2}\right)}{1+\tan^2\left(\frac{\alpha}{2}\right)}$
37	$\cot\alpha = \frac{\cos\alpha}{\sin\alpha} = \pm\sqrt{\cos ec^2\alpha - 1} = \frac{1+\cos 2\alpha}{\sin 2\alpha} = \frac{\sin 2\alpha}{1-\cos 2\alpha} = \pm\sqrt{\frac{1+\cos 2\alpha}{1-\cos 2\alpha}} = \frac{1-\tan^2\left(\frac{\alpha}{2}\right)}{2\tan^2\left(\frac{\alpha}{2}\right)}$
38	$\sec\alpha = \frac{1}{\cos\alpha} = \pm\sqrt{1+\tan^2\alpha} = \frac{1+\tan^2\left(\frac{\alpha}{2}\right)}{1-\tan^2\left(\frac{\alpha}{2}\right)}$
39	$\cos ec\alpha$ $= \frac{1}{\sin\alpha}$ $= \pm\sqrt{1+\cot^2\alpha}$ $= \frac{1+\tan^2\left(\frac{\alpha}{2}\right)}{2\tan\left(\frac{\alpha}{2}\right)}$
40	$\sin(\alpha+\beta) = \sin\alpha\cos\beta + \sin\beta\cos\alpha$

41	$\sin(\alpha-\beta)=\sin\alpha\cos\beta-\sin\beta\cos\alpha$
42	$\cos(\alpha+\beta)=\cos\alpha\cos\beta-\sin\alpha\sin\beta$
43	$\cos(\alpha-\beta)=\cos\alpha\cos\beta+\sin\alpha\sin\beta$
44	$\tan(\alpha+\beta)=\dfrac{\tan\alpha+\tan\beta}{1-\tan\alpha\tan\beta}$
45	$\tan(\alpha-\beta)=\dfrac{\tan\alpha-\tan\beta}{1+\tan\alpha\tan\beta}$
46	$\cot(\alpha+\beta)=\dfrac{1-\tan\alpha\tan\beta}{\tan\alpha+\tan\beta}$
47	$\cot(\alpha-\beta)=\dfrac{1+\tan\alpha\tan\beta}{\tan\alpha-\tan\beta}$
48	$\sin 2\alpha=2\sin\alpha\cdot\cos\alpha$
49	$\cos 2\alpha=\cos^2\alpha-\sin^2\alpha=1-2\sin^2\alpha=2\cos^2\alpha-1$
50	$\tan 2\alpha=\dfrac{2\tan\alpha}{1-\tan^2\alpha}=\dfrac{2}{\cot\alpha-\tan\alpha}$
51	$\cot 2\alpha=\dfrac{\cot^2\alpha-1}{2\cot\alpha}=\dfrac{\cot\alpha-\tan\alpha}{2}$
52	$\sin 3\alpha=3\sin\alpha-4\sin^3\alpha=3\cos^2\alpha\cdot\sin\alpha-\sin^3\alpha$
53	$\sin 4\alpha=4\sin\alpha\cdot\cos\alpha-8\sin^3\alpha\cdot\cos\alpha$
54	$\sin 5\alpha=5\sin\alpha-20\sin^3\alpha+16\sin^5\alpha$
55	$\cos 3\alpha=4\cos^3\alpha-3\cos\alpha=\cos^3\alpha-3\cos\alpha\cdot\sin^2\alpha$
56	$\cos 4\alpha=8\cos^4\alpha-8\cos^2\alpha+1$
57	$\cos 5\alpha=16\cos^5\alpha-20\cos^3\alpha+5\cos\alpha$
58	$\tan 3\alpha=\dfrac{3\tan\alpha-\tan^3\alpha}{1-3\tan^2\alpha}$
59	$\tan 4\alpha=\dfrac{4\tan\alpha-4\tan^3\alpha}{1-6\tan^2\alpha+\tan^4\alpha}$
60	$\tan 5\alpha=\dfrac{\tan^5\alpha-10\tan^3\alpha+5\tan\alpha}{1-10\tan^2\alpha+5\tan^4\alpha}$

61	$\cot 3\alpha = \frac{\cot^3 \alpha - 3 \cot \alpha}{3 \cot^2 \alpha - 1}$
62	$\cot 4\alpha = \frac{1 - 6 \tan^2 \alpha + \tan^4 \alpha}{4 \tan \alpha - 4 \tan^3 \alpha}$
63	$\cot 5\alpha = \frac{1 - 10 \tan^2 \alpha + 5 \tan^4 \alpha}{\tan^5 \alpha - 10 \tan^3 \alpha + 5 \tan \alpha}$
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64	$\sin\left(\frac{\alpha}{2}\right) = \pm \sqrt{\frac{1 - \cos \alpha}{2}}$
65	$\cos\left(\frac{\alpha}{2}\right) = \pm \sqrt{\frac{1 + \cos \alpha}{2}}$
66	$\tan\left(\frac{\alpha}{2}\right) = \pm \sqrt{\frac{1 - \cos \alpha}{1 + \cos \alpha}} = \frac{\sin \alpha}{1 + \cos \alpha} = \frac{1 - \cos \alpha}{\sin \alpha} = \cos ec\alpha - \cot \alpha$
67	$\cot\left(\frac{\alpha}{2}\right) = \pm \sqrt{\frac{1 + \cos \alpha}{1 - \cos \alpha}} = \frac{\sin \alpha}{1 - \cos \alpha} = \frac{1 + \cos \alpha}{\sin \alpha} = \cos ec\alpha + \cot \alpha$
68	$\sin \alpha = \frac{2 \tan\left(\frac{\alpha}{2}\right)}{1 + \tan^2\left(\frac{\alpha}{2}\right)}$
69	$\cos \alpha = \frac{1 - \tan^2\left(\frac{\alpha}{2}\right)}{1 + \tan^2\left(\frac{\alpha}{2}\right)}$
70	$\tan \alpha = \frac{2 \tan\left(\frac{\alpha}{2}\right)}{1 - \tan^2\left(\frac{\alpha}{2}\right)}$
71	$\cot \alpha = \frac{1 - \tan^2\left(\frac{\alpha}{2}\right)}{2 \tan\left(\frac{\alpha}{2}\right)}$
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72	$\sin \alpha + \sin \beta = 2 \sin\left(\frac{\alpha + \beta}{2}\right) \cos\left(\frac{\alpha - \beta}{2}\right)$
73	$\sin \alpha - \sin \beta = 2 \cos\left(\frac{\alpha + \beta}{2}\right) \sin\left(\frac{\alpha - \beta}{2}\right)$
74	$\cos \alpha + \cos \beta = 2 \cos\left(\frac{\alpha + \beta}{2}\right) \cos\left(\frac{\alpha - \beta}{2}\right)$
75	$\cos \alpha - \cos \beta = -2 \sin\left(\frac{\alpha + \beta}{2}\right) \sin\left(\frac{\alpha - \beta}{2}\right)$
76	$\tan \alpha + \tan \beta = \frac{\sin(\alpha + \beta)}{\cos \alpha \cdot \cos \beta}$

77	$\tan\alpha - \tan\beta = \dfrac{\sin(\alpha-\beta)}{\cos\alpha\cdot\cos\beta}$
78	$\cot\alpha + \cot\beta = \dfrac{\sin(\beta+\alpha)}{\sin\alpha\cdot\sin\beta}$
79	$\cot\alpha - \cot\beta = \dfrac{\sin(\beta-\alpha)}{\sin\alpha\cdot\sin\beta}$
80	$\cos\alpha + \sin\alpha = \sqrt{2}\cos\left(\dfrac{\pi}{4}-\alpha\right) = \sqrt{2}\sin\left(\dfrac{\pi}{4}+\alpha\right)$
81	$\cos\alpha - \sin\alpha = \sqrt{2}\sin\left(\dfrac{\pi}{4}-\alpha\right) = \sqrt{2}\cos\left(\dfrac{\pi}{4}+\alpha\right)$
82	$\tan\alpha + \cot\beta = \dfrac{\cos(\alpha-\beta)}{\cos\alpha\cdot\sin\beta}$
83	$\tan\alpha - \cot\beta = \dfrac{\cos(\alpha+\beta)}{\cos\alpha\cdot\sin\beta}$
84	$1+\cos\alpha = 2\cos^2\left(\dfrac{\alpha}{2}\right)$
85	$1-\cos\alpha = 2\sin^2\left(\dfrac{\alpha}{2}\right)$
86	$1+\sin\alpha = 2\cos^2\left(\dfrac{\pi}{4}-\dfrac{\alpha}{2}\right)$
87	$1-\sin\alpha = 2\sin^2\left(\dfrac{\pi}{4}-\dfrac{\alpha}{2}\right)$
88	$\sin\alpha\cdot\sin\beta = \dfrac{\cos(\alpha-\beta)-\cos(\alpha+\beta)}{2}$
89	$\cos\alpha\cdot\cos\beta = \dfrac{\cos(\alpha-\beta)+\cos(\alpha+\beta)}{2}$
90	$\sin\alpha\cdot\cos\beta = \dfrac{\sin(\alpha-\beta)+\sin(\alpha+\beta)}{2}$
91	$\tan\alpha\cdot\tan\beta = \dfrac{\tan\alpha+\tan\beta}{\cot\alpha+\cot\beta}$
92	$\cot\alpha\cdot\cot\beta = \dfrac{\cot\alpha+\cot\beta}{\tan\alpha+\tan\beta}$
93	$\tan\alpha\cdot\cot\beta = \dfrac{\tan\alpha+\cot\beta}{\cot\alpha+\tan\beta}$

94	$\sin^2\alpha = \dfrac{1-\cos 2\alpha}{2}$
95	$\sin^3\alpha = \dfrac{3\sin\alpha - \sin 3\alpha}{4}$
96	$\sin^4\alpha = \dfrac{\cos 4\alpha - 4\cos 2\alpha + 3}{8}$
97	$\sin^5\alpha = \dfrac{10\sin\alpha - 5\sin 3\alpha + \sin 5\alpha}{16}$
98	$\sin^6\alpha = \dfrac{10 - 15\cos 2\alpha + 6\cos 4\alpha - \cos 6\alpha}{32}$
99	$\cos^2\alpha = \dfrac{1+\cos 2\alpha}{2}$
100	$\cos^3\alpha = \dfrac{3\cos\alpha + \cos 3\alpha}{4}$
101	$\cos^4\alpha = \dfrac{\cos 4\alpha + 4\cos 2\alpha + 3}{8}$
102	$\cos^5\alpha = \dfrac{10\cos\alpha + 5\sin 3\alpha + \cos 5\alpha}{16}$
103	$\cos^6\alpha = \dfrac{10 + 15\cos 2\alpha + 6\cos 4\alpha + \cos 6\alpha}{32}$
104	**Inverse Sine Function** $y = \sin^{-1}x,\ -1 \le x \le 1,\ -\dfrac{\pi}{2} \le \sin^{-1}x \le \dfrac{\pi}{2}$
105	**Inverse Cosine Function** $y = \cos^{-1}x,\ -1 \le x \le 1, 0 \le \cos^{-1}x \le \pi$
106	**Inverse Tangent Function** $y = \tan^{-1}x,\ -\infty \le x \le \infty,\ -\dfrac{\pi}{2} < \tan^{-1}x < \dfrac{\pi}{2}$
107	**Inverse Cotangent Function** $y = \cot^{-1}x,\ -\infty \le x \le \infty, 0 < \cot^{-1}x < \pi$
108	**Inverse Secant Function** $y = \sec^{-1}x, x \in (-\infty, -1] \cup [1, \infty), \sec^{-1}x \in \left[0, \dfrac{\pi}{2}\right) \cup \left(\dfrac{\pi}{2}, \pi\right]$
109	**Inverse Cosecant Function**

	$y = \cos^{-1}ecx, x \in (-\infty, -1] \cup [1, \infty), \cos^{-1}ecx \in \left[-\frac{\pi}{2}, 0\right) \cup \left(0, \frac{\pi}{2}\right]$

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Principal Values of Inverse Trigonometric Functions

x	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1
$\sin^{-1}x$	0°	30°	45°	60°	90°
$\cos^{-1}x$	90°	60°	45°	30°	0°
x	$-\frac{1}{2}$	$-\frac{\sqrt{2}}{2}$	$-\frac{\sqrt{3}}{2}$	-1	
$\sin^{-1}x$	-30°	-45°	-60°	-90°	
$\cos^{-1}x$	120°	135°	150°	180°	

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x	0	$\frac{\sqrt{3}}{3}$	1	$\sqrt{3}$	$-\frac{\sqrt{3}}{3}$	-1	$-\sqrt{3}$
$\tan^{-1}x$	0°	30°	45°	60°	-30°	-45°	-60°
$\cot^{-1}x$	90°	60°	45°	30°	120°	135°	150°

112	$\sin^{-1}(-x) = -\sin^{-1}x$
113	$\sin^{-1}x = \frac{\pi}{2} - \cos^{-1}x$
114	$\sin^{-1}x = \cos^{-1}\sqrt{1-x^2}, 0 \le x \le 1$
115	$\sin^{-1}x = -\cos^{-1}\sqrt{1-x^2}, -1 \le x \le 0$
116	$\sin^{-1}x = \tan^{-1}\left(\frac{x}{\sqrt{1-x^2}}\right), x^2 < 1$
117	$\sin^{-1}x = \cot^{-1}\left(\frac{\sqrt{1-x^2}}{x}\right), 0 < x \le 1$
118	$\sin^{-1}x = \cot^{-1}\left(\frac{\sqrt{1-x^2}}{x} - \pi\right), -1 \le x < 0$
119	$\cos^{-1}(-x) = \pi - \cos^{-1}x$

120

	$\cos^{-1} x = \frac{\pi}{2} - \sin^{-1} x$
121	$\cos^{-1} x = \sin^{-1} \sqrt{1 - x^2}, 0 \leq x \leq 1$
122	$\cos^{-1} x = \pi - \sin^{-1} \sqrt{1 - x^2}, \ -1 \leq x \leq 0$
123	$\cos^{-1} x = \tan^{-1} \left(\frac{\sqrt{1 - x^2}}{x} \right), 0 < x \leq 1$
124	$\cos^{-1} x = \pi + \tan^{-1} \left(\frac{\sqrt{1 - x^2}}{x} \right), \ -1 \leq x < 0$
125	$\cos^{-1} x = \cot^{-1} \left(\frac{x}{\sqrt{1 - x^2}} \right), \ -1 \leq x \leq 1$
126	$\tan^{-1}(-x) = -\tan^{-1} x$
127	$\tan^{-1} x = \frac{\pi}{2} - \cot^{-1} x$
128	$\tan^{-1} x = \sin^{-1} \left(\frac{x}{\sqrt{1 + x^2}} \right)$
129	$\tan^{-1} x = \cos^{-1} \left(\frac{1}{\sqrt{1 + x^2}} \right), x \geq 0$
130	$\tan^{-1} x = -\cos^{-1} \left(\frac{1}{\sqrt{1 + x^2}} \right), x \leq 0$
131	$\tan^{-1} x = \frac{\pi}{2} - \tan^{-1} \left(\frac{1}{x} \right), x > 0$
132	$\tan^{-1} x = -\frac{\pi}{2} - \tan^{-1} \left(\frac{1}{x} \right), x < 0$
133	$\tan^{-1} x = \cot^{-1} \left(\frac{1}{x} \right), x > 0$
134	$\tan^{-1} x = \cot^{-1} \left(\frac{1}{x} \right) - \pi, x < 0$
135	$\cot^{-1}(-x) = \pi - \cot^{-1} x$
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136	$\cot^{-1} x = \frac{\pi}{2} - \tan^{-1} x$
137	

	$\cot^{-1} x = \sin^{-1}\left(\frac{1}{\sqrt{1+x^2}}\right), x > 0$
138	$\cot^{-1} x = \pi - \sin^{-1}\left(\frac{1}{\sqrt{1+x^2}}\right), x < 0$
139	$\cot^{-1} x = \cos^{-1}\left(\frac{x}{\sqrt{1+x^2}}\right)$
140	$\cot^{-1} x = \tan^{-1}\left(\frac{1}{x}\right), x > 0$
141	$\cot^{-1} x = \pi + \tan^{-1}\left(\frac{1}{x}\right), x < 0$
142	$\sin x = a, x = (-1)^n \sin^{-1} a + \pi n$
143	$\cos x = a, x = \pm \cos^{-1} a + 2\pi n$
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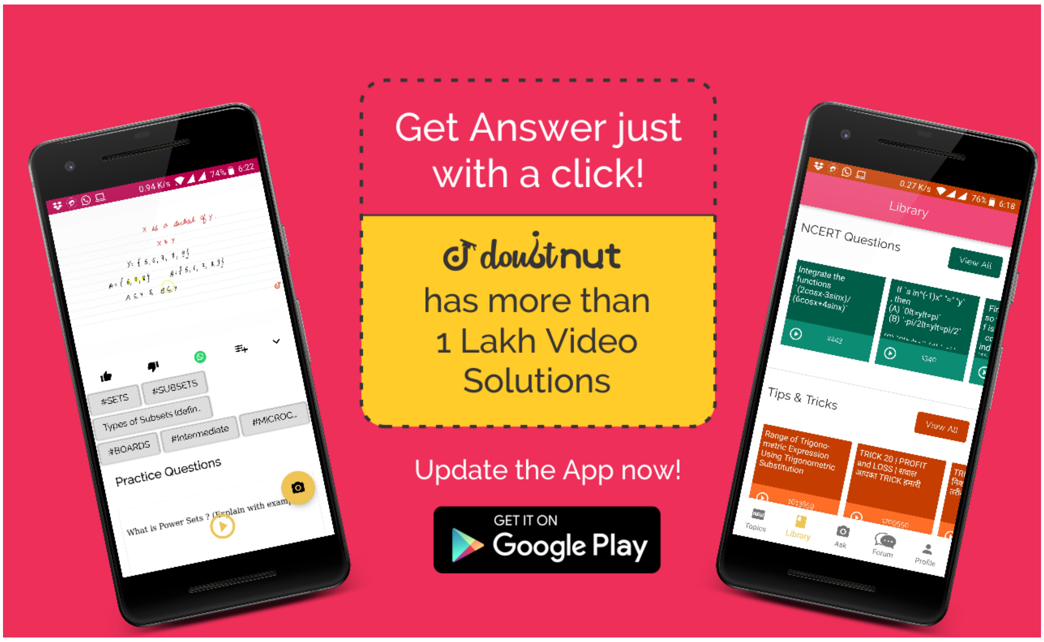
144	$\tan x = a, x = \tan^{-1} a + \pi n$
145	$\cot x = a, x = \cot^{-1} a + \pi n$
146	$\sin(ix) = i \sinh x$
147	$\tan(ix) = i \tanh x$
148	$\cot(ix) = -i \coth x$
149	$\sec(ix) = \operatorname{sech} x$
150	$\cos ec(ix) = -i \cos echx$



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BAAP OF ALL FORMULA LISTS

FOR IIT JEE

VECTORS

SL#	FORMULA
1	**Unit Vectors,** $\overrightarrow{i} = (1, 0, 0), \overrightarrow{j} = (0, 1, 0), \overrightarrow{k} = (0, 0, 1), \left\|\overrightarrow{i}\right\|\left\|\overrightarrow{j}\right\| = \left\|\overrightarrow{k}\right\| = 1,$
2	$\overrightarrow{r} = \overrightarrow{AB} = (x_1 - x_0)\overrightarrow{i} + (y_1 - y_0)\overrightarrow{j} + (z_1 - z_0)\overrightarrow{k}$
3	$\left\|\overrightarrow{r}\right\| = \left\|\overrightarrow{AB}\right\| = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2 + (z_1 - z_0)^2}$
4	**If** $\overrightarrow{AB} = \overrightarrow{r}, then \overrightarrow{BA} = -\overrightarrow{r}$.
5	$X = \left\|\overrightarrow{r}\right\|\cos\alpha, Y = \left\|\overrightarrow{r}\right\|\cos\beta, Z = \left\|\overrightarrow{r}\right\|\cos\gamma$
6	**If** $\overrightarrow{r}(X, Y, Z) = \overrightarrow{r}_1(X_1, Y_1, Z_1),$ **then** $X = X_1, Y = Y_1, Z - Z_1$
7	$\overrightarrow{w} = \overrightarrow{u} + \overrightarrow{v}$
8	$\overrightarrow{w} = \overrightarrow{u}_1 + \overrightarrow{u}_2 + \overrightarrow{u}_3 + \ldots\ldots\ldots + \overrightarrow{u}_m$
9	**Cummutative Law** $\overrightarrow{u} + \overrightarrow{v} = \overrightarrow{v} + \overrightarrow{u}$
10	**Associative Law** $\left(\overrightarrow{u} + \overrightarrow{v}\right) + \overrightarrow{w} = \overrightarrow{u}\left(\overrightarrow{v} + \overrightarrow{w}\right)$
11	$\overrightarrow{u} + \overrightarrow{v} = (X_1 + X_2, Y_1 + Y_2, Z_1 + Z_2)$
12	$\overrightarrow{w} = \overrightarrow{u} - \overrightarrow{v}$ if $\overrightarrow{c} + \overrightarrow{w} = \overrightarrow{u}$
13	$\overrightarrow{u} - \overrightarrow{v} = \overrightarrow{u} + \left(= \overrightarrow{c}\right)$
14	$\overrightarrow{u} - \overrightarrow{u} = \overrightarrow{0} = (0, 0, 0)$
15	

	$\left\lvert\overrightarrow{0}\right\rvert = 0$
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16	$\overrightarrow{u} - \overrightarrow{v} = (X_1 - X_2, Y_1 - Y_2, Z_1 - Z_2)$
17	$\overrightarrow{w} = \lambda\overrightarrow{u}$
18	$\left\lvert\overrightarrow{w}\right\rvert = \lvert\lambda\rvert.\left\lvert\overrightarrow{u}\right\rvert$
19	$\lambda\overrightarrow{u} = (\lambda X, \lambda Y, \lambda Z)$
20	$(\lambda + \mu)\overrightarrow{u} = \lambda\overrightarrow{u} + \mu\overrightarrow{u}$
21	$\lambda\left(\mu\overrightarrow{u}\right) = \mu\left(\lambda\overrightarrow{u}\right) = (\lambda\mu)\overrightarrow{u}$
22	$\lambda\left(\overrightarrow{u} + \overrightarrow{v}\right) = \lambda\overrightarrow{u} + \lambda\overrightarrow{v}$
23	**Scalar Product of Vectors** $\overrightarrow{u}$ and $\overrightarrow{v}\overrightarrow{u}.\overrightarrow{v} = \left\lvert\overrightarrow{u}\right\rvert.\left\lvert\overrightarrow{v}\right\rvert.\cos\theta$, where θ is the angle betwewen vectors $\overrightarrow{u}$ and $\overrightarrow{v}$.
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24	**Scalar Product in Coordinate Form** If $\overrightarrow{u} = (X_1, Y_1, Z_1) = \overrightarrow{v} = (X_2, Y_2, Z_2)$ then $\overrightarrow{u}.\overrightarrow{v} = X_1X_2 + Y_1Y_2 + Z_1Z_2$.
25	**Angle Between Two vectors** If $\overrightarrow{u} = (X_1, Y_1, Z_1), \overrightarrow{v} = (X_2, Y_2, Z_2)$, then $\cos\theta = \dfrac{X_1X_2 + Y_1Y_2 + Z_1 + Z_2}{\sqrt{X_1^2 + Y_1^2 + Z_1^2}\sqrt{X_2^2 + Y_2^2 + Z_2^2}}$
26	Commutative Property $\overrightarrow{u}.\overrightarrow{v} = \overrightarrow{v}.\overrightarrow{u}$
27	Associative Property $\left(\lambda\overrightarrow{u}\right).\left(\mu\overrightarrow{v}\right) = \lambda\mu\overrightarrow{u}.\overrightarrow{v}$
28	Distributive Property $\overrightarrow{u}.\left(\overrightarrow{v} + \overrightarrow{w}\right) = \overrightarrow{u}.\overrightarrow{v} + \overrightarrow{u}.\overrightarrow{w}$
29	$\overrightarrow{u}.\overrightarrow{v} = 0$ if $\overrightarrow{u}, \overrightarrow{v}$ are orthogonal $\left(\theta = \dfrac{\pi}{2}\right)$

30	$\vec{u}\,.\,\vec{v} > 0$ if $0 < \theta < \frac{\pi}{2}$
31	$\vec{u}\,.\,\vec{v} < 0$ if $\frac{\pi}{2} < \theta < \pi$
32	$\vec{u}\,.\,\vec{v} \le \lvert\vec{u}\rvert.\lvert\vec{v}\rvert$
33	$veu.\,\vec{v} = \lvert\vec{u}\rvert.\lvert\vec{v}\rvert$ if $\vec{u}, \vec{v}$ are parallel $(\theta = 0)$
34	If $\vec{u} = (X_1, Y_1, Z_1)$, then $\vec{u}\,.\,\vec{u} = \vec{u}^2 = \lvert\vec{u}\rvert^2 = X_1^2 + Y_1^2 + Z_1^2$
35	$\vec{i}\,.\,\vec{i} = \vec{j}\,.\,\vec{j} = \vec{k}\,.\,\vec{k} = 1$
36	$\vec{i}\,.\,\vec{j} = \vec{j}\,.\,\vec{k} = \vec{k}\,.\,\vec{k} = 0$
37	**Vector Product of Vectos** $\vec{u}$ and $\vec{c}\,\overrightarrow{\times}\,\vec{v} = \vec{w}$, where, $\lvert\vec{w}\rvert = \lvert\vec{u}\rvert.\lvert\vec{v}\rvert.\sin\theta$, where $0 \le \theta \le \frac{\pi}{2}$, $\vec{w} \perp \vec{u}$ and $\vec{w} \perp \vec{v}$; Vectors $\vec{u}, \vec{v}, \vec{w}$ form a right handed scerew.
38	$\vec{w} = \vec{u} \times \vec{v} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ X_1 & Y_1 & Z_1 \\ X_2 & Y_2 & Z_2 \end{vmatrix}$
39	$\vec{w} = \vec{u} \times \vec{c} = \left(\begin{vmatrix} Y_1 & Z_1 \\ Y_2 & Z_2 \end{vmatrix}, -\begin{vmatrix} X_1 & Z_1 \\ X_2 & Z_2 \end{vmatrix}, \begin{vmatrix} X_1 & Y_1 \\ X_2 & Y_2 \end{vmatrix}\right)$
40	$S = \lvert\vec{u} \times \vec{v}\rvert = \lvert\vec{u}\rvert.\lvert\vec{v}\rvert.\sin\theta$
41	Angle Between Two Vectors $\sin\theta = \dfrac{\vec{u} + \vec{v}}{\lvert\vec{u}\rvert.\lvert\vec{v}\rvert}$
42	Noncommutative Property $\vec{u} \times \vec{v} = -\left(\vec{v} \times \vec{u}\right)$

43	**Associative Property** $\left(\lambda\vec{u}\right)\times\left(\mu\vec{v}\right)=\lambda\vec{u}\times\vec{v}$
44	**Distributive Property** $\vec{u}\times\left(\vec{v}+\vec{w}\right)=\vec{u}\times\vec{v}+\vec{u}+\vec{w}$
45	$\vec{u}\times\vec{v}=\vec{0}$ **if** $\vec{u}$ **and** $\vec{c}$ **are parallel** $(\theta=0)$
46	$\vec{i}\times\vec{x}=\vec{j}\times\vec{j}=\vec{k}\times\vec{k}=\vec{0}$
47	$\vec{i}\times\vec{x}=\vec{j}\times\vec{j}=\vec{k}\times\vec{k}=\vec{0}$
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48	**Scalar Triple Product** $\left[\vec{u}\,\vec{v}\,\vec{w}\right]=\vec{u}.\left(\vec{v}\times\vec{w}\right)=\vec{v}.\left(\vec{w}\times\vec{u}\right)=\vec{w}.\left(\vec{u}\times\vec{v}\right)$
49	$\left[\vec{u}\,\vec{v}\,\vec{w}\right]=\left[\vec{w}\,\vec{u}\,\vec{v}\right]=\left[\vec{v}\,\vec{w}\,\vec{u}\right]=-\left[\vec{v}\,\vec{u}\,\vec{w}\right]=-\left[\vec{w}\,\vec{v}\,\vec{u}\right]=-\left[\vec{u}\,\vec{w}\,\vec{v}\right]$
50	$k\vec{u}.\left(\vec{v}\times\vec{w}\right)=k\left[\vec{u}\,\vec{v}\,\vec{w}\right]$
51	**Scalar Triple Product in Coordinate Form** $\vec{u}.\left(\vec{v}\times\vec{w}\right)=\begin{vmatrix}X_1 & Y_1 & Z_1\\ X_2 & Y_2 & Z_2\\ X_3 & Y_3 & Z_3\end{vmatrix}$, **where** $\vec{u}=(X_1,Y_1,Z_1),\vec{v}=(X_2,Y_2,Z_2),\vec{w}=(X_3,Y_3,Z_3)$
52	**Volume of Parallelpiped** $V=\left\vert\vec{u}.\left(\vec{v}\times\vec{w}\right)\right\vert$
53	**Volume of Pyramid** $V=\frac{1}{6}\left\vert\vec{u}.\left(\vec{v}\times\vec{w}\right)\right\vert$
54	**If** $\vec{u}.\left(\vec{v}\times\vec{w}\right)=0$, **then the vectors** $\vec{u},\vec{v}$ **and** $\vec{w}$ **are linearly dependent so** $\vec{w}=\lambda\vec{u}+\mu\vec{v}$ **for some scalars** λ **and** μ
55	**If** $\vec{u}.\left(\vec{v}\times\vec{w}\right)\neq 0$, **then the vectors** $\vec{u}$, $\vec{v}$, **and** $\vec{w}$ **are linearly independent.**
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56	**Vector Triple Product** $\vec{u}\times\left(\vec{v}\times\vec{w}\right)=\left(\vec{u}.\vec{w}\right)\vec{v}-\left(\vec{u}.\vec{v}\right)\vec{w}$
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