PART : MATHEMATICS

1. $|\vec{a}| = \sqrt{6}, |\vec{b}| = \sqrt{14}$ | and $|\vec{a}\times\vec{b}| = \sqrt{48}$ then find $(\vec{a}.\vec{b})^2$

Ans. (36)

Sol. $(\vec{a}.\vec{b})^2 + (\vec{a}\times\vec{b})^2 = |a|^2|b|^2$

$(\vec{a}.\vec{b})^2 + 48 = 14\times 6$

$(\vec{a}.\vec{b})^2 = 84 - 48 = 36$

2. A bag contains 6 balls. 2 balls are drawn randomly if both are black then find probability that bag contains at least 5 black balls.

(1) $\left(\frac{5}{7}\right)$ (2) $\left(\frac{1}{2}\right)$ (3) $\left(\frac{1}{7}\right)$ (4) $\left(\frac{3}{7}\right)$

Ans. (1)

Sol. Total possibility = 2B + 4 others
or
= 3B +3 others
or
4B + 2 others
or
5B + 1 others
or
6B + 0 others

Now

$$\text{required probability} = \frac{\frac{^5C_2}{^6C_2}+\frac{^6C_2}{^6C_2}}{\frac{^2C_2}{^6C_2}+\frac{^3C_2}{^6C_2}+\frac{^4C_2}{^6C_2}+\frac{^5C_2}{^6C_2}+\frac{^6C_2}{^6C_2}}$$

$$= \frac{10+15}{1+3+6+10+15} = \frac{25}{35} = \frac{5}{7}$$

3. Find remainder when 5^{99} is divided by 11

Ans. (9)

Sol. $5^{99} = 625 \times 5^{95}$

$= 625 \times (3124 + 1)^{19}$

$= 625 \times (11\lambda + 1)^{19}$

Remainder = 625 or 9

4. Sum of four consecutive terms of a G.P. is 126 and their product is 1296 then find sum of common ratio of all G.P.

Ans. (3)

Sol. G.P. $\Rightarrow \frac{a}{r^3}, \frac{a}{r}, ar, ar^3$

given : $\frac{a}{r^3}.\frac{a}{r}.ar.ar^3 = 1296 \Rightarrow a^4 = 1296 \Rightarrow a = 6$

and $\frac{a}{r^3}+\frac{a}{r}+ar+ar^3 = 126 \Rightarrow \frac{1}{r^3}+\frac{1}{r}+r+r^3 = 21$

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$(r^3 + \frac{1}{r^3}) + (r + \frac{1}{r}) = 21$

$\Rightarrow \quad (r + \frac{1}{r})^3 - 3r.\frac{1}{r}(r + \frac{1}{r}) + (r + \frac{1}{r}) = 21$

$t^3 - 2t - 21 = 0$

$(t - 3)(t^2 + 3t + 7) = 0,$

$t = 3$

$r + \frac{1}{r} = 3$

$r^2 - 3r + 1 = 0 \langle^{r_1}_{r_2}$

Sum = 3

5. Find number of four digit number which are divisible by 3 or 11 and less than and equal to 2800.

Ans. (709)

Sol. Number of four digit numbers which are divisible by 3 is 600

1002.........., 2799

Number of four digit numbers which are divisible by 11 is 163

Number of four digit numbers which are divisible by 33 is 54

so required number is = 600+ 163 –54= 709

6. For ellipse $\frac{x^2}{4} + \frac{y^2}{b^2} = 1$, $0 < b < 2$ maximum distance of normal at point P from its centre is 1 then e equal to

(1) $\frac{\sqrt{3}}{2}$ (2) $\frac{\sqrt{3}}{3}$ (3) $\frac{\sqrt{3}}{4}$ (4) $\frac{3}{4}$

Ans. (1)

Sol. Normal at $(2\cos\theta, b\sin\theta)$ is

$2x\sec\theta - by\,\text{cosec} = 4 - b^2$

Now, $1 = \left(\frac{4 - b^2}{\sqrt{4\sec^2\theta + b^2\text{cosec}^2\theta}}\right)_{max.}$

$1 = \frac{4 - b^2}{2 + b}$

$2 + b = 4 - b^2$

$b^2 + b - 2 = 0$

$b = -2$ or 1

so $b = 1$

Now $e = \sqrt{1 - \frac{1}{4}} = \frac{\sqrt{3}}{2}$

7. If $a_1, a_2 \ldots\ldots\ldots a_n$ is an A.P such that $a_5 = 2a_7$ and $a_{11} = 18$ then find

$$12\left[\frac{1}{\sqrt{a_{10}} + \sqrt{a_{11}}} + \frac{1}{\sqrt{a_{11}} + \sqrt{a_{12}}} + \frac{1}{\sqrt{a_{12}} + \sqrt{a_{13}}} + \ldots\ldots + \frac{1}{\sqrt{a_{17}} + \sqrt{a_{18}}}\right]$$

(1) 8 (2) 4 (3) 10 (4) 6

Ans. (1)

Sol. Given $a + 4d = 2(a + 6d)$

Ans. (1)

Sol. Given $a + 4d = 2(a + 6d)$

$a + 8d = 0$ ....(1)

and $a_{11} = 18 \Rightarrow a + 10d = 18$ ....(2)

From (1) and (2)

$-8d + 10d = 18 \Rightarrow d = 9$ and $a = -72$

$a_{10} = a + 9d = -72 + 81 = 9$

$a_{18} = a + 17d = -72 + 153 = 81$

Now

$$12\left[\frac{1}{\sqrt{a_{10}}+\sqrt{a_{11}}}+\frac{1}{\sqrt{a_{11}}+\sqrt{a_{12}}}+\ldots\ldots+\frac{1}{\sqrt{a_{17}}+\sqrt{a_{18}}}\right]$$

$$12\left[\frac{\sqrt{a_{10}}-\sqrt{a_{11}}}{-d}+\frac{\sqrt{a_{11}}-\sqrt{a_{12}}}{-d}+\ldots\ldots+\frac{\sqrt{a_{17}}-\sqrt{a_{18}}}{-d}\right]$$

$$12\left[\frac{\sqrt{a_{10}}-\sqrt{a_{18}}}{-d}\right]=12\left[\frac{3-9}{-9}\right]=12\times\frac{6}{9}=8$$

8. Five digit numbers are formed using 0, 2,3,4,7,9 (repetition is allowed) and arranged in increasing order then the rank of 42937 is

Ans. (3005)

Sol. Number starting with 2 &3 $= 2 \times 6^4$

Number starting with 40 $= 6^3$

Number starting with 420, 422, 423, 424

$427 = 5 \times 6^2$

Similarly starting with 4290 & 4292 $= 2 \times 6$

Number starting with 4293 before 42937 $= 6 - 1 = 5$

Total $= 2 \times 6^4 + 6^3 + 5 \times 6^2 + 2 \times 6 + 5 = 3005$

9. If $f(x) + \int_3^x \frac{f(t)}{t}\,dt = \sqrt{x+1}$; $f(3) = 2$ and $x \geq 3$ then find $12f(8)$

(1) 11 (2) 17 (3) 1 (4) 7

Ans. (2)

Sol. $f'(x) + \frac{f(x)}{x} = \frac{1}{2\sqrt{x+1}}$

$\frac{dy}{dx} + \frac{y}{x} = \frac{1}{2\sqrt{x+1}}$

$I.F = e^{\int \frac{1}{x}dx} = x$

$y.x = \int x \frac{1}{2\sqrt{x+1}}\,dx + c$ put $x + 1 = t^2$, $dx = 2tdt$

$y.x = \frac{1}{2}\int \frac{(t^2-1)2tdt}{t} + c$

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$$y.x = \frac{1}{2}\left(\frac{2}{3}t^3 - 2t\right) + c$$

$$y.x = \frac{\left(\sqrt{x+1}\right)^3}{3} - \sqrt{x+1} + c$$

now $f(3) = 2$

$$6 = \frac{(2)^3}{3} - 2 + c$$

$$8 - \frac{8}{3} = c$$

$$\frac{16}{3} = c$$

$$\therefore f(x) = \frac{1}{x}\left(\frac{\left(\sqrt{x+1}\right)^3}{3} - \left(\sqrt{x+1}\right) + \frac{16}{3}\right)$$

$$\therefore 12f(8) = \frac{12}{8}\left(\frac{27}{3} - 3 + \frac{16}{3}\right)$$

$$= \frac{3}{2}\left(6 + \frac{16}{3}\right) = 17$$

10. Find the shortest distance between lines $\frac{x-1}{3} = \frac{y-2}{0} = \frac{z-3}{-1}$ & $\frac{x-1}{1} = \frac{y-1}{1} = \frac{4-z}{1}$

(1) 3 (2) 2 (3) 1 (4) 4

Ans. **(3)**

Sol. $\frac{x-1}{3} = \frac{y-2}{0} = \frac{z-3}{-1}$ & $\frac{x-1}{1} = \frac{y-1}{1} = \frac{4-z}{1}$

$$\text{S.D.} = \left|\frac{(\vec{a}_2 - \vec{a}_1)\cdot(\vec{b}\times\vec{d})}{(\vec{b}\times\vec{d})}\right|$$

$$\vec{b}\times\vec{d} = \begin{vmatrix} i & j & k \\ 3 & 0 & -1 \\ 1 & 1 & -1 \end{vmatrix} = i(1) - j(-2) + k(3)$$

$$\text{S.D.} = \begin{vmatrix} 0 & 1 & -1 \\ 3 & 0 & -1 \\ 1 & 1 & -1 \end{vmatrix}$$

$$= |0(1) - 1(-2) - 1(3)|$$

$$= 1$$

11. A Circle $x^2 + y^2 - 4x - 6y + 11 = 0$ on the tangent to it at (3, 2) is rolled up by 4 units upwards. If M and N are foot of perpendiculars of centres on x-axis, then area of quadrilateral by centres, M and N is

(1) 20 (2) 10 (3) 30 (4) 40

Ans **(1)**

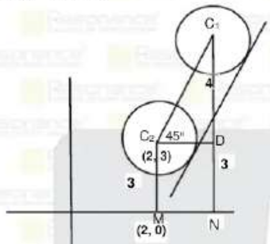
Sol. tangent; $x - y - 1 = 0$

since $\angle C_1 C_2 D = 45°$

Sol. tangent; $x - y - 1 = 0$

since $\angle C_1 C_2 D = 45°$

$C_2 D = C_1 D = 4$



$\text{Area} = \frac{1}{2}(3 + 7) \times 4$

$= 20$ units.

12. A wire of ℓ length is divided into 2 parts of length ℓ_1 and ℓ_2. From wire of length ℓ_1 a square is formed with area 'a_1' and with wire of length ℓ_2 a circle is formed with area a_2. If $2a_1 + 3a_2$ is minimum then find $\frac{\pi \ell_1}{\ell_2}$

Ans. (6)

Sol. $\ell = 4x + 2\pi r$, where x = side of square and r = radius of circle

now let $2a_1 + 3a_2 = A$

$A = 2x^2 + 3\pi r^2$

$= 2x^2 + 3\pi \left(\frac{\ell - 4x}{2\pi}\right)^2 = 2x^2 + \frac{3}{4\pi}(\ell - 4x)^2$

$\frac{dA}{dx} = 4x - \frac{2 \times 3 \times 4}{4\pi}(\ell - 4x)$

for maxima minima

$\frac{dA}{dx} = 0$

$\therefore x = \frac{2 \times 3}{4\pi}(\ell - 4\pi)$

$4\pi x = 6\ell - 24x$

$x = \frac{6\ell}{4\pi + 24}$

now $4x = \ell_1 = \frac{6\ell}{\pi + 6}$ also $\ell_2 = 2\pi r$

$= \ell - 4x = \ell - \frac{6\ell}{\pi + 6} = \frac{\pi\ell + 6\ell - 6\ell}{\pi + 6} = \frac{\pi\ell}{\pi + 6}$

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now $\frac{\pi\ell_1}{\ell_2} = \frac{\frac{\pi(6\ell)}{\pi+6}}{\frac{\pi\ell}{\pi+6}} = 6$

13. Let $A = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 4 & -1 \\ 0 & 12 & -3 \end{bmatrix}$ then sum of diagonal element of $(A + I)^{11}$ is

(1) 4097 (2) 4095 (3) 6466 (4) 2048

Ans. (1)

Sol. $A^2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 4 & -1 \\ 0 & 12 & -3 \end{bmatrix}\begin{bmatrix} 1 & 0 & 0 \\ 0 & 4 & -1 \\ 0 & 12 & -3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 4 & -1 \\ 0 & 12 & -3 \end{bmatrix} = A$

Now $(A + I)^{11} = {}^{11}C_0 A^{11} + {}^{11}C_1 + {}^{11}C_1 A^{10} + \ldots\ldots + {}^{11}C_{11} I$

$= A\,({}^{11}C_0 + {}^{11}C_1 + \ldots\ldots\ldots + {}^{11}C_{10}) + I$

$= A\,(2^{11} - 1) + I$

Trace of $(A + I)^{11}$

$= 2^{11} + 4(2^{11} - 1) + 1 + (-3)\,(2^{11} - 1) + 1$

$= 2 \times 2^{11} + 1$

$= 2^{12} + 1$

14. If $\sin^{-1}(\alpha/17) + \cos^{-1}(4/5) - \tan^{-1}\left(\frac{77}{36}\right) = 0$ then find $\sin^{-1}(\sin\alpha) + \cos^{-1}(\cos\alpha)$

(1) π (2) 2π (3) 3π (4) 4π

Ans. (1)

Sol. $\sin^{-1}\frac{\alpha}{17} = \tan^{-1}\frac{77}{36} - \cos^{-1}\frac{4}{5}$

$\sin^{-1}\frac{\alpha}{17} = \tan^{-1}\frac{77}{36} - \sin^{-1}\frac{3}{5}$

$\frac{\alpha}{17} = \sin\left(\tan^{-1}\frac{77}{36}\right)\cos\sin^{-1}\left(\frac{3}{5}\right) - \cos\tan^{-1}\left(\frac{77}{36}\right)\sin\sin^{-1}\left(\frac{3}{5}\right)$

$\frac{\alpha}{17} = \frac{77}{85} \times \frac{4}{5} - \frac{36}{85}.\frac{3}{5}$

$= \frac{308 - 108}{425} = \frac{200}{425} = \frac{8}{17}$

$\alpha = 8$

Now $\sin^{-1}\sin\alpha + \cos^{-1}\cos\alpha$

$= \sin^{-1}\sin 8 + \cos^{-1}\cos 8$

$-8 + 3\pi + 8 - 2\pi$

$= \pi$

15. If $B = \ln(1 - x)$ and $P(x) = \left(x + \frac{x^2}{2} + \frac{x^3}{3} + \ldots + \frac{x^{50}}{50}\right)$, then $\int \frac{t^{50}}{1-t}\,dt$ equals

15. If $B = \ln(1-x)$ and $P(x) = \left(x + \frac{x^2}{2} + \frac{x^3}{3} + ... + \frac{x^{50}}{50}\right)$, then $\int_0^x \frac{t^{50}}{1-t}\,dt$ equals

(1) $-(B + P(x))$ (2) $-B + P(x)$

(3) $B - P(x)$ (4) $B + P(x)$

Ans. **(3)**

Sol. $\int_0^x t^{50}(1-t)^{-1}dt$

$= \int_0^x t^{50}(1 + t + t^2 + ...\infty)dt = \left(\frac{t^{51}}{51} + \frac{t^{52}}{52} + ...\right)_0^x = \frac{x^{51}}{51} + \frac{x^{52}}{52} + ...\infty$

$\ln(1-x) - P(x) = B - P(x)$

16. If $\sqrt{x^2 - 4x + 3} + \sqrt{x^2 - 9} = \sqrt{4x^2 - 14x + 6}$ then find real roots.

Ans. **(3)**

Sol. $\sqrt{(x-1)(x-3)} + \sqrt{(x-3)(x+3)} = \sqrt{2(2x-1)(x-3)}$

$x - 3 = 0$ and $\sqrt{x-1} + \sqrt{x+3} = \sqrt{2(2x-1)}$ ....(1)

Squaring both side ; $x - 1 + x + 3 + 2\sqrt{(x-1)(x+3)} = 4x - 2$

$2\sqrt{(x-1)(x+3)} = 2x - 4$

$\sqrt{x^2 + 3x - x - 3} = x - 2$........(2)

Squaring both side ; $x^2 + 2x - 3 = x^2 - 4x + 4$

$6x = 7 \Rightarrow x = \frac{7}{6}$

At $x = \frac{7}{6}$ equation (2) positive = negative

Rejected

$\therefore$ real root $x = 3$

17. Curve $C_1 : |z| = 4$ and C_2 : the locus of $z + \frac{1}{z}$ (where z satisfy the curve c_1) then C_1 & C_2

(1) Intersect at 2 points (2) Intersect at 4 points

(3) do not intersect (4) None of these

Ans. **(2)**

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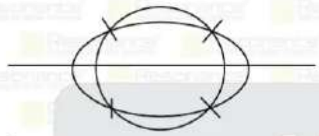
Sol. $|z| = 4$ is a circle and $z + \frac{1}{z}$ is an ellipse $\frac{x^2}{\left(\frac{17}{4}\right)^2} + \frac{y^2}{\left(\frac{15}{4}\right)^2} = 1$



18. $\int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \frac{2+3\sin x}{\sin x(1+\cos x)} dx$

(1) $\frac{10}{3} + \sqrt{3} - \frac{1}{2}\log 3$ (2) $\frac{20}{3} + \sqrt{3} - \log 3$

(3) $\frac{10}{3} - \sqrt{3} + \frac{1}{2}\log 3$ (4) $\frac{20}{3} - \sqrt{3} + \log 3$

Ans. (3)

Sol. $= \int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \frac{2(1-\cos x)}{\sin x(1-\cos^2 x)} dx + \int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \frac{3}{1+\cos x} dx$

$= \int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \frac{2}{\sin^3 x} dx - 2\int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \cot x.\text{cosec}^2 x dx + \frac{3}{2}\int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \sec^2 \frac{x}{2} dx$

$= 2\int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \sqrt{1+\cot^2 x}.\text{cosec}^2 x dx - 2\int_{\frac{\pi}{3}}^{\frac{\pi}{2}} \cot x.\text{cosec}^2 x ds + 3\left[\tan\frac{x}{2}\right]_{\frac{\pi}{3}}^{\frac{\pi}{2}}$

Let $\cot x = t$

$= -2\int_{\frac{1}{\sqrt{3}}}^{0} \sqrt{1+t^2} dt + 2\int_{\frac{1}{\sqrt{3}}}^{0} t dt + 3\left[1 - \frac{1}{\sqrt{3}}\right]$

$= 2\left[\frac{t}{2}\sqrt{1+t^2} + \frac{1}{2}\log\left(t + \sqrt{1+t^2}\right)\right]_0^{\frac{1}{\sqrt{3}}} - \left[t^2\right]_0^{\frac{1}{\sqrt{3}}} + 3 - \sqrt{3}$

$= \frac{2}{3} + \log\sqrt{3} - \frac{1}{3} + 3 - \sqrt{3} = \frac{10}{3} - \sqrt{3} + \frac{1}{2}\log 3$

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19. The direction ratio of two lines which are parallel are given by < 2, 1, –1, > and < $\alpha + \beta$, $1 + \beta$, 2>. Then the value of $|2\alpha + 3\beta|$ is ______.

19. The direction ratio of two lines which are parallel are given by < 2, 1, –1, > and < $\alpha + \beta$, $1 + \beta$, 2>. Then the value of $|2\alpha + 3\beta|$ is ______.

Ans. (11)

Sol. $\frac{\alpha+\beta}{2} = \frac{1+\beta}{1} = \frac{2}{-1}$

$\alpha = -1, \quad \beta = -3$

$|2\alpha + 3\beta| = 11$

20. Domain of the function $y = \frac{[x]}{1+x^2}$ is [2, 6) then Range of y is

(1) $\left(\frac{5}{37}, \frac{2}{5}\right]$ (2) $\left(\frac{5}{26}, \frac{2}{5}\right]$ (3) $\left(\frac{4}{26}, \frac{2}{5}\right]$ (4) $\left(\frac{5}{26}, \frac{2}{5}\right)$

Ans. (1)

Sol. $y = \frac{[x]}{1+x^2} = \begin{cases} \frac{2}{1+x^2} & ; \ 2 \le x < 3 \\ \frac{3}{1+x^2} & ; \ 3 \le x < 4 \\ \frac{4}{1+x^2} & ; \ 4 \le x < 5 \\ \frac{5}{1+x^2} & ; \ 5 \le x < 6 \end{cases}$

Since, $y = \frac{[x]}{1+x^2}$ is decreasing.

for range, $f(2) = \frac{2}{5} = 0.4$

$f(3) = \frac{3}{10} = 0.3$

$f(4) = \frac{4}{17} = 0.23$

$f(5) = \frac{5}{26} = 0.19$

$f(6) = \frac{5}{37} = 0.13$

So range of $y \in \left(\frac{5}{37}, \frac{2}{5}\right]$

21. Let $\vec{a} = 2\hat{i} + \hat{j} - \hat{k}$ and $\vec{b}, \vec{c}$ are non-zero vectors such that $\vec{b}.\vec{c} = 0$ and $|\vec{a} + \vec{b} + \vec{c}| = |\vec{a} + \vec{b} - \vec{c}|$

Statement -1 : $|\vec{a} + \lambda\vec{c}| \ge |\vec{a}|$ for $\lambda \in R$

Statement -2 : $\vec{a}$ & $\vec{c}$ are parallel, then

(1) Both correct (2) Both wrong

(3) Only S-1 correct (4) Only S_2 correct

Ans. (3)

Sol. $|\vec{a} + \vec{b} + \vec{c}|^2 = |\vec{a} + \vec{b} - \vec{c}|^2$

Sol. $|\vec{a}+\vec{b}+\vec{c}|^2 = |\vec{a}+\vec{b}-\vec{c}|^2$

$4\vec{b}.\vec{c} + 4\vec{a}.\vec{c} = 0 \Rightarrow \vec{a}.\vec{c} = 0$

Statement -1 $|\vec{a}+\lambda\vec{c}|^2 \geq |\vec{a}|^2$

$a^2 + \lambda^2c^2 + 2\vec{a}.\vec{c}\lambda \geq a^2$

$\lambda^2c^2 \geq 0$ which is true

Statement -1 is true

Statement -2 $\vec{a}$ & $\vec{c}$ are perpendicular. So, statement 2 is false

22. $y = f(x)$ is a parabola with focus $\left(-\frac{1}{2}, 0\right)$ and directrix $y = -\frac{1}{2}$.

Given that $\tan^{-1}\sqrt{f(x)} + \sin^{-1}\sqrt{f(x)+1} = \frac{\pi}{2}$. Then number of solution for x is

Ans. (2)

Sol. Equation of parabola $\sqrt{\left(x+\frac{1}{2}\right)^2 + y^2} = \left|y+\frac{1}{2}\right|$

$x^2 + \frac{1}{4} + x + y^2 = y^2 + \frac{1}{4} + y$

$x^2 + x = y$

$\left(x+\frac{1}{2}\right)^2 = \left(y+\frac{1}{4}\right)$

$Y = f(x) = \left(x+\frac{1}{2}\right)^2 - \frac{1}{4}$

Now $\tan^{-1}\sqrt{f(x)} + \sin^{-1}\sqrt{f(x)+1} = \frac{\pi}{2}$

$\cos^{-1}\frac{1}{\sqrt{1+f(x)}} + \sin^{-1}\sqrt{f(x)+1} = \frac{\pi}{2}$

So $\sqrt{f(x)+1} = \frac{1}{\sqrt{1+f(x)}}$

$f(x) + 1 = 1$

$f(x) = 0$

$\left(x+\frac{1}{2}\right) = \pm\frac{1}{2}$

$x = 0, -1$