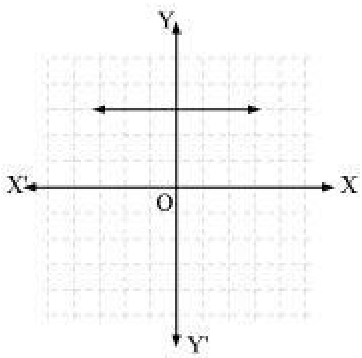
Polynomials

Exercise 2.1

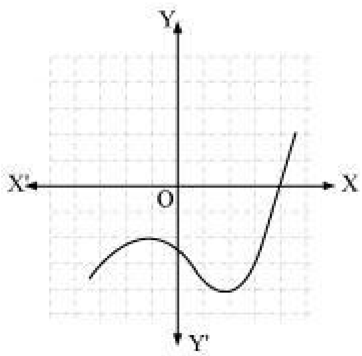
Question 1:

The graphs of y = p(x) are given in following figure, for some polynomials p(x). Find the number of zeroes of p(x), in each case.

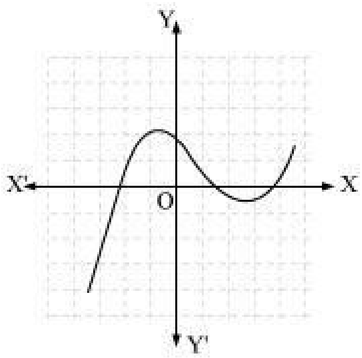
(i)



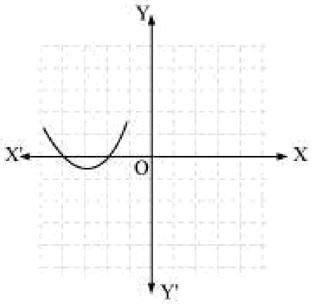
(ii)



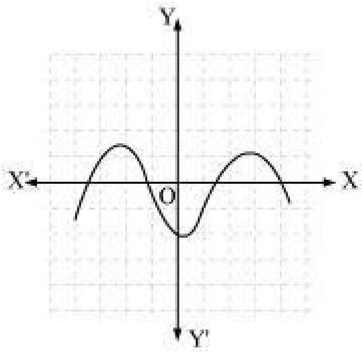
(iii)



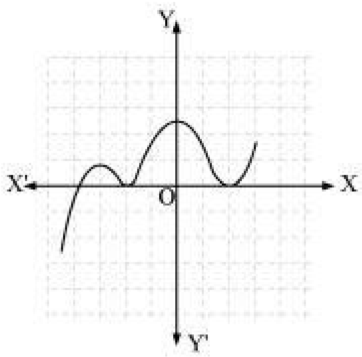
(iv)



(v)



(v)



Answer:

(i) The number of zeroes is 0 as the graph does not cut the x-axis at any point.

(ii) The number of zeroes is 1 as the graph intersects the x-axis at only 1 point.

(iii) The number of zeroes is 3 as the graph intersects the x-axis at 3 points.

(iv) The number of zeroes is 2 as the graph intersects the x-axis at 2 points.

(v) The number of zeroes is 4 as the graph intersects the x-axis at 4 points.

(vi) The number of zeroes is 3 as the graph intersects the x-axis at 3 points.

Exercise 2.2

Question 1:

Find the zeroes of the following quadratic polynomials and verify the relationship between the zeroes and the coefficients.

$$(\text{i})\, x^2 - 2x - 8 \quad (\text{ii})\, 4s^2 - 4s + 1 \quad (\text{iii})\, 6x^2 - 3 - 7x$$

$$(\text{iv})\, 4u^2 + 8u \quad (\text{v})\, t^2 - 15 \quad (\text{vi})\, 3x^2 - x - 4$$

Answer:

$$(\text{i}) \qquad x^2 - 2x - 8 = (x-4)(x+2)$$

The value of $x^2 - 2x - 8$ is zero when x − 4 = 0 or x + 2 = 0, i.e., when x = 4 or x = −2

Therefore, the zeroes of $x^2 - 2x - 8$ are 4 and −2.

Sum of zeroes = $4 - 2 = 2 = \frac{-(-2)}{1} = \frac{-(\text{Coefficient of } x)}{\text{Coefficient of } x^2}$

Product of zeroes $= 4 \times (-2) = -8 = \frac{(-8)}{1} = \frac{\text{Constant term}}{\text{Coefficient of } x^2}$

$$(\text{ii}) \qquad 4s^2 - 4s + 1 = (2s-1)^2$$

The value of $4s^2 - 4s + 1$ is zero when 2s − 1 = 0, i.e., $s = \frac{1}{2}$

Therefore, the zeroes of $4s^2 - 4s + 1$ are and .

Sum of zeroes =

Product of zeroes $= \frac{1}{2} \times \frac{1}{2} = \frac{1}{4} = \frac{\text{Constant term}}{\text{Coefficient of } s^2}$

(iii) $6x^2 - 3 - 7x = 6x^2 - 7x - 3 = (3x+1)(2x-3)$

The value of $6x^2 - 3 - 7x$ is zero when $3x + 1 = 0$ or $2x - 3 = 0$, i.e., $x = \frac{-1}{3}$ or $x = \frac{3}{2}$

Therefore, the zeroes of $6x^2 - 3 - 7x$ are $\frac{-1}{3}$ and $\frac{3}{2}$.

Sum of zeroes = $\frac{-1}{3} + \frac{3}{2} = \frac{7}{6} = \frac{-(-7)}{6} = \frac{-(\text{Coefficient of } x)}{\text{Coefficient of } x^2}$

Product of zeroes = $\frac{-1}{3} \times \frac{3}{2} = \frac{-1}{2} = \frac{-3}{6} = \frac{\text{Constant term}}{\text{Coefficient of } x^2}$

(iv) $4u^2 + 8u = 4u^2 + 8u + 0$

$= 4u(u+2)$

The value of $4u^2 + 8u$ is zero when $4u = 0$ or $u + 2 = 0$, i.e., $u = 0$ or $u = -2$

Therefore, the zeroes of $4u^2 + 8u$ are 0 and −2.

Sum of zeroes = $0 + (-2) = -2 = \frac{-(8)}{4} = \frac{-(\text{Coefficient of } u)}{\text{Coefficient of } u^2}$

Product of zeroes = $0 \times (-2) = 0 = \frac{0}{4} = \frac{\text{Constant term}}{\text{Coefficient of } u^2}$

(v) $t^2 - 15$

$= t^2 - 0t - 15$

$= (t - \sqrt{15})(t + \sqrt{15})$

The value of $t^2 - 15$ is zero when $t-\sqrt{15}=0$ or $t+\sqrt{15}=0$, i.e., when $t=\sqrt{15}$ or $t=-\sqrt{15}$

Therefore, the zeroes of $t^2 - 15$ are $\sqrt{15}$ and $-\sqrt{15}$.

Sum of zeroes = $\sqrt{15}+\left(-\sqrt{15}\right)=0=\frac{-0}{1}=\frac{-(\text{Coefficient of } t)}{\left(\text{Coefficient of } t^2\right)}$

Product of zeroes = $\left(\sqrt{15}\right)\left(-\sqrt{15}\right)=-15=\frac{-15}{1}=\frac{\text{Constant term}}{\text{Coefficient of } x^2}$

(vi) $3x^2-x-4$

$=(3x-4)(x+1)$

The value of $3x^2 - x - 4$ is zero when $3x - 4 = 0$ or $x + 1 = 0$, i.e., when $x=\frac{4}{3}$ or $x = -1$

Therefore, the zeroes of $3x^2 - x - 4$ are $\frac{4}{3}$ and -1.

Sum of zeroes = $\frac{4}{3}+(-1)=\frac{1}{3}=\frac{-(-1)}{3}=\frac{-(\text{Coefficient of } x)}{\text{Coefficient of } x^2}$

Product of zeroes $=\frac{4}{3}(-1)=\frac{-4}{3}=\frac{\text{Constant term}}{\text{Coefficient of } x^2}$

Question 2:

Find a quadratic polynomial each with the given numbers as the sum and product of its zeroes respectively.

(i) $\frac{1}{4},-1$ (ii) $\sqrt{2},\frac{1}{3}$ (iii) $0,\sqrt{5}$

(iv) $1,1$ (v) $-\frac{1}{4},\frac{1}{4}$ (vi) $4,1$

Answer:

(i) $\frac{1}{4}, -1$

Let the polynomial be $ax^2 + bx + c$, and its zeroes be α and β .

$$\alpha + \beta = \frac{1}{4} = \frac{-b}{a}$$
$$\alpha\beta = -1 = \frac{-4}{4} = \frac{c}{a}$$
$$\text{If } a = 4, \text{ then } b = -1, \; c = -4$$

Therefore, the quadratic polynomial is $4x^2 - x - 4$.

(ii) $\sqrt{2}, \frac{1}{3}$

Let the polynomial be $ax^2 + bx + c$, and its zeroes be α and β .

$$\alpha + \beta = \sqrt{2} = \frac{3\sqrt{2}}{3} = \frac{-b}{a}$$
$$\alpha\beta = \frac{1}{3} = \frac{c}{a}$$
$$\text{If } a = 3, \text{ then } b = -3\sqrt{2}, \; c = 1$$

Therefore, the quadratic polynomial is $3x^2 - 3\sqrt{2}x + 1$.

(iii) $0, \sqrt{5}$

Let the polynomial be $ax^2 + bx + c$, and its zeroes be α and β .

$$\alpha+\beta=0=\frac{0}{1}=\frac{-b}{a}$$
$$\alpha\times\beta=\sqrt{5}=\frac{\sqrt{5}}{1}=\frac{c}{a}$$
If $a=1$, then $b=0$, $c=\sqrt{5}$

Therefore, the quadratic polynomial is $x^2+\sqrt{5}$.

(iv) 1, 1

Let the polynomial be ax^2+bx+c , and its zeroes be α and β .

$$\alpha+\beta=1=\frac{1}{1}=\frac{-b}{a}$$
$$\alpha\times\beta=1=\frac{1}{1}=\frac{c}{a}$$
If $a=1$, then $b=-1$, $c=1$

Therefore, the quadratic polynomial is x^2-x+1 .

(v) $-\frac{1}{4},\frac{1}{4}$

Let the polynomial be ax^2+bx+c , and its zeroes be α and β .

$$\alpha+\beta=\frac{-1}{4}=\frac{-b}{a}$$
$$\alpha\times\beta=\frac{1}{4}=\frac{c}{a}$$
If $a=4$, then $b=1$, $c=1$

Therefore, the quadratic polynomial is $4x^2+x+1$.

(vi) 4, 1

Let the polynomial be ax^2+bx+c .

$$\alpha+\beta=4=\frac{4}{1}=\frac{-b}{a}$$
$$\alpha\times\beta=1=\frac{1}{1}=\frac{c}{a}$$
$$\text{If } a=1,\ \text{then } b=-4,\ c=1$$

Therefore, the quadratic polynomial is x^2-4x+1 .

Exercise 2.3

Question 1:

Divide the polynomial p(x) by the polynomial g(x) and find the quotient and remainder in each of the following:

(i) $p(x)=x^3-3x^2+5x-3, \qquad g(x)=x^2-2$

(ii) $p(x)=x^4-3x^2+4x+5, \qquad g(x)=x^2+1-x$

(iii) $p(x)=x^4-5x+6, \qquad g(x)=2-x^2$

Answer:

(i) $p(x)=x^3-3x^2+5x-3$

$q(x)=x^2-2$

$$\begin{array}{r|l} & \quad x-3 \\ \hline x^2-2 & x^3-3x^2+5x-3 \\ & x^3 \qquad\; -2x \\ & - \qquad\quad + \\ \hline & \quad -3x^2+7x-3 \\ & \quad -3x^2 \qquad +6 \\ & \quad + \qquad\quad - \\ \hline & \qquad\qquad 7x-9 \end{array}$$

Quotient = x − 3

Remainder = 7x − 9

(ii) $p(x)=x^4-3x^2+4x+5=x^4+0.x^3-3x^2+4x+5$

$q(x)=x^2+1-x=x^2-x+1$

$$
\begin{array}{r|l}
 & x^2+x-3 \\
\hline
x^2-x+1 & x^4+0.x^3-3x^2+4x+5 \\
 & x^4-x^3+x^2 \\
 & -\quad+\quad- \\
\hline
 & x^3-4x^2+4x+5 \\
 & x^3-x^2+x \\
 & -\quad+\quad- \\
\hline
 & -3x^2+3x+5 \\
 & -3x^2+3x-3 \\
 & +\quad-\quad+ \\
\hline
 & 8 \\
\hline
\end{array}
$$

Quotient = x^2+x-3

Remainder = 8

(iii) $p(x)=x^4-5x+6=x^4+0.x^2-5x+6$

$q(x)=2-x^2=-x^2+2$

$$
\begin{array}{r|l}
 & -x^2-2 \\
\hline
-x^2+2 & x^4+0.x^2-5x+6 \\
 & x^4-2x^2 \\
 & -\quad+ \\
\hline
 & 2x^2-5x+6 \\
 & 2x^2\quad-4 \\
 & -\quad+ \\
\hline
 & -5x+10 \\
\hline
\end{array}
$$

Quotient = $-x^2-2$

Remainder = $-5x+10$

Question 2:

Check whether the first polynomial is a factor of the second polynomial by dividing the second polynomial by the first polynomial:

(i) $t^2-3, 2t^4+3t^3-2t^2-9t-12$

(ii) $x^2+3x+1, 3x^4+5x^3-7x^2+2x+2$

(iii) $x^3-3x+1, x^5-4x^3+x^2+3x+1$

Answer:

(i) $t^2-3,\ 2t^4+3t^3-2t^2-9t-12$

t^2-3 = $t^2+0.t-3$

$$
\begin{array}{r|l}
 & 2t^2+3t+4 \\
\hline
t^2+0.t-3 & 2t^4+3t^3-2t^2-9t-12 \\
 & 2t^4+0.t^3-6t^2 \\
 & -\quad -\quad + \\
\hline
 & 3t^3+4t^2-9t-12 \\
 & 3t^3+0.t^2-9t \\
 & -\quad -\quad + \\
\hline
 & 4t^2+0.t-12 \\
 & 4t^2+0.t-12 \\
 & -\quad -\quad + \\
\hline
 & 0
\end{array}
$$

Since the remainder is 0,

Hence, t^2-3 is a factor of $2t^4+3t^3-2t^2-9t-12$.

(ii) $x^2+3x+1,\ 3x^4+5x^3-7x^2+2x+2$

$$
\begin{array}{r|l}
 & 3x^2-4x+2 \\
\hline
x^2+3x+1 & 3x^4+5x^3-7x^2+2x+2 \\
 & 3x^4+9x^3+3x^2 \\
 & -\quad -\quad - \\
\hline
 & -4x^3-10x^2+2x+2 \\
 & -4x^3-12x^2-4x \\
 & +\quad +\quad + \\
\hline
 & 2x^2+6x+2 \\
 & 2x^2+6x+2 \\
\hline
 & 0 \\
\hline
\end{array}
$$

Since the remainder is 0,

Hence, x^2+3x+1 is a factor of $3x^4+5x^3-7x^2+2x+2$.

(iii) $x^3-3x+1,\ x^5-4x^3+x^2+3x+1$

$$
\begin{array}{r|l}
 & x^2-1 \\
\hline
x^3-3x+1 & x^5-4x^3+x^2+3x+1 \\
 & x^5-3x^3+x^2 \\
 & -\quad +\quad - \\
\hline
 & -x^3\qquad +3x+1 \\
 & -x^3\qquad +3x-1 \\
 & +\qquad -\quad + \\
\hline
 & 2 \\
\hline
\end{array}
$$

Since the remainder $\neq 0$,

Hence, x^3-3x+1 is not a factor of $x^5-4x^3+x^2+3x+1$.

Question 3:

Obtain all other zeroes of $3x^4+6x^3-2x^2-10x-5$, if two of its zeroes are $\sqrt{\frac{5}{3}}$ and $-\sqrt{\frac{5}{3}}$.

Answer:

$p(x) = 3x^4 + 6x^3 - 2x^2 - 10x - 5$

Since the two zeroes are $\sqrt{\frac{5}{3}}$ and $-\sqrt{\frac{5}{3}}$,

$\therefore \left(x - \sqrt{\frac{5}{3}}\right)\left(x + \sqrt{\frac{5}{3}}\right) = \left(x^2 - \frac{5}{3}\right)$ is a factor of $3x^4 + 6x^3 - 2x^2 - 10x - 5$.

Therefore, we divide the given polynomial by $x^2 - \frac{5}{3}$.

$$
\begin{array}{r|l}
 & 3x^2 + 6x + 3 \\
x^2 + 0.x - \frac{5}{3} & 3x^4 + 6x^3 - 2x^2 - 10x - 5 \\
 & 3x^4 + 0x^3 - 5x^2 \\
 & - \quad - \quad + \\
\hline
 & 6x^3 + 3x^2 - 10x - 5 \\
 & 6x^3 + 0x^2 - 10x \\
 & - \quad - \quad + \\
\hline
 & 3x^2 + 0x - 5 \\
 & 3x^2 + 0x - 5 \\
 & - \quad - \quad + \\
\hline
 & 0 \\
\hline
\end{array}
$$

$$
\begin{aligned}
3x^4 + 6x^3 - 2x^2 - 10x - 5 &= \left(x^2 - \frac{5}{3}\right)\left(3x^2 + 6x + 3\right) \\
&= 3\left(x^2 - \frac{5}{3}\right)\left(x^2 + 2x + 1\right)
\end{aligned}
$$

We factorize $x^2 + 2x + 1$

$= (x+1)^2$

Therefore, its zero is given by x + 1 = 0

x = −1

As it has the term $(x+1)^2$, therefore, there will be 2 zeroes at x = −1.

Hence, the zeroes of the given polynomial are $\sqrt{\frac{5}{3}}, -\sqrt{\frac{5}{3}}$, −1 and −1.

Question 4:

On dividing $x^3 - 3x^2 + x + 2$ by a polynomial g(x), the quotient and remainder were x − 2 and − 2x + 4, respectively. Find g(x).

Answer:

$$p(x) = x^3 - 3x^2 + x + 2 \qquad (\text{Dividend})$$

g(x) = ? (Divisor)

Quotient = (x − 2)

Remainder = (− 2x + 4)

Dividend = Divisor × Quotient + Remainder

$$x^3 - 3x^2 + x + 2 = g(x) \times (x-2) + (-2x+4)$$
$$x^3 - 3x^2 + x + 2 + 2x - 4 = g(x)(x-2)$$
$$x^3 - 3x^2 + 3x - 2 = g(x)(x-2)$$

g(x) is the quotient when we divide $(x^3 - 3x^2 + 3x - 2)$ by $(x-2)$

$$
\begin{array}{r|l}
 & x^2 - x + 1 \\
\hline
x-2 & x^3 - 3x^2 + 3x - 2 \\
 & x^3 - 2x^2 \\
 & - \quad + \\
\hline
 & -x^2 + 3x - 2 \\
 & -x^2 + 2x \\
 & + \quad - \\
\hline
 & x - 2 \\
 & x - 2 \\
 & - \quad + \\
\hline
 & 0 \\
\hline
\end{array}
$$

$$\therefore g(x) = (x^2 - x + 1)$$

Question 5:

Give examples of polynomial p(x), g(x), q(x) and r(x), which satisfy the division algorithm and

(i) deg p(x) = deg q(x)

(ii) deg q(x) = deg r(x)

(iii) deg r(x) = 0

Answer:

According to the division algorithm, if p(x) and g(x) are two polynomials with

g(x) ≠ 0, then we can find polynomials q(x) and r(x) such that

p(x) = g(x) × q(x) + r(x),

where r(x) = 0 or degree of r(x) < degree of g(x)

Degree of a polynomial is the highest power of the variable in the polynomial.

(i) deg p(x) = deg q(x)

Degree of quotient will be equal to degree of dividend when divisor is constant (i.e., when any polynomial is divided by a constant).

Let us assume the division of $6x^2 + 2x + 2$ by 2.

Here, p(x) = $6x^2 + 2x + 2$

g(x) = 2

q(x) = $3x^2 + x + 1$ and r(x) = 0

Degree of p(x) and q(x) is the same i.e., 2.

Checking for division algorithm,

p(x) = g(x) × q(x) + r(x)

$6x^2 + 2x + 2$ =2($3x^2 + x + 1$)

= $6x^2 + 2x + 2$

Thus, the division algorithm is satisfied.

(ii) deg q(x) = deg r(x)

Let us assume the division of $x^3 + x$ by x^2,

Here, p(x) = $x^3 + x$

g(x) = x^2

q(x) = x and r(x) = x

Clearly, the degree of q(x) and r(x) is the same i.e., 1.

Checking for division algorithm,

p(x) = g(x) × q(x) + r(x)

$x^3 + x = (x^2) \times x + x$

$x^3 + x = x^3 + x$

Thus, the division algorithm is satisfied.

(iii)deg r(x) = 0

Degree of remainder will be 0 when remainder comes to a constant.

Let us assume the division of $x^3 + 1$by x^2.

Here, $p(x) = x^3 + 1$

$g(x) = x^2$

q(x) = x and r(x) = 1

Clearly, the degree of r(x) is 0.

Checking for division algorithm,

p(x) = g(x) × q(x) + r(x)

$x^3 + 1 = (x^2) \times x + 1$

$x^3 + 1 = x^3 + 1$

Thus, the division algorithm is satisfied.

Exercise 2.4

Question 1:

Verify that the numbers given alongside of the cubic polynomials below are their zeroes. Also verify the relationship between the zeroes and the coefficients in each case:

(i) $2x^3 + x^2 - 5x + 2; \quad \frac{1}{2}, 1, -2$

(ii) $x^3 - 4x^2 + 5x - 2; \quad 2, 1, 1$

Answer:

(i) $p(x) = 2x^3 + x^2 - 5x + 2.$

Zeroes for this polynomial are $\frac{1}{2}, 1, -2$

$$p\left(\frac{1}{2}\right) = 2\left(\frac{1}{2}\right)^3 + \left(\frac{1}{2}\right)^2 - 5\left(\frac{1}{2}\right) + 2$$
$$= \frac{1}{4} + \frac{1}{4} - \frac{5}{2} + 2$$
$$= 0$$
$$p(1) = 2 \times 1^3 + 1^2 - 5 \times 1 + 2$$
$$= 0$$
$$p(-2) = 2(-2)^3 + (-2)^2 - 5(-2) + 2$$
$$= -16 + 4 + 10 + 2 = 0$$

Therefore, $\frac{1}{2}$, 1, and −2 are the zeroes of the given polynomial.

Comparing the given polynomial with $ax^3 + bx^2 + cx + d$, we obtain a = 2, b = 1, c = −5, d = 2

We can take $\alpha = \frac{1}{2}, \beta = 1, \gamma = -2$

$$\alpha + \beta + \gamma = \frac{1}{2} + 1 + (-2) = -\frac{1}{2} = \frac{-b}{a}$$
$$\alpha\beta + \beta\gamma + \alpha\gamma = \frac{1}{2} \times 1 + 1(-2) + \frac{1}{2}(-2) = \frac{-5}{2} = \frac{c}{a}$$
$$\alpha\beta\gamma = \frac{1}{2} \times 1 \times (-2) = \frac{-1}{1} = \frac{-(2)}{2} = \frac{-d}{a}$$

Therefore, the relationship between the zeroes and the coefficients is verified.

(ii) $p(x) = x^3 - 4x^2 + 5x - 2$

Zeroes for this polynomial are 2, 1, 1.

$$p(2) = 2^3 - 4(2^2) + 5(2) - 2$$
$$= 8 - 16 + 10 - 2 = 0$$
$$p(1) = 1^3 - 4(1)^2 + 5(1) - 2$$
$$= 1 - 4 + 5 - 2 = 0$$

Therefore, 2, 1, 1 are the zeroes of the given polynomial.

Comparing the given polynomial with $ax^3 + bx^2 + cx + d$, we obtain a = 1, b = −4, c = 5, d = −2.

Verification of the relationship between zeroes and coefficient of the given polynomial

$$\text{Sum of zeroes} = 2 + 1 + 1 = 4 = \frac{-(-4)}{1} = \frac{-b}{a}$$

Multiplication of zeroes taking two at a time = (2)(1) + (1)(1) + (2)(1) =2 + 1 + 2 = 5 $= \frac{(5)}{1} = \frac{c}{a}$

Multiplication of zeroes = 2 × 1 × 1 = 2 $= \frac{-(-2)}{1} = \frac{-d}{a}$

Hence, the relationship between the zeroes and the coefficients is verified.

Question 2:

Find a cubic polynomial with the sum, sum of the product of its zeroes taken two at a time, and the product of its zeroes as 2, − 7, − 14 respectively.

Answer:

Let the polynomial be $ax^3 + bx^2 + cx + d$ and the zeroes be $\alpha, \beta, \text{ and } \gamma$.

It is given that

$$\alpha+\beta+\gamma=\frac{2}{1}=\frac{-b}{a}$$
$$\alpha\beta+\beta\gamma+\alpha\gamma=\frac{-7}{1}=\frac{c}{a}$$
$$\alpha\beta\gamma=\frac{-14}{1}=\frac{-d}{a}$$

If a = 1, then b = −2, c = −7, d = 14

Hence, the polynomial is $x^3-2x^2-7x+14$.

Question 3:

If the zeroes of polynomial x^3-3x^2+x+1 are $a-b, a, a+b$, find a and b.

Answer:

$$p(x)=x^3-3x^2+x+1$$

Zeroes are a − b, a + a + b

Comparing the given polynomial with px^3+qx^2+rx+t , we obtain

p = 1, q = −3, r = 1, t = 1

$$\text{Sum of zeroes} = a-b+a+a+b$$
$$\frac{-q}{p}=3a$$
$$\frac{-(-3)}{1}=3a$$
$$3=3a$$
$$a=1$$

The zeroes are $1-b, 1, 1+b$.

$\text{Multiplication of zeroes} = 1(1-b)(1+b)$

$\frac{-t}{p} = 1-b^2$

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

$1-b^2 = -1$

$1+1 = b^2$

$b = \pm\sqrt{2}$

Hence, a = 1 and b = $\sqrt{2}$ or $-\sqrt{2}$.

Question 4:

]It two zeroes of the polynomial $x^4 - 6x^3 - 26x^2 + 138x - 35$ are $2 \pm \sqrt{3}$, find other zeroes.

Answer:

Given that 2 + $\sqrt{3}$ and 2 $-\sqrt{3}$ are zeroes of the given polynomial.

Therefore, $\left(x-2-\sqrt{3}\right)\left(x-2+\sqrt{3}\right)$ = $x^2 + 4 - 4x - 3$

= $x^2 - 4x + 1$ is a factor of the given polynomial

For finding the remaining zeroes of the given polynomial, we will find the quotient by dividing $x^4 - 6x^3 - 26x^2 + 138x - 35$ by $x^2 - 4x + 1$.

$$
\begin{array}{r|l}
 & x^2 - 2x - 35 \\
\hline
x^2 - 4x + 1 & x^4 - 6x^3 - 26x^2 + 138x - 35 \\
 & x^4 - 4x^3 + x^2 \\
 & - \quad + \quad - \\
\hline
 & -2x^3 - 27x^2 + 138x - 35 \\
 & -2x^3 + 8x^2 - 2x \\
 & + \quad - \quad + \\
\hline
 & -35x^2 + 140x - 35 \\
 & -35x^2 + 140x - 35 \\
 & + \quad - \quad + \\
\hline
 & 0
\end{array}
$$

Clearly, $x^4 - 6x^3 - 26x^2 + 138x - 35$ = $(x^2 - 4x + 1)(x^2 - 2x - 35)$

It can be observed that $(x^2 - 2x - 35)$ is also a factor of the given polynomial.

And $(x^2 - 2x - 35)$ = $(x - 7)(x + 5)$

Therefore, the value of the polynomial is also zero when $x - 7 = 0$ or $x + 5 = 0$

Or x = 7 or −5

Hence, 7 and −5 are also zeroes of this polynomial.

Question 5:

If the polynomial $x^4 - 6x^3 + 16x^2 - 25x + 10$ is divided by another polynomial $x^2 - 2x + k$, the remainder comes out to be x + a, find k and a.

Answer:

By division algorithm,

Dividend = Divisor × Quotient + Remainder

Dividend − Remainder = Divisor × Quotient

$x^4-6x^3+16x^2-25x+10-x-a=x^4-6x^3+16x^2-26x+10-a$ will be perfectly divisible by x^2-2x+k .

Let us divide $x^4-6x^3+16x^2-26x+10-a$ by x^2-2x+k

$$
\begin{array}{r|l}
 & x^2-4x+(8-k) \\
\hline
x^2-2x+k & x^4-6x^3+16x^2-26x+10-a \\
 & x^4-2x^3+\ kx^2 \\
 & -\quad +\quad - \\
\hline
 & -4x^3+(16-k)x^2-26x \\
 & -4x^3+\quad 8x^2-\ 4kx \\
 & +\quad -\qquad + \\
\hline
 & (8-k)x^2-(26-4k)x+10-a \\
 & (8-k)x^2-(16-2k)x+(8k-k^2) \\
 & -\qquad +\qquad - \\
\hline
 & (-10+2k)x+(10-a-8k+k^2)
\end{array}
$$

It can be observed that $(-10+2k)x+(10-a-8k+k^2)$ will be 0.

Therefore, $(-10+2k)$ = 0 and $(10-a-8k+k^2)$ = 0

For $(-10+2k)$ = 0,

2 k =10

And thus, k = 5

For $(10-a-8k+k^2)$ = 0

10 − a − 8 × 5 + 25 = 0

10 − a − 40 + 25 = 0

$-5 - a = 0$ Therefore,

$a = -5$ Hence, $k = 5$

and $a = -5$