

1

Real Numbers

Exercise 1.1 Multiple Choice Questions (MCQs)

Q. 1 For some integer m , every even integer is of the form

- (a) m (b) $m + 1$ (c) $2m$ (d) $2m + 1$

Sol. (c) We know that, even integers are 2, 4, 6, ...

So, it can be written in the form of $2m$.

where,

$$m = \text{Integer} = Z \quad [\text{since, integer is represented by } Z]$$

or

$$m = \dots, -1, 0, 1, 2, 3, \dots$$

\therefore

$$2m = \dots, -2, 0, 2, 4, 6, \dots$$

Alternate Method

Let 'a' be a positive integer. On dividing 'a' by 2, let m be the quotient and r be the remainder. Then, by Euclid's division algorithm, we have

$$a = 2m + r, \text{ where } a \leq r < 2 \text{ i.e., } r = 0 \text{ and } r = 1.$$

$$\Rightarrow a = 2m \text{ or } a = 2m + 1$$

when, $a = 2m$ for some integer m , then clearly a is even.

Q. 2 For some integer q , every odd integer is of the form

- (a) q (b) $q + 1$ (c) $2q$ (d) $2q + 1$

Sol. (d) We know that, odd integers are 1, 3, 5, ...

So, it can be written in the form of $2q + 1$.

where,

$$q = \text{integer} = Z$$

or

$$q = \dots, -1, 0, 1, 2, 3, \dots$$

\therefore

$$2q + 1 = \dots, -3, -1, 1, 3, 5, \dots$$

Alternate Method

Let 'a' be given positive integer. On dividing 'a' by 2, let q be the quotient and r be the remainder. Then, by Euclid's division algorithm, we have

$$a = 2q + r, \text{ where } 0 \leq r < 2$$

$$\Rightarrow a = 2q + r, \text{ where } r = 0 \text{ or } r = 1$$

$$\Rightarrow a = 2q \text{ or } 2q + 1$$

when $a = 2q + 1$ for some integer q , then clearly a is odd.

Q. 3 $n^2 - 1$ is divisible by 8, if n is

- (a) an integer (b) a natural number
(c) an odd integer (d) an even integer

Sol. (c) Let $a = n^2 - 1$

Here n can be even or odd.

Case I $n = \text{Even i.e., } n = 2k$, where k is an integer.

$$\Rightarrow a = (2k)^2 - 1$$

$$\Rightarrow a = 4k^2 - 1$$

At $k = -1$, $a = 4(-1)^2 - 1 = 4 - 1 = 3$, which is not divisible by 8.

At $k = 0$, $a = 4(0)^2 - 1 = 0 - 1 = -1$, which is not divisible by 8, which is not

Case II $n = \text{Odd i.e., } n = 2k + 1$, where k is an odd integer.

$$\Rightarrow a = 2k + 1$$

$$\Rightarrow a = (2k + 1)^2 - 1$$

$$\Rightarrow a = 4k^2 + 4k + 1 - 1$$

$$\Rightarrow a = 4k^2 + 4k$$

$$\Rightarrow a = 4k(k + 1)$$

At $k = -1$, $a = 4(-1)(-1 + 1) = 0$ which is divisible by 8.

At $k = 0$, $a = 4(0)(0 + 1) = 4$ which is divisible by 8.

At $k = 1$, $a = 4(1)(1 + 1) = 8$ which is divisible by 8.

Hence, we can conclude from above two cases, if n is odd, then $n^2 - 1$ is divisible by 8.

Q. 4 If the HCF of 65 and 117 is expressible in the form $65m - 117$, then the value of m is

- (a) 4 (b) 2 (c) 1 (d) 3

Thinking Process

Apply Euclid's division algorithm until the remainder is 0. Finally we get divisor, which is the required HCF of 65 and 117. Now, put $65m - 117 = \text{HCF}(65, 117)$ and get the value of m .

Sol. (b) By Euclid's division algorithm,

$$b = aq + r, 0 \leq r < a \quad [\because \text{dividend} = \text{divisor} \times \text{quotient} + \text{remainder}]$$

$$\Rightarrow 117 = 65 \times 1 + 52$$

$$\Rightarrow 65 = 52 \times 1 + 13$$

$$\Rightarrow 52 = 13 \times 4 + 0$$

$$\therefore \text{HCF}(65, 117) = 13 \quad \dots(i)$$

$$\text{Also, given that, HCF}(65, 117) = 65m - 117 \quad \dots(ii)$$

From Eqs. (i) and (ii),

$$65m - 117 = 13$$

$$\Rightarrow 65m = 130$$

$$\Rightarrow m = 2$$

Q. 5 The largest number which divides 70 and 125, leaving remainders 5 and 8 respectively, is

- (a) 13 (b) 65 (c) 875 (d) 1750

Thinking Process

First, we subtract the remainders 5 and 8 from corresponding numbers respectively and then get HCF of resulting numbers by using Euclid's division algorithm, which is the required largest number.

Sol. (a) Since, 5 and 8 are the remainders of 70 and 125, respectively. Thus, after subtracting these remainders from the numbers, we have the numbers $65 = (70 - 5)$, $117 = (125 - 8)$, which is divisible by the required number.

Now, required number = HCF of 65, 117 [for the largest number]

For this, $117 = 65 \times 1 + 52$ [\because dividend = divisor \times quotient + remainder]

$$\Rightarrow 65 = 52 \times 1 + 13$$

$$\Rightarrow 52 = 13 \times 4 + 0$$

$$\therefore \text{HCF} = 13$$

Hence, 13 is the largest number which divides 70 and 125, leaving remainders 5 and 8.

Q. 6 If two positive integers a and b are written as $a = x^3y^2$ and $b = xy^3$, where x, y are prime numbers, then HCF (a, b) is

- (a) xy (b) xy^2 (c) x^3y^3 (d) x^2y^2

Sol. (b) Given that, $a = x^3y^2 = x \times x \times x \times y \times y$
and $b = xy^3 = x \times y \times y \times y$

$$\therefore \text{HCF of } a \text{ and } b = \text{HCF}(x^3y^2, xy^3) = x \times y \times y = xy^2$$

[since, HCF is the product of the smallest power of each common prime factor involved in the numbers]

Q. 7 If two positive integers p and q can be expressed as $p = ab^2$ and $q = a^3b$; where a, b being prime numbers, then LCM (p, q) is equal to

- (a) ab (b) a^2b^2 (c) a^3b^2 (d) a^3b^3

Sol. (c) Given that, $p = ab^2 = a \times b \times b$
and $q = a^3b = a \times a \times a \times b$

$$\therefore \text{LCM of } p \text{ and } q = \text{LCM}(ab^2, a^3b) = a \times b \times b \times a \times a = a^3b^2$$

[since, LCM is the product of the greatest power of each prime factor involved in the numbers]

Q. 8 The product of a non-zero rational and an irrational number is

- (a) always irrational (b) always rational
(c) rational or irrational (d) one

Sol. (a) Product of a non-zero rational and an irrational number is always irrational i.e.,

$$\frac{3}{4} \times \sqrt{2} = \frac{3\sqrt{2}}{4} \text{ (irrational).}$$

Q. 9 The least number that is divisible by all the numbers from 1 to 10 (both inclusive)

- (a) 10 (b) 100 (c) 504 (d) 2520

Sol. (d) Factors of 1 to 10 numbers

$$\begin{aligned} 1 &= 1 \\ 2 &= 1 \times 2 \\ 3 &= 1 \times 3 \\ 4 &= 1 \times 2 \times 2 \\ 5 &= 1 \times 5 \\ 6 &= 1 \times 2 \times 3 \\ 7 &= 1 \times 7 \\ 8 &= 1 \times 2 \times 2 \times 2 \\ 9 &= 1 \times 3 \times 3 \\ 10 &= 1 \times 2 \times 5 \end{aligned}$$

$$\begin{aligned} \therefore \text{LCM of number 1 to 10} &= \text{LCM}(1, 2, 3, 4, 5, 6, 7, 8, 9, 10) \\ &= 1 \times 2 \times 2 \times 2 \times 3 \times 3 \times 5 \times 7 = 2520 \end{aligned}$$

Q. 10 The decimal expansion of the rational number $\frac{14587}{1250}$ will terminate after

- (a) one decimal place (b) two decimal places
(c) three decimal places (d) four decimal places

💡 Thinking Process

In terminating rational number the denominator always have the form $2^m \times 5^n$.

Sol. (d) Rational number = $\frac{14587}{1250} = \frac{14587}{2^1 \times 5^4}$

$$\begin{aligned} &= \frac{14587}{10 \times 5^3} \times \frac{(2)^3}{(2)^3} \\ &= \frac{14587 \times 8}{10 \times 1000} \\ &= \frac{116696}{10000} = 11.6696 \end{aligned}$$

2	1250
5	625
5	125
5	25
5	5
	1

Hence, given rational number will terminate after four decimal places.

Exercise 1.2 Very Short Answer Type Questions

Q. 1 Write whether every positive integer can be of the form $4q + 2$, where q is an integer. Justify your answer.

Sol. No, by Euclid's Lemma, $b = aq + r$, $0 \leq r < a$ [\because dividend = divisor \times quotient + remainder]

Here, b is any positive integer $a = 4$, $b = 4q + r$ for $0 \leq r < 4$ i.e., $r = 0, 1, 2, 3$

So, this must be in the form $4q$, $4q + 1$, $4q + 2$ or $4q + 3$.

Q. 2 'The product of two consecutive positive integers is divisible by 2'. Is this statement true or false? Give reasons.

Thinking Process

The product of two consecutive numbers i.e., $n(n+1)$ will always be even, as one out of n or $(n+1)$ must be even.

Sol. Yes, two consecutive integers can be $n, (n+1)$. So, one number of these two must be divisible by 2. Hence, product of numbers is divisible by 2.

Q. 3 'The product of three consecutive positive integers is divisible by 6'. Is this statement true or false? Justify your answer.

Sol. Yes, three consecutive integers can be $n, (n+1)$ and $(n+2)$. So, one number of these three must be divisible by 2 and another one must be divisible by 3. Hence, product of numbers is divisible by 6.

Q. 4 Write whether the square of any positive integer can be of the form $3m+2$, where m is a natural number. Justify your answer.

Sol. No, by Euclid's lemma, $b = aq + r, 0 \leq r < a$. Here, b is any positive integer, $a = 3, b = 3q + r$ for $0 \leq r < 3$

So, any positive integer is of the form $3k, 3k+1$ or $3k+2$.

Now, $(3k)^2 = 9k^2 = 3m$ [where, $m = 3k^2$]

and $(3k+1)^2 = 9k^2 + 6k + 1 = 3(3k^2 + 2k) + 1 = 3m + 1$ [where, $m = 3k^2 + 2k$]

Also, $(3k+2)^2 = 9k^2 + 12k + 4 = 3(3k^2 + 4k + 1) + 1 = 3m + 1$ [where, $m = 3k^2 + 4k + 1$]

which is in the form of $3m$ and $3m+1$. Hence, square of any positive number cannot be of the form $3m+2$.

Q. 5 A positive integer is of the form $3q+1$, q being a natural number. Can you write its square in any form other than $3m+1$, i.e., $3m$ or $3m+2$ for some integer m ? Justify your answer.

Sol. No, by Euclid's Lemma, $b = aq + r, 0 \leq r < a$. Here, b is any positive integer $a = 3, b = 3q + r$ for $0 \leq r < 3$

So, this must be in the form $3q, 3q+1$ or $3q+2$.

Now, $(3q)^2 = 9q^2 = 3m$ [here, $m = 3q^2$]

and $(3q+1)^2 = 9q^2 + 6q + 1 = 3(3q^2 + 2q) + 1 = 3m + 1$ [where, $m = 3q^2 + 2q$]

Also, $(3q+2)^2 = 9q^2 + 12q + 4 = 3(3q^2 + 4q + 1) + 1 = 3m + 1$ [here, $m = 3q^2 + 4q + 1$]

Hence, square of a positive integer is of the form $3q+1$ is always in the form $3m+1$ for some integer m .

Q. 6 The numbers 525 and 3000 are both divisible only by 3, 5, 15, 25 and 75. What is HCF (525, 3000)? Justify your answer.

Sol. Since, the HCF (525, 3000) = 75
 By Euclid's Lemma, $3000 = 525 \times 5 + 375$ [\therefore dividend = divisor \times quotient + remainder]
 $525 = 375 \times 1 + 150$
 $375 = 150 \times 2 + 75$
 $150 = 75 \times 2 + 0$

and the numbers 3, 5, 15, 25 and 75 divides the numbers 525 and 3000 that mean these terms are common in both 525 and 3000. So, the highest common factor among these is 75.

Q. 7 Explain why $3 \times 5 \times 7 + 7$ is a composite number.

💡 Thinking Process

A number which has more than two factors is known as a composite number.

Sol. We have, $3 \times 5 \times 7 + 7 = 105 + 7 = 112$
 Now, $112 = 2 \times 2 \times 2 \times 2 \times 7 = 2^4 \times 7$
 So, it is the product of prime factors 2 and 7. *i.e.*, it has more than two factors.
 Hence, it is a composite number.

Q. 8 Can two numbers have 18 as their HCF and 380 as their LCM? Give reasons.

Sol. No, because HCF is always a factor of LCM but here 18 is not a factor of 380.

Q. 9 Without actually performing the long division, find if $\frac{987}{10500}$ will have terminating or non-terminating (repeating) decimal expansion. Give reasons for your answer.

Sol. Yes, after simplification denominator has factor $5^3 \cdot 2^2$ and which is of the type $2^m \cdot 5^n$. So, this is terminating decimal.

$$\begin{aligned} \therefore \frac{987}{10500} &= \frac{47}{500} = \frac{47}{5^3 \cdot 2^2} \times \frac{2}{2} \\ &= \frac{94}{5^3 \times 2^3} = \frac{94}{(10)^3} = \frac{94}{1000} = 0.094 \end{aligned}$$

Q. 10 A rational number in its decimal expansion is 327.7081. What can you say about the prime factors of q , when this number is expressed in the form $\frac{p}{q}$? Give reasons.

Sol. 327.7081 is terminating decimal number. So, it represents a rational number and also its denominator must have the form $2^m \times 5^n$.

$$\text{Thus, } 327.7081 = \frac{3277081}{10000} = \frac{p}{q} \quad (\text{say})$$

$$\begin{aligned} \therefore q &= 10^4 = 2 \times 2 \times 2 \times 2 \times 5 \times 5 \times 5 \times 5 \\ &= 2^4 \times 5^4 = (2 \times 5)^4 \end{aligned}$$

Hence, the prime factors of q is 2 and 5.

Exercise 1.3 Short Answer Type Questions

Q. 1 Show that the square of any positive integer is either of the form $4q$ or $4q + 1$ for some integer q .

Thinking Process

Use Euclid's division algorithm, put the value of divisor as 4 and then put the value of remainder from 0 to 3 and get the different form. Now, squaring every different form and get the required form.

Sol. Let a be an arbitrary positive integer. Then, by, Euclid's division algorithm, corresponding to the positive integers a and 4, there exist non-negative integers m and r , such that

$$a = 4m + r, \text{ where } 0 \leq r < 4$$

$$\Rightarrow a^2 = 16m^2 + r^2 + 8mr \quad \dots(i)$$

$$\text{where, } 0 \leq r < 4 \quad [\because (a + b)^2 = a^2 + 2ab + b^2]$$

Case I When $r = 0$, then putting $r = 0$ in Eq. (i), we get

$$a^2 = 16m^2 = 4(4m^2) = 4q$$

where, $q = 4m^2$ is an integer.

Case II When $r = 1$, then putting $r = 1$ in Eq. (i), we get

$$\begin{aligned} a^2 &= 16m^2 + 1 + 8m \\ &= 4(4m^2 + 2m) + 1 = 4q + 1 \end{aligned}$$

where, $q = (4m^2 + 2m)$ is an integer.

Case III When $r = 2$, then putting $r = 2$ in Eq. (i), we get

$$\begin{aligned} a^2 &= 16m^2 + 4 + 16m \\ &= 4(4m^2 + 4m + 1) = 4q \end{aligned}$$

where, $q = (4m^2 + 4m + 1)$ is an integer.

Case IV When $r = 3$, then putting $r = 3$ in Eq. (i), we get

$$\begin{aligned} a^2 &= 16m^2 + 9 + 24m = 16m^2 + 24m + 8 + 1 \\ &= 4(4m^2 + 6m + 2) + 1 = 4q + 1 \end{aligned}$$

where, $q = (4m^2 + 6m + 2)$ is an integer.

Hence, the square of any positive integer is either of the form $4q$ or $4q + 1$ for some integer q .

Q. 2 Show that cube of any positive integer is of the form $4m$, $4m + 1$ or $4m + 3$, for some integer m .

Thinking Process

Use Euclid's division algorithm. Put the value of remainder from 0 to 3, get the different forms of any positive integer. Now cubing to every different form of positive integer and get the required forms.

Sol. Let a be an arbitrary positive integer. Then, by Euclid's division algorithm, corresponding to the positive integers a and 4, there exist non-negative integers q and r such that

$$a = 4q + r, \text{ where } 0 \leq r < 4$$

$$\Rightarrow a^3 = (4q + r)^3 = 64q^3 + r^3 + 12qr^2 + 48q^2r \quad [\because (a + b)^3 = a^3 + b^3 + 3ab^2 + 3a^2b]$$

$$\Rightarrow a^3 = (64q^2 + 48q^2r + 12qr^2) + r^3 \quad \dots(i)$$

$$\text{where, } 0 \leq r < 4$$

Case I When $r = 0$,

Putting $r = 0$ in Eq. (i), we get

$$a^3 = 64q^3 = 4(16q^3)$$

$\Rightarrow a^3 = 4m$ where $m = 16q^3$ is an integer.

Case II When $r = 1$, then putting $r = 1$ in Eq. (i), we get

$$\begin{aligned} a^3 &= 64q^3 + 48q^2 + 12q + 1 \\ &= 4(16q^3 + 12q^2 + 3q) + 1 \\ &= 4m + 1 \end{aligned}$$

where, $m = (16q^3 + 12q^2 + 3q)$ is an integer.

Case III When $r = 2$, then putting $r = 2$ in Eq. (i), we get

$$\begin{aligned} a^3 &= 64q^3 + 144q^2 + 108q + 27 \\ &= 64q^3 + 144q^2 + 108q + 24 + 3 \\ &= 4(16q^3 + 36q^2 + 27q + 6) + 3 = 4m + 3 \end{aligned}$$

where, $m = (16q^3 + 36q^2 + 27q + 6)$ is an integer.

Hence, the cube of any positive integer is of the form $4m$, $4m + 1$ or $4m + 3$ for some integer m .

Q. 3 Show that the square of any positive integer cannot be of the form $5q + 2$ or $5q + 3$ for any integer q .

Sol. Let a be an arbitrary positive integer.

Then, by Euclid's divisions Algorithm, corresponding to the positive integers a and 5 , there exist non-negative integers m and r such that

$$\begin{aligned} a &= 5m + r, \text{ where } 0 \leq r < 5 \\ \Rightarrow a^2 &= (5m + r)^2 = 25m^2 + r^2 + 10mr \quad [:(a + b)^2 = a^2 + 2ab + b^2] \\ \Rightarrow a^2 &= 5(5m^2 + 2mr) + r^2 \quad \dots(i) \end{aligned}$$

where, $0 \leq r < 5$

Case I When $r = 0$, then putting $r = 0$ in Eq. (i), we get

$$a^2 = 5(5m^2) = 5q$$

where, $q = 5m^2$ is an integer.

Case II When $r = 1$, then putting $r = 1$ in Eq. (i), we get

$$a^2 = 5(5m^2 + 2m) + 1$$

$\Rightarrow q = 5q + 1$

where, $q = (5m^2 + 2m)$ is an integer.

Case III When $r = 2$, then putting $r = 2$ in Eq. (i), we get

$$a^2 = 5(5m^2 + 4m) + 4 = 5q + 4$$

where, $q = (5m^2 + 4m)$ is an integer.

Case IV When $r = 3$, then putting $r = 3$ in Eq. (i), we get

$$\begin{aligned} a^2 &= 5(5m^2 + 6m) + 9 = 5(5m^2 + 6m) + 5 + 4 \\ &= 5(5m^2 + 6m + 1) + 4 = 5q + 4 \end{aligned}$$

where, $q = (5m^2 + 6m + 1)$ is an integer.

Case V When $r = 4$, then putting $r = 4$ in Eq. (i), we get

$$a^2 = 5(5m^2 + 8m) + 16 = 5(5m^2 + 8m) + 15 + 1$$

$$\Rightarrow a^2 = 5(5m^2 + 8m + 3) + 1 = 5q + 1$$
 where, $q = (5m^2 + 8m + 3)$ is an integer.

Hence, the square of any positive integer cannot be of the form $5q + 2$ or $5q + 3$ for any integer q .

Q. 4 Show that the square of any positive integer cannot be of the form $6m + 2$ or $6m + 5$ for any integer m .

Sol. Let a be an arbitrary positive integer, then by Euclid's division algorithm, corresponding to the positive integers a and 6 , there exist non-negative integers q and r such that

$$a = 6q + r, \text{ where } 0 \leq r < 6$$

$$\Rightarrow a^2 = (6q + r)^2 = 36q^2 + r^2 + 12qr \quad [\because (a + b)^2 = a^2 + 2ab + b^2]$$

$$\Rightarrow a^2 = 6(6q^2 + 2qr) + r^2 \quad \dots(i)$$

where, $0 \leq r < 6$

Case I When $r = 0$, then putting $r = 0$ in Eq. (i), we get

$$a^2 = 6(6q^2) = 6m$$

where, $m = 6q^2$ is an integer.

Case II When $r = 1$, then putting $r = 1$ in Eq. (i), we get

$$a^2 = 6(6q^2 + 2q) + 1 = 6m + 1$$

where, $m = (6q^2 + 2q)$ is an integer.

Case III When $r = 2$, then putting $r = 2$ in Eq (i), we get

$$a^2 = 6(6q^2 + 4q) + 4 = 6m + 4$$

where, $m = (6q^2 + 4q)$ is an integer.

Case IV When $r = 3$, then putting $r = 3$ in Eq. (i), we get

$$a^2 = 6(6q^2 + 6q) + 9$$

$$= 6(6q^2 + 6q) + 6 + 3$$

$$\Rightarrow a^2 = 6(6q^2 + 6q + 1) + 3 = 6m + 3$$

where, $m = (6q + 6q + 1)$ is an integer.

Case V When $r = 4$, then putting $r = 4$ in Eq. (i), we get

$$a^2 = 6(6q^2 + 8q) + 16$$

$$= 6(6q^2 + 8q) + 12 + 4$$

$$\Rightarrow a^2 = 6(6q^2 + 8q + 2) + 4 = 6m + 4$$

where, $m = (6q^2 + 8q + 2)$ is an integer.

Case VI When $r = 5$, then putting $r = 5$ in Eq. (i), we get

$$a^2 = 6(6q^2 + 10q) + 25$$

$$= 6(6q^2 + 10q) + 24 + 1$$

$$\Rightarrow a^2 = 6(6q^2 + 10q + 4) + 1 = 6m + 1$$

where, $m = (6q^2 + 10q + 4)$ is an integer.

Hence, the square of any positive integer cannot be of the form $6m + 2$ or $6m + 5$ for any integer m .

Q. 5 Show that the square of any odd integer is of the form $4m + 1$, for some integer m .

Sol. By Euclid's division algorithm, we have $a = bq + r$, where $0 \leq r < 4$... (i)

On putting $b = 4$ in Eq. (i), we get

$$a = 4q + r, \text{ where } 0 \leq r < 4 \text{ i.e., } r = 0, 1, 2, 3 \quad \dots \text{(ii)}$$

If $r = 0 \Rightarrow a = 4q$, $4q$ is divisible by 2 $\Rightarrow 4q$ is even.

If $r = 1 \Rightarrow a = 4q + 1$, $(4q + 1)$ is not divisible by 2.

If $r = 2 \Rightarrow a = 4q + 2$, $2(2q + 1)$ is divisible by 2 $\Rightarrow 2(2q + 1)$ is even.

If $r = 3 \Rightarrow a = 4q + 3$, $(4q + 3)$ is not divisible by 2.

So, for any positive integer q , $(4q + 1)$ and $(4q + 3)$ are odd integers.

Now, $a^2 = (4q + 1)^2 = 16q^2 + 1 + 8q = 4(4q^2 + 2q) + 1$

$$[\because (a + b)^2 = a^2 + 2ab + b^2]$$

is a square which is of the form $4m + 1$, where $m = (4q^2 + 2q)$ is an integer.

and $a^2 = (4q + 3)^2 = 16q^2 + 9 + 24q = 4(4q^2 + 6q + 2) + 1$ is a square

$$[\because (a + b)^2 = a^2 + 2ab + b^2]$$

which is of the form $4m + 1$, where $m = (4q^2 + 6q + 2)$ is an integer.

Hence, for some integer m , the square of any odd integer is of the form $4m + 1$.

Q. 6 If n is an odd integer, then show that $n^2 - 1$ is divisible by 8.

Sol. Let $a = n^2 - 1$... (i)

Given that, n is an odd integer.

$$\therefore n = 1, 3, 5, \dots$$

From Eq. (i), at $n = 1$, $a = (1)^2 - 1 = 1 - 1 = 0$,

which is divisible by 8.

From Eq. (i), at $n = 3$, $a = (3)^2 - 1 = 9 - 1 = 8$,

which is divisible by 8.

From Eq. (i), at $n = 5$, $a = (5)^2 - 1 = 25 - 1 = 24 = 3 \times 8$,

which is divisible by 8.

From Eq. (i), at $n = 7$, $a = (7)^2 - 1 = 49 - 1 = 48 = 6 \times 8$,

which is divisible by 8.

Hence, $(n^2 - 1)$ is divisible by 8, where n is an odd integer.

Alternate Method

We know that an odd integer n is of the form $(4q + 1)$ or $(4q + 3)$ for some integer q .

Case I When $n = 4q + 1$

In this case, we have

$$\begin{aligned} (n^2 - 1) &= (4q + 1)^2 - 1 \\ &= 16q^2 + 1 + 8q - 1 \end{aligned}$$

$$(a + b)^2 = a^2 + 2ab + b^2]$$

$$= 16q^2 + 8q = 8q(2q + 1)$$

$$= 16q^2 + 8q = 8q(2q + 1)$$

which is clearly, divisible by 8.

Case II When $n = 4q + 3$

In this case, we have

$$\begin{aligned} (n^2 - 1) &= (4q + 3)^2 - 1 \\ &= 16q^2 + 9 + 24q - 1 \quad [\because (a + b)^2 = a^2 + 2ab + b^2] \\ &= 16q^2 + 24q + 8 \\ &= 8(2q^2 + 3q + 1) \end{aligned}$$

which is clearly divisible by 8.

Hence, $(n^2 - 1)$ is divisible by 8.

Q. 7 Prove that, if x and y are both odd positive integers, then $x^2 + y^2$ is even but not divisible by 4.

Thinking Process

Here we have to take any two consecutive odd positive integers. After that squaring and adding both the number and check it is even but not divisible by 4.

Sol. Let $x = 2m + 1$ and $y = 2m + 3$ are odd positive integers, for every positive integer m .

Then,

$$\begin{aligned} x^2 + y^2 &= (2m + 1)^2 + (2m + 3)^2 \\ &= 4m^2 + 1 + 4m + 4m^2 + 9 + 12m \quad [\because (a + b)^2 = a^2 + 2ab + b^2] \\ &= 8m^2 + 16m + 10 = \text{even} \\ &= 2(4m^2 + 8m + 5) \text{ or } 4(2m^2 + 4m + 2) + 1 \end{aligned}$$

Hence, $x^2 + y^2$ is even for every positive integer m but not divisible by 4.

Q. 8 Use Euclid's division algorithm to find the HCF of 441, 567 and 693.

Thinking Process

First we use Euclid's division algorithm between two larger numbers any of three and get the HCF between these two. After that we take the third number and resulting HCF of two numbers and apply again Euclid's division algorithm and get the required HCF.

Sol. Let $a = 693$, $b = 567$ and $c = 441$

By Euclid's division algorithms,

$$a = bq + r \quad \dots(i)$$

[\because dividend = divisor \times quotient + remainder]

First we take, $a = 693$ and $b = 567$ and find their HCF.

$$\begin{aligned} 693 &= 567 \times 1 + 126 \\ 567 &= 126 \times 4 + 63 \\ 126 &= 63 \times 2 + 0 \end{aligned}$$

$$\therefore \text{HCF}(693, 567) = 63$$

Now, we take $c = 441$ and say $d = 63$, then find their HCF.

Again, using Euclid's division algorithm,

$$c = dq + r$$

$$\Rightarrow 441 = 63 \times 7 + 0$$

$$\therefore \text{HCF}(693, 567, 441) = 63$$

Q. 9 Using Euclid's division algorithm, find the largest number that divides 1251, 9377 and 15628 leaving remainders 1, 2 and 3, respectively.

Sol. Since, 1, 2 and 3 are the remainders of 1251, 9377 and 15628, respectively. Thus, after subtracting these remainders from the numbers.

We have the numbers, $1251 - 1 = 1250$, $9377 - 2 = 9375$ and $15628 - 3 = 15625$

which is divisible by the required number.

Now, required number = HCF of 1250, 9375 and 15625 [for the largest number]

By Euclid's division algorithm,

$$a = bq + r \quad \dots(i)$$

[\because dividend = divisor \times quotient + remainder]

For largest number, put $a = 15625$ and $b = 9375$

$$15625 = 9375 \times 1 + 6250 \quad [\text{from Eq. (i)}]$$

$$\Rightarrow 9375 = 6250 \times 1 + 3125$$

$$\Rightarrow 6250 = 3125 \times 2 + 0$$

$$\therefore \text{HCF}(15625, 9375) = 3125$$

Now, we take $c = 1250$ and $d = 3125$, then again using Euclid's division algorithm,

$$d = cq + r \quad [\text{from Eq. (i)}]$$

$$\Rightarrow 3125 = 1250 \times 2 + 625$$

$$\Rightarrow 1250 = 625 \times 2 + 0$$

$$\therefore \text{HCF}(1250, 9375, 15625) = 625$$

Hence, 625 is the largest number which divides 1251, 9377 and 15628 leaving remainder 1, 2 and 3, respectively.

Q. 10 Prove that $\sqrt{3} + \sqrt{5}$ is irrational.

Thinking Process

In this type of question, we use the contradiction method i.e., we assume given number is rational and at last we have to prove our assumption is wrong, i.e., the number is irrational.

Sol. Let us suppose that $\sqrt{3} + \sqrt{5}$ is rational.

Let $\sqrt{3} + \sqrt{5} = a$, where a is rational.

Therefore,
$$\sqrt{3} = a - \sqrt{5}$$

On squaring both sides, we get

$$(\sqrt{3})^2 = (a - \sqrt{5})^2$$

$$\Rightarrow 3 = a^2 + 5 - 2a\sqrt{5} \quad [\because (a - b)^2 = a^2 + b^2 - 2ab]$$

$$\Rightarrow 2a\sqrt{5} = a^2 + 2$$

Therefore,
$$\sqrt{5} = \frac{a^2 + 2}{2a} \text{ which is contradiction.}$$

As the right hand side is rational number while $\sqrt{5}$ is irrational. Since, 3 and 5 are prime numbers. Hence, $\sqrt{3} + \sqrt{5}$ is irrational.

Q. 11 Show that 12^n cannot end with the digit 0 or 5 for any natural number n .

Sol. If any number ends with the digit 0 or 5, it is always divisible by 5.

If 12^n ends with the digit zero it must be divisible by 5.

This is possible only if prime factorisation of 12^n contains the prime number 5.

Now,
$$12 = 2 \times 2 \times 3 = 2^2 \times 3$$

$$\Rightarrow 12^n = (2^2 \times 3)^n = 2^{2n} \times 3^n \quad [\text{since, there is no term contains 5}]$$

Hence, there is no value of $n \in N$ for which 12^n ends with digit zero or five.

Q. 12 On a morning walk, three persons step off together and their steps measure 40 cm, 42 cm and 45 cm, respectively. What is the minimum distance each should walk, so that each can cover the same distance in complete steps?

Sol. We have to find the LCM of 40 cm, 42 cm and 45 cm to get the required minimum distance.
 For this, $40 = 2 \times 2 \times 2 \times 5$,
 $42 = 2 \times 3 \times 7$
 and $45 = 3 \times 3 \times 5$
 \therefore LCM (40, 42, 45) = $2 \times 3 \times 5 \times 2 \times 2 \times 3 \times 7$
 $= 30 \times 12 \times 7 = 210 \times 12$
 $= 2520$

Minimum distance each should walk 2520 cm. So that, each can cover the same distance in complete steps.

Q. 13 Write the denominator of rational number $\frac{257}{5000}$ in the form $2^m \times 5^n$, where m, n are non-negative integers. Hence, write its decimal expansion, without actual division.

Sol. Denominator of the rational number $\frac{257}{5000}$ is 5000.

Now, factors of $5000 = 2 \times 2 \times 2 \times 5 \times 5 \times 5 \times 5 = (2)^3 \times (5)^4$, which is of the type $2^m \times 5^n$, where $m = 3$ and $n = 4$ are non-negative integers.

$$\therefore \text{Rational number} = \frac{257}{5000} = \frac{257}{2^3 \times 5^4} \times \frac{2}{2}$$

$$\begin{aligned} & \text{[since, multiplying numerator and denominator by 2]} \\ & = \frac{514}{2^4 \times 5^4} = \frac{514}{(10)^4} \\ & = \frac{514}{10000} = 0.0514 \end{aligned}$$

Hence, which is the required decimal expansion of the rational $\frac{257}{5000}$ and it is also a terminating decimal number.

Q. 14 Prove that $\sqrt{p} + \sqrt{q}$ is irrational, where p and q are primes.

Sol. Let us suppose that $\sqrt{p} + \sqrt{q}$ is rational.

Again, let $\sqrt{p} + \sqrt{q} = a$, where a is rational.

Therefore, $\sqrt{q} = a - \sqrt{p}$

On squaring both sides, we get

$$q = a^2 + p - 2a\sqrt{p} \quad [\because (a - b)^2 = a^2 + b^2 - 2ab]$$

Therefore, $\sqrt{p} = \frac{a^2 + p - q}{2a}$, which is a contradiction as the right hand side is rational number while \sqrt{p} is irrational, since p and q are prime numbers.

Hence, $\sqrt{p} + \sqrt{q}$ is irrational.

Exercise 1.4 Long Answer Type Questions

Q. 1 Show that the cube of a positive integer of the form $6q + r$, q is an integer and $r = 0, 1, 2, 3, 4, 5$ is also of the form $6m + r$.

Sol. Let a be an arbitrary positive integer. Then, by Euclid's division algorithm, corresponding to the positive integers ' a ' and 6, there exist non-negative integers q and r such that

$$a = 6q + r, \text{ where, } 0 \leq r < 6$$

$$\Rightarrow a^3 = (6q + r)^3 = 216q^3 + r^3 + 3 \cdot 6q \cdot r(6q + r)$$

$$\qquad \qquad \qquad [\because (a + b)^3 = a^3 + b^3 + 3ab(a + b)]$$

$$\Rightarrow a^3 = (216q^3 + 108q^2r + 18qr^2) + r^3 \qquad \dots(i)$$

where, $0 \leq r < 6$

Case I When $r = 0$, then putting $r = 0$ in Eq. (i), we get

$$a^3 = 216q^3 = 6(36q^3) = 6m$$

where, $m = 36q^3$ is an integer.

Case II When $r = 1$, then putting $r = 1$ in Eq. (i), we get

$$a^3 = (216q^3 + 108q^3 + 18q) + 1 = 6(36q^3 + 18q^3 + 3q) + 1$$

$$\Rightarrow a^3 = 6m + 1, \text{ where } m = (36q^3 + 18q^3 + 3q) \text{ is an integer.}$$

Case III When $r = 2$, then putting $r = 2$ in Eq. (i), we get

$$a^3 = (216q^3 + 216q^2 + 72q) + 8$$

$$a^3 = (216q^3 + 216q^2 + 72q + 6) + 2$$

$$\Rightarrow a^3 = 6(36q^3 + 36q^2 + 12q + 1) + 2 = 6m + 2$$

where, $m = (36q^3 + 36q^2 + 12q + 1)$ is an integer.

Case IV When $r = 3$, then putting $r = 3$ in Eq. (i), we get

$$a^3 = (216q^3 + 324q^2 + 162q) + 27 = (216q^3 + 324q^2 + 162q + 24) + 3$$

$$= 6(36q^3 + 54q^2 + 27q + 4) + 3 = 6m + 3$$

where, $m = (36q^3 + 54q^2 + 27q + 4)$ is an integer.

Case V When $r = 4$, then putting $r = 4$ in Eq. (i), we get

$$a^3 = (216q^3 + 432q^2 + 288q) + 64$$

$$= 6(36q^3 + 72q^2 + 48q) + 60 + 4$$

$$= a^3 = 6(36q^3 + 72q^2 + 48q + 10) + 4 = 6m + 4$$

where, $m = (36q^3 + 72q^2 + 48q + 10)$ is an integer.

Case VI When $r = 5$, then putting $r = 5$ in Eq. (i), we get

$$a^3 = (216q^3 + 540q^2 + 450q) + 125$$

$$\Rightarrow a^3 = (216q^3 + 540q^2 + 450q) + 120 + 5$$

$$\Rightarrow a^3 = 6(36q^3 + 90q^2 + 75q + 20) + 5$$

$$\Rightarrow a^3 = 6m + 5$$

where, $m = (36q^3 + 90q^2 + 75q + 20)$ is an integer.

Hence, the cube of a positive integer of the form $6q + r$, q is an integer and $r = 0, 1, 2, 3, 4, 5$ is also of the forms $6m, 6m + 1, 6m + 2, 6m + 3, 6m + 4$ and $6m + 5$ i.e., $6m + r$.

Q. 2 Prove that one and only one out of n , $(n + 2)$ and $(n + 4)$ is divisible by 3, where n is any positive integer.

Thinking Process

Since, n is positive integer put $n = 1, 2, 3, \dots$ in the given numbers and makes the order triplets, then we see that any one digit in a triplet is divisible by 3.

Sol. Let $a = n$, $b = n + 2$ and $c = n + 4$

\therefore Order triplet is $(a, b, c) = (n, n + 2, n + 4)$... (i)

Where, n is any positive integer i.e., $n = 1, 2, 3, \dots$

At $n = 1$; $(a, b, c) = (1, 1 + 2, 1 + 4) = (1, 3, 5)$

At $n = 2$; $(a, b, c) = (2, 2 + 2, 2 + 4) = (2, 4, 6)$

At $n = 3$; $(a, b, c) = (3, 3 + 2, 3 + 4) = (3, 5, 7)$

At $n = 4$; $(a, b, c) = (4, 4 + 2, 4 + 4) = (4, 6, 8)$

At $n = 5$; $(a, b, c) = (5, 5 + 2, 5 + 4) = (5, 7, 9)$

At $n = 6$; $(a, b, c) = (6, 6 + 2, 6 + 4) = (6, 8, 10)$

At $n = 7$; $(a, b, c) = (7, 7 + 2, 7 + 4) = (7, 9, 11)$

At $n = 8$; $(a, b, c) = (8, 8 + 2, 8 + 4) = (8, 10, 12)$

We observe that each triplet consist of one and only one number which is multiple of 3 i.e., divisible by 3.

Hence, one and only one out of $n, (n + 2)$ and $(n + 4)$ is divisible by 3, where, n is any positive integer.

Alternate Method

On dividing 'n' by 3, let q be the quotient and r be the remainder.

Then, $n = 3q + r$, where, $0 \leq r < 3$

$\Rightarrow n = 3q + r$, where, $r = 0, 1, 2$

$\Rightarrow n = 3q$ or $n = 3q + 1$ or $n = 3q + 2$

Case I If $n = 3q$, then n is only divisible by 3.
but $n + 2$ and $n + 4$ are not divisible by 3.

Case II If $n = 3q + 1$, then $(n + 2) = 3q + 3 = 3(q + 1)$, which is only divisible by 3,
but n and $n + 4$ are not divisible by 3.
So, in this case, $(n + 2)$ is divisible by 3.

Case III When $n = 3q + 2$, then $(n + 4) = 3q + 6 = 3(q + 2)$, which is only divisible by 3,
but n and $(n + 2)$ are not divisible by 3.
So, in this case, $(n + 4)$ is divisible by 3.

Hence, one and only one out of $n, (n + 2)$ and $(n + 4)$ is divisible by 3.

Q. 3 Prove that one of any three consecutive positive integers must be divisible by 3.

Sol. Any three consecutive positive integers must be of the form $n, (n + 1)$ and $(n + 2)$, where n is any natural number. i.e., $n = 1, 2, 3, \dots$

Let, $a = n, b = n + 1$ and $c = n + 2$

\therefore Order triplet is $(a, b, c) = (n, n + 1, n + 2)$, where $n = 1, 2, 3, \dots$... (i)

At $n = 1$; $(a, b, c) = (1, 1 + 1, 1 + 2) = (1, 2, 3)$

At $n = 2$; $(a, b, c) = (2, 2 + 1, 2 + 2) = (2, 3, 4)$

At $n = 3$; $(a, b, c) = (3, 3 + 1, 3 + 2) = (3, 4, 5)$

At $n = 4$; $(a, b, c) = (4, 4 + 1, 4 + 2) = (4, 5, 6)$

At $n = 5$; $(a, b, c) = (5, 5 + 1, 5 + 2) = (5, 6, 7)$

At $n = 6$; $(a, b, c) = (6, 6 + 1, 6 + 2) = (6, 7, 8)$

At $n = 7$; $(a, b, c) = (7, 7 + 1, 7 + 2) = (7, 8, 9)$

At $n = 8$; $(a, b, c) = (8, 8 + 1, 8 + 2) = (8, 9, 10)$

We observe that each triplet consist of one and only one number which is multiple of 3 i.e., divisible by 3.

Hence, one of any three consecutive positive integers must be divisible by 3.

Q. 4 For any positive integer n , prove that $n^3 - n$ is divisible by 6.

Sol. Let $a = n^3 - n \Rightarrow a = n \cdot (n^2 - 1)$
 $\Rightarrow a = n \cdot (n - 1) \cdot (n + 1)$ [$\because (a^2 - b^2) = (a - b)(a + b)$]
 $\Rightarrow a = (n - 1) \cdot n \cdot (n + 1)$... (i)

We know that,

I. If a number is completely divisible by 2 and 3, then it is also divisible by 6.

II. If the sum of digits of any number is divisible by 3, then it is also divisible by 3.

III. If one of the factor of any number is an even number, then it is also divisible by 2.

$\therefore a = (n - 1) \cdot n \cdot (n + 1)$ [from Eq. (i)]

Now, sum of the digits $= n - 1 + n + n + 1 = 3 \cdot n$

$=$ multiple of 3, where n is any positive integer.

and $(n - 1) \cdot n \cdot (n + 1)$ will always be even, as one out of $(n - 1)$ or n or $(n + 1)$ must of even.

Since, conditions II and III is completely satisfy the Eq. (i).

Hence, by condition I the number $n^3 - n$ is always divisible by 6, where n is any positive integer. **Hence proved.**

Q. 5 Show that one and only one out of $n, n + 4, n + 8, n + 12$ and $n + 16$ is divisible by 5, where n is any positive integer.

Sol. Given numbers are $n, (n + 4), (n + 8), (n + 12)$ and $(n + 16)$, where n is any positive integer.
 Then, let $n = 5q, 5q + 1, 5q + 2, 5q + 3, 5q + 4$ for $q \in N$ [by Euclid's algorithm]
 Then, in each case if we put the different values of n in the given numbers. We definitely get one and only one of given numbers is divisible by 5.

Hence, one and only one out of $n, n + 4, n + 8, n + 12$ and $n + 16$ is divisible by 5.

Alternate Method

On dividing on n by 5, let q be the quotient and r be the remainder.

Then $n = 5q + r$, where $0 \leq r < 5$.

$\Rightarrow n = 5q + r$, where $r = 0, 1, 2, 3, 4$

$\Rightarrow n = 5q$ or $5q + 1$ or $5q + 2$ or $5q + 3$ or $5q + 4$.

Case I If $n = 5q$, then n is only divisible by 5.

Case II If $n = 5q + 1$, then $n + 4 = 5q + 1 + 4 = 5q + 5 = 5(q + 1)$, which is only divisible by 5.

So, in this case, $(n + 4)$ is divisible by 5.

Case III If $n = 5q + 3$, then $n + 2 = 5q + 3 + 2 = 5q + 5 = 5(q + 1)$, which is divisible by 5.

So, in this case $(n + 2)$ is only divisible by 5.

Case IV If $n = 5q + 4$, then $n + 16 = 5q + 4 + 16 = 5q + 20 = 5(q + 4)$, which is divisible by 5.

So, in this case, $(n + 16)$ is only divisible by 5.

Hence, one and only one out of $n, n + 4, n + 8, n + 12$ and $n + 16$ is divisible by 5, where n is any positive integer.