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Convergence of Sequences

1. **Convergent sequence :** A sequence $<a_n>$ is said to be convergent iff limit of sequence is exist.

$<(-1)^n>$

Result :

(1) If any sequence $\langle a_n \rangle$ contain more than one limit points then this sequence is not convergent.

$\langle (-1)^n \rangle$

(2) Every convergent sequence is bounded but the converse is not true.

$\langle n \rangle, \langle -n \rangle$

(3) Unbounded sequence never convergent.

(4) A bounded sequence with unique limit point is convergent.

$$\begin{cases} 2 & \text{if } n \text{ is prime} \\ n & \text{if } n \text{ is not prime} \end{cases}$$

2

Divergent Sequence : If the sequence does not have any limit point then this sequence is called divergent sequence.

Another Definition : If the limit of sequence is $\pm\infty$, then this sequence is called divergent sequence.

$\langle a_n \rangle = \langle 2^n \rangle$

$\langle n \rangle$

$\langle n^2 \rangle$

$\langle n^2 + n \rangle$

$\langle -n \rangle$

Result :

(1) A monotonic and unbounded above sequence is always divergence to ∞.

$\langle n \rangle$

(2) A monotonic and unbounded below sequence is always divergence to $-\infty$.

$\langle -n \rangle$

Some important result on divergence sequence :

(1) If $\langle a_n \rangle$ and $\langle b_n \rangle$ are two divergence sequence then $\langle a_n + b_n \rangle$ is may ~~also divergence.~~ be div. or conv.

Example : Let $\langle a_n \rangle = \langle n \rangle$ & $\langle b_n \rangle = \langle 2^n \rangle$

Then $\langle n + 2^n \rangle$ is divergence sequence.

(2) If $\langle a_n \rangle$ and $\langle b_n \rangle$ are two convergent sequence then $\langle a_n + b_n \rangle$ is also convergent.

(3) If $\langle a_n \rangle$ and $\langle b_n \rangle$ are divergent sequence then $\langle a_n b_n \rangle$ is also divergent sequence.

(4) Let $\langle a_n \rangle$ is a convergent sequence and $\langle b_n \rangle$ is divergent sequence then $\langle a_n + b_n \rangle$ is always divergent sequence.

Oscillatory Sequence : A sequence which is neither converges nor divergent, then this sequence is called oscillatory sequence.

Another Definition : If sequence have more than one limit points then it is called oscillatory sequence.

$\langle (-1)^n \rangle$

$\langle 1+(-1)^n \rangle$

Types of Oscillatory Sequence :

(1) **Finitely Oscillatory Sequence :** If limit point of oscillatory sequence are finite then this sequence is called finitely oscillatory sequence.

Note : Any bounded sequence which does not converge is said to oscillate finitely.

(2) **Infinitely oscillatory sequence :** A sequence $\langle a_n \rangle$ is said to oscillate infinitely, if it is unbounded and is divergent neither ∞ nor $-\infty$.

$(-1)^n (n^2+n)$

$\langle (-1)^n n \rangle$

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Result :

(1) Every oscillatory sequence is non-monotonic but converse need not be true.

$< 1 + \frac{1}{n} >$

Monotonic sequence and their convergence

(1) Every monotonically increasing sequence which is bounded above is always convergent and converge to its least upper bound.

(2) Every monotonic decreasing sequence which is bounded below is always convergent and converges to greatest lower bound.

(3) A necessary and sufficient condition for a monotonic sequence to be convergent if it is bounded.

$\langle \frac{1}{n} \rangle$

$\langle n \rangle$

$\langle -n \rangle$

Q.1. Let $\langle x_n \rangle$ be a real sequence such that $7x_{n+1} = x_n^3 + 6$ for $n \geq 1$. Then which of the following is/are true? **IIT-JAM 2017**

(a) If $x_1 = \frac{1}{2}$ then , $\langle x_n \rangle$ converges to 1.

(b) If $x_1 = \frac{1}{2}$ then , $\langle x_n \rangle$ converges to 2.

(c) If $x_1 = \frac{3}{2}$ then , $\langle x_n \rangle$ converges to 1.

(d) If $x_1 = \frac{3}{2}$ then , $\langle x_n \rangle$ converges to -3.

2017

$\langle a_n \rangle$, $a_1 = 1$ $a_{n+1} = \frac{7a_n + 11}{21}$

(a) $\langle a_n \rangle \uparrow$ dv.

(b) $\langle a_n \rangle \uparrow$ $\lim_{n \to \infty} a_n = \frac{11}{14}$

(c) $\langle a_n \rangle \downarrow$ dv.

(d) $\langle a_n \rangle \downarrow$ $\lim_{n \to \infty} a_n = \frac{11}{14}$

$l = \frac{7l + 11}{21}$

$21l = 7l + 11$

$14l = 11$

$l = \frac{11}{14}$

$a_1 = 1$

$a_2 = \frac{7 + 11}{21} = \frac{18}{21}$

Q

$\langle x_n \rangle$ is convergent
$\langle y_n \rangle$ is bounded

then

(a) $\langle x_n + y_n \rangle$ is convergent
(b) $\langle x_n + y_n \rangle$ is bounded
(c) $\langle x_n + y_n \rangle$ is oscillating
(d) $\langle x_n + y_n \rangle$ is div.

$\langle \frac{1}{n} \rangle$

$\langle (-1)^n \rangle$

$\langle \frac{1}{n} + (-1)^n \rangle$

$\langle \frac{1}{n} \rangle$

$\langle \frac{1}{n^2} \rangle$

$\langle \frac{1}{n} + \frac{1}{n^2} \rangle$

Q.2. Let <x_n> and <y_n> be sequence of real numbers defined by $x_1 = 1$, $y_1 = \frac{1}{2}$, $x_{n+1} = \frac{x_n + y_n}{2}$ and $y_{n+1} = \sqrt{x_n . y_n}$ for all $n \in N$. then which one of the following is true. **IIT JAM 2022**

(a) <x_n> is convergent and <y_n> is not convergent

(b) <x_n> is not convergent and <y_n> is convergent

(c) Both are convergent and $\lim_{n\to\infty} x_n > \lim_{n\to\infty} y_n$

(d) Both are convergent and $\lim_{n\to\infty} x_n = \lim_{n\to\infty} y_n$

Q.3. Let $0 < a \le 1$, $S_1 = \frac{a}{2}$ and for $n \in \mathbb{N}$. Let $S_{n+1} = \frac{1}{2}(S_n{}^2 + a)$.

Show that the sequence $\langle S_n \rangle$ is convergent and its limit are

IIT-JAM 2013

(a) $a - 1$ ~~(b) $1-\sqrt{1-a}$~~

(c) $1-\sqrt{1+a}$ (d) $1 + a$

$2l = l^2 + a$

$l^2 - 2l + a = 0$

$l = \frac{2 \pm \sqrt{4-4a}}{2}$

$l = 1 \pm \sqrt{1-a}$

$1+\sqrt{1-a}$

$1-\sqrt{1-a}$

Trick : Let $< x_n >$ and $< y_n >$ are two sequence s.t. $< y_n >$ is monotonic increasing sequence then $\lim_{n\to\infty}\left\langle \frac{x_n}{y_n} \right\rangle = \lim_{n\to\infty}\frac{(x_{n+1}-x_n)}{(y_{n+1}-y_n)}$

Q.4. Let $\langle x_n \rangle$ be a sequence of real numbers such that $\lim_{n\to\infty}(x_{n+1}-x_n) = C$ where C is positive real number, then the sequence $\left\langle \frac{x_n}{n} \right\rangle$. **IIT-JAM 2014**

(a) is not bounded

(b) is bounded but not convergent

(c) converge to C

(d) converge to 0

29

6

$$\lim_{n\to\infty}\left(\frac{x_n}{n}\right) = \lim_{n\to\infty}\left(\frac{x_{n+1}-x_n}{(n+1)-(n)}\right)$$

$$= C$$

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$\langle n \rangle \quad \langle -n \rangle$

Q5. Let $\langle a_n \rangle$, $\langle b_n \rangle$ and $c_n = \langle a_n + b_n \rangle$ are sequence s.t. $\lim_{n\to\infty} a_n = \infty$ and $\lim_{n\to\infty} b_n = -\infty$ then which of the following may be true?

$\cancel{\langle n+n^2 \rangle} \quad \langle -n \rangle$

$\langle n \rangle \quad \langle -n-n^2 \rangle$

(a) $\langle c_n \rangle$ convergent sequence

(b) $\langle c_n \rangle$ divergent to ∞

(c) $\langle c_n \rangle$ divergent to $-\infty$

(d) We can't say that $\langle c_n \rangle$ will always convergent

Q6. Let <a_n> be a sequence defined by $a_n = \sin\frac{n\pi}{2}$ then <a_n> is

< 1, 0, -1, 1, 0, -1, 1, 0, -1 >

(a) Convergent Sequence

(b) Divergent Sequence

(c) Oscillate Sequence

(d) None of these

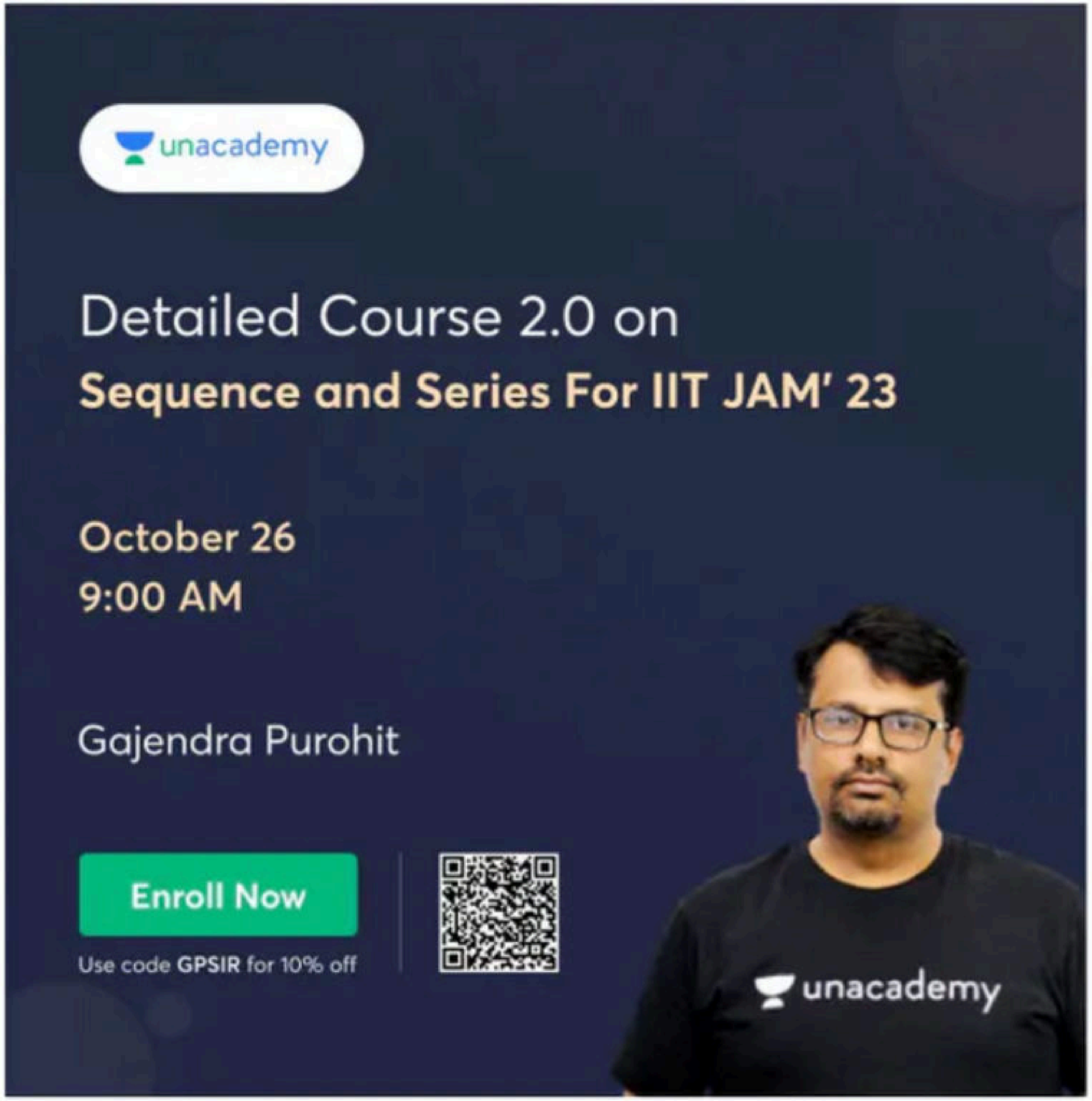
Q7. Let $\langle a_n \rangle$, $\langle b_n \rangle$ and $\langle c_n \rangle = \langle a_n + b_n \rangle$ are sequence of real number. Which of the following is/are true?

(a) If $\langle a_n \rangle$ and $\langle b_n \rangle$ both are convergent then $\langle a_n + b_n \rangle$ is divergent.

(b) If $\langle a_n \rangle$ is convergent and $\langle b_n \rangle$ is divergent then $\langle c_n \rangle$ is convergent.

(c) If $\langle a_n \rangle$ is convergent and $\langle b_n \rangle$ is divergent then $\langle c_n \rangle$ is divergent.

(d) None of these.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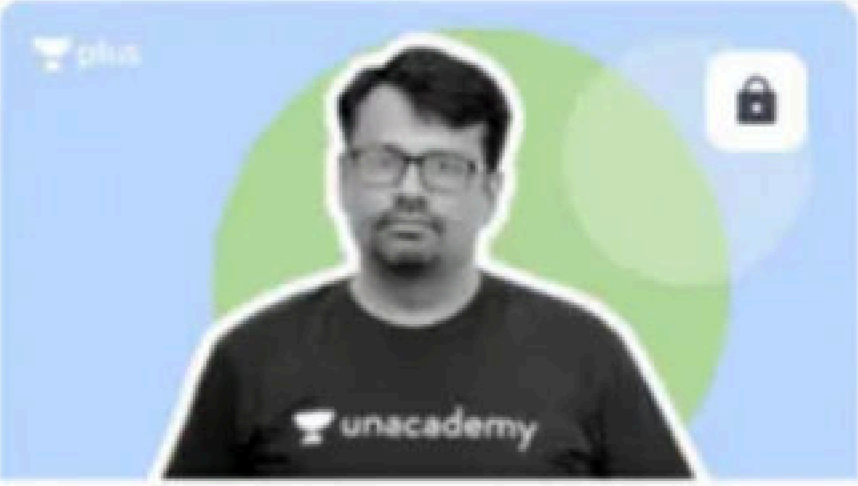

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Educator highlights

- Works at **Pacific Science College**
- Studied at **M.Sc., NET, PhD(Algebra), MBA(Finance), BEd**
- PhD, NET | Plus Educator For CSIR NET | Youtuber (260K+Subs.) | Director Pacific Science College |
- Lives in **Udaipur, Rajasthan, India**
- Unacademy Educator since

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