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Inequalities of AM GM HM

Sequences & Series

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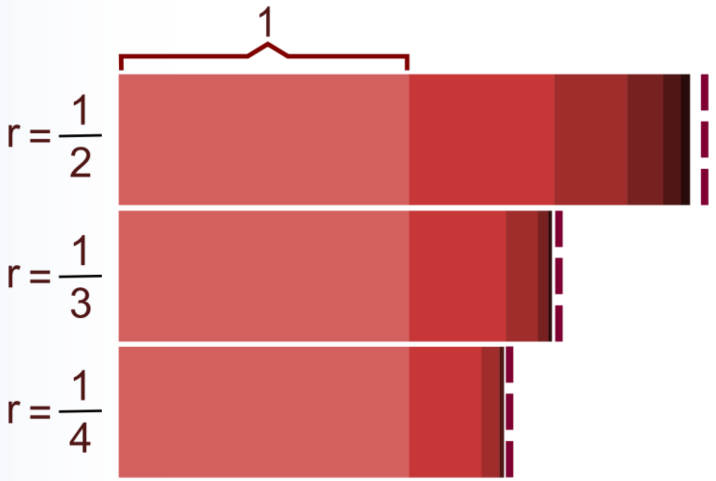

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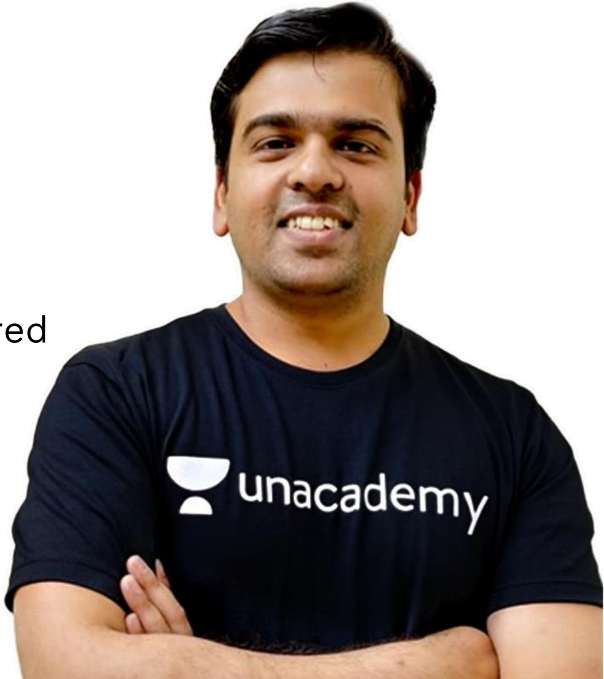

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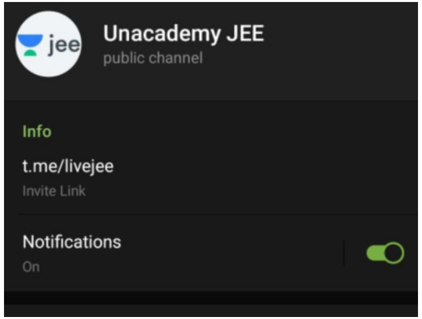

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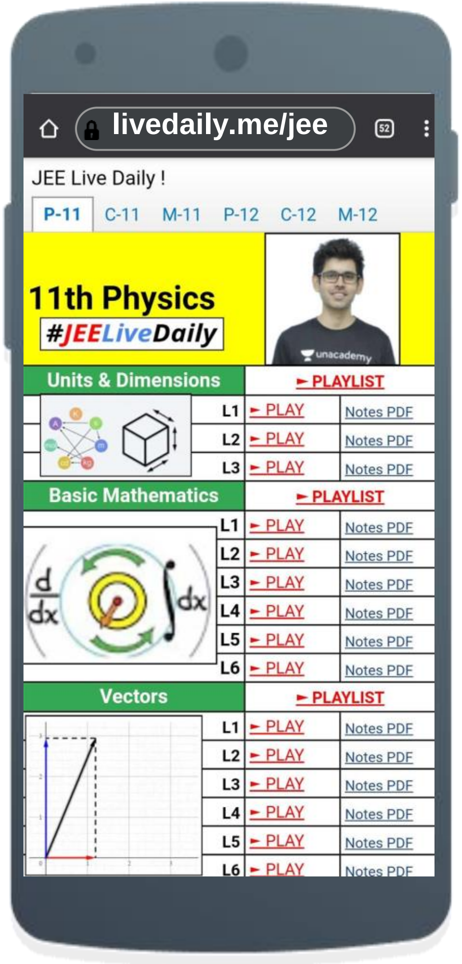

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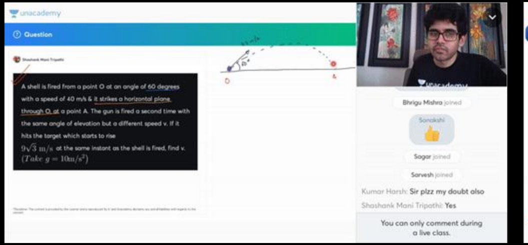

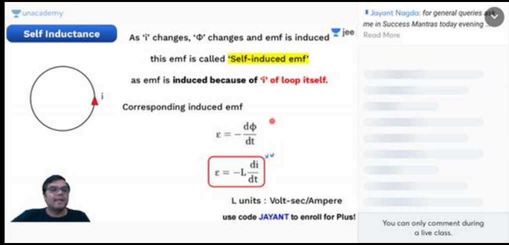

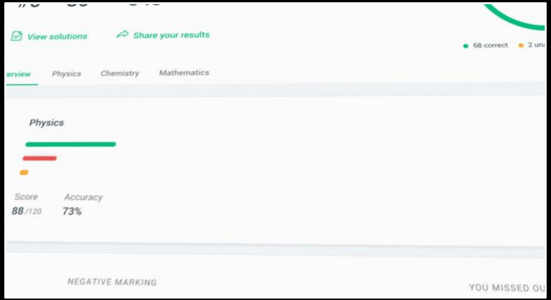

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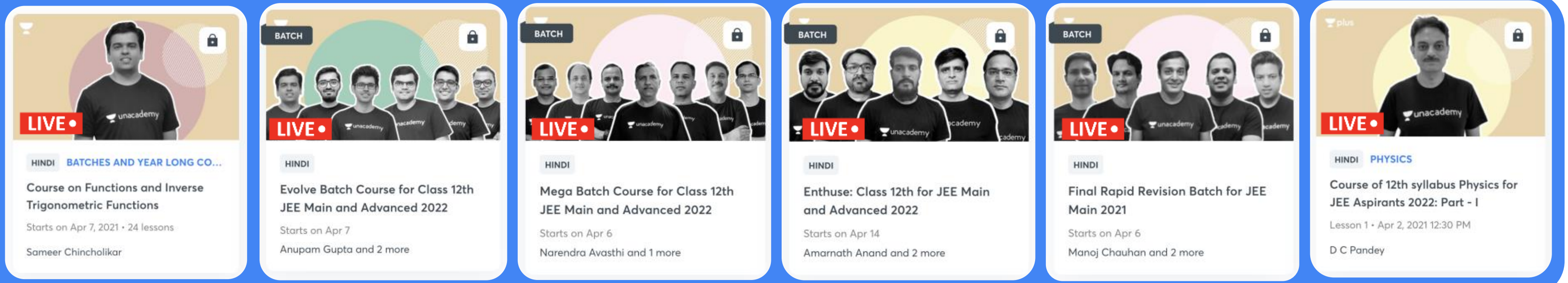

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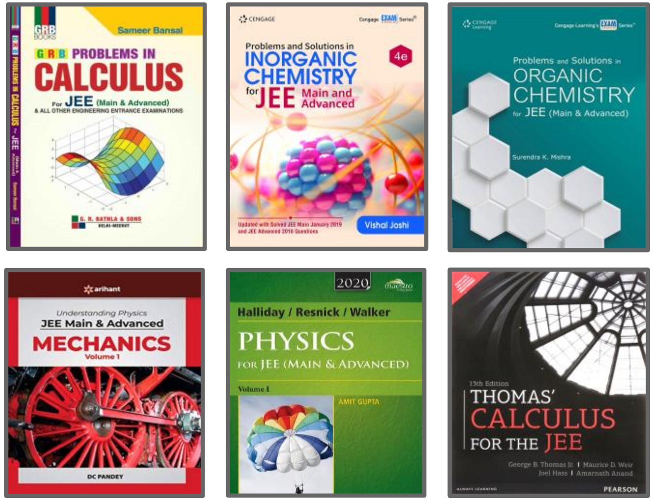


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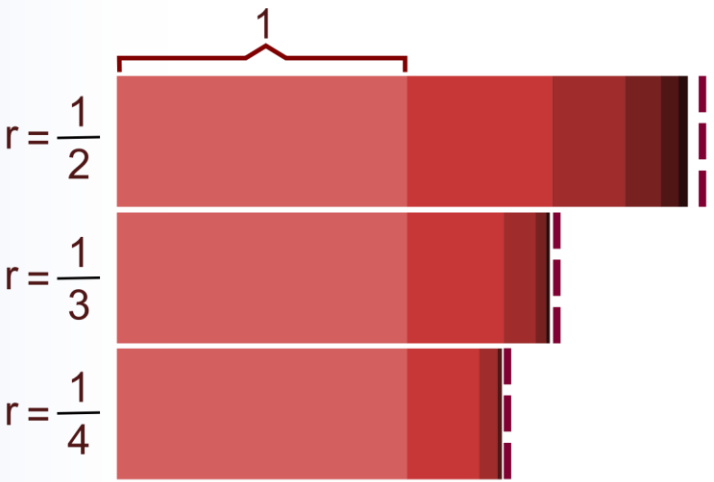

LET'S BEGIN!!

Homework Question

If a, b and c are distinct positive integers less than or equal to **10.** The arithmetic mean of a and b is **9.** The geometric mean of a and c is **$6\sqrt{2}$.** If the harmonic mean of b and c is H, then find the value of ***19H***.

A. 175 **B.** 180 **C.** 195 **D.** 200

a , b , c

$\frac{a+b}{2} = 9$

$\boxed{a+b=18}$

$\sqrt{ac} = 6\sqrt{2}$

$\boxed{ac = 72}$

a + b = 18

10 , 8 ✗

9 , 9 ✗

8 , 10

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$$\begin{cases} \cdot\ ac = 72 \\ \cdot\ \text{if } a = 10 \\ \text{then } c = 7.2 \\ \boxed{\text{neglect}} \end{cases}$$

if $a = 8$

& $ac = 72 \Rightarrow \boxed{c = 9}$ ✓

$$\therefore \begin{cases} a = 8 \\ b = 10 \\ c = 9 \end{cases}$$

$$\cdot\ H = \frac{2(10)(9)}{(10+9)}$$

$$\boxed{H = \frac{180}{19}}$$

Inequalities of AM, GM, HM

For positive numbers

For two numbers a & b

$$\begin{cases} A = \dfrac{a+b}{2} \\ G = \sqrt{ab} \\ H = \dfrac{2ab}{a+b} \end{cases}$$

$A - G$

$$= \frac{a+b}{2} - \sqrt{ab}$$

$$= \frac{a+b-2\sqrt{ab}}{2}$$

$$= \frac{(\sqrt{a})^2 + (\sqrt{b})^2 - 2\sqrt{a}\sqrt{b}}{2}$$

$$\Rightarrow A - G = \frac{(\sqrt{a}-\sqrt{b})^2}{2}$$

$$A - G \geq 0$$

$$\boxed{A \geq G} \text{ —— } 1$$

<u>Now:</u> $G - H$

$$= \sqrt{ab} - \frac{2ab}{(a+b)}$$

$$= \sqrt{ab}\left(1 - \frac{2\sqrt{ab}}{(a+b)}\right)$$

$$= \sqrt{ab}\left(\frac{a+b-2\sqrt{ab}}{a+b}\right)$$

$$= \sqrt{ab}\left(\frac{(\sqrt{a}-\sqrt{b})^2}{(a+b)}\right)$$

$$\geq 0$$

$\Rightarrow G - H \geq 0$

$\Rightarrow \boxed{G \geq H}$ — (2)

using (1) & (2) :

$$\boxed{A \geq G \geq H}$$

NOTE:

(1) This result is true for 'n' numbers as well.

(2) For Distinct Numbers.

$$A > G > H$$

NOTE:

Equality hold when all the numbers are equal.

$a = 4$

$b = 4$

$c = 4$

$$A = \frac{4+4+4}{3} = 4$$

$$G = (4 \times 4 \times 4)^{1/3} = 4$$

$$H = \frac{3}{\frac{1}{4}+\frac{1}{4}+\frac{1}{4}} = 4$$

For negative numbers

Eg: $\begin{cases} a = -8 \\ b = -2 \end{cases}$

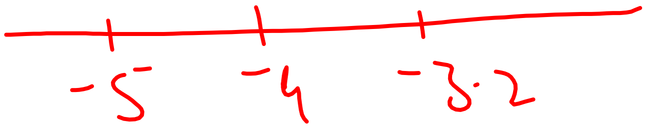
$$A = \frac{(-8)+(-2)}{2} = -5$$

$$G = -\sqrt{(-8)(-2)} = -4$$

$$H = \frac{2(-8)(-2)}{(-8)+(-2)}$$

$$= \frac{2 \times 16}{-10}$$

$$= -3.2$$



For Negative Nos :

$$\boxed{A \leq G \leq H}$$

Type-1: Direct application

Inequality ?

Values/Numbers ?

$$\begin{cases} A > G \\ G > H \\ A > H \end{cases}$$

If x, y, z be positive numbers, show that $(x + y + z)^3 \geq 27xyz$

$$A \geq G$$

$$\frac{x+y+z}{3} \geq (xyz)^{1/3}$$

$$(x+y+z)^3 \geq 27(xyz) \quad ✓$$

Prove that for positive numbers a, b, c and d:

$$(a+b+c+d)\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}\right) \geq 16$$

$$A \geq H$$

$$\frac{a+b+c+d}{4} \geq \frac{4}{\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+d\right)}$$

$$(a+b+c+d)\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}\right) \geq 16$$

If $a > 0$, then least value of $(a^3 + a^2 + a + 1)^2$ is

A. $64\ a^2$ B. $16\ a^4$ C. $16\ a^3$ D. None of these

$$A \geq G$$

$$\frac{a^3 + a^2 + a + 1}{4} \geq (a^3 \cdot a^2 \cdot a \cdot 1)^{1/4}$$

$$\frac{(a^3 + a^2 + a + 1)}{4} \geq (a)^{3/2}$$

$$(a^3+a^2+a+1)^2 \geqslant 16(a^3)$$

If **l, m, n** are the three positive roots of the equation $x^3 - ax^2 + bx - 48 = 0$, then the minimum value of $(1/l) + (2/m) + (3/n)$ equals

A. 1   B. 2   C. 3/2   D. 5/2

A $\geq$ G

$$\frac{\left(\frac{1}{l} + \frac{2}{m} + \frac{3}{n}\right)}{3} \geq \left(\frac{1}{l} \frac{2}{m} \frac{3}{n}\right)^{1/3}$$

$$\boxed{l \cdot m \cdot n = 48}$$

$$\left(\frac{1}{l} + \frac{2}{m} + \frac{3}{n}\right) \geq \boxed{3\left(\frac{6}{48}\right)^{1/3}}$$

$3/2$

Minimum value of $(b + c)/a + (c + a)/b + (a + b)/c$

(for real positive numbers a, b, c) is

A. 1 B. 2 C. 4 D. 6 ✓

*

$$\frac{b+c}{a} + \frac{c+a}{b} + \frac{a+b}{c}$$

$$= \left(\frac{b+c}{a} + 1\right) + \left(\frac{c+a}{b} + 1\right) + \left(\frac{a+b}{c} + 1\right) - 3$$

$$= \left(\frac{a+b+c}{a} + \frac{a+b+c}{b} + \frac{a+b+c}{c}\right) - 3$$

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$$= \underbrace{(a+b+c)\left[\frac{1}{a}+\frac{1}{b}+\frac{1}{c}\right]} - 3$$

Now

$$A \geq H$$

$$\frac{a+b+c}{3} \geq \frac{3}{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}}$$

$$(a+b+c)\left(\frac{1}{a}+\frac{1}{b}+\frac{1}{c}\right) \geq 9$$

NOTE:

jee

Range of expressions containing reciprocal system can be calculated using AM. GM inequality

$$f(x) = x^2 + \frac{1}{x^2}$$

$$\frac{x^2 + \frac{1}{\cancel{x^2}}}{2} \geq \sqrt{\cancel{x^2} \cdot \frac{1}{\cancel{x^2}}}$$

$$\boxed{x^2 + \frac{1}{x^2} \geq 2\sqrt{1}}$$

The sum of the first three terms of a G.P is S and their product is 27. Then all such S lie in:

Sep 02, 2020

A. $(-\infty, -9] \cup [3, \infty)$

B. $[-3, \infty)$

C. $(-\infty, -3] \cup [9, \infty)$

D. $(-\infty, 9]$

Let the three nos. be $\boxed{\frac{a}{r}, a, ar}$

Product: $\frac{a}{\cancel{r}} a \cdot a\cancel{r} = 27$

$a^3 = 27 \Rightarrow \boxed{a = 3}$

1, 2, 4, 8 - - -

$\underbrace{\frac{1}{2}, 1}, 2, 4, 8$ - -

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$$S = \frac{a}{r} + a + ar$$

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

$$S = 3\left(\frac{1}{r} + 1 + r\right)$$

$$\boxed{S = 3\left(\left(r + \frac{1}{r}\right) + 1\right)}$$

<u>Case-1</u> $r > 0$

$$A \geq G$$

$$\frac{r + \frac{1}{r}}{2} \geq \sqrt{\cancel{r} \cdot \frac{1}{\cancel{r}}}$$

$$\boxed{\left(r + \frac{1}{r}\right) \geq 2} \text{ --- } (1)$$

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Case-2 : $x < 0$

$$A \leq G$$

$$\frac{x + \frac{1}{x}}{2} \leq -\sqrt{\cancel{x} \cdot \frac{1}{\cancel{x}}}$$

$$\boxed{\left(x + \frac{1}{x}\right) \leq -2} \quad 2$$

$S \in (-\infty, -3] \cup [9, \infty)$

Type-2: Following some restriction

Find the $\boxed{\text{greatest}}$ value of **abc** for positive value of **a, b, c** subject to the condition **ab + bc + ca = 12**

$$A \geq G$$

$$\frac{(ab)+(bc)+(ca)}{3} \geq (ab \cdot bc \cdot ca)^{1/3}$$

$$\left(\frac{12}{3}\right) \geq (a^2b^2c^2)^{1/3}$$

$$(abc)^{2/3} \leq 4$$

$$(abc) \leq (4)^{3/2}$$

$$\boxed{(abc) \leq 8}$$

max value = 8

If a, b, c are positive real numbers such that a + b + c = 1, then find the minimum value of

$$\frac{1}{ab}+\frac{1}{bc}+\frac{1}{ac}$$

$$= \frac{c+a+b}{abc}$$

$$= \frac{1}{abc}$$

$$A \geq G$$

$$\frac{a+b+c}{3} \geq (a\,b\cdot c)^{1/3}$$

$$\frac{1}{3} \geq (abc)^{1/3}$$

$$\frac{1}{27} \geq (abc)$$

$$\boxed{\frac{1}{abc} \geq 27}$$

min value = 27

If $a, b, c \in R^+$ such that $a + b + c = 18$, then the maximum value of $a^2 b^3 c^4$ is equal to

A. $2^{18} \times 3^2$ B. $2^{18} \times 3^3$ C. $2^{19} \times 3^2$ D. $2^{19} \times 3^3$

$$\frac{\left(\frac{a}{2}+\frac{a}{2}\right)+\left(\frac{b}{3}+\frac{b}{3}+\frac{b}{3}\right)+\left(\frac{c}{4}+\frac{c}{4}+\frac{c}{4}+\frac{c}{4}\right)}{9} \geq \left(\frac{a^2}{2^2}\cdot\frac{b^3}{3^3}\cdot\frac{c^4}{4^4}\right)^{1/9}$$

$$2 \geq \frac{(a^2 b^3 c^4)^{1/9}}{(2^2\, 3^3\, 4^4)^9}$$

$$\frac{a^2 b^3 c^4}{2^2 \cdot 3^3 \cdot 4^4} \geq 2^9$$

$$\boxed{a^2 b^3 c^4 \geq 2^{19} \cdot 3^3}$$

Type-3: Using more than one inequalities

$$\begin{cases} P > Q \\ R > S \end{cases}$$

$$P + R > Q + S$$

$$P \cdot R > Q \cdot S$$

If a, b, c are positive real numbers then prove that:

$(b + c)(c + a)(a + b) \geq 8abc$

$$\frac{b+c}{2} \geq \sqrt{bc}$$

$$\frac{c+a}{2} \geq \sqrt{ca}$$

$$\frac{a+b}{2} \geq \sqrt{ab}$$

$$\frac{(b+c)(c+a)(a+b)}{8} \geq \sqrt{bc \cdot ca \cdot ab}$$

$$(b+c)(c+a)(a+b) \geq 8abc$$

If **a, b, c are positive real numbers** then prove that:

$$(a^2b + b^2c + c^2a)\ \underbrace{(ab^2 + bc^2 + ca^2)}\geq 9.a^2\, b^2\, c^2$$

$$\frac{a^2b+b^2c+c^2a}{3} \geq \left(a^2b \cdot b^2c \cdot c^2a\right)^{1/3}$$

$$\left(a^2b+b^2c+c^2a\right) \geq 3abc \quad \text{—} \quad 1$$

Similarly, $\left(ab^2+bc^2+ca^2\right) \geq 3abc \quad \text{—} \quad 2$

multiply ① & ②

If $a^2 + b^2 = 1$, and $x^2 + y^2 = 1$, then find the maximum value of $ax + by$

$$\frac{a^2 + x^2}{2} \geq (a^2x^2)^{1/2}$$

$$\boxed{a^2 + x^2 \geq 2ax} \quad - (1)$$

$$\& \quad \frac{b^2 + y^2}{2} \geq (b^2y^2)^{1/2}$$

$$\boxed{b^2 + y^2 \geq 2by} \quad - (2)$$

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(1) + (2) :

$a^2+x^2+b^2+y^2 \geq 2ax+2by$

$\underbrace{a^2+b^2}_{1} \quad \underbrace{x^2+y^2}_{1}$

$2 \geq 2ax+2by$

$\boxed{ax+by \leq 1}$

$\therefore$ max value $= 1$

Type-4: Combining two inequalities

$P > Q$, $Q > R$

$$\boxed{P > R}$$

If a, b, c are positive numbers then prove that: $\underbrace{a^4 + b^4 + c^2}$ $\geq 2\sqrt{2}\, abc$

M-1

$$\frac{a^4 + b^4}{2} \geq (a^4 b^4)^{1/2}$$

$$a^4 + b^4 \geq 2a^2 b^2$$

$$\boxed{a^4 + b^4 + c^2 \geq 2a^2 b^2 + c^2} \quad \text{---} \; 1$$

Now:

$$\frac{2a^2b^2+c^2}{2} \geq (2a^2b^2c^2)^{1/2}$$

$$\boxed{2a^2b^2+c^2 \geq 2\sqrt{2}\,abc} \text{ --- } (2)$$

Using: (1) & (2):

$$(a^4+b^4+c^2) \geq 2\sqrt{2}\,abc$$

M-2

$$\frac{a^4+b^4+\frac{c^2}{2}+\frac{c^2}{2}}{4} \geq \left(a^4 \cdot b^4 \cdot \frac{c^4}{4}\right)^{1/4}$$

$$a^4+b^4+c^2 \geq \frac{4}{\sqrt{2}}(abc)$$

Type-5: Given numbers are in AP, GP or HP

① If a, b, c are in A.P.

$$A.M.(a, c) = \frac{a+c}{2} = \boxed{b}$$

② If a, b, c are in G.P

$$G.M.(a, c) = \sqrt{ac} = \boxed{b}$$

③ $a, b, c \longrightarrow H.P.$

$$HM(a,c) = \left(\frac{2}{\frac{1}{a}+\frac{1}{c}}\right) = \boxed{b}$$

1. If a, b, c, d are four distinct positive quantities in A.P. then prove that: $bc > ad$

2. If a, b, c, d are four distinct positive quantities in G.P. then prove that: $a + d > b + c$

3. If a, b, c, d are four distinct positive quantities in H.P. then prove that: $ad > bc$.

(1) $a, b, c, d \rightarrow$ A.P

$AM(a, c) = \frac{a+c}{2} = b$

$AM(b, d) = \frac{b+d}{2} = c$

$AM > GM$

$\frac{a+c}{2} > \sqrt{ac}$

$\boxed{b > \sqrt{ac}}$ — (1)

$$\frac{b+d}{2} > \sqrt{bd}$$

$$\boxed{c > \sqrt{bd}} \quad 2$$

1 × 2 :

$$bc > \sqrt{abcd}$$

$$b^2c^2 > abcd$$

$$\boxed{bc > ad}$$

2 if a, b, c, d → G ?

$$\sqrt{ac} = b \; ; \; \sqrt{bd} = c$$

$$A > G$$

$$\frac{a+c}{2} > \sqrt{ac}$$

$$\frac{a+c}{2} > b$$

$$\boxed{a+c > 2b} \quad -(3)$$

Now:

$$A > G$$

$$\frac{b+d}{2} > \sqrt{bd}$$

$$\frac{b+d}{2} > c$$

$$\boxed{b+d > 2c} \quad -(4)$$

$$(3) + (4)$$

$$a+b+c+d > 2b+2c$$

$$\boxed{a+d > b+c}$$

③ $a, b, c, d \rightarrow HP.$

$$\begin{cases} HM(a,c) = b \\ HM(b,d) = c \end{cases}$$

$$G > H$$

$$\begin{cases} \sqrt{ac} > b \\ \sqrt{bd} > c \end{cases}$$

$$\sqrt{abcd} > bc$$

$$abcd > b^2c^2$$

$$\boxed{ad > bc}$$

Type-6: Using actual numbers

For every integer n > 1, the inequality $(n!)^{1/n} < \frac{n+1}{2}$ holds.

Eg: $5! = 5 \times 4 \times 3 \times 2 \times 1$

$3! = 3 \times 2 \times 1$

$n! = n(n-1)(n-2) \cdot - - - - 1$

$= 1 \cdot 2 \cdot 3 \cdot - - - - (n-1)n$

$$A > G$$

$$\frac{1+2+3+\cdots+n}{n} > (1\cdot 2\cdot 3\cdots n)^{1/n}$$

$$\frac{\frac{\cancel{n}(n+1)}{2}}{\cancel{n}} > (1\cdot 2\cdot 3\cdots n)^{1/n}$$

$$(n!)^{1/n} < \frac{n+1}{2}$$

If n is positive integer, then show that: $2^{2n+1} > 1 + (2n + 1)2^n$

H.W.

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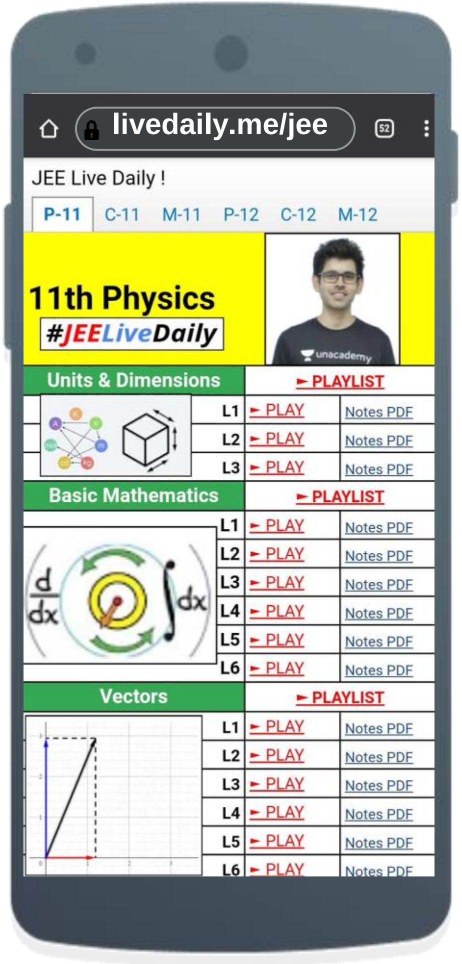

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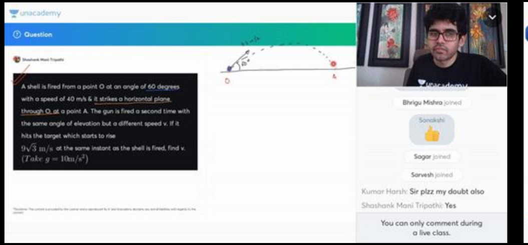

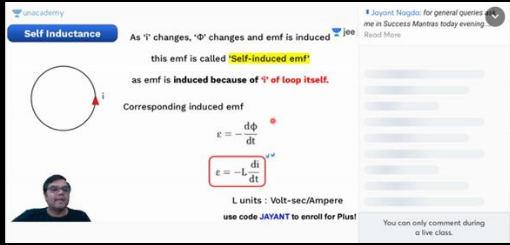

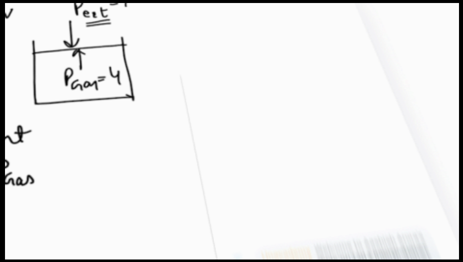

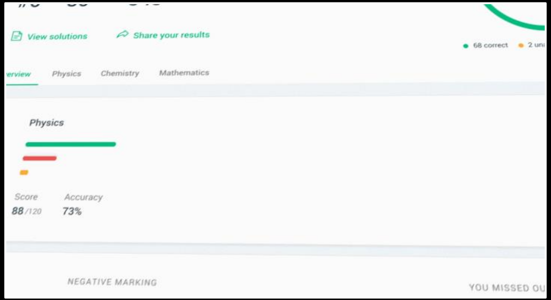

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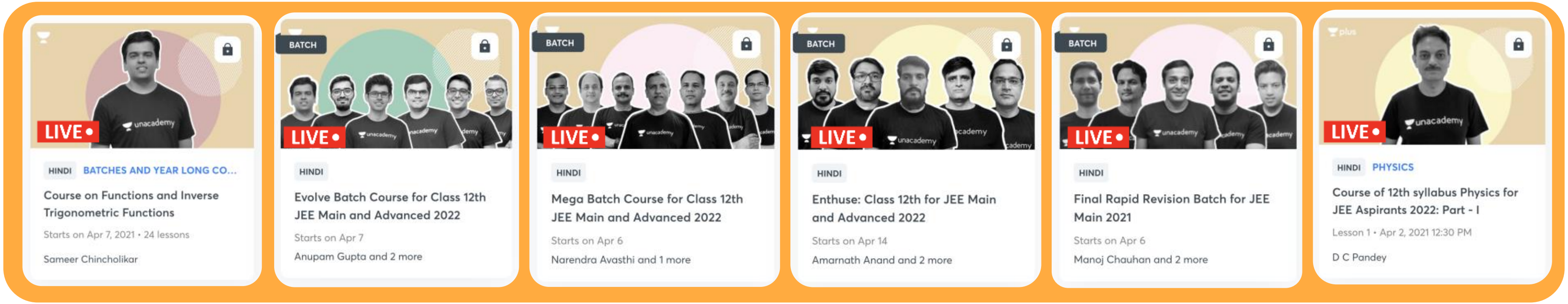

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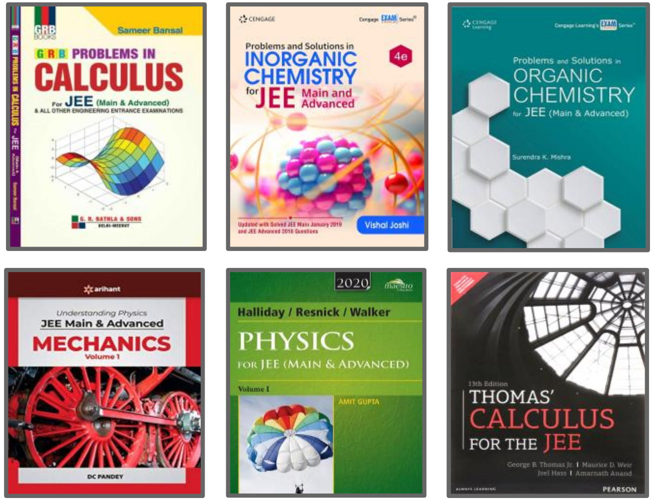

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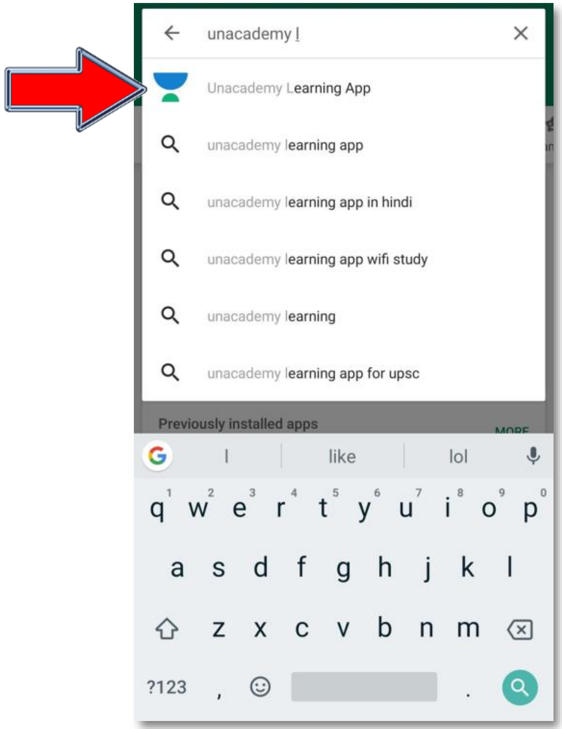

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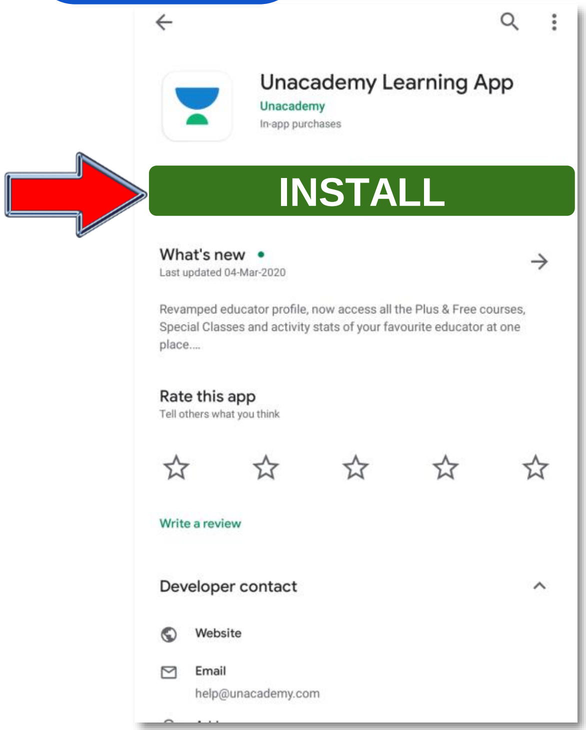

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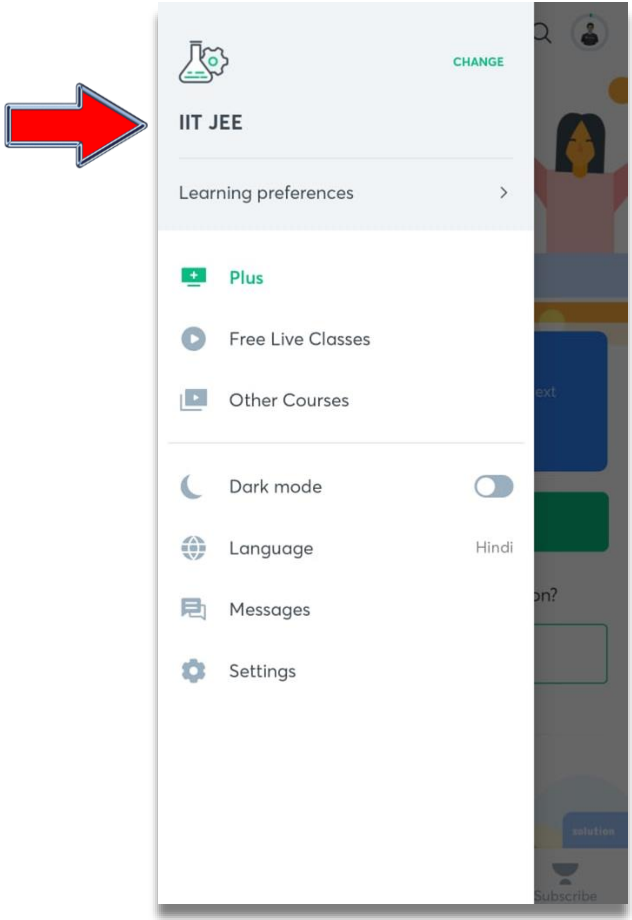
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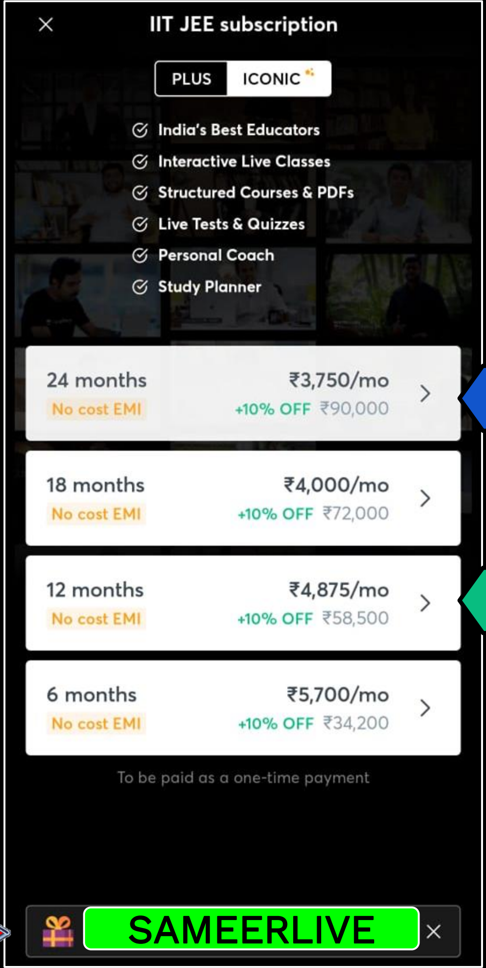

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