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Nature of Roots

Quadratic Equations

3

$$\alpha + \beta = \frac{-b}{a}$$

$$\alpha\beta = \frac{c}{a}$$

$$|\alpha - \beta| = \frac{\sqrt{D}}{|a|}$$

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B.Tech, M.Tech - IIT-Roorkee

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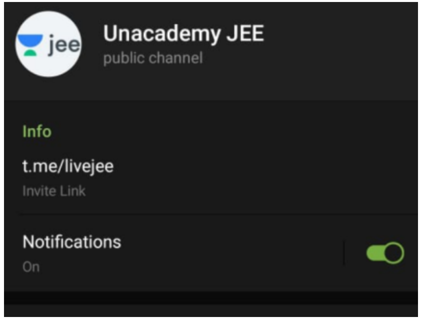

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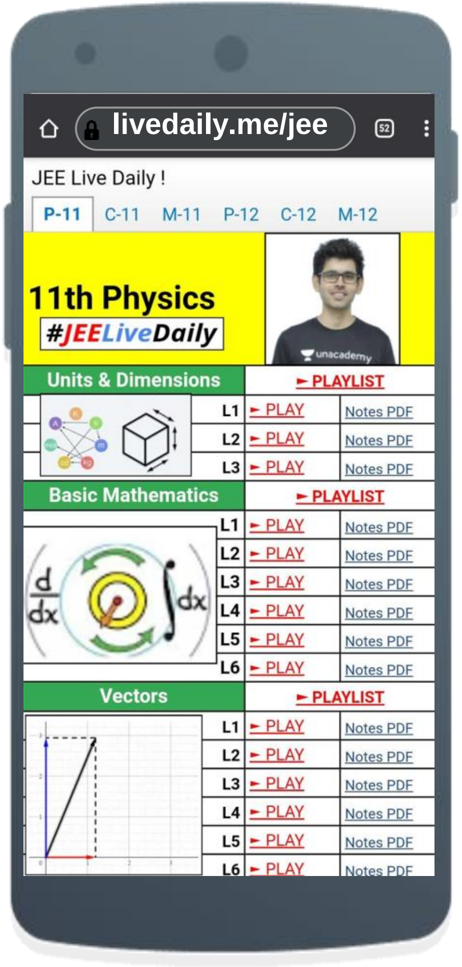

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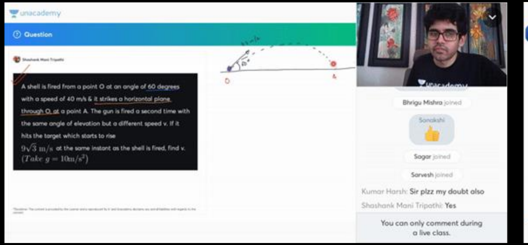

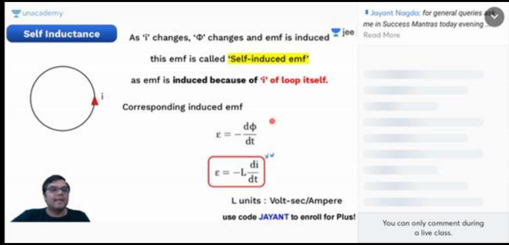

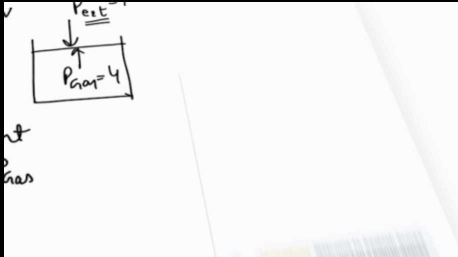

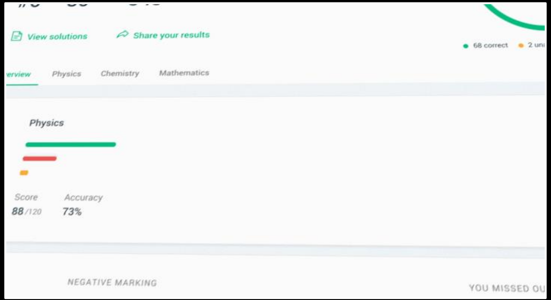

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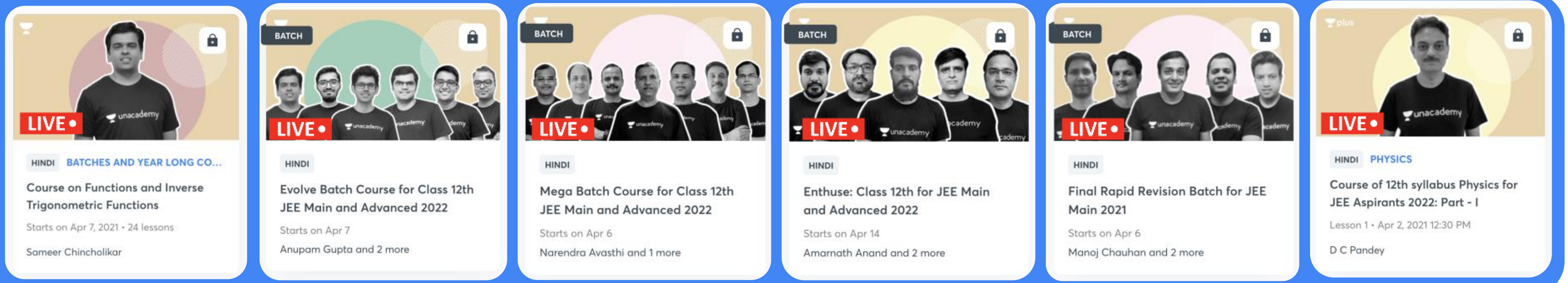

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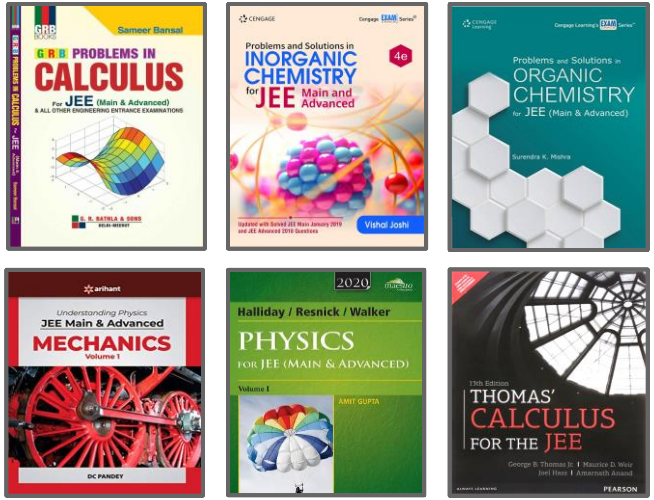


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LET'S BEGIN!!

Homework Questions

If α, β, γ are the roots of the cubic $x^3 + qx + r = 0$ then find the **equation** whose roots are $\alpha\beta, \beta\gamma, \gamma\alpha$.

$\boxed{\alpha^3 + q\alpha + r = 0}$

$\alpha\beta\gamma = -r$

$$\left\{\begin{aligned} \alpha\beta &= \frac{-r}{\gamma} \\ \beta\gamma &= \frac{-r}{\alpha} \\ \gamma\alpha &= \frac{-r}{\beta} \end{aligned}\right\}$$

Now:

$x = \frac{-r}{\alpha} \Rightarrow \alpha = \frac{-r}{x}$

$$\Rightarrow \left(\frac{-r}{x}\right)^3 + q\left(\frac{-r}{x}\right) + r = 0$$

$$-r^3 - qr x^2 + r x^3 = 0$$

$$x^3 - qx^2 - r^2 = 0$$

If $x^2 - 3x + 2$ is one of the **factors** of the expression $x^4 - px^2 + q$, then:

A. $p = 4, q = 5$

B. $p = 5, q = 4$ ✓

C. $p = -5, q = -4$

D. None of these

$$\frac{(x^4 - px^2 + q)}{(x^2 - 3x + 2)} = Q(x)$$

$$(x^4 - px^2 + q) = (x^2 - 3x + 2)\,Q(x)$$

$\boxed{x = 1}$:

$1 - p + q = 0$

$\boxed{x = 2}$:

$16 - 4p + q = 0$

Nature of Roots

Nature of Roots

The roots of the quadratic equation, **$ax^2 + bx + c = 0$** is given by

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

The expression
$D = b^2 - 4ac$
is called the **discriminant** of the quadratic equation.

$D > 0 \Rightarrow$ Real & Distinct

$D = 0 \Rightarrow$ Real & equal

$D < 0 \Rightarrow$ Complex

Eg: $x^2+2x+2=0$

$$x=\frac{-2\pm\sqrt{4-8}}{2}$$

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

$$=\frac{-2\pm2\sqrt{-1}}{2}$$

$$\boxed{\sqrt{-1}=i}$$

$$=-1\pm i$$

$(-1+i)$ $(-1-i)$

If **a, b, c** are non zero real numbers then comment on the **nature of roots** of the equations $x^2 - 2ax + a^2 - b^2 - c^2 = 0$

A. Real and equal

B. Complex

C. Real and unequal

D. None of these.

$$D = (-2a)^2 - 4(1)(a^2 - b^2 - c^2)$$

$$= \cancel{4a^2} - \cancel{4a^2} + 4b^2 + 4c^2$$

$$= \boxed{4(c^2 + b^2)} > 0$$

If $\sin^2\alpha \cos^2\alpha = \sin^2\beta$, then the **roots of the equation** $x^2 + 2x\cot\beta + 1 = 0$ are always

A. Equal

B. Imaginary

C. Real and distinct

D. Greater than 1

$$D = 4\cot^2\beta - 4$$

$$= 4(\cot^2\beta - 1)$$

$$= \boxed{4(\operatorname{cosec}^2\beta - 2)}$$

$$= 4\left(\frac{1}{\sin^2\beta} - 2\right)$$

$$= 4\left(\frac{1}{\sin^2\alpha\cos^2\alpha} - 2\right)$$

$$= 4\left(\frac{4}{(2\sin\alpha\cos\alpha)^2} - 2\right)$$

$$D = 4\left(\frac{4}{\sin^2 2\alpha} - 2\right)$$

$$= 8\left(\frac{2 - \sin^2 2\alpha}{\sin^2 2\alpha}\right)$$

$$> 0$$

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Let **p, q ∈ {1, 2, 3, 4}**. The **number of equations** of the form **$px^2 + qx + 1 = 0$** having real roots is

A. 15 **B.** 9

C. 7 **D.** 8

$q^2 - 4p \geq 0$

$p = 1$ | $q = 2, 3, 4$

$= 2$ | $q = 3, 4$

$= 3$ | $q = 4$

$= 4$ | $q = 4$

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Let **S** be the set of all non-zero real numbers a such that the quadratic equation **$ax^2 - x + a = 0$** has two distinct real roots **x_1 and x_2** satisfying the inequality **$|x_1 - x_2| < 1$**. Which of the **following intervals** is (are) a subset (s) of S?

A. $\left(-\frac{1}{2}, -\frac{1}{\sqrt{5}}\right)$

B. $\left(0, \frac{1}{\sqrt{5}}\right)$

C. $\left(\frac{1}{\sqrt{5}}, 0\right)$

D. $\left(\frac{1}{\sqrt{5}}, \frac{1}{2}\right)$

$ax^2 - x + a = 0$

$D > 0 \Rightarrow 1 - 4a^2 > 0$

$4a^2 - 1 < 0$

$(2a+1)(2a-1) < 0$

$-\frac{1}{2} \qquad \frac{1}{2}$

$$|x_1 - x_2| = \frac{\sqrt{D}}{|a|} < 1$$

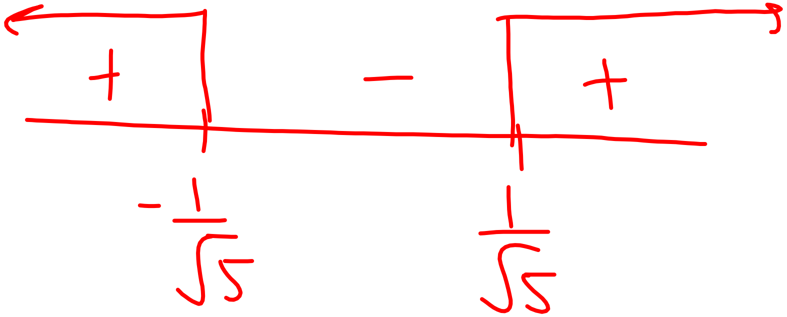
$$\sqrt{D} < |a|$$

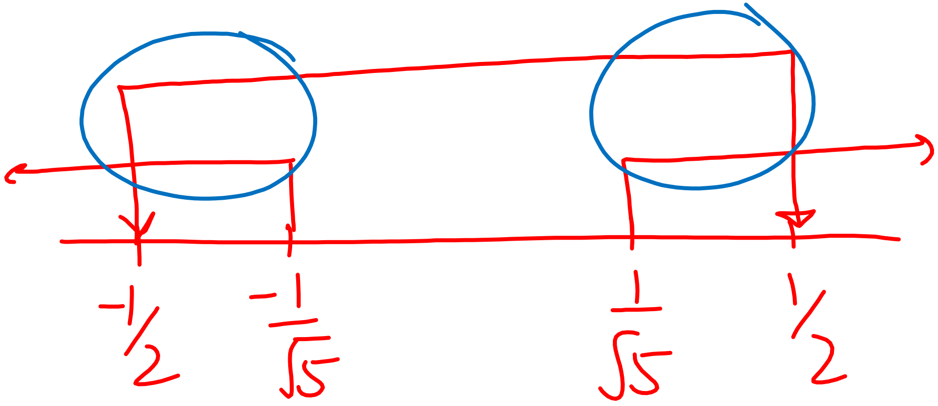
$$D < a^2$$

$$1 - 4a^2 < a^2$$

$$5a^2 - 1 > 0$$

$$(\sqrt{5}a - 1)(\sqrt{5}a + 1) > 0$$





$$\left(-\frac{1}{2}, -\frac{1}{\sqrt{5}}\right) \cup \left(\frac{1}{\sqrt{5}}, \frac{1}{2}\right)$$

Nature of Roots

Important Results For the quadratic: $ax^2 + bx + c = 0$

- If **a, b and c** are rational and **D > 0** but is NOT a perfect square then roots are **conjugate surds** of each other

Eg: $x^2 - 2x - 2 = 0$

$$x = \frac{2 \pm \sqrt{4+8}}{2}$$

$$x = 1 \pm \sqrt{3}$$

$\boxed{1+\sqrt{3}}$ $\boxed{1-\sqrt{3}}$

Nature of Roots

Important Results For the quadratic: $ax^2 + bx + c = 0$

If **a, b, c** are real and **$D < 0$** then roots are $\boxed{\text{complex conjugate}}$ of each other.

Eg: $x^2 + 2x + 2 = 0$ → $-1 + i$, $-1 - i$

Nature of Roots

Important Results For the quadratic: $ax^2 + bx + c = 0$

- If **a, b and c** are rational and **D > 0** and is a perfect square then roots are rational.

$\rightarrow D = p^2$

$$x = \frac{-b \pm \sqrt{D}}{2a} = \frac{-b \pm \sqrt{p^2}}{2a} = \left(\frac{-b \pm p}{2a}\right)$$

Nature of Roots

Important Results For the quadratic: $ax^2 + bx + c = 0$

- If **a, b, c** are **odd integers** then the quadratic cannot have rational roots

let: $\underbrace{a, b \;\&\; c \text{ are}}$ odd

& also $D = p^2$

$b^2 - 4ac = p^2$

$b^2 - p^2 = 4ac$

$(b+p)(b-p) = 4ac$

$$(b+p)(b-p) = 4(a)(c)$$

odd

even

odd

even

$\boxed{\text{even}}$

(odd) (odd)

odd

$$(b+p)(b-p) = 4ac$$

$$\begin{cases} b = 2m+1 \\ p = 2n+1 \end{cases}$$

$$b+p = 2(m+n+1)$$

$$b-p = 2(m-n)$$

$$2(m+n+1)\ 2(m-n) = 4ac$$

$$\underbrace{(m+n+1)}\,\underbrace{(m-n)} = a \cdot c$$

$(O+1) \to E \cdot O$ $\qquad$ odd odd

$(E+1) \to O \cdot E$

odd

If $2 + i\sqrt{3}$ is a root of the equation $x^2 + px + q = 0$, where **p** and **q** are real, then **(p, q)** =

$$x^2+px+q=0$$

$$\alpha = 2+i\sqrt{3}$$

$$\beta = 2-i\sqrt{3}$$

$$\begin{cases} \alpha+\beta = -p \\ \alpha\beta = q \end{cases}$$

$$4 = -p$$

$$\Rightarrow \boxed{p=-4}$$

$$(2+i\sqrt{3})(2-i\sqrt{3})$$

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

$$= 4 - i^2 3$$

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

$$= \boxed{7}$$

$$\boxed{i = \sqrt{-1}}$$

$$\downarrow$$

$$i^2 = -1$$

Nature of Roots

If D_1 and D_2 are the discriminant of two quadratic equations then

1.	If $D_1 + D_2 \geq 0 \Rightarrow$ **at least one of the equation** has real roots

$2 + 4 = 6$

$-2 + 4 = 2$

Nature of Roots

If D_1 and D_2 are the discriminant of two quadratic equations then

2. If $D_1 + D_2 < 0 \Rightarrow$ **at least one of the equation** has **imaginary roots**

Nature of Roots

If D_1 and D_2 are the discriminant of two quadratic equations then

3. If $D_1 D_2 < 0 \Rightarrow$ **one equation** has **real and distinct root** and **other** has **imaginary roots**

Nature of Roots

If D_1 and D_2 are the discriminant of two quadratic equations then

4. If $D_1 D_2 > 0 \Rightarrow$ either **both equation has real and distinct roots** or **both has imaginary roots**

Consider the equations $x^2 + 2bx + (c - 1) = 0$, and $4x^2 + cx + (b - 1) = 0$

A. Both equations have real roots

B. At least one equation has real roots

C. Both equations have imaginary roots

D. At least one equation has imaginary roots

$$\begin{cases} D_1 = 4b^2 - 4(c-1) \\ D_2 = c^2 - 4(4)(b-1) \end{cases}$$

$D_1 + D_2 =$

$4b^2 - 4c + 4$

$+ c^2 - 16b + 16$

$= 4(b^2 - 4b + 4)$

$+ (c^2 - 4c + 4)$

$$= \boxed{4(b-2)^2 + (c-2)^2}$$

* $D_1 + D_2 < 0$

atleast one of D_1 & D_2 is negative

$\Rightarrow$ atleast one eqn has imag. roots.

If α and β are the roots of $x^2 + px + q = 0$ and α^4, β^4 are the roots of $x^2 - rx + s = 0$, then the equation $x^2 - 4qx + 2q^2 - r = 0$ has always

A. two real roots

B. two positive roots

C. two negative roots

D. one positive and one negative root

$$\left(\text{Prod. of roots}\right) = \left(2q^2 - r\right)$$

$$\begin{cases} \alpha + \beta = -p & \text{--- (1)} \\ \alpha\beta = q & \text{--- (2)} \end{cases}$$

$$\alpha^4 + \beta^4 = r \quad \text{--- (3)}$$

$$\alpha^4 \cdot \beta^4 = s \quad \text{--- (4)}$$

$$x^2 - 4qx + 2q^2 - r = 0$$

$$D = 16q^2 - 4(2q^2 - r)$$

$$= 8q^2 + 4r$$

$$= 4(2q^2 + r)$$

$$= 4(2(\alpha\beta)^2 + \alpha^4 + \beta^4)$$

$$= 4((\alpha^2 + \beta^2)^2)$$

$$> 0$$

$\Rightarrow$ <u>real roots</u>

Now:

$$\left(\begin{array}{c}\text{Product of}\\ \text{roots}\end{array}\right) = 2q^2 - r$$

$$= 2(\alpha^2\beta^2) - \alpha^4 - \beta^4$$

$$= -\left((\alpha^2)^2 + (\beta^2)^2 - 2\alpha^2\beta^2\right)$$

$$= -\left((\alpha^2 - \beta^2)^2\right)$$

$$< 0$$

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Namo Sir | Physics

6:00 - 7:30 PM

Ashwani Sir | Chemistry

7:30 - 9:00 PM

Sameer Sir | Maths

9:00 - 10:30 PM

12th

Jayant Sir | Physics

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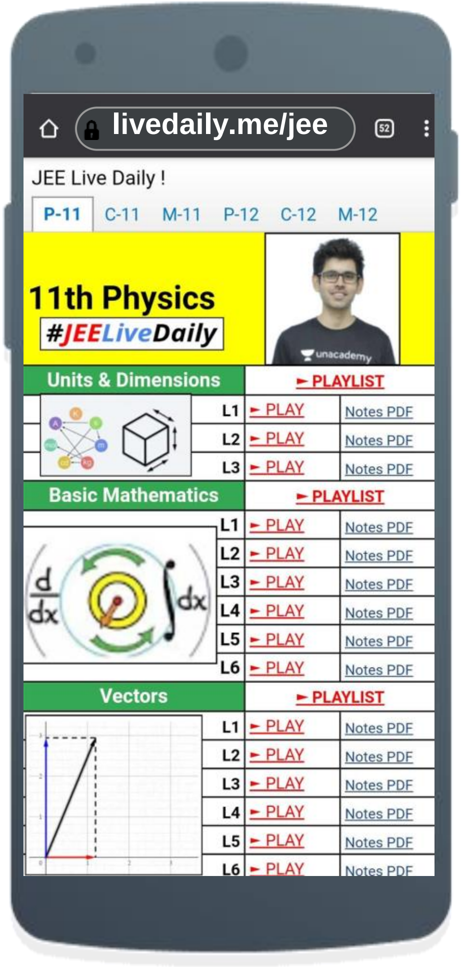

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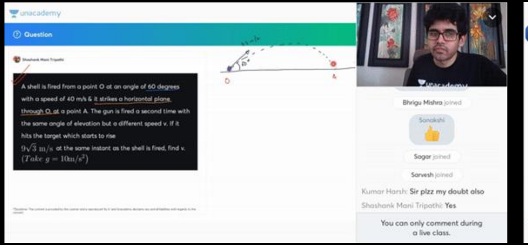

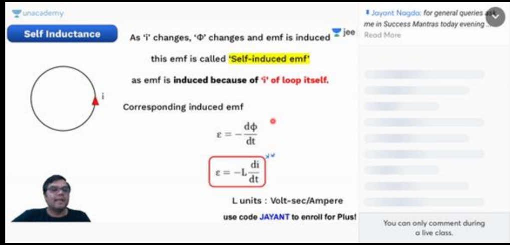

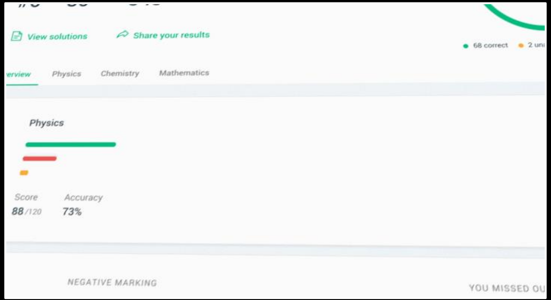

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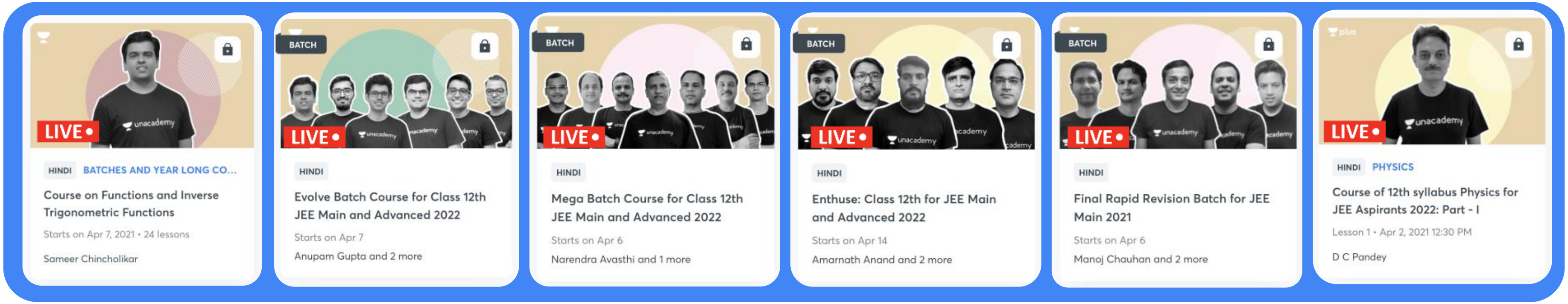

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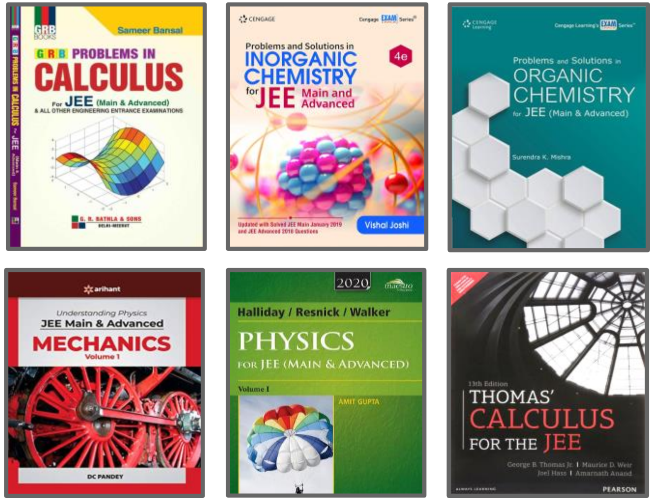


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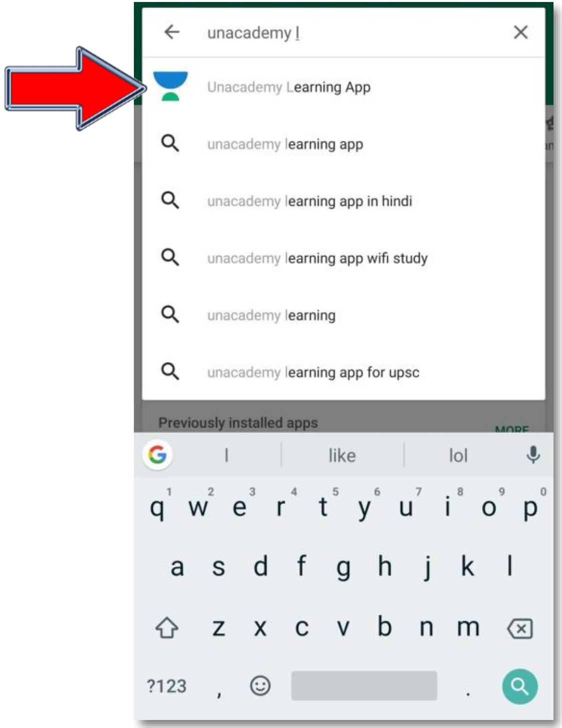
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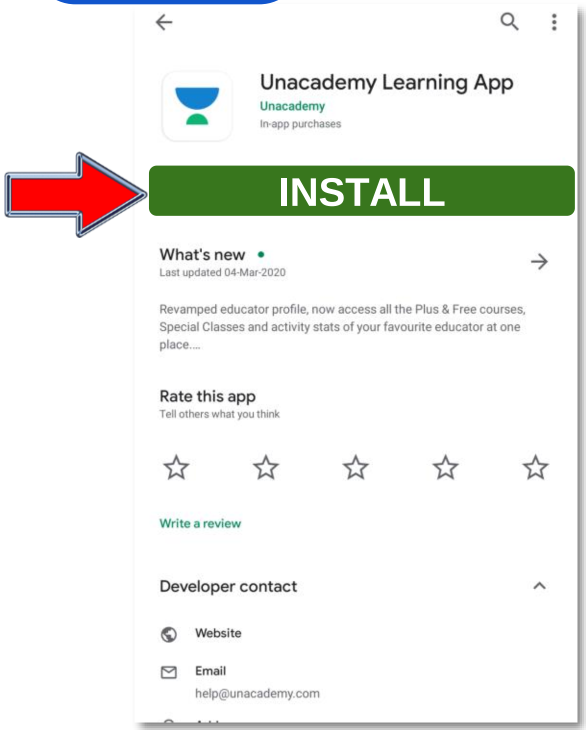
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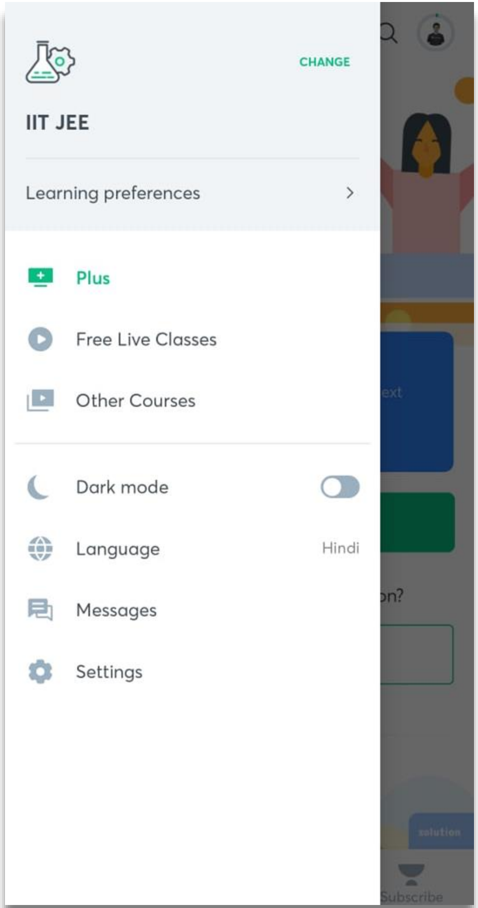
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