

Functions



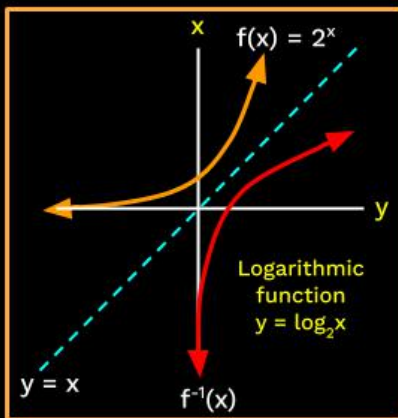
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Logarithmic Function - 1



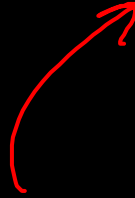


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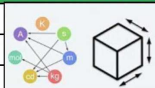
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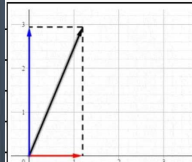
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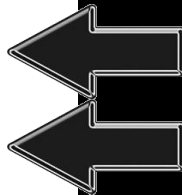
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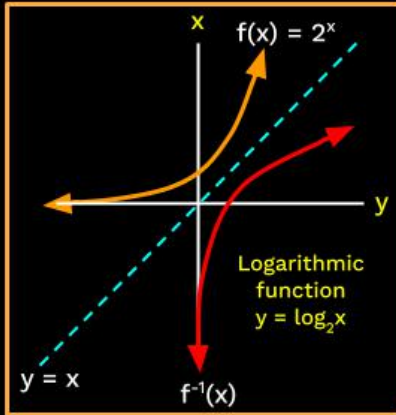
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LECTURE

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$|n|, n^2$

Logarithmic Function - 1



Definition of Logarithm

The **logarithm of the number N** to the base ' a ' is the **exponent indicating the power** to which the base ' a ' must be raised to obtain the number N .
This number is designated as $\log_a N$.

Example:

$$\log_2 8 = k \Rightarrow$$

\swarrow \nwarrow
 a (base) N (input)

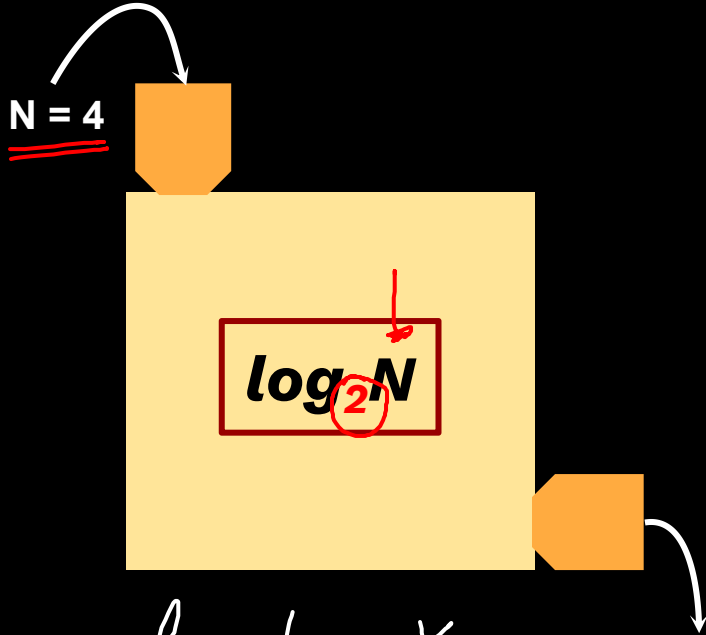
$$8 = (2)^k$$

$$2^3 = (2)^k$$

$$\Rightarrow \boxed{k=3}$$

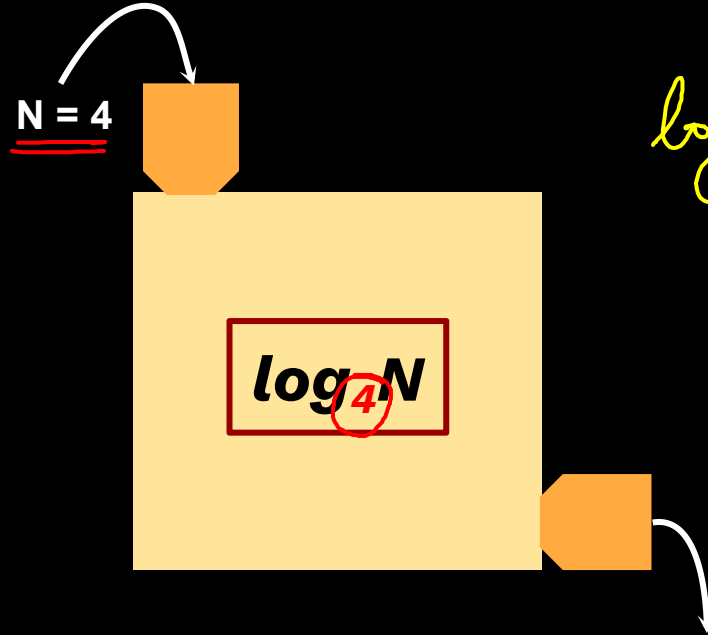
$$\log_a N = k \Leftrightarrow \boxed{N = a^k}$$

Different versions of Log



$$\log_2 4 = K$$

$$4 = 2^K \Rightarrow K = 2$$



$$\log_4 4 = x$$

$$4 = 4^x$$

$$x = 1$$

Domain: Restrictions on base and input

$$\log_a N = x \Leftrightarrow \underbrace{a^x = N}, \underbrace{a > 0}, \underbrace{a \neq 1} \text{ and } \underbrace{N > 0}$$

$$\log_1 2 = x$$

$$\downarrow$$

$$2 = 1^x$$

$$(a)^x$$

$$\left\{ \begin{array}{l} (-2)^x \rightarrow \frac{1}{2} \\ (2)^x \rightarrow \frac{1}{2}, 2, -\frac{1}{2} \end{array} \right.$$

$$a^x$$



$$\text{eg } a=2$$



$$2^x$$

always (+ve)

$$\begin{array}{l} [3] \leftarrow \text{power} \\ [2] \leftarrow \text{base} \end{array}$$

$$\overrightarrow{0}^x = \underline{\underline{N}} \quad \times$$

Frequently used base values

If $a = 10$, then write $\log N$ rather than $\log_{10} N$.

If $a = e$, we write $\ln N$ rather than $\log_e N$.

natural
base

$e=2.71828$

Example

Find the value of

i. $\log_{1000} 100$

ii. $\log_{0.01} 10000$

iii. $\log_{0.01} 0.0001 = K$

(i) $\log_{1000} 100 = K$

↓

$$100 = (1000)^K$$

$$(10^2) = (10^3)^K$$

$$2 = 3K$$

$$K = \frac{2}{3} \checkmark$$

(ii) $\log_{0.01} 10000 = K$

↓

$$10000 = (0.01)^K$$

$$10^4 = 10^{-2K}$$

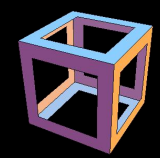
$$K = -2$$

(iii)

$$(10^{-4}) = (10^{-2})^K$$

$$-4 = -2K$$

$$K = 2$$



Example

Find the value of

i. $\log_{(2-\sqrt{3})}(2+\sqrt{3}) = K$

$$(2+\sqrt{3}) = (2-\sqrt{3})^K$$
$$\frac{(2+\sqrt{3})(2-\sqrt{3})}{(2-\sqrt{3})} = (2-\sqrt{3})^K$$

$$\Rightarrow \left(\frac{1}{2-\sqrt{3}} \right) = (2-\sqrt{3})^K$$

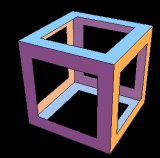
$$\boxed{K = -1}$$

ii. $\log_{(1/3)}(3\sqrt{3}) = K$

$$3\sqrt{3} = \left(\frac{1}{3}\right)^K$$

$$(3)^{3/2} = (3)^{-K}$$

$$\boxed{K = -3/2}$$



Example

Logarithm of $32^{\sqrt[5]{4}}$ to the base $2\sqrt{2}$ is

~~A.~~ 3.6

B. 5

C. 5.6

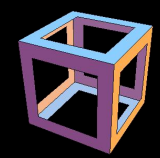
D. None of these

$$\log_{(2\sqrt{2})} (32^{\sqrt[5]{4}}) = K$$

$$\left\{ \begin{array}{l} \frac{27}{5} = \frac{3K}{2} \\ K = \frac{18}{5} = \underline{\underline{3.6}} \end{array} \right.$$

$$\underline{\underline{(2^5)}} (4)^{\sqrt[5]{4}} = (2\sqrt{2})^K$$

$$(2)^{\left(\frac{5 + \frac{2}{5}}{5}\right)} = (2)^{\left(\frac{3K}{2}\right)}$$



Example

The number $\log_2 7$ is

A. An integer

B. A rational number

C. An irrational number

D. A prime number

Let; $\log_2 7$ is rational $\left(\frac{p}{q}\right)$

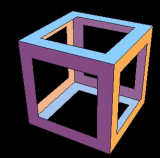
$$\log_2 7 = \frac{p}{q}$$

$$7 = (2)^{p/q}$$

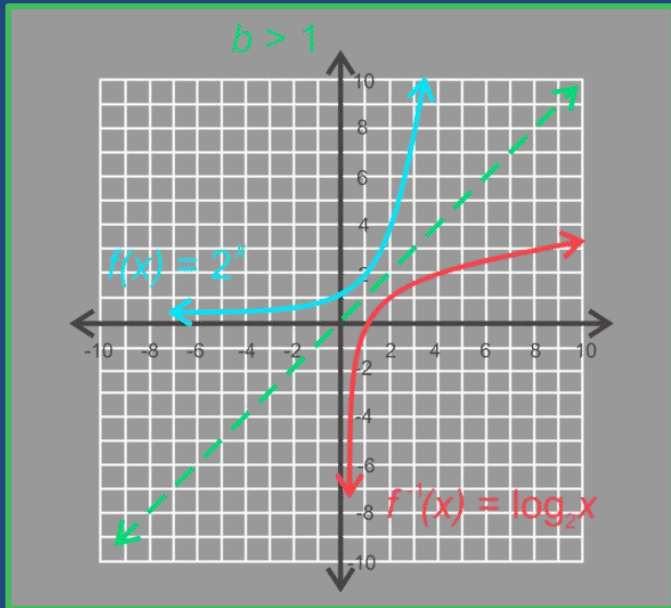
$$7^q = 2^p$$

Not possible

assumption was wrong



Properties of Log Function



Properties of Log Function

Property 1

$$\log_a 1 = 0 \quad (a \neq 1, a > 0)$$

$$\log_a 1 = K$$



$$\boxed{1 = a^K} \rightarrow 0$$

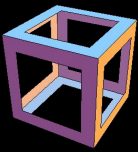
Properties of Log Function

Property 2

$$\log_a a = 1 \quad (a \neq 1, a > 0)$$

$$\log_a a = k$$

$$\downarrow$$
$$\boxed{a = a^k} \rightarrow 1$$



Properties of Log Function

Property 3

$$\log_a m + \log_a n = \log_a (m \cdot n)$$

$$\begin{aligned} \log_a m = k_1 &\rightarrow m = (a)^{k_1} \\ \log_a n = k_2 &\rightarrow n = (a)^{k_2} \end{aligned} \quad \left. \vphantom{\begin{aligned} \log_a m = k_1 \\ \log_a n = k_2 \end{aligned}} \right\} \rightarrow (m \cdot n) = (a)^{k_1 + k_2}$$

$$\log_a (m \cdot n) = k_1 + k_2$$

Properties of Log Function

Property 4

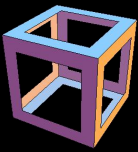
$$\log_a m - \log_a n = \log_a \left(\frac{m}{n} \right)$$

$$\log_a m = k_1 \Rightarrow m = a^{k_1} \quad \text{--- (1)}$$

$$\log_a n = k_2 \Rightarrow n = a^{k_2} \quad \text{--- (2)}$$

$$\text{(1)} \div \text{(2)}$$

$$\left(\frac{m}{n} \right) = \left(\underline{a} \right)^{\underline{k_1 - k_2}} \Rightarrow \log_a \left(\frac{m}{n} \right) = (k_1 - k_2)$$



Properties of Log Function

Property 5

$$\log_a(m)^\alpha = \alpha \cdot \log_a m$$

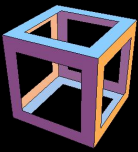
$$\log_a(m^\alpha) = \alpha$$

$$\Rightarrow m^\alpha = a^\alpha$$

$$\Rightarrow m = (a^\alpha)^{1/\alpha}$$

$$\Rightarrow \underline{m} = (\underline{a})^{(\alpha/\alpha)}$$

$$\left\{ \begin{array}{l} \log_a m = \frac{\alpha}{\alpha} \\ \alpha \cdot \log_a m = \alpha \end{array} \right.$$



Properties of Log Function

Property 6

$$\log_{(a^\beta)} m = \frac{1}{\beta} \log_a m$$

$$\begin{aligned} \log_{(a^\beta)} m &= K \\ \Rightarrow m &= (a^\beta)^K \\ \Rightarrow \underline{m} &= \underline{(a)^{\beta K}} \end{aligned}$$

$$\begin{aligned} \Rightarrow \log_a(m) &= \beta K \\ \Rightarrow \boxed{\frac{1}{\beta} \log_a m &= K} \end{aligned}$$

Properties of Log Function

*

Property 7

$$\log_a m = \frac{\log_b m}{\log_b a}$$

$$\log_a m = K$$

↓

$$m = a^K$$

↓

$$\log_b m = \log_b a^K$$

$$\log_b m = K \cdot (\log_b a)$$

$$\frac{\log_b m}{\log_b a} = K$$

Properties of Log Function

*

Property 8

$$\log_a m = \frac{1}{\log_m a}$$

$$\log_a m = \frac{\log_b m}{\log_b a}$$

$$\Rightarrow \boxed{b=m} = \frac{\log_m m}{\log_m a} = \frac{1}{\log_m a}$$

Properties of Log Function

Property 9

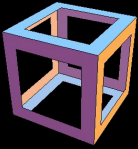
$$a^{\log_a x} = x$$

$$\log_a x = K$$



$$x = a^K$$

$$\boxed{x = a^{\log_a x}}$$



Properties of Log Function

Property 10

$$a^{\log_b c} = c^{\log_b a}$$

$$a^{\log_b c} = K$$

$$\log_b (a^{\log_b c}) = \log_b K$$

$$(\log_b c) (\log_b a) = \log_b K$$

$$(\log_b a) (\log_b c) = \log_b K$$

$$\log_b (c^{\log_b a}) = \log_b K$$

$$c^{\log_b a} = K$$



Example

$$\log_{11} \left(1 - \frac{1}{3} \right) + \log_{11} \left(1 - \frac{1}{4} \right) + \log_{11} \left(1 - \frac{1}{5} \right) + \cdots + \log_{11} \left(1 - \frac{1}{242} \right)$$

When simplified has the value equal to

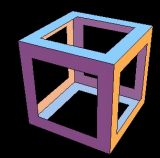
A. 2

B. - 2

C. 6

D. None of these

H.W. - 1





Example

If $\log_7 2 = m$, then $\log_{49} 28$ is equal to

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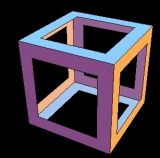
HW-2

A. $2(1 + 2m)$

B. $\frac{1 + 2m}{2}$

C. $\frac{2}{1 + 2m}$

D. $1 + m$



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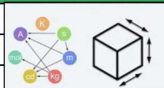
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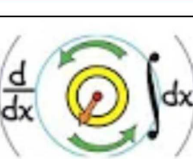
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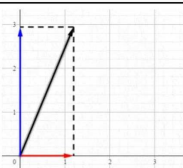
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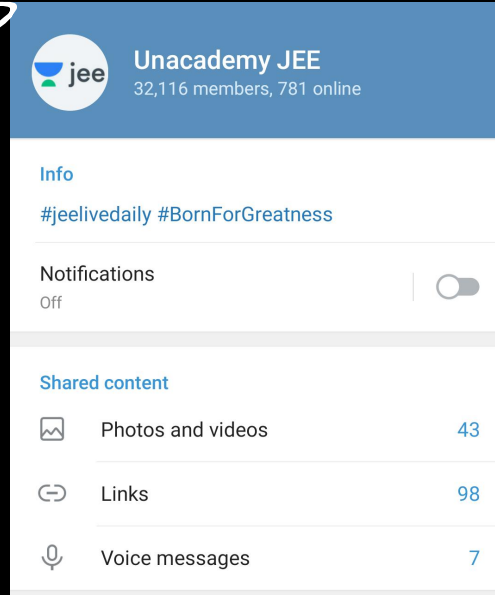
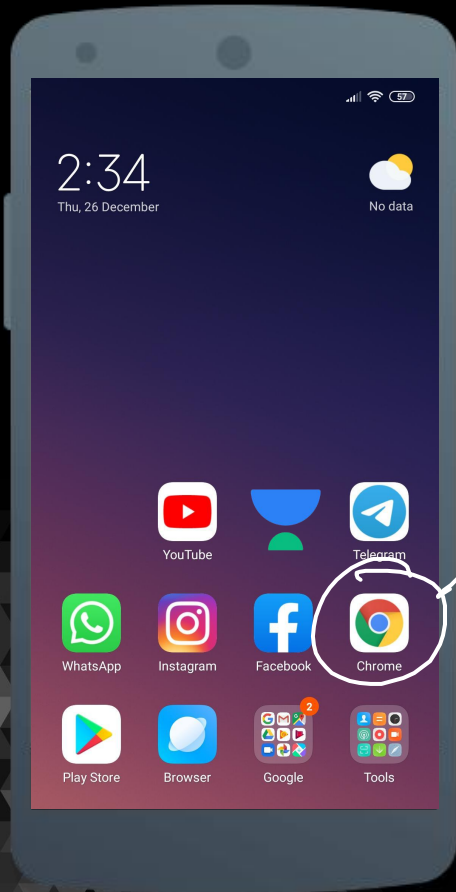
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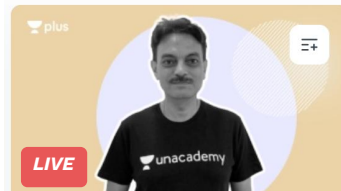


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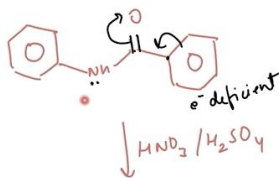
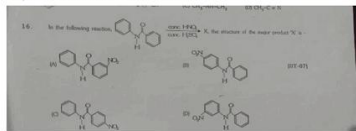
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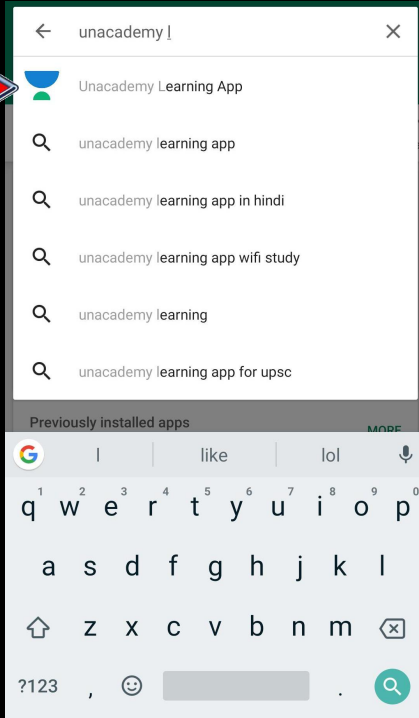
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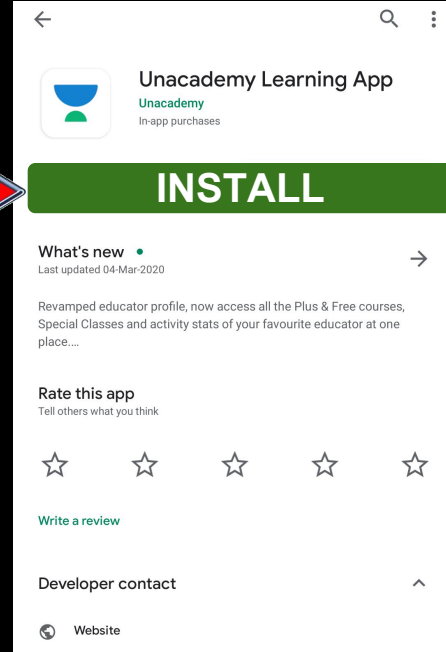


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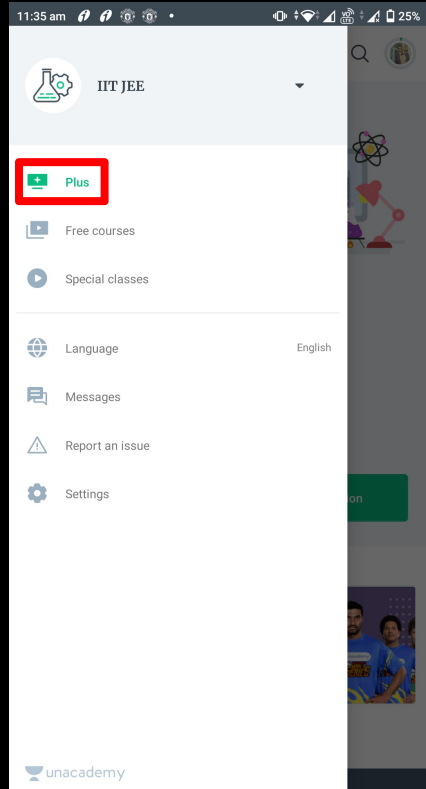
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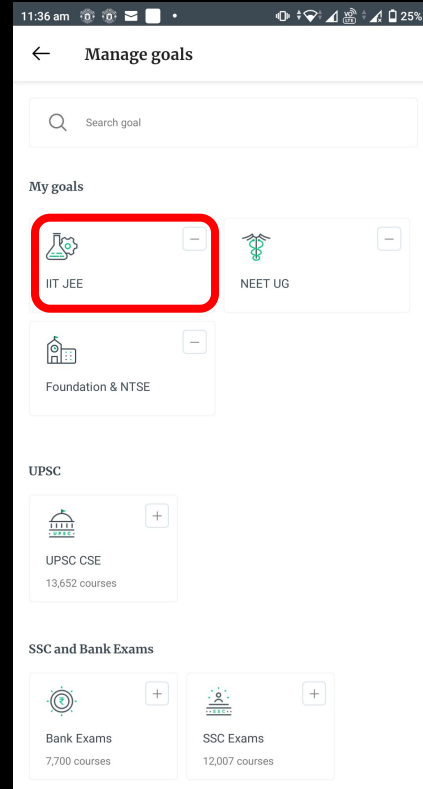
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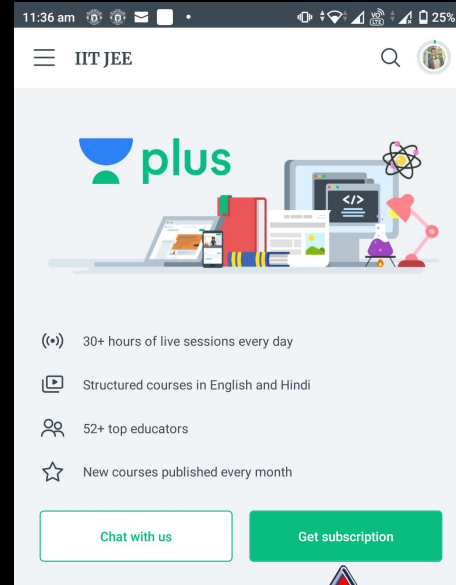
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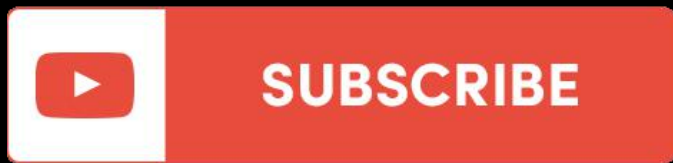
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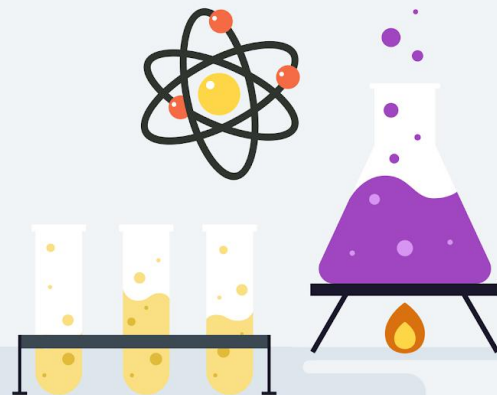
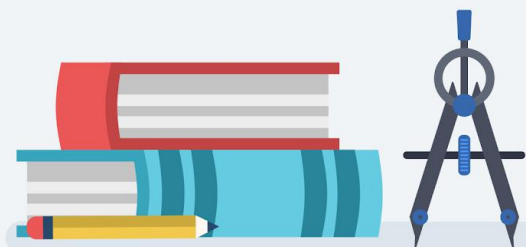
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