Step 1 : Formulate H_0 & H_a.

Step 2 : Decide cut-off in terms of α.

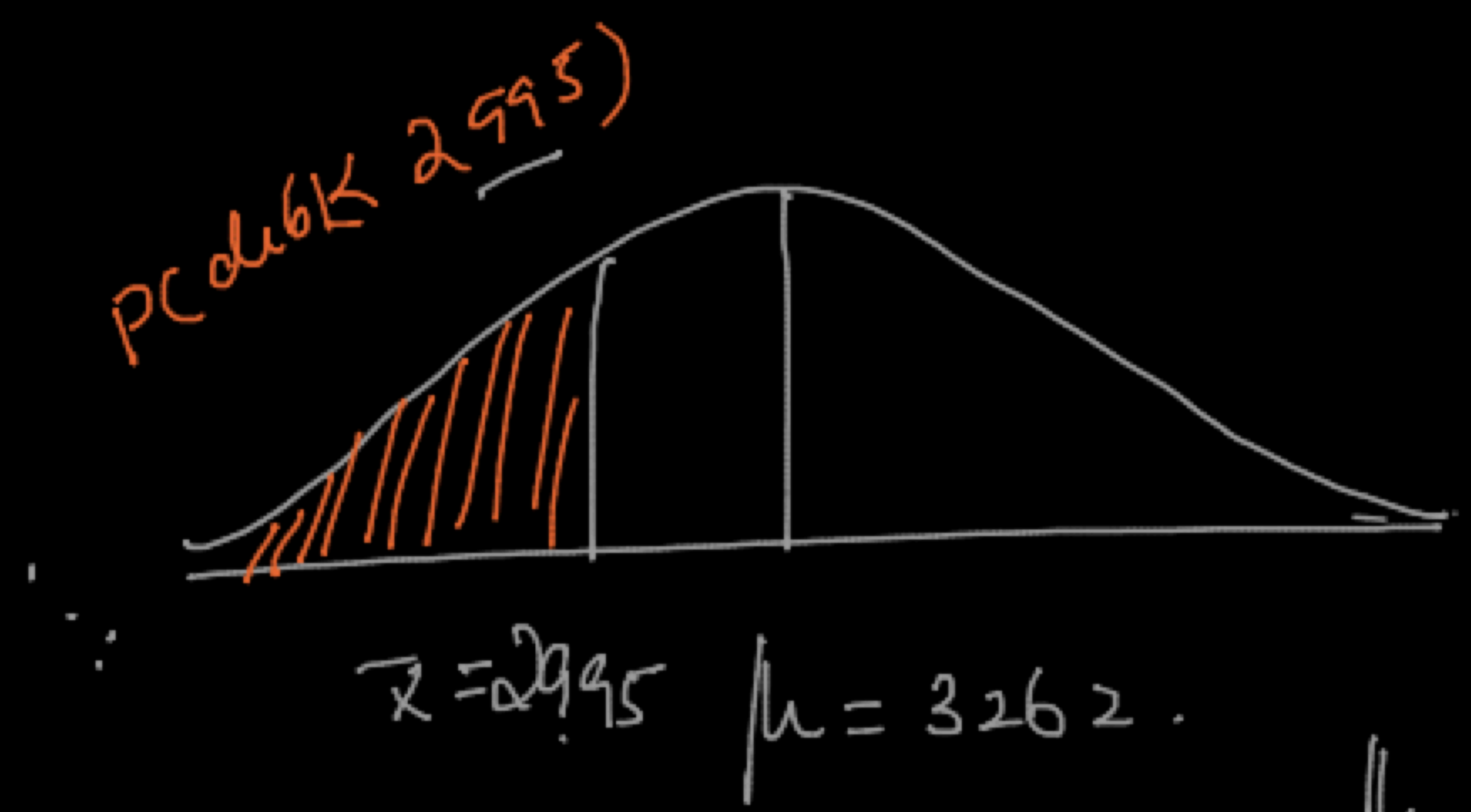
Step 3 : Collect Evidence from Sample.
($\bar{x}$).

Step 4 : Based on Evidence & the significance level
accept / reject H_0.

1. H_0 always contains '='.
2. The H_0 & H_a are applied to the 'population'
3. The evidence is collected from the Sample.
4. We always accept / reject the 'Null hypothesis' only.

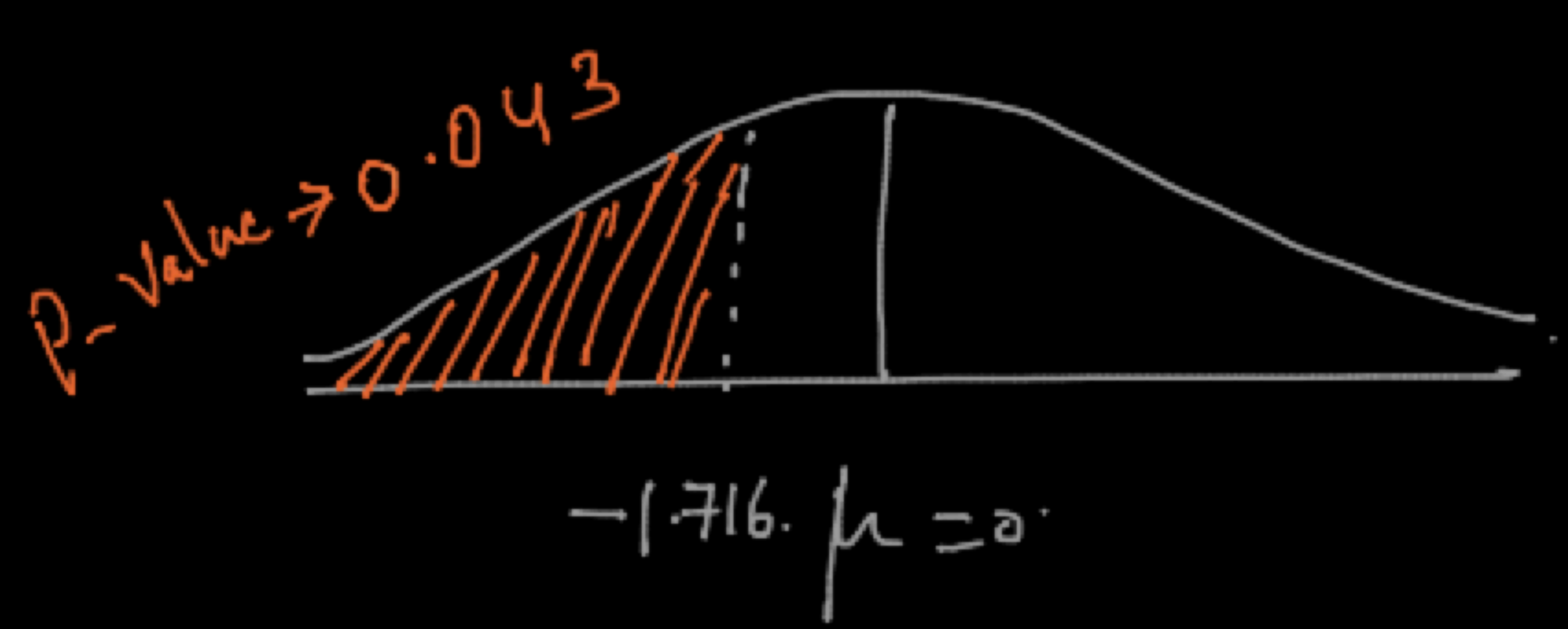
$H_0: \mu \geq 3262$. $\quad n = 50 \rightarrow \bar{x} = 2995$

$H_a: \mu < 3262$. $\quad \sigma = 1100$



$\Downarrow$ Z dist.

$$Z_{2995} = \frac{2995 - 3262}{1100/\sqrt{50}} = -1.716$$



Compare

p-value $\Leftrightarrow$ $\alpha = 0.05$

$P < \alpha \rightarrow$ Reject H_0

$P > \alpha \rightarrow$ accept H_0

$0.043 < 0.05$

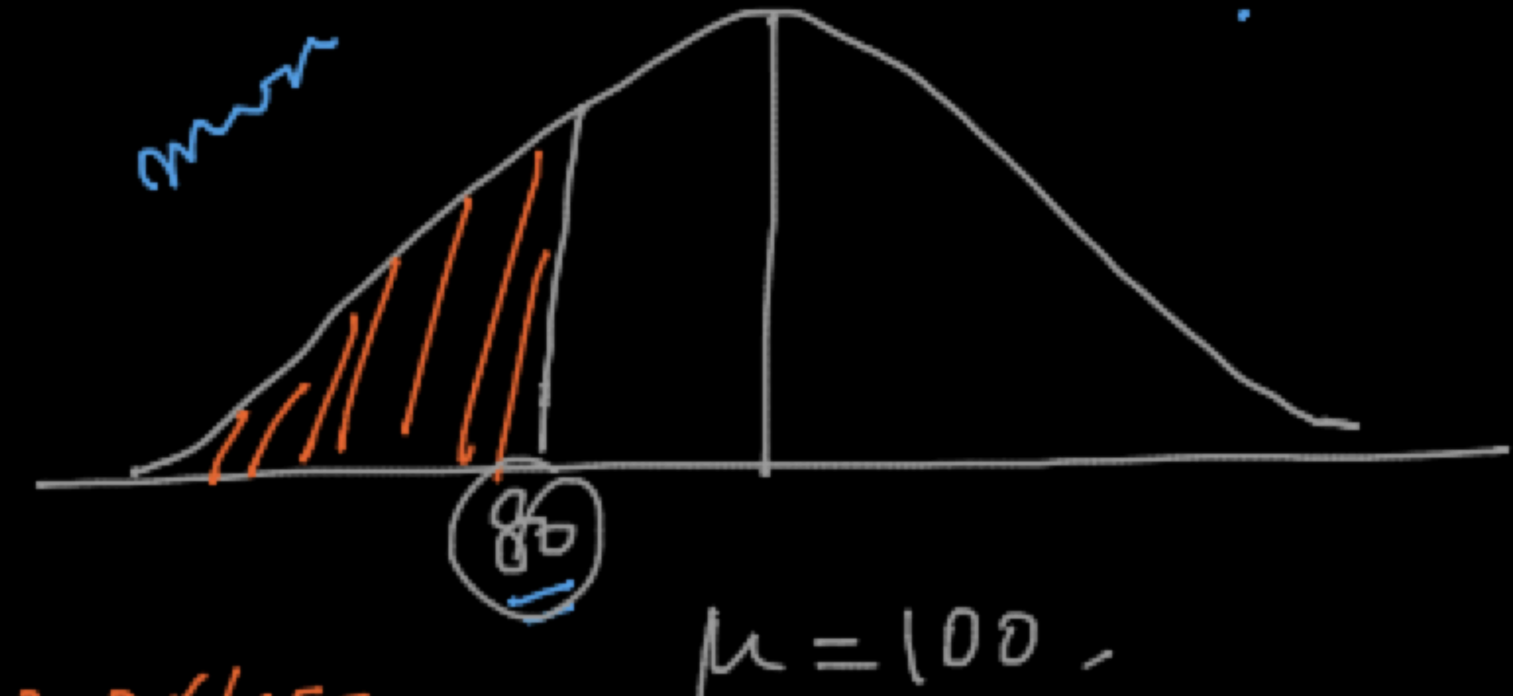
$\rightarrow$ Reject H_0.

P-Value: If H_0 is true, what is the prob. of observing this evidence or more extreme value of the evidence.

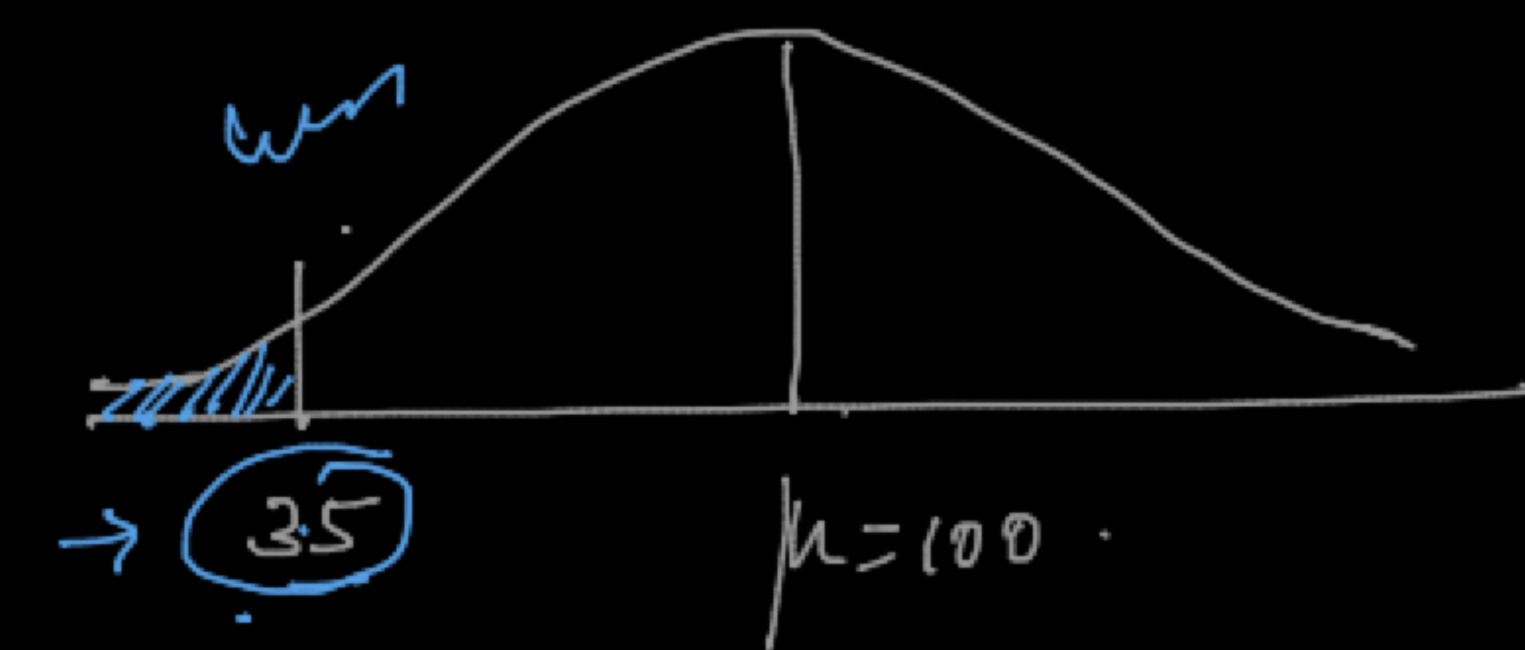
$H_0: \mu \geq 100$ ... ✓ X

$\alpha = 0.05$

$H_a: \mu < 100$

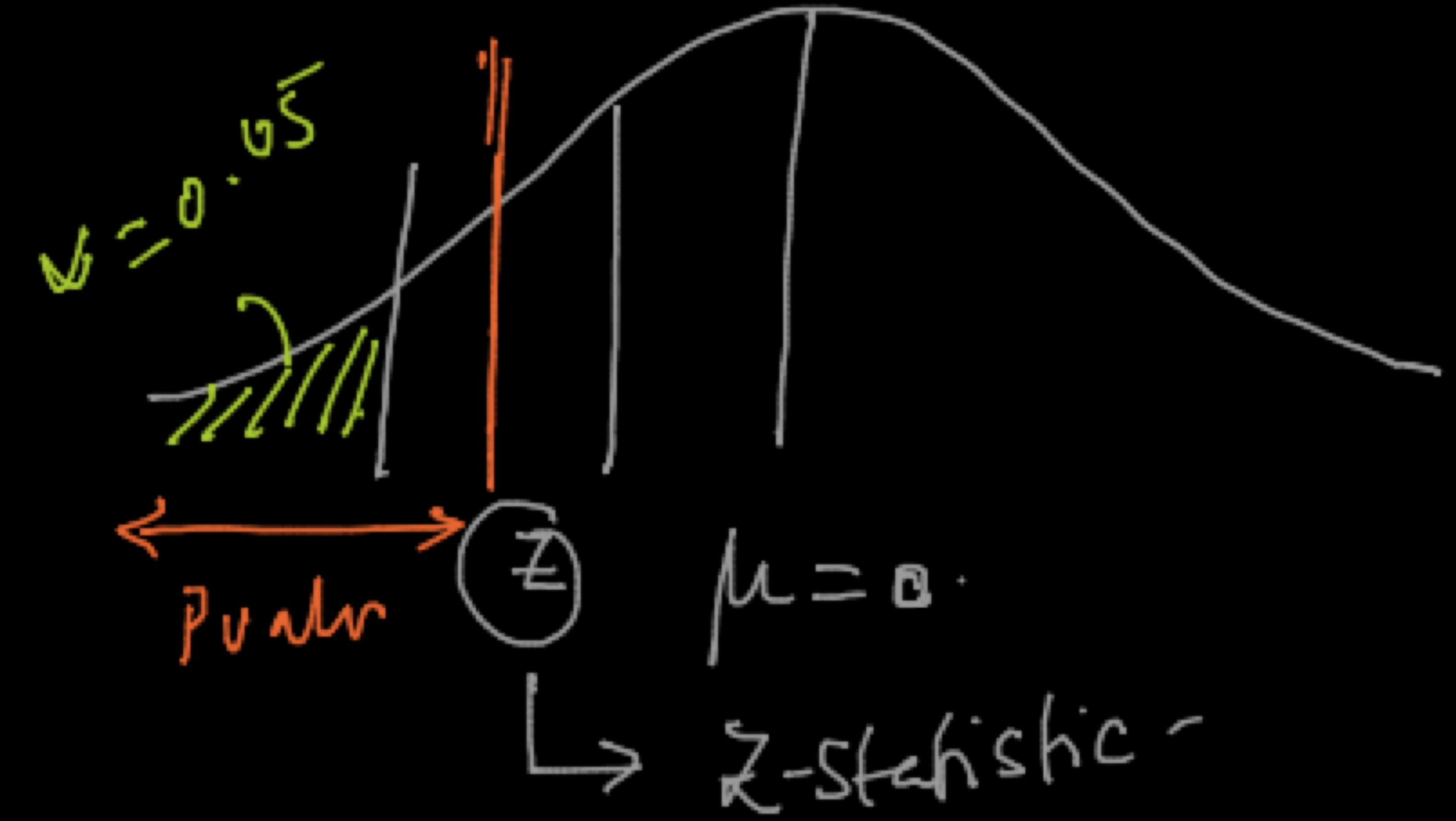


P. Value: 80 or less

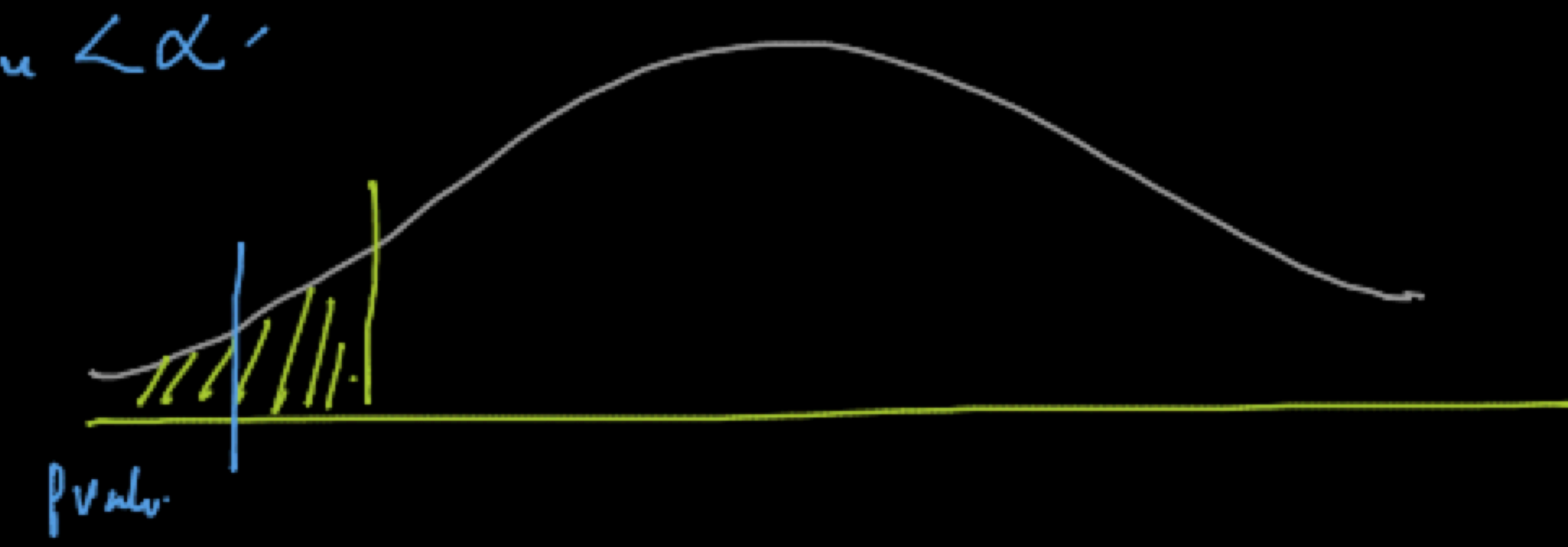


P-value: 35 or less

Accept H_0.



Pvalue < α



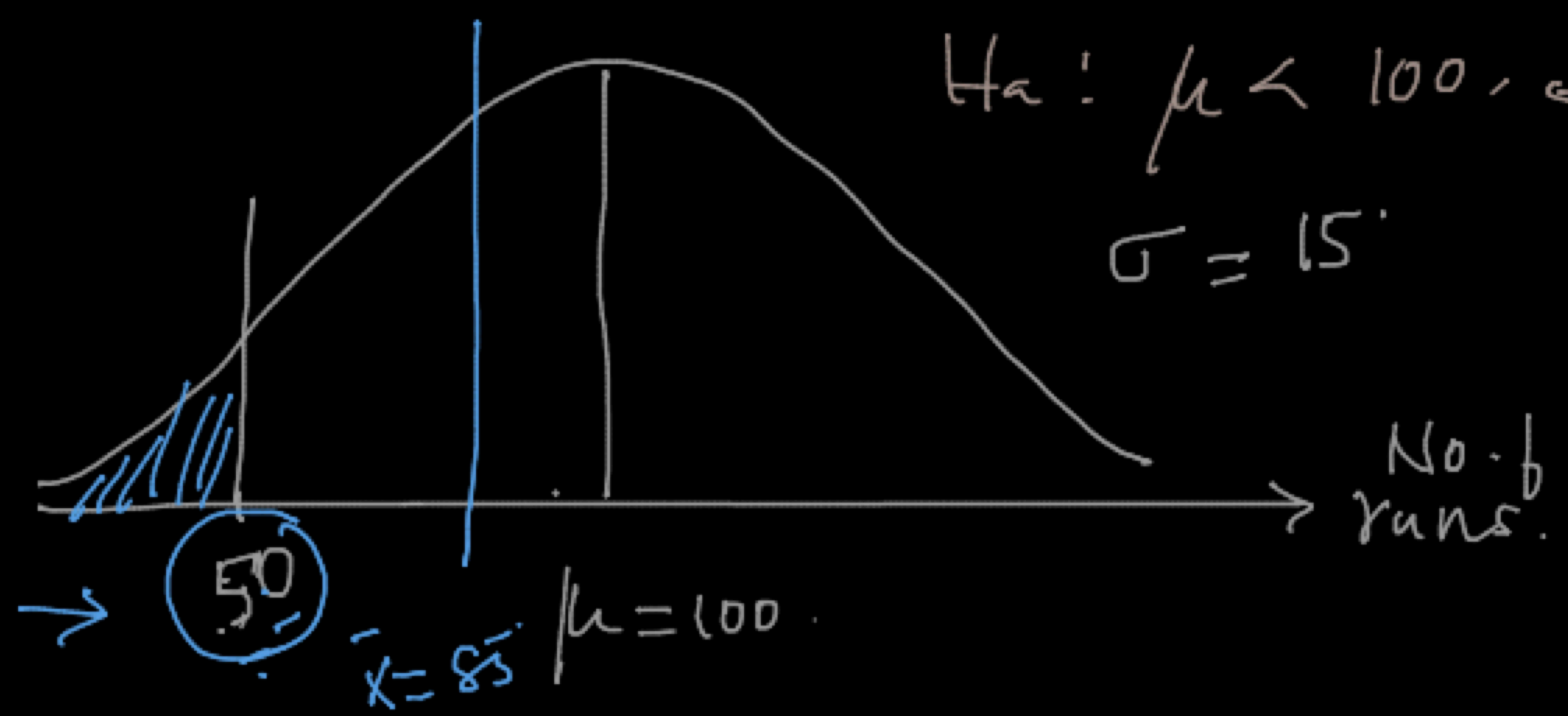
Friend.

$\rightarrow H_0 : \mu \geq 100.$

$H_a : \mu < 100.$

$\sigma = 15.$

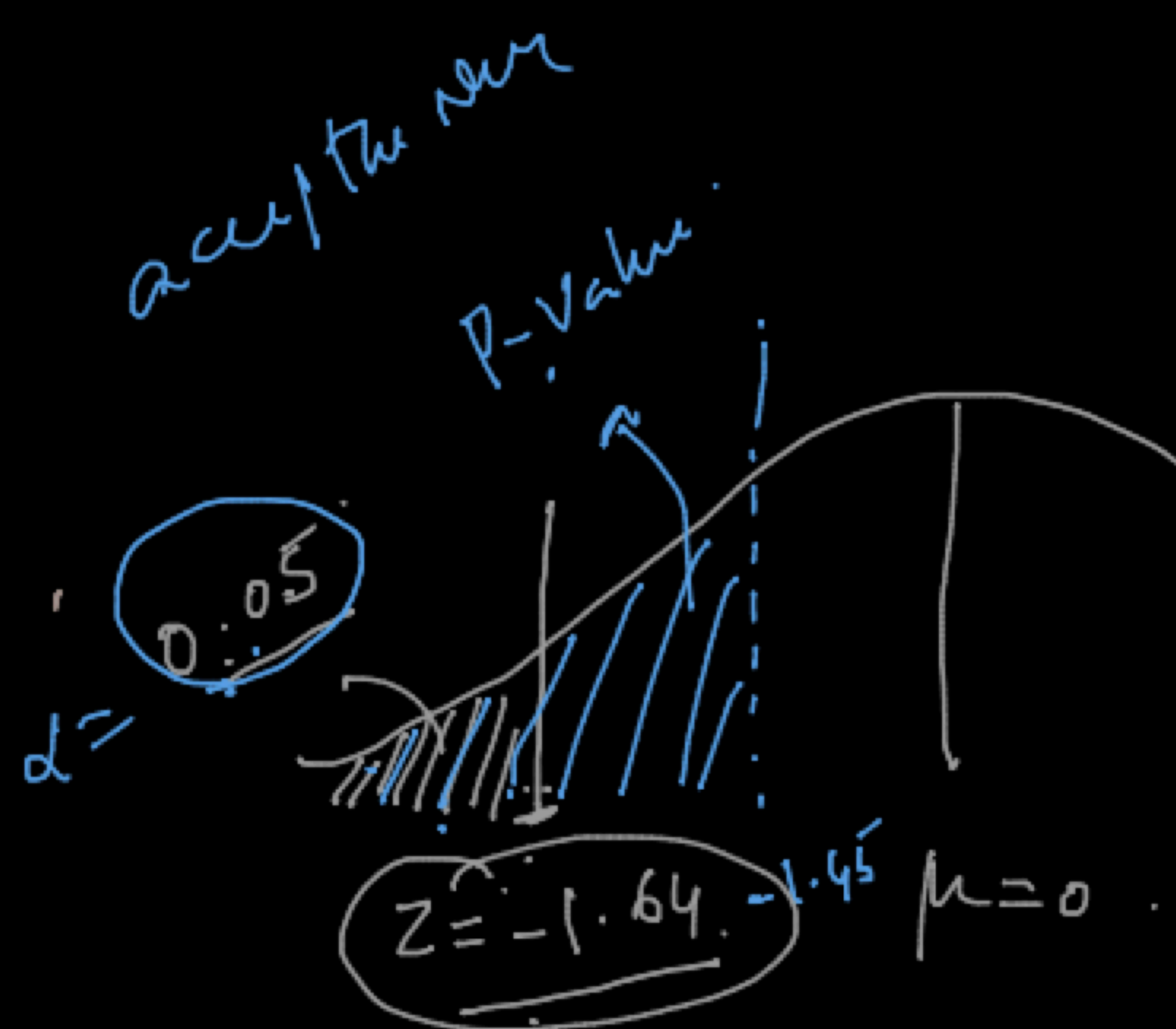
$Z_X = \dfrac{\bar{X} - \mu}{\sigma}$



$\sigma Z_x = x - \mu$

$$\boxed{X = \mu + \sigma Z_{\bar{x}}}$$

Evidence $= \bar{X} = 85.$



Boss:

$\alpha \Rightarrow$ How willing are we to reject H_0 when it's actually true.

Ground truth

Test	H_0 = True	H_0 = False
H_0 = True	✓	β
H_0 = False	α	✓

α – We reject H_0 when it is actually true.

β → We fail to reject H_0 when it is actually false.

$\mu = \boxed{3262}$ ✓

1 - sample test.

$n = 50$; $\bar{X} = 2995$.

1 sample test

National std. = $\boxed{}$

1
2
3
⋮
$n = 50$

$\bar{X}$ = Evidence

1
2
3
⋮
$n = 50$.

$\bar{X} =$.

2-sample test.

Two classes.

1	35
2	63
3	75
⋮	21
	⋮

$n = 40$.

$\bar{x}_1 =$.

1	63
2	58
3	75
⋮	⋮

$n = 50$.

$\bar{x}_2 =$.

$H_0: \mu_1 \le \mu_2 \quad \mu_1 \ge \mu_2 \quad \mu_1 = \mu_2$

$H_a: \mu_1 > \mu_2 \quad \mu_1 < \mu_2 \quad \mu_1 \ne \mu_2$

→ Independent Samples-

→ Paired Samples.

Before

After

Paired -

	Before	After
1	35	53
2	62	71
3	55	65
⋮	⋮	⋮

$n = 1$

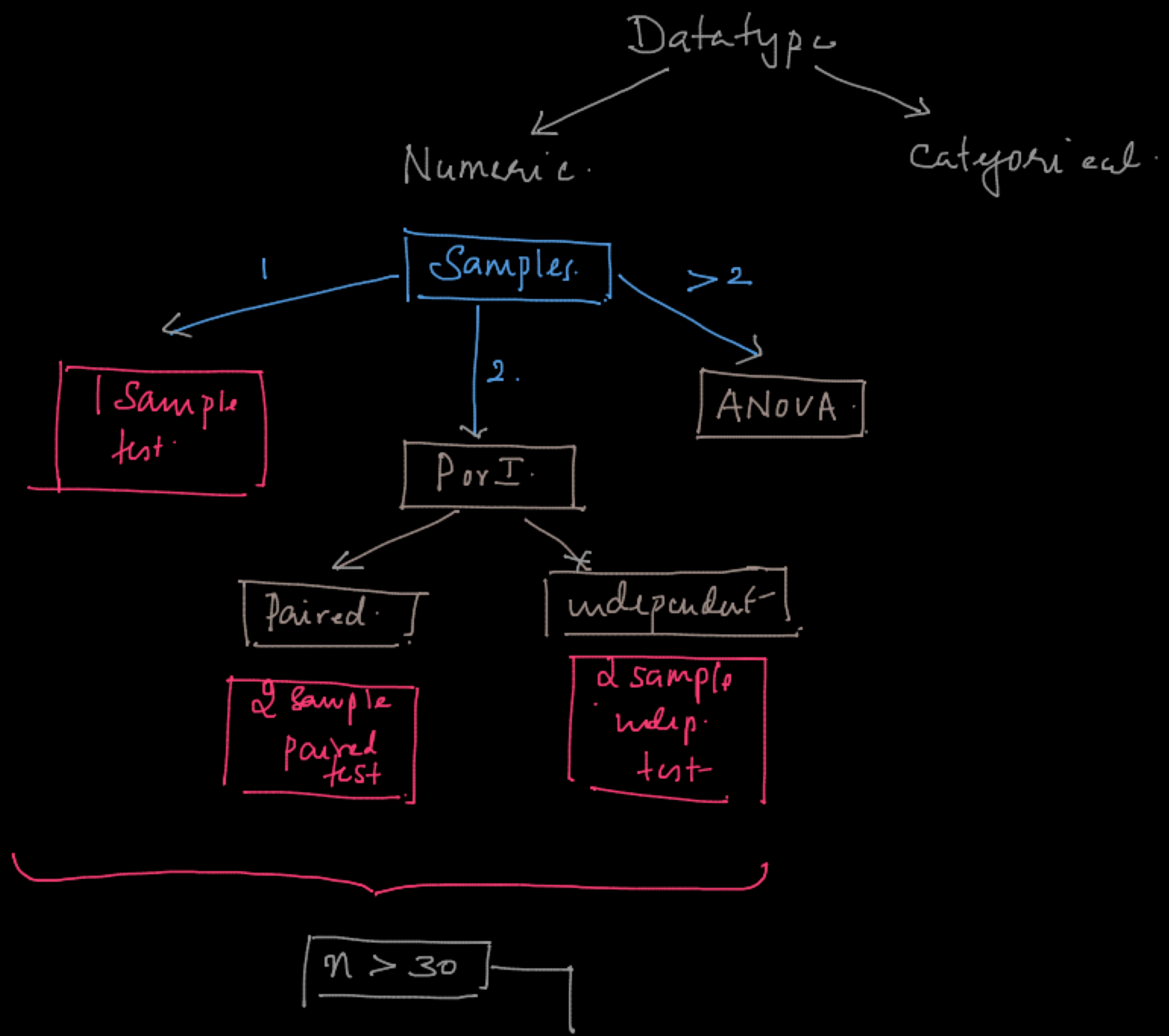
Engine oil.

F1		F2	
C1	—	C1	—
C2	—	C2	—
C3	—	C3	—
⋮	—	⋮	—
C10	—	C10	—

Paired

$n_1 = n_2$

F_1		F_2
C_1		C_{11}
C_2		C_{12}
C_3		C_{13}
$\vdots$		$\vdots$
C_{10}		C_{20}
$n_1 = 20$	Independent Sample	$n_2 = 15$


Datatype
Numeric.
Categorical.
Samples.
1
2.
> 2
1 Sample test.
P or I.
ANOVA.
Paired.
independent
2 Sample paired test
2 sample indep. test
n > 30

Datatype

- Numeric
  - Samples
    - 1 → 1 Sample test
      - z-statistic
      - t-statistic
    - 2 → P or I
      - Paired → 2 sample paired test
      - independent → 2 sample indep. test
    - > 2 → ANOVA
      - F-statistic
- Categorical

$H_0: \mu = ?$

$H_a: \mu > ?$

$\mu < ?$

$\mu \neq ?$

$H_0: \mu_1 = \mu_2 = \mu_3 = \dots$

H_a: Atleast one mean is different.

$H_0: \mu_1 = \mu_2; \quad \mu_1 - \mu_2 = 0$

$H_a: \mu_1 < \mu_2; \quad \mu_1 - \mu_2 < 0$

$\mu_1 > \mu_2; \quad \mu_1 - \mu_2 > 0$

$\mu_1 \neq \mu_2; \quad \mu_1 - \mu_2 \neq 0$

$n > 30$

- Yes → z-statistic
- No → σ_{pop}
  - known → z-statistic

$n_1 - 1$ $\quad$ $n_2 - 1$ $\quad$ $n_3 - 1$

n_1 $\quad$ n_2 $\quad$ n_3.

Diet 1. $\quad$ Diet 2 $\quad$ Diet 3.

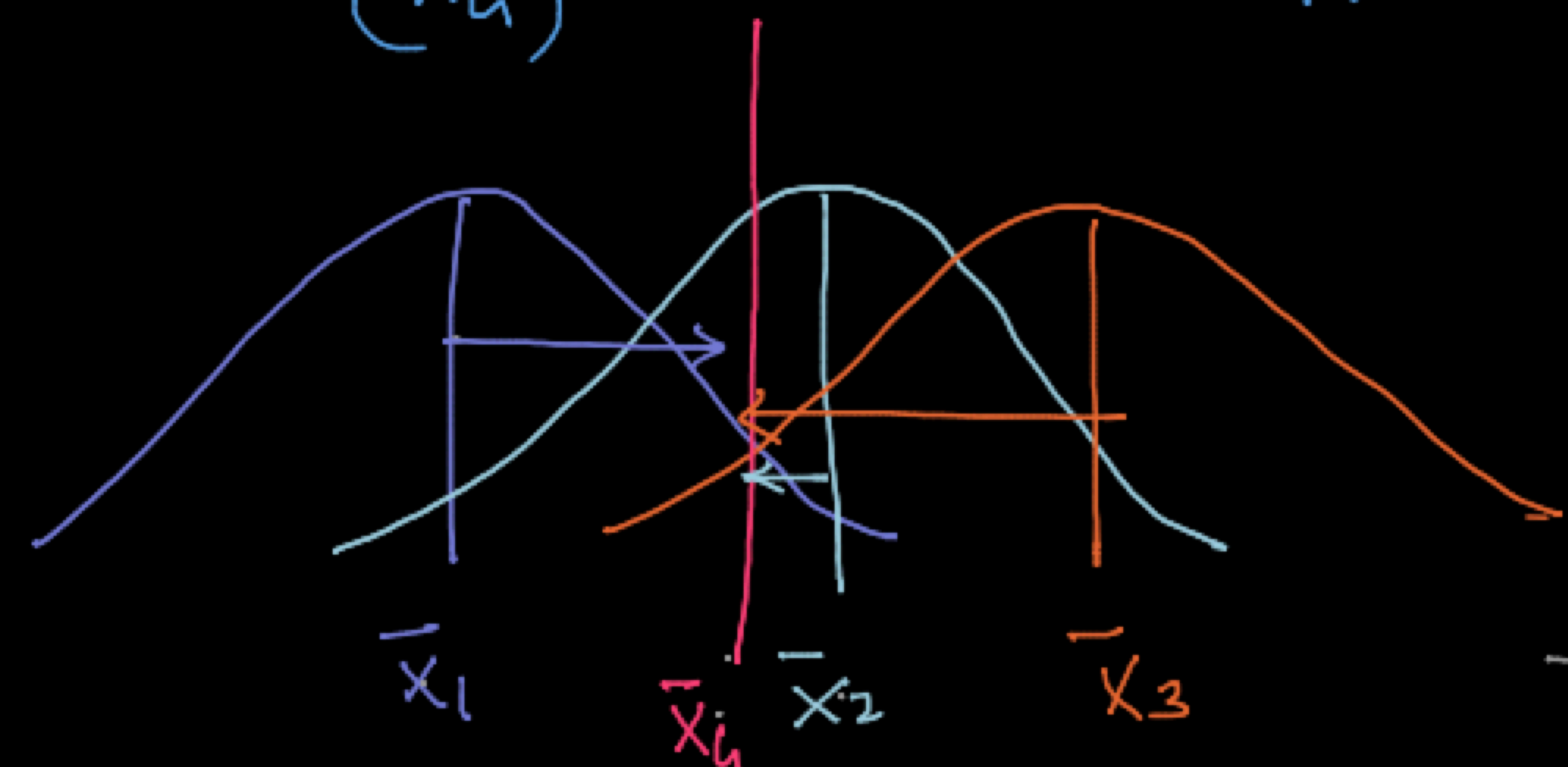
Diet 1		Diet 2		Diet 3	
x_{11}	—	x_{21}	—	x_{31}	—
x_{12}	—	x_{22}	—	x_{32}	—
x_{13}	—	x_{23}	—	x_{33}	—
⋮		⋮		⋮	
x_{1n_1}	—	x_{2n_2}	—	x_{3n_3}	—
$\bar{x}_1 =$	___	$\bar{x}_2 =$	___	$\bar{x}_3$	___

$$\frac{1}{n_1-1}\sum_{i=1}^{n_1}(x_{1i}-\bar{x}_1)^2 \quad \frac{1}{n_2-1}\sum_{i=1}^{n_2}(x_{2i}-\bar{x}_2)^2 \quad \frac{1}{n_3-1}\sum_{i=1}^{n_3}(x_{3i}-\bar{x}_3)$$

$$dr. = \frac{1}{N-K}\sum_{j=1}^{K}\sum_{i=1}^{n_K}(x_{ji}-\bar{x}_j)^2$$

$$F\text{-statistic} = \frac{\text{Across group Variance}}{\text{Within Group Variance}}$$

$$\text{Grand Mean } (\bar{X}_G) = \frac{\bar{x}_1+\bar{x}_2+\bar{x}_3+\dots+\bar{x}_k}{K}$$



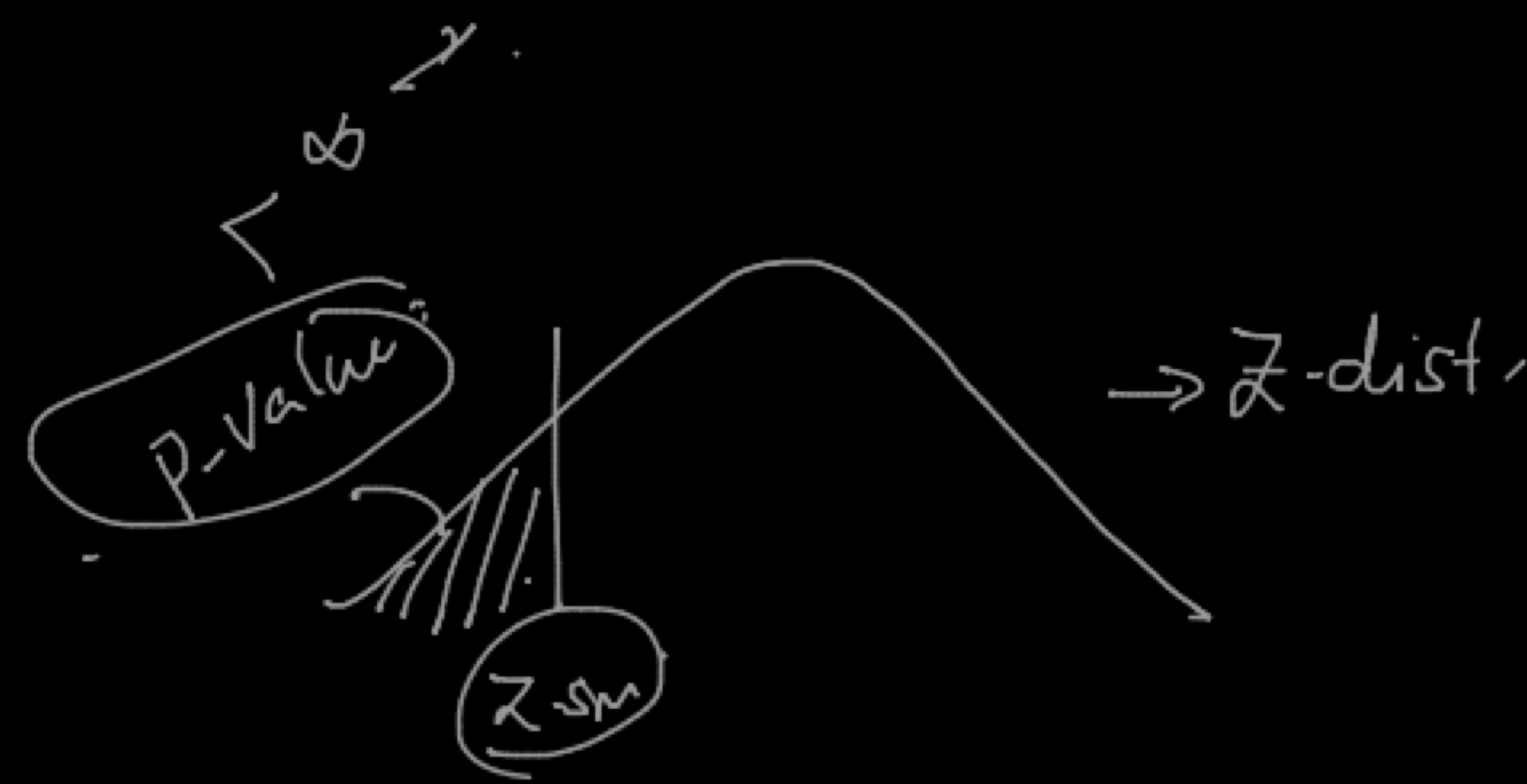
→ Avg Wt loss.

$$\text{Variance} = \frac{1}{n-1}\sum_{i=1}^{n}(x_i-\bar{x})^2$$

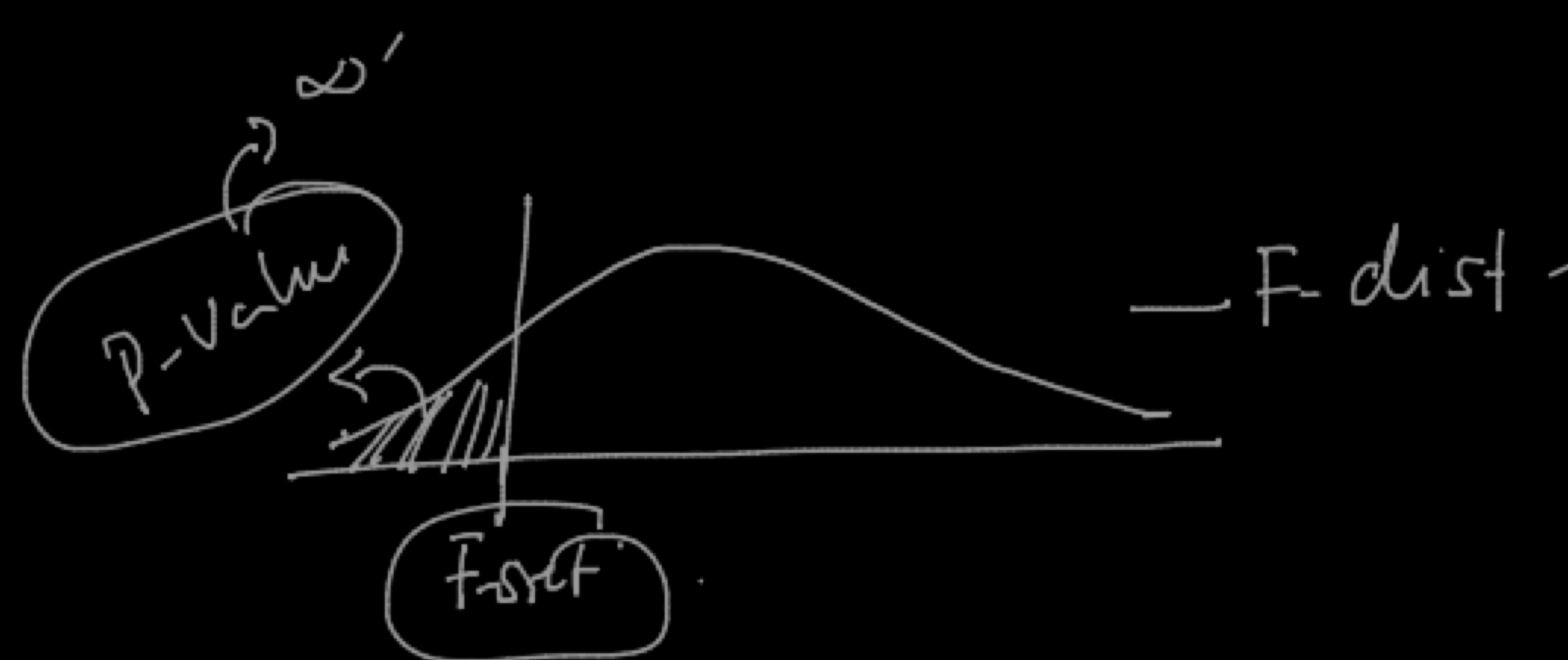
$$Nr. = \frac{1}{k-1}\sum_{i=1}^{k}(\bar{x}_i-\bar{x}_G)^2$$

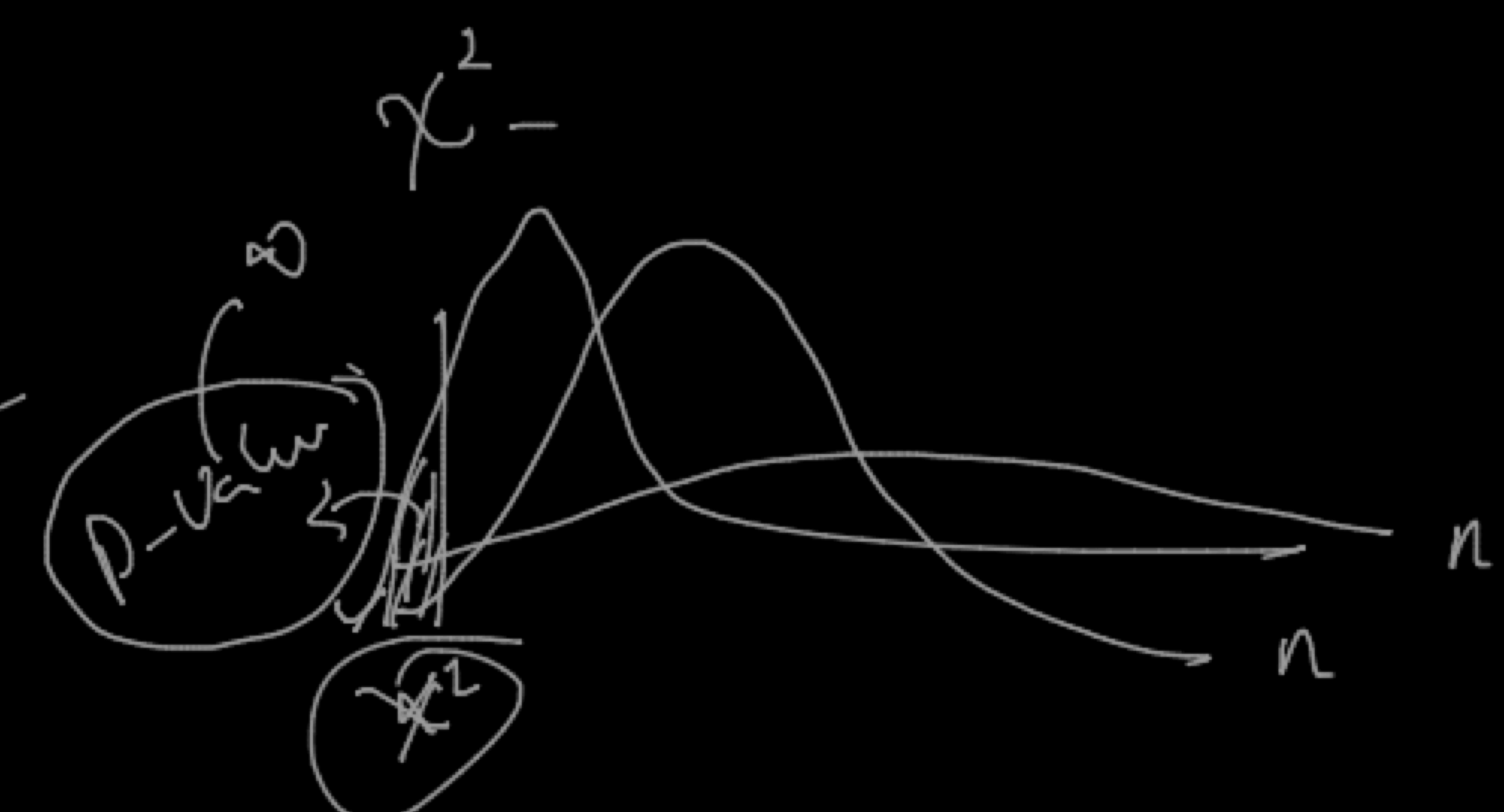
$n_1 - 1 + n_2 - 1 + n_3 - 1 + \cdots n_k - 1$

$\underbrace{n_1 + n_2 + n_3 \cdots + n_k}_{N} - k \Rightarrow N - K.$


α
p-value
Z-dist.


α
p-value
t-dist.
t-statistic


α
p-value
F-dist.
F-stat


χ²
α
p-value
n.
n
χ²

Categorical:

Samples

1

1 proportion test

$H_0: p : 94$

$H_a: p_1 > 94$.

$p_1 < 94 \rightarrow 94\%$.

$p \neq 94$

Yes

Yes

No

No

Proportion:

2

2 proportion test

H_0:

$H_a: P_1 > P_2$

$P_1 < P_2$

$P_1 \neq P_2$

$P_1 = \cdot$ P_2.

> 2

χ^2 – Goodness of Fit

Test of independence

$\bar{P}_1 = 94\%$.

H_0: $\cancel{P_1 < 94}$ %.

$H_a: P_1 > 94\%$.