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Notes for Students – Lesson 9

Q1:-

Hypothesis Testing

Dependent Variable (Measured on scale from 1 to 10)	Sample Mean $\bar{x}$ (n = 20)	Probability	Likely or unlikely?
Student engagement	$\bar{x}_E$ = Something	$p \approx 0.05$	
Student learning	$\bar{x}_L$ = Something else	$p \approx 0.10$	

Q2:-

α Levels

$\alpha = .05$ (5%)

$\alpha = .01$ (1%)

$\alpha = .001$ (0.1%)

← Sampling distribution

95%

5%

z*

Which of the following are true?

☐ If the probability of getting a particular sample mean is less than α, it is "unlikely" to occur.

☐ If a sample mean has a z-score greater than z*, it is "unlikely" to occur.

☐ If the probability of getting a particular sample mean is "unlikely", the sample mean is in the orange region.
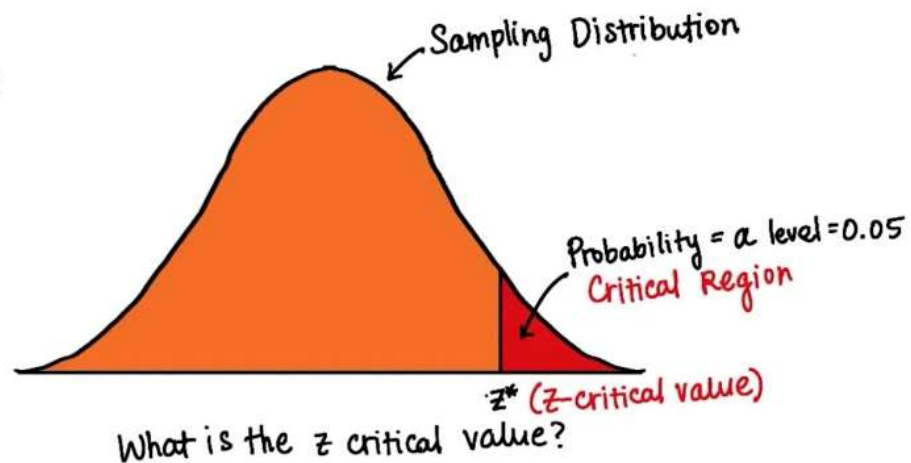
☐ The alpha level corresponds to the orange region.

Q3 Part 1:-

α Levels

$\alpha = .05$ (5%)
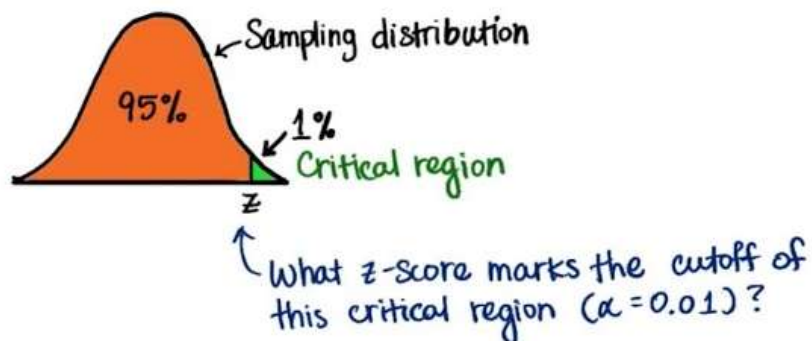
$\alpha = .01$ (1%)

$\alpha = .001$ (0.1%)

Sampling Distribution

Probability = α level = 0.05
Critical Region

z^* (z-critical value)

What is the z critical value?

Q3 Part 2:-

α Levels

$\alpha = .05$ (5%)

$\alpha = .01$ (1%)

$\alpha = .001$ (0.1%)

Sampling distribution

95%

1%
Critical region

z

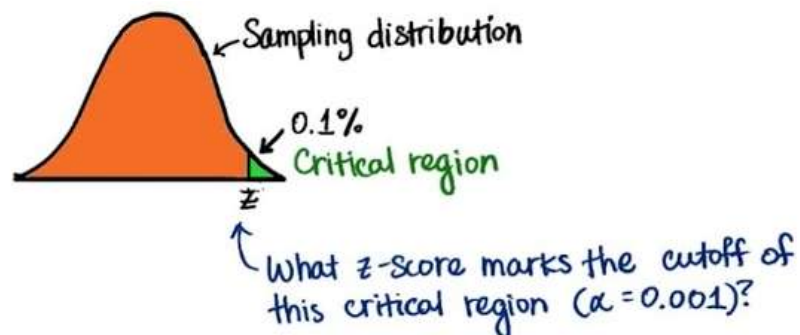What z-score marks the cutoff of this critical region ($\alpha = 0.01$)?

Q3 Part 3:-

α Levels

$\alpha = .05$ (5%)

$\alpha = .01$ (1%)

$\alpha = .001$ (0.1%)

Sampling distribution

0.1%
Critical region

z

What z-score marks the cutoff of this critical region ($\alpha = 0.001$)?

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α Levels

$\alpha = .05 \ (5\%)$

$\alpha = .01 \ (1\%)$

$\alpha = .001 \ (0.1\%)$

Sample mean $\bar{x}$

$Z = \dfrac{\bar{x} - \mu}{(\sigma / \sqrt{n})} = 1.82$

$\bar{x}$ is significant at $p < 0.05$

← Sampling distribution

Critical regions

$\alpha = 0.05$
$\alpha = 0.01$
$\alpha = 0.001$

O

Z-Scores

3.08
2.32
1.65
$\}$ z-critical values

Q4:-

Z-Score	Significant at:
3.14	$p <$ _____
2.07	$p <$ _____
2.57	$p <$ _____
14.31	$p <$ _____

α Levels

$\alpha = .05 \ (5\%)$

$\alpha = .01 \ (1\%)$

$\alpha = .001 \ (0.1\%)$

← Sampling distribution

Critical regions

$\alpha = 0.05$
$\alpha = 0.01$
$\alpha = 0.001$

O

Z-Scores

3.08
2.32
1.65
$\}$ z-critical values
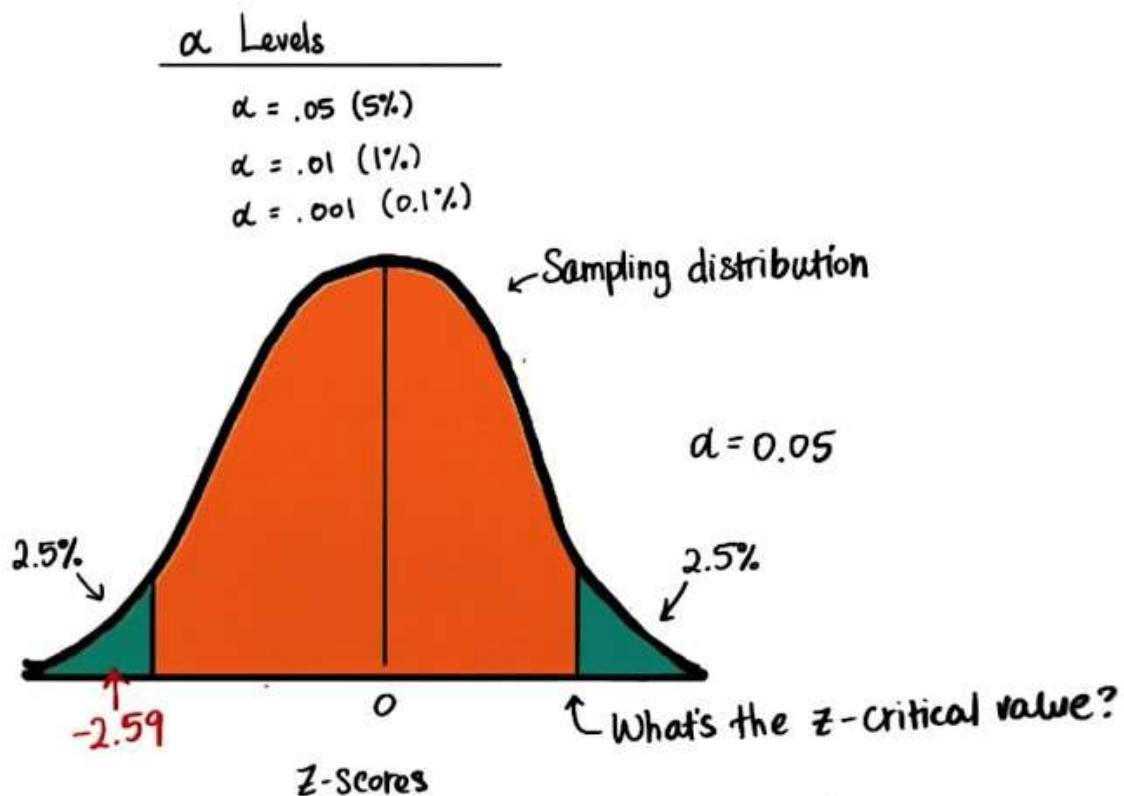
Q5:-

Hypothesis Testing

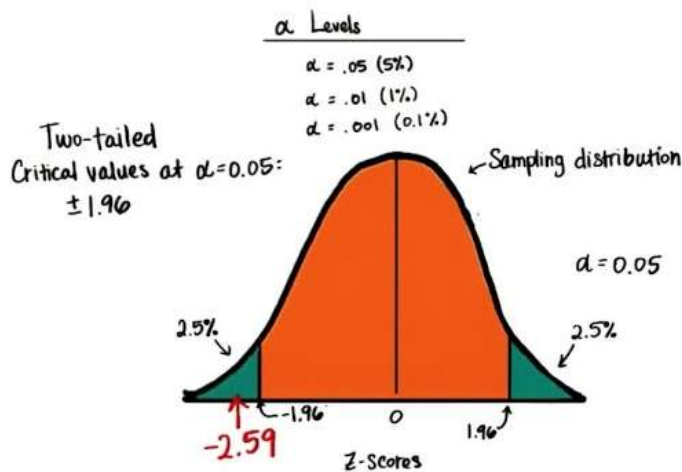| Population Parameters |
| --- |
| $\mu = 7.5$ |
| $\sigma = 0.64$ |

Dependent Variable
(Measured on scale from 1 to 10)

Sample Mean $\bar{x}$
($n = 20$)

Probability

Student engagement

$\bar{x}_E = 7.13$

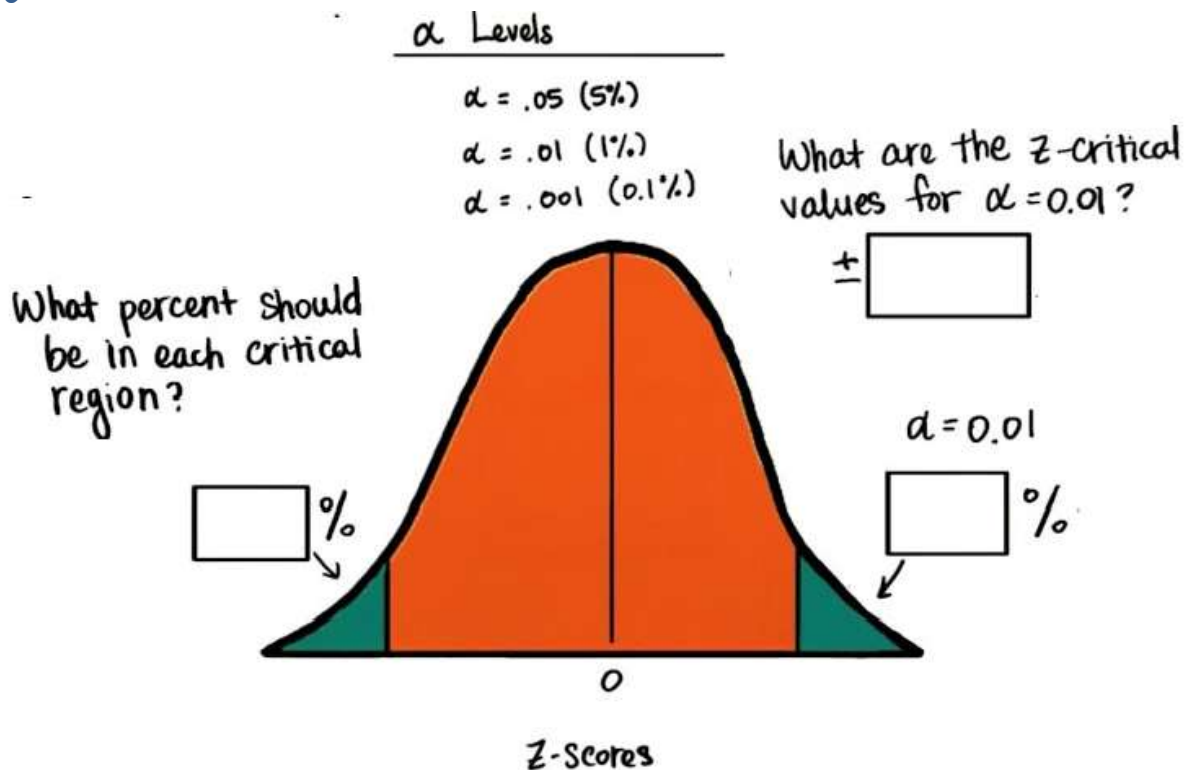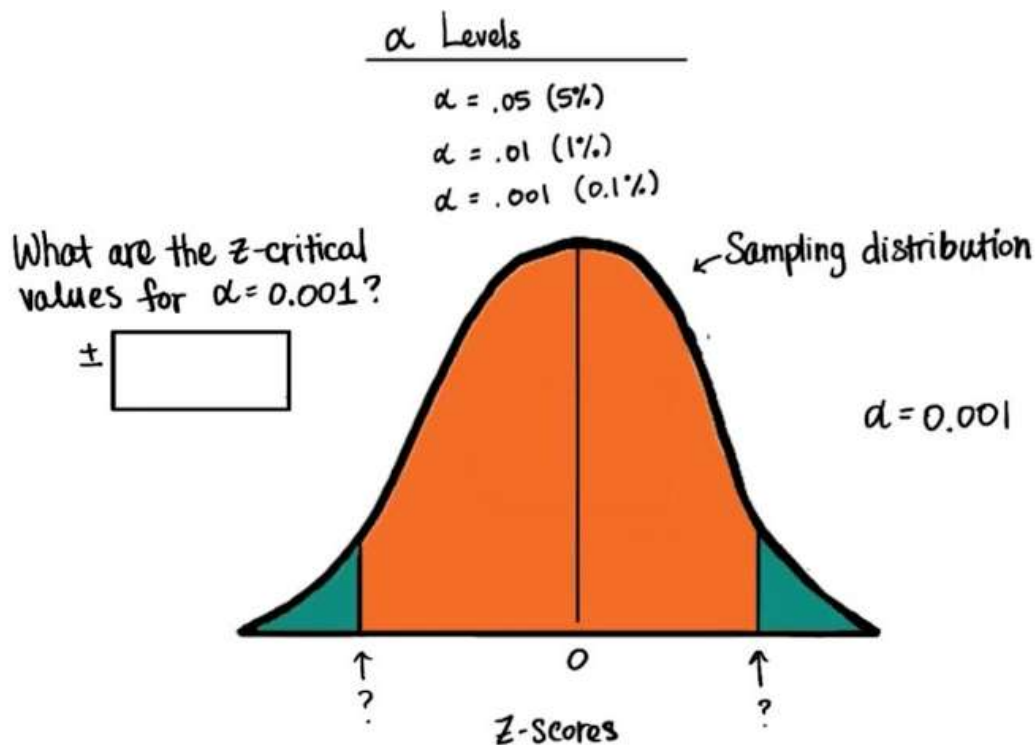What is the z-score of this sample mean?

Q6:- Two Tailed Test

α Levels

$\alpha = .05 \ (5\%)$

$\alpha = .01 \ (1\%)$

$\alpha = .001 \ (0.1\%)$

← Sampling distribution

$\alpha = 0.05$

2.5%

2.5%

-2.59

0

What's the z-critical value?

Z-Scores

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Q7:-

α Levels

α = .05 (5%)
α = .01 (1%)
α = .001 (0.1%)

Two-tailed
Critical values at α=0.05:
±1.96

← Sampling distribution

α = 0.05

2.5%   2.5%

-1.96   0   1.96
-2.59

Z-Scores

What can we say about the
Sample mean $\bar{x} = 7.13$ (z-score
= -2.59) ?

☐ It is unlikely to have gotten
a mean engagement score
of 7.13

☐ A mean engagement score of
7.13 does <u>not</u> fall in the
critical region

☐ There is evidence that Katie's
singing made students less
engaged

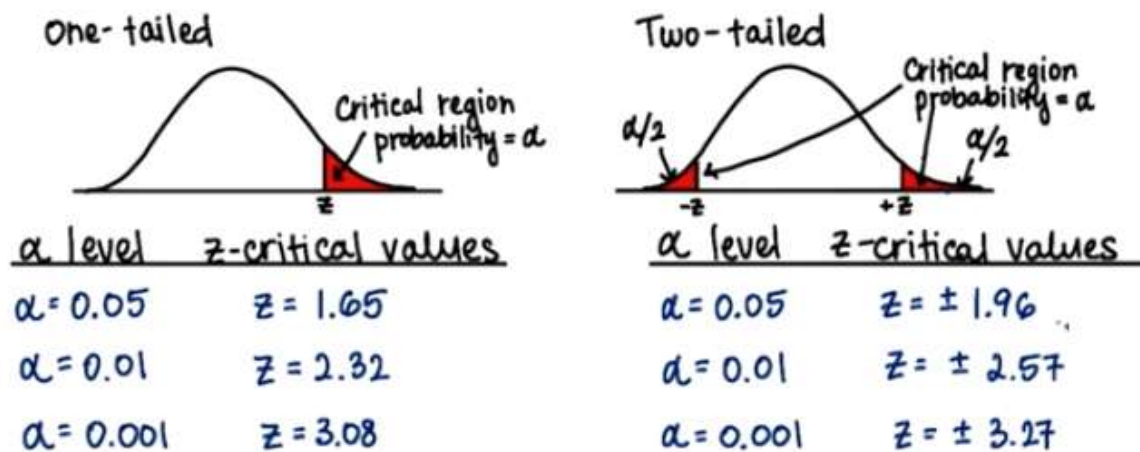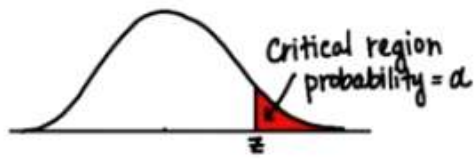☐ A mean engagement score
of 7.13 is significant at
$p < 0.05$

Q8 Part 1

α Levels

α = .05 (5%)
α = .01 (1%)
α = .001 (0.1%)

What are the z-critical
values for α = 0.01 ?

± [　　　]

What percent should
be in each critical
region?

α = 0.01

[　　] %   [　　] %

0

Z-Scores

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Q8 Part 2

α Levels

$\alpha = .05$ (5%)

$\alpha = .01$ (1%)

$\alpha = .001$ (0.1%)

What are the z-critical
values for $\alpha = 0.001$?

$\pm$ [   ]

← Sampling distribution

$\alpha = 0.001$

↑
?

0

↑
?

Z-Scores

Hypothesis

One-tailed

Critical region
probability = α

z

α level	z-critical values
α = 0.05	z = 1.65
α = 0.01	z = 2.32
α = 0.001	z = 3.08

Two-tailed

Critical region
probability = α

$\alpha/2$

$\alpha/2$

-z

+z

α level	z-critical values
α = 0.05	z = ± 1.96
α = 0.01	z = ± 2.57
α = 0.001	z = ± 3.27

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One-tailed

Critical region
probability = α

Two-tailed

$\alpha/2$

Critical region
probability = α

$\alpha/2$

$-z$ $+z$

z

$\alpha = 0.05$ $z = 1.65$

$\alpha = 0.05$ $z = \pm 1.96$

H_0 (null hypothesis) : $\mu = \mu_I$

H_a (alternative hypothesis) : $\mu < \mu_I$

$\mu > \mu_I$

$\mu \neq \mu_I$

One-tailed

Critical region
probability = α

Two-tailed

$\alpha/2$

Critical region
probability = α

$\alpha/2$

z

$-z$ $+z$

$\alpha = 0.05$ $z = 1.65$

$\alpha = 0.05$ $z = \pm 1.96$

H_0 (null hypothesis) : $\mu = \mu_I$

H_a (alternative hypothesis) : $\mu < \mu_I$

$\mu > \mu_I$

$\mu \neq \mu_I$

Q9:-

H_o: Most dogs have four legs. (Most = more than 50%)

H_A: Most dogs have less than four legs.

Sample 10 dogs and find that all have four legs.

Did we prove that the null hypothesis is true (that most dogs have four legs)?

      o Yes

      o No

Q10:-

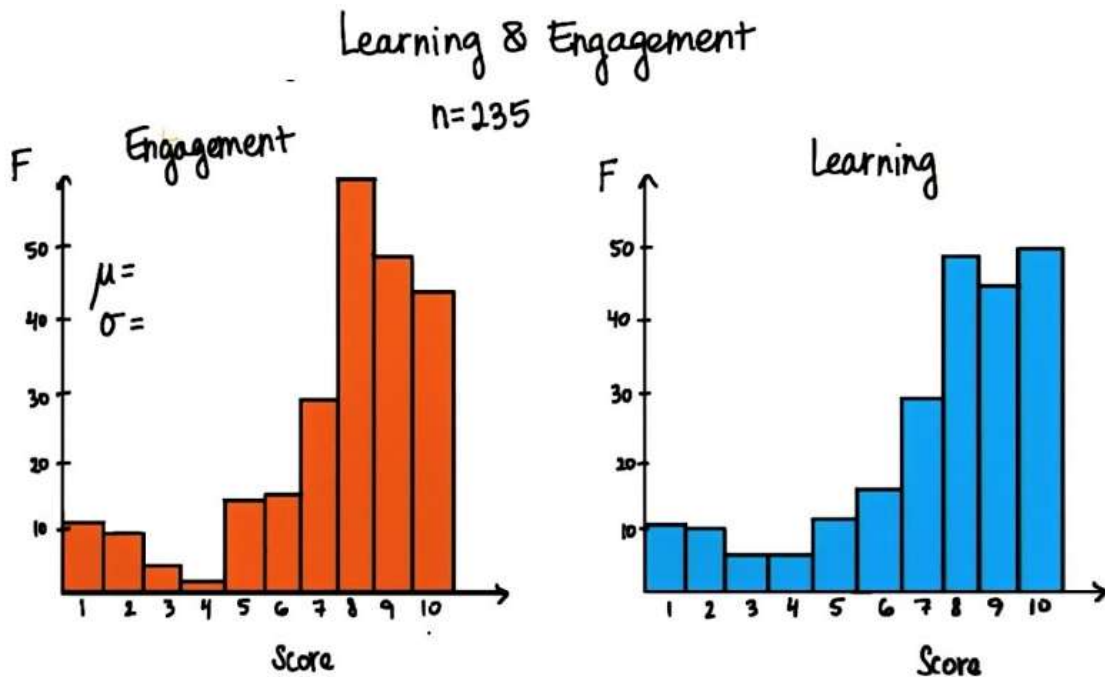H_o: Most dogs have four legs. (Most = more than 50%)

H_A: Most dogs have less than four legs.
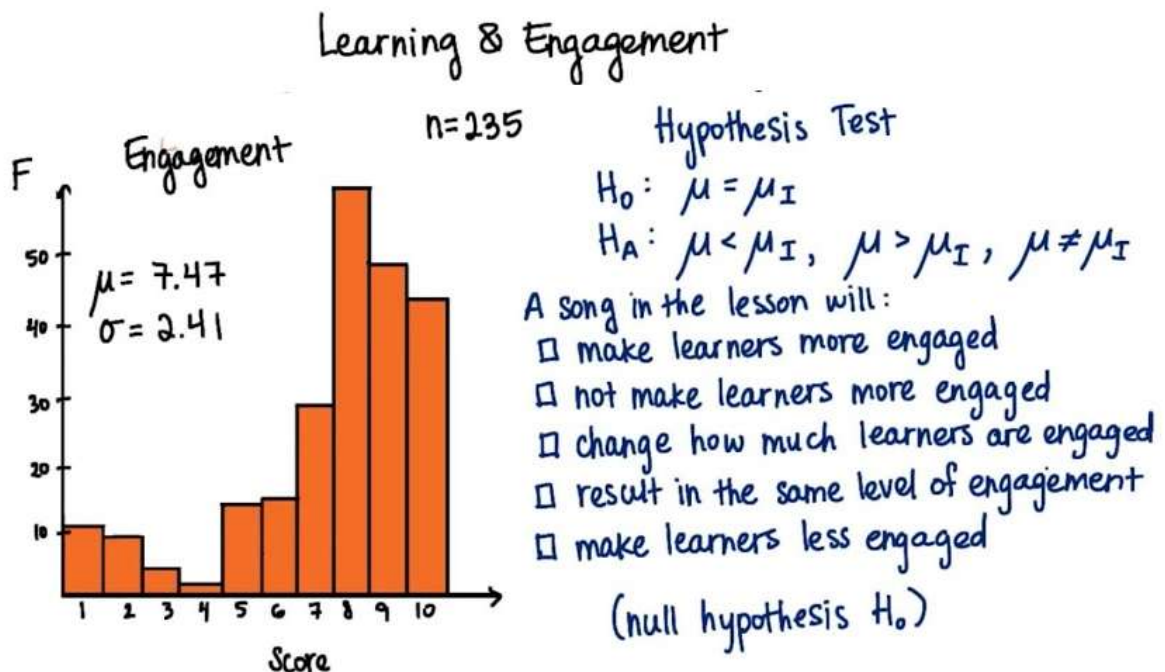
Sample 10 dogs and find that 6 dogs have three legs.

Is this evidence to reject the null hypothesis that most dogs have four legs?
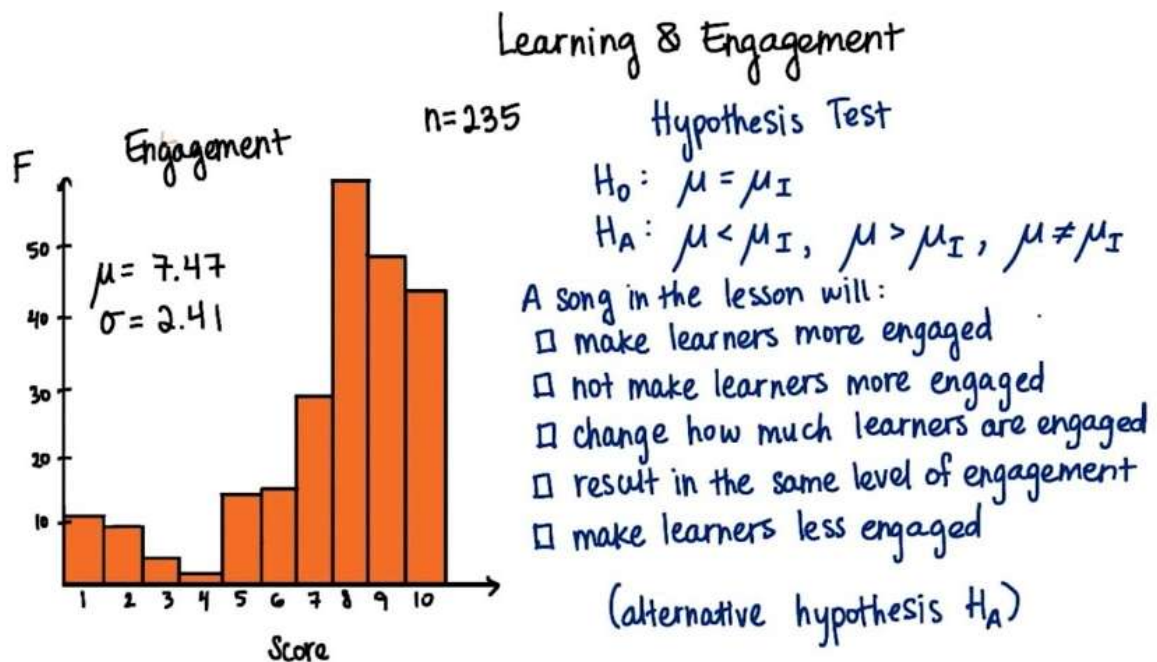
      o Yes

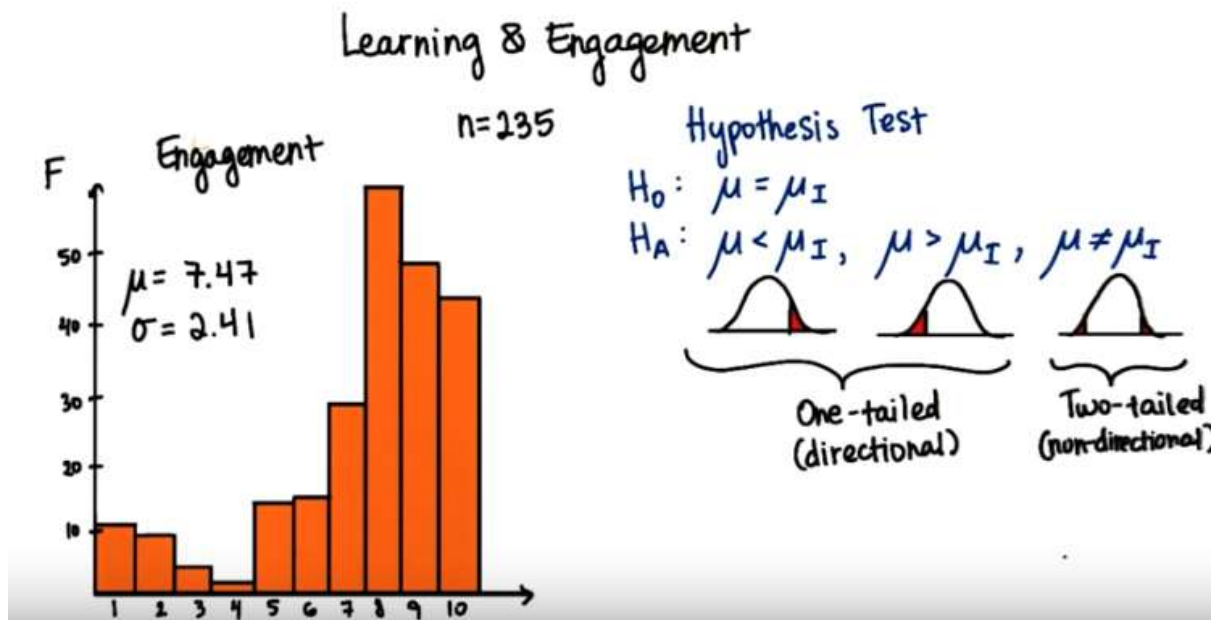   o No

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Q11.

Learning & Engagement
n=235

Engagement — F, $\mu =$, $\sigma =$, Score

Learning — F, Score

Q12 Part 1

Learning & Engagement
n=235

Engagement — F, $\mu = 7.47$, $\sigma = 2.41$, Score

Hypothesis Test
$H_0: \mu = \mu_I$
$H_A: \mu < \mu_I, \ \mu > \mu_I, \ \mu \neq \mu_I$

A song in the lesson will:
☐ make learners more engaged
☐ not make learners more engaged
☐ change how much learners are engaged
☐ result in the same level of engagement
☐ make learners less engaged

(null hypothesis H_0)

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Q12 Part 2

Learning 8 Engagement

$n = 235$

Hypothesis Test

$H_0: \mu = \mu_I$
$H_A: \mu < \mu_I, \ \mu > \mu_I, \ \mu \neq \mu_I$

Engagement

F

$\mu = 7.47$
$\sigma = 2.41$

Score

A song in the lesson will:
☐ make learners more engaged
☐ not make learners more engaged
☐ change how much learners are engaged
☐ result in the same level of engagement
☐ make learners less engaged

(alternative hypothesis H_A)

One Tailed and Two Tailed Test

Learning 8 Engagement

$n = 235$

Hypothesis Test

$H_0: \mu = \mu_I$
$H_A: \mu < \mu_I, \ \mu > \mu_I, \ \mu \neq \mu_I$

Engagement

F

$\mu = 7.47$
$\sigma = 2.41$

One-tailed
(directional)

Two-tailed
(non-directional)

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Overview of Hypothesis Testing

Learning 8 Engagement

$n=135$

Hypothesis Test

$H_0: \mu = \mu_{song}$
$H_A: \mu \neq \mu_{song}$

.025   .025 $\alpha = 0.05$

$-z$ $+z$

Two-tailed
(non-directional)

Engagement

$\mu = 7.47$
$\sigma = 2.41$

Q13.

Learning 8 Engagement

$\mu = 7.47$
$\sigma = 2.41$

Hypothesis Test

$H_0: \mu = \mu_{song}$
$H_A: \mu \neq \mu_{song}$

.025   .025 $\alpha = 0.05$

$-z$ $+z$

Two-tailed
(non-directional)
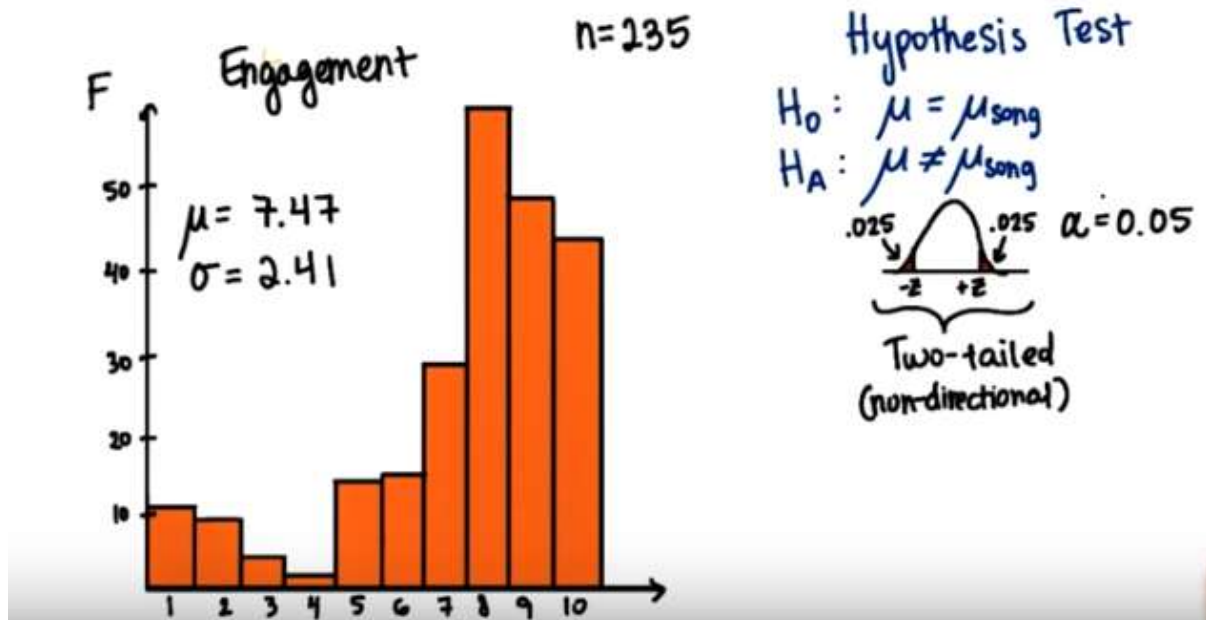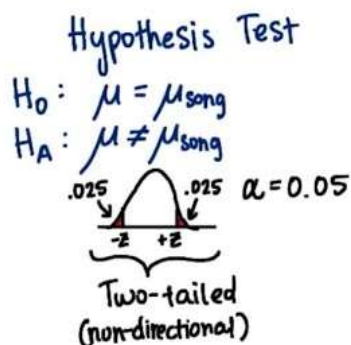
What does it mean to reject the null?

Our sample mean falls within/outside the critical region.

The z-score of our sample mean is (assume z>0) less than/greater than the z-critical value.

The probability of obtaining the sample mean is less than/greater than the alpha level.

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Q14.

Learning & Engagement

$\mu = 7.47$
$\sigma = 2.41$

$a = 0.05$

Hypothesis Test

$H_0 : \mu = \mu_{song}$
$H_A : \mu \neq \mu_{song}$

0.025   0.025

.025   .025 $\alpha = 0.05$

-z   +z

Two-tailed
(non-directional)
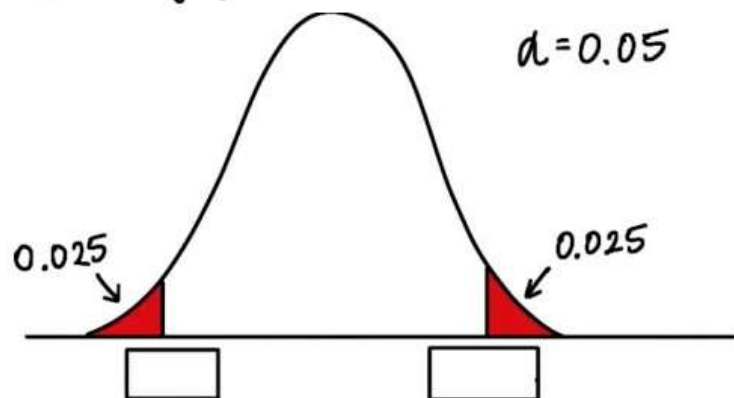
Q15.Part 1

Learning & Engagement
F

$\mu = 7.47$
$\sigma = 2.41$

50

40

Hypothesis Test

30        $a = 0.05$

$H_0 : \mu = \mu_{song}$ QUIZ   20
$H_A : \mu \neq \mu_{song}$ What's the z-score
                             of this sample   10
                             mean on the sampling   0.025   0.025
$n = 30$ distribution?
$\bar{x} = 8.3$ (mean engagement score   1 2 3 4 5 6 7 8 9 10
              of sample)   Score
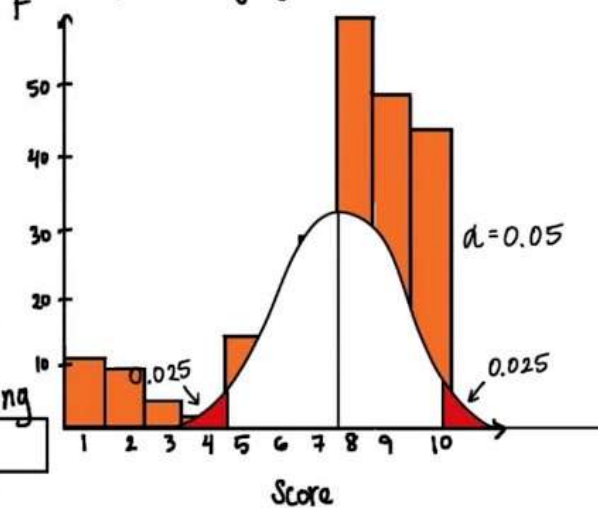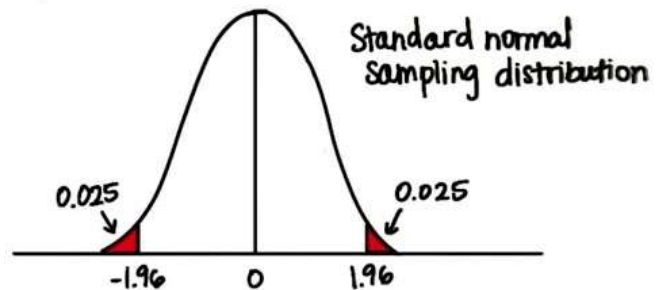
Q15.Part 2

Learning 8 Engagement

$\mu = 7.47$
$\sigma = 2.41$

Hypothesis Test

$H_0: \mu = \mu_{song}$
$H_A: \mu \neq \mu_{song}$

$n = 30$
$\bar{x} = 8.3 \leftarrow z\text{-score} = 1.89$

Standard normal
Sampling distribution

0.025   0.025
↓   ↓
-1.96   0   1.96

At $\alpha = 0.05$, do we reject or fail to reject the null?

○ Reject H_0

○ Fail to reject H_0

Q16. Part 1
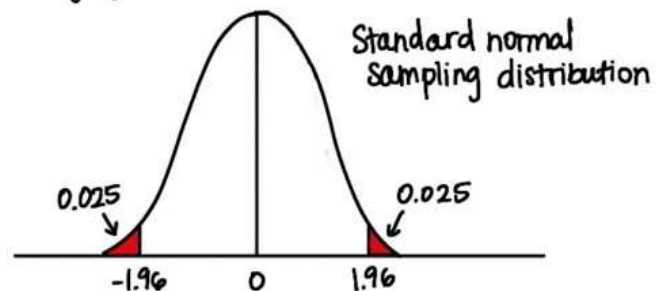
Learning 8 Engagement

$\mu = 7.47$
$\sigma = 2.41$
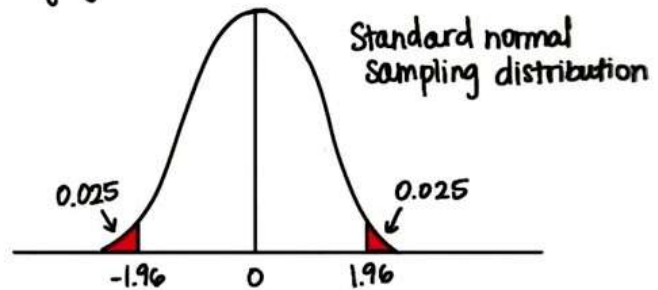
Hypothesis Test

$H_0: \mu = \mu_{song}$
$H_A: \mu \neq \mu_{song}$

$n = 50$
$\bar{x} = 8.3 \leftarrow z\text{-score} = \boxed{}$

Standard normal
Sampling distribution

0.025   0.025
↓   ↓
-1.96   0   1.96

If we increase the sample size to 50.

Find the new z-score?

Q16.Part 2

Learning 8 Engagement

$\mu = 7.47$
$\sigma = 2.41$

Hypothesis Test

$H_0: \mu = \mu_{song}$
$H_A: \mu \neq \mu_{song}$

$n = 50$
$\bar{x} = 8.3 \leftarrow z\text{-score} = 2.44$

Standard normal Sampling distribution

0.025   0.025

-1.96   0   1.96

At $\alpha = 0.05$, do we reject the null or fail to reject the null?

o Reject

o Fail to reject

Q16.Part 3
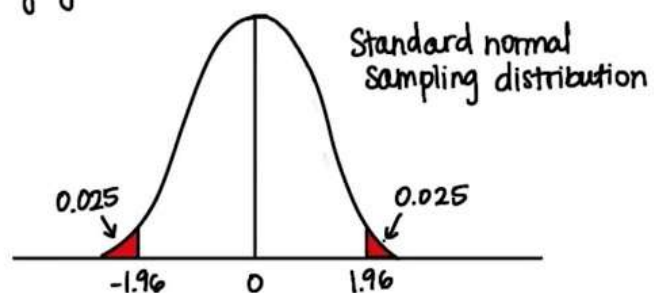
Learning 8 Engagement

$\mu = 7.47$
$\sigma = 2.41$

Hypothesis Test

$H_0: \mu = \mu_{song}$
$H_A: \mu \neq \mu_{song}$

$n = 50$
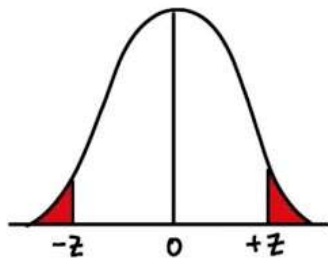$\bar{x} = 8.3 \leftarrow z\text{-score} = 2.44$

Standard normal Sampling distribution

0.025   0.025

-1.96   0   1.96

What's the probability of randomly Selecting a sample of size 50 with a mean of at least 8.3 from this population?

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Hypothesis Testing is prone to misinterpretations

Q17.

Hypothesis testing is prone to misinterpretations.

Which areas in this diagram correspond to making the wrong statistical decision?

Decision

	Reject H_0	Retain H_0
H_0 true		
H_0 false		

State of the world

Q18.

H_0: The beverage is fine to drink now.

H_A: The beverage is too hot to drink.

Map statement A,B,C,D with the respective boxes below.

A You decide the beverage is fine to drink now, but it's too hot and you burn your tongue.

B You decide the beverage is fine to drink now, and it is!

C You think the beverage is too hot so you wait to drink it, but it's actually fine now and by the time you drink it, it's too cold.

D You think the beverage is too hot and indeed it is, so you wait to drink it and then it's perfect.

Decision

State of the world

	Reject H_0	Retain H_0
H_0 true	WRONG Type I error	CORRECT
H_0 false	CORRECT	WRONG Type II error

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Q19.

H_0: It's not going to rain

H_A: It will rain

Match each statement with the boxes below

A   It doesn't rain

B   You don't bring your umbrella

C   You bring your umbrella

D   It rains

Decision

	Reject H_0 ☐	Retain H_0 ☐
H_0 true ☐	WRONG Type I error	CORRECT
H_0 false ☐	CORRECT	WRONG Type II error

State of the world

Q20.

H_0: $\mu_{song} = \mu$

H_A: $\mu_{song} \neq \mu$

$\mu = 7.47$

$\sigma = 2.41$

$n = 30$ $\bar{x} = 8.3$
$\mu_{song} = 7.8$

$\alpha = 0.05$
two-tailed test

Decision

	Reject H_0	Retain H_0
H_0 true	• WRONG Type I error	• CORRECT
H_0 false	• CORRECT	• WRONG Type II error

State of the world

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Q21.

$H_0: \mu_{song} = \mu$

$H_A: \mu_{song} \neq \mu$

$\mu = 7.47$

$\sigma = 2.41$

$n = 50$ $\bar{x} = 8.3$
$\mu_{song} = 7.8$

$\alpha = 0.05$

two-tailed test

Decision

State of the world

	Reject H_0	Retain H_0
H_0 true	WRONG Type I error	CORRECT
H_0 false	CORRECT	WRONG Type II error