Name: ______________________________ Hour: _____ Date: ______

Lesson 9.1: Day 1: Is Mrs. Gallas a good free throw shooter?

Mrs. Gallas claims she is an 80% free throw shooter. To prove her skills she shoots 50 free throws and makes 32 shots. Is Mrs. Gallas exaggerating about her free throw skills?

1. Identify the population, parameter, sample and statistic.

Population: All free throws shot by Mrs.G Parameter: $p \rightarrow$ true prop. made FT

Sample: 50 free throws Statistic: $\hat{p} = \frac{32}{50} = .64$

2. There are two possible explanations for why Mrs. Gallas only made 32/50 shots.

$H_o: p = .80$ 1.) Mrs. G is an 80% shooter but had an off day..

$H_a: p < .80$ 2.) Mrs. G is a liar.

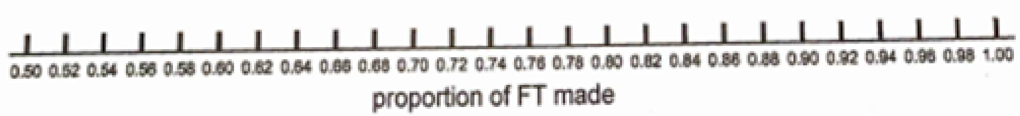
To test Mrs. Gallas' claim, we will **assume #1, she is an 80% free throw shooter**, and examine the likelihood that she makes 32/50 shots through simulation. $\hat{p} =$

3. Use the spinner provided to simulate 50 free throws **shot by an 80% free throw shooter** by spinning 50 times. What is your sample proportion of shots made?

$\hat{p} =$

4. Repeat for another sample of 50 spins. Calculate the sample proportion.

5. Add your sample proportions to the dotplot on the board. Each person in your group should add two dots to the board. Sketch the dotplot below.



Name: ______________________________ Hour: _____ Date: _____

6. What does each dot represent?

The proportion of free throws made from a sample of 50. shot by an 80% shooter.

7. One student says, "Each dot represents the proportion of free throws made out of 50 free throws shot by Mrs. Gallas." Is this correct? Explain.

No, we do not know if Mrs. G is an 80% shooter. The dots represent a proportion of made shots by an 80% shooter.

P-value

8. What percentage of the dots represent a percentage of 64% or less?

Interpret this percentage in context.

Assuming Mrs. Gallas is an 80% free throw shooter, there is a ______ probability of gettin[g] a sample proportion of .64 or less purely by ch[ance]

9. Based on your answer to Question 8, does the observed $\hat{p}$ = 0.64 result give convincing evidence that Mrs. Gallas is exaggerating? Or is it plausible that an 80% shooter can have a performance this poor by chance alone?

Conclusion

Because the p-value of ______ is less/greater than 5% we do/do not have convincing evidence that Ms. Gallas is not an 80% shooter.

Name: ______________________________ Hour: _____ Date: _____

Lesson 9.1: Day 2: Is this gender discrimination?

A local engineering firm had to conduct a series of lay offs recently. They will lay off 10 people. The company has 180 employees that could be laid off. All are equally qualified so the company decides to use a lottery system to be carried out by the manager to decide who will be laid off. The manager posts a list of the employees. Five employees are women and 5 are men. One of the women claims this is gender discrimination and starts a lawsuit against the company.

60 females
120 males

1. The manager responds, "How could there be gender discrimination when half of the employees laid off were female and half were male?" What additional information do you need to evaluate this statement?

   We need to know how many males and females work at the company.

2. How can you investigate the gender discrimination claim? Detail a process that could be used.

   Dice: 1 & 2 are women
   3 to 6 are men

   RNG: 1–60 women
   61–180 men

   Spinner: 1/3 women
   2/3 men

   RNG: 1 → women
   2 & 3 → men

3. Complete your investigation below.

0 .1 .2 .3 .4 .5 .6 .7 .8 .9 .10

Proportion Female

4. What percentage of the dots represent a percentage of 50% or greater?

5. Interpret this percentage in context.

   Assuming the lottery was carried out fairly, there is a ___ probability of getting a sample proportion of 0.5 or higher.

6. Do you have convincing evidence of gender discrimination? Explain.

   No, a sample proportion of 0.5 or higher happens fairly often.

TheStatsMedic

Name: ______________________ Hour: _____ Date: _____

Lesson 9.1 Day 1– Significance Tests: The Basics

Important ideas:		
LT#1 Hypotheses: Null: H_0: μ / p = Null value Alternative: H_a: μ / p $<$ / $>$ / $\neq$ Null value	LT#2 P-value The probability of getting the results & more extreme purely by chance if the null is true.	LT #3 Conclusions We do/do not have convincing evidence against the null. α = significance level P-value $< \alpha$: Significant

Check Your Understanding

Calcium is a vital nutrient for healthy bones and teeth. The National Institutes of Health (NIH) recommends a calcium intake of 1300 milligrams (mg) per day for teenagers. The NIH is concerned that teenagers are not getting enough calcium, on average. Is this true?

1. State appropriate hypotheses for performing a significance test. Be sure to define the parameter of interest.

$H_0: \mu = 1300$ $\quad$ $\mu \rightarrow$ true mean daily calcium intake.

$H_a: \mu < 1300$

Researchers decide to perform a test using the hypotheses stated in #1. They ask a random sample of 20 teens to record their food and drink consumption for 1 day. The researchers then compute the calcium intake for each student. Data analysis reveals that $\bar{x}$ = 1198 mg and s_x = 411 mg. Researchers performed a significance test and obtained a P-value of 0.1404.

2. Explain what it would mean for the null hypothesis to be true in this setting.

If $H_0: \mu = 1300$ is true, the mean daily calcium intake in the population of teens is 1300mg.

3. Interpret the P-value.

Assuming the mean daily intake is 1300mg, there is a 0.1404 probability of getting a sample mean of 1198 mg or less purely by chance.

4. What conclusion would you make at the α = 0.05 level?

Because the p-value = .1404 $> \alpha$ = .05, we fail to reject H_0. We don't have convincing evidence against the null hypothesis.

Name: ______________________________ Hour: _____ Date: _____

Lesson 9.1: Day 2: Should Rockford switch to bottled water?

The Wolverine Worldwide (a shoe company in Rockford) improperly disposed of chemicals (PFAS), which have leaked into the ground water. The state's drinking water limit of 70 parts per trillion (ppt) is considered safe, while anything above 70 ppt is considered dangerous. Officials believes the water in Rockford may be unsafe. They take a random sample of 200 households in Rockford. They find the average lead level of the sample is 70.5 ppt.

1. State appropriate hypotheses for performing a significance test using words and symbols.

2. After conducting a significance test, a *P*-value of 0.045 is found. Interpret this value.

3. Based on the P-value, should Rockford keep the current water or switch to bottled water? Explain.

4. Let's suppose this decision is wrong. What would be a consequence of this error?

5. Given the water is safe, how often will this error occur?

6. Now suppose the P-value was 0.14. Should the town keep the current water or switch to bottled water?

7. Let's suppose this decision is wrong. What would be a consequence of this error?

8. Are the consequences in question #4 or question #7 more serious? Explain.

Name: ______________________________ Hour: _____ Date: ______

Lesson 9.1: Day 2: Should Rockford switch to bottled water?

WOLVERINE

The Wolverine Worldwide (a shoe company in Rockford) disposed of chemicals (PFAS) which have leaked into the ground water. The state's drinking water limit of 70 parts per trillion (ppt) is considered safe, while anything above 70 ppt is considered dangerous. Officials believes the water in nearby towns may also be unsafe. They take a random sample of 200 households in a nearby town. They find the average lead level of the sample is 70.5 ppt.

1. State appropriate hypotheses for performing a significance test using words and symbols.

   $H_0: \mu = 70$ ppt : The water is safe. $\alpha = .05$

   $H_a: \mu > 70$ ppt : The water is unsafe.

2. After conducting a significance test, a *P*-value of 0.045 is found. Interpret this value.

   Assuming the water is safe ($\mu = 70$ppt) there is a .045 probability of getting a sample mean of 70.5 ppt or more purely by chance.

3. Based on the P-value, should the town keep the current water or switch to bottled water? Explain. They should switch to bottled water since we have convincing evidence for the alternative hypothesis.

4. Let's suppose this decision is wrong. What would be a consequence of this error?

   They would waste money and resources on bottled water. Type I Error $\rightarrow H_0$ is true

Type I occurs α%

5. How often will this error occur?

   5% of the time we get statistically significant results purely by chance.

6. Now suppose the P-value is 0.14. Should the town keep the current water or switch to bottled water? They should keep the current water since they don't have convincing evidence against the null.

7. Let's suppose this decision is wrong. What would be a consequence of this error?

   People would drink unsafe water and could get sick and possibly die. Type II Error $\rightarrow H_a$ is true.

8. Are the consequences in question #4 or question #7 more serious? Explain.

   #7, people would get very sick which is much worse than wasting money.

Name: ______________________________ Hour: _____ Date: _____

Lesson 9.1 Day 2 – Type 1 and Type 2 Errors

Important ideas:

Type I Error: The null hypothesis is true but.... we make the wrong decision. } occurs by chance α%.

Type II Error: The alternative hypothesis is true but... we make the wrong decision.

Check Your Understanding

The manager of a fast-food restaurant wants to reduce the proportion of drivethru customers who have to wait longer than 2 minutes to receive their food after placing an order. Based on store records, the proportion of customers who had to wait longer than 2 minutes was $p = 0.63$. To reduce this proportion, the manager assigns an additional employee to drive-thru orders. During the next month, the manager collects a random sample of 250 drive-thru times and finds that $\hat{p} = \frac{144}{250} = 0.576$. The manager then performs a test of the following hypotheses at the $\alpha = 0.10$ significance level:

$$H_0: p = 0.63$$
$$H_a: p < 0.63$$

where p = the true proportion of drive-thru customers who have to wait longer than 2 minutes to receive their food.

1. Describe a Type I error and a Type II error in this setting.

Type I: 63% of customers wait longer than 2 min but the manager thinks less than that do.

Type II: Less than 63% wait but the manager thinks 63% wait.

2. Which type of error is more serious in this case? Justify your answer.

Type I because the manager believes the extra employee reduces the proportion of customers who wait but it does not.

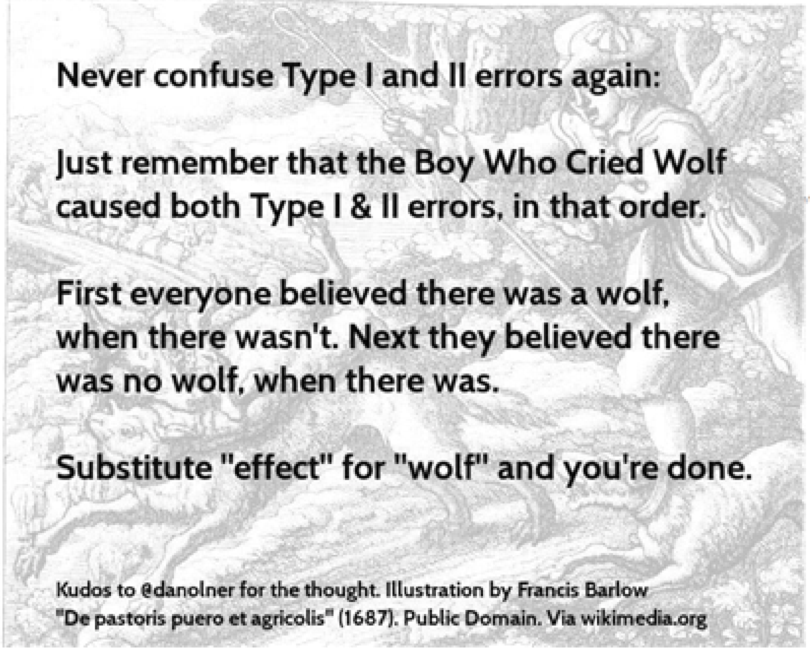
3. Based on your answer to Question 2, do you agree with the company's choice of $\alpha = 0.10$? Why or why not?

No, if the null is true, $\alpha = 0.10$ will result in a Type I error 10% of the time just by chance. They should use a smaller value of α.

4. The P-value of the manager's test is 0.0385. Interpret the P-value.

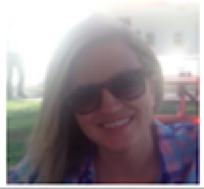
Assuming the true proportion of customers who have to wait is $p = .63$, there is a .0385 probability of getting a sample proportion of .576 or less purely by chance.

		Truth about the population	
		H_0 true	H_a true
Conclusion based on sample	Reject H_0	Type I error	Correct conclusion
	Fail to reject H_0	Correct conclusion	Type II error



Name: ______________________________ Hour: _____ Date: ______

Lesson 9.2: Day 1: Are you sure Mrs. Gallas isn't a good free throw shooter?



VS

In Lesson 9.1 we used simulation to estimate a P-value to decide whether or not Mrs. Gallas was exaggerating about her free throw percentage. Today, we will use a formula to find a P-value.

1. We're going to carry out the significance test from lesson 9.1 again. Begin by writing the hypotheses.

2. a. Each class found a different P-value because each dotplot was different. Would it be appropriate to use a Normal distribution to model the sampling distribution of $\hat{p}$? Justify your answer.

   b. Are there any other conditions we should check?

3. Now that conditions have been met, find the mean and standard deviation of the sampling distribution of $\hat{p}$.

4. Use the mean and standard deviation you found to label the Normal curve.

5. How many standard deviations below the mean (z-score) is $\hat{p} = 0.64$? Label it on the normal curve.

6. Find the probability of an 80% shooter making 32/50 ($\hat{p} = 0.64$) or less.

7. What conclusion can we make?

Name: ______________________________ Hour: _____ Date: _____

Lesson 9.2: Day 1: Are you sure Mrs. Gallas isn't a good free throw shooter?

In Lesson 9.1 we used simulation to decide whether or not Mrs. Gallas was exaggerating about her free throw percentage. However, all the classes found different P-values; some were statistically significant and some were not. How can we find the true P-value so that we make the correct conclusion?

1. We're going to carry out the significance test from lesson 9.1 again. Begin by writing the hypotheses.

   $H_0: p = 0.8$

   $H_a: p < 0.8$

2. a. Each class found a different P-value because each dotplot was different. Would it be appropriate to use a normal distribution to model the sampling distribution of $\hat{p}$? Justify your answer. Large Counts

   $n \cdot p = 50 \times .80 = 40 \geq 10$ ✓

   $n \cdot (1-p) = 50 \times .20 = 10 \geq 10$ ✓

   b. Are there any other conditions we should check?

   Random & 10%

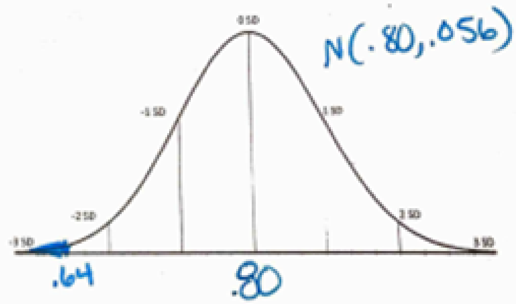
3. Now that conditions have been met, find the mean and standard deviation of the sampling distribution of $\hat{p}$.

   $\mu_{\hat{p}} = p = 0.8$ $\quad \sigma_{\hat{p}} = \sqrt{\frac{p(1-p)}{n}} = \sqrt{\frac{.8 \times .20}{50}} = .056$

4. Use the mean and standard deviation you found to label the normal curve.

5. How many standard deviations below the mean (z-score) is $\hat{p} = 0.64$? Label it on the normal curve.

   $\frac{.64 - .80}{.056} = -2.86$



6. Find the probability of an 80% shooter making 32/50 ($\hat{p} = 0.64$) or less.

   $= .002$

7. What conclusion can we make?

   We have convincing evidence against the null hypothesis. (.002 < .05).

TheStatsMedic

Name: ______________________ Hour: _____ Date: ______

Lesson 9.2 Day 1– Significance Test for p

Important ideas:

LT#1 Conditions

Random

10%: Sample < to pop.

Large Counts

$n \cdot p \geq 10$

$n \cdot (1-p) \geq 10$

LT#2 Test Stat & p-value

$N(\mu_{\hat{p}}, \sigma_{\hat{p}})$

$\mu_{\hat{p}} = p$

$\sigma_{\hat{p}} = \sqrt{\frac{p(1-p)}{n}}$

$z = \frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}}$

$\rightarrow$ P-value

Check Your Understanding

According to the U.S. Census Bureau, the proportion of students in high school who have a part-time job is 0.25. An administrator at a local high school suspects that the proportion of students at her school who have a part-time job is less than the national figure. She would like to carry out a test at the $\alpha = 0.05$ significance level. The administrator selects a random sample of 200 students from the school and finds that 39 of them have a part-time job.

(a) State appropriate hypotheses for performing a significance test. Be sure to define the parameter of interest.

$H_0: p = .25$

$H_a: p < .25$

(b) Explain why the sample result gives some evidence for the alternative hypothesis.

$39/200 = .195$ which is less than .25.

(c) Check if the conditions for performing the significance test are met.

$200 \cdot .25 = 50$
$200 \cdot .75 = 150$ ≥ 10 ✓

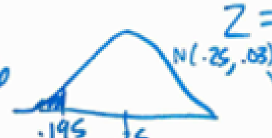
Random: "Random Sample"

10%: $200 < 1/10 \cdot$ all students at school

(d) Calculate the standardized test statistic and P-value.

$\mu_{\hat{p}} = .25$

$\sigma_{\hat{p}} = .0306$



$z = \frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}} = \frac{.195 - .25}{.0306} = -1.797$

≈ -1.80

$\rightarrow .036$

(e) What conclusion would you make?

We have convincing evidence against the null ($.036 < .05$).

The proportion at this school is less than .25.

TheStatsMedic

Name: ______________________________ Hour: _____ Date: ______

Lesson 9.2: Day 2: Can you taste the rainbow?

TASTE THE RAINBOW

Skittles

TASTE THE RAINBOW

Many students claim that they can taste the different colors of Skittles. Today we will conduct an experiment and perform a significance test to see if students really can "taste the rainbow".

Collect data: **How many correct?** 101 **How many total?** 190

STATE: Parameter: p – proportion of skittles guessed correctly.

Statistic: $\hat{p} = .53$ n = 190

Hypotheses:

$H_0: p = .20$

$H_a: p > .20$

Significance level: 5% ($\alpha = 0.05$)

PLAN: Name of procedure: One sample z test for p

Check conditions:

Random: Random sample of skittles ✓

10%: $190 < \frac{1}{10}$ all skittles

Large counts ✓: $n \cdot p \geq 10$, $n(1-p) \geq 10$

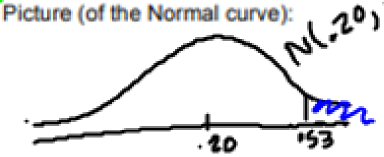
$190(.2) \geq 10$ ✓

$190(.8) \geq 10$ ✓

DO: General Formula: $\text{test statistic} = \frac{\text{statistic} - \text{null}}{\text{standard deviation}}$

Specific Formula: $z = \frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}}$

Picture (of the Normal curve): N(.20, .029)



Work:

$z = \frac{.53 - .20}{.029}$

$= \boxed{11.379}$

Test statistic: $z = 11.379$

P-value: ≈ 1 table A $1 - \approx 1 \approx 0$

CONCLUDE: Based on the P-value, what conclusion do you make?

We have evidence that we can taste the rainbow (reject the null)

$\approx 0 < .05$

TheStatsMedic

conclude: We do/do not have convincing evidence against the null.

$\boxed{\text{LT\#2: Two Sided Multiply P-value by 2}}$

Check Your Understanding

According to the National Institute for Occupational Safety and Health, job stress poses a major threat to the health of workers. A news report claims that 75% of restaurant employees feel that work stress has a negative impact on their personal lives. Managers of a large restaurant chain wonder whether this claim is valid for their employees. A random sample of 100 employees finds that 68 answer "Yes" when asked, "Does work stress have a negative impact on your personal life?"

2 sided

1. Do these data provide convincing evidence at the α = 0.10 significance level that the proportion of all employees in this chain who would say "Yes" differs from 0.75?

STATE: Parameter: $p \rightarrow$ true proportion of employees who say yes. Statistic: $\hat{p} = 68/100 = 0.68$

Hypotheses: $H_0: p = .75$ Significance level: $\alpha = .10$

$H_a: p \neq .75$

PLAN: Name of procedure: One sample z test for p

Check conditions:

Random: "Random sample of 100."

10%: $100 < \frac{1}{10}$ all employees

Large Count: $100 \times .75$, $100 \times .25 \geq 10$ ✓

DO: General Formula: $\text{Test Stat} = \frac{\text{Stat} - \text{Null}}{\text{SD}}$ Specific Formula: $z = \frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}}$

Two sided!

Work: Picture:

$$z = \frac{.68 - .75}{\sqrt{\frac{.75(1-.75)}{100}}} = -1.63$$

.68 Test statistic: $z = -1.63$

P-value: $.0516 \times 2 = .1032$

-1.62

$.052 \times 2 = .1052$

CONCLUDE: Assuming the prop. of employees who answer yes is .75, there is a .1032 probability of getting a sample proportion as far as 0.68 or further purely by chance. We fail to reject the null.

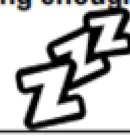
2. A 90% confidence interval for the restaurant worker data was also created and found to be (0.603272, 0.756728). Explain how the confidence interval is consistent with, but gives more information than, the test. The null value of 0.75 is included in the interval so it is plausible. The interval also gives other plausible values for the null.

TheStatsMedic

Name: ______________________ Hour: _____ Date: _____

6, 7, 8, 5, 8, 9, 8, 4, 6.5, 4,

Lesson 9.3: Day 1: Are you getting enough sleep?

It's recommended that teenagers get 8 hours of sleep a night. Mrs. Gallas believes her AP Stats students are getting less than the recommended 8 hours of sleep per night. To test her belief, take a random sample of 10 students in class and record the number of hours of sleep for each. Do these data provide convincing evidence that the AP stats students get less than 8 hours of sleep per night using α = 0.05?

1. Calculate the sample mean and standard deviation.

$\bar{x} = 6.55$ $S_x = 1.771$

2. State the appropriate hypotheses for a significance test. Be sure to define the parameter of interest.

$H_0: \mu = 8$ $H_a: \mu < 8$ μ = true mean of sleep for all Islands students.

3. What conditions must be met? Check them.

Random NO

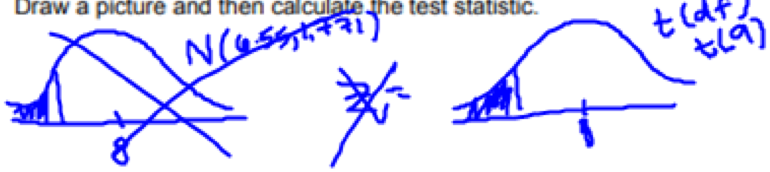
10% $10 < \frac{1}{10}$ Islands students

Normal CLT $10 \geq 30$ ✗ No strong skew or outliers ✓

4. Give the formulas for the mean and standard deviation of the sampling distribution of $\bar{x}$ and calculate the values.

$\mu_{\bar{x}} = \mu = 8$ $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} = \frac{S_x}{\sqrt{n}}$ / $\sigma_{\bar{x}} = \frac{S_x}{\sqrt{n}} = \frac{1.771}{\sqrt{10}} = .56$

5. Draw a picture and then calculate the test statistic.



$t = \frac{\bar{x} - \mu}{\frac{S_x}{\sqrt{n}}} = \frac{6.55 - 8}{.56} = -2.589$

6. Remember, since we are working with means, the test statistic is a *t* value. Use table B to find the P-value.

$df = n - 1 = 10 - 1 = 9$ $\boxed{\text{P-value} \approx .02}$

7. What conclusion can we make?

Table B *t* **distribution critical values**

	Tail probability *p*											
df	.25	.20	.15	.10	.05	.025	.02	.01	.005	.0025	.001	.0005
1	1.000	1.376	1.963	3.078	6.314	12.71	15.89	31.82	63.66	127.3	318.3	636.6
2	.816	1.061	1.386	1.886	2.920	4.303	4.849	6.965	9.925	14.09	22.33	31.60
3	.765	.978	1.250	1.638	2.353	3.182	3.482	4.541	5.841	7.453	10.21	12.92
4	.741	.941	1.190	1.533	2.132	2.776	2.999	3.747	4.604	5.598	7.173	8.610
5	.727	.920	1.156	1.476	2.015	2.571	2.757	3.365	4.032	4.773	5.893	6.869
6	.718	.906	1.134	1.440	1.943	2.447	2.612	3.143	3.707	4.317	5.208	5.959
7	.711	.896	1.119	1.415	1.895	2.365	2.517	2.998	3.499	4.029	4.785	5.408
8	.706	.889	1.108	1.397	1.860	2.306	2.449	2.896	3.355	3.833	4.501	5.041
9	.703	.883	1.100	1.383	1.833	2.262	2.398	2.821	3.250	3.690	4.297	4.781
10	.700	.879	1.093	1.372	1.812	2.228	2.359	2.764	3.169	3.581	4.144	4.587
11	.697	.876	1.088	1.363	1.796	2.201	2.328	2.718	3.106	3.497	4.025	4.437
12	.695	.873	1.083	1.356	1.782	2.179	2.303	2.681	3.055	3.428	3.930	4.318
13	.694	.870	1.079	1.350	1.771	2.160	2.282	2.650	3.012	3.372	3.852	4.221
14	.692	.868	1.076	1.345	1.761	2.145	2.264	2.624	2.977	3.326	3.787	4.140
15	.691	.866	1.074	1.341	1.753	2.131	2.249	2.602	2.947	3.286	3.733	4.073
16	.690	.865	1.071	1.337	1.746	2.120	2.235	2.583	2.921	3.252	3.686	4.015
17	.689	.863	1.069	1.333	1.740	2.110	2.224	2.567	2.898	3.222	3.646	3.965
18	.688	.862	1.067	1.330	1.734	2.101	2.214	2.552	2.878	3.197	3.611	3.922
19	.688	.861	1.066	1.328	1.729	2.093	2.205	2.539	2.861	3.174	3.579	3.883
20	.687	.860	1.064	1.325	1.725	2.086	2.197	2.528	2.845	3.153	3.552	3.850
21	.686	.859	1.063	1.323	1.721	2.080	2.189	2.518	2.831	3.135	3.527	3.819
22	.686	.858	1.061	1.321	1.717	2.074	2.183	2.508	2.819	3.119	3.505	3.792
23	.685	.858	1.060	1.319	1.714	2.069	2.177	2.500	2.807	3.104	3.485	3.768
24	.685	.857	1.059	1.318	1.711	2.064	2.172	2.492	2.797	3.091	3.467	3.745
25	.684	.856	1.058	1.316	1.708	2.060	2.167	2.485	2.787	3.078	3.450	3.725
26	.684	.856	1.058	1.315	1.706	2.056	2.162	2.479	2.779	3.067	3.435	3.707
27	.684	.855	1.057	1.314	1.703	2.052	2.158	2.473	2.771	3.057	3.421	3.690
28	.683	.855	1.056	1.313	1.701	2.048	2.154	2.467	2.763	3.047	3.408	3.674
29	.683	.854	1.055	1.311	1.699	2.045	2.150	2.462	2.756	3.038	3.396	3.659
30	.683	.854	1.055	1.310	1.697	2.042	2.147	2.457	2.750	3.030	3.385	3.646
40	.681	.851	1.050	1.303	1.684	2.021	2.123	2.423	2.704	2.971	3.307	3.551
50	.679	.849	1.047	1.299	1.676	2.009	2.109	2.403	2.678	2.937	3.261	3.496
60	.679	.848	1.045	1.296	1.671	2.000	2.099	2.390	2.660	2.915	3.232	3.460
80	.678	.846	1.043	1.292	1.664	1.990	2.088	2.374	2.639	2.887	3.195	3.416
100	.677	.845	1.042	1.290	1.660	1.984	2.081	2.364	2.626	2.871	3.174	3.390
1000	.675	.842	1.037	1.282	1.646	1.962	2.056	2.330	2.581	2.813	3.098	3.300
∞	.674	.841	1.036	1.282	1.645	1.960	2.054	2.326	2.576	2.807	3.091	3.291
	50%	60%	70%	80%	90%	95%	96%	98%	99%	99.5%	99.8%	99.9%
	Confidence level *C*											

Lesson 9.3 Day 1– Significance Test for μ

Important ideas: LT#1 Conditions:	LT#2 Test Statistic	LT#3 P-value
Random; Normal ← Pop is Normal / $n \geq 30$ CLT / No strong skew or outliers; 10%: $n < \frac{1}{10}N$	$t = \frac{\bar{x} - \mu}{s_x/\sqrt{n}}$ 	Use table B with df and tail probability. OR tcdf(lower, upper, df)

Check Your Understanding

The level of dissolved oxygen (DO) in a stream or river is an important indicator of the water's ability to support aquatic life. A researcher measures the DO level at 30 randomly chosen locations along a stream. Here are the results in milligrams per liter (mg/l): $\bar{x} = 4.77$ and $s_x = 0.939$. An average dissolved oxygen level below 5 mg/l puts aquatic life at risk. Do the data provide convincing evidence at the α = 0.05 significance level that aquatic life in this stream is at risk?

State: Parameter: $\mu \to$ true mean DO level Statistic: $\bar{x} = 4.77$

Hypotheses: $H_0: \mu = 5$ α Level: .05

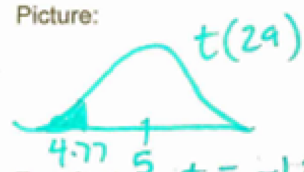
$H_a: \mu < 5$

Plan: Name of procedure: One sample t test for μ

Check conditions: Random "randomly chosen"

10% $30 < \frac{1}{10}$ all locations Normal: $30 \geq 30$ CLT

Do: General: test stat $= \frac{\text{Stat} - \text{Null}}{\text{SD}}$ Picture:



Specific: $t = \frac{\bar{x} - \mu}{s_x/\sqrt{n}}$

Work: $\frac{4.77 - 5}{.939/\sqrt{30}} = -1.33$ Test Statistic: $t = -1.33$

P-value: Between .05 and .10

tcdf$(-1000, -1.33, 29) = .097$

Conclude:

Assuming the mean DO level is 5mg/l, there is a .097 probability of getting a sample mean of 4.77 mg/l or less purely by chance. This provides weak evidence against the null and is not stat. sig. (.097 > .05). We fail to reject the null and do not have convincing evidence for the alternative.

http://digitalfirst.bfwpub.com/stats_applet/stats_applet_9_power.html

Name: ______________________________ Hour: _____ Date: ______

Lesson 9.3: Day 2: How powerful is EKHS math?

SAT

The national mean score on the math portion of the SAT is 511 with a standard deviation of 120. We believe the students at EKHS have a higher mean than the national average. To find out, we take a random sample of 8 students and find their average. We will then use the data to conduct a significance test with $\alpha = 0.05$.

1. Write the appropriate hypotheses for the significance test. Be sure to define the parameter of interest.

$H_0: \mu = 511$

$H_a: \mu > 511$

μ = true mean math SAT score at EKHS

Suppose the mean math SAT score at EKHS is $\boxed{\text{535 (alt. } \mu\text{)}}$. Go to stapplet.com and launch the "Statistical Power" applet. Enter all of this information into the fields on the left of the applet. You'll notice a value called "Power". This is the probability that the significance test will find convincing evidence against the null with the information you've entered.

2. What is the probability that the test will find convincing evidence against the null hypothesis?

power

Power = 0.140

Interpret this value in context.

If the mean SAT score at EK is 535, there is a 14% probability of the test giving convincing evidence for the alternative ($\mu > 511$)

3. We want to increase the power of our test. How could we adjust each of the following

3. We want to **increase** the power of our test. How could we adjust each of the following factors to increase our power? Use the applet to explore each.

a. Sample size: increase the sample

b. Alpha level: increase α

c. Alternative μ: increase alt. μ and the null value

Distance between

Name: ______________________________ Hour: _____ Date: _____

Lesson 9.3 Day 2– Power of a Test

Important ideas:

Power interpretation:
Assuming the true mean is ____, there is a power probability of finding convincing evidence for the alternative ______

Truth:

Decision:	H_0 is true	H_a is true
Reject H_0	Type 1	Good
Fail to reject H_0	Good	Type 2

Type II = 1 − Power
Type I = α level

Check Your Understanding

Can a six-month exercise program increase the total body bone mineral content (TBBMC) of young women? A team of researchers is planning a study to examine this question. The researchers would like to perform a test of H_0: $\mu = 0$ H_a: $\mu > 0$ where μ is the true mean percent change in TBBMC during the exercise program.

1. The power of the test to detect a mean increase in TBBMC of 1% using $\alpha = 0.05$ and $n = 25$ subjects is 0.80. Interpret this value.

Assuming the true mean percent of change is 1%, there is an 80% probability that the test gives convincing evidence for the alternative ($\mu > 0$).

2. Find the probability of a Type I error and the probability of a Type II error for the test in Question 1.

Type I = α = .05
Type II = 1 − Power = 1 − .80 = .20

3. Determine whether each of the following changes would increase or decrease the power of the test. Explain your answers.

(a) Use $\alpha = 0.01$ instead of $\alpha = 0.05$.

Decrease, using a smaller α level makes finding convincing evidence more difficult.

(b) Use $n = 100$ instead of $n = 25$.

Increase, using a larger sample size increases power.

AP Stats Chapter 9 Formula Study Sheet

Lesson	9.2 – Significance Test for a Proportion	9.3 – Significance Test for a Mean
Symbol for statistic (sample)		
Symbol for parameter (population)		
Name the procedure		
RANDOM condition		
10% condition		
NORMAL condition		
Formula for mean of the sampling distribution		
Formula for standard deviation of the sampling distribution		
General formula for test statistic		
Specific formula for test statistic		
Picture		
How to find P-value		

4 STEP PROCESS

STATE: Parameter, statistic, hypotheses, and significance level.

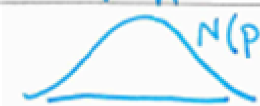
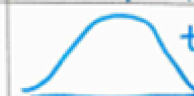
PLAN: Name the appropriate inference method and check conditions.

DO: If the conditions are met, perform the calculations.

Picture, general formula, specific formula, work, test statistic, P-value.

CONCLUDE: Make a conclusion about the hypotheses in the context of the problem.

AP Stats Chapter 9 Formula Study Sheet

Lesson	9.2 – Significance Test for a Proportion	9.3 – Significance Test for a Mean
Symbol for statistic (sample)	$\hat{p}$	$\bar{x}$
Symbol for parameter (population)	p	μ
Name the procedure	One Sample z _ for p	One sample t for μ
RANDOM condition	"SRS" "Random Sample"	"SRS" "Random"
10% condition	sample $n < \frac{1}{10} N$ population	sample $n < \frac{1}{10} N$ population
NORMAL condition	Large Counts $n \cdot p \geq 10$ $n \cdot (1-p) \geq 10$	① Pop is approx. Normal ② $n \geq 30$ CLT ③ No strong skew or outlier
Formula for mean of the sampling distribution	$\mu_{\hat{p}} = p$	$\mu_{\bar{x}} = \mu$
Formula for standard deviation of the sampling distribution	$\sigma_{\hat{p}} = \sqrt{\frac{p(1-p)}{n}}$	$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \approx \frac{S_x}{\sqrt{n}} = SE_{\bar{x}}$
General formula for test statistic	$\text{Test Stat} = \frac{\text{Stat} - \text{Null}}{\text{SD}}$	$\text{Test Stat} = \frac{\text{Stat} - \text{Null}}{\text{SD}}$
Specific formula for test statistic	$z = \frac{\hat{p} - p}{\sqrt{\frac{p(1-p)}{n}}}$	$t = \frac{\bar{x} - \mu}{S_x / \sqrt{n}}$
Picture	 $N(p, \sqrt{\frac{p(1-p)}{n}})$	 $t(df)$
How to find P-value	Table A or Normcdf	Table B or tcdf $df = n-1$

4 STEP PROCESS

STATE: Parameter, statistic, hypotheses, and significance level.

PLAN: Name the appropriate inference method and check conditions.

DO: If the conditions are met, perform the calculations.

Picture, general formula, specific formula, work, test statistic, P-value.

CONCLUDE: Make a conclusion about the hypotheses in the context of the problem.