These are solutions done using a calculator and methods from our class (which is the way I want you to answer on our unit tests).

But because these are actual FRQs from previous year AP Statistics exams, you can also look up the official AP answer keys and scoring guidelines.

You can find that info online here:

https://apcentral.collegeboard.org/courses/ap-statistics/exam

(or just Google "AP statistic free response")

Scroll down to see FRQ problem info by year. Note that some years have a "form B" test so find the correct version.

Also: the last FRQ is a "question 6". AP exam question #6 is always "unusual" in some way. Interesting, and good to know for those taking the AP exam, but things like this will not be on our unit tests.

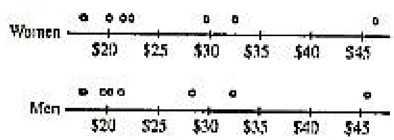
5. A researcher conducted a study to investigate whether local car dealers tend to charge women more than men for the same car model. Using information from the county tax collector's records, the researcher randomly selected one man and one woman from among everyone who had purchased the same model of an identically equipped car from the same dealer. The process was repeated for a total of 8 randomly selected car models.

The purchase prices and the differences (woman − man) are shown in the table below. Summary statistics are also shown.

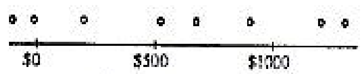
Car model	1	2	3	4	5	6	7	8
Women	\$20,100	\$17,400	\$22,300	\$32,500	\$17,710	\$21,500	\$29,600	\$46,300
Men	\$19,580	\$17,500	\$21,400	\$32,300	\$17,720	\$20,300	\$28,300	\$45,630
Difference	\$520	−\$100	\$900	\$200	−\$10	\$1,200	\$1,300	\$670

	Mean	Standard Deviation
Women	\$25,926.25	\$9,846.61
Men	\$25,341.25	\$9,728.60
Difference	\$585.00	\$530.71

Dotplots of the data and the differences are shown below.



Purchase Price (in thousands of dollars)



Difference in Purchase Price
(woman − man, in dollars)

Do the data provide convincing evidence that, on average, women pay more than men in the county for the same car model?

D = \$women − \$men

$H_0: \mu_D = 0$

$H_A: \mu_D > 0$

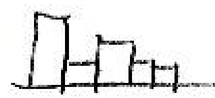
Conditions

✓ • matched pairs (by car model)

✓ • SRS "randomly selected"

✓ • $n < 10\%$ pop (assumed)

✓ • NN



NPP

looks skewed

~~but~~ AP key says dotplot of difference is symmetrical enough to be NN

perform a TTest in calc with data L3(diff)

women − men

$t = 3.1177$

p-val = .008

With $\alpha = .05$, $p = .008$ is low so we reject H_0.

We do have sufficient statistical evidence that local car dealers charge women more than men for the same car model.

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Unit 6 name:

1998 AP STATISTICS

Section II

Part A

Questions 1-5

Spend about 65 minutes on this part of the exam.

Percent of Section II grade—75

To obtain full credit for a free-response question, you must analyze the situation completely and communicate your analyses and results clearly. Your answers should show enough work so that your reasoning process can be tracked through the analysis. It is also important to do this if you expect to earn partial credit when warranted.

1. Consider the sampling distribution of a sample mean obtained by random sampling from an infinite population. This population has a distribution that is highly skewed toward the larger values.

   (a) How is the mean of the sampling distribution related to the mean of the population?
   (b) How is the standard deviation of the sampling distribution related to the standard deviation of the population?
   (c) How is the shape of the sampling distribution affected by the sample size?

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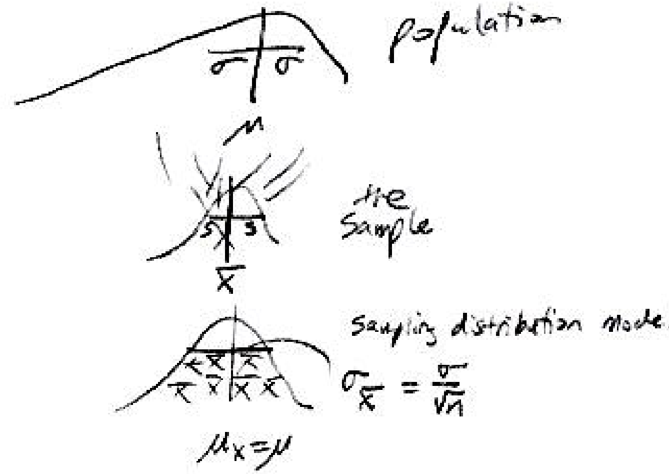

(a) For means, $\mu_{\bar{x}} = \mu$, so the mean of the sampling distribution will equal the mean of the population.

(b) For means, $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$, so the standard deviation of the sampling distribution will equal the standard deviation of the population divided by the square root of the sample size. As the sample size increases, the standard deviation of the sampling distribution will decrease.

(c) As sample size increases not only does the standard deviation decrease, but the sampling distribution shape gets more 'normal'. For $n \geq 25$ the shape can be assumed to be normal by the Central Limit Theorem.

2000 AP® STATISTICS FREE-RESPONSE QUESTIONS

4. Baby walkers are seats hanging from frames that allow babies to sit upright with their legs dangling and feet touching the floor. Walkers have wheels on their legs that allow the infant to propel the walker around the house long before he or she can walk or even crawl. Typically, babies use walkers between the ages of 4 months and 11 months.

Because most walkers have tray tables in front that block babies' views of their feet, child psychologists have begun to question whether walkers affect infants' cognitive development. One study compared mental skills of a random sample of those who used walkers with a random sample of those who never used walkers. Mental skill scores averaged 113 for 54 babies who used walkers (standard deviation of 12) and 123 for 55 babies who did not use walkers (standard deviation of 15).

(a) Is there evidence that the mean mental skill score of babies who use walkers is different from the mean mental skill score of babies who do not use walkers? Explain your answer.

a) babies in groups are indep, 2SampleTTest

μ_W = mean skill score of all babies using walkers

μ_{NW} = " " never using walkers

Ho: $\mu_W = \mu_{NW}$

Ha: $\mu_W \neq \mu_{NW}$

conditions

✓ SRS problem state: "random sample"

✓ n<10%pop 109<10% of all babies

✓ groups indep. (implied in random)

• NN (each sample)
no data, but $n_W = 54$, $n_{NW} = 55$
which can be assumed NN because $n \geq 40$

Perform 2SampleTTest using:

X1: 113 X2: 123
Sx1: 12 Sx2: 15
n1: 54 n2: 55

$\mu_1 \neq \mu_2$ no pooling

$t = -3.8468$
p-val = $2.0778 \cdot 10^{-4}$
df = 102.8280

with $\alpha = .05$, p-val = $2.0778 \cdot 10^{-4}$ is low so we reject Ho. We do have sufficient statistical evidence to conclude that the mean mental skill score of babies who use walkers is different from the mean mental skill score of babies who do not use walkers.

(b) Suppose that a study using this design found a statistically significant result. Would it be reasonable to conclude that using a walker causes a change in mean mental skill score? Explain your answer.

b) A "study" implies this is not an experiment. Unless we conduct a controlled experiment we cannot claim a cause-and-effect, even if there is a statistically significant association.

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5. A growing number of employers are trying to hold down the costs that they pay for medical insurance for their employees. As part of this effort, many medical insurance companies are now requiring clients to use generic brand medicines when filling prescriptions. An independent consumer advocacy group wanted to determine if there was a difference, in milligrams, in the amount of active ingredient between a certain "name" brand drug and its generic counterpart. Pharmacies may store drugs under different conditions. Therefore, the consumer group randomly selected ten different pharmacies in a large city and filled two prescriptions at each of these pharmacies, one for the "name" brand and the other for the generic brand of the drug. The consumer group's laboratory then tested a randomly selected pill from each prescription to determine the amount of active ingredient in the pill. The results are given in the following table.

ACTIVE INGREDIENT
(in milligrams)

	Pharmacy	1	2	3	4	5	6	7	8	9	10
L1	Name brand	245	244	240	250	243	246	246	246	247	250
L2	Generic brand	246	240	235	237	243	239	241	238	238	234

L3 D=N−G

Based on these results, what should the consumer group's laboratory report about the difference in the active ingredient in the two brands of pills? Give appropriate statistical evidence to support your response.

possible differences between pharmacies mean we should analyze this data as a matched pair data set.

Define D = Name brand − Generic brand

$H_0: \mu_D = 0$

$H_A: \mu_D \neq 0$

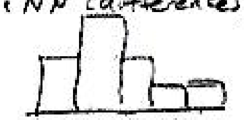
conditions

✓ SRS "randomly selected"

✓ n<10% pop 10<10% of all pharmacies

✓ matched pairs (matched by pharmacy)

✓ NN (differences)



possible skew

but NPP

looks straight

Test in calculator using data in L3 (Name brand − Generic brand)

$\mu_0: 0$ $\quad t = 3.958$

$\mu \neq \mu_0$ $\quad$ p-val = .0033

with $\alpha = .05$, p-val = .0033 is low, so we reject Ho.

We do have sufficient statistical evidence to conclude that there is a difference in the mean amount of active ingredient between name brand and generic drugs.

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4. The principal at Crest Middle School, which enrolls only sixth-grade students and seventh-grade students, is interested in determining how much time students at that school spend on homework each night. The table below shows the mean and standard deviation of the amount of time spent on homework each night (in minutes) for a random sample of 20 sixth-grade students and a separate random sample of 20 seventh-grade students at this school.

	Mean	Standard Deviation
Sixth-grade students	27.3	10.8
Seventh-grade students	47.0	12.4

Based on dotplots of these data, it is not unreasonable to assume that the distribution of times for each grade were approximately normally distributed.

(a) Estimate the difference in mean times spent on homework for all sixth- and seventh-grade students in this school using an interval. Be sure to interpret your interval.

(b) An assistant principal reasoned that a much narrower confidence interval could be obtained if the students were paired based on their responses; for example, pairing the sixth-grade student and the seventh-grade student with the highest number of minutes spent on homework, the sixth-grade student and seventh-grade student with the next highest number of minutes spent on homework, and so on. Is the assistant principal correct in thinking that matching students in this way and then computing a matched-pairs confidence interval for the mean difference in time spent on homework is a better procedure than the one used in part (a)? Explain why or why not.

(a) 2 Sample indep TInterval

conditions

✓. SRS states "random"

✓. n<10% pop 20<10% of all 6th/7th grade students

✓. groups indep. (separate, random samples)

✓. NN problem states true

2SampleTInt in calc

using $\bar{x}_1$: 27.3 $\bar{x}_2$: 47.0

Sx1: 10.8 Sx2: 12.4

n1: 20 n2: 20

C-level: .95

No pooling

(−27.15, −12.25) calculator does $\mu_1-\mu_2$ (negative difference indicates lower mean HW time in 6th grade)

We are 95% confident that, for all 6th 7th grade students, 6th graders spend an average of somewhere between 12.25 and 27.15 fewer minutes on homework than 7th graders.

(b) This procedure would produce a narrower CI, but is not appropriate.

Optional

A matched-pair study, in analyzing differences between more similar students, effectively removes (or at least reduces) the variability between harder working students (who spend more time) and other students (who spend less time on homework in general).

This is what they are looking for

However, matching should always be done based upon a trait other than what is being studied. It is inappropriate to artificially match students based upon time spent on homework, when we are studying time spent on homework.

STATISTICS

Section II

Part B

Question 6

Spend about 25 minutes on this part of the exam.

Percent of Section II grade—25

Directions: Show all your work. Indicate clearly the methods you use, because you will be graded on the correctness of your methods as well as on the accuracy of your results and explanation.

6. A pharmaceutical company has developed a new drug to reduce cholesterol. A regulatory agency will recommend the new drug for use if there is convincing evidence that the mean reduction in cholesterol level after one month of use is more than 20 milligrams/deciliter (mg/dl), because a mean reduction of this magnitude would be greater than the mean reduction for the current most widely used drug.

   The pharmaceutical company collected data by giving the new drug to a random sample of 50 people from the population of people with high cholesterol. The reduction in cholesterol level after one month of use was recorded for each individual in the sample, resulting in a sample mean reduction and standard deviation of 24 mg/dl and 15 mg/dl, respectively.

   (a) The regulatory agency decides to use an interval estimate for the population mean reduction in cholesterol level for the new drug. Provide this 95 percent confidence interval. Be sure to interpret this interval.

   (b) Because the 95 percent confidence interval includes 20, the regulatory agency is not convinced that the new drug is better than the current best-seller. The pharmaceutical company tested the following hypotheses.

   $$H_0: \mu = 20 \text{ versus } H_1: \mu > 20,$$

   where μ represents the population mean reduction in cholesterol level for the new drug.

   The test procedure resulted in a t-value of 1.89 and a p-value of 0.033. Because the p-value was less than 0.05, the company believes that there is convincing evidence that the mean reduction in cholesterol level for the new drug is more than 20. Explain why the confidence interval and the hypothesis test led to different conclusions.

   (c) The company would like to determine a value L that would allow them to make the following statement.

   We are 95 percent confident that the true mean reduction in cholesterol level is greater than L.

   A statement of this form is called a one-sided confidence interval. The value of L can be found using the following formula.

   $$L = \bar{x} - t^* \frac{s}{\sqrt{n}}$$

   This has the same form as the lower endpoint of the confidence interval in part (a), but requires a different critical value, t^*. What value should be used for t^*?

   Recall that the sample mean reduction in cholesterol level and standard deviation are 24 mg/dl and 15 mg/dl, respectively. Compute the value of L.

   (d) If the regulatory agency had used the one-sided confidence interval in part (c) rather than the interval constructed in part (a), would it have reached a different conclusion? Explain.

END OF EXAMINATION

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a) data is reduction in cholesterol, per patient, so matched pair data. D = level after − level before drug

$\bar{x}_D = 24$ mg/dl $s_{x_D} = 15$ mg/dl $n_D = 50$

conditions
- ✓ • SRS "random sample"
- ✓ • $n < 10\%$ pop $50 < 10\%$ of all patients
- ✓ • matched pairs (by patient)
- ✓ • NN can assume b/c $n \geq 40$

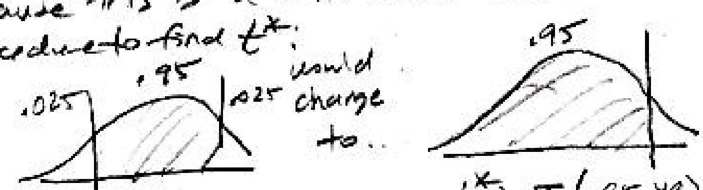
Perform TInterval using
$\bar{x} = 24$
$Sx = 15$
$n = 50$
C-level $= .95$

$\boxed{(19.737, 28.263)}$

We are 95% ~~confident that the~~ true mean reduction in blood cholesterol for all patients is between 1.9737 and 28.263 mg/dl!

b) The hypothesis test used $H_A: \mu > 20$ which is one-sided so the p-value of .033 is a one-sided p-value. Confidence intervals are inherently two-sided. If the one-sided p-value of .033 were doubled, the corresponding two-sided p-value would be .066, which is above $\alpha = .05$ so the researchers would conclude the drug was likely not effective (which matches the conclusion for the confidence interval.)

c) Because this is a one-sided CI, the usual procedure to find t^*:



would change to..

$t^* = invT(.975, 49)$ → $t^* = invT(.95, 49)$

$\boxed{t^* = 1.6766}$

So $L = \bar{x} - t^* \frac{s}{\sqrt{n}} = 24 - (1.6766)\left(\frac{15}{\sqrt{50}}\right) \boxed{= 20.4434 \text{ mg/dl}}$

d) Yes, the agency would reach a different conclusion. With this one-sided lower bound of the confidence level at 20.4434 mg/dl, the lowest likely value for reduction in cholesterol level is 20.4434 mg/dl which is higher than the required 20 mg/dl level to recommend the new drug.