2. As dogs age, diminished joint and hip health may lead to joint pain and thus reduce a dog's activity level. Such a reduction in activity can lead to other health concerns such as weight gain and lethargy due to lack of exercise. A study is to be conducted to see which of two dietary supplements, glucosamine or chondroitin, is more effective in promoting joint and hip health and reducing the onset of canine osteoarthritis. Researchers will randomly select a total of 300 dogs from ten different large veterinary practices around the country. All of the dogs are more than 6 years old, and their owners have given consent to participate in the study. Changes in joint and hip health will be evaluated after 6 months of treatment.

   (a) What would be an advantage to adding a control group in the design of this study?

   (b) Assuming a control group is added to the other two groups in the study, explain how you would assign the 300 dogs to these three groups for a completely randomized design.

   (c) Rather than using a completely randomized design, one group of researchers proposes blocking on clinics, and another group of researchers proposes blocking on breed of dog. How would you decide which <u>one</u> of these two variables to use as a blocking variable?

3. Big Town Fisheries recently stocked a new lake in a city park with 2,000 fish of various sizes. The distribution of the lengths of these fish is approximately normal.

   (a) Big Town Fisheries claims that the mean length of the fish is 8 inches. If the claim is true, which of the following would be more likely?

   - A random sample of 15 fish having a mean length that is greater than 10 inches

   or

   - A random sample of 50 fish having a mean length that is greater than 10 inches

   Justify your answer.

   (b) Suppose the standard deviation of the sampling distribution of the sample mean for random samples of size 50 is 0.3 inch. If the mean length of the fish is 8 inches, use the normal distribution to compute the probability that a random sample of 50 fish will have a mean length less than 7.5 inches.

   (c) Suppose the distribution of fish lengths in this lake was nonnormal but had the same mean and standard deviation. Would it still be appropriate to use the normal distribution to compute the probability in part (b) ? Justify your answer.



GO ON TO THE NEXT PAGE.

4. Investigators at the U.S. Department of Agriculture wished to compare methods of determining the level of *E. coli* bacteria contamination in beef. Two different methods (A and B) of determining the level of contamination were used on each of ten randomly selected specimens of a certain type of beef. The data obtained, in millimicrobes/liter of ground beef, for each of the methods are shown in the table below.

| | | Specimen | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Method | A | 22.7 | 23.6 | 24.0 | 27.1 | 27.4 | 27.8 | 34.4 | 35.2 | 40.4 | 46.8 |
| | B | 23.0 | 23.1 | 23.7 | 26.5 | 26.6 | 27.1 | 33.2 | 35.0 | 40.5 | 47.8 |

Is there a significant difference in the mean amount of *E. coli* bacteria detected by the two methods for this type of beef? Provide a statistical justification to support your answer.

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## Question 3

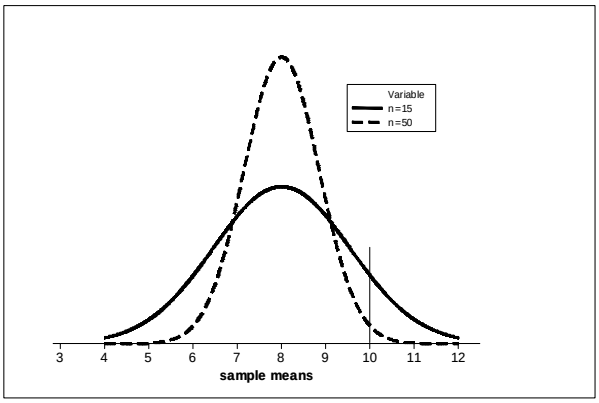
**Intent of Question**

This question was developed to assess a student's understanding of the sampling distribution of the sample mean: in particular, a student's ability to: (1) compare probabilities concerning sample means from different sample sizes; (2) compute an appropriate probability; and (3) recognize that an application of the Central Limit Theorem is being evaluated.

**Solution**

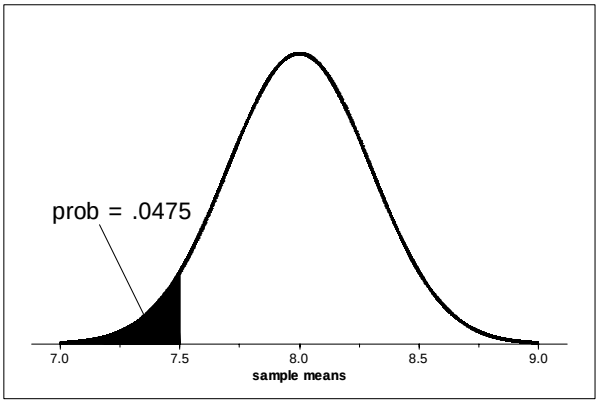
**Part (a):**

The random sample of $n = 15$ fish is more likely to have a sample mean length greater than 10 inches. The sampling distribution of the sample mean $\bar{x}$ is normal with mean $\mu = 8$ and standard deviation $\sigma/\sqrt{n}$. Thus, both sampling distributions will be centered at 8 inches, but the sampling distribution of the sample mean when $n = 15$ will have more variability than the sampling distribution of the sample mean when $n = 50$. The tail area ($\bar{x} > 10$) will be larger for the distribution that is less concentrated about the mean of 8 inches when the sample size is $n = 15$, as shown in the following graph.




**Part (b):**

$$P(\bar{x} < 7.5) = P\left(z < \frac{7.5 - 8}{0.3}\right) = P\left(z < -\frac{5}{3}\right) = P(z < -1.67) = 0.0475$$



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## Question 3 (continued)

**Part (c):**

Yes. The Central Limit Theorem says that the sampling distribution of the sample mean will become approximately normal as the sample size *n* increases. Since the sample size is reasonably large ($n = 50$), the calculation in part (b) will provide a good approximation to the probability of interest even though the population is nonnormal.

**Scoring**

Parts (a), (b), and (c) are scored as essentially correct (E), partially correct (P), or incorrect (I).

**Part (a)** is scored as essentially correct (E) if the student says that the sample of 15 fish is more likely to have a mean length that is greater than 10, AND the justification is based on *variability* in the *sampling* distributions.

Part (a) is scored as partially correct (P) if:
the student makes correct statements about the sampling distribution of the sample mean or the probabilities but does not specifically refer to the variability in these two sampling distributions;
*OR*
the student remarks that the sample mean approaches the population mean as the sample size increases (an argument based on the Law of Large Numbers).

Some examples of partially correct statements are:
- With the smaller sample size we will be more likely to get an extreme value for the sample mean.
- Variability in the smaller sample is larger.
- Variability in the larger sample is smaller.
- The sample mean approaches the population mean as the sample size increases.

Part (a) is scored as incorrect (I) if an answer is provided with no justification or incorrect justification.

Note: If a student chooses a particular value for a standard deviation and goes through the correct calculations, or shows the result algebraically based on a generic standard deviation, then the response should be scored essentially correct.

**Part (b)** is scored essentially correct (E) if the probability is calculated correctly and a reasonable sketch or evidence of calculation is shown.

Part (b) is scored partially correct (P) if:
an incorrect but plausible calculation is shown. Examples include using an incorrect standard deviation (such as $0.3/\sqrt{50}$) to obtain the probability;
*OR*
the student switches the sample mean and the population mean to obtain a standardized *z* value of 1.67.

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## Question 3 (continued)

Part (b) is scored incorrect (I) if an answer is provided with no justification or incorrect justification.

Note: Normalcdf (…) with no additional work is at best partially correct. If an appropriate sketch accompanies the calculator command, *OR* if the components of the calculator command are clearly identified/labeled, then the solution should be scored essentially correct.

**Part (c)** is scored as essentially correct (E) if the student says that the probability is a reasonable approximation because of the Central Limit Theorem and also refers to the large sample size in this case.

Part (c) is scored partially correct (P) if the student indicates that the response in part (b) would not change but provides a weak justification. Examples of a weak justification include mentioning CLT without reference to sample size, and mentioning sample size without reference to CLT.

Part (c) is scored incorrect (I) if an answer is provided with no justification or incorrect justification.

Note: An E counts for 2 points in part (a), and an E counts for 1 point in each of parts (b) and (c). Similarly, a P counts for 1 point in part (a), and a P counts for ½ point in parts (b) and (c). When the total number of points earned is not an integer, the final score earned will be rounded down to the integer value.

**4 Complete Response**

4 points earned

**3 Substantial Response**

3 or 3½ points earned

**2 Developing Response**

2 or 2½ points earned

**1 Minimal Response**

1 or 1½ points earned