Chapter 1: Mathematics and Statistics
Test Bank

MULTIPLE CHOICE

1. The radiation intensity from a point source of ^{99m}Tc is 9 mR/hr at 3 m from the source. If the distance is changed to 9 m, what is the new radiation intensity?
   a. 0.5 mR/hr
   b. 1.0 mR/hr
   c. 2.0 mR/hr
   d. 3.0 mR/hr

   ANS: B
   The inverse square law results in the radiation intensity quadrupling if the distance from the source is halved, or it results in the radiation intensity decreasing to one fourth of its value if the distance is doubled.

   REF: p. 4

2. A technologist is sitting near a bone mineral densitometer, which is a point source of x-rays. If the x-ray intensity at 1 m from the x-ray beam is 0.20 mR/hr, to what distance from the x-ray beam should the technologist move to decrease total weekly exposure to the occupational limit of 2 mR for a 40-hour workweek?
   a. 0.5 m
   b. 1.5 m
   c. 2.0 m
   d. 2.5 m

   ANS: C
   The inverse square law results in the radiation intensity quadrupling if the distance from the source is halved, or it results in the radiation intensity decreasing to one fourth of its value if the distance is doubled. The unit of intensity is mR/hr, but a 40-hour workweek must be taken into consideration when calculating the final answer.

   REF: p. 4

3. 10 mCi is equal to how many becquerels?
   a. 370 Bq
   b. 370 kBq
   c. 370 MBq
   d. 370 GBq

   ANS: C
   1 curie = 3.7×10^{10} disintegrations per second [dps]), and in Système International d’Unités (SI units), 1 Bq = 1 dps; therefore, 1 Ci = 37 GBq and 1 mCi = 37 MBq. In this problem, activity in Bq =

   $$10\,\mathrm{mCi} \times \left(10^{-3}\,\frac{\mathrm{Ci}}{\mathrm{mCi}}\right) \times \left(3.7 \times 10^{10}\,\frac{\mathrm{Bq}}{\mathrm{Ci}}\right)$$

   REF: p. 6

4. 20 mCi is equal to how many becquerels?
   a. 0.74 GBq
   b. 0.37 GBq
   c. 0.54 GBq
   d. 0.20 GBq

ANS: A
1 curie = 3.7×10^{10} disintegrations per second [dps]), and in SI units 1 Bq = 1 dps; therefore, 1 Ci = 37 GBq and 1 mCi = 37 MBq. In this problem, activity in Bq =
$$20\,\mathrm{mCi} \times \left(10^{-3}\,\frac{\mathrm{Ci}}{\mathrm{mCi}}\right) \times \left(3.7 \times 10^{10}\,\frac{\mathrm{Bq}}{\mathrm{Ci}}\right)$$

REF: p. 6

5. The dose equivalent for occupational whole-body exposure is commonly limited to 50 mSv. How many rem is this?
   a. 5000 rem
   b. 500 rem
   c. 50 rem
   d. 5 rem

ANS: D
To convert the dose equivalent in the new SI units of 1 cSv into the old unit of rem:
Dose equivalent = $1\mathrm{cSv} \times 10^{-2}\,\frac{\mathrm{Sv}}{\mathrm{cSv}} \times \frac{100\mathrm{rem}}{\mathrm{Sv}} = 1\ \mathrm{rem}$

REF: p. 6

6. A source of $^{131}\mathrm{I}\left(t_{\frac{1}{2}} = 8.05\,\mathrm{d}\right)$ is delivered to the nuclear medicine department calibrated for 100 mCi at 8:00 AM on Monday. If this radioactivity is injected into a patient at noon on Tuesday, what radioactivity will the patient receive?
   a. 80 mCi
   b. 85 mCi
   c. 90 mCi
   d. 95 mCi

ANS: C
Solving the differential equation yields the radioactive decay law: $A = A_0e^{-\lambda t}$ where A = activity at time t, A_0 = activity at starting time, λ = decay constant, t = time since starting time The *decay constant* λ is the fraction of atoms that decay per (small) time interval, and has units of 1 over time (e.g., 1/hr) or inverse time (hr^{-1}). The typical radioactive decay calculation required in nuclear medicine specifies three of the four variables (A, A_0, λ, t) in the decay equation, requiring that the fourth unknown variable be solved for.

REF: p. 11

7. A patient was injected with ^{131}I on Monday at 10:00 AM. On Tuesday at 10:00 AM, the thyroid probe was placed over the thyroid and produced 100,000 counts. On Thursday at 10:00 AM, the probe showed 25,000 counts. What is the effective half-life in this patient's thyroid?
   a. 12 hr
   b. 24 hr
   c. 48 hr
   d. 72 hr

   ANS: B
   Typically the patient's organ excretes the radiopharmaceutical with some biologic half-life t_B while the radioactivity also decays physically with a **physical half-life** that is denoted as t_P. The counts observed by the gamma camera follow an exponential decay law based on the ***effective half-life*** t_E, where: $\frac{1}{t_E} = \frac{1}{t_P} + \frac{1}{t_B}$ or, in a format that is much easier for calculation purposes, $t_E = \frac{t_P \times t_B}{(t_P + t_B)}$.
   The effective half-life is always less than or equal to the smaller of t_P or t_B.

   REF: pp. 16, 17

8. A ^{99}Mo-^{99m}Tc generator is eluted Monday at 7:00 AM, producing 1.8 Ci of ^{99m}Tc in the eluate vial, in 20 ml saline. What volume of eluate should be withdrawn from the eluate vial into a syringe in order to inject a patient with 20 mCi of ^{99m}Tc at 3:00 PM? (Given the half-life of ^{99m}Tc is 6.02 hours.)
   a. 0.56 ml
   b. 0.66 ml
   c. 0.76 ml
   d. 0.86 ml

   ANS: A
   The radioactive decay law can be algebraically rearranged (dividing both sides of the decay equation by A_0) as: $A/A_0 = e^{-0.639\left(t/t^1/_2\right)}$. After solving for the half-life, the concentration (radioactivity per volume) in the eluate vial is then determined and the volume needed to be withdrawn into the syringe can be calculated from the equation activity = concentration × volume: A = C × V.

   REF: p. 15

9. If the HVL for some radionuclide in lead is 0.30 mm, what thickness of lead shielding is necessary to reduce the radiation exposure from 8 mR/hr to 1 mR/hr?
   a. 0.30 mm
   b. 0.45 mm
   c. 0.60 mm
   d. 0.90 mm

   ANS: D

It is common to follow the method used in radioactive decay and define a half-value layer (HVL) as that thickness of material that absorbs 50% of the photons. The HVL is the analog of $t_{\{1/2\}}$ in radioactive decay. One HVL transmits 50% of the photons. The equation of photon attenuation then can be expressed as: $I = I_0e^{-\mu x} = I_0e^{-0.693 \times (x/HVL)}$ and a relationship exists between μ and HVL, given by $\mu = 0.693/HVL$. Remember the units of x and HVL must be the same, and remember that this equation calculates the *transmitted* intensity.

REF: pp. 17, 18

10. The linear attenuation coefficient in lead for ^{99m}Tc gamma rays (140 keV) is 23 cm^{-1}. What percentage of these gamma rays will be absorbed by a lead apron that contains 0.60 mm of lead?
    a. 75%
    b. 50%
    c. 25%
    d. 12.5%

    ANS: A
    The intensity of the transmitted radiation is given by:
    $$I = I_0e^{-\mu x}$$
    where μ is the linear attenuation coefficient, or the fraction of the beam absorbed in some (very small) thickness x. The linear attenuation coefficient μ is the analog of the decay constant λ in radioactive decay. The linear attenuation coefficient μ depends on the type of absorbing material and the energy of the photons.

    REF: pp. 17, 18

11. A new gamma camera/computer system that uses a new method of calculating cardiac ejection fraction (EF) is installed in a nuclear medicine department. The department decides to calculate EF for the next 25 patients on both the old gamma camera and the new gamma camera before discontinuing the use of the old camera. In the future, if it is desirable to convert the new EF value to that which would have been obtained on the old gamma camera (e.g., to assess if the patient's EF had changed), the mathematical analysis to be used is called:
    a. independent *t*-test
    b. linear regression
    c. standard error
    d. chi-square

    ANS: B
    The least squares method, or linear regression, calculates the best-fit values for *y*-intercept (*a*) and slope (*b*) in the best-fit straight line: $y = a + bx$. The line of identity is often drawn on regression graphs when the *same* parameter, here the ejection fraction, is being plotted on both the x and y axes. The line of identity facilitates an evaluation of whether the two methods (the x and y axes) are predicting the same result for ejection fraction. If the two methods produce the same value for ejection fraction, then the regression line should be the same as the line of identity.

    REF: p. 21

12. What is the standard deviation of 40,000 counts?

a. 4000 counts
b. 2000
c. 400
d. 200

ANS: D
Counting statistics, meaning the number of counts expected from a sample, follow the Poisson distribution. In the Poisson distribution, the standard deviation (σ_C) for any number of counts *(C)* is fixed at the square root of *C:*

$$\sigma_c = \sqrt{C}$$

This fixed definition of standard deviation does not exist in Gaussian distributions; essentially only counting statistics are Poisson.

REF: p. 26

13. What is the coefficient of variation of 40,000 counts?
a. 2%
b. 1%
c. 0.5%
d. 0.25%

ANS: C
The standard deviation can be expressed as a percentage of the mean value, which is frequently called the percent standard deviation, or coefficient of variation (CV):

$$CV = \left(\frac{\sigma}{\bar{x}}\right) \times 100$$

In this problem, the counts would be substituted for the mean in the equation.

REF: p. 27

14. How many counts should be acquired into each pixel of a nuclear medicine flood image if it is desired to be 95% confident that the true count in each pixel is within 1% of the measured counts in each pixel?
a. 100,000 counts
b. 40,000 counts
c. 10,000 counts
d. 4000 counts

ANS: B
Counting statistics, besides being Poisson, are also described by a Gaussian distribution as long as the number of counts is greater than about 30. Hence, given some number of counts *C*, the standard deviation is automatically known. It is also known that 68% of repeat measures of the sample falls within C ± $\sqrt{C}$ and 95% of repeat measures of the sample fall within C ±$2\sqrt{C}$ and so on (95% confidence = C ± $2\sigma_c$ = C ± $2\sqrt{C}$).
Sometimes this type of problem is expressed by saying that a certain number of counts are needed to be 95% confident that the true count is within 2% of the measured value. The presence of two different percentage values can seem confusing. The 95% confidence interval on 10,000 counts is ±200 counts, and this figure of 200 counts represents 2% of 10,000 counts. The general formula expressing the number of counts needed to be “nσ” sure that the true answer is within some percent *(p)* of the measured counts is given by:

$$C = \left[\frac{n}{\left(\frac{P}{100\%} \right)} \right]^2$$

In this formula, *n* is replaced with a 1 for 68% confidence, a 2 for 95% confidence, and a 3 for 99% confidence.

REF: pp. 27, 28

15. A patient's thyroid is counted with the thyroid probe and produces 8000 counts. Then the patient is removed and background is found to be 2000 counts. The (net counts) ± (standard deviation in the net counts) in this patient is:
    a. 10,000 ± 100 counts
    b. 10,000 ± 77 counts
    c. 6000 ± 77 counts
    d. 6000 ± 100 counts

ANS: D

Background counts are a problem in most measurements of counts from a radioactive sample. Background arises from natural terrestrial and cosmic sources of radioactivity or from other nearby sources of radioactive material. The sample is usually counted in the presence of some background radiation, yielding a gross count for sample plus background, denoted by the letter C. The sample is then removed from the counter and the background B is counted. The net, or true counts, which represents the sample only, is denoted by N and given by:

N = C – B

The standard deviation of the net counts is given by:

$\sigma_N = \sqrt{(C+B}$

This is an example of the rules for combinations of errors, which states that for addition or subtraction, errors add in quadrature within the square root:

$$\sigma_N = \sqrt{\sigma^2{}_C + \sigma^2{}_B}$$

Additionally, since

$$\sigma_C = \sqrt{C} \text{ and } \sigma_B = \sqrt{B}$$

we obtain

$$\sigma_N = \sqrt{(C+B)}$$

REF: p. 28

16. The gamma camera seems to be producing erratic results. A ^{57}Co flood source is counted 10 times, producing the following count values: 1000, 975, 1032, 1096, 982, 997, 1012, 1090, 994, 977. What is the chi-square value for these counts?
    a. 19.3
    b. 18.3
    c. 17.3
    d. 16.3

ANS: C

Too little or too much variation in repeat measurements indicates equipment may not be functioning properly. The **chi-square test** is used to determine an acceptable range of variability in the repeat measurements. The mean $\bar{C}$ of the 10 measurements is determined ($\bar{C} = \Sigma C/n$), and chi-square is calculated as:

$$\chi^2 = \frac{\left[\sum (C-\bar{C})^2\right]}{\bar{C}}$$

REF: pp. 28, 29

17. Which expression describes the operation of the gamma camera in question 16?
    a. Operating properly
    b. Showing too much variation
    c. Showing too little variation
    d. Not enough information to answer the question

ANS: B
The definition of acceptable chi-square is given by looking up the probability *(P)* of this chi-square value for the *n* repeated measures in a table. Too little variation is shown by a chi-square smaller than the $P = 0.9$ value; an amount of variation exactly as expected from the statistical nature of the decay process would yield $P = 0.50$; and an unacceptably large chi-square would yield a P value greater than 0.10. So, $P = 0.90$–0.10 range is acceptable.

REF: p. 29

18. One group of 20 patients is given a drug that is thought to have an effect on kidney function, and another group of 20 patients is given a placebo (i.e., sugar pill, which is known not to have an effect on kidney function). The nuclear medicine gamma camera is used to calculate the glomerular filtration rate (GFR) in these two groups of patients. What would be the proper statistical test to use to test the hypothesis that no difference in GFR exists between these two groups of patients?
    a. Chi-square test
    b. Paired *t*-test
    c. Independent *t*-test
    d. Linear regression analysis

ANS: C
The *t*-test is used to test for differences between *mean* values. The two forms of the *t*-test are for *independent* samples and *paired* samples. For independent *t*-tests, two independent groups of data are used. The two groups are completely independent. No relationship or correlation exists between the two groups, typically because the groups represent different patients. The two groups have mean and standard deviations denoted by $\bar{x}_1$, SD_1, $\bar{x}_2$, and SD_2.

$$t = (\bar{x}_1 - \bar{x}_2) /$$

$$\left\{ \frac{\left[(n_1 - 1)\times SD_1^2 + (n_2 - 1)\times SD_2^2\right] \times \left(\frac{1}{n_1} \times \frac{1}{n_2}\right)}{n_1 + n_2 - 2} \right\}^{1/2}$$

REF: p. 30

19. A nuclear medicine test produces a positive test result in only 80 of the 100 patients known to be ill. Similarly, the test produces a negative test result in only 190 of the 200 patients known to be not ill. Which is correct?
a. Sensitivity = 80%, specificity = 95%, accuracy = 90%, prevalence = 33%
b. Sensitivity = 90%, specificity = 95%, accuracy = 90%, prevalence = 33%
c. Sensitivity = 90%, specificity = 80%, accuracy = 90%, prevalence = 33%
d. Sensitivity = 90%, specificity = 80%, accuracy = 70%, prevalence = 33%

ANS: A
The *sensitivity,* or *true positive fraction (TPF),* is the percentage or fraction of ill patients who have a positive test:

$$\text{Sensitivity} = \text{TPF} = \frac{\text{TP}}{(\text{TP}+\text{FN})}$$

The *specificity,* or *true negative fraction (TNF),* is the percentage or fraction of well patients who have a negative test:

$$\text{Sensitivity} = \text{TNF} = \left(\frac{\text{TN}}{(\text{TN}+\text{FP})}\right)$$

The *prevalence* is the fraction or percentage of ill persons in the study population:

$$\text{Prevalence} = \frac{(\text{TP}+\text{FN})}{(\text{TP}+\text{FN}+\text{TN}+\text{FP})}$$

REF: pp. 33-35

20. One radiologist is known to be a lax reader compared with another radiologist who is known to be a strict reader. In comparing these radiologists, how would one expect their sensitivity and specificity to compare?
a. The lax reader would have lower sensitivity and higher specificity.
b. The lax reader would have higher sensitivity and lower specificity.
c. The readers would be expected to have the same sensitivity and specificity.
d. Not enough information is given to answer the question.

ANS: B
The sensitivity, or *true positive fraction (TPF),* is the percentage or fraction of ill patients who have a positive test:

$$\text{Sensitivity} = \text{TPF} = \frac{\text{TP}}{(\text{TP}+\text{FN})}$$

The specificity, or *true negative fraction (TNF),* is the percentage or fraction of well patients who have a negative test:

$$\text{Sensitivity} = \text{TNF} = \left(\frac{\text{TN}}{(\text{TN}+\text{FP})}\right)$$

For an example, data that show a sensitivity of 78%, less than the specificity of 95%, mean that this test does a better job at correctly diagnosing well people than it does at correctly diagnosing ill people. High sensitivity = correctly finding ill people; high specificity = correctly finding well people.

REF: pp. 33, 34

21. A ^{99}Mo-^{99m}Tc generator is calibrated for 1.00 Ci of ^{99}Mo at 7:00 AM Monday. The generator is eluted daily Monday through Friday at 8:00 AM, but the workload is especially heavy on Friday so the generator is eluted again at 3:00 PM to obtain more ^{99m}Tc. Assuming 100% elution efficiency, how many mCi of ^{99m}Tc will be eluted at 3:00 PM Friday?
a. 930 mCi
b. 710 mCi
c. 160 mCi
d. 80 mCi

ANS: C
The ^{99m}Tc radioactivity expected to be eluted from the generator can be calculated by knowing three values: (1) the activity of ^{99}Mo in the generator, (2) the time since the last elution of the generator, and (3) the ratio of ^{99m}Tc to ^{99}Mo in the generator. Using the equation, $A = \times \text{Ci} \times e^{-0.693 \times (t/65.9\text{ hr})}$, enter in the known values and solve for the unknown.

REF: p. 15

22. A radioactive source of ^{137}Cs ($t_{1/2}$= 30 y) was calibrated on October 23, 2000 to contain 10 μCi. This is used as a daily accuracy check source in the dose calibrator. Presuming the dose calibrator is working properly, what activity should the dose calibrator show on April 23, 2006?
a. 9.6 μCi
b. 8.8 μCi
c. 5.4 μCi
d. 2.2 μCi

ANS: B
The radioactive decay law can be algebraically rearranged (dividing both sides of the decay equation by A_0) as $A/A_0 = e^{-0.693\times(t/t_{1/2})}$.

REF: p. 15

23. A source of ^{18}F ($t_{1/2}$ = approximately 2 hr) is noted to contain 3 mCi at noon. What was the radioactivity at 8:00 AM that same day?
a. 24 mCi
b. 18 mCi
c. 12 mCi
d. 6 mCi

ANS: C
The radioactive decay law can be algebraically rearranged (dividing both sides of the decay equation by A_0) as: $A/A_0 = e^{-0.693 \times (t/t_{1/2})}$.

REF: pp. 12-15

24. The biological half-life of ^{131}I in a particular patient is 30 days. The physical half-life is 193 hours. If the patient's thyroid is counted with the thyroid probe detector, what effective half-life will be observed?
a. 26 days
b. 6.3 days

c. 5.1 days
d. 1.2 days

ANS: B
Typically the patient's organ excretes the radiopharmaceutical with some biologic half-life t_B while the radioactivity also decays physically with a *physical half-life* that is denoted as t_P. The counts observed by the gamma camera follow an exponential decay law based on the *effective half-life* t_E, where:

$$\frac{1}{t_E} = \frac{1}{t_P} + \frac{1}{t_B}$$

or in a format that is much easier for calculation purposes,

$$t_E = \frac{t_P \times t_B}{(t_P + t_B)}$$

The effective half-life is always less than or equal to the smaller of t_P or t_B.

REF: pp. 16, 17

25. A radioactive source decays from 20 mCi to 2.5 mCi in 18 hours. What is the physical half-life?
a. 8 hr
b. 7 hr
c. 6 hr
d. 5 hr

ANS: C
The $t_{1/2}$, which depends on the radioactive material involved, is the time in which the activity is decreased to half its original value. The radioactive decay law may alternatively be expressed as

$$A/A_0 \; e^{-0.693 \times (t/t\,1/2)}$$

The factor 0.693 is actually ln 2, which is commonly written with three significant figures. Each half-life of radioactive decay causes the activity level to drop by 50%.

REF: p. 12

26. A sample shows a count rate of 36,000 cpm during a 3-minute counting period. Express this as the count rate ± standard deviation.
a. 36,000 ± 220 cpm
b. 36,000 ± 110 cpm
c. 12,000 ± 55 cpm
d. 12,000 ± 28 cpm

ANS: B
Counting statistics, meaning the number of counts expected from a sample, follow the Poisson distribution. In the Poisson distribution, the standard deviation (σ_C) for any number of counts *(C)* is fixed at the square root of *C:*

$$\sigma_C = \sqrt{C}$$

This fixed definition of standard deviation does not exist in Gaussian distributions; essentially only counting statistics are Poisson. In this problem, cpm must be calculated first.

REF: p. 26

27. A long-lived radioactive source is counted for 1 minute and yields 10,000 counts. If this source is counted immediately again, there is a 95% probability that the result will be in the range:
   a. 9950 to 10,050
   b. 9900 to 10,100
   c. 9800 to 10,200
   d. 9700 to 10,300

ANS: C
Counting statistics, besides being Poisson, are also described by a Gaussian distribution as long as the number of counts is greater than approximately 30. Hence given some number of counts *C*, the standard deviation is automatically known. It is also known that 68% of repeat measures of the sample falls within C ± $\sqrt{C}$ and 95% of repeat measures of the sample fall within C ± $2\sqrt{C}$, and so on: 95% confidence = C ± $2\sigma_c$ = C ± $2\sqrt{C}$.

REF: p. 26

28. A 5-ml sample of a standard diluted 1:10,000 produces 27,200 counts in the well counter. A 5-ml sample of patient plasma, counted for the same time as the diluted standard sample, produces 99,100 counts. What is the plasma volume?
   a. 10.8 liter
   b. 2.74 liter
   c. 1.73 liter
   d. 0.91 liter

ANS: B
The dilution principle can also be used to measure an unknown volume. Using the dilution principle, it is possible to estimate a patient's plasma volume, $C_1V_1 = C_2 V_2$. Because the standard may be too concentrated, a portion of the standard is diluted and counted while the full-strength undiluted standard can be injected into the patient. The standard can be diluted by adding 1 ml of it to a flask, which is then filled to 500 ml with distilled water. It could then be expressed as a 1:500 diluted standard. The standard counts have to be multiplied by the dilution factor of 500 to obtain the true standard concentration that was injected into the patient. Taking this into consideration and the new equation to be used to calculate the plasma volume would be $C_1V_1 = (DF)C_2V_2$

REF: p. 15

29. Readers are encouraged to use Microsoft Excel to solve this problem. What is the mean of the following five numbers: 6.40, 7.20, 3.50, 9.20, 5.10?
   a. 9.01
   b. 6.28
   c. 5.97
   d. 4.83

ANS: B

Precision refers to the spread, or range, of data values obtained when some parameter is measured many times or in many patients. A small precision means that little variation exists in the data values. Then, the mean (or average) of the *n* values of the parameters *x* is defined by the symbol:

$$\bar{x} = \frac{\sum x}{n}$$

The symbol Σx means the sum of all the measurements of *x*.

REF: pp. 21, 22

30. Readers are encouraged to use Microsoft Excel to solve this problem. What is the standard deviation of the following five numbers: 6.40, 7.20, 3.50, 9.20, 5.10?
a. 4.02
b. 3.26
c. 2.15
d. 1.92

ANS: C

The standard deviation, a measure of the precision of the data, is given by the symbol σ, defined as:

$$\sigma = \left[\frac{\sum\left(x-\bar{x}\right)^2}{n-1}\right]^{\frac{1}{2}}$$

Recall that an exponent of $\frac{1}{2}$ means the same as the square root $\left(\sqrt{\ }\right)$. The standard deviation is a measure of the deviation or spread of the data points from the mean value. The standard deviation is often expressed in a format of the mean value ±σ. A large σ value indicates data with a large range and, therefore, poor precision.

REF: pp. 24, 25

31. Readers are encouraged to use Microsoft Excel to solve this problem. What is the coefficient of variation (CV) of the following five numbers: 6.40, 7.20, 3.50, 9.20, 5.10?
a. 34%
b. 31%
c. 28%
d. 12%

ANS: A

The standard deviation is a percentage of the mean value, which is frequently called the percent standard deviation, or coefficient of variation (CV):

$$CV = \left(\frac{\sigma}{\bar{x}}\right) \times 100$$

REF: p. 25

32. Readers are encouraged to use Microsoft Excel to solve this problem. In a nuclear medicine technology training program, the students wonder if their final exam grade in their training program is related to their subsequent board score on the NMTCB exam. The five students attain the following pairs of scores (exam score, board score) = (72, 60), (84, 74), (88, 71), (68, 60), (91, 79). What is the linear correlation coefficient, *r*, between exam score and board score?

a. 0.99
b. 0.95
c. 0.86
d. 0.75

ANS: B

The value of goodness-of-fit parameters helps determine whether it is reasonable that the data points are truly represented by a straight line. The linear correlation coefficient, *r*, is calculated from the sums used to find the intercept and slope, along with one additional sum from the data points (Σy^2):

$$r = \frac{n\left(\sum xy\right) - \sum x\left(\sum y\right)}{\left[n\left(\sum x^2\right) - \sum x\right]^{1/2}\left[n\left(\sum y^2\right) - \sum y\left(\sum y\right)\right]^{1/2}}$$

The sign of the correlation coefficient is merely the same as the sign of the slope.

REF: p. 29

33. Using Table 1-9 in the book, what is the *P* value for the linear correlation coefficient *r* in question 31?

a. $P = 0.001$
b. $0.01 < P < 0.05$
c. $0.05 < P < 0.1$
d. $P > 0.10$

ANS: B

A correlation $r = 1$ is a perfect fit, with the straight line passing exactly through each data point. The closer *r* is to 1, the more highly correlated are the *x* and *y* data. A chance, or probability (*P*), always exists that data that are truly not linearly related to each other will randomly appear in a fairly linear fashion. The statistical significance of correlation values less than 1 must be evaluated from statistical tables of probability.

REF: p. 29

34. Using Table 1-9 in the book, does a linear correlation coefficient $r = 0.95$ for $n = 5$ data points indicate a statistically significant linear relationship between the *x* and *y* variables?

a. Yes
b. No
c. There is not enough information to answer the question.
d. None

ANS: A

A correlation $r = 1$ is a perfect fit, with the straight line passing exactly through each data point. The closer r is to 1, the more highly correlated are the x and y data. A chance, or probability (P), always exists that data that are truly not linearly related to each other will randomly appear in a fairly linear fashion. The statistical significance of correlation values less than 1 must be evaluated from statistical tables of probability.

REF: p. 29

35. Readers are encouraged to use Microsoft Excel to solve this problem. What is the slope and intercept in the regression equation for problem 31?
(board score) = intercept + (slope) × (exam score)
a. intercept = 7.15, slope = 0.502
b. intercept = 6.15, slope = 0.602
c. intercept = 5.15, slope = 0.702
d. intercept = 4.15, slope = 0.802

ANS: D
The intercept and slope are calculated

$$a=\frac{\left[\sum x^2\left(\sum y\right)-\sum x\left(\sum xy\right)\right]}{\left[n\left(\sum x^2\right)-\sum x\left(\sum x\right)\right]}$$

REF: pp. 10, 22, 29

36. Using the regression equation in Problem 31, if your training program exam score was 84, what does the regression equation predict for your board score?
a. 92
b. 82
c. 72
d. 62

ANS: C
The standard deviation can be expressed as a percentage of the mean value, which is frequently called the percent standard deviation, or coefficient of variation (CV):

$$CV=\left(\frac{\sigma}{\bar{x}}\right)\times 100$$

In this problem, the score would be substituted for the mean in the equation.

REF: p. 25

37. A thyroid uptake dose of 10 μCi is equal to how much radioactivity in SI units?
a. 37 kBq
b. 370 kBq
c. 3.7 MBq
d. 37 MBq

ANS: B
The curie = 3.7×10^{10} disintegrations per second [dps], and the Bq =1 dps; therefore, 1 Ci = 37 GBq and 1 mCi = 37 MBq and 1 μCi = 37 kBq.

REF: p. 6

38. What is the proper number of significant figures for the quotient $(6.1 \times 10^{-2})/(0.1232)$?
a. 0.49513
b. 0.4951
c. 0.495
d. 0.50

ANS: D
The *exponent* on the 10 specifies how many places the decimal point in the number is to be shifted to the left (for negative exponents) or shifted to the right (for positive exponents). In addition, the accuracy of the result in multiplication or division is such that the product or quotient has the number of significant figures equal to that of the term with the smaller number of significant figures.

REF: pp. 3, 9

39. What is the proper number of decimal places in the sum of (0.3) + (3.5264)?
a. 3.8264
b. 3.826
c. 3.83
d. 3.8

ANS: D
For addition and subtraction the final result has the same number of significant *decimal places* (rather than significant figures) as the number in the problem with the least number of significant decimal places.

REF: pp. 3, 9

40. It is known that 75% of a radionuclide decays away in 12 hours. If starting with 10 mCi, how much will be left after 6 hours?
a. 7.5 mCi
b. 5 mCi
c. 2.5 mCi
d. 1.25 mCi

ANS: B
Calculations in nuclear medicine often involve expressing a mathematical concept as a ratio. The equation generally contains several numbers and one unknown value; here the unknown value is *(x).* The object is to solve for the unknown value by rearranging the terms in the equation. In this situation, the half-life of the material is t hours. Start with 10 mCi. After t hours, there is 5 mCi left. After another t hours, there is 2.5 mCi left. Starting with 10 mCi, after $2t$ hours, there is 2.5 mCi left, which is only 25% of the initial quantity, and so 75% decayed away. It is given that 75% decays away in 12 hours. So $2t = 12$ hours and $t = 6$ hours. With a half-life of 6 hours, starting with 10 mCi, there would be 5 mCi left after 6 hours

REF: p. 4

41. Convert 5 mBq to kBq and GBq.

a. 50 kBq and 0.5 GBq
b. 500 kBq and 0.05 GBq
c. 5000 kBq and 0.005 GBq
d. 5×10^4 and 5×10^{-4} GBq

ANS: C
The decimal point can be shifted *left* if the exponent is *increased* by 1 for each left shift and the decimal can be shifted to the right if the exponent is decreased

REF: pp. 2-3

42. $\frac{1}{2} + \frac{1}{3} =$
a. $\frac{2}{5}$
b. $\frac{2}{6}$
c. $\frac{4}{6}$
d. $\frac{5}{6}$

ANS: D
Fractions, such as $\frac{1}{3}$, consist of a numerator (1) that is to be divided by a denominator (3). When using fractions to perform the calculations, a common denominator must be used. The mathematical manipulation of fractions requires care as to the number of digits and placement of the decimal point. The safest way to handle the mathematical manipulation of fractions is to simply use the power of the pocket calculator to perform calculations such as 1/3 + 9/4 by first converting the fractions to decimals and then carrying out the other arithmetic.

REF: p. 3

43. 30% of 7 ml =
a. 0.23 ml
b. 2.10 ml
c. 2.30 ml
d. 4.90 ml

ANS: B
Percentages are values expressed as a fraction of some whole, entire value: 75% of some number is the same as 0.75 multiplied by that number.

REF: p. 3

44. A patient may had a kidney function test last month that showed a kidney clearance rate of 45 milliliters per minute (ml/min). The patient returns today and has a kidney clearance rate of 60 ml/min. What is the percent increase in kidney function?
a. 7%
b. 14%
c. 25%
d. 33%

ANS: D
Percentages are often used to express percentage change between two values: % change = [(new value – old value)/old value] × 100.

REF: p. 3

45. An intensity setting of 250 on a display screen may produce a suitable image for a bar phantom with 500K counts in the acquisition. Now it is desired to change to 350K counts in the image. The intensity on the screen is known to change linearly with the intensity control setting. What intensity setting should be used for the new 350K-count image?
a. 100,000
b. 150,000
c. 175,000
d. 200,000

ANS: C
Calculations in nuclear medicine often involve expressing a mathematical concept as a ratio. The equation generally contains several numbers and one unknown value; here the new intensity setting is the unknown value *(x).* The object is to solve for the unknown value by rearranging the terms in the equation. Cross-multiplying is a technique used to solve a proportion $\left(\text{e.g., } \frac{x}{350} = \frac{250}{500}\right)$.

REF: p. 3

46. The morning elution of the ^{99}Mo-^{99m}Tc generator yields 850 mCi of ^{99m}Tc radioactivity in 20 ml of saline eluate. What volume should be withdrawn from the eluate vial into a patient syringe to immediately perform a 25-mCi patient scan?
a. 0.2 ml
b. 0.30 ml
c. 0.59 ml
d. 1.7 ml

ANS: C
Calculations in nuclear medicine often involve expressing a mathematical concept as a ratio. The equation generally contains several numbers and one unknown value; here the unknown value *(x).* The object is to solve for the unknown value by rearranging the terms in the equation. Cross-multiplying is a technique used to solve a proportion $\left(\text{e.g., } \frac{x}{25} = \frac{20}{850}\right)$

REF: p. 3