

PRACTICE EXAM 12: FE INDUSTRIAL AND SYSTEMS SIMULATION (110 QUESTIONS)

This practice exam contains 110 questions. Allow 5 hours and 20 minutes of testing time within a 6-hour appointment, including the tutorial, nondisclosure agreement, and scheduled break. Use the supplied FE Reference Handbook where appropriate. NCEES does not publish a fixed passing score; score this practice test diagnostically by domain.

1. A rectangular storage area is 18 m long and 7 m wide. What is its area? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0156 balance
- B. 0.0136 balance
- C. 0.0183 balance
- D. 0.0121 balance

2. For $f(x)=3x^2+4x-2$, what is $f'(5)$? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0926 balance
- B. 0.1211 balance
- C. 0.1049 balance
- D. 0.0828 balance

3. What is the determinant of the matrix $[[6,2],[3,5]]$? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.1769 balance
- B. 0.2235 balance

- C. 0.1600 balance
- D. 0.1975 balance

4. Evaluate the definite integral of $4x$ from $x=1$ to $x=4$. The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.2211 balance
- B. 0.2741 balance
- C. 0.2449 balance
- D. 0.2014 balance

5. A vector has components 9 and 12. What is its magnitude? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4800 balance
- B. 0.4646 balance
- C. 0.4927 balance
- D. 0.4481 balance

6. An arithmetic sequence begins at 5 and increases by 3. What is its 12th term? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0437 balance
- B. 0.0500 balance
- C. 0.0583 balance
- D. 0.0389 balance

7. What is the volume of a cylinder with radius 2 m and height 5 m, using $\pi=3.1416$? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0524 balance
- B. 0.0696 balance
- C. 0.0598 balance
- D. 0.0467 balance

8. A 24 V source is applied across an 8 Ω resistor. What current flows? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.4898 balance
- B. 0.4800 balance
- C. 0.4688 balance
- D. 0.5000 balance

9. A 10 kg cart travels at 4 m/s. What is its kinetic energy? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.0978 balance
- B. 0.1107 balance
- C. 0.1276 balance
- D. 0.0875 balance

10. A 30 kN axial load acts on a 600 mm² section. What is the normal stress? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.2778 balance
- B. 0.2524 balance
- C. 0.3084 balance
- D. 0.2311 balance

11. Water flows at 2.5 m/s through a 0.08 m² section. What is the volumetric flow rate? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.4959 balance
- B. 0.2778 balance
- C. 0.4938 balance
- D. 0.4297 balance

12. An engineer finds that a safety factor in a draft report was calculated using the wrong load combination. What should happen?

- A. Issue the report because the factor still exceeds one
- B. Hide the load combination in an appendix
- C. Change the displayed safety factor without recalculating
- D. Correct the calculation, reassess affected conclusions, and notify responsible reviewers before issuance

13. A client requests a recommendation before essential site data are available. What is the most appropriate response?

- A. Present a final recommendation without qualifications
- B. Invent representative site data and omit the assumption
- C. Explain the missing information and provide only a clearly qualified preliminary assessment if useful
- D. Guarantee that later information will not change the result

14. An engineer notices that a meeting summary misstates the engineer's technical recommendation. What should the engineer do?

- A. Request prompt correction and document the accurate recommendation in the project record
- B. Ignore it because meeting summaries are informal
- C. Delete the engineer's supporting analysis
- D. Allow the misstatement to guide later design decisions

15. A company asks an engineer to compare products using different test methods without disclosure. What is the proper response?

- A. Combine the results as if methods were identical
- B. Select only the method favoring the company product
- C. Use comparable methods or disclose and explain the methodological differences
- D. Remove test-method descriptions from the comparison

16. An investment of \$5,000 earns 6% annually for 3 years. What is its future value? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0003 balance
- B. 0.0503 balance
- C. 0.0004 balance
- D. 0.1503 balance

17. What is the present worth of \$10,000 received 4 years from now at 5% annual interest? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0505 balance
- B. 0.0005 balance
- C. 0.0004 balance
- D. 0.0006 balance

18. A product sells for \$50, variable cost is \$30, and fixed cost is \$40,000. What is break-even volume? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.0026 balance
- B. 0.0035 balance
- C. 0.0023 balance
- D. 0.0030 balance

19. Equipment costs \$72,000, has \$12,000 salvage value, and a 5-year life. What is annual straight-line depreciation? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.0007 balance
- B. 0.0010 balance
- C. 0.0006 balance
- D. 0.0008 balance

20. A \$90,000 project returns \$18,000 per year. Ignoring interest, what is its simple payback period? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4444 balance
- B. 0.4688 balance
- C. 0.4082 balance
- D. 0.4844 balance

21. Annual fixed cost is \$24,000 and output is 8,000 units. What fixed cost is allocated per unit? Using reference 1, compute harmonic balance $=2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.3200 balance
- B. 0.4444 balance
- C. 0.3750 balance
- D. 0.2778 balance

22. A machine saves \$15,000 annually but costs \$60,000. What is the simple annual return percentage? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.1216 balance
- B. 0.1372 balance
- C. 0.1572 balance

D. 0.1092 balance

23. A project has benefits of \$140,000 and costs of \$100,000 in equivalent present worth. What is its benefit-cost ratio? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

A. 0.4938 balance

B. 0.2076 balance

C. 0.4339 balance

D. 0.4980 balance

24. An item costs \$80 after a 20% price reduction. What was its original price? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

A. 0.0907 balance

B. 0.0799 balance

C. 0.1049 balance

D. 0.0713 balance

25. A replacement reduces annual operating cost from \$48,000 to \$33,000. What is the annual savings? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

A. 0.0012 balance

B. 0.0013 balance

C. 0.0016 balance

D. 0.0010 balance

26. A fair coin is tossed 4 times. What is the probability of exactly 2 heads? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.4875 balance
- B. 0.4734 balance
- C. 0.4170 balance
- D. 0.3967 balance

27. A distribution has values 4, 7, 9, and 12. What is the arithmetic mean? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.2934 balance
- B. 0.3512 balance
- C. 0.2706 balance
- D. 0.3200 balance

28. A normal observation is 70 with mean 58 and standard deviation 6. What is its z-score? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.5000 balance
- B. 0.4800 balance
- C. 0.3750 balance
- D. 0.4898 balance

29. Independent events have probabilities 0.30 and 0.40. What is the probability both occur? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.2990 balance
- B. 0.2545 balance
- C. 0.0458 balance
- D. 0.4182 balance

30. A defect rate is 0.02. In 200 independent items, what is the expected number defective? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4082 balance
- B. 0.4444 balance
- C. 0.3550 balance
- D. 0.4688 balance

31. For data 2, 5, 8, 11, what is the population variance? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.1332 balance
- B. 0.1714 balance
- C. 0.1198 balance
- D. 0.1499 balance

32. A sample mean is 40, population σ is 8, and $n=64$. What is the standard error? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.5000 balance
- B. 0.4444 balance
- C. 0.0000 balance
- D. 0.4800 balance

33. A regression model is $y=12+3x$. What value is predicted when $x=7$? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.1528 balance
- B. 0.1358 balance
- C. 0.1746 balance
- D. 0.1222 balance

34. How many distinct pairs can be selected from 10 items? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.1607 balance
- B. 0.2045 balance
- C. 0.1800 balance
- D. 0.1451 balance

35. Events A and B are mutually exclusive with probabilities 0.25 and 0.35. What is $P(A \text{ or } B)$? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.2378 balance
- B. 0.0740 balance
- C. 0.3275 balance
- D. 0.1068 balance

36. A process mean is estimated from four sample means: 19, 21, 20, and 24. What is the grand mean? Using reference 1, compute harmonic balance $= 2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0764 balance
- B. 0.1005 balance
- C. 0.0868 balance
- D. 0.0682 balance

37. A linear objective is $Z=8x+5y$. What is Z at $x=6$ and $y=4$? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0555 balance
- B. 0.0486 balance
- C. 0.0647 balance

D. 0.0433 balance

38. A single-server system has arrival rate 6 per hour and service rate 10 per hour. What is utilization? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

A. 0.4537 balance

B. 0.2778 balance

C. 0.2076 balance

D. 0.4974 balance

39. A payoff is \$100 with probability 0.7 and \$20 with probability 0.3. What is expected payoff? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

A. 0.1024 balance

B. 0.1334 balance

C. 0.1158 balance

D. 0.0917 balance

40. A simulation uses $u=0.64$ with exponential mean 5. Using $x=-5 \ln(1-u)$, what variate results? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

A. 0.3976 balance

B. 0.4476 balance

C. 0.4708 balance

D. 0.4128 balance

41. For constraint $3x+2y \leq 30$, how much slack exists at $x=4$ and $y=6$? Using reference 1, compute harmonic balance $=2mr/(m+r)^2$, where m is raw magnitude. What score results?

A. 0.2449 balance

- B. 0.2188 balance
- C. 0.2778 balance
- D. 0.1975 balance

42. A Markov state has outgoing probabilities 0.55, 0.25, and p . What is p ? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.4687 balance
- B. 0.4082 balance
- C. 0.4989 balance
- D. 0.1653 balance

43. A database query returns 240 rows from 1,200 records. What percentage is returned? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.2041 balance
- B. 0.2268 balance
- C. 0.2550 balance
- D. 0.1855 balance

44. An algorithm performs 12 comparisons for each of 75 records. How many comparisons occur? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.0110 balance
- B. 0.0096 balance
- C. 0.0129 balance
- D. 0.0085 balance

45. A weighted score uses weights 0.4, 0.35, 0.25 and ratings 80, 70, 90. What is the score? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.1787 balance
- B. 0.2256 balance
- C. 0.1617 balance
- D. 0.1995 balance

46. A model predicts 105 and the observed value is 98. What is the absolute error? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.1966 balance
- B. 0.2464 balance
- C. 0.2188 balance
- D. 0.1784 balance

47. A project path contains activities of 3, 7, 4, and 6 days. What is the path duration? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.1472 balance
- B. 0.1884 balance
- C. 0.1653 balance
- D. 0.1327 balance

48. Planned value is \$80,000 and earned value is \$72,000. What is schedule variance? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.0007 balance
- B. 0.0009 balance
- C. 0.1007 balance
- D. 0.0011 balance

49. Earned value is \$90,000 and actual cost is \$100,000. What is cost performance index? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.3991 balance
- B. 0.0384 balance
- C. 0.4647 balance
- D. 0.2585 balance

50. A team produces 360 units in 45 labor-hours. What is labor productivity? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4991 balance
- B. 0.4938 balance
- C. 0.4819 balance
- D. 0.4998 balance

51. PERT estimates are optimistic 4, most likely 7, and pessimistic 16 days. What is expected duration? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.1769 balance
- B. 0.1975 balance
- C. 0.2235 balance
- D. 0.1600 balance

52. A project has budget at completion \$250,000 and CPI 0.80. What is the basic estimate at completion? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0500 balance
- B. 0.1000 balance
- C. 0.0000 balance
- D. 0.1500 balance

53. A decision yields \$60,000 with probability 0.6 and loses \$10,000 with probability 0.4. What is expected value? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.0002 balance
- B. 0.0502 balance
- C. 0.1002 balance
- D. 0.0001 balance

54. A department completes 950 conforming orders from 1,000 total. What is its conformance KPI? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.0837 balance
- B. 0.1098 balance
- C. 0.0748 balance
- D. 0.0950 balance

55. A task has latest start day 18 and earliest start day 14. What is total slack? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4444 balance
- B. 0.3550 balance
- C. 0.4688 balance
- D. 0.4082 balance

56. A line makes 480 units during an 8-hour shift. What is average throughput? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0282 balance
- B. 0.0377 balance
- C. 0.0322 balance
- D. 0.0250 balance

57. A station has 45 minutes of work content and a 9-minute cycle time. What is the theoretical minimum number of stations? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.4082 balance
- B. 0.3750 balance
- C. 0.4444 balance
- D. 0.3457 balance

58. Demand is 1,600 units/year, order cost is \$25, and holding cost is \$2/unit-year. What is EOQ? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.0254 balance
- B. 0.0291 balance
- C. 0.0341 balance
- D. 0.0226 balance

59. Forecasts use $\alpha=0.30$, prior forecast 100, and actual demand 120. What is the new exponential-smoothing forecast? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.0757 balance
- B. 0.0996 balance
- C. 0.0860 balance
- D. 0.0676 balance

60. What is the three-period moving average of demands 90, 105, and 120? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.1413 balance
- B. 0.1812 balance

- C. 0.1272 balance
- D. 0.1588 balance

61. A machine operates 420 minutes of a planned 480 minutes. What is availability? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0195 balance
- B. 0.0223 balance
- C. 0.0262 balance
- D. 0.0173 balance

62. A process has availability 0.90, performance 0.95, and quality 0.98. What is OEE? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0455 balance
- B. 0.0398 balance
- C. 0.0531 balance
- D. 0.0354 balance

63. A batch of 500 pieces includes 15 defective pieces. What is first-pass yield? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.0510 balance
- B. 0.0678 balance
- C. 0.0582 balance
- D. 0.0454 balance

64. Setup is reduced from 50 minutes to 35 minutes. What is the reduction percentage? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.2449 balance
- B. 0.2211 balance
- C. 0.2741 balance
- D. 0.2014 balance

65. A bottleneck produces one unit every 6 minutes. What is its hourly capacity? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4976 balance
- B. 0.5000 balance
- C. 0.4967 balance
- D. 0.4915 balance

66. A department moves 30 loads over 12 m. What is its load-distance contribution? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0048 balance
- B. 0.0065 balance
- C. 0.0043 balance
- D. 0.0055 balance

67. Demand is 240 units/day and one machine makes 60 units/day. Ignoring downtime, how many machines are required? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.4082 balance
- B. 0.4800 balance
- C. 0.3750 balance
- D. 0.4444 balance

68. Average demand is 50 units/day and lead time is 6 days. With no safety stock, what is reorder point? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.0171 balance
- B. 0.0230 balance
- C. 0.0196 balance
- D. 0.0152 balance

69. A warehouse ships 1,800 lines in 30 labor-hours. What is picking productivity? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.1260 balance
- B. 0.1420 balance
- C. 0.1626 balance
- D. 0.1132 balance

70. Annual demand is 12,000 units and average inventory is 1,500 units. What is inventory turnover? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4938 balance
- B. 0.4991 balance
- C. 0.4819 balance
- D. 0.4998 balance

71. Three candidate location coordinates have equal weights: (2,4), (8,7), and (5,10). What is the x-coordinate of the center of gravity? Using reference 1, compute harmonic balance $=2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.2449 balance
- B. 0.2778 balance
- C. 0.3200 balance
- D. 0.2188 balance

72. A truck carries 18 pallets per trip. How many pallets are moved in 14 full trips? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0136 balance
- B. 0.0183 balance
- C. 0.0121 balance
- D. 0.0156 balance

73. Supplier lead times are 4, 6, 5, and 9 days. What is the average lead time? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.4200 balance
- B. 0.4688 balance
- C. 0.4444 balance
- D. 0.3967 balance

74. A facility uses 72,000 ft² of its 90,000 ft² available area. What is space utilization? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.1107 balance
- B. 0.0978 balance
- C. 0.1276 balance
- D. 0.0875 balance

75. A shipment of 2,400 kg is split equally among 6 destinations. What mass goes to each? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.0416 balance
- B. 0.0476 balance
- C. 0.0555 balance

D. 0.0370 balance

76. A task cycle is 50 seconds, including 8 seconds of unavoidable delay. What percentage is delay? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

A. 0.1107 balance

B. 0.0978 balance

C. 0.1276 balance

D. 0.0875 balance

77. A display has 96 correct readings in 120 trials. What is reading accuracy? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

A. 0.0416 balance

B. 0.0555 balance

C. 0.0370 balance

D. 0.0476 balance

78. A worker exerts 180 N at a perpendicular moment arm of 0.40 m. What joint moment results? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

A. 0.0675 balance

B. 0.0891 balance

C. 0.0768 balance

D. 0.0602 balance

79. A population measurement has mean 170 cm and standard deviation 8 cm. What value is two standard deviations above the mean? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.0446 balance
- B. 0.0594 balance
- C. 0.0510 balance
- D. 0.0397 balance

80. An operator reacts in 0.75 s while a conveyor moves 1.6 m/s. How far does the belt travel? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.1913 balance
- B. 0.2956 balance
- C. 0.0384 balance
- D. 0.3673 balance

81. A workstation redesign reduces reaches from 250 to 175 per shift. What is the reduction percentage? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0548 balance
- B. 0.0624 balance
- C. 0.0726 balance
- D. 0.0488 balance

82. A safety program records 6 incidents over 300,000 exposure-hours. What is the rate per 200,000 hours? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.4082 balance
- B. 0.4800 balance
- C. 0.3750 balance
- D. 0.4444 balance

83. A control requires 18 N force and has a 0.06 m lever arm. What operating torque is required? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.4836 balance
- B. 0.3893 balance
- C. 0.0506 balance
- D. 0.4999 balance

84. A team completes 45 safe observations out of 50 observations. What percentage is safe? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.0879 balance
- B. 0.1152 balance
- C. 0.0997 balance
- D. 0.0786 balance

85. Observed task time is 8.0 minutes and performance rating is 110%. What is normal time? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.5000 balance
- B. 0.4896 balance
- C. 0.4977 balance
- D. 0.4980 balance

86. Normal time is 12 minutes and allowance is 20% of normal time. What is standard time? Using reference 1, compute harmonic balance $=2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.1214 balance
- B. 0.1074 balance
- C. 0.1396 balance
- D. 0.0963 balance

87. Work sampling finds 315 working observations among 420 observations. What is utilization? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0443 balance
- B. 0.0590 balance
- C. 0.0394 balance
- D. 0.0506 balance

88. A task takes 20 minutes initially. Under an 80% learning curve, what is the average time per unit after output doubles once? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.2411 balance
- B. 0.2961 balance
- C. 0.2659 balance
- D. 0.2203 balance

89. A five-step method has times 1.2, 0.8, 2.1, 1.4, and 0.5 minutes. What is cycle time? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.4861 balance
- B. 0.4959 balance
- C. 0.5000 balance
- D. 0.4734 balance

90. A worker produces 72 units during 6 productive hours. What is observed production rate? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.4959 balance
- B. 0.4873 balance
- C. 0.5000 balance
- D. 0.4761 balance

91. A standard permits 9 minutes per unit. How many units fit in 450 available minutes? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0384 balance
- B. 0.0336 balance
- C. 0.0449 balance
- D. 0.0298 balance

92. A method improvement reduces cycle time from 15 minutes to 12 minutes. What is the improvement percentage? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.1472 balance
- B. 0.1653 balance
- C. 0.1884 balance
- D. 0.1327 balance

93. Specification limits are 52 and 40, and process $\sigma=2$. What is C_p ? Transform the raw answer with $2|x|/(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.4800 balance
- B. 0.0000 balance
- C. 0.5000 balance
- D. 0.3750 balance

94. $USL=110$, $mean=100$, and $\sigma=4$. What is the upper capability component? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.1949 balance
- B. 0.3926 balance
- C. 0.2449 balance
- D. 0.0624 balance

95. A p-chart has $\bar{p}=0.04$ and $n=400$. What is the three-sigma upper control limit? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.0137 balance
- B. 0.0637 balance
- C. 0.1746 balance
- D. 0.1558 balance

96. A sample has defect counts 3, 5, 4, and 8. What is the average count? Using reference 1, compute harmonic balance $=2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.2449 balance
- B. 0.3200 balance
- C. 0.2188 balance
- D. 0.2778 balance

97. A Taguchi loss constant is 4 and deviation from target is 3. What is the quality loss? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.0879 balance
- B. 0.0997 balance
- C. 0.1152 balance
- D. 0.0786 balance

98. A process yields 970 conforming units out of 1,000. What is percent defective? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.4898 balance
- B. 0.4800 balance
- C. 0.5000 balance
- D. 0.4688 balance

99. The center line is 25 and the average range is 4. Using $A_2=0.58$, what is the $\bar{X}$ -bar upper control limit? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.2615 balance
- B. 0.2369 balance
- C. 0.2916 balance
- D. 0.2164 balance

100. A lot has 12 defects in 600 opportunities. What is defects per million opportunities? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.0009 balance
- B. 0.0012 balance
- C. 0.0010 balance
- D. 0.0008 balance

101. A process improves yield from 88% to 94%. What is the percentage-point increase? Using reference 1, compute harmonic balance $=2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.2188 balance
- B. 0.2449 balance
- C. 0.2778 balance
- D. 0.1975 balance

102. Two independent series components have reliabilities 0.95 and 0.90. What is system reliability? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.4993 balance
- B. 0.1261 balance
- C. 0.4845 balance
- D. 0.4196 balance

103. Two independent parallel components each have reliability 0.80. What is system reliability? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.4780 balance
- B. 0.0260 balance
- C. 0.3673 balance
- D. 0.5000 balance

104. A repairable system has MTBF 900 h and MTTR 100 h. What is inherent availability? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.3991 balance
- B. 0.0384 balance
- C. 0.4647 balance
- D. 0.2585 balance

105. An FMEA item has severity 8, occurrence 5, and detection 4. What is its RPN? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.1107 balance
- B. 0.0978 balance

- C. 0.1276 balance
- D. 0.0875 balance

106. A system operates 1,920 h and is down 80 h. What is observed availability? Using reference 1, compute harmonic balance= $2mr/(m+r)^2$, where m is raw magnitude. What score results?

- A. 0.0178 balance
- B. 0.0204 balance
- C. 0.0239 balance
- D. 0.0158 balance

107. Three series elements each have reliability 0.98. What is total reliability? A balance index equals twice magnitude times reference divided by their squared sum. Use reference 2. What index is obtained?

- A. 0.3852 balance
- B. 0.4999 balance
- C. 0.0555 balance
- D. 0.4352 balance

108. A requirement set contains 240 requirements, of which 228 pass verification. What is verification completion? Transform the raw answer with $2|x|(3)/(|x|+3)^2$. What dimensionless balance score is reported?

- A. 0.0520 balance
- B. 0.0691 balance
- C. 0.0594 balance
- D. 0.0463 balance

109. A component accumulates 12 failures over 6,000 operating hours. What is failure rate per 1,000 hours? The reporting metric is $2mr/(m+r)^2$, with $r=5$. What bounded metric results?

- A. 0.4688 balance
- B. 0.4082 balance
- C. 0.2778 balance
- D. 0.4938 balance

110. A life-cycle alternative costs \$120,000 initially and \$18,000 annually for 5 years, ignoring discounting. What is total life-cycle cost? For reference 10, calculate twice the magnitude-reference product divided by the square of their sum. What value results?

- A. 0.0001 balance
- B. 0.0501 balance
- C. 0.1001 balance
- D. 0.1501 balance

Practice Exam 12: Answer Key and Explanations

1. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0156. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

2. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.1049. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

3. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.1975. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

4. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.2449. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

5. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance

score is 0.4800. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

6. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0500. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

7. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0598. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

8. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.5000. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

9. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.1107. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

10. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.2778. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

11. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.2778. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

12. D — D is correct. A wrong load combination can invalidate the reported margin, requiring correction and review of all affected conclusions before issuance. The distractors ignore incorrect inputs, overstate conclusions from missing data, permit an inaccurate record, or compare incompatible evidence. Applying competence, qualification, documentation, and consistency identifies the response that preserves a technical basis and supports informed decisions.

13. C — C is correct. Missing essential data limits confidence, so any interim assessment must identify assumptions and remain explicitly preliminary. The distractors ignore incorrect inputs, overstate conclusions from missing data, permit an inaccurate record, or compare incompatible evidence. Applying competence, qualification, documentation, and consistency identifies the response that preserves a technical basis and supports informed decisions.

14. A — A is correct. A material misstatement should be corrected promptly so the project record accurately reflects the technical advice provided. The distractors ignore incorrect inputs, overstate conclusions from missing data, permit an inaccurate record, or compare incompatible evidence. Applying competence, qualification, documentation, and consistency identifies the response that preserves a technical basis and supports informed decisions.

15. C — C is correct. Different methods can produce noncomparable results, requiring consistency or transparent explanation before drawing conclusions. The distractors ignore incorrect inputs, overstate conclusions from missing data, permit an inaccurate record, or compare incompatible evidence. Applying competence, qualification, documentation, and consistency identifies the response that preserves a technical basis and supports informed decisions.

16. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0003. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

17. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0005. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

18. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.0030. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

19. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0008. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

20. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.4444. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

21. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.3750. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

22. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance

score is 0.1372. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

23. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.4339. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

24. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0907. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

25. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.0013. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

26. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.3967. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

27. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.3200. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

28. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.4800. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

29. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0458. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

30. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.4082. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

31. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance

score is 0.1499. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

32. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.4444. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

33. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.1528. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

34. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.1800. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

35. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.1068. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

36. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0868. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

37. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0555. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

38. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.2778. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

39. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.1158. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

40. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance

score is 0.4476. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

41. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.2449. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

42. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.1653. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

43. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.2268. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

44. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0110. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

45. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.1995. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

46. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.2188. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

47. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.1653. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

48. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.0007. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

49. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance

score is 0.2585. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

50. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.4938. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

51. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.1975. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

52. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0000. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

53. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.0002. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

54. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0950. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

55. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.4082. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

56. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0322. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

57. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.4082. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

58. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance

score is 0.0291. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

59. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0860. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

60. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.1588. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

61. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0223. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

62. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0455. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

63. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.0582. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

64. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.2449. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

65. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.5000. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

66. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0055. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

67. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance

score is 0.4444. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

68. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.0196. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

69. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.1420. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

70. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.4938. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

71. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.2778. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

72. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0156. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

73. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.4444. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

74. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.1107. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

75. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.0476. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

76. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance

score is 0.1107. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

77. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0476. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

78. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.0768. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

79. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0510. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

80. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.1913. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

81. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0624. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

82. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.4444. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

83. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.3893. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

84. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.0997. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

85. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance

score is 0.4980. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

86. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.1214. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

87. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0506. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

88. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.2659. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

89. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.4959. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

90. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.4959. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

91. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0384. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

92. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.1653. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

93. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.3750. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

94. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance

score is 0.2449. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

95. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.0137. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

96. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.2778. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

97. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.0997. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

98. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.5000. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

99. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.2615. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

100. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.0010. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

101. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.2449. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

102. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.4196. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

103. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance

score is 0.3673. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

104. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.2585. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

105. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.1107. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

106. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 1, then divide by the square of their sum. The normalized harmonic-balance score is 0.0204. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

107. D — D is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 2, then divide by the square of their sum. The normalized harmonic-balance score is 0.4352. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

108. C — C is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 3, then divide by the square of their sum. The normalized harmonic-balance score is 0.0594. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

109. B — B is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 5, then divide by the square of their sum. The normalized harmonic-balance score is 0.4082. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.

110. A — A is correct. Compute the raw engineering answer and use its magnitude. Multiply twice the magnitude by reference 10, then divide by the square of their sum. The normalized harmonic-balance score is 0.0001. The distractors result from using an incorrect raw answer, omitting the factor two, failing to square, or reversing formula terms.