1. One role of a metrologist is to:
   a. Develop the quality manual
   b. Calibrate inspection instruments
   c. Create the inspection report
   d. Make accept or reject decisions

2. One role of an inspector is to:
   a. Create the measurement plan
   b. Develop the quality manual
   c. Implement the measurement plan
   d. Determine what relationships to measure

3. In this course, the definition for the term "quality" involves:
   a. Having near nominal precision
   b. Conformance to specifications
   c. Being of superior characteristics
   d. Having a high capability index - CpK

4. Inspection is important because it ensures that:
   a. Engineering designs are complete
   b. Correct processes are in place
   c. Customers are satisfied
   d. None of the above

5. Which is not a part of a quality manual?
   a. Defining the responsibility of each department
   b. Defining training and qualification requirements of inspectors
   c. Defining sample sizes and frequency of inspections
   d. Defining the means of distribution

6. Metrology is:
   a. The study of a part's dimensional variations
   b. The process of implementing the measurement plan
   c. The science of measurement and its application
   d. The practice of using judgment to determine if parts pass or fail

7. Inspection is:
   a. The practice of providing oversight for manufacturing process variations over time
   b. The process of creating the measurement plan and determining measurement uncertainty
   c. The practical aspects of measurement and uncertainty as directed by the quality manual
   d. The process of measuring or otherwise comparing part characteristics to drawing specifications

8. The four types of inspection are final, process, receiving, and:
   a. Partial
   b. Preliminary
   c. Secondary
   d. Batch

9. The purpose of a quality manual is to define responsibilities and authorities for:
   a. The plant
   b. Inspectors
   c. The quality system
   d. Inspection

10. An inspector:
   a. Conducts tests
   b. Calibrates equipment
   c. Creates measurement plans
   d. None of the above

1. The smallest change in a quantity being measured that causes a perceptible change in the corresponding indication is called:
   a. Accuracy of an instrument
   b. Precision of an instrument
   c. Resolution of an instrument
   d. None of the above

2. Where measurement uncertainty is estimated using statistical methods, it is referred to as:
   a. Type A
   b. Type B
   c. Expanded
   d. Combined

3. What does measurement uncertainty mean?
   a. Doubt about how to measure
   b. Doubt about the measurement result
   c. Doubt about where to measure
   d. None of the above

4. Understanding the amount of uncertainty is important because it allows:
   a. Guard bands to be optimized
   b. Inspectors to do a better job
   c. More good parts to pass inspection
   d. None of the above

5. What is the definition of "measurand"?
   a. The result of a measurement
   b. Parameter of a measurement
   c. A quantity intended to be measured
   d. None of the above

6. Common contributors to measurement uncertainty are the operator, the drawing specification, and:
   a. Part
   b. The drawing creator
   c. Calculation errors made by the inspector
   d. None of the above

7. Physical differences contribute to which measurement uncertainty category?
   a. Environment
   b. Measurement setup
   c. Measurement equipment
   d. Operator

8. What is a decision rule?
   a. A documented rule describing how uncertainty is allocated in measurements
   b. A documented policy describing when deviations are appropriate
   c. A policy to guide inspectors in documenting measured values
   d. None of the above

9. The choice of a decision rule is based on:
   a. The ability to rework nonconforming parts
   b. Measurement equipment resolution
   c. Management acceptance of missed quotas
   d. Cost of rejecting in tolerance parts vs. cost of acceptance out-of-tolerance parts

10. A guard band contains:
    a. The uncertainty of the measurement
    b. The allowable tolerance
    c. A safety factor
    d. None of the above

11. What is a simple rejection?
    a. The rejection zone consists of all values inside the guard band
    b. Measurements inside this zone are rejected even if they are inside the specification
    c. The rejection zone consists of all values outside of the specification zone
    d. None of the above

12. The location and decision outcome of any _____ must be documented in the decision rule.
    a. Relaxed acceptance zone
    b. Relaxed rejection zone
    c. Transition zone
    d. None of the above

13. The resolution of the measurement equipment is important for:
    a. Calculating uncertainty
    b. Establishing gage R& R values
    c. Selecting the decision rule
    d. None of the above

14. T F Simple rejection means any measurement result that lies outside of the specification zone may be rejected.

15. T F Relaxed acceptance with stringent rejection is one of the four decision rules.

16. T F A decision rule must document the location of the acceptance, rejection, and transition zones.

17. T F Using the stringent acceptance rule lowers manufacturing cost.

18. T F A decision rule must include a decision for any measurement result that lies within the transition zone.

1. The three categories of inspection tools are:
   a. GO/NOGO, functional, and feeler
   b. Attribute, variables, and algorithmic
   c. Touch, non-contact scanning, and vision
   d. None of the above

2. Which type of measurement provides a measured value directly from the inspection tool?
   a. Attribute
   b. Functional
   c. Algorithmic
   d. None of the above

3. Which inspection tool is commonly used to make an attribute measurement?
   a. Laser tracker
   b. Calipers
   c. Air gage
   d. Plug gage

4. A variable measurement may be affected by:
   a. Class of tolerance
   b. Tolerance accumulation
   c. Fixture loads
   d. Excessive play

5. A digital micrometer is typically considered to be what type of inspection tool?
   a. Attribute
   b. Variables
   c. Algorithmic
   d. None of the above

6. A "least squares" algorithm is commonly used with:
   a. A CMM
   b. A digital height gage
   c. An optical comparator
   d. None of the above

7. A basic operating principle of an attribute gage is that the gage should:
   a. Go into or over the part feature without excessive force
   b. Be made of the same material as the part
   c. Never reject a good part
   d. None of the above

8. What is a basic principle of algorithmic type inspection tools?
   a. They are faster than attribute or variable measurement tools
   b. They require the part to be clamped to the table for inspection
   c. They collect a set of data points
   d. None of the above

9. What is a basic principle of variable measurement type inspection tools?
   a. They require a skilled operator to align or orient the measurement device to the workpiece correctly
   b. They are used to collect a set of data points for use in an algorithm
   c. They are not affected by Abbe error, backlash, or friction
   d. None of the above

10. An optical comparator is commonly considered to be what type of inspection tool?
    a. Algorithmic
    b. Attribute
    c. Variable measurement
    (d.) Both B and C

11. (T) F A ring gage is a type of attribute inspection tool.

12. T (F) Attribute data includes a value of the measurement.

13. (T) F The tolerance policy used for a functional gage should be stated in the measurement plan.

14. T (F) An algorithmic measurement device costs less than a variable measurement device.

15. (T) F An optical comparator is often used as an attribute measurement device.

1. Which Y14.5 concept supports the use of an attribute gage?
   a. Bonus tolerance
   b. RMB
   c. Position tolerance
   d. None of the above

2. How is a round hole of a workpiece simulated in a functional gage?
   a. With a conical-shaped pin
   b. With a diamond-shaped pin
   c. With a set of two opposed points
   d. With a full-form cylindrical pin

3. An attribute gage cannot be used to verify which geometric attributes?
   a. Rule #1 boundary
   b. Location of a feature of size
   c. Orientation of a feature
   d. None of the above

4. Which gage tolerancing policy accepts a few bad parts but rejects no good parts?
   a. Absolute tolerancing policy
   b. Optimistic tolerancing policy
   c. Tolerant tolerancing policy
   d. None of the above

5. Using the absolute tolerancing policy on a functional gage, the gage tolerances are:
   a. Subtracted from the specification limits
   b. Added to the specification limits
   c. Added and subtracted from the specification limits
   d. None of the above

6. The Y14.43 recommended tolerance for an attribute gage is:
   a. 10% gage tolerance and 10% wear allowance
   b. 10% gage tolerance and 5% wear allowance
   c. 5% gage tolerance and 5% wear allowance
   d. None of the above

7. When using the tolerant gage tolerancing policy, a functional gage will…
   a. Rejected all noncompliant parts
   b. Accepted all compliant parts
   c. Accept some noncompliant and reject some compliant parts
   d. None of the above

8. The optimistic gage tolerancing policy places the gage tolerance _____ the specification limits.
   a. All outside
   b. All inside
   c. Half inside and half outside
   d. None of the above

9. Which gage tolerancing policy is most likely to accept out-of-spec features?
   a. Absolute
   b. Optimistic
   c. Tolerant
   d. Depends upon the class of gage tolerance

10. How much tolerance does a 50mm class 'X' gage pin get?
    a. 0.0019
    b. 0.0023
    c. 0.0050
    d. None of the above

11. What is one result of using a class "Z" gage tolerance?
    a. Rejection of good parts decreases
    b. Rejection of good parts increases
    c. Gage cost increases
    d. None of the above

12. A gage with a class X tolerance should be used to verify a workpiece feature with:
    a. Class H11 tolerance
    b. Class H9 tolerance
    c. Class H8 tolerance
    d. Class H7 tolerance

1. While a GO gage uses less than 10% of the design tolerance, a functional gage may actually use:
   a. Up to 20%
   b. Up to 30%
   c. Up to 40%
   d. Up to 50%

2. Which are design constraints of a functional gage?
   a. The size and weight of the functional gage
   b. The resolution of the indicator
   c. A functional gage is only suitable for in-process inspection
   d. None of the above

3. An in-process gage is a gage:
   a. Used by manufacturing personnel to inspect the process
   b. Used in a non-hostile environment
   c. That has a gage tolerance more precise than a final inspection gage
   d. Made by the manufacturing process

4. When is it acceptable to depart from the two opposed points LMC gaging principle with an attribute type gage?
   a. On most attribute gages, flats may be used to avoid excessive wear
   b. On very large holes
   c. On large shaft diameters
   d. None of the above

5. How does a datum feature referenced at RMB affect the gage design?
   a. The datum feature simulator must be adjustable
   b. The part cannot be displaced on the gage
   c. The inspector can optimize the part position on the gage
   d. Both A and B

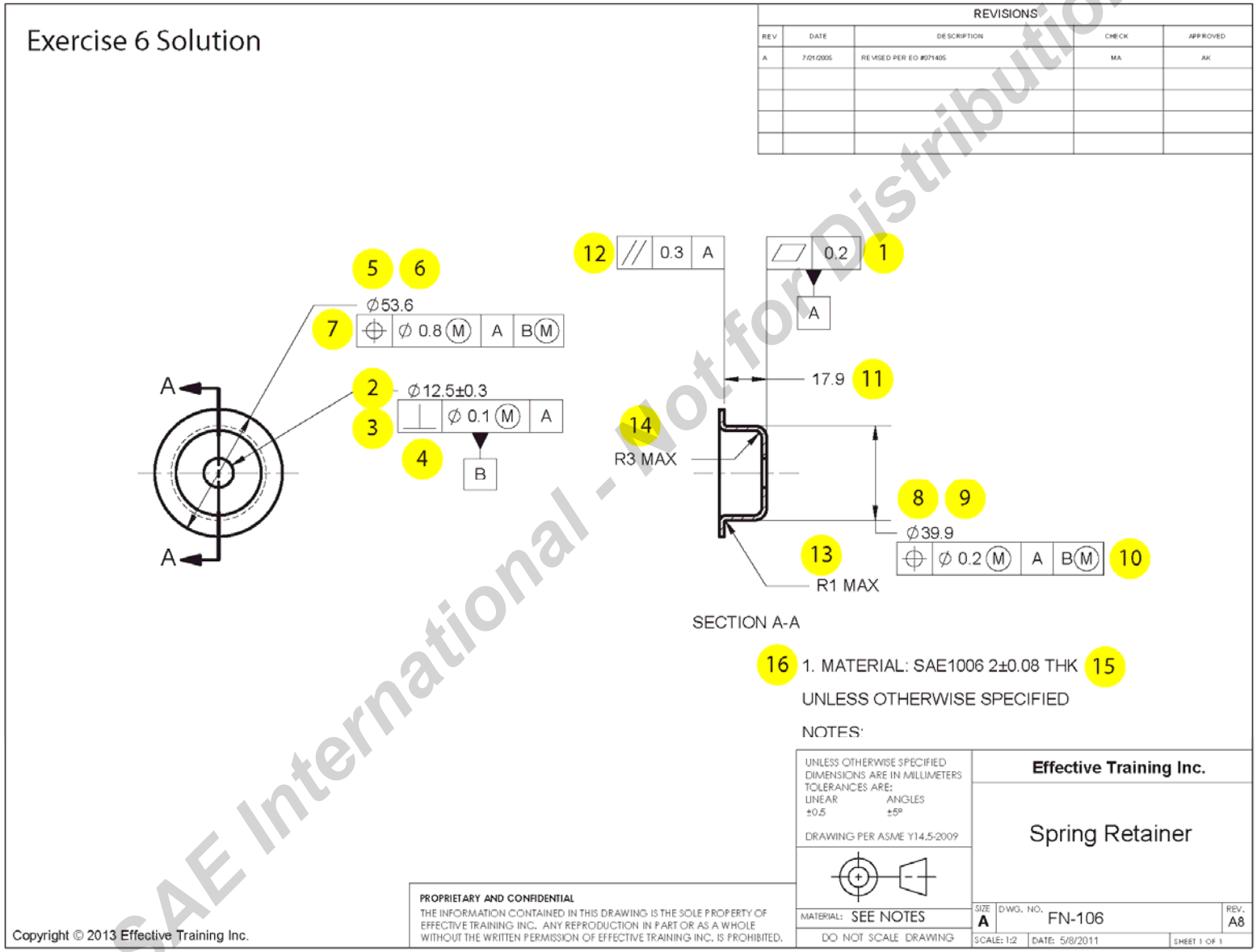
6. Unless otherwise specified, workpieces are to be inspected:
   a. In the restrained state, where necessary to make repeatable measurements
   b. Only restrained against the datum features
   c. In the same orientation as they'll be in the final assembly
   d. Without any force at all (free state)

7. Why is a referee gage necessary?
   a. Because inspectors may make errors when using unfamiliar gages
   b. To mediate acceptance disputes from other gages
   c. Because of the uncertainty in measurement
   d. To calibrate the production gage

8. When is it permissible to depart from full-form, full-length MMC gage principles?
   a. When gaging an extremely long (deep) hole
   b. When gaging an extremely small diameter
   c. When gaging a flexible (non-rigid) part
   d. None of the above

9. Using a 10% gage tolerance and absolute gaging policy, what size would the GO gage pin be for a 12.3-12.7 diameter hole?
   a. 12.30 – 12.34 dia.
   b. 12.28 – 13.32 dia.
   c. 12.26 – 12.30 dia.
   d. None of the above

10. Using a 10% gage tolerance and the optimistic gaging policy, what size would the GO-ring gage be for a 54.2-54.7 diameter shaft?
    a. 54.675 – 54.725 dia.
    b. 54.65 – 54.70 dia.
    c. 54.75 – 54.80 dia.
    d. None of the above



Dimensional Measurement Plan

Dimensional Measurement Plan Information			Page 1 of 2
[ ] Prototype [X] First Article [ ] Production Measurement Plan Number: **Exercise 6**	Key Contact/Phone:	Date (Orig.):	Date (Rev.):
Part Number/Latest Change Level: FN-106 Rev A	Core Team:	Customer Engineering Approval/Date (If Req'd):	
Part Name/Description: Spring retainer	Supplier/Plant Approval/Date:	Customer Quality Approval/Date (If Req'd):	
Supplier/Plant: Supplier Code:	Design Function Analysis #:	DFMEA#:	

Dimensional Information						Methods				Measurement Conditions	
Dim No.	Description	MFG Process	MFG C_PK	Special Char. Class	Specification/ Tolerance	Evaluation Measurement Method	Sample Size	Sample Freq.	Measurement Equipment	Acceptable Limits	Decision Rule/ Attribute Gage Tolerance Policy
1	Flatness on datum feature A	N/A	N/A	N/A	0.2 max	Use flatness gage (surface plate with dial indicator mounted in hole)	N/A	N/A	Flatness gage #XXXXX	0-0.2	Simple acceptance rule 5:1
2	Local size of hole	N/A	N/A	N/A	12.5 ±0.3	Measure two places 90° apart.	N/A	N/A	Digital calipers #XXXX	11.9-12.5	Simple acceptance rule 5:1
3	Rule #1 on hole	N/A	N/A	N/A	12.2	Use GO-plug gage	N/A	N/A	GO Gage #XXXXX	Pass	Absolute gaging policy
4	Perpendicularity to datum A	N/A	N/A	N/A	Ø12.1 VC	Use functional gage	N/A	N/A	Functional Gage (XXXX)	Pass	Absolute gaging policy
5	Local size of O.D.	N/A	N/A	N/A	53.6 ±0.5	Measure two places 90° apart	N/A	N/A	Digital calipers #XXXX	53.1-54.1	Simple acceptance rule 4:1
6	Rule #1 on O.D.	N/A	N/A	N/A	54.1	Use GO-ring gage	N/A	N/A	GO Gage #XXXXX	Pass	Absolute gaging policy
7	Position of O.D.	N/A	N/A	N/A	Ø54.9 VC	Use functional gage	N/A	N/A	Functional Gage (#XXXX)	Pass	Absolute gaging policy
8	Local size of tower diameter	N/A	N/A	N/A	39.9 ±0.5	Measure two places 90° apart.	N/A	N/A	Digital calipers #XXXX	39.4-40.4	Simple acceptance rule 5:1
9	Rule #1 on tower diameter	N/A	N/A	N/A	40.4	Use GO-ring gage	N/A	N/A	GO Gage #XXXXX	Pass	Absolute gaging policy
10	Position of tower diameter	N/A	N/A	N/A	Ø40.6 VC	Use functional gage	N/A	N/A	Functional Gage (#XXXX)	Pass	Absolute gaging policy
11	Step dimension	N/A	N/A	N/A	17.9 ±0.5	1. Rest flanged surface of part on surface plate. 2. Measure distance from top surface of flange to top surface of part in 4 places 90° apart.	N/A	N/A	Surface plate, height gage	17.4-18.4	Simple acceptance rule 5:1
12	Parallelism of flange	N/A	N/A	N/A	0.3 max	Check at least 18 points equally spaced	N/A	N/A	Surface plate Height gage (#xxxxx)	0.3 max	Simple acceptance rule 5:1

Dimensional Measurement Plan

Dimensional Measurement Plan Information				Page 2 of 2
[ ] Prototype [X] First Article [ ] Production Measurement Plan Number: **Exercise 6**	Key Contact/Phone:	Date (Orig.):	Date (Rev.):	
Part Number/Latest Change Level: FN-106 Rev A	Core Team:	Customer Engineering Approval/Date (If Req'd):		
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Supplier/Plant: / Supplier Code:	Design Function Analysis #:	DFMEA#:		

Dimensional Information						Methods				Measurement Conditions	
Dim No.	Description	MFG Process	MFG C_PK	Special Char. Class	Specification/ Tolerance	Evaluation Measurement Method	Sample Size	Sample Freq.	Measurement Equipment	Acceptable Limits	Decision Rule/ Attribute Gage Tolerance Policy
13	Flange to tower radius	N/A	N/A	N/A	R1 max	Use radius gage template	N/A	N/A	Radius gage #XXXX	0-1	Absolute gaging policy
14	Tower wall to bottom radius	N/A	N/A	N/A	R3 max	Use radius gage template	N/A	N/A	Radius gage #XXXX	0-3	Absolute gaging policy
15	Stock thickness	N/A	N/A	N/A	2 ±0.08	1. Measure flange 2 places 180° apart. 2. Measure side wall 2 places 180° apart. 3. Measure bottom wall 4 places 90° apart.	N/A	N/A	Digital calipers #XXXX Need to identify a tool for steps 2 & 3.	1.92-2.08	Simple acceptance rule 5:1
16	Material	N/A	N/A	N/A	SAE 1060	Verify material certification	N/A	N/A			

1. T (F) An inspection report establishes the plan for how to inspect the part.
2. (T) F One requirement of an inspection report is to correlate the measurements to the print dimensions.
3. T (F) On large complex drawings, numbering dimensions may be omitted to keep the drawing clear.
4. (T) F Where an attribute gage is used, the inspection report does not report numbers or magnitude.
5. T (F) A nonconformance report should be an internal document not shared with the customer.

6. The practice of numbering dimensions and tolerances for inspection aids in:
   (a.) Ensuring that all dimensions are identified for inspection
   b. Identifying the proper algorithm for inspection
   c. Choosing the best inspection tool
   d. Identifying tolerances that are overly restrictive

7. When numbering a size dimension that applies to a pattern of holes, the dimension is assigned a base number and:
   a. The base number applies to all of the holes
   (b.) Each hole in the pattern is assigned a sub-number
   c. Each hole in the pattern is assigned a different base number
   d. The holes in the pattern are not assigned any number

8. A nonconformance report documents the _____ for a workpiece that failed the gaging or had a measurement outside its tolerance specification.
   a. Gage R&R
   b. Measurement procedure used
   c. Corrective action
   d. Nonconformity costs

9. An inspection report may display the results of a measurement by using:
   a. Marks on the drawing
   b. Color coding
   c. A signed certificate of approval
   d. Special symbols

10. A standard format for inspection reports is:
   a. ASME Y14.5.1
   b. ASME Y14.43
   c. APQP
   d. AS9102A

1. Which algorithm is most accurate when inspecting the Rule #1 requirement of a hole?
   a. Least squares best fit cylinder
   b. Maximum inscribed cylinder
   c. Minimum circumscribed cylinder
   d. Minimum zone cylinder

2. Which method is most accurate when inspecting the Rule #1 requirement of a hole?
   a. A GO-snap gage
   b. A GO-ring gage
   c. A GO-plug gage
   d. A caliper

3. Which method or gage may be used to inspect the LMC size limit of a shaft diameter?
   a. A NOGO-snap gage
   b. A CMM using the minimum circumscribe algorithm
   c. A CMM using the least squares algorithm
   d. None of the above

4. When inspecting the Rule #1 requirement of a shaft diameter, what is reported?
   a. Pass or fail results of the diameter fitting a GO-ring gage
   b. Maximum measured actual local size
   c. Set of all measured actual local sizes
   d. None of the above

5. When inspecting the LMC size limit of a shaft diameter, what is reported?
   a. Maximum measured actual local size
   b. Set of all measured actual local sizes
   c. Minimum measured actual local size
   d. None of the above

6. When is Rule #1 not inspected?
   a. When inspecting a regular feature of size to which a position tolerance applies
   b. When inspecting a regular feature of size to which a perpendicularity tolerance applies
   c. When inspecting the thickness of 16 GA sheet metal
   d. None of the above

7. Which statement is true when using an attribute gage to inspect an actual local size?
   a. It requires two gages: one for the max size limit and one for the min size limit
   b. The gage should not be a full-length, full-form gage
   c. Both A & B
   d. None of the above

8. When using a CMM to inspect the size of a hole, which algorithm complies with the Y14.5 definition of an actual local size?
   a. Least squares best fit circle
   b. Minimum circumscribed circle
   c. Maximum inscribed circle
   d. None of the above

9. When inspecting an internal regular feature of size, what should be indicated on the inspection report?
   a. The pass or fail results for Rule #1
   b. The largest actual local size measurement
   c. Both A & B
   d. None of the above

10. When using a CMM to inspect Rule #1 on a shaft with an anticipated form error greater than 10% of size tolerance, what is the suggested minimum number of points needed?
    a. 20 equally spaced points on four equally spaced circular elements
    b. 28 equally spaced points on at least 4 equally spaced circular elements
    c. 80 equally spaced points on four equally spaced circular elements
    d. None of the above

1. (T) F A candidate datum set is the set of all possible datums established from a datum feature.

2. (T) F Any one of the qualified candidate datums may be used for inspection.

3. T (F) A datum plane is always established from the largest surface on the part.

4. (T) F Form variations on the datum features may cause a part with all planar datums to have more than one orientation in its datum reference frame.

5. (T) F If a part does not meet a requirement on one candidate datum, but does meet the requirement on another, the part is considered to have passed the requirement.

6. (T) F One way to reduce the effects a candidate datum set has on inspection is to specify a flatness tolerance on the primary datum feature.

7. (T) F Using the candidate datum set concept increases measurement uncertainty.

8. T (F) Specifying datum targets will eliminate the candidate datum set.

9. T (F) Using the candidate datum set will reduce the amount of parts that are accepted.

10. Which drawing indication communicates how the part is located and oriented in a gage or fixture during inspection?
    a. Datum reference sequence
    b. Coordinate linear and angular dimensions
    c. General (title block) tolerances
    d. None of the above

11. A primary datum plane is a plane established from _____ of the datum feature.
    a. The three highest points
    b. A least squares plane passing through all points
    c. The single highest point
    d. The two highest points

12. A primary datum must constrain a minimum of ___ degrees of freedom.
    a. 2
    b. 3
    c. 4
    d. 6

13. If a primary planar datum feature is concave, it:
    a. Will only have one candidate datum plane
    b. May have several candidate datum planes
    c. Cannot be used as a primary datum feature
    d. None of the above

14. One of the Y14.5 requirements for a datum feature is that it must be:
    a. Accessible
    b. An external feature
    c. Simulated in the restrained state for a flexible part
    d. None of the above

1. (T) F Using the proper probing strategies with CMM datum simulation reduces measurement uncertainty.
2. (T) F Failure to correctly simulate a datum reference frame may affect all geometric tolerances related to the datum reference frame.
3. T (F) A CMM operator should <u>always</u> probe the workpiece to simulate a datum reference frame.
4. T (F) A least squares cylinder should be used to establish a datum axis RMB.
5. T (F) Datum feature shift cannot be done when measuring with a CMM.

6. When simulating a primary datum plane with a CMM where the flatness of the surface is unknown, what is the suggested minimum number of points that should be taken?
   a. 3
   b. 9
   (c.) 20
   d. 500

7. When simulating a primary datum axis using a CMM where the form error of the diameter is unknown, what is the suggested minimum number of points that should be taken?
   a. 5
   b. 28
   c. 80
   d. 160

8. When simulating a datum axis (primary RMB) with a functional fixture, the candidate datum set concept:
   a. Does not apply
   b. Does apply
   c. Only applies if the part is non-rigid
   d. Only applies if the part not restrained

9. When using a CMM to simulate a primary datum axis (RMB) from a hole which algorithm should be used?
   a. Least squares best fit cylinder
   b. Minimum circumscribed cylinder
   c. Maximum inscribed cylinder
   d. None of the above

1. What is the Y14.5 requirement of flatness?
   a. That two planar surfaces are parallel
   b. That the surface is not wavy or convex
   c. The high and low points of a surface are limited by two parallel planes
   d. The high and low points of each line are limited by two parallel lines

2. When using a CMM to inspect flatness of a workpiece, what is the algorithm that best matches the Y14.5 requirement?
   a. Least squares
   b. Minimum tangent plane
   c. Minimum circumscribed
   d. Minimum zone

3. What is one limitation of variable measurement inspection of flatness?
   a. The part must be light enough for the inspector to manipulate
   b. Algorithmic measurement is far more accurate
   c. Open setup inspections of flatness are time consuming
   d. Only attribute data can be collected

4. What is one benefit of variable measurement inspection of flatness?
   a. The required equipment is relatively economical
   b. The inspection is unaffected by small amounts of dirt
   c. The resolution of the indicator has only a minimal effect on accuracy
   d. The tip size of the indicator has only a minimal effect on accuracy

5. When using a CMM to inspect flatness on a surface with a form error greater than 10%, what is the recommended minimum number of points?
   a. 9
   b. 25
   c. 80
   d. None of the above

6. When using the Ad Hoc probing strategy to distribute 80 points on a 20 x 60 mm surface, which grid pattern size should be used?
   a. 4 X 20
   b. 8 X 10
   c. 9 X 9
   d. None of the above

7. What is the Y14.5 requirement for a flatness tolerance at MMC applied to a planar feature of size?
   a. The derived median plane must fit within two parallel planes
   b. The two opposed surfaces must fit within a virtual condition boundary
   c. Both opposed surfaces must fit with two parallel planes
   d. None of the above

8. For a planar feature of size (width), its virtual condition may be simulated using:
   a. Two gage blocks spaced apart at the virtual condition distance
   b. A mylar overlay on an optical comparator
   c. Calipers set at the virtual condition size
   d. None of the above

9. In a traditional inspection report, how is the measurement result of a flatness tolerance applied to a surface reported?
   a. Pass / fail result of the part fitting a GO gage
   b. The value of the furthest point from a least squares plane
   c. The max measured deviation between the highest and lowest points on the surface
   d. None of the above

10. Which of these is an example of a computer-aided inspection report for a flatness tolerance applied to a surface?
   a. A CMM report showing the max measured deviation value
   b. A color-coded surface topography map
   c. A whisker plot
   d. None of the above

1. In Y14.5, a straightness tolerance applied to a surface requires that:
   a. All surface line elements are parallel
   b. The surface is not wavy or convex
   c. All points of a surface must be between two parallel planes
   d. All points of each line element must be between two parallel lines

2. What is one option for variable measurement of straightness of a line element?
   a. Set the part in a V-block, and run an indicator along the surface
   b. Use an optical comparator to measure the distance from a line tangent to the highest or lowest points of a line element to the furthest point from the tangent line
   c. Establish a least squares mid-line, and measure the distance between the furthest points on each side of that line
   d. None of the above

3. What are the two most common algorithms used when inspecting straightness of a line element on a CMM?
   a. Least squares and two-point measurement
   b. Least squares and maximum tangent plane
   c. Least squares and minimum zone
   d. Least squares and minimum tangent plane

4. What is a common inspection method for straightness at MMC applied to a feature of size?
   a. A CMM & least squares algorithm
   b. A GO Gage
   c. A CMM and minimum zone algorithm
   d. Surface plate and wire gage

5. Which symbol must be specified when a straightness tolerance is applied to a feature of size?
   a. Square symbol
   b. LMC symbol
   c. MMC symbol
   d. Diameter symbol

6. In a traditional inspection report for a straightness tolerance applied to a surface line element, which value is reported?
   a. The average of all measured straightness deviations of all line elements
   b. The distance between the single highest point and the lowest point
   c. The distance between a least squares line and furthest point
   d. The distance from a tangent line to the furthest point

7. (T) F According to Y14.5, acceptance limits are treated as absolute values.

8. (T) F Decision rules explain the difference between design tolerances and acceptance limits.

9. T (F) When inspecting straightness of a pin surface element, the indicator is moved radially along the surface.

10. T (F) When inspecting straightness of a surface element on a CMM, the line element must be set parallel to the surface plate.

1. How does a circularity tolerance limit the lobing of a diameter?
   a. By limiting all circular elements within one circular boundary
   b. By limiting all circular elements between two concentric circles
   c. By limiting all circular elements within one cylindrical boundary
   d. By limiting all line elements between two coaxial cylinders

2. Why is it important to conduct dimensional measurement planning for a circularity tolerance?
   a. There is no other way to indicate the filtering parameter
   b. There is no other way to indicate the applied algorithm
   c. There is no other way to indicate the stylus tip size
   d. There is no other way to indicate the number of surface points

3. Why can't a part be automatically rejected if its runout deviation is greater than its circularity tolerance using the circular runout method?
   a. Because of the roundness deviation of the centers and center holes
   b. Because of the straightness deviation of the part
   c. Because the runout measurement includes the eccentricity of the circular element to the axis of rotation
   d. Because of the misalignment of the centers on the gage

4. When inspecting circularity using a precision spindle machine, what is the algorithm that best matches the Y14.5 definition of the tolerance zone?
   a. Minimum radial separation
   b. Least squares circle
   c. Minimum circumscribed circle
   d. Maximum inscribed circle

5. When inspecting circularity of a 12mm diameter, what is the default UPR filtering?
   a. 15
   b. 30
   c. 50
   d. 100

6. What is one way to reduce specification uncertainty with circularity?
   a. Conduct design reviews that include manufacturing and quality personnel
   b. Use the complete circularity specification
   c. Conduct measurement planning for all parts
   d. Use established standards

7. When using an algorithmic measurement method to inspect cylindricity, how is the reference axis established?
   a. By locating the part on centers in a fixture
   b. By using a chuck, collect, or other centering device
   c. By using a minimum zone algorithm
   d. None of the above

8. What is one source of uncertainty unique to using the total runout method to inspect cylindricity?
   a. The number of data points
   b. The misalignment of the centers
   c. The surface roughness of the diameter
   d. The algorithm that is used

9. When using a CMM to inspect cylindricity, the applied algorithm:
   a. Should be specified as a complete cylindricity tolerance on the drawing
   b. Should be specified in the inspection or non-conformance report
   c. Should default to the algorithms defined in the ASME Y14.5 standard
   d. Should be documented in the dimensional measurement plan

10. When using algorithmic measurement method to inspect a cylindricity tolerance, the measurement result is affected by:
    a. The number of data points
    b. The applied algorithm
    c. The shape of the part (e.g., hour glass, barrel, waisting, etc.)
    d. All of the above

1. What is one Y14.5 requirement of an angular dimension?
   a. The high and low points of the surface must be within the tolerance zone
   b. Only the high points of the surface must be within the tolerance zone
   c. Only the low points of the surface must be within the tolerance zone
   d. A tangent plane of each line element must be within the tolerance zone

2. When verifying an angular dimension, which method/tool is Y14.5 compliant?
   a. A protractor
   b. Applying the least squares algorithm
   c. Applying the max tangent plane algorithm
   d. None of the above

3. What is one Y14.5 requirement of a perpendicularity tolerance applied to a surface?
   a. The tolerance zone must always be 90 degrees to the primary datum referenced
   b. Only the high points of the part surface must be within the tolerance zone
   c. Only the least squares plane of the part surface must be within the tolerance zone
   d. The orientation of the tolerance zone is established from the high points of the part surface

4. When using a dial indicator to inspect a perpendicularity tolerance applied to a surface, the part is placed on the datum plane and the dial indicator is:
   a. Moved vertically from the bottom to the top of the surface
   b. Moved across the full length and width of the surface
   c. Held stationary to check one point of the surface
   d. None of the above

5. What is one source of measurement uncertainty when using a dial indicator to inspect a perpendicularity tolerance applied to a surface?
   a. The shape of the tolerance zone
   b. Whether the tangent plane or least squares algorithm is used
   c. Probe tip size
   d. None of the above

6. When using CMM to inspect a perpendicularity tolerance applied to a surface, the CMM calculates:
   a. The distance between the highest and lowest points normal to a reference plane that is perpendicular to the datum plane
   b. The angular deviation of a least squares plane of the toleranced surface
   c. The angular deviation of a max or min tangent plane of the toleranced surface
   d. None of the above

7. What is one source of measurement uncertainty when using a CMM to inspect a perpendicularity tolerance applied to a surface of a rigid part?
   a. The shape of the tolerance zone
   b. The hardness of the part surface
   c. The form deviation of the datum feature (e.g., convex surface)
   d. None of the above

8. What is one Y14.5 requirement of a perpendicularity tolerance at MMC applied to a feature of size?
   a. It must be verified using variable-type measurement
   b. The surface(s) of the feature of size must not violate a virtual condition boundary
   c. The axis/center plane of the actual mating envelope must be within the tolerance zone
   d. None of the above

9. What is the most common method/tool used to verify a perpendicularity tolerance at MMC applied to a feature of size?
   a. A protractor
   b. A dial indicator
   c. A functional gage
   d. None of the above

10. What is one source of measurement uncertainty when using a functional gage to verify a perpendicularity tolerance at MMC applied to a feature of size?
    a. The shape of the tolerance zone
    b. The form error of the feature of size
    c. Tolerance accumulation within the gage
    d. None of the above

1. Which statement is a Y14.5 requirement for a position tolerance (RFS) applied to a hole?
   a. The high and low points of the hole's surface must be within the tolerance zone
   b. The axis of the unrelated actual mating envelope of the hole must be within the tolerance zone
   c. The derived median line of the hole must be within the tolerance zone
   d. A center point at each end of the hole must be within the tolerance zone

2. Which statement is a Y14.5 requirement of a position tolerance (MMC) applied to a hole?
   a. The high and low points of the hole's surface must be within the tolerance zone
   b. The surface of the hole must not violate a virtual condition boundary located at its true position
   c. The derived median line of the hole must be within the tolerance zone
   d. A center point at each end of the hole must be within the tolerance zone

3. When using a functional gage to inspect a position tolerance (MMC) applied to a hole, which step should be done first?
   a. Measure the size of the hole and determine the amount of bonus tolerance available
   b. Place a virtual condition pin into the hole
   c. Locate the part relative to the datum reference frame
   d. None of the above

4. What is one source of measurement uncertainty when using an attribute (functional) gage to inspect a position tolerance (MMC) applied to a hole?
   a. The shape of the tolerance zone
   b. How many points are taken on the hole surface
   c. Probe tip size
   d. None of the above

5. When verifying position tolerance (RFS) applied to a hole, the axis of the unrelated actual mating envelope may be simulated using:
   a. A virtual condition gage pin
   b. A best fit gage pin
   c. An MMC gage pin
   d. An LMC gage pin

6. Which of these choices is a source of measurement uncertainty when inspecting a position tolerance (RFS) applied to a hole using a variable measurement method?
   a. Location of the measurement
   b. How many points are taken on the hole surface
   c. The algorithm used
   d. None of the above

7. When verifying position tolerance (RFS) applied to a hole using a CMM, the axis of the unrelated actual mating envelope may be simulated using a:
   a. Virtual condition gage pin
   b. Least squares circle at each end of the hole
   c. Max inscribed cylinder
   d. None of the above

8. Which of these choices is a source of measurement uncertainty when inspecting a position tolerance (RFS) applied to a hole using a CMM?
   a. The shape of the tolerance zone
   b. Including the effects of the bonus tolerance
   c. Datum reference frame construction
   d. None of the above

9. Which formula should be used to calculate the position tolerance deviation using th delta X and delta Y coordinates from true position?
   a. ½ (X * Y)
   b. $2\sqrt{\Delta X^2 \times \Delta Y^2}$
   c. $(\sum X - Y)/ 2$
   d. None of the above

10. When creating a dimensional measurement plan for a position tolerance (RFS), which item from the list below should be documented in the "measurement method" box of the form?
   a. Algorithm
   b. Equipment ID
   c. Sample size
   d. None of the above

1. Which statement describes a requirement from Y14.5 for a circular runout tolerance applied to a cylindrical surface?
   a. The tolerance zone applies simultaneously to all circular elements of the surface
   b. The tolerance zone is not related to any datums
   c. The tolerance zone applies independently to each circular element
   d. None of the above

2. Which statement describes a requirement from Y14.5 for a total runout tolerance applied to a cylindrical surface?
   a. The tolerance zone applies simultaneously to all circular elements of the surface
   b. The tolerance zone is not related to any datums
   c. The tolerance zone applies independently to each circular element
   d. None of the above

3. Which statement best describes how to verify a circular runout tolerance using a dial indicator?
   a. An indicator contacts normal to the surface at a fixed location as the part is rotated about the datum axis
   b. An indicator contacts normal to the surface and moves parallel to the datum axis as the part is rotated
   c. An indicator contacts normal to the surface and moves parallel to the datum axis
   d. None of the above

4. Which statement best describes how to verify a total runout tolerance using a dial indicator?
   a. An indicator contacts normal to the surface at a fixed location as the part is rotated about the datum axis
   b. An indicator contacts normal to the surface and moves parallel to the datum axis as the part is rotated
   c. An indicator contacts normal to the surface and moves parallel to the datum axis
   d. None of the above

5. Which of these choices is a source of measurement uncertainty when using a dial indicator to inspect a circular runout tolerance applied to a cylindrical surface?
   a. Instrument resolution
   b. How many points are taken on the surface
   c. The algorithm used
   d. None of the above

6. When using a CMM to inspect a total runout tolerance, the CMM calculates and reports the:
   a. Max distance between the datum axis and the center point of a least squares circle at several cross sections
   b. Maximum radial deviation between highest and lowest point out of all measured circular cross sections
   c. Radial distance between the furthest point and closet point to the datum axis for the full length and circumference of the surface
   d. None of the above

7. Which of these choices is a source of measurement uncertainty when using a CMM to inspect a circular runout tolerance applied to a cylindrical surface?
   a. Datum axis simulation
   b. Instrument resolution
   c. Tolerance zone shape
   d. None of the above

8. When creating a dimensional measurement plan for a runout tolerance, which item from the list below should be documented in the "measurement method" box of the form?
   a. Frequency
   b. Equipment ID
   c. Sample size
   d. None of the above

1. Which statement is a requirement of Y14.5 for a profile of a surface tolerance applied to a surface?
   a. The tolerance zone is a three-dimensional boundary
   b. The tolerance zone is a two-dimensional boundary
   c. The tolerance zone is a one-dimensional boundary
   d. None of the above

2. When verifying a profile tolerance, an attribute gage can be used to verify:
   a. How much the surface varies from its true profile
   b. If the surface is within the profile tolerance zone
   c. How much the surface varies from its true position
   d. None of the above

3. When using a functional gage to inspect a profile of a surface tolerance applied to a surface, which step should be done first?
   a. Use a gage pin to determine if the surface is within the tolerance zone
   b. Locate the part relative to its true profile
   c. Locate the part relative to the datum reference frame
   d. None of the above

4. When using an indicator to verify a profile of a surface tolerance, the dial indicator checks the location of the surface relative to the:
   a. True profile
   b. Extreme boundaries
   c. Profile tolerance value
   d. None of the above

5. What is one source of measurement uncertainty when using variable measurement methods to inspect a profile tolerance applied to a surface?
   a. The shape of the tolerance zone
   b. Probe tip size
   c. The algorithm used
   d. None of the above

6. When using a CMM to verify a profile of a surface tolerance, the CMM uses an algorithm to determine the:
   a. True profile of the surface
   b. Location of the surface
   c. Profile tolerance value
   d. None of the above

7. Which of these choices is a source of measurement uncertainty when using algorithmic measurement methods to inspect a profile tolerance applied to a surface?
    a. The shape of the tolerance zone
    b. Resolution of the indicator
    c. Datum reference frame simulation
    d. None of the above

8. When creating a dimensional measurement plan for a profile tolerance, which item from the list below should be documented in the "measurement method" box of the form?
    a. The shape of the tolerance zone
    b. Number and spacing of points
    c. Sample size
    d. None of the above