Certified Manufacturing Technologist

Practice Exam

SOCIETY OF MANUFACTURING ENGINEERS

FOREWORD

Certification is the formal recognition of an individual's skills, expertise, and comprehension of a specified body of knowledge. Obtaining certification in your field is a significant personal achievement that also demonstrates your commitment to continuing education.

This workbook is designed to direct your studies as you prepare to join the ranks of Certified Manufacturing Technologists. It is comprised of a list of references used to develop examination questions, a list of recommended reading, and problems like those found on the Certified Manufacturing Technologist Examination.

Questions or comments should be directed to:

Manufacturing Engineering Certification Institute
Society of Manufacturing Engineers
One SME Drive, PO Box 930
Dearborn, MI 48121
(313) 271-1500
Fax: (313) 271-2861
e-mail: cert@sme.org
home page: http://www.sme.org/certification

The Manufacturing Engineering Certification Institute of the Society of Manufacturing Engineers (MECI/SME) was established in 1971 as a means of recognizing manufacturing engineers and technologists for their years of work experience and academic knowledge. MECI/SME's purpose: to provide additional credentials for manufacturing professionals and encourage continuing education.

SME first introduced certification in January 1972 with the Certified Manufacturing Engineer (CMfgE) program. The Certified Manufacturing Technologist (CMfgT) credential was implemented in 1976. Now, SME offers a third certification in the Certified Enterprise Integrator.

ACKNOWLEDGEMENT

MECI/SME would like to express its appreciation to Philip Rufe, CMfgE, for his technical contribution to this Practice Exam. His suggestions will help improve the study process for Manufacturing Technologist Examination applicants.

TABLE OF CONTENTS

What is a Manufacturing Technologist?

A Manufacturing Technologist is one who carries out manufacturing projects in a responsible manner, using proven techniques known by those who are technically trained in the field of manufacturing. A Manufacturing Technologist is capable of performing job assignments which may involve: working on design, development and implementation of engineering plans; drafting; the erection of manufacturing engineering equipment; estimating; inspection and testing of materials and components. In performing these functions, the candidate must apply sound knowledge and understanding of materials, manufacturing processes and people.

In carrying out these duties, the competent supervision of skilled craftsmen may be necessary. The techniques employed demand acquired experience and knowledge of manufacturing technology, combined with the ability to organize the details of a job using established practices.

A Manufacturing Technologist is competent in the fundamentals of manufacturing, including:

- Mathematics/Applied Science/ Materials
- Product/Process design
- Manufacturing Processes
- Production System and Equipment Design
- Automated Systems and Control
- Quality and Customer Service
- Manufacturing Management and Personal Effectiveness

The candidate must have a minimum of four years of education and/or manufacturing-related work experience. Full-time students who have completed two years of education in a manufacturing-related curriculum may pursue professional certification at the Technologist level.

About The Certified Manufacturing Technologist Examination

The Certified Manufacturing Technologist Examination, also called the Fundamentals of Manufacturing Examination, relies strongly on proven principles, calculations, data-driven answers and industry-wide norms. The examination contains 130 multiple-choice questions. Three hours are allowed for completion of the exam.

The Certified Manufacturing Technologist Examination is based on the proven experience of recognized experts in the field. Questions were written following proven professional test development procedures and were evaluated numerous times to assure relevancy and fairness. Following every exam cycle, each question is reviewed to assess its accuracy and reliability. This repeated assessment helps to ensure that the exam is able to test what is expected of candidates in a fair and effective manner.

The Certified Manufacturing Technologist Examination draws questions from a wide range of topics. It is expected that individuals who meet the candidate eligibility requirements and successfully complete this examination will have the broad base to fit into many applications and organizations.

Experts from both industry and academia identified competencies most important for individuals who hoped to achieve success in manufacturing engineering. These competencies are listed in the Examination Body of Knowledge. **Note: NOT ALL OF THE TOPICS LISTED WILL NECESSARILY BE REPRESENTED ON THE EXAMINATION, as the examination is constructed as a sampling of the many topics covered in the Body of Knowledge.**

Preparing For The Examination

The amount of time needed to prepare for the Certified Manufacturing Technologist Examination will depend largely upon your level of education and experience. The examination is designed for an individual with at least four years of education and/or manufacturing experience. Full-time students who have completed two years of education in a manufacturing-related curriculum may pursue the Certified Manufacturing Technologist exam.

SME's Certification Committee recommends the following tips to anyone preparing to take a certification examination:

- Prepare for the certification examination as you would for any professional test (i.e. bar or medical examinations).
- Review the Examination Body of Knowledge and compare it to your own knowledge and experience. Make a list of those areas not in your background.
- Focus much of your attention and effort on these topics as you study.
- Practice taking the examination using the sample problems in this practice exam or in the Fundamentals of Manufacturing Self-Assessment Program (available from SME Customer Service).
- Focus additional studies in those topics you missed on the sample problems.
- Study the *Fundamentals of Manufacturing* workbook (available from SME Customer Service.
- Participate in an examination review course, if one is available in your area.
- Join a study group of others taking the examination.
- Organize your reference materials prior to the examination by indexing particular information you expect you will need to access quickly.

All certification exams are open book, and candidates are permitted to bring reference materials into the exam room. A hand-held calculator is necessary; computers are NOT allowed. No sharing of materials or calculators is allowed. No cell phones are permitted, and beepers must be in a silent mode.

Retaining Certification

Certified individuals need to recertify every three years to ensure their technical knowledge is kept up-to-date. This is done by accumulating sufficient recertification credits or by retaking and passing the examination. Credits are awarded for most educational activities, including in-plant training programs, part-time teaching, patents, and attendance at conferences, courses, clinics and expositions.

Fundamentals of Manufacturing (CMfgT)
Certification Exam

Body
Of
Knowledge

Certified Manufacturing Technologist (CMfgT)
Body of Knowledge – Revised May 2001

Module 1. MATHEMATICS, APPLIED & ENGINEERING SCIENCES, & MATERIALS APPLICATION (16.3%)

1.1 Mathematics
- 1.1.1 Algebra
- 1.1.2. Trigonometry
- 1.1.3. Analytical Geometry
- 1.1.4. Calculus

1. 2. Applied and Engineering Sciences
- 1.2.1. Metrication/SI System
- 1.2.2. Physics
- 1.2.3. Chemistry
- 1.2.4. Statics
- 1.2.5. Dynamics
- 1.2.6.Fluid Mechanics
- 1.2.7.Thermodynamics/Heat Transfer
- 1.2.8. Electrical Circuits/Electronics

1.3. Materials Application
- 1.3.1. Metals (Properties and Applications)
- 1.3.2. Plastics/Polymers (Properties and Applications)
- 1.3.3. Composites (Properties and Applications)
- 1.3.4. Ceramics (Properties and Applications)
- 1.3.5. Fluids (Properties and Applications)

Module 2. PRODUCT/PROCESS DESIGN & DEVELOPMENT (13.4%)

2.1 Research and Development
- 2.1.1. Product R&D
- 2.1.2. Process R&D
- 2.1.3. Market/Sales/Life Cycle Analysis
- 2.1.4. Intellectual Property Protection

2.2 Design
- 2.2.1. Design Management
- 2.2.2. Concurrent Engineering
- 2.2.3. Design for X (Mfg/Assy/Maint/etc)
- 2.2.4. Drafting/Drawing/Engineering Graphics
- 2.2.5. CAD/CAM/CAE Applications
- 2.2.6. Simulation/Engineering Design Analysis
- 2.2.7. Tolerance Analysis/GD&T
- 2.2.8. Engineering Economics/Value Analysis
- 2.2.9. Product Prototype Build and Test
- 2.2.10. Process Development and Test

Module 3. MANUFACTURING PROCESS APPLICATIONS & OPERATION (14.1%)

3.1 Manufacturing Process Applications and Operation
- 3.1.1. Material Removal Processes
- 3.1.2. Fabrication Processes
- 3.1.3. Hot and Cold Forming Processes
- 3.1.4. Casting and Molding Processes
- 3.1.5. Electrical/Electronics Mfg. Processes
- 3.1.6. Heat Treatment Processes
- 3.1.7. Joining, Welding, and Assembly Processes
- 3.1.8. Finishing Processes
- 3.1.9. Bulk and Continuous Flow Processes
- 3.1.10. Material Handling/Packaging
- 3.1.11. Hand Tool Use/Machine Operating

Module 4. PRODUCTION SYSTEM and EQUIPMENT DESIGN/DEVELOPMENT (20.9%)

4.1 Production System Design and Development
- 4.1.1 Infrastructure/Plant Location Analysis
- 4.1.2. Facility Planning/Plant Layout
- 4.1.3. Process Planning
- 4.1.4. Capacity Planning
- 4.1.5. Production/Manufacturing System Design
- 4.1.6. Process Documentation/Work Instructions
- 4.1.7. Tool and Equipment Selection
- 4.1.8. Process and Equipment Capability Analysis
- 4.1.9. Cost Justification
- 4.1.10 Production System Build/Test
- 4.1.11. Human Factors, Ergonomics, and Safety
- 4.1.12. Maintenance Systems
- 4.1.13. Environmental Protection/Waste Management

4.2 Equipment/Tool Design and Development
- 4.2.1. Cutting Tool Design
- 4.2.2. Workholding Tool Design
- 4.2.3. Die/Mold Design
- 4.2.4. Gage Design
- 4.2.5. Machine Design
- 4.2.6. Power Systems (Mech/Elec/Fluid)
- 4.2.7. Control Systems (Mech/Elec/Fluid)

Module 5. AUTOMATED SYSTEMS and CONTROL (5.3%)

5.1. Automated Systems and Control
- 5.1.1. Automated Systems (Hard/Flexible)
- 5.1.2. CNC/PLC/Computer Control
- 5.1.3. CIM Systems
- 5.1.4. Computer Systems and Networks
- 5.1.5. Information Technology/Database Systems (MIS,etc.)
- 5.1.6. Enterprise-wide Systems Integration (MES,ERP,etc.)

Module 6. QUALITY and CUSTOMER SERVICE (13.0%)

6.1. Quality and Customer Service
- 6.1.1. Customer Focus (Research/Test/Satisfaction)
- 6.1.2. Quality System and Standards (QS/ISO/CE Mark/etc)
- 6.1.3. Probability and Statistics
- 6.1.4. Statistical Control Methods (Sampling/Charting/etc)
- 6.1.5. Problem Analysis & Solving (Fishbone/Pareto/FMEA/etc)
- 6.1.6. Factor Analysis (DOE/Correlation/etc)
- 6.1.7. Capability Analysis (Process/Equipment/etc)
- 6.1.8. Inspection/Test/Validation
- 6.1.9. Metrology
- 6.1.10. Reliability Analysis
- 6.1.11. System/Process/Continuous Improvement (BPR/kaizen,etc)
- 6.1.12. Customer and Field Service

Module 7. MANUFACTURING MANAGEMENT (10.8%)

7.1. Manufacturing Management

- 7.1.1. Strategic Planning/Global Competitiveness
- 7.1.2. Organizational Design and Management
- 7.1.3. Project Management
- 7.1.4. Personnel Management Methods (x/y/team/matrix/etc)
- 7.1.5. Human Behavior/Motivation/Leadership
- 7.1.6. Labor Relations
- 7.1.7. Education/Training
- 7.1.8. Operations Research, Analysis, & Forecasting
- 7.1.9. Production Organization Systems (agile/lean/mass/etc)
- 7.1.10. Material and Resource Management/Logistics
- 7.1.11. Accounting/Finance/Economics
- 7.1.12. Business/Engineering Ethics and Social Responsibility
- 7.1.13. Standards, Laws, and Regulations

Module 8. PERSONAL EFFECTIVENESS (6.2%)

8.1. Personal Effectiveness

- 8.1.1. Interpersonal Skills (listening, courtesy, etc.)
- 8.1.2. Negotiating & Conflict Management (persuasion, conflict resolution)
- 8.1.3. Presentation Skills & Oral Communication (formal & informal)
- 8.1.4. Written Communication Skills (reports, computer literacy)
- 8.1.5. Innovation & Creativity (idea generation & acceptance)
- 8.1.6. Learning & Knowledge Transfer (info research & sharing; education)

SAMPLE PROBLEMS

1. Which of the following equations factors in $a^3 - 3a^2b + 3ab^2 - b^3$?

A. $(a+b)^3$
B. $(a-b)^3$
C. $(a^2 - 2ab + b^2)(a+b)$
D. $(a^2 - 2ab - b^2)(a-b)$

2. What is the average of the sample listed below?

Observation #	Measurement
1	0.786 mm
2	0.793 mm
3	0.754 mm
4	0.779 mm
5	0.782 mm
6	0.786 mm
7	0.780 mm

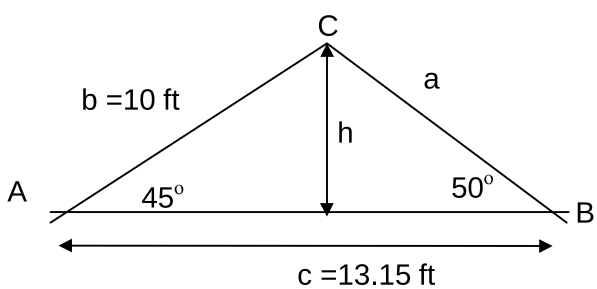
A. 0.779 mm
B. 0.780 mm
C. 0.781 mm
D. 0.782 mm

3. **What is the standard deviation of the sample listed below?**

Observation #	Measurement
1	0.786 mm
2	0.793 mm
3	0.754 mm
4	0.779 mm
5	0.782 mm
6	0.786 mm
7	0.780 mm

A. 0.00015 mm
B. 0.0124 mm
C. 0.780 mm
D. 6.50 mm

4. **Determine height (h) of the triangle and the length of side a.**



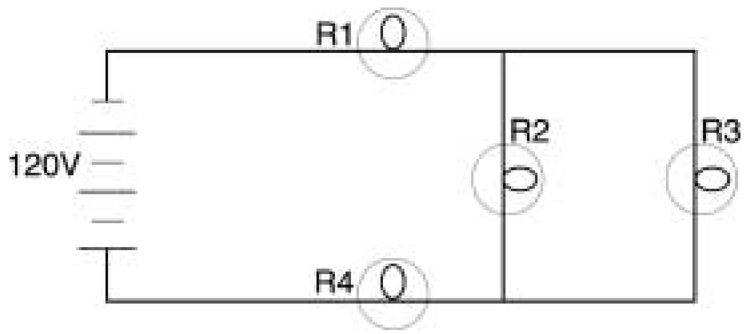
A. h= 7.07 ft, a= 9.23 ft
B. h= 6.70 ft, a= 10.00 ft
C. h= 7.07 ft, a= 8.23 ft
D. h= 6.73 ft, a= 9.23 ft

5. **What is the radiant power of a laser that delivers 50 joules of energy in one millisecond?**

A. 5.0×10^3 joules
B. 5.0×10^4 joules
C. 5.0×10^3 watts
D. 5.0×10^4 watts

6. **What is the total resistance of the circuit if the resistance of the lamps are as follows:**

R1 = 8Ω
R2 = 20Ω
R3 = 30Ω
R4 = 10Ω



A. 3.24Ω
B. 30.00Ω
C. 54.80Ω
D. 68.00Ω

7. **The unit of electric current rate is:**

A. voltage
B. coulomb
C. watt
D. ampere

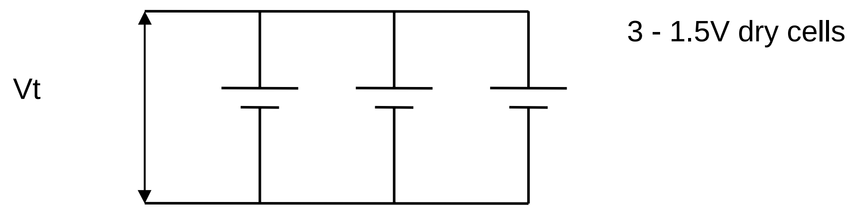
8. **An electrical transformer is a device used to:**

A. increase or decrease voltage
B. open and close an electric circuit
C. provide over-current protection
D. convert alternating current to direct current

9. **When an electric motor is turned off, its speed decreases exponentially. The motor's initial speed is 1,000 rpm. Its speed will decrease by half every 4 seconds. How long after the motor is turned off does the speed slow down to 31.25 rpm.**

A. 12 seconds
B. 16 seconds
C. 20 seconds
D. 24 seconds

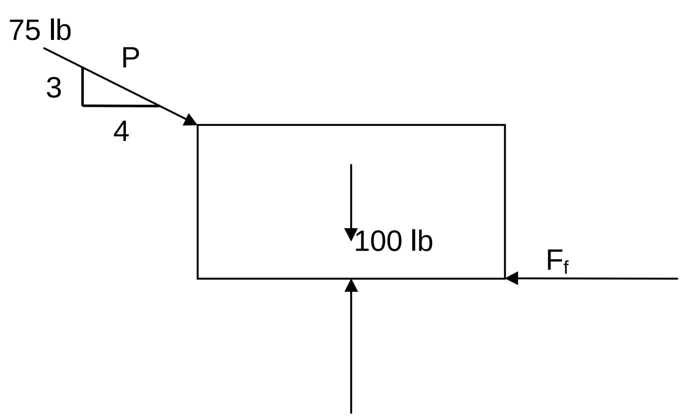
10. **Three 1.5 volt dry cells connected in parallel will produce:**



A. 1.5 volts
B. 3.5 volts
C. 4.0 volts
D. 4.5 volts

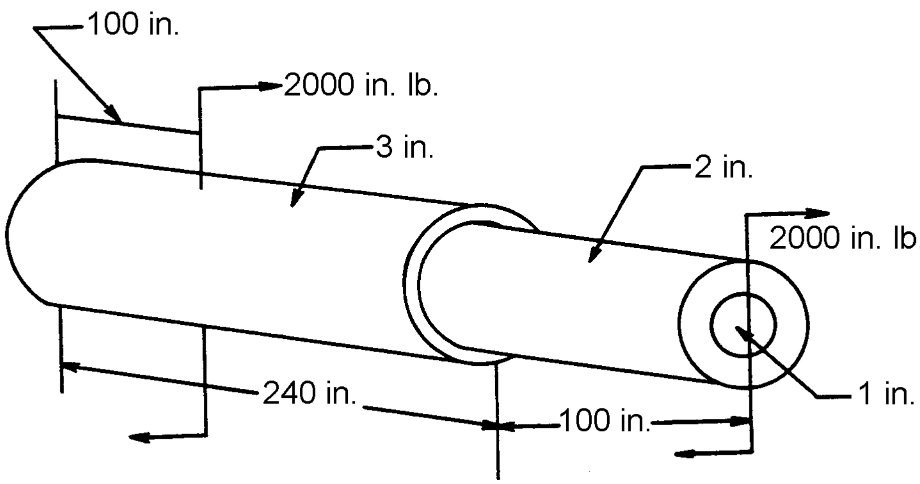
11. **A 100 lb block is pushed along a horizontal surface by force P. The coefficient of friction between the block and the horizontal surface is 0.4. Find the acceleration experienced by the block when the pushing force (P) is 75 lb.**

A. 0.444 ft/sec^2
B. 0.644 ft/sec^2
C. 3.824 ft/sec^2
D. 6.440 ft/sec^2

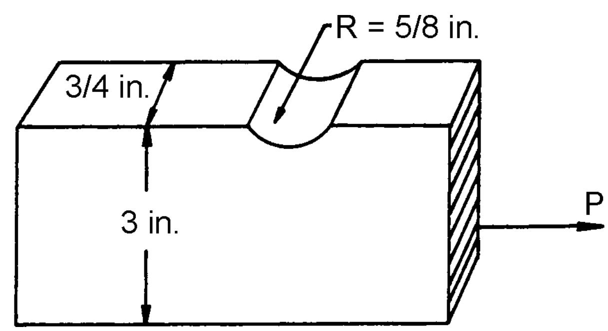


12. **For the steel torsion member shown, only the smaller portion (2 inch diameter section) is hollow. The member experiences two 2000 in-lb torsional loads as shown. Find the torsional deflection (angle of twist) developed in the 340 inch long member. (Modulus of Elasticity = 30,000,000 psi, Shear Modulus of Elasticity = 12,000,000 psi).**

A. 0.0163 Rad
B. 0.0184 Rad
C. 0.0214 Rad
D. 0.0298 Rad



13. **If the simple normal stress for the material in the member below is not to exceed 65,000 psi, find the maximum allowable load (P). (Ignore the stress concentration).**



A. 106,366 lb
B. 115,781 lb
C. 116,352 lb
D. 146,250 lb

14. When a metal is referred to as “tough”, this means that the metal:

A. resists grinding
B. does not deform plastically but breaks into pieces when stressed
C. dulls tools almost immediately
D. resists being broken or deformed by mechanical shock forces

15. When a metal is referred to as “hard”, this means:

A. the metal resists indentation, penetration, and scratching
B. the same thing as toughness
C. the metal is more ductile
D. the metal can deform plastically

16. The critical temperature for any metal is the temperature:

A. at which the metal goes through a phase change
B. below which the metal loses its magnetic properties
C. below which the metal does not deform plastically but shatters
D. above which the metal melts

17. Which of the following is the best engineering plastics material that has high tensile strength, high compressive strength, with minimal elongation to use for a product that will be injection molded?

A. polycarbonate
B. polystyrene
C. phenolic
D. epoxy

18. The best process for making a kitchen drawer divider tray out of plastic sheets is:

A. pulforming
B. thermoforming (vacuum forming)
C. compression forming
D. blowmolding

19. **The method of presentation of an object utilizing conventional drafting practice is commonly referred to as:**

A. orthographic projection
B. side projection
C. right projection
D. left side projection

20. **Which of the following organizations specifies standards for designing drafting?**

A. Association for National Standards in Industry
B. Affiliated National Standards, Inc.
C. Association of National Societies in Industry
D. American National Standards Institute

21. **The principal CIM technology that begins a product design cycle is:**

A. CAM
B. CAD
C. CAE
D. CAPP

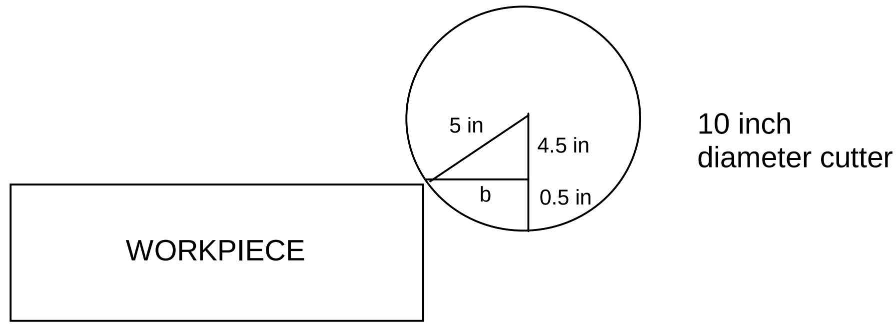
22. **Tolerance is:**

A. difference between mating parts
B. same as allowance
C. permissible deviation from a desired dimension
D. deviation between a drawing and the actual part produced

23. **A turning operation is to be done on a piece of alloy steel that has a diameter of 3.5 inches. If the depth of cut is set at 0.125 inches, the feed is set at 0.012 inches per revolution, and the recommended cutting speed using a carbide tool is 275 feet per minute, what rpm setting available on the machine should be used?**

A. 264 rpm
B. 300 rpm
C. 420 rpm
D. 532 rpm

24. **The following diagram shows a 10 inch peripheral milling cutter that is set to cut a piece of steel. If the depth of cut is 0.5 inches, how far must the tool travel until the tool is engaged at its full depth on the workpiece (center of tool is positioned over the edge)?**



A. 2.18 in.
B. 3.11 in.
C. 4.52 in.
D. 4.75 in.

25. **If the diameter of a milling cutter is 12 inches and the cutting speed is 90 fpm, what is the approximate number of revolutions per minute the machine should be set at?**

A. 30 rpm
B. 45 rpm
C. 60 rpm
D. 4.75 rpm

26. **The purpose of a riser in a mold is:**

A. to help raise the molder
B. the same as a cope
C. to enhance the draft
D. to feed liquid metal into the body of the casting as it solidifies

27. **Emulsified oils are:**

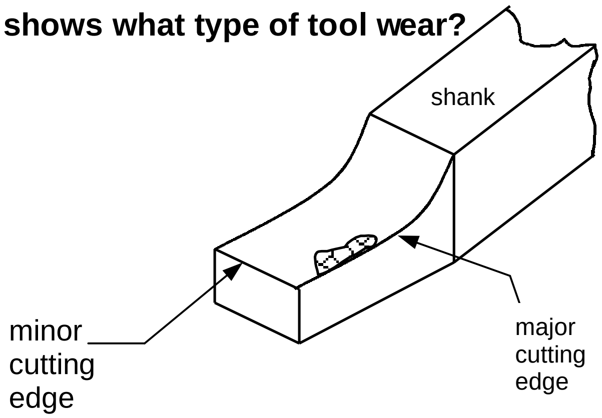
A. high in sulphur content
B. oil and water mixtures used for both lubricating and cooling
C. lubricating oils diluted with naphta, kerosene or other petroleum-base solvents
D. oils that have degraded over time

28. **A tapered bushing is 4 inches long. The diameter of one end should be 0.250 inch larger than the other end. The bushing is mounted on a 16 inch mandrel between centers and is turned with a taper attachment. What should be the setting of the taper attachment in inches per foot?**

A. 0.250 inch per foot
B. 0.375 inch per foot
C. 0.500 inch per foot
D. 0.750 inch per foot

29. **The following diagram shows what type of tool wear?**

A. crater wear
B. flank wear
C. edge wear
D. relief wear



30. **How much horsepower is needed for a drilling operation to produce a 1.25 inch hole in a workpiece made of cast iron with a hardness of 150 HB. The speed used for this operation is 900 rpm, the feed rate is 0.005 ipr and the unit power requirement is 1.0 hp/in^3/min. Assume the machine is running at 80% efficiency.**

A. 0.4 HP
B. 0.7 HP
C. 4.0 HP
D. 7.0 HP

31. **The most common type of locating pin designed to minimize contact area between the workpiece and the locating pin, thereby reducing the chances of sticking or jamming is known as?**

A. tertiary locator
B. fixture key
C. low limit pin
D. diamond pin

32. The simplest and least expensive type of clamping device used to retain the workpiece in a jig or fixture is known as a:

A. strap clamp
B. pipe clamp
C. “C” clamp
D. Jorgeson clamp

33. The portion of a technical report which is written: (1) to avoid technical details, (2) to succinctly present the summary and conclusions of a project or investigation and (3) especially to be read by management is called a:

A. precis
B. abstract
C. executive summary
D. management synopsis

34. OSHA inspections are almost always conducted:

A. after written notification
B. without prior notice
C. after a company has been operating for five years
D. on an annual basis

35. The Occupational Safety and Health Act places the legal obligation to comply on:

A. supervisors
B. employers
C. every employee
D. manufacturers in interstate commerce

36. If a manufacturing plant had 20 injuries and job-related illnesses during a period in which all employees worked a total of 800,000 hours, what would be the plant’s total injury-illness rate based upon OSHA’s current factor of hours worked per year by 100 employees?

A. 5.0
B. 5.2
C. 10.4
D. 15.0

37. A letter of transmittal is used:

A. to confirm receipt of a fax document
B. as an e-mail boilerplate
C. to accompany shipments to customers
D. to convey a report from one firm to another

38. What is the available production capacity per week of four automated machines working two eight-hour shifts per day, six days per week, with an average machine utilization rate of 90%?

A. 86 hours
B. 173 hours
C. 345 hours
D. 384 hours

39. The following data is available: labor and machine total cost is $10.00/hr, operation time is 3 min/part, material cost is $0.10/part. The total cost per part would be:

A. $.40
B. $.60
C. $.75
D. $30.10

40. The initial process through which labor unions and company officials meet to adjust conflicting perspectives and interests is known as:

A. mediation
B. arbitration
C. negotiation
D. collective bargaining

41. When using production flow analysis, which of the following criteria is the primary determinant of group membership.

A. tolerances
B. geometeric attributes
C. functional attributes of the part
D. operation sequence and machine routing

42. **The analysis of the aggregate production plan, or the master production schedule to determine if there is sufficient capacity at critical points in the production process, is best accomplished with:**

A. Material Requirements Planning
B. Capacity Requirements Planning
C. Rough-Cut Planning
D. Manufacturing Resource Planning

43. **An Ishikawa diagram can be used to:**

A. graphically display the relationships between variables in a two-way factorial experiment
B. analyze the causal relationships between process variables that can affect the quality of the product
C. determine the loss function for a given set of quality characteristics
D. determine the capacity of a process

44. **In statistical process control, the most common size for a sample subgroup is:**

A. 5
B. 10
C. 10% of the group
D. 20% of the group

45. **The term X-bar refers to the:**

A. mode
B. range
C. mean
D. standard deviation

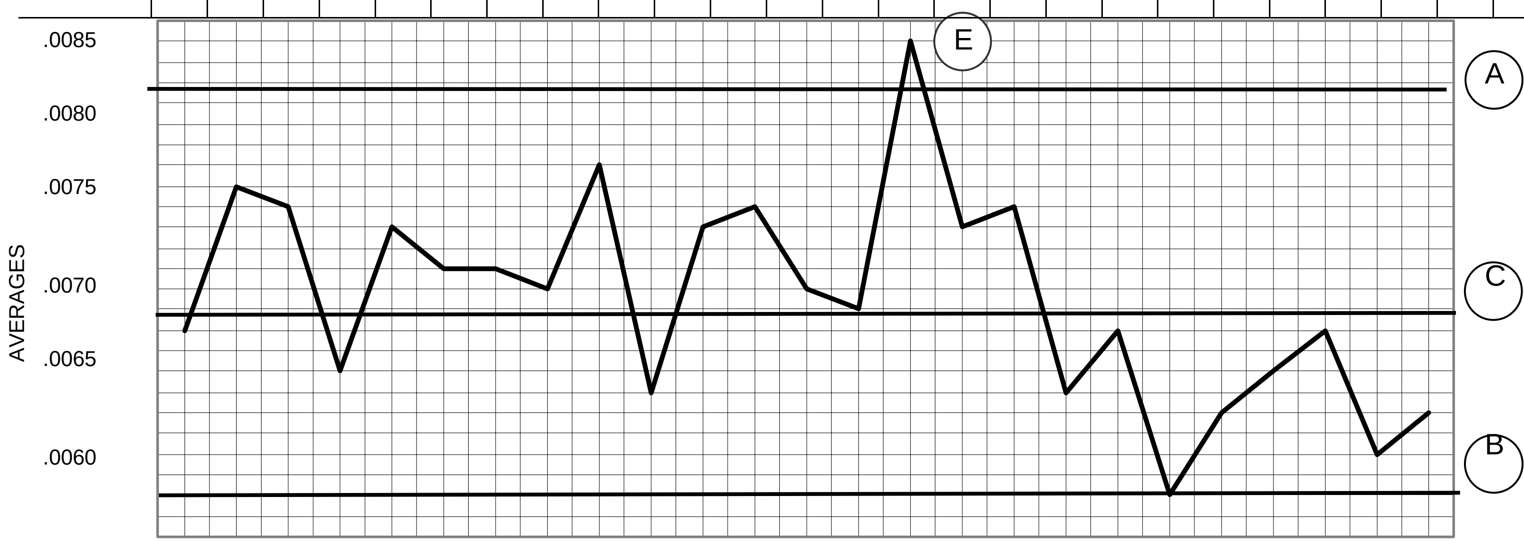
46. **Point E on chart 1 indicates a period when:**

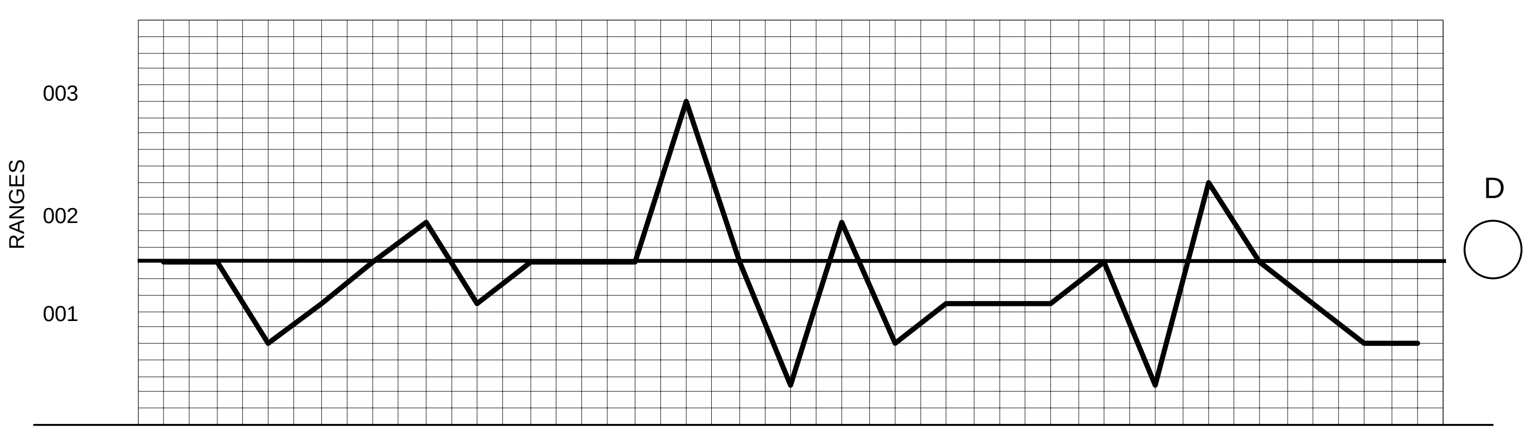
A. the upper control limit was exceeded
B. quality was highest
C. the average process capability exceeded 0.0080
D. the upper tolerance limit was exceeded

CHART 1

PART NO.	CHART NO.
PART NAME (PRODUCT)	OPERATION (PROCESS)
SPECIFICATION LIMITS	
OPERATOR	MACHINE
GAGE	UNIT OF MEASURE
ZERO EQUALS	
DATE	

TIME																										
SAMPLE MEASUREMENTS ⊗	1	6.5	7.5	7.5	6.0	7.0	6.0	7.5	6.0	6.5	6.0	8.0	8.5	7.0	6.5	9.0	7.5	7.5	7.5	6.5	6.0	5.0	6.0	8.0	6.5	6.5
	2	7.0	8.5	8.0	7.0	7.5	7.0	8.0	7.0	8.0	7.0	7.5	7.5	7.0	7.0	8.0	8.0	7.0	7.0	6.5	6.0	5.5	8.0	6.5	6.0	7.0
	3	6.5	7.5	8.0	7.0	7.5	8.0	6.5	8.0	8.5	6.0	9.0	8.5	7.5	8.5	8.0	7.5	8.5	6.0	8.5	6.5	6.5	6.5	6.5	6.5	7.0
	4	6.5	8.5	7.0	7.5	8.5	7.5	7.5	7.5	8.5	8.0	5.0	6.5	7.5	7.5	8.5	8.0	7.0	7.0	6.5	6.0	8.0	6.5	6.5	6.0	6.0
	5	8.5	6.5	7.5	6.5	8.0	7.0	7.0	7.5	7.5	6.5	8.0	7.0	7.0	6.0	8.5	6.5	8.0	6.0	7.0	6.5	8.0	7.5	6.5	7.0	6.5
SUM		35	38.5	38	34	37.5	36.5	36.5	36	39	33.5	37.5	38	36	36.5	42	37.5	38	33.5	35	31	33	34.5	34	32	33
AVERAGE		7.0	7.7	7.6	6.8	7.5	7.3	7.3	7.2	7.8	6.7	7.5	7.6	7.2	7.1	8.4	7.5	7.6	6.7	7.0	6.2	6.6	6.8	7.0	6.4	6.6
RANGE		2.0	2.0	1.0	1.5	2.0	1.5	1.5	2.0	2.0	2.0	4.0	2.0	0.5	2.5	1.0	1.5	1.5	1.5	2.0	0.5	3.0	2.0	1.5	1.0	1.0
NOTES																										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25





47. Line D in Chart 1 represents:

A. R-bar
B. X
C. X-bar
D. R

48. The Capability Index (Cp) is used to:

A. establish the tolerance for a given characteristic
B. determine the accuracy of the equipment that will be used for a process
C. calculate the control limits for X-Bar and R charts
D. determine if a process in a state of control is able to consistently produce results that are within the required tolerances

49. A ring gage is used to measure:

A. outside diameter
B. roundness
C. outside diameter and roundness
D. integrity of a grinding wheel

50. Snap gages are used to check:

A. profiles
B. outside diameters
C. diameters of holes
C. surface roughness

51. An inspector must precisely measure a machined, angled surface on a casting. Which of the following measuring devices would be an appropriate instrument for this application?

A. sine bars
B. Vernier caliper
C. telescopic gages
D. sliding T-Bevel

52. **The buttons on a sine bar are 10.0000 inches apart on centers. The bar is to be rested on gage blocks at an angle of 30^o. The difference in height between the two piles of gage blocks must be:**

A. 0.866 in.
B. 2.588 in.
C. 5.000 in.
D. 7.071 in.

53. **A 1" to 2" micrometer reads as follows: barrel reads .550 and the thimble reads 12. The reading is:**

A. 0.552
B. 0.562
C. 1.552
D. 1.562

54. **What would be the value A after evaluating the following arithmetic expression?**
A= INT(SQRT((2.0*3.0) + (4.0*4.0)))

A. 5
B. 5.0
C. 7
D. 7.0

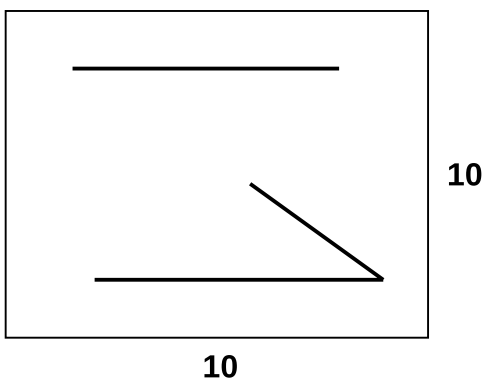
55. **NC contouring is an example of:**

A. continuous-path positioning
B. point to point positioning
C. absolute positioning
E. incremental positioning

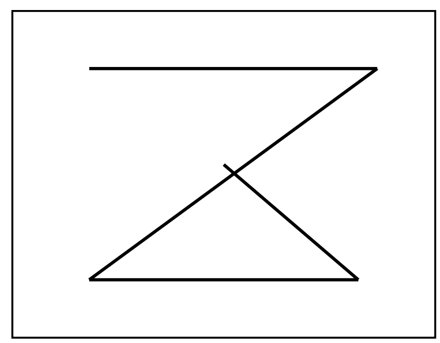
56. **The following NC program will produce which of the in-cut tool paths below?**

```
N1    G90  G00  X-2.  Y2.  Z2.  S1000  T1  M06
N2    X2.  Z.1
N3    G01  Z-.125  F8
N4    X8
N5    X5.  Y5.
N6    G00  Z.1
N7    X8.  Y8.
N9    G01  Z-.125 F8
N10   X2.
N11   G00  Z2.
N12   X0  Y0
N13   Z0  M30
```

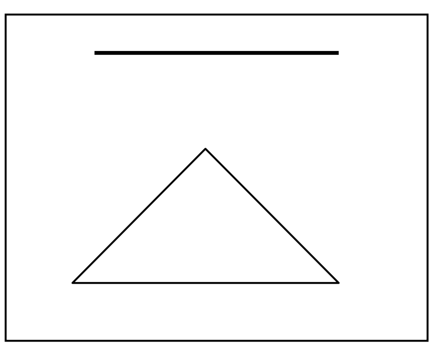
A



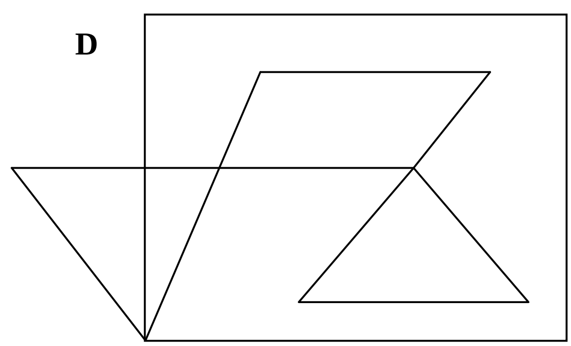
B



C



D



A. A
B. B
C. C
D. D

57. A CNC machine tool that defaults to "leading zero suppression" and is capable of three decimal place accuracy would interpret the number 12 as:

A. 0.012
B. 0.120
C. 1.200
D. 12.000

58. On a cylindrical robot, which of the following is <u>not</u> a basic degree of freedom?

A. the rotation of the arm
B. the radial telescoping
C. the closing of the end effector
D. the left to right swivel of the wrist

59. Which type of robotic power system should be selected for extremely quick and accurate assembly of small components?

A. mechanical
B. pneumatic
C. electrical
D. hydraulic

SOLUTIONS

Problem Statement

1. Which of the following equations factors in $a^3 - 3a^2b + 3ab^2 - b^3$?

   A. $(a+b)^3$
   B. $(a-b)^3$
   C. $(a^2 - 2ab + b^2)(a+b)$
   D. $(a^2 - 2ab - b^2)(a-b)$

Solution

$(a-b)^3 = (a-b)(a-b)^2 = (a-b)(a^2 - 2ab + b^2) = a^3 - 3a^2b + 3ab^2 - b^3$

Answer is (B) $(a-b)^3$

Problem Statement

2. What is the average of the sample listed below?

Observation #	Measurement
1	0.786 mm
2	0.793 mm
3	0.754 mm
4	0.779 mm
5	0.782 mm
6	0.786 mm
7	0.780 mm

A. 0.779 mm
B. 0.780 mm
C. 0.781 mm
D. 0.782 mm

Given

Sample measurements

Find

Sample average

Definitions

$\bar{x}$ = sample average
n= sample size
x_i= individual measurements

Formula

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Solution

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad = \frac{1}{7}(0.786\text{mm} + 0.793\text{mm} + 0.754\text{mm} + 0.779\text{mm} + 0.782\text{mm} + 0.786\text{mm} + 0.780\text{mm})$$

$\bar{x}$ = <u>0.780mm</u>

Answer is (B) 0.780 mm

Beyer, W.H. (Eds.). (1987). CRC Standard Mathematical Tables (28th ed.) Boca Raton FL: CRC Press.

Problem Statement

3. What is the standard deviation of the sample listed below?

Observation #	Measurement
1	0.786 mm
2	0.793 mm
3	0.754 mm
4	0.779 mm
5	0.782 mm
6	0.786 mm
7	0.780 mm

A. 0.00015 mm
B. 0.0124 mm
C. 0.780 mm
D. 6.50 mm

Given

Sample measurements

Definitions

s= sample standard deviation
n= sample size
x_i= individual measurements

$\bar{x}$ = sample average

Formula

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{n-1}}$$

Solution

s = [1/6 [(0.786mm -0.780mm)^2 + (0.793mm - 0.780mm)^2 + (0.754mm - 0.780mm)^2 +(0.779mm - 0.780mm)^2+(0.782mm - 0.780mm)^2 +(0.786mm - 0.780mm)^2 +(0.780mm - 0.780mm)^2]]$^{1/2}$

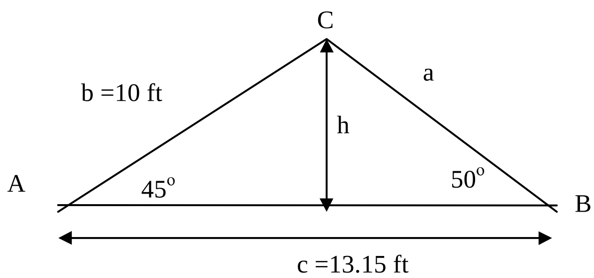
s = 0.0124mm

Answer is (B) 0.0124 mm

Beyer, W.H. (Eds.). (1987). CRC Standard Mathematical Tables (28th ed.) Boca Raton FL: CRC Press.

Problem Statement

4. Determine height (h) of the triangle and the length of side a.



A. h= 7.07 ft, a= 9.23 ft
B. h= 6.70 ft, a= 10.00 ft
C. h= 7.07 ft, a= 8.23 ft
D. h= 6.73 ft, a= 9.23 ft

Given

A= 45 deg
B = 50 deg
C = 180 - 95 = 85 deg
b = 10 ft
c = 13.15 ft

Find

a and h

Definitions

a = side a
h = height of the triangle

Formulas

Law of Sines = $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Solution

$\frac{a}{\sin 45} = \frac{10ft}{\sin 50}$ a= 9.23 ft

$$\cos\theta = \frac{opp}{hyp} = \frac{h}{10ft}$$

h = 10ft cos 45

h = 7.07 ft

Answer is (A) h= 7.07 ft, a= 9.23 ft

Problem Statement

5. What is the radiant power of a laser that delivers 50 joules of energy in one millisecond?

A. 5.0×10^3 joules
B. 5.0×10^4 joules
C. 5.0×10^3 watts
D. 5.0×10^4 watts

Given

Energy = 50 joules
Time = 0.001 sec

Find

Power delivered

Definition

Power = work/unit time

Solution

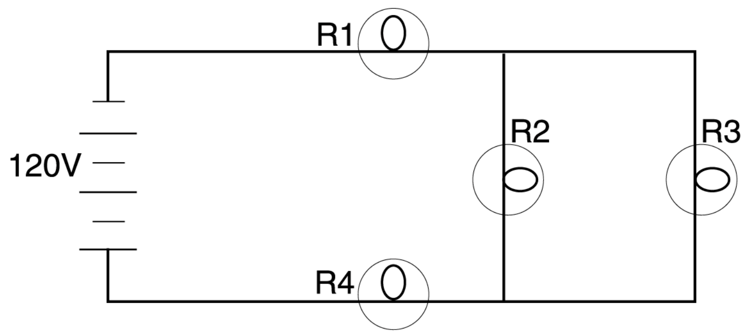
$$\text{Power} = \frac{\text{work}}{\text{unit time}} = \frac{\text{joules}}{\text{seconds}} = \frac{50\ \text{joules}}{0.001\,\text{sec}} = 5.0 \times 10^4\ \text{Watts}$$

Answer is (D) 5.0×10^4 watts

Problem Statement

6. What is the total resistance of the circuit if the resistance of the lamps are as follows:

R1 = 8Ω
R2 = 20Ω
R3 = 30Ω
R4 = 10Ω



A. 3.24Ω
B. 30.00Ω
C. 54.80Ω
D. 68.00Ω

Given

R1 = 8Ω
R2 = 20Ω
R3 = 30Ω
R4 = 10Ω

Find

Total circuit resistance

Definitions

R= resistance

Formulas

Resistors in parallel

$$R23 = \frac{R1\,R2}{R1 + R2}$$

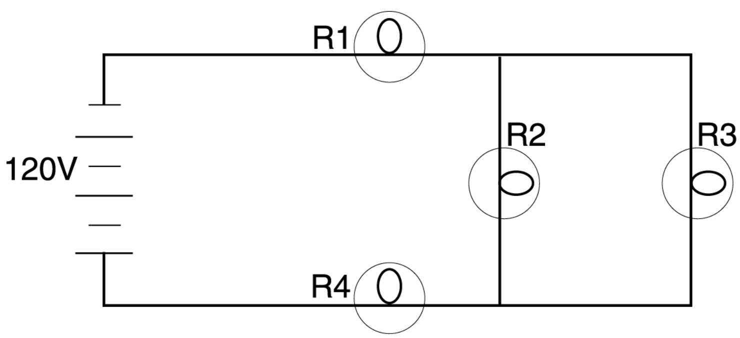
Resistors in series

Req = R1 + R2 + R3

Solution

R2 and R3 are in parallel and can be combined as follows.

$$R23 = \frac{R1\,R2}{R1 + R2} = \frac{600\Omega}{50\Omega} = 12\Omega$$



Resistors in series

$Req = R1 + R23 + R4 =$ 8Ω + 12Ω + 10Ω = 30Ω

Answer is (B) 30Ω

Problem Statement

7. The unit of electric current rate is:

A. voltage
B. coulomb
C. watt
D. ampere

Answer is (D) amperes

Power = Watts
Voltage = Volts
Charge = Coulombs
Current rate = Amperes[7]

[7]Reprinted from Halliday, D., & Resnick, R.,1988. Fundamentals of Physics 3rd ed. NewYork: John Wiley & Sons, Inc. Reproduced with permission.

Problem Statement

8. An electrical transformer is a device used to:

A. increase or decrease voltage
B. open and close an electric circuit
C. provide over-current protection
D. convert alternating current to direct current

Answer is (A) increase or decrease voltage

An electric transformer is a device used to increase or decrease voltage. Step down tranformers reduce voltage and increase current flow. Step up transformers increase the voltage and reduce the current flow.[8]

[8]Reprinted from Halliday, D., & Resnick, R.,1988. Fundamentals of Physics 3rd ed. NewYork: John Wiley & Sons, Inc. Reproduced with permission.

Problem Statement

9. When an electric motor is turned off, its speed decreases exponentially. The motor's initial speed is 1,000 rpm. Its speed will decrease by half every 4 seconds. How long after the motor is turned off does the speed slow down to 31.25 rpm.

A. 12 seconds
B. 16 seconds
C. 20 seconds
D. 24 seconds

Given

Initial speed = 1000 rpm
Decreases speed by ½ every 4 seconds

Definitions

C = initial value of y
k = constant of proportionality
t = time

Formula

Exponential growth: $y = Ce^{kt}$

Solution

At time = 0, y = 1000 rpm

$1000 = Ce^{k(0)}$
$C = 1000$

At time = 4 sec, y = 500 rpm

$500 = 1000e^{k(4)}$
$\ln(500/1000) = 4k$
$k = -0.1733$

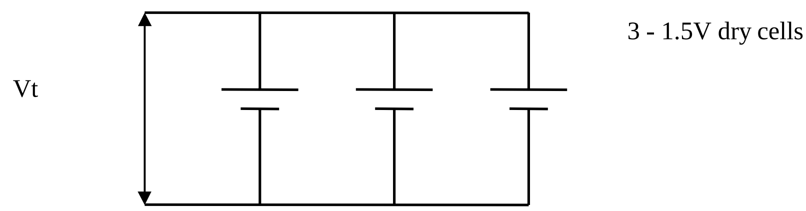
When y = 31.25 rpm, t = ?

$31.25 = 1000e^{-0.1733t}$
$\ln(31.25/1000) = -0.1733t$
$t = 20$ sec

Answer is (C) 20 seconds

Problem Statement

10. Three 1.5 volt dry cells connected in parallel will produce:



A. 1.5 volts
B. 3.5 volts
C. 4.0 volts
D. 4.5 volts

Given

Three 1.5 volt dry cells connected in parallel

Find

Total voltage

Definitions

Vt = total voltage
V= voltage of each dry cell

Formula

For dry cells in parallel

Vt = V

Solution

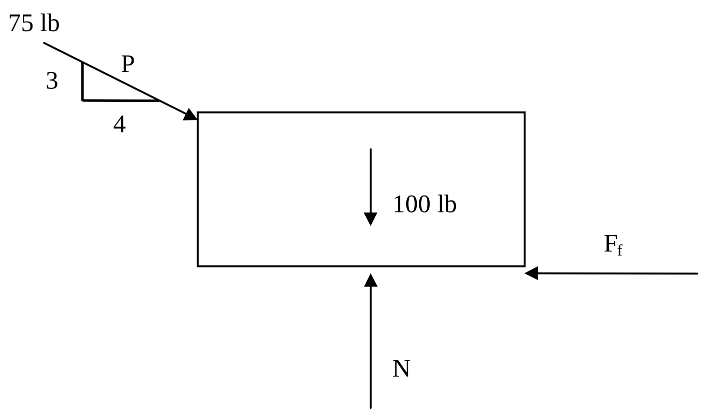
Vt= 1.5 Volts

Answer is (A) 1.5 volts

Problem Statement

11. A 100 lb block is pushed along a horizontal surface by force P. The coefficient of friction between the block and the horizontal surface is 0.4. Find the acceleration experienced by the block when the pushing force (P) is 75 lb.

A. 0.444 ft/sec^2
B. 0.644 ft/sec^2
C. 3.824 ft/sec^2
D. 6.440 ft/sec^2



Find

Acceleration (a)

Given

P = 75 lb
W = 100 lb
μ = 0.4

Definitions

F_f = frictional force
N = normal force
m = mass

Formulas

F = ma

$\Sigma Fx = F_* \cos\Theta - F_{f = 0}$

$\Sigma Fy = -W - (F_* \sin\Theta) + N = 0$

Solution

(1) $\Sigma Fx = 75 \text{ lb } (4/5) - F_f$

(2) $\Sigma Fy = -100 \text{ lb} - 75 \text{ lb}(3/5) + N = 0$

(1) $N = 145 \text{ lb}$

$F_f = \mu N = 0.4(145 \text{ lb}) = 58 \text{ lb}$

(1) 75 lb (4/5) - 58 lb = 2 lb net to the right

(3) F = ma or a = F/m

$$a = \frac{2 \text{ lb}}{100 \text{ lb} / 32.2 \text{ ft/s}^2}$$

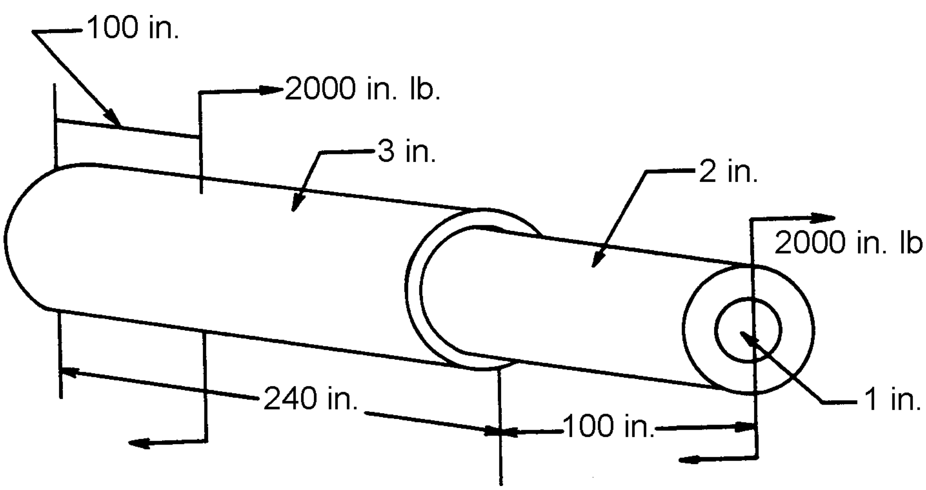
$a = 0.644 \text{ ft/s}^2$

Answer is (B) 0.644 ft/sec^2

Problem Statement

12. For the steel torsion member shown, only the smaller portion (2 inch diameter section) is hollow. The member experiences two 2000 in-lb torsional loads as shown. Find the torsional deflection (angle of twist) developed in the 340 inch long member. (Modulus of Elasticity = 30,000,000 psi, Shear Modulus of Elasticity = 12,000,000 psi).

A. 0.0163 Rad
B. 0.0184 Rad
C. 0.0214 Rad
D. 0.0298 Rad



Given

Two 2000 in-lb torsional loads
The 2 inch diameter section is hollow
Section one is 240 inches long and section two is 100 inches long
G = 12,000,000 psi

Find

Torsional deflection

Definitions

θ = angle of twist in radians
T = internal resisting torque
L = length
G = shear modulus
J = polar moment of inertia

Formulas

$$\theta = \frac{TL}{JG}$$

$$J_{solid\ shaft} = \frac{\pi d^4}{32}$$

$$J_{hollow\ shaft} = \frac{\pi (d_o{}^4 - d_i{}^4)}{32}$$

Steps

1. Cut the shaft where there is a change in load or geometry
2. Draw free body diagrams of each cut.
3. Calculate the internal resisting torque (T) for each free body diagram.
4. Calculate the angle of twist for each section.
5. Sum the angles for the total deflection.

Solution

T_1 = 4000 in-lb

T_2 = 2000 in-lb

T_3 = 2000 in-lb

$$\theta_1 = \frac{T\,L}{J\,G} = \frac{4000\,\text{lb}\,(100\,\text{in})}{[\pi(3\,\text{in}^4)/32][12\text{ x }10^6\,\text{psi}]} = 0.00419\,\text{rad}$$

$$\theta_2 = \frac{T\,L}{J\,G} = \frac{2000\,\text{lb}\,(140\,\text{in})}{[\pi(3\,\text{in}^4)/32][12\text{ x }10^6\,\text{psi}]} = 0.00293\,\text{rad}$$

$$\theta_3 = \frac{T\,L}{J\,G} = \frac{2000\,\text{lb}\,(100\,\text{in})}{[\pi(2\,\text{in}^4 - 1\text{in}^4)/32][12\text{ x }10^6\,\text{psi}]} = 0.01132\,\text{rad}$$

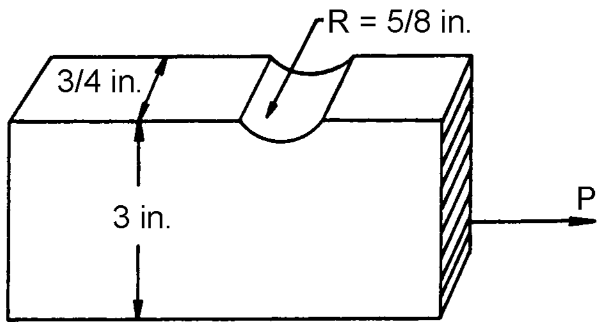
$$\theta_T = \theta_1 + \theta_2 + \theta_3 = 0.0184\text{rad}$$

Answer is (B) 0.0184 Rad

Problem Statement

13. If the simple normal stress for the material in the member below is not to exceed 65,000 psi, find the maximum allowable load (P). (Ignore the stress concentration).

A. 106,366 lb
B. 115,781 lb
C. 116,352 lb
D. 146,250 lb



Given

$S_{allowable}$ = 65,000 psi

Ignore stress concentration

Find

Maximum allowable load, P

Definitions

P = load
S = stress

Formula

Stress = Load/Cross Sectional Area

Solution

Load = Stress x Cross Sectional Area

P = 65,000 psi [2.375 in (0.750 in)]

P = 115,781 lb

Answer is (B) 115,781 lb

Problem Statement

14. When a metal is referred to as "tough", this means that the metal:

A. resists grinding
B. does not deform plastically but breaks into pieces when stressed
C. dulls tools almost immediately
D. resists being broken or deformed by mechanical shock forces.

Answer is (D) resist being broken or deformed by mechanical shock

Toughness is a mechanical property which can be defined as a materials resistance to a sudden load or shock without failure.[14]

[14] Reprinted from DeGarmo P.E., Black, J.T., & Kohser, R.A., 1997, Materials and Processes in Manufacturing, 8th edition. New Jersey: Prentice Hall. Reproduced with permission.

Problem Statement

15. When a metal is referred to as “hard”, this means:

A. the metal resists indentation, penetration and scratching
B. the same thing as toughness
C. the metal is more ductile
D. the metal can deform plastically

The answer is (A) the metal resists indentation, penetration and scratching

The harder a metal becomes the lower its toughness, ductility and plasticity.[15]

[15] Reprinted from DeGarmo P.E., Black, J.T., & Kohser, R.A., 1997, Materials and Processes in Manufacturing, 8th edition. New Jersey: Prentice Hall. Reproduced with permission.

Problem Statement

16. The critical temperature for any metal is the temperature:

A. at which the metal goes through a phase change
B. below which the metal loses its magnetic properties
C. below which the metal does not deform plastically but shatters
D. above which the metal melts

The answer is (A) at which the metal goes through a phase change

Metals, being composed of phases, transform from one phase to another after passing through a specific temperature boundary. In the case of steel, austenite transforms into pearlite and ferrite after cooling through the critical temperature of 1330^{o} F.[16]

[16] Reprinted from DeGarmo P.E., Black, J.T., & Kohser, R.A., 1997, Materials and Processes in Manufacturing, 8th edition. New Jersey: Prentice Hall. Reproduced with permission.

Problem Statement

17. Which of the following is the best engineering plastics material that has high tensile strength, high compressive strength, with minimal elongation to use for a product that will be injection molded?

A. polycarbonate
B. polystyrene
C. phenolic
D. epoxy

The answer is (B) polystyrene

Polycarbonate and polystyrene are thermoplastics which are easier to injection mold than phenolics and epoxies which are thermosets. Polystyrene has a lower percent elongation than polycarbonate.[17]

[17] Reprinted from DeGarmo P.E., Black, J.T., & Kohser, R.A.,1997, Materials and Processes in Manufacturing, 8th edition. New Jersey: Prentice Hall. Reproduced with permission.

Problem Statement

18. The best process for making a kitchen drawer divider tray out of plastic sheets is:

A. pulforming
B. thermoforming (vacuum forming)
C. compression forming
D. blowmolding

Answer is (B) thermoforming (vacuum forming)

Thermoforming is a good process for producing thin wall plastic parts with depressions or cavities. Pulforming is usually used for continuously reinforced parts. Compression forming is typically used for thermoset plastics and blowmolding is generally used for parts with an enclosed cavity such as a pop bottle.[18]

[18] Reprinted from DeGarmo P.E., Black, J.T., & Kohser, R.A., 1997, Materials and Processes in Manufacturing, 8th edition. New Jersey: Prentice Hall. Reproduced with permission.

Problem Statement

19. The method of presentation of an object utilizing conventional drafting practice is commonly referred to as:

A. orthographic projection
B. side projection
C. right projection
D. left side projection

Answer is (A) orthographic projection

The method of presentation of an object utilizing conventional drafting practice is commonly referred to as orthographic projection. Side projection, right projection and left side projection are types of orthographic projection. The prefix ortho means at right angles.[19]

[19] Reprinted from Earle, J. H., 1994,. Engineering Design Graphics , 8th ed., with permission from Addison Wesley Publishing Company.

Problem Statement

20. Which of the following organizations specifies standards for designing drafting?

A. Association for National Standards in Industry
B. Affiliated National Standards, Inc.
C. Association of National Societies in Industry
D. American National Standards Institute

Answer is (D) American National Standards Insitute

The American National Standards Institute (ANSI) specifies standards for design drafting. ANSI sets standard for drawing parts such as cap screws, machine screws, etc.[20]

[20] Reprinted from Earle, J. H., 1994, Engineering Design Graphics, 8th ed., with permission from Addison Wesley Publishing Company.

Problem Statement

21. The principal CIM technology that begins a product design cycle is:

A. CAM
B. CAD
C. CAE
D. CAPP

Answer is (B) CAD

CAD or Computer-Aided Design is the principal CIM (Computer Integrated Manufacturing) technology that begins a product design cycle. Computer Aided Manufacturing, Computer Aided Engineering, and Computer Aided Process Planning are all integral parts of CIM, however a preliminary CAD design is the initial step.[21]

[21] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988, Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

22. Tolerance is:

A. difference between mating parts
B. same as allowance
C. permissible deviation from a desired dimension
D. deviation between a drawing and the actual part produced

Answer is (C) permissible deviation from a desired dimension

The total amount by which a dimension may vary or the difference between the limits is the tolerance.[22]

[22] Reprinted from Fundamentals of Manufacturing, pg. 115,1993, Dearborn, MI: Society of Manufacturing Engineers.

Problem Statement

23. A turning operation is to be done on a piece of alloy steel that has a diameter of 3.5 inches. If the depth of cut is set at 0.125 inches, the feed is set at 0.012 inches per revolution, and the recommended cutting speed using a carbide tool is 275 feet per minute, what rpm setting available on the machine should be used?

A. 264 rpm
B. 300 rpm
C. 420 rpm
D. 532 rpm

Given

Steel Diameter (d)	= 3.5 in
Cutting Depth	= 0.125 in
Feed Rate	= 0.012 in/rev
Cutting Speed (CS)	= 275 fpm

Find

Rpm setting

Definitions

d= diameter
CS = cutting speed of the metal

Formula

$$RPM = \frac{12\,(\mathrm{CS})}{\pi\ \mathrm{d}}$$

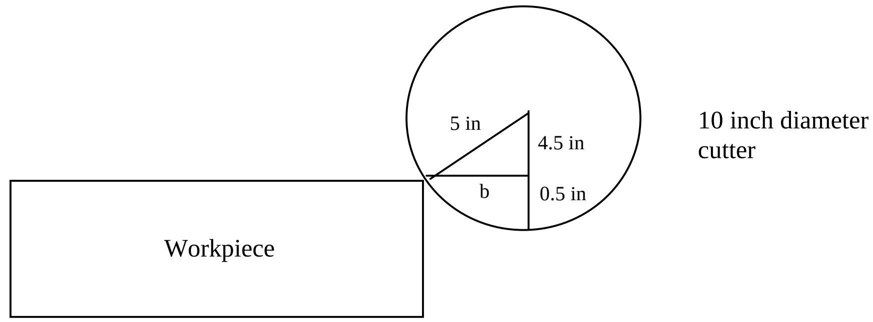
Solution

$$RPM = \frac{12\,(\mathrm{CS})}{\pi\ \mathrm{d}} = \frac{12\ \mathrm{in/ft}\ (275\ \mathrm{ft/min})}{\pi(3.5\ \mathrm{in})/\mathrm{rev}} = 300.1\ \mathrm{rpm}$$

Answer is (B) 300 rpm

Problem Statement

24. The following diagram shows a 10 inch peripheral milling cutter that is set to cut a piece of steel. If the depth of cut is 0.5 inches, how far must the tool travel until the tool is engaged at its full depth on the workpiece (center of tool is positioned over the edge)?



A. 2.18 in.
B. 3.11 in.
C. 4.52 in.
D. 4.75 in.

Given

Cutter diameter = 10 in
Depth of cut = 0.5 in

Find

How far must the tool travel before it is to its full depth of cut.

Definitions

b = distance the cutter must travel before it is to its full depth of cut

Formula

$$b = \sqrt{c^2 - a^2}$$

Solution

The distance the tool must travel, d, is the side of a right triangle. Using the Pythagorean theorem, $c^2 = a^2 + b^2$.

$$b = \sqrt{c^2 - a^2} = \sqrt{5\text{in}^2 - 4.5\text{in}^2} = 2.18\text{in}$$

Answer is (A) 2.18 in

Problem Statement

25. If the diameter of a milling cutter is 12 inches and the cutting speed is 90 fpm, what is the approximate number of revolutions per minute the machine should be set at?

A. 30 rpm
B. 45 rpm
C. 60 rpm
D. 4.75 rpm

Given

Cutter diameter = 12 inches
Cutting speed = 90 ft/min

Find

rpm setting

Definitions

CS = cutting speed of the metal
d= cutter diameter

Formula

$$RPM = \frac{12\,(\mathrm{CS})}{\pi\ \mathrm{d}}$$

Solution

$$RPM = \frac{12\,(\mathrm{CS})}{\pi\ \mathrm{d}} = \frac{12\ \mathrm{in/ft}\ (90\ \mathrm{ft/min})}{\pi(12\ \mathrm{in})/\mathrm{rev}} = 28.7\ \mathrm{rpm}$$

Answer is (A) 30 rpm

Problem Statement

26. The purpose of a riser in a mold is:

A. to help raise the molder
B. the same as a cope
C. to enhance the draft
D. to feed liquid metal into the body of the casting as it solidifies

Answer is (D) to feed liquid metal into the body of the casting as it solidifies

The purpose of a riser in the gating system of a mold is to feed liquid metal into the body of the casting as it solidifies. Risers prevent shrinkage voids which occur where the casting solidifies.[26]

[26] Reprinted from DeGarmo P.E., Black, J.T., & Kohser, R.A., 1997, Materials and Processes in Manufacturing, 8th edition. New Jersey: Prentice Hall. Reproduced with permission.

Problem Statement

27. Emulsified oils are:

A. high in sulphur content
B. oil and water mixtures used for both lubricating and cooling
C. lubricating oils diluted with naphta, kerosene or other petroleum-base solvents
D. oils that have degraded over time

Answer is (B) oil and water mixtures used for both lubricating and cooling

Emulsified oils are oil and water mixtures used for both lubrication and cooling. The oil provides lubrication and corrosion resistance and the water provides excellent cooling characteristics.[27]

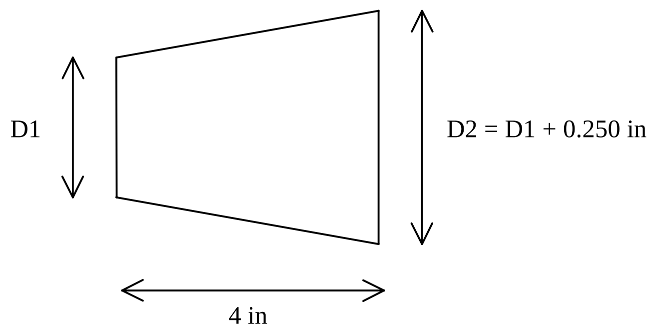
[27] Reprinted from Oberg, E., Jones, F.D., & Holbrook, H.L., 1996. Machinery's Handbook, 25th ed. New York: Industrial Press, Inc. Used with permission.

Problem Statement

28. A tapered bushing is 4 inches long. The diameter of one end should be 0.250 inch larger than the other end. The bushing is mounted on a 16 inch mandrel between centers and is turned with a taper attachment. What should be the setting of the taper attachment in inches per foot?

A. 0.250 inch per foot
B. 0.375 inch per foot
C. 0.500 inch per foot
D. 0.750 inch per foot

Given



Find

Taper setting in inches per foot

Definitions

D1 = smaller diameter
D2 = larger diameter
L = part length

Formula

$$\text{taper per foot} = \frac{D2 - D1}{L}$$

Solution

$$\text{taper per foot} = \frac{D2 - D1}{L} = \frac{0.250\text{in}}{4\,\text{in}\ (1\text{ft}/12\text{in})} = 0.750\text{in}$$

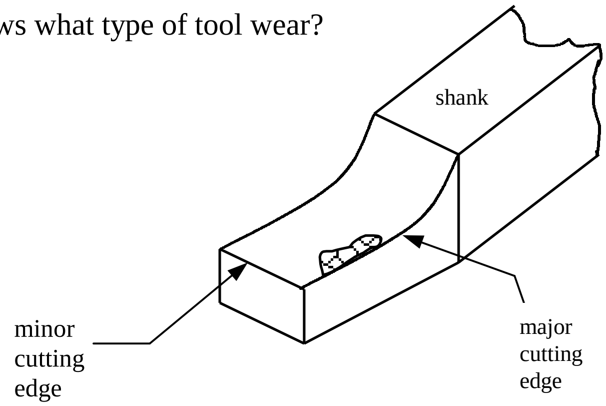
Answer is (D) 0.750 inches per foot

Problem Statement

29. The following diagram shows what type of tool wear?

A. crater wear
B. flank wear
C. edge wear
D. relief wear

Answer is (A) crater wear



The diagram shows crater wear.

Crater wear forms on the face of the tool and forms a short distance behind the cutting edge.[29]

[29] Reprinted from Oberg, E., Jones, F.D., & Holbrook, H.L., 1996, Machinery's Handbook, 25th ed. New York: Industrial Press, Inc. Used with permission.

Problem Statement

30. How much horsepower is needed for a drilling operation to produce a 1.25 inch hole in a workpiece made of cast iron with a hardness of 150 HB. The speed used for this operation is 900 rpm, the feed rate is 0.005 ipr and the unit power requirement is 1.0 $hp/in^3/min$. Assume the machine is running at 80% efficiency.

A. 0.4 HP
B. 0.7 HP
C. 4.0 HP
D. 7.0 HP

Given

d= 1.25 in
rpm = 900
f_r= 0.005 in/rev
P= 1.0 $hp/in^3/min$
E= 80%
Q = material removal rate

Find

Horsepower required

Definitions

d = drill diameter
f_r = feed rate
P = unit horsepower
E= efficiency
Q = material removal rate
n_r = rpm

Formula

$$Q = \frac{\pi}{4} d^2 f_r (n_r)$$

$$hp = \frac{QP}{E}$$

Solution

$$\text{hp} = \frac{QP}{E} = \frac{[\frac{\pi(1.25\,\text{in})^2}{4}(0.005\,\text{in/min})(900\,\text{rpm})][1\text{hp/in}^3/\text{min}]}{0.80} = 6.9\text{hp}$$

Answer is (D) 7.0 HP

Problem Statement

31. The most common type of locating pin designed to minimize contact area between the workpiece and the locating pin, thereby reducing the chances of sticking or jamming is known as?

A. tertiary locator
B. fixture key
C. low limit pin
D. diamond pin

Answer is (D) diamond pin

The most common type of locating pin designed to minimize sticking and jamming by reducing the contact area between the workpiece and the locating pin is the diamond pin. The diamond pin, as its name indicates, is in the shape of a diamond to minimize the contact area.[31]

[31] Reprinted from Curtis, M.A., 1998, Tool Design for Manufacturing. Englewood Cliffs NJ: Prentice Hall.

Problem Statement

32. The simplest and least expensive type of clamping device used to retain the workpiece in a jig or fixture is known as a:

A. strap clamp
B. pipe clamp
C. "C" clamp
D. Jorgeson clamp

Answer is (A) strap clamp

The strap clamp is the simplest and least expensive type of clamping device used to retain the workpiece in a jig or fixture. The strap clamp is used in low-production applications and is available in a variety of configurations.[32]

[32] Reprinted from Curtis, M.A., 1998, Tool Design for Manufacturing. Englewood Cliffs NJ: Prentice Hall.

Problem Statement

33. The portion of a technical report which is written: (1) to avoid technical details, (2) to succinctly present the summary and conclusions of a project or investigation and (3) especially to be read by management is called a:

A. precis
B. abstract
C. executive summary
D. management synopsis

Answer is (C) executive summary

The portion of a technical report which is written: (1) to avoid technical details, (2) to succinctly present the summary and conclusions of a project or investigation and (3) especially to be ready by management is called an executive summary. An executive summary gives the main points and basic details of the entire report. An abstract is a miniature version of the much longer report.[33]

[33] Reprinted from Pauley, S.E., & Riordan, D.G., 1990, Technical Report Writing Today, 4th ed. Boston: Houghton Mifflin Company. Reprinted with permission.

Problem Statement

34. OSHA inspections are almost always conducted:

A. after written notification
B. without prior notice
C. after a company has been operating for five years
D. on an annual basis

Answer is (B) without prior notice

OSHA inspections are almost always conducted without prior notice. An employer representative and employee representative can accompany the compliance officer during the inspection.[34]

[34] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

35. The Occupational Safety and Health Act places the legal obligation to comply on:

A. supervisors
B. employers
C. every employee
D. manufacturers in interstate commerce

Answer is (B) employers

The Occupational Safety and Health Act places the legal obligation to comply on employers. Employers are obligated to provide employees with a workplace free from recognized hazards that are likely to cause death or serious physical harm to the employees.[35]

[35] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

36. If a manufacturing plant had 20 injuries and job-related illnesses during a period in which all employees worked a total of 800,000 hours, what would be the plant's total injury-illness rate based upon OSHA's current factor of hours worked per year by 100 employees?

A. 5.0
B. 5.2
C. 10.4
D. 15.0

Given

20 job related injuries and illnesses
800,000 employee hours worked during that period

Find

Plant's total injury-illness rate

Formula

$$\frac{\text{hours worked by employees during a period}}{\text{work hours per year}} = \frac{\text{number of injuries during the period}}{\text{total injury - illness rate}}$$

Solution

Work weeks per year = 52-2(vacation) = 50 weeks

Hours per year = 50 weeks per year x 40 hours per week) = 2000 hours/year

$$\frac{800{,}000}{200{,}000} = \frac{20}{x}$$

$$x = \frac{(20)(200{,}000)}{800{,}000} = 5.0$$

Answer is (A) 5.0

Problem Statement

37. A letter of transmittal is used:

A. to confirm receipt of a fax document
B. as an e-mail boilerplate
C. to accompany shipments to customers
D. to convey a report from one firm to another

Answer is (D) to convey a report from one firm to another

A letter of transmittal is used to convey a report from one firm to another. Transmittal letters indicate the report enclosed, the date it was requested and a paragraph indicating the report's purpose and scope.[37]

[37] Reprinted from Pauley, S.E., & Riordan, D.G., 1990. Technical Report Writing Today,4th ed. Boston: Houghton Mifflin Company. Reprinted with permission.

Problem Statement

38. What is the available production capacity per week of four automated machines working two eight-hour shifts per day, six days per week, with an average machine utilization rate of 90%?

A. 86 hours
B. 173 hours
C. 345 hours
D. 384 hours

Given

4 automated machines
two 8 hour shifts per day
six days per week
90% average utilization rate

Find

Total available production capacity per week

Formula

Production capacity per week = Design Capacity x Utilization rate

Solution

4 machines (8 hours/shift) (2 shifts/day) (6 days/week) (0.90) = 345.6 hours

Answer is (C) 345 hours

Problem Statement

39. The following data is available: labor and machine total cost is $10.00/hr, operation time is 3 min/part, material cost is $0.10/part. The total cost per part would be:

A. $.40
B. $.60
C. $.75
D. $30.10

Given

labor and machine total cost = $10/hr
operation time = 3 min/part
material cost = $0.10/part

Find

Total cost per part

Solution

Total cost per part = $10/hr (3 min/part) (1 hr/60min) + $0.10 per part = $0.60

Answer is (B) $.60

Problem Statement

40. The initial process through which labor unions and company officials meet to adjust conflicting perspectives and interests is known as:

A. mediation
B. arbitration
C. negotiation
D. collective bargaining

Answer is (C) negotiation

The initial process through which labor unions and company officials meet to adjust conflicting perspectives and interests is known as negotiation. Mediation is when an outside unbiased person helps both parties achieve an agreement. Arbitration is when an outside unbiased person or group develops an arbitrary agreement for both parties involved. Collective bargaining is the process where the union bargains for wages, benefits, etc., with management for all of the union membership.[40]

[40] Reprinted from Amrine, H.T., Ritchey, J.A., & Moodie, C.L., 1987. Manufacturing Organization and Management. Englewood Cliffs NJ: Prentice-Hall. Reprinted with permission.

Problem Statement

41. When using production flow analysis, which of the following criteria is the primary determinant of group membership.

A. tolerances
B. geometeric attributes
C. functional attributes of the part
D. operation sequence and machine routing

Answer is (D) operation sequence and machine routing

When using production flow analysis, operation sequence and machine routing are the criteria for group membership. Production flow analysis is a methodology for grouping parts into families. Group technology decreases part proliferation, design time and equipment cost.[41]

[41] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

42. The analysis of the aggregate production plan, or the master production schedule to determine if there is sufficient capacity at critical points in the production process, is best accomplished with:

A. Material Requirements Planning
B. Capacity Requirements Planning
C. Rough-Cut Planning
D. Manufacturing Resource Planning

Answer is (C) rough-cut planning

Rough-cut planning analyzes the aggregate production plan or the master production schedule to determine if there is sufficient capacity at critical points in the production process. It tests the feasibility of the master schedule and gives an indication of loading levels for both personnel and machine groups involved.[42]

[42] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

43. An Ishikawa diagram can be used to:

A. graphically display the relationships between variables in a two-way factorial experiment
B. analyze the causal relationships between process variables that can affect the quality of the product
C. determine the loss function for a given set of quality characteristics
D. determine the capacity of a process

Answer is (B) analyze the causal relationships between process variables that can affect the quality of the product

An Ishikawa diagram can be used to analyze the causal relationships between process variables that can affect the quality of the product. This is typically called a cause-and-effect analysis. This diagram enables the analysis of an effect for causes by considering the many diverse and complex relationships that exist.[43]

[43] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

44. In statistical process control, the most common size for a sample subgroup is:

A. 5
B. 10
C. 10% of the group
D. 20% of the group

Answer is (A) 5

In statistical process control, the most common size for a sample subgroup is 5. Sample sizes from 2 to 20 can be used, however 5 is commonly used because of the relative ease of further computations. A sample size of 5 is usually large enough to detect small shifts in the mean along with ensuring a normal distribution for the sample means.[44]

[44] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

45. The term X-bar refers to the:

A. mode
B. range
C. mean
D. standard deviation

Answer is (C) mean

The mean shows the value that the measurements tend to cluster around. The arithmetic mean is often called the average value $\bar{x}$ (called "x bar").[45]

[45] Reprinted from Fundamentals of Manufacturing, pg. 124, 1993. Dearborn, MI: Society of Manufacturing Engineers.

Problem Statement

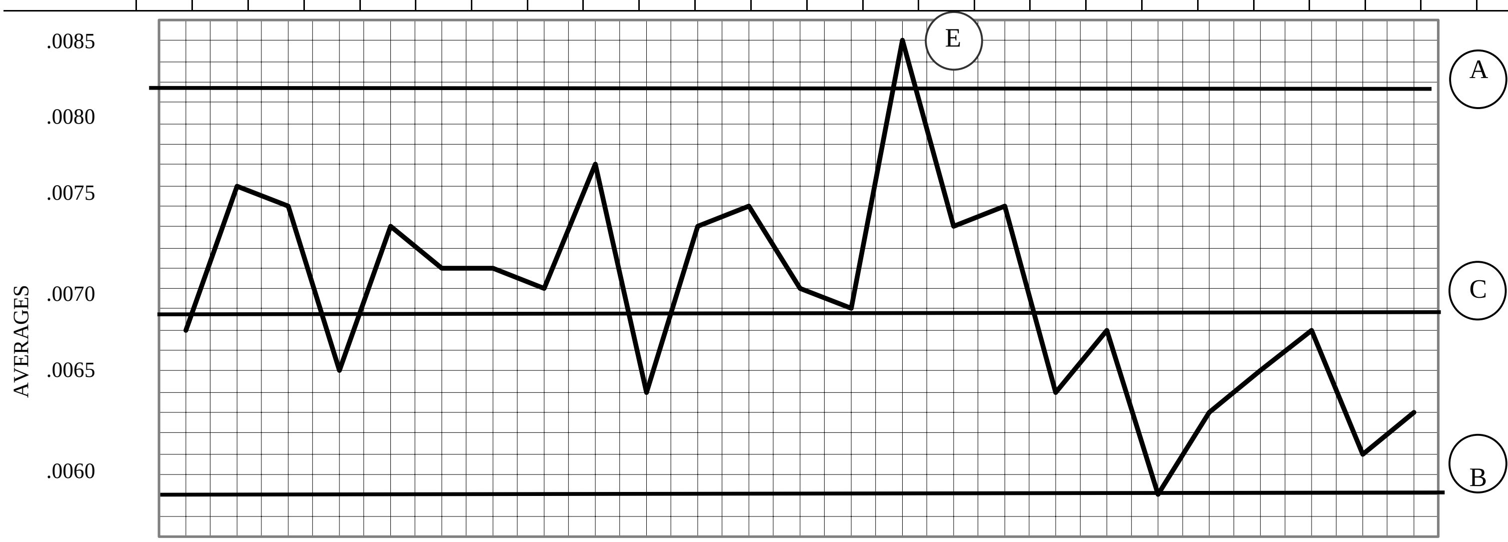
46. Point E on chart 1 indicates a period when:

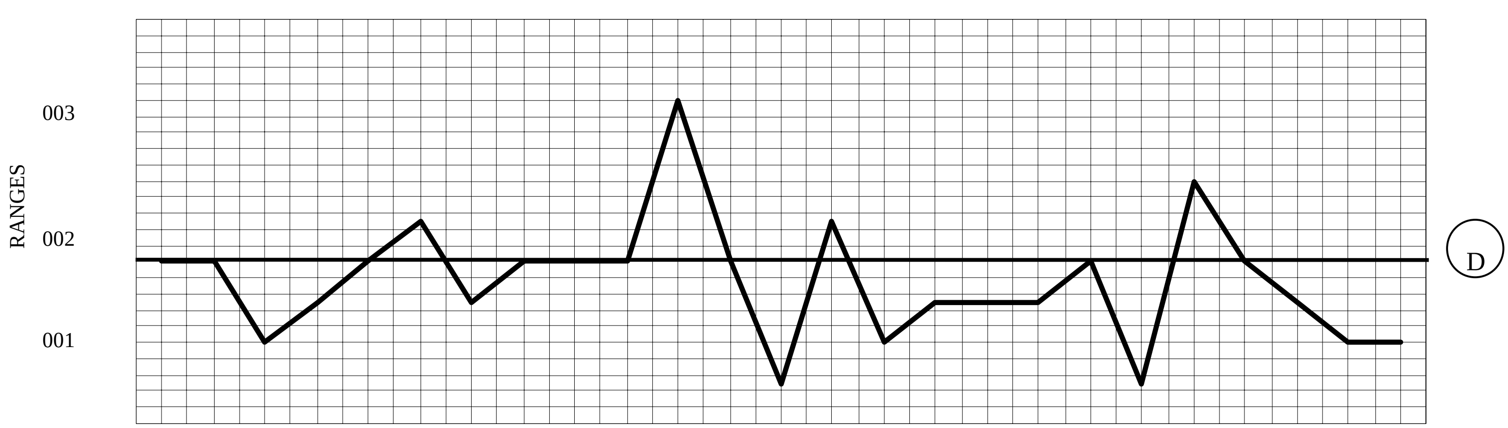
A. the upper control limit was exceeded
B. quality was highest
C. the average process capability exceeded 0.0080
D. the upper tolerance limit was exceeded

CHART 1

			PART NO.	CHART NO.
PART NAME (PRODUCT)	OPERATION (PROCESS)		SPECIFICATION LIMITS	
OPERATOR	MACHINE	GAGE	UNIT OF MEASURE	ZERO EQUALS

DATE																										
TIME																										
SAMPLE MEASUREMENTS	1	6.5	7.5	7.5	6.0	7.0	6.0	7.5	6.0	6.5	6.0	8.0	8.5	7.0	6.5	9.0	7.5	7.5	7.5	6.5	6.0	5.0	6.0	8.0	6.5	6.5
	2	7.0	8.5	8.0	7.0	7.5	7.0	8.0	7.0	8.0	7.0	7.5	7.5	7.0	7.0	8.0	8.0	7.0	7.0	6.5	6.0	5.5	8.0	6.5	6.0	7.0
	3	6.5	7.5	8.0	7.0	7.5	8.0	6.5	8.0	8.5	6.0	9.0	8.5	7.5	8.5	8.0	7.5	8.5	6.0	8.5	6.5	6.5	6.5	6.5	6.5	7.0
	4	6.5	8.5	7.0	7.5	8.5	7.5	7.5	7.5	8.5	8.0	5.0	6.5	7.5	7.5	8.5	8.0	7.0	7.0	6.5	6.0	8.0	6.5	6.5	6.0	6.0
	5	8.5	6.5	7.5	6.5	8.0	7.0	7.0	7.5	7.5	6.5	8.0	7.0	7.0	6.0	8.5	6.5	8.0	6.0	7.0	6.5	8.0	7.5	6.5	7.0	6.5
SUM		35	38.5	38	34	37.5	36.5	36.5	36	39	33.5	37.5	38	36	36.5	42	37.5	38	33.5	35	31	33	34.5	34	32	33
AVERAGE		7.0	7.7	7.6	6.8	7.5	7.3	7.3	7.2	7.8	6.7	7.5	7.6	7.2	7.1	8.4	7.5	7.6	6.7	7.0	6.2	6.6	6.8	7.0	6.4	6.6
RANGE		2.0	2.0	1.0	1.5	2.0	1.5	1.5	2.0	2.0	2.0	4.0	2.0	0.5	2.5	1.0	1.5	1.5	1.5	2.0	0.5	3.0	2.0	1.5	1.0	1.0
NOTES																										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25





Given

Sample averages	Sample ranges
7.0	2.0
7.7	2.0
7.6	1.0
6.8	1.5
7.5	1.5
7.3	2.0
7.3	1.5
7.2	2.0
7.8	2.0
6.7	2.0
7.5	4.0
7.6	2.0
7.2	0.5
7.1	2.5
8.4	1.0
7.5	1.5
7.6	1.5
6.7	1.5
7.0	2.0
6.2	0.5
6.6	3.0
6.9	2.0
6.3	1.5
6.4	1.0
6.6	1.0

Find

UCL = Upper Control Limit

Definitions

X-bar bar = mean of the X-bars
R-bar = mean range
n = number of samples
A_2 = constant

Formulas

$$\bar{\bar{x}} = \frac{1}{n}\sum_{i=1}^{n}\bar{x}$$

$$\bar{R} = \frac{1}{n}\sum_{i=1}^{n}R$$

$$UCL = \text{x} + \text{A}_2(\bar{R})$$

Solution

$$\bar{\bar{x}} = \frac{1}{n}\sum_{i=1}^{n}\bar{x} = 7.136$$

$$\bar{R} = \frac{1}{n}\sum_{i=1}^{n}R = 1.720$$

$$UCL = \text{x} + \text{A}_2(\bar{R}) = 7.136 + 0.729(1.720) = 8.390$$

Sample average #15 (8.40) is greater than 8.390. Therefore, the upper control limit was exceeded.

Answer is (A) the upper control limit was exceeded.

Problem Statement

47. Line D in Chart 1 represents:

A. R-bar
B. X
C. X-bar
D. R

Answer is (A) R-bar

Line D in Chart 1 represents R bar. R bar is equal to 1.720 as calculated in problem 46.

R-bar is the mean or average of all the sample ranges.[47]

[47] Reprinted from Fundamentals of Manufacturing, 1993. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

48. The Capability Index (Cp) is used to:

A. establish the tolerance for a given characteristic
B. determine the accuracy of the equipment that will be used for a process
C. calculate the control limits for X-Bar and R charts
D. determine if a process in a state of control is able to consistently produce results that are within the required tolerances

Answer is (D) determine if a process in a state of control is able to consistently produce results that are within the required tolerances

The Capability Index (Cp) is used to determine if a process in a state of control is able to consistently produce results that are within the required tolerances. The capability of a process can be viewed as the relationship between the specified limits for a dimension and the limits of the natural variability of the dimension.[48]

[48] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

49. A ring gage is used to measure:

A. outside diameter
B. roundness
C. outside diameter and roundness
D. integrity of a grinding wheel

Answer is (C) outside diameter and roundness

A ring gage is selected to functionally check the external diameters of a part for a combination of size and roundness. This functional check is performed with the employment of a Go ring and a separate No Go ring, which are ground to the high and low limits of the diameter in question, respectively. When a diameter is passed as good via inspection with ring gages, it is safe to assume that the diameter will fit its mating part at assembly. When roundness is not a major consideration, a snap gage would provide a less expensive alternative for checking the limits of external diameters.[49]

[49] Reprinted from Curtis, M.A.,1998. Tool Design for Manufacturing, pg. 142. Englewood Cliffs, NJ: Prentice Hall.

Problem Statement

50. Snap gages are used to check:

A. profiles
B. outside diameters
C. diameters of holes
D. surface roughness

Answer is (B) outside diameters

A snap gage is used for external dimensions such as the diameter of a shaft.[50]

[50] Reprinted from Fundamentals of Manufacturing, pg. 118, 1993. Dearborn; MI: Society of Manufacturing Engineers.

Problem Statement

51. An inspector must precisely measure a machined, angled surface on a casting. Which of the following measuring devices would be an appropriate instrument for this application?

A. sine bars
B. Vernier caliper
C. telescopic gages
D. sliding T-Bevel

Answer is (A) sine bars

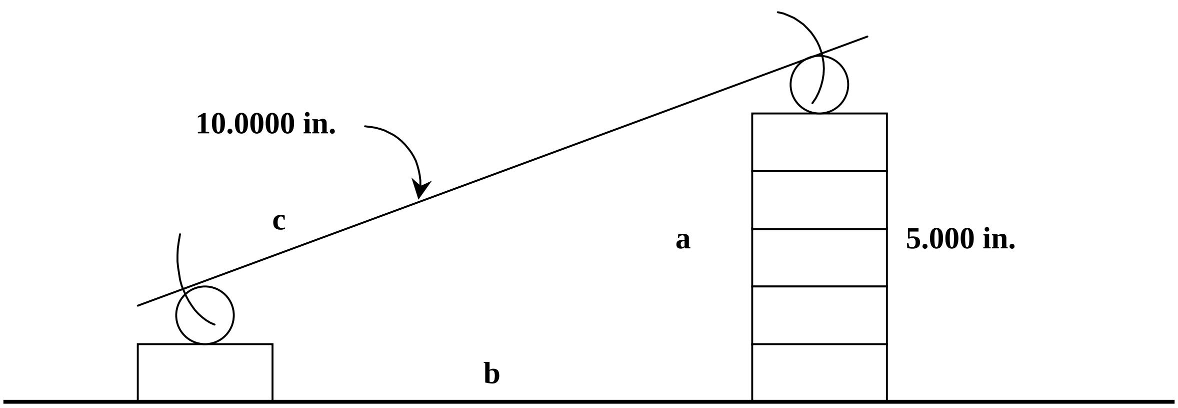
An inspector must measure the angle of a beveled surface on a casting. Sine bars would be an appropriate measuring device for this inspection. The sine bar is very useful when measuring angles when the limit of accuracy is 5 minutes or less.[52]

[52] Reprinted from Oberg, E., Jones, F.D., & Holbrook, H.L.,1996. Machinery's Handbook 25th ed. NewYork: Industrial Press, Inc. Used with permission.

Problem Statement

52. The buttons on a sine bar are 10.0000 inches apart on centers. The bar is to be rested on gage blocks at an angle of 30^o. The difference in height between the two piles of gage blocks must be:

A. 0.866 in.
B. 2.588 in.
C. 5.000 in.
D. 7.071 in.



Given :

$\Theta = 30°$

$C = 10.0000$

$$SIN\Theta = \frac{OPP}{HYP} = \frac{A}{C} = \frac{A}{10}$$

$$a = SIN30°(10) = 0.5000(10.0000)$$

$$a = 5.000 \text{ inches}$$

Answer is (C) 5.000 inches

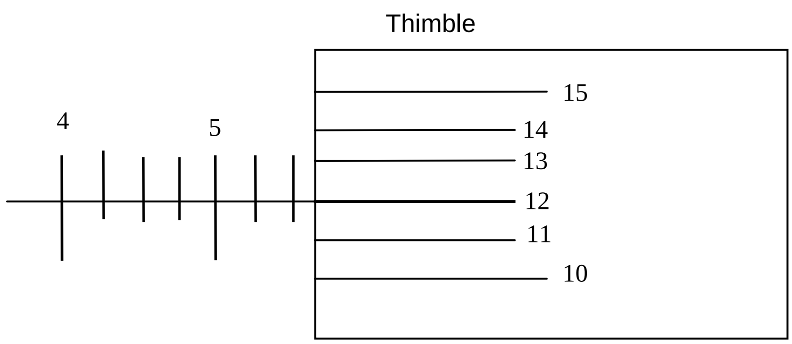
Problem Statement

53. A 1” to 2” micrometer reads as follows: barrel reads .550 and the thimble reads 12. The reading is:

A. 0.552
B. 0.562
C. 1.552
D. 1.562

Answer is (D) 1.562

As illustrated below, the barrel reads .550 and the thimble indicates 0.012. Since this is a 1 in to 2 in micrometer, the diameter is 1.562.



Problem Statement

54. What would be the value A after evaluating the following arithmetic expression?
A= INT(SQRT((2.0*3.0) + (4.0*4.0)))

A. 5
B. 5.0
C. 7
D. 7.0

Answer is (A) 5

The value of A would be 5 after evaluating the expression. The square root of ((2.0*3.0) + (4.0*4.0)) is 4.690. The preceding INT command rounds the answer to the nearest integer which is 5.

Problem Statement

55. NC contouring is an example of:

A. continuous-path positioning
B. point to point positioning
C. absolute positioning
D. incremental positioning

Answer is (A) continuous-path positioning

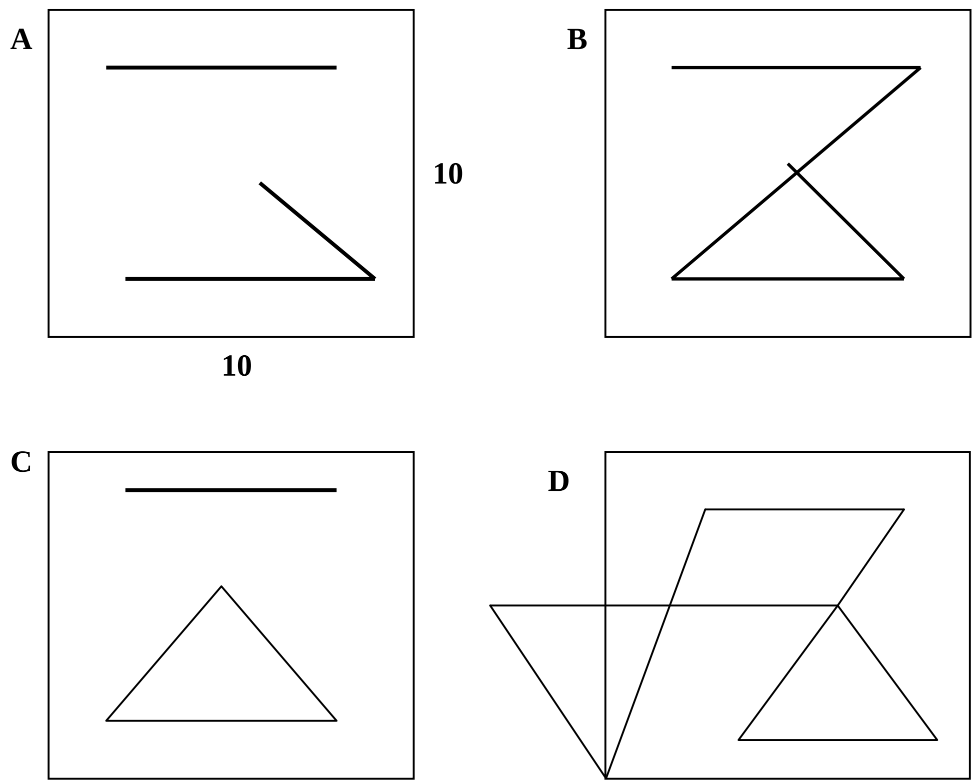
NC contouring is an example of continuous path positioning. Continuous path positioning allows NC machines to perform contouring. Rate and direction of relative movement of machine members is under continuous numerical control. Point to point positioning moves the machine slides until a point is reached with no path control during the transition form one point to the next.[56]

[56] Reprinted from Tool and Manufacturing Engineers Handbook Desk Edition (Desk Edition), 1988. Dearborn, MI: Society of Manufacturing Engineers.

Problem Statement

56. The following NC program will produce which of the in-cut tool paths below?

```
N1     G90  G00  X-2.  Y2.  Z2.  S1000  T1  M06
N2     X2.  Z.1
N3     G01  Z-.125  F8
N4     X8
N5     X5.  Y5.
N6     G00  Z.1
N7     X8.  Y8.
N9     G01  Z-.125 F8
N10    X2.
N11    G00  Z2.
N12    X0  Y0
N13    Z0  M30
```



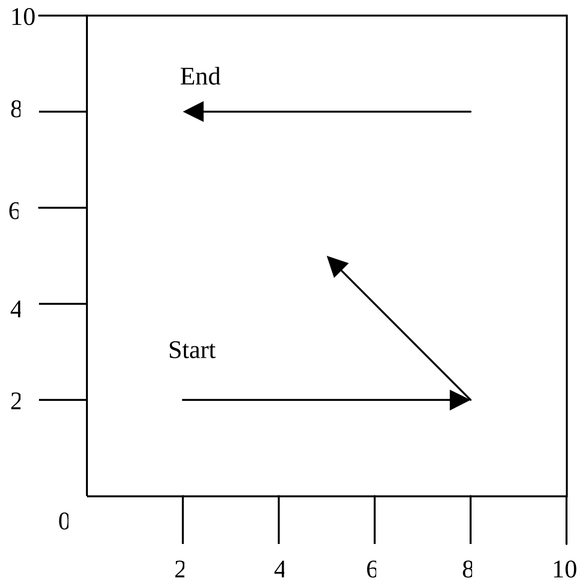
A. A
B. B
C. C
D. D

Answer is (A) shown below

The NC program will generate the following tool path.

According to the program, absolute positioning is specified where the lower left edge of the work is X0, Y0 and the surface is Z0. The tool starts off the work piece at X-2, Y2, Z2. The tool then rapidly traverses over the work to X2, Z.1. The cutter feeds into the work to a depth of 0.125 in. and then proceeds in a straight line to X8. The cutter then proceeds to X5, Y5. It then retracts to 0.1 off the work and rapidly traverses to X8, Y8. The cutter then plunges down 0.125 into the work piece and then proceeds to X2.

A



Problem Statement

57. A CNC machine tool that defaults to "leading zero suppression" and is capable of three decimal place accuracy would interpret the number 12 as:

A. 0.012
B. 0.120
C. 1.200
D. 12.000

Answer is (A) 0.012

A CNC machine tool that defaults to "leading zero suppression" and is capable of three decimal place accuracy would interpret the number 12 as 0.012. Leading zero suppression eliminates the insignificant leading zeroes to the left of the significant digits.[58]

[58] Reprinted from Seamers, W.S., 1986. Computer Numerical Control: Concepts and Programming. Albany NY: Delmar Publishers. Reproduced by permission.

Problem Statement

58. On a cylindrical robot, which of the following is not a basic degree of freedom?

A. the rotation of the arm
B. the radial telescoping
C. the closing of the end effector
D. the left to right swivel of the wrist

Answer is (C) the closing of the end effector

On a robot the closing of the end effector is not a basic degree of freedom. A degree of freedom is a joint linking two sections of a robot allowing freedom of motion. The base of the robot can move in the X and Y direction and twist accounting for 3 degrees of freedom. The wrist of the robot has pitch, roll, and yaw which account for another 3 degrees of freedom.[59]

[59] Reprinted from Tool and Manufacturing Engineers Handbook (Desk Edition), 1988. Dearborn MI: Society of Manufacturing Engineers.

Problem Statement

59. Which type of robotic power system should be selected for extremely quick and accurate assembly of small components?

A. mechanical
B. pneumatic
C. electrical
D. hydraulic

Answer is (C) electrical

Electricity is the power system of choice for robot arms. It is clean, quiet, capable of fast moves, well understood, and requires little maintenance.[60]

[60] Reprinted from Fundamentals of Manufacturing, 1993. Dearborn, MI: Society of Manufacturing Engineers.

Sample Problems
Reference List

This section contains a list of references used for the sample problems.

1. Advanced Manufacturing Technology, Goetsch, D.L., Albany NY: Delmar, 1990.

2. Applied Statics and Strength of Materials 2nd ed., Spiegel, L., & Limbrunner, G.F., New York: Macmillan, 1991.

3. Calculus 4th ed., Larson, R.E., Hostetler, R.P., & Edwards, B.E., Lexington, MA: D.C. Heath & Company, 1990.

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5. CRC Standard Mathematical Tables 28th ed., Beyer, W.H. (Eds.), Boca Raton, FL: CRC Press, 1987.

6. Dictionary of Manufacturing Terms, R. Veilleux, Society of Manufacturing Engineers: Dearborn, MI, 1987.

7. Engineering Design Graphics 8th ed., Earle, James H., New York: Addison Wesley Publishing Company, 1994.

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9. Fundamentals of Physics 3rd ed., Halliday, D., & Resnick, R., New York: John Wiley & Sons, Inc., 1988.

10. Machinery's Handbook 25th ed., Oberg, E., Jones, F.D., & Holbrook, H.L., New York: Industrial Press, Inc., 1996.

11. Manufacturing Organization and Management, Amrine, H.T., Ritchey, J.A., & Moodie, C.L., Englewood Cliffs, NJ: Prentice-Hall, 1987, 1992.

12. Materials and Processes in Manufacturing, 8^{th} edition, DeGarmo P.E., Black, J.T., & Kohser, R.A., New Jersey: Prentice Hall, 1997.

13. Problem Solving and Structured Programming in FORTRAN 77 4th ed., Koffman, E.B., & Friedman, F.L., New York: Addison-Wesley, 1990.

14. Production Operations and Management 6th ed., Chase, R.B., & Aquilno, N.J., Boston: Irwin, 1992.

15. Technical Report Writing Today 4th ed., Pauley, S.E., & Riordan, D.G., Boston: Houghton Mifflin, 1990.

16. Tool and Manufacturing Engineers Handbook Desk Edition, Dearborn, MI: Society of Manufacturing Engineers, 1988.

17. Tool Design for Manufacturing, Curtis, M.A., Englewood Cliffs, NJ: Prentice Hall, 1986, 1998.

Additional References

This section contains a list of references covering exam content areas.

Since the examination covers a broad range of content, you may find the following three references to be most beneficial.

1. Fundamentals of Manufacturing, Dearborn, MI: Society of Manufacturing Engineers, 1993.

2. Fundamentals of Manufacturing Self-Assessment Program, Dearborn, MI: Society of Manufacturing Engineers, 1996.

3. Tool and Manufacturing Engineers Handbook (TMEH) Desk Edition, Dearborn, MI: Society of Manufacturing Engineers, 1988.

Below is a list of references used to develop items for the Fundamentals of Manufacturing Exam. Some references contain similar information so you may not need to consult each one.

1. Mathematics/Applied Science

Machinery's Handbook, 25th Edition, E. Oberg, F. Jones, H. Horton, Industrial Press, 1996.

2. Materials

Machinery's Handbook, 25th Edition, E. Oberg, F. Jones, H. Horton, Industrial Press, 1996.

Tool and Manufacturing Engineers Handbook, Desk Edition, SME, Dearborn, MI, 1988.

3. Product Design

Manufacturing Organization and Management 5th Edition, H. Amrine, J. Ritchie and C. Moodie, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1992.

Tool and Manufacturing Engineers Handbook, Desk Edition, SME, Dearborn, MI, 1988.

4. Manufacturing Processes

Fundamentals of Tool Design, 4th Edition, SME, Dearborn, MI, 1998.

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Manufacturing Organization and Management, 5th Edition, H. Amrine, J. Ritchie and C. Moodie, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1992.

Tool and Manufacturing Engineers Handbook, Desk Edition, SME, Dearborn, MI, 1988.

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Tool and Manufacturing Engineers Handbook, Volume 4, Quality Control and Assembly, SME, Dearborn, MI, 1988.

5. Management and Economics

Fundamentals of Tool Design, 4th Edition, SME, Dearborn, MI, 1998.

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Statistical Quality Control, 6th Edition, E. Grant and R. Leavenworth, McGraw-Hill, New York, 1988.

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7. Computer Applications and Automation

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