

STUDENTS DO NOT OPEN THIS TEST OR BEGIN UNTIL INSTRUCTED TO START

2023 Examination for the National Agricultural Technology and Mechanical Systems Career Development Event

Answer Key Do Not Distribute

- If a diagram, picture, or table is needed to answer a question, the question will refer to the appropriate figure/page.
- Read each question carefully and determine the single correct answer.
- If a mark on the scan sheet needs to be changed, completely erase the incorrect answer and clearly mark the appropriate answer on the answer sheet.
- Each student needs a calculator to complete this examination, but calculators may not be shared between students.
- Formulas and conversion values are provided. Do not round off intermediate answers when using the calculator to solve these problems.

Students are **NOT allowed** to use any type of electronic communication device, including but not limited to cellular telephones, pagers, two way radios, or PDAs, during the CDE on Wednesday or Thursday. If a student uses, handles, or accesses any type of electronic communication device, she or he may be disqualified. If a personal emergency should arise during the CDE, students should contact a CDE official immediately for assistance.

Order, Point Assignment, and AFNR Alignment* for Exam Questions (2 points each)

1. Machinery PST.02.02	6. Environmental ESS.05.01	11. Structural PST.04.01.02.c	16. Compact Equipment PST.03.01	21. Electrical PST.03.02.01.c
2. Electrical PST.03.02	7. Machinery PST.03.03	12. Environmental ESS.03.02	17. Structural PST.04.03	22. Compact Equipment CS.03.02
3. Compact Equipment PST.03.01.01.a	8. Electrical PST.04.04	13. Machinery PST.03.03	18. Environmental CS.04.01	23. Structural PST.04.02
4. Structural PST.04.02.01.b	9. Compact Equipment PST.03.01	14. Electrical PST.04.04	19. Machinery PST.01.03	24. Environmental ESS.05.01
5. Environmental NRS.03.02	10. Structural PST.04.02.02.c	15. Compact Equipment PST.03.01	20. Electrical PST.05.02	25. Machinery PST.02.02

*Competency numbers (PST.02.02.) accompanying each question coincides with numbered AFNR performance indicators listed in the ATMS Handbook.

This exam begins on the back of this sheet.

You may write on this exam, but information written on this exam is not graded.
Mark all answers on the scan sheet.

2023 Written Examination for the National Agricultural Technology & Mechanical Systems Career Development Event

Mark all answers on the scan sheet using a pencil. Read each question carefully and mark the single correct answer on the scan sheet. Each student needs a calculator to complete this examination, but calculators may not be shared between students. Information written on this exam will not be graded.

1. **Machinery:** A combine costs \$1.55 per acre, what is the cost to operate the combine for a rectangular field measuring 2147 meters by 0.85 miles? 1 acre = 43,560 square feet 1 hectare = 2.47 acres 1 acre = 0.4045 Hectares

Area of Rectangle = length x width

1 mile = 5,280 feet

1 foot = 0.3048 meter

- A. \$578.60
B. \$613.50
C. \$1,123.50
D. \$1,124.90

$$2147 \text{ m} \times 1 \text{ ft} / 0.3048 \text{ m} \times 0.85 \text{ mi} \times 5280 \text{ ft} / 1 \text{ mi} \times 1 \text{ ac} / 43,560 \text{ ft}^2 = 725.7416 \text{ ac}$$

$$725.7416 \times \$1.55 = \$1,124.89948$$

2. **Electrical:** A variety of incandescent lights are all operating on a single 120-volt electrical circuit in a livestock barn. The circuit includes ten 150-watt lights, three 300-watt lights, and twelve 40-watt lights. What is the amperage of the circuit with all of these lights operating?

Total Wattage = Voltage x Amperage

- A. 13.2 amps
B. 17.5 amps
C. 23.2 amps
D. 24.0 amps

$$W = V \times A$$

$$(10 \times 150 \text{ Watts}) + (3 \times 300 \text{ Watts}) + (12 \times 40 \text{ Watts}) = 2880 \text{ watts}$$

$$2880 \text{ watts} = 120\text{-Volt} \times \text{Amps}$$

$$2880 \text{ watts} \div 120\text{-volts} = \text{Amps} = 24 \text{ Amps}$$

3. **Compact Equipment:** For a naturally aspirated engine, what component mixes air and fuel in the proper ratio for efficient combustion?

- A. Throttle body
B. Choke Valve
C. Carburetor
D. Injector

While spark ignition engines can be equipped with carburetor or fuel injection system, injectors do not mix air and fuel. The injector meters the fuel based on inputs received by the onboard engine controller. Throttle body varies the amount of air entering an engine.

4. **Structural:** Steel angle iron is sold for \$1.79 per linear foot, steel tubing is sold for \$2.11 per linear foot, and rebar is sold for 56 cents per linear foot. If 112 feet of angle iron, 95 feet of tubing, and twelve 20-foot lengths of rebar are purchased, and 6.67% taxes are paid with the purchase, what is the approximate total price for the metal?

- A. \$ 474.96
B. \$ 493.96
C. \$ 524.96
D. \$ 571.04

$$112' \times \$1.79 / \text{ft} = \$200.48$$

$$95' \times \$2.11 / \text{ft} = \$200.45$$

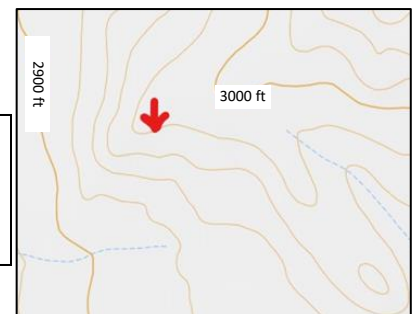
$$12 \times 20' \times \$0.56 / \text{ft} = \$134.40 \quad \text{Total} = \$535.33$$

$$\$535.33 \times 1.0667 \text{ tax} = \$571.036511$$

5. **Environmental:** Refer to the enlarged view of contour lines (in feet) on the topographic map at the right of the page. What is the elevation of the line marked by the arrow?

- A. 2980 feet
B. 3500 feet
C. 4100 feet
D. 4600 feet

There are five spaces (equal changes in elevation) between 2900 feet and 3000 feet. $(3000' - 2900') \div 5 = 20 \text{ ft}$. Each space between lines represents 20' of elevation change. There are four spaces from 2900' so: $(2900') + (4 \times 20') = 2980'$



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6. **Environmental:** Using the foresight rod measurement marked with the arrow in the image provided, what is the elevation of the unknown point? Assume a benchmark elevation of 1,252 feet and a backsight of 2.45. A Philadelphia rod is used.

- A. 1,242.20 feet
 B. 1,247.02 feet
 C. 1,254.45 feet
 D. 1,261.80 feet

Height of instrument = $2.45 + 1,252 \text{ ft} = 1,254.45 \text{ ft}$

Elevation = $1,254.45 \text{ ft} - 7.43 = 1,247.02$



7. **Machinery:** For a hydraulic cylinder, which dimension determines the output force in psi?

- A. Diameter of the cylinder
 B. Length of the cylinder
 C. SAE grade of the hydraulic oil
 D. The horsepower of the hydraulic pump

Pressure (PSI) is a function of force applied to a specific area.
 Diameter of a cylinder is used to find the area.

8. **Electrical:** Circuit protection devices for motor circuits incorporate a time-delay component to allow for a brief period of overload needed for electric motor _____.

- A. controllers
 B. cool-down
 C. starting
 D. shifting

electric motor start up general draws higher amperage and requires a small time delay to protect the conductors in the circuit.

9. **Compact Equipment:** Which component would not be at fault when troubleshooting the fuel delivery system of a gravity-feed float bowl style carburetor?

- A. Fuel pump
 B. Emulsion tube
 C. Fuel hose
 D. Float-needle

Gravity-feed carburetors rely on atmospheric pressure and a negative pressure created by the venturi to force fuel into the air stream entering the carburetor. Fuel travels through a fuel hose from the tank directly to the carburetor and the fuel level in the bowl is controlled by the needle and float

10. **Structural:** For a non-family placement/internship agricultural production SAE, what is the FLSA maximum height that a person under 16 years old may work from using a ladder or scaffold?

- A. 15 feet
 B. 18 feet
 C. 20 feet
 D. 25 feet

Non-family indicates this is not a family-owned employer. This would be a farm-based or agricultural production SAE which falls underneath the FLSA regarding youth employment. Youth under the age of 16 are prohibited from working from heights greater than 20 ft unless a written agreement indicated that work be under direct and close supervision of a qualified and experienced person, and it should be incidental to the training. Additionally, exemptions can be revoked if the situation indicates that reasonable precautions were not observed for the safety of minors employed. Prohibited work that exceeds one hour a day to be more than intermittent and more than for short periods of time. The Wage and Hour Division also considers the performance of otherwise prohibited work which totals more than 20% of the student-learner's work shift to be more than for short periods of time. It is highly recommended to limit youth from working at these heights as part of an SAE.

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11. **Structural: Which roof type is the most used for agricultural structures?**

- A. Gambrel
- B. Gable
- C. Arch
- D. Hip and Gable

Gable roofs are the simplest roof style and has been used extensively in agricultural structures. Other roof styles are architecturally more visually appealing but require extensive design to construct thereby increasing cost of construction and maintenance. Given the practicality and function, most of the roofs found on agricultural structures are gable for reduced cost and maintenance.

12. **Environmental: The Revised Universal Soil Loss Equation is composed of six factors to predict the long-term average annual soil loss and one of those values is the soil erodibility factor (K factor). What is the soil texture with the highest K factor range?**

- A. Sandy loam
- B. Silt loam
- C. Clay
- D. Silt

Soils high in clay resist detachment while soils with coarse texture such as sand increase permeability but often are easily detached. Medium texture soils such as silt are moderately susceptible to detachment and produce moderate runoff. Soils having a high silt content are most erodible of all soils. They are easily detached; tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4.

13. **Machinery: What is the approximate speed, in miles per hour, for a fertilizer spreader that travels 176 yards in 1 minute and 53.5 seconds?**

5,280 ft = 1 mile 60 seconds = 1 minute 60 minutes = 1 hour 1 foot = 0.3048 meter

- A. 2.95 miles per hour
- B. 3.17 miles per hour
- C. 3.95 miles per hour
- D. 4.34 miles per hour

$(176 \text{ yds} / 113.5 \text{ sec}) \times (3 \text{ ft} / 1 \text{ yd}) \times (60 \text{ sec.} / \text{min.} \times 60 \text{ min.} / 1 \text{ hr}) \times (1 \text{ mi} / 5,280 \text{ ft})$
Speed = 3.171806167 mph

14. **Electrical: In a series-wound motor , the stator windings are connected in series with the armature, while in a _____, wound-motor the stator windings are parallel.**

- A. perpendicular
- B. resistance
- C. reverse
- D. shunt

A series motor responds by decreasing its speed with small increase in current for a given load torque. A shunt motor holds its speed nearly constant with large increase in input current for same amount

15. **Compact Equipment: Each cylinder in a three-cylinder engine has a circumference of 11.6 inches and a piston stroke of 6.5 inches. What is the approximate total displacement of the engine in liters?**

Information: 1 liter = 61 cubic inches Circumference of a circle = $2 \times \pi \times \text{radius}$
Area of a cylinder bore = $\pi \times \text{radius}^2$ $\pi = 3.14$ radius = diameter $\div$ 2
Displacement of a single cylinder = (length of piston stroke) x (the area of the cylinder bore)

- A. 3.4 liters
- B. 4.1 liters
- C. 4.6 liters
- D. 5.1 liters

$3 \text{ cyl} \times 3.14 \times [11.6" \div (2 \times 3.14)]^2 \times 6.5" \times 1 \text{ lit} / 61 \text{ in}^3 = 3.424767 \text{ liters}$

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16. **Compact Equipment:** A gasoline mower's power takeoff (PTO) produces 20 horsepower and turns at 1500 revolutions per minute. Approximately how much torque, in foot-pounds, can this PTO produce?

$$\text{Torque in foot-pounds} = \frac{\text{PTO Horsepower} \times 5252}{\text{Revolutions / Minute}}$$

- A. 65.02 foot-pounds
 B. 70.03 foot-pounds
 C. 85.02 foot-pounds
 D. 95.03 foot-pounds

$$20 \text{ hp} \times 5252 \div 1500 \text{ rpms} = 70.026 \text{ ft-lbs}$$

17. **Structural:** Concrete is poured inside a vertical tube form to construct a pylon. If 1.50 cubic yards of concrete are needed to fill the pylon that is 12 feet 5 inches tall, what is the approximate inside diameter of the pylon in inches?

1 cubic yard = 27 cubic feet

1 cubic foot = 1728 cubic inches

1 foot = 12 inches

Volume of cylinder = $\pi \times (\text{cylinder radius})^2 \times \text{cylinder height}$

$\pi = 3.14$ diameter = $(2 \times \text{radius})$

- A. 12.23 inches
 B. 15.65 inches
 C. 24.46 inches
 D. 28.55 inches

Convert the 5 inches to feet $(5/12) = 0.41667 \text{ ft} + 12 \text{ ft} = 12.41667 \text{ ft}$ height of tube

Convert 1.50 yd³ to cu.ft $(27\text{ft}^3 \times 1.50\text{yd}^3) = 40.5 \text{ ft}^3 / 12.41667 \text{ ft} = 3.26174409\text{ft}^2$

$3.26174409 \text{ ft}^2 \div 3.14 = \sqrt{1.038772003\text{ft}^2} = 1.01920165 \text{ ft} * 12 = 12.2304198 \text{ in}$

$12.2304198 * 2 = 24.4608396 \text{ inches diameter}$

18. **Environmental:** What flood control mechanism serves to contain excess water runoff temporarily to allow the water to slowly drain or evaporate?

- A. detention pond
 B. retention pond
 C. swale
 D. culvert

Differences between retention and detention ponds are the location of the drain and the permanent presence of water. Retention ponds has a riser and orifice at a higher point than a detention pond and therefore keep water. The retention pond is used to remove pollutants from the runoff. Swales are types of ditches or channels to divert water away from crops. A culvert is a structure that channels water past an obstacle or to a subterranean waterway.

19. **Machinery:** A recommendation for a CNC plasma table is to ensure an air pressure of 80 psi for high quality cuts. The air compressor provides 235 psi, what component should be installed to ensure high quality cuts?

- A. gouging torch tip
 B. voltmeter
 C. oil injection pump
 D. pressure regulator

While water is a major source of contamination that deteriorates torch consumables, air pressure should be reduced using a pressure regulator. Pressure regulators are adjustable to allow for specific pressures to be used with the system. Gouging tips are not used for cutting and do not affect pressure rates.

20. **Electrical:** When wiring to control the same light from three different locations, what switch combination must be used?

- A. (2) three-way switches
 B. (2) three-way switches and a four-way switch
 C. (3) four-way switches and a three-way switch
 D. (3) DPDT switches

Four-way switches must be used with a pair of three-way switches

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21. **Electrical:** A water supply station used to refill pesticide tanks has a 3-horsepower electrical pump that operates at 120 volts. If the motor is 90 percent efficient and has a 0.8 power factor, what is the approximate amperage of the motor?

1 horsepower = 746 Watts

$$\text{horsepower} = \frac{\text{voltage} \times \text{amperage} \times \text{power factor} \times \text{efficiency}}{746}$$

- A. 8.1 amps
- B. 26.0 amps
- C. 32.5 amps
- D. 259.1 amps

$$3 \text{ hp} = \frac{120 \text{ V} \times ? \text{ A} \times 0.8 \times 0.90}{746} \quad \text{Amps} = 25.9027777777778$$

22. **Compact Equipment:** What does the pictorial represent?

- A. safety alert
- B. slow moving vehicle alert
- C. service alert
- D. tire pressure alert

AEM general hazard alert or warning



23. **Structural:** Which construction material would have the highest K-value but the lowest R-value?

- A. Polyurethane foam
- B. 2x4 Wood stud
- C. Concrete block
- D. Cellulose insulation

The k-factor is the conductivity while the R-value is the resistance to heat flow. Concrete has a very high k-factor and therefore low resistance to heat flow.

24. **Environmental:** What computer software is used to map, model, query, and analyze large quantities of data within a single database according to georeferenced data?

- A. Variable-rate technology
- B. Site-specific management
- C. Global positioning system
- D. Geographic information system

Global positioning system is a U.S.-owned utility that provides users with positioning, navigation, and timing (PNT) services. GIS connects data to a map, integrating location data with all types of descriptive data. This provides a foundation for mapping and analysis. GIS helps users understand patterns, relationships, and geographic context.

25. **Machinery:** When driving agricultural machinery traveling at speeds 25 miles per hour or less on public roads, what should be visible from at least 500 feet from the rear of the equipment?

- A. Speed Identification Sign
- B. Operator Station
- C. Slow Moving Vehicle Emblem
- D. Registration and License Plate

Slow moving vehicle emblems should be visible at least 500 feet from the rear of the machinery traveling 25 mph or less on public roads. Speed identification signs are used when machinery is traveling over 25 mph but under 40 mph. Registration and licensing is not a requirement of implements of husbandry. Many large foldable tillage implements may block the visibility of the operator station from oncoming traffic.

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