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

2016 Examination for the
National Agricultural Technology and Mechanical Systems
Career Development Event

Name ____________________________________________

Print Name Legibly

Read the following instructions:
Mark all answers on the Scantron sheet using a pencil.

• You have one hour to complete this exam.
• You may write on this exam, but information on this exam is not graded. Blank sheets are provided if additional calculation space or scratch paper is needed.
• If a diagram, picture, or table is needed to answer a question, the question will refer to the appropriate page.
• Read each question carefully and determine the single correct answer.
• If a marked on the Scantron answer needs to be changed, completely erase the incorrect answer and clearly mark the appropriate answer on the Scantron.
• Each student needs a calculator to complete this examination, but calculators may not be shared between students.
• Formulas and conversion values are provided. Take care not to round off intermediate answers when using a calculator to solve 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 and Point Assignment for Exam Questions (2 points each)

|--------------|------------------|---------------|-----------|---------------|

This exam begins on the back of this sheet.

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Mark all answers on the Scantron sheet.
2016 Written Examination for the
National Agricultural Technology & Mechanical Systems
Career Development Event

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1. Machinery: Approximately how many acres are in a rectangular field measuring 1094 meters by 1.25 miles?
   
   \[ \text{Acre} = 43,560 \text{ square feet} \quad \text{Hectare} = 2.47 \text{ acres} \quad 1 \text{ acre} = 0.4045 \text{ Hectares} \]
   
   Area of Rectangle = length \times width \quad 1 \text{ mile} = 5,280 \text{ feet} \quad 1 \text{ foot} = 0.3048 \text{ meter}
   
   A. 321.6 acres  
   B. 391.7 acres  
   C. 463.5 acres  
   D. 543.8 acres

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 60-watt lights, eight 100-watt lights, and four 200-watt lights. What is the amperage of the circuit with all of these light operating?

   Total Wattage = Voltage \times Amperage

   A. 8.6 amps  
   B. 12.5 amps  
   C. 15.4 amps  
   D. 18.3 amps

3. Energy: A 180 horsepower eight-cylinder engine is operating at 4870 feet above sea level. What approximate horsepower can be produced by the engine when the engine’s power is reduced 2.25 percent for each 1000 feet of elevation above sea level?

   A. 133.1 horsepower  
   B. 147.2 horsepower  
   C. 160.3 horsepower  
   D. 172.4 horsepower

4. Structural: Four solid rectangular steel bars each has cross sectional measurements of 1.5 inches by 3 inches and a combined maximum tensile strength 1,170,000 pounds. What is the maximum tensile strength of each bar in pounds per square inch (psi)?

   A. 11,700 psi  
   B. 65,000 psi  
   C. 260,000 psi  
   D. 292,500 psi

5. Environmental: In order to protect ground water from animal waste contaminants a concrete slab will be poured using forms that have inside dimensions of 34 feet, 9 inches by 23 feet, 3 inches. The forms allow for a concrete slab that is 6 inches deep. What is the approximate quantity of concrete that will be needed to pour this slab?

   1 cubic yard = 27 cubic feet
   1 gallon = 231 cubic inches  
   1 cubic-foot = 1728 cubic-inches
   Volume of rectangular prism = \text{Length} \times \text{Width} \times \text{Height}

   A. 13 \text{ yd}^3  
   B. 15 \text{ yd}^3  
   C. 17 \text{ yd}^3  
   D. 19 \text{ yd}^3

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6. Environmental: If a center pivot irrigation system is 500 meters long (has a 500-meter radius), approximately how many acres can be irrigated under the pivot's boom during 360 degrees of travel?

\[
\text{Area of a circle} = \pi \times (\text{radius})^2 \quad \text{diameter} = 2 \times \text{radius} \\
1 \text{ acre} = 43,560 \text{ square feet} \quad 1 \text{ mile} = 5,280 \text{ feet} \quad 1 \text{ foot} = 0.3048 \text{ meter}
\]

A. 18.0 acres  
B. 111.8 acres  
C. 181.8 acres  
D. 1,118.6 acres

7. Machinery: Each cylinder in a six-cylinder tractor engine has a bore (diameter) of 4.62 inches and a piston stroke of 6.1 inches. What is the approximate total displacement of this engine in liters?

\[
\text{Area of a cylinder bore} = \pi \times (\text{radius})^2 \quad \pi = 3.14 \quad \text{radius} = (\text{diameter} \div 2) \\
\text{Volumetric displacement of a single cylinder} = \text{(length of piston stroke)} \times (\text{the area of the cylinder bore}) \\
1 \text{ liter} = 61 \text{ cubic inches} \quad 1 \text{ cubic inch} = 0.0164 \text{ liter}
\]

A. 6 liters  
B. 8 liters  
C. 10 liters  
D. 12 liters

8. Electrical: A water pump for stock tanks has an electrical motor that operates at 120 volts and uses 20 amps of current. If the motor is 87.5 percent efficient and has a 0.89 power factor, what is the approximate horsepower of the motor?

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

A. 2.5 horsepower  
B. 7.6 horsepower  
C. 9.7 horsepower  
D. 11.8 horsepower

9. Energy: An available electronic thermometer is calibrated in degrees Fahrenheit (°F). A livestock feed decontamination process indicates that a temperature of 82 degrees Celsius (°C) is necessary. What is the approximate temperature equivalent in degrees Fahrenheit?

\[
\text{°F} = \frac{9}{5} \text{°C} + 32 \quad \text{°C} = \frac{5}{9} (\text{°F} - 32) \quad \text{Water freezes at 32 °F} \quad \text{Water boils at 212 °F}
\]

A. 100 °F  
B. 140 °F  
C. 180 °F  
D. 220 °F

10. Structural: Steel angle iron is sold for $1.79 per linear foot, steel rod is sold for 92 cents per linear foot, and steel pipe is sold for $2.91 per linear foot. If 60 feet of angle iron, 20 feet of rod, and 63 feet of pipe are purchased, and 7% taxes are paid with the purchase, what is the approximate total price for the metal?

A. $330.77  
B. $383.66  
C. $429.55  
D. $493.44

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11. **Structural:** Which of the following quantities of lumber has the greatest number of board-feet?

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1 board-foot = 144 cubic inches</td>
<td>1 square foot = 144 square inches</td>
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</tbody>
</table>

A. 13 boards measuring 1 inches by 6 inches by 12 feet  
B. 11 boards measuring 1 inch by 8 inches by 12 feet  
C. 12 boards measuring 2 inches by 4 inches by 10 feet  
D. 9 boards measuring 2 inches by 6 inches by 8 feet

12. **Environmental:** If a animal waste storage tank measures 60 feet wide by 33 yards long. Approximately how deep must the container be to hold 200,500 gallons of liquid?

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<table>
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<tbody>
<tr>
<td>1 gallon = 0.133681 cubic feet</td>
<td>1 yard = 3 feet</td>
</tr>
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</table>

A. 2.90 feet  
B. 3.41 feet  
C. 4.92 feet  
D. 5.63 feet

13. **Machinery:** What is the approximate speed, in miles per hour, for a planter that travels 100 meters in 39.5 seconds?  

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<tr>
<td>5,280 ft = 1 mile</td>
<td>3600 seconds = 1 hour</td>
</tr>
</tbody>
</table>

A. 3.44 miles per hour  
B. 4.55 miles per hour  
C. 5.66 miles per hour  
D. 6.77 miles per hour

14. **Electrical:** Three incandescent light bulbs (100 Watts, 200 Watts, 300 Watts) are operating properly in a 120 volt electrical circuit. If each bulb operates at 120 volts, which of the following statements is correct in regard to the operation of the bulbs?

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<table>
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<tbody>
<tr>
<td>Wattage = Voltage × Amperage</td>
<td>Voltage = Amperage × Resistance</td>
</tr>
</tbody>
</table>

A. All three bulbs operate at the same amperage.  
B. All three bulbs have the same electrical resistance.  
C. The 100-watt light bulb has less electrical resistance (ohms) than the 200- or 300-Watt light bulbs.  
D. The 100-watt light bulb has more electrical resistance (ohms) than the 200- or 300-Watt light bulbs.

15. **Energy:** This question refers to the sample gas bill for a large dairy shown below. Including the connection fee, taxes, and the gas consumption charge, what is the total amount paid by the dairy operator for each cubic-foot of natural gas?

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>$ 0.79 per ft³</td>
<td>$ 0.86 per ft³</td>
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</tbody>
</table>

A. $ 0.79 per ft³  
B. $ 0.86 per ft³  
C. $ 24.08 per ft³  
D. $ 29.35 per ft³

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**Sample Natural Gas Monthly Bill:**  
September 29, 2016 to October 27, 2016 (28 days)

<p>| | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>NATURAL GAS CONSUMPTION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current Meter Reading (cubic-feet)</td>
<td>1932</td>
<td>Gas Consumption Charge</td>
</tr>
<tr>
<td>Previous Meter Reading (cubic-feet)</td>
<td>1533</td>
<td>Monthly Connection Fee</td>
</tr>
<tr>
<td>Meter Difference (cubic-feet)</td>
<td>399</td>
<td>Subtotal</td>
</tr>
<tr>
<td>Average Consumption (cubic-feet / day)</td>
<td>14.25</td>
<td>City/State/Energy Taxes (8.9%)</td>
</tr>
</tbody>
</table>

| Volume Multiplier | 0.088894 | Current Total Due | $ 343.14 |

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1 kWh = 3412.3 Btu  
1 therm = 100,000 Btu (approximate, varies seasonally)

*Volume Multiplier: Converts gas volume (cubic-feet read on meter) to therms of gas consumed (value varies seasonally).

A British thermal unit (Btu) is the heat required to raise the temperature of one pound of water one degree Fahrenheit.

Therm: Unit of measurement used by gas companies to convert the volume of gas to its heat equivalent (actual energy).
16. Energy: A water pump has a 3.5-inch diameter pulley that must turn at 1000 revolutions per minute (rpm). The shaft of a electric motor rotates at 1725 rpm and powers the belt that turns the pump's pulley. What is the approximate diameter of the pulley needed on the motor shaft to turn the pump at 1000 rpm? Pulley Size Formula: (Diameter of Pulley 1 x Speed of Pulley 1) = (Diameter of Pulley 2 x Speed of Pulley 2)
   A. 1.0 inches 
   B. 1.3 inches 
   C. 1.7 inches 
   D. 2.0 inches 

17. Structural: A rectangular wooden box is used to ship livestock mineral blocks. Each mineral block weights 42.5 pounds and measures 10 inches by 10 inches by 14 inches. Only whole blocks are shipped. This wooden box has a maximum carrying capacity of 2,050 pounds. The boards used in the box are 1.5 inches thick and each side, top, and bottom of the box is two boards thick. The external length and width of the box each measurements 48 inches. There are 16 mineral blocks on each layer within the box. What is an appropriate measurement for the box's external height?
   Volume of rectangular prism = Length \times Width \times Height
   A. 40 inches 
   B. 44 inches 
   C. 48 inches 
   D. 52 inches 

18. Environmental: Water flows through 109 feet of horizontal pipeline that includes four 90 degree elbows. The water flow rate is 6.25 gallons per minute where the water exits the 109-foot pipeline. The pressure loss through the pipeline is equivalent to 6.4 vertical feet of head (pressure) loss per 100 feet of horizontal run. The head loss through each elbow is equivalent to that of 4.85 feet of additional horizontal length. Approximately, what is the vertical head (pressure) loss for this horizontal pipeline?
   A. 8.2 feet of head loss 
   B. 12.4 feet of head loss 
   C. 69.2 feet of head loss 
   D. 109.0 feet of head loss 

19. Machinery: A hydraulic cylinder that operates the arm of a skid steer loader has a bore diameter of 3 inches and a stroke of 36 inches. The tractor's hydraulic system produces a maximum pressure of 2,900 pounds per square inch. Approximately, what is the maximum force the cylinder can exert on the lift arm?
   Area of a cylinder bore = \(\pi \times \text{(radius)}^2\) 
   \(\pi = 3.14\) 
   \(\text{radius} = (\text{diameter} \div 2)\) 
   A. 11,099 pounds 
   B. 14,811 pounds 
   C. 17,644 pounds 
   D. 20,488 pounds 

20. Electrical: The monthly charge to operate an electric pump is 12.75 cents per kilowatt hour (kwh) for the first 1000 hours and 13.9 cents for each kwh greater than 1000 hours. If the pump uses 6.75 kilowatts per hour and it operates 22 days each month for 12 hours each day, what is the approximate monthly kwh charge to operate the pump?
   Information: 1 kilowatt = 1000 Watts \hspace{1cm} 100 cents = $1.00
   A. $196.30 
   B. $236.20 
   C. $274.10 
   D. $314.00
21. Electrical: An old electrical motor has 'burned' out and must be replaced. The old motor operated an average of 10.5 hours each day, 27 days each month, and its average annual electrical bill was $11,895. The replacement cost for a motor (identified as A) that is identical to the old motor sells for $789 dollars and the installation charge is $276. An energy efficient motor (identified as B) sells for $1,092 and the installation charge is $314. Motor B will have an average cost of $3.39 per hour to operate. Approximately how many months must motor B operate to make up (payback) the higher cost to purchase and install an energy efficient motor rather than motor A? 1 year = 12 months

Motor Burnout Payback Period = \( \frac{(\text{total cost for high efficient equipment B}) - (\text{total cost for identical equipment A})}{\text{(average saving in energy cost per month)}} \)

A. 10.4 months  
B. 11.3 months  
C. 12.2 months  
D. 13.1 months

22. Energy: This question refers to the sample natural gas bill for the dairy that is printed at the bottom of page 4 (accompanying Question 15) on this exam. Based on the values show on the sample bill, what is the approximate charge per therm for natural gas (excluding connection fee and taxes)?

A. $5.84 per therm  
B. $6.79 per therm  
C. $7.63 per therm  
D. $8.50 per therm

23. Structural: A round concrete column (cylinder) is fabricated using 1.5 cubic yards of concrete. If the concrete column is 15 feet 6 inches in height, what is the approximate diameter of the column?

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. 21.9 inches  
B. 27.8 inches  
C. 28.4 inches  
D. 29.7 inches

24. Environmental: When a large quantity of manure was initially stored on a concrete slab it was 27 percent solids and 73 percent moisture by weight. In the spring the unprotected manure's moisture content increased to 90 percent due to melting snow. The weep walls around the manure storage slab allowed 19 percent of the manure's moisture (19% of 90%) to be drained off prior to a field application. What approximate percentages of solids remain at the time of application?

\[ 1.00 = 100\% \]

A. 12.1% solids  
B. 13.2% solids  
C. 14.3% solids  
D. 15.4% solids

25. Machinery: Refer to the information in Question 24 above. Assume a manure spreader will is used for a field application of the manure (solids and liquids) described in Question 24. The manure spreader will hold a maximum of 4800 gallons of the manure and the manure (liquid and solids) will have an average weight of 8.43 pounds per gallon. Approximately how many pounds of solids are applied with each of the spreader's full loads?

A. 4,896 pounds  
B. 5,341 pounds  
C. 5,786 pounds  
D. 6,231 pounds