

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

## 2017 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 Competency Alignment\* for Exam Questions (2 points each)

1. Machinery 1.16, 6.1, 6.4-7	6. Environmental 4.17, 4.18, 4.19, 6.1, 6.4-7	11. Structural 5.1, 5.2, 5.3, 5.22, 6.1, 6.4-7	16. Compact Equipment 3.1, 3.4, 3.15, 3.21, 6.1, 6.4-7	21. Electrical 2.4, 2.6, 2.7, 2.10, 6.1, 6.4-7
2. Electrical 2.4, 6.1, 6.4-7	7. Machinery 1.14, 1.16, 1.17, 6.1, 6.4-7	12. Environmental 4.2, 4.11, 6.1, 6.4-7	17. Structural 5.1, 5.2, 5.3, 5.4, 6.1, 6.4-7	22. Compact Equipment 3.1, 3.15, 3.21, 6.1, 6.4-7
3. Compact Equipment 3.1, 3.4, 6.1, 6.4-7	8. Electrical 2.4, 2.10, 6.1, 6.4-7	13. Machinery 1.16, 1.17, 6.1, 6.4-7	18. Environmental 4.15, 4.18, 6.1, 6.4-7	23. Structural 5.1, 5.3, 5.6, 6.1, 6.4-7
4. Structural 5.2, 5.22, 6.1, 6.4-7	9. Compact Equipment 6.1, 6.4-7	14. Electrical 2.4, 2.11, 6.1, 6.4-7	19. Machinery 1.17, 3.5, 6.1, 6.4-7	24. Environmental 1.16, 4.2, 4.4, 4.5, 4.14, 4.18, 6.1, 6.4-7
5. Environmental 4.2, 4.4, 4.14, 6.4-7	10. Structural 5.2, 6.1, 6.4-7	15. Compact Equipment 3.15, 6.1, 6.4-7	20. Electrical 2.1, 2.11, 6.1, 6.4-7	25. Machinery 1.15, 1.16, 1.17, 6.1, 6.4-7

\*Competency numbers (1.2, 2.1, 3.1, 4.1, 6.1 etc.) accompanying each question coincide with numbered competencies listed on ATMS CDE web site.

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Mark all answers on the scan sheet.*

## 2017 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 1940 meters by 0.75 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. 491.6 acres
- B. 578.6 acres
- C. 613.5 acres
- D. 683.5 acres

$$1940 \text{ m} \times 1 \text{ ft} / 0.3048 \text{ m} \times 0.75 \text{ mi} \times 5280 \text{ ft} / 1 \text{ mi} \times 1 \text{ ac} / 43,560 \text{ ft}^2 = 578.621 \text{ ac}$$

2. **Electrical:** A variety of incandescent lights are all operating on a single 120-volt electrical circuit in a livestock barn. The circuit includes four 100-watt lights, five 150-watt lights, and six 60-watt lights. What is the amperage of the circuit with all of these lights operating?

Total Wattage = Voltage x Amperage

- A. 10.5 amps
- B. 12.6 amps
- C. 14.7 amps
- D. 16.8 amps

$$W = V \times A$$

$$(4 \times 100 \text{ Watts}) + (5 \times 150 \text{ Watts}) + (6 \times 60 \text{ Watts}) = 120 \text{ volts} \times \text{amps}$$

$$\text{amps} = 12.5833333 \text{ amps}$$

3. **Compact Equipment:** A 25 horsepower single-cylinder engine is operating at 3,480 feet above sea level. What approximate horsepower can be produced by the engine if the engine's power is reduced 1.5 percent for each 1000 feet of elevation above sea level?

- A. 23.1 horsepower
- B. 23.7 horsepower
- C. 24.3 horsepower
- D. 24.9 horsepower

$$25 \text{ horsepower} - [ 25 \text{ hp} \times 3480 \text{ ft} \times (0.015 / 1000 \text{ ft}) ] = 23.695 \text{ hp}$$

4. **Structural:** Steel angle iron is sold for \$1.46 per linear foot, steel rod is sold for 94 cents per linear foot, and steel pipe is sold for \$2.76 per linear foot. If 35.5 feet of angle iron, 12 feet of rod, and 100 inches of pipe are purchased, and 7% taxes are paid with the purchase, what is the approximate total price for the metal?

- A. \$ 78.14
- B. \$ 86.11
- C. \$ 92.14
- D. \$ 100.11

$$35.5' \times \$1.46 / \text{ft} = \$51.83$$

$$12' \times \$0.94 / \text{ft} = \$11.28$$

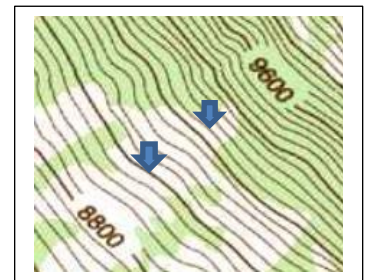
$$100'' \times 1 \text{ ft} / 12'' \times \$2.76 / \text{ft} = \$23 \quad \text{Total} = \$86.11$$

$$\$86.11 \times 1.07 \text{ tax} = \$92.1377$$

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 change between the lines identified by the tips of the two arrows?

- A. 120 feet
- B. 240 feet
- C. 360 feet
- D. 480 feet

There are 20 spaces (equal changes in elevation) between 8800 feet and 9600 feet.  $(9600' - 8800') \div 20 = 40 \text{ ft}$   
 Each space between lines represents 40' of elevation change.  
 There are six spaces between arrows so:  $6 \times 40' = 240'$  in elevation change.



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6. **Environmental:** A 10 horsepower pump is required to produce the desired flow rate for water. The new piping/plumbing system that will be used will reduce the efficiency of a pump 12 percent. If the manufacturer of the pump being purchased recommends a 10 percent oversizing of horsepower to compensate for pump inefficiency, what approximate size water pump should be purchased for this situation? 1.00 = 100%

- A. 7.5 horsepower
- B. 10.0 horsepower
- C. 12.5 horsepower
- D. 13.0 horsepower

$$\text{Pump HP} = 10 \text{ hp} \times 1.12 \times 1.10 = 12.32 \text{ hp}$$

7. **Machinery:** A portable irrigation pump has a 5.5-inch diameter pulley that must turn at approximately 400 revolutions per minute (rpm). The shaft of the tractor's PTO that powers the pump rotates at 540 rpm and rotates the pump using a belt and two-pulley system. What is the approximate diameter of the pulley needed on the PTO shaft to turn the pulley on the pump at 400 rpms? Pulley Size Formula: (Diameter of Pulley 1 x Speed of Pulley 1) = (Diameter of Pulley 2 x Speed of Pulley 2)

- A. 3.0 inches
- B. 3.5 inches
- C. 4.0 inches
- D. 4.5 inches

$$(5.5 \text{ in} \times 400 \text{ rpms}) = (? \text{ in} \times 540 \text{ rpms}) \Rightarrow \text{diameter} = 4.074''$$

8. **Electrical:** A water pump for stock tanks has an electrical motor that operates at 120 volts and uses 13.8 amps of current. If it is a 1.5 horsepower motor and it operates with a power factor of 0.92, what is the approximate efficiency of the motor? 1 horsepower = 746 Watts

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

- A. 2.5 %
- B. 64.3 %
- C. 73.4 %
- D. 81.5 %

$$1.5 \text{ hp} = \frac{120 \text{ V} \times 13.8 \text{ A} \times 0.92 \times \text{Efficiency}}{746} \ggggg \text{Eff.} = 0.7344833$$

$$\text{Eff.} = 73.4\%$$

9. **Compact Equipment:** Which of the following will have the greatest weight in pounds: 4.6 gallons of gasoline, 4.1 gallons of diesel, 3.8 gallons of 15W-40 engine oil, or 3.9 gallons of automatic transmission fluid?

1 gallon of gasoline = 6.3 pounds                      1 gallon of diesel = 6.943 pounds  
 1 gallon 15W-40 engine oil = 7.3 pounds              1 gallon automatic transmission fluid = 7.298 pounds

- A. 4.6 gallons of gasoline
- B. 4.1 gallons of diesel
- C. 3.8 gallons of 15W-40 engine oil
- D. 3.9 gallons of automatic transmission fluid

4.6 gals gas x 6.3 lbs / 1 gal	=	28.98 lbs
4.1 gals diesel x 6.943 lbs / 1 gal	=	28.4663 lbs
3.8 gals oil x 7.3 lbs / 1 gal	=	27.74 lbs
3.9 gals fluid x 7.298 lbs / 1 gal	=	28.4622 lbs

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

1 board-foot = 144 cubic inches                      1 square foot = 144 square inches

- A. 10 boards measuring 1 inches by 10 inches by 10 feet
- B. 10 boards measuring 1 inch by 8 inches by 12 feet
- C. 7 boards measuring 2 inches by 6 inches by 12 feet
- D. 5 boards measuring 2 inches by 10 inches by 10 feet

Nominal Measurement Comparison (same answer for actual)

$$10 \times 1'' \times 10'' \times 10' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 83.33 \text{ bd-ft}$$

$$10 \times 1'' \times 8'' \times 12' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 80 \text{ bd-ft} \text{ ***}$$

$$7 \times 2'' \times 6'' \times 12' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 84 \text{ bd-ft}$$

$$5 \times 2'' \times 10'' \times 10' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 83.33 \text{ bd-ft}$$

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11. **Structural:** Four solid round steel rods are 12 feet long and each have a diameter of 2.5 inches. If the rods have a cross sectional tensile strength of 70,000 pounds per square inch, what is the combined maximum tensile strength (approximate value in pounds) for all four rods?

Area of a circle =  $(\pi) \times (\text{radius})^2$        $\pi = 3.14$       radius = (diameter  $\div$  2)

- A. 1,131,250 pounds
- B. 1,265,500 pounds
- C. 1,373,750 pounds
- D. 1,492,000 pounds

$$4 \times 3.14 \times (2.5'' / 2)^2 \times 70,000 \text{ psi} = 1,373,750 \text{ lbs}$$

12. **Environmental:** The Universal Soil Loss Equation is composed of six factors to predict the long-term average annual soil loss and one of those values is slope of the land area expressed as a percentage. What is the approximate slope (percentage) of the land that changes elevation from 1875 feet to 1384 feet over a distance of 1.24 miles?      Slope = Rise  $\div$  Run  $\times$  (100% / 1)

- A. 4.5 %
- B. 5.5 %
- C. 6.5 %
- D. 7.5 %

$$\begin{aligned} \text{Slope} &= (1875' - 1384') \div (1.24 \text{ miles} \times 5,280 \text{ ft. / mi.}) \times 100\% / 1 \\ \text{Slope} &= 7.499389\% \end{aligned}$$

13. **Machinery:** What is the approximate speed, in miles per hour, for a fertilizer spreader that travels 110 meters in 1 minute and 6.5 seconds?

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

- A. 3.7 miles per hour
- B. 4.2 miles per hour
- C. 4.7 miles per hour
- D. 5.2 miles per hour

$$\begin{aligned} (110 \text{ m} / 66.5 \text{ sec}) \times (1 \text{ ft} / 0.3048 \text{ m}) \times (60 \text{ sec.} / \text{min.} \times 60 \text{ min.} / 1 \text{ hr}) \times (1 \text{ mi} / 5,280 \text{ ft}) \\ \text{Speed} = 3.7002 \text{ mph} \end{aligned}$$

14. **Electrical:** A 240-volt air conditioning unit uses 63 kilowatt hours of power during 24 hours of operation. What is the approximate size of this air conditioning unit in tons of refrigeration (disregard efficiency)? One ton of air conditioning removes heat at the rate equivalent to melting one ton of ice during a period of 24 hours.

Information: British Thermal Unit (BTU): 3412.14 BTUs = 1 kilowatt hour  
1 Ton of Refrigeration = 12,000 BTUs / hour (the rate of heat removal)

- A. Three-Quarter Ton
- B. One Ton
- C. One and One-Half Tons
- D. Two Tons

$$\begin{aligned} \text{Ton Refrigeration} &= \frac{3412.14 \text{ BTUs}}{1 \text{ kwh}} \times \frac{\text{Ton}}{12,000 \text{ BTUs} / \text{hr}} \times \frac{63 \text{ kwh}}{24 \text{ hrs}} \\ &\gg = 0.746 \text{ or } 3/4 \text{ Ton Refrigeration} \end{aligned}$$

15. **Compact Equipment:** An engine manual requires each head bolt to be torqued to 13 Newton meters (Nm) during reassembly. The torques wrench available is calibrated in foot pounds (ft. lbs.). What approximate torque in ft. lbs. is equivalent to 13 Nm?

4.44822 Newtons = 1 pound force      0.22481 pound force = 1 Newton  
1 meter = 3.28084 feet      1 foot = 0.3048 meters

- A. 6.3 ft. lbs.
- B. 7.4 ft. lbs.
- C. 8.5 ft. lbs.
- D. 9.6 ft. lbs.

$$\begin{aligned} 13 \text{ Nm} \times 0.22481 \text{ lbs} / 1 \text{ N} \times 3.28084 \text{ ft} / 1 \text{ m} &= 9.58835 \text{ ft. lbs.} \\ \text{Or} \\ 13 \text{ Nm} \times 1 \text{ lbs} / 4.44822 \text{ N} \times 1 \text{ ft} / 0.3048 \text{ m} &= 9.58831 \text{ ft. lbs.} \end{aligned}$$

16. **Compact Equipment:** A gasoline mower's power takeoff (PTO) produces 18 horsepower and turns at 540 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. 142.4 foot-pounds
- B. 153.3 foot-pounds
- C. 164.2 foot-pounds
- D. 175.1 foot-pounds

$$18 \text{ hp} \times 5252 \div 540 \text{ rpms} = 175.06667 \text{ ft-lbs}$$

17. **Structural:** Concrete is poured inside a vertical pipe to provide rigidity to the pipe. If 0.75 cubic yards of concrete are needed to fill the pipe that is 10 feet 9 inches tall, what is the approximate inside diameter of the pipe 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. 18.6 inches
- B. 19.9 inches
- C. 20.2 inches
- D. 21.5 inches

$$0.75 \text{ yd}^3 = 3.14 \times (\text{diameter} \div 2 \times 1' / 12'')^2 \times 10.75' \times (1 \text{ yd}^3 / 27 \text{ ft}^3)$$

$$\text{diameter} = (\sqrt{0.75 \text{ yd}^3 \times 27 \text{ ft}^3 / 1 \text{ yd}^3 \div 3.14 \div 10.75'}) \times 2 \times 12'' / 1'$$

$$\text{diameter} = 18.588943''$$

18. **Environmental:** Water flows through 97.5 feet of horizontal pipeline that includes three 90 degree elbows. The water flow rate is 5.5 gallons per minute (GPM) where the water exits the 97.5-foot pipeline. The pressure loss through the pipeline is equivalent to 6.6 vertical feet of head (pressure) loss per 100 feet of horizontal run. The head loss through each elbow is equivalent to that of 4.9 feet of additional horizontal length and there are no water leaks. Approximately, what is the water flow rate at the source and what is the equivalent vertical head (pressure) loss for this horizontal pipeline?

- A. 6.5 GPM and 4.2 feet of head loss
- B. 6.5 GPM and 6.3 feet of head loss
- C. 5.5 GPM and 7.4 feet of head loss
- D. 5.5 GPM and 8.5 feet of head loss

$$\text{loss} = [97.5 \text{ ft} + (3 \text{ els.} \times 4.9 \text{ ft} / \text{el.})] \times (6.6 \text{ ft loss} / 100 \text{ ft}) = 7.4052 \text{ ft}$$

Flow rate at source = flow rate at end

19. **Machinery:** Each of two hydraulic cylinders raise and lower the arms that operate the bucket on a skid steer loader. Each cylinder has a bore diameter of 2.75 inches and a stroke of 34.5 inches. The tractor's hydraulic system produces a maximum pressure of 3,200 pounds per square inch. Approximately, what is the maximum combined force that these two cylinders can exert on the lift arms?

Area of a cylinder bore =  $(\pi) \times (\text{radius})^2$        $\pi = 3.14$   
 Force = Pressure  $\times$  Area      radius =  $(\text{diameter} \div 2)$

- A. 19,334 pounds
- B. 25,884 pounds
- C. 31,664 pounds
- D. 37,994 pounds

$$\text{Force} = 2 \times \text{Pressure} \times \text{Area} = 2 \times 3,200 \text{ lb/in}^2 \times 3.14 \times (2.75 \text{ in.} / 2)^2 = 37,994 \text{ lbs}$$

20. **Electrical:** A farm building that is poorly insulated is located in a zone of the U.S. that typically requires 50 BTUs per square-foot of floor area to adequately heat the interior. If the interior dimension of the rectangular building is 26.75 feet by 13 yards and the model of furnace being purchased is 87% efficient, what approximate size furnace is required?

Information: Furnace output is rated in British Thermal Units (BTUs)  
 1 yard = 3 feet      Furnace Size in BTUs =  $\frac{\text{Number of square feet} \times \text{Number of BTUs per square foot}}{\text{Furnace Efficiency}}$

- A. 60,000 BTUs
- B. 70,000 BTUs
- C. 80,000 BTUs
- D. 90,000 BTUs

$$\text{Furnace Size} = \frac{26.75' \times 13 \text{ yds} \times 3' / 1 \text{ yd} \times 50 \text{ BTUs} / \text{sq ft}}{0.87} = 59,956.897 \text{ BTUs}$$

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21. **Electrical:** Refer to the nameplate shown at the right of the page for an electric motor. Which of the following describes the characteristics of: (1) this motor when it is correctly operating at full load amperage (FLA) on 230 volts and (2) the maximum safe amperage when the 230-volt motor is slightly overloaded and must operate at an amperage higher than full load amperage?

ELECTRIC MOTOR NAMEPLATE					
MODEL 500	SPLIT PHASE		TOTALLY ENCLOSED		
FRAME	TYPE	INS. CLASS	IDENTIFICATION NO.		
145	KC	J	2538094990298209		
HP	RPM	VOLTS	AMPS	CYC	S.F.
1 1/2	1725	115/230	15/7.5	60	1.25
DESIGN CODE: B			PHASE	EFF	p.f.
DRIVE END BEARING BBD 116			1	62%	75%
OPP. END BEARING B0B 117			DUTY: CONTINUOUS		
AMB 40 C			NO THERMAL PROTECTION		

From Nameplate:  
 At 230 volts (connected for high voltage operation)  
 The motor has a FLA of 7.5 amps.  
 The Service Factor (SF) allows 1.25 x 7.5 amps = 9.375 amps

- A. 15 FLA and cannot be safety operated over 15 amps
- B. 7.5 FLA and cannot be safety operated over 7.5 amps
- C. 15 FLA and safely up to 18.75 amps when overloaded
- D. 7.5 FLA and safely up to 9.375 amps when overloaded

22. **Compact Equipment:** Each cylinder in a four-cylinder tractor engine has a bore (diameter) of 2.85 inches and a piston stroke of 4.25 inches. What is the approximate total displacement of this engine in liters?

Area of a cylinder bore =  $(\pi) \times (\text{radius})^2$        $\pi = 3.14$       radius = (diameter  $\div$  2)  
 Volumetric displacement of a single cylinder = (length of piston stroke) x (the area of the cylinder bore)

- A. 1.2 liters      1 liter = 61 cubic inches      1 cubic inch = 0.0164 liter
- B. 1.8 liters
- C. 2.5 liters
- D. 2.9 liters

$$4 \text{ cyl} \times 3.14 \times (2.85 \text{ in} / 2)^2 \times 4.25 \text{ in} \times (1 \text{ L} / 61 \text{ in}^3) = 1.77696 \text{ L}$$

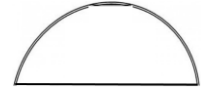
23. **Structural:** Intake and/or exhaust fans should have the capacity in cubic feet per minute to adequate exchange the air in a greenhouse every three minutes. The rectangular floor of a greenhouse measures 40 feet by 80 feet and the walls and roof are made of plastic sheeting stretched over plastic pipe hoops positioned as half circles. The hoops give the greenhouse a perfect half cylinder shape with each hoop having a diameter of 40 feet. In cubic feet per minute, what is the approximate size fan needed to ventilate the greenhouse?

Volume of a cylinder =  $(\pi) \times (\text{radius})^2 \times \text{length}$   
 $\pi = 3.14$       diameter =  $(2 \times \text{radius})$

- A. 16,750 cubic feet per minute
- B. 17,250 cubic feet per minute
- C. 17,750 cubic feet per minute
- D. 18,250 cubic feet per minute

$$\text{CFM} = 1/3 \times 1/2 [3.14 \times (40' \div 2)^2 \times 80']$$

$$\text{CFM} = 16,746.66667 \text{ ft}^3 / \text{min.}$$



End view of greenhouse.

24. **Environmental:** A field has a legal land area of 100 acres with horizontal measurements being 800 feet by 5,445 feet. The 800-foot dimension is flat (horizontal), but the longer dimension has a gradual elevation change from 2006 feet to 2998 feet. Although the legal land area is 100 acres, the sloped surface area must be used when calculation fertilizer, pesticide, and seeding applications. What is the approximate area, in acres, for the sloped surface of the field?

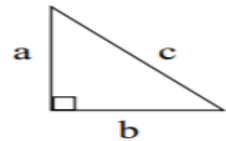
Calculating length of side for right triangle uses the Pythagorean Theorem:  $a^2 + b^2 = c^2$   
 Area of rectangle = Length x Width      1 acre = 43,560 square feet

- A. 100.54 acres
- B. 101.65 acres
- C. 102.76 acres
- D. 103.87 acres

$$\text{Sloped Area of Land:}$$

$$= 800' \times \sqrt{[(2,998' - 2,006')^2 + (5,445')^2]} \times 1 \text{ ac} / 43,560 \text{ ft}^2$$

$$= 101.6460306 \text{ acres}$$



25. **Machinery:** A utility tractor is re-equipped with high profile tires (larger diameter than the factory equipped tires). If the original tires had a 38.5-inch outside diameter and the new larger tires have a 44.8-inch outside diameter, what is the approximate speed of the tractor (miles per hour, with larger diameter tires) when the tractor's mechanical speedometer displays 15 miles per hour? Assume all tires are properly inflated, tires have no slippage, and the speedometer is still calibrated for the smaller diameter tires.

Circumference of a circle =  $(2) \times (\pi) \times (\text{radius})$        $\pi = 3.14$       diameter of circle =  $(2) \times (\text{radius})$

- A. 16.0 mph
- B. 16.5 mph
- C. 17.0 mph
- D. 17.5 mph

Answer: Two step complicated method:  
 $\text{rpm} = 15 \text{ mi} / \text{hr} \div [(3.14 \times 38.5'' \times 1' / 12'') / \text{rev} \times 1 \text{ mi} / 5280' \times 60 \text{ min} / \text{hr}] = 131.0282075 \text{ rpm}$   
 $\text{mph} = [(3.14 \times 44.8'' \times 1' / 12'') / \text{rev}] \times 1 \text{ mi} / 5280' \times 60 \text{ min} / \text{hr} \times 131.0282075 \text{ rpm} = 17.454546 \text{ mph}$   
 Simple method:  $[44.8'' \div 38.5''] \times 15 \text{ mph} = 17.454546 \text{ mph}$

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3. Compact Equipment	8. Electrical	13. Machinery	18. Environmental	23. Structural
4. Structural	9. Compact Equipment	14. Electrical	19. Machinery	24. Environmental
5. Environmental	10. Structural	15. Compact Equipment	20. Electrical	25. Machinery

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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: Approximately how many acres are in a rectangular field measuring 2147 yards by 984 meters?**    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. 477.4 acres  
B. 498.4 acres  
C. 523.6 acres  
D. 573.6 acres

$$984 \text{ m} \times 1 \text{ ft} / 0.3048 \text{ m} \times 2147 \text{ yds} \times 3 \text{ ft} / 1 \text{ yd} \times 1 \text{ ac} / 43,560 \text{ ft}^2 = 477.3595 \text{ ac}$$

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

$$\text{Total Wattage} = \text{Voltage} \times \text{Amperage}$$

- A. 13.2 amps  
B. 14.5 amps  
C. 15.2 amps  
D. 16.5 amps

$$\begin{aligned} W &= V \times A \\ (6 \times 150 \text{ Watts}) + (2 \times 300 \text{ Watts}) + (12 \times 40 \text{ Watts}) &= 120 \text{ volts} \times \text{amps} \\ \text{amps} &= 16.5 \text{ amps} \end{aligned}$$

3. **Compact Equipment: A 12 horsepower single-cylinder engine is operating at 5,150 feet above sea level. What approximate horsepower can be produced by this engine if the engine's power is reduced 1.75 percent for each 1000 feet of elevation above sea level?**

- A. 10.4 horsepower  
B. 10.9 horsepower  
C. 11.4 horsepower  
D. 11.9 horsepower

$$12 \text{ horsepower} - [12 \text{ hp} \times 5,150 \text{ ft} \times (0.0175 / 1000 \text{ ft})] = 10.9185 \text{ hp}$$

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 38 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. \$ 543.96

$$\begin{aligned} 112' \times \$ 1.79 / \text{ft} &= \$ 200.48 \\ 95' \times \$ 2.11 / \text{ft} &= \$ 200.45 \\ 12 \times 20' \times \$ 0.38 / \text{ft} &= \$ 91.20 \quad \text{Total} = \$ 492.13 \\ \$ 492.13 \times 1.0667 \text{ tax} &= \$ 524.955071 \end{aligned}$$

5. **Environmental: Water flows through 119 feet of pipeline that includes five 90 degree elbows. The water flow rate is 5.25 gallons per minute where the water exits the 119-foot pipeline. The pressure loss through the pipeline is equivalent to 6.5 vertical feet of head (pressure) loss per 100 feet of horizontal run. The head loss through each elbow is equivalent to that of 4.25 feet of additional horizontal length. What is the approximate vertical head (pressure) loss for this horizontal pipeline?**

- A. 29 feet of head loss  
B. 35 feet of head loss  
C. 41 feet of head loss  
D. 46 feet of head loss

$$\text{loss} = (5 \text{ elbows} \times 4.25 \text{ ft} / \text{elbow}) + 119 \text{ ft} \times (6.5 \text{ ft loss} / 100 \text{ ft}) = \underline{28.985 \text{ ft}}$$

*You may write on this exam, but information written on this exam is not graded.*

*Mark all answers on the scan sheet.*

You may write on this exam, but only the scan sheet is graded.



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6. **Environmental:** If a center pivot irrigation system is 0.5 mile long (has a 0.5 mile radius), approximately how many acres can be irrigated under the pivot's boom during 360 degrees of travel? Information: Area of a circle =  $(\pi) \times (\text{radius})^2$        $\pi = 3.14$       diameter =  $2 \times$  radius  
 1 acre = 43,560 square feet      1 mile = 5,280 feet

- A. 404.8 acres
- B. 433.4 acres
- C. 488.8 acres
- D. 502.4 acres

$\text{Acres} = 3.14 \times (0.5 \text{ mi} \times 5280 \text{ ft} / \text{mi})^2 \times 1 \text{ ac} / 43,560 \text{ ft}^2 = \underline{502.4 \text{ ac}}$

7. **Machinery:** A utility tractor is re-equipped with high profile tires (larger diameter than the factory equipped tires). If the original tires had a 38.9-inch outside diameter and the new larger tires have a 44.6-inch outside diameter, what is the actual speed of the tractor when the tractor's mechanical speedometer displays 25 miles per hour? Assume all tires are properly inflated, tires have no slippage, and the speedometer is still calibrated for the smaller diameter tires.

Information: Circumference of a circle =  $(2) \times (\pi) \times (\text{radius})$        $\pi = 3.14$       diameter of circle =  $(2) \times (\text{radius})$

- A. 22.6 mph
- B. 25.7 mph
- C. 23.6 mph
- D. 28.7 mph

**Answer: Two step complicated method:**  
 $\text{rpm} = 25 \text{ mi} / \text{hr} \times 5280' / 1 \text{ mi} \times 1 \text{ hr} / 60 \text{ min}] \div [(3.14 \times 38.9'' \times 1' / 12'') / \text{rev}] = 216.1347896 \text{ rpm}$   
 $\text{mph} = [(3.14 \times 44.6'' \times 1' / 12'') / \text{rev}] \times 1 \text{ mi} / 5280' \times 60 \text{ min} / \text{hr} \times 216.1347896 \text{ rpm} = 28.663239 \text{ mph}$   
**Simple method:**  $[44.6'' \div 38.9''] \times 25 \text{ mph} = 28.66324 \text{ mph}$

8. **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 9.25 kilowatts per hour and it operates 25 days each month for 8 hours each day, what is the approximate monthly kWh charge to operate the pump? Information: 1 kilowatt = 1000 Watts      100 cents = \$1.00

- A. \$ 154.50
- B. \$ 189.65
- C. \$ 219.50
- D. \$ 245.65

$\text{kWh} / \text{month} = 9.25 \text{ kW} \times 25 \text{ days} / \text{mth} \times 8 \text{ hrs} / \text{day} = 1850 \text{ kWh} / \text{mth}$   
 $\$ = (1000 \text{ kWh} / \text{mth} \times \$0.1275 / \text{kWh}) + [(1850 \text{ kWh} / \text{mth} - 1000 \text{ kWh} / \text{mth}) \times \$0.139 / \text{kWh}] = \$ 245.65$

9. **Compact Equipment:** A planter has a 24-foot effective swath width, it travels at 5.25 miles per hour, and it operates with a field efficiency of 88.5 percent. What is the approximate effective field capacity (EFC) of the planter in acres per hour?

Information:  $\text{EFC} = \frac{\text{width of implement in feet} \times \text{speed in miles per hour} \times \text{efficiency}}{8.25}$

- A. 13.5 acres per hour
- B. 17.9 acres per hour
- C. 21.5 acres per hour
- D. 24.9 acres per hour

$13.51636 \text{ ac/hr} = (24 \text{ ft} \times 5.25 \text{ mph} \times 0.885) / 8.25$

10. **Structural:** Which of the following will have the greatest weight: 0.0039 acre-feet of water, 170 cubic-feet of water, 1275 gallons of water, or 4850 liters of water?

Information: 1 cubic foot of water = 62.43 pounds      1 gallon of water = 8.34 pounds  
 1 liter of water = 2.20 pounds      1 acre-foot water = 43,560 cubic feet of water

- A. 0.0039 acre feet of water
- B. 170 cubic-feet of water
- C. 1275 gallons of water
- D. 4850 liters of water

**Answer:**  $0.0039 \text{ ac-ft} \times 43,560 \text{ ft}^3 / \text{ac-ft} \times 62.43 \text{ lbs/ft}^3 = 10,605.9 \text{ lbs}$   
 $170 \text{ ft}^3 \times 62.43 \text{ lbs/ft}^3 = 10,613.1 \text{ lbs}$   
 $1275 \text{ gal} \times 8.34 \text{ lbs/gal} = 10,633.5 \text{ lbs}$   
 $4850 \text{ lit} \times 2.2 \text{ lbs/lit} = 10,670 \text{ lbs}$

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

1 board-foot = 144 cubic inches      1 square foot = 144 square inches

- A. 6 boards measuring 2 inches by 10 inches by 10 feet
- B. 9 boards measuring 2 inches by 6 inches by 12 feet**
- C. 12 boards measuring 1 inch by 8 inches by 12 feet
- D. 12 boards measuring 1 inches by 10 inches by 10 feet

Nominal Measurement Comparison (same answer for actual)  
 $6 \times 2'' \times 10'' \times 10' \times 12'' / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 100 \text{ bd-ft}$   
 $9 \times 2'' \times 6'' \times 12' \times 12'' / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 108 \text{ bd-ft} ***$   
 $12 \times 1'' \times 8'' \times 12' \times 12'' / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 96 \text{ bd-ft}$   
 $12 \times 1'' \times 10'' \times 10' \times 12'' / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 100 \text{ bd-ft}$

**12. Environmental: The 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 slope of the land area expressed as a percentage. What is the approximate slope (percentage) of the land that changes elevation from 2255 feet to 1876 feet over a distance of 1.58 miles?**      Slope = Rise ÷ Run x (100% / 1)

- A. 4.54 %**
- B. 5.54 %
- C. 6.54 %
- D. 7.51 %

$\text{Slope} = (2255' - 1876') \div (1.58 \text{ miles} \times 5,280 \text{ ft. / mi.}) \times 100\% / 1$   
 $\text{Slope} = 4.54306\%$

**13. Machinery: What is the approximate speed, in miles per hour, for a fertilizer spreader that travels 200 yards in 43.5 seconds?**

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

- A. 6.1 miles per hour
- B. 7.4 miles per hour
- C. 8.1 miles per hour
- D. 9.4 miles per hour**

$(200 \text{ yds} / 43.5 \text{ sec}) \times (3 \text{ ft} / 1 \text{ yd}) \times (60 \text{ sec.} / \text{min.} \times 60 \text{ min.} / 1 \text{ hr}) \times (1 \text{ mi} / 5,280 \text{ ft})$   
 $\text{Speed} = 9.404389 \text{ mph}$

**14. Electrical: An electric water heater uses 1910 kilowatt-hours (kWh) of power each day. If electric power cost 14.75 cents per kWh, approximately how much energy (in therms) does this water heater use during 60 days of operation?** Information: 1 kWh = 3412 BTUs of energy

1 therm of energy = 100,000 BTUs of energy

- A. 2280 therms
- B. 2810 therms
- C. 3380 therms
- D. 3910 therms**

$1910 \text{ kWh} / \text{day} \times 60 \text{ days} \times 3412 \text{ Btus} / \text{kWh} \times 1 \text{ therm} / 100,000 \text{ BTUs} =$   
 $3910.152 \text{ therms}$

**15. Compact Equipment: Each cylinder in a four 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 ÷ 2  
 Displacement of a single cylinder = (length of piston stroke) x (the area of the cylinder bore)

- A. 3.6 liters
- B. 4.1 liters
- C. 4.6 liters**
- D. 5.1 liters

$4 \text{ cyl} \times 3.14 \times [11.6'' \div (2 \times 3.14)]^2 \times 6.5'' \times 1 \text{ lit} / 61 \text{ in}^3 = 4.5663569 \text{ liters}$

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16. **Compact Equipment:** A gasoline mower’s power takeoff (PTO) produces 25 horsepower and turns at 1000 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. 85.2 foot-pounds
- B. 100.3 foot-pounds
- C. 115.2 foot-pounds
- D. 131.3 foot-pounds

$$25 \text{ hp} \times 5252 \div 1000 \text{ rpms} = 131.3 \text{ ft-lbs}$$

17. **Structural:** Concrete is poured inside a vertical pipe to provide rigidity to the pipe. If 1.25 cubic yards of concrete are needed to fill the pipe that is 12 feet 5 inches tall, what is the approximate inside diameter of the pipe 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. 16.33 inches
- B. 19.55 inches
- C. 22.33 inches
- D. 25.55 inches

$$1.25 \text{ yd}^3 = 3.14 \times (\text{diameter} \div 2 \times 1' / 12'')^2 \times 12.41667' \times (1 \text{ yd}^3 / 27 \text{ ft}^3)$$

$$\text{diameter} = (\sqrt{1.25 \text{ yd}^3 \times 27 \text{ ft}^3 / 1 \text{ yd}^3 \div 3.14 \div 12.41667'}) \times 2 \times 12'' / 1'$$

$$\text{diameter} = 22.329589''$$

18. **Environmental:** A thermometer calibrated in degrees Celsius (°C) is used to measure the temperature during a feed processing operation that requires heating to 240 degrees Fahrenheit (°F). What temperature on the Celsius thermometer is approximately equal to 240 °F?

Information:      °F =  $(9/5 \text{ } ^\circ\text{C}) + 32$       °C =  $5/9 (\text{ } ^\circ\text{F} - 32)$       Water freezes at 32 °F

- A. 155.2 °C
- B. 175.6 °C
- C. 195.2 °C
- D. 115.6 °C

$$^\circ\text{C} = 5/9 \times (240^\circ\text{F} - 32^\circ) \rightarrow \rightarrow 115.555556^\circ\text{C}$$

19. **Machinery:** Each of two hydraulic cylinders raise and lower the arms that operate the bucket on a skid steer loader. Each cylinder has a bore diameter of 3.25 inches and a stroke of 36 inches. The tractor’s hydraulic system produces a maximum pressure of 3,600 pounds per square inch. Approximately, what is the maximum combined force that these two cylinders can exert on the lift arms?

Area of a cylinder bore =  $(\pi) \times (\text{radius})^2$        $\pi = 3.14$   
 Force = Pressure X Area      radius =  $(\text{diameter} \div 2)$

- A. 24,699 pounds
- B. 29,699 pounds
- C. 44,699 pounds
- D. 59,699 pounds

$$\text{Force} = 2 \times \text{Pressure} \times \text{Area} = 2 \times 3,600 \text{ lb/in}^2 \times 3.14 \times (3.25 \text{ in.} / 2)^2 = 59,699.25 \text{ lbs}$$

20. **Electrical:** A farm building that is poorly insulated is located in a zone of the U.S. that typically requires 45 BTUs per square-foot of floor area to adequately heat the interior. If the interior dimension of the rectangular building is 80 feet by 24 feet and the model of furnace being purchased is 90% efficient, what approximate size furnace is required?

Information:      Furnace output is rated in British Thermal Units (BTUs)  
 1 yard = 3 feet      Furnace Size in BTUs =  $\frac{\text{Number of square feet} \times \text{Number of BTUs per square foot}}{\text{Furnace Efficiency}}$

- A. 88,000 BTUs
- B. 96,000 BTUs
- C. 104,000 BTUs
- D. 110,000 BTUs

$$\text{Furnace Size} = \frac{80' \times 24' \text{ yd} \times 45 \text{ BTUs/sq ft}}{0.90} = 96,000 \text{ BTUs}$$

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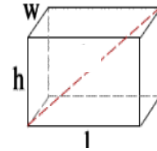
21. **Electrical:** The interior electrical lighting of a farm structure is being replaced with high efficiency lighting. The 36 incandescent, 100-Watt lights will be replaced with 36 LED, 40-Watt lights. If the lights are operated 100 hours per month and electricity cost 12.75 cents per kilowatt-hour (kWh), what is the approximate reduction in electrical power costs each month? 1000 Watts = 1 kilowatt

- A. \$ 27.54
- B. \$ 31.45
- C. \$ 36.54
- D. \$ 40.45

$$\$ \text{ saving / mth} = (100 \text{ W} - 40 \text{ W}) \times \$0.1275 / \text{kwh} \times 100 \text{ hrs/mth} \times 36 \text{ lights} \times 1 \text{ kwh} / 1000 \text{ W} = \$27.54$$

22. **Compact Equipment:** A rectangular shaped plastic hopper is used to transport granular fertilizer in bulk. This hopper is transported on a trailer with a 4500-pound maximum load carrying capacity. The internal dimensions of the hopper are 7.25 feet wide, 8.25 feet long and 4.5 feet deep. What is the maximum weight in pounds per cubic foot (approximate value) that granular fertilizer can weigh and completely fill the hopper, while still transporting the load within safe limits?

1 gallon = 231 cubic inches      1 cubic-foot = 1728 cubic-inches  
 Volume of rectangular prism = Length × Width × Height



Picture of rectangular prism

- A. 16.7 lbs / ft<sup>3</sup>
- B. 19.6 lbs / ft<sup>3</sup>
- C. 23.7 lbs / ft<sup>3</sup>
- D. 27.6 lbs / ft<sup>3</sup>

$$4500 \text{ lbs} = \text{lbs} / \text{ft}^3 \times 7.25' \times 8.25' \times 4.5' \rightarrow \text{lbs} / \text{ft}^3 = 4500 \text{ lbs} / 68.15625 \text{ ft}^3 \rightarrow 16.71891327 \text{ lbs} / \text{ft}^3$$

23. **Structural:** Intake and/or exhaust fans should have the capacity in cubic feet per minute to adequately exchange the air in a greenhouse every three minutes. The rectangular floor of the greenhouse measures 36 feet by 60 feet and the walls/roof is made of plastic sheeting stretched over plastic pipe hoops positioned as half circles. The hoops give the greenhouse a perfect half cylinder shape with each half-circle hoop having a diameter of 36 feet. In cubic feet per minute, what is the approximate size fan needed to ventilate the greenhouse?

Volume of a cylinder = (π) x (radius)<sup>2</sup> x length  
 π = 3.14      diameter = (2 × radius)

- A. 4,347.2 cubic feet per minute
- B. 6,173.6 cubic feet per minute
- C. 8,347.2 cubic feet per minute
- D. 10,173.6 cubic feet per minute

$$\text{CFM} = 1/3 \times 1/2 [3.14 \times (36' \div 2)^2 \times 60']$$

$$\text{CFM} = 10,173.6 \text{ ft}^3 / \text{min.}$$



End view of Greenhouse

24. **Environmental:** A 21-foot length of unthreaded black pipe is to be cut into 11 pieces of equal length. Both ends of the 21-foot pipe are already cut square (90 degrees) and the 11 pieces will also have square cut ends. The metal saw being used cuts a kerf (material removed by saw blade) that is 1/8 inch wide. Other than the material lost by the saw kerf, none of the pipe is wasted or unused in cutting the 11 pieces of equal length. What is the approximate length (in feet, inches and fraction of an inch) of each piece of the pipe. Information: 1 foot = 12 inches      5/32 inch = 0.15625 inch

- A. 1 foot, 4 and 25/32 inches
- B. 1 foot, 6 and 25/32 inches
- C. 1 foot, 8 and 25/32 inches
- D. 1 foot, 10 and 25/32 inches

$$[(21 \text{ feet} \times 12''/\text{ft}) - (10 \text{ cuts} \times 1/8'' / \text{cut})] \div 11 \text{ pieces} = 22.79545455''$$

$$\rightarrow 1 \text{ foot } 10 \text{ inches} + 0.79545455 \text{ inch} \rightarrow 1' 10'' + \approx 25/32''$$

$$\rightarrow \approx 1' 10 \sim 25/32''$$

25. **Machinery:** A water pump has a 6.75-inch diameter pulley that must turn at 1150 revolutions per minute (rpm). The shaft of an electric motor rotates at 1725 rpm and powers the belt that operates the pump. What is the approximate diameter of the pulley needed on the motor shaft to turn the pump at 1150 rpms?

Pulley Size Formula: (Diameter of Pulley 1 x Speed of Pulley 1) = (Diameter of Pulley 2 x Speed of Pulley 2)

- A. 4.00-inch diameter pulley
- B. 4.25-inch diameter pulley
- C. 4.50-inch diameter pulley
- D. 4.75-inch diameter pulley

$$(6.75 \text{ in} \times 1150 \text{ rpms}) = (?? \text{ in} \times 1725 \text{ rpms}) \rightarrow \text{diameter} = 4.5''$$

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

## 2019 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 Competency Alignment\* for Exam Questions (2 points each)

1. Machinery 1.16, 6.1, 6.4-7	6. Environmental 4.17, 4.18, 4.19, 6.1, 6.4-7	11. Structural 5.1, 5.2, 5.3, 5.22, 6.1, 6.4-7	16. Compact Equipment 3.1, 3.4, 3.15, 3.21, 6.1, 6.4-7	21. Electrical 2.4, 2.6, 2.7, 2.10, 6.1, 6.4-7
2. Electrical 2.4, 6.1, 6.4-7	7. Machinery 1.14, 1.16, 1.17, 6.1, 6.4-7	12. Environmental 4.2, 4.11, 6.1, 6.4-7	17. Structural 5.1, 5.2, 5.3, 5.4, 6.1, 6.4-7	22. Compact Equipment 3.1, 3.15, 3.21, 6.1, 6.4-7
3. Compact Equipment 3.1, 3.4, 6.1, 6.4-7	8. Electrical 2.4, 2.10, 6.1, 6.4-7	13. Machinery 1.16, 1.17, 6.1, 6.4-7	18. Environmental 4.15, 4.18, 6.1, 6.4-7	23. Structural 5.1, 5.3, 5.6, 6.1, 6.4-7
4. Structural 5.2, 5.22, 6.1, 6.4-7	9. Compact Equipment 6.1, 6.4-7	14. Electrical 2.4, 2.11, 6.1, 6.4-7	19. Machinery 1.17, 3.5, 6.1, 6.4-7	24. Environmental 1.16, 4.2, 4.4, 4.5, 4.14, 4.18, 6.1, 6.4-7
5. Environmental 4.2, 4.4, 4.14, 6.4-7	10. Structural 5.2, 6.1, 6.4-7	15. Compact Equipment 3.15, 6.1, 6.4-7	20. Electrical 2.1, 2.11, 6.1, 6.4-7	25. Machinery 1.15, 1.16, 1.17, 6.1, 6.4-7

\*Competency numbers (1.2, 2.1, 3.1, 4.1, 6.1 etc.) accompanying each question coincide with numbered competencies listed on ATMS CDE web site.

This exam begins on the back of this sheet.

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Mark all answers on the scan sheet.

**2019 Written Examination for the  
National Agricultural Technology & Mechanical Systems  
Career Development Event**

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*You may write on this exam, but only the scan sheet is graded.*

- 1. Machinery:** Approximately how many acres are in a rectangular field measuring 5,040 meters by 4,867 yards?      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. 394.6 acres
- B. 474.6 acres
- C. 554.3 acres
- D. 684.3 acres

$$5040 \text{ m} \times 1 \text{ ft} / 0.3048 \text{ m} \times 486.7 \text{ yd} \times 3 \text{ ft} / 1 \text{ yd} \times 1 \text{ ac} / 43,560 \text{ ft}^2 = 554.25587 \text{ ac}$$

- 2. Electrical:** A variety of incandescent lights are all operating on a single 120-volt electrical circuit in a livestock barn. The circuit includes two 200-watt lights, four 100-watt lights, and five 60-watt lights. What is the amperage of the circuit with all of these lights operating?

Total Wattage = Voltage x Amperage

- A. 5.6 amps
- B. 6.3 amps
- C. 8.7 amps
- D. 9.2 amps

$$W = V \times A$$

$$(2 \times 200 \text{ Watts}) + (4 \times 100 \text{ Watts}) + (5 \times 60 \text{ Watts}) = 120 \text{ volts} \times \text{amps}$$

$$\text{amps} = 9.16667 \text{ amps}$$

- 3. Compact Equipment:** A 100 horsepower six-cylinder engine is operating at 5,400 feet above sea level. What approximate horsepower can be produced by the engine if the engine's power is reduced 1.5 percent for each 1000 feet of elevation above sea level?

- A. 91.9 horsepower
- B. 93.8 horsepower
- C. 95.7 horsepower
- D. 97.6 horsepower

$$100 \text{ horsepower} - [ 100 \text{ hp} \times 5400 \text{ ft} \times (0.015 / 1000 \text{ ft}) ] = 91.9 \text{ hp}$$

- 4. Structural:** Steel angle iron is sold for \$1.16 per linear foot, steel rod is sold for 88 cents per linear foot, and steel pipe is sold for \$2.44 per linear foot. If 25.8 feet of angle iron, 19 feet of rod, and 231 inches of pipe are purchased, and 7% taxes are paid with the purchase, what is the approximate total price for the metal?

- A. \$ 90.17
- B. \$ 95.11
- C. \$ 100.17
- D. \$ 105.11

$$25.8' \times \$ 1.16 / \text{ft} = \$ 29.928$$

$$19' \times \$ 0.88 / \text{ft} = \$ 16.72$$

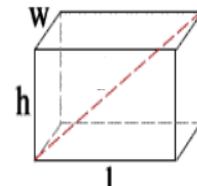
$$231'' \times 1 \text{ ft} / 12'' \times \$ 2.44 / \text{ft} = \$ 46.97 \quad \text{Total} = \$ 93.618$$

$$\$ 93.618 \times 1.07 \text{ tax} = \$ 100.17126$$

- 5. Environmental:** A rectangular shaped plastic hopper is used to transport granular pesticide in bulk. This hopper is transported on a trailer with a 4,500-pound maximum load carrying capacity in addition to the weight of the hopper. The internal dimensions of the hopper are 7.75 feet wide, 11.75 feet long and 5.25 feet deep. What is the maximum weight in pounds per cubic foot (approximate value) that granular pesticide can weigh, completely fill the hopper, and still transport within safe load carrying limits?

1 gallon = 231 cubic inches      1 cubic-foot = 1728 cubic-inches  
Volume of rectangular prism = Length × Width × Height

- A. 7.3 lbs / ft<sup>3</sup>
- B. 7.7 lbs / ft<sup>3</sup>
- C. 8.1 lbs / ft<sup>3</sup>
- D. 9.4 lbs / ft<sup>3</sup>



Picture of rectangular prism

$$4500 \text{ lbs} = \text{lbs} / \text{ft}^3 \times 7.75' \times 11.75' \times 5.25 \text{ feet} \Rightarrow \text{lbs} / \text{ft}^3 = 4500 \text{ lbs} / 478.078125 \text{ ft}^3 \Rightarrow 9.412688 \text{ lbs} / \text{ft}^3$$

6. **Environmental:** If a center pivot irrigation system is 0.25 mile long (has a 0.25 mile radius), approximately how many acres can be irrigated under 270 degrees of the pivot's travel?

Area of a circle =  $(\pi) \times (\text{radius})^2$        $\pi = 3.14$       diameter =  $2 \times \text{radius}$   
 1 acre = 43,560 square feet      1 mile = 5,280 feet

- A. 60.5 acres
- B. 71.4 acres
- C. 83.3 acres
- D. 94.2 acres

$\text{Acres} = 3/4 \times 3.14 \times (0.25 \text{ mi} \times 5280 \text{ ft} / \text{mi})^2 \times 1 \text{ ac} / 43,560 \text{ ft}^2 = 94.2 \text{ ac}$

7. **Machinery:** Each cylinder in a six cylinder tractor engine has a bore (diameter) of 4.56 inches and a piston stroke of 6.45 inches. What is the approximate total displacement of this engine in liters?

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

- A. 7.4 liters
- B. 8.4 liters
- C. 9.4 liters
- D. 10.4 liters

$6 \text{ cyl} \times 3.14 \times (4.56 \text{ in} / 2)^2 \times 6.45 \text{ in} \times (1 \text{ L} / 61 \text{ in}^3) = 10.3557 \text{ L}$

8. **Electrical:** The interior electrical lighting of a farm structure is being replaced with high efficiency lighting. The 36 incandescent, 150-Watt lights will be replaced with 24 LED, 60-Watt lights. If the lights are operated 105 hours each month and electricity cost 11.74 cents per kilowatt-hour (kWh), what is the approximate reduction in electrical power costs each month? 1000 Watts = 1 kilowatt

- A. \$ 48.81
- B. \$ 50.61
- C. \$ 52.41
- D. \$ 54.21

$\$ \text{ saving} / \text{ mth} = [(36 \text{ lights} \times 150 \text{ W}) - (24 \text{ lights} \times 60 \text{ W})] \times \$0.1174 / \text{ kwh} \times 105 \text{ hrs} / \text{mth} \times 1 \text{ kwh} / 1000 \text{ W} = \$48.81492$

9. **Compact Equipment:** Which of the following will have the lowest weight in pounds: 5.47 gallons of gasoline, 4.97 gallons of diesel, 4.71 gallons of 15W-40 engine oil, or 4.72 gallons of automatic transmission fluid?

1 gallon of gasoline = 6.3 pounds      1 gallon of diesel = 6.943 pounds  
 1 gallon 15W-40 engine oil = 7.3 pounds      1 gallon automatic transmission fluid = 7.298 pounds

- A. 5.37 gallons of gasoline
- B. 4.97 gallons of diesel
- C. 5.71 gallons of 15W-40 engine oil
- D. 4.72 gallons of automatic transmission fluid

$5.47 \text{ gals gas} \times 6.3 \text{ lbs} / 1 \text{ gal}$	$= 34.461 \text{ lbs}$
$4.97 \text{ gals diesel} \times 6.943 \text{ lbs} / 1 \text{ gal}$	$= 34.50671 \text{ lbs}$
$4.71 \text{ gals oil} \times 7.3 \text{ lbs} / 1 \text{ gal}$	$= 34.383 \text{ lbs}$
$4.72 \text{ gals fluid} \times 7.298 \text{ lbs} / 1 \text{ gal}$	$= 34.44656 \text{ lbs}$

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

1 board-foot = 144 cubic inches      1 square foot = 144 square inches

- A. 20 boards measuring 1 inches by 10 inches by 10 feet
- B. 20 boards measuring 1 inch by 8 inches by 12 feet
- C. 14 boards measuring 2 inches by 6 inches by 12 feet
- D. 10 boards measuring 2 inches by 10 inches by 10 feet

Nominal Measurement Comparison (same answer for actual)  
 $20 \times 1" \times 10" \times 10' \times 12" / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 166.67 \text{ bd-ft}$   
 $20 \times 1" \times 8" \times 12' \times 12" / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 160 \text{ bd-ft} \text{ ***}$   
 $14 \times 2" \times 6" \times 12' \times 12" / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 168 \text{ bd-ft}$   
 $10 \times 2" \times 10" \times 10' \times 12" / 1 \text{ ft} \times 1 \text{ bd-ft} / 144 \text{ in}^3 = 166.67 \text{ bd-ft}$

You may write on this exam, but only the scan sheet is graded.

11. **Structural:** The round support column (cylinder) in a building is a vertical steel pipe with an outside diameter of 36 inches. The pipe has a wall thickness of 1/2" and will be filled with concrete. If the 18-foot tall pipe is to be completely filled, approximately how many cubic-yards of concrete are needed?  
 Volume of cylinder =  $(\pi) \times (\text{radius})^2 \times \text{height}$      $\pi = 3.14$     radius = (diameter  $\div$  2)    27 cubic feet = 1 cubic yard

- A. 3.55 cubic yards
- B. 3.85 cubic yards
- C. 4.15 cubic yards
- D. 4.45 cubic yards

Radius =  $(36'' - 1/2'' - 1/2'') \div 2 = (36'' - 0.5'' - 0.5'') \div 2 = 17.5''$   
 Radius =  $17.5'' \times 1' / 12'' = 1.458333333'$   
 Vol. of Cylinder =  $\pi \times r^2 \times h = \pi \times (1.458333333')^2 \times 18' = 120.2640939 \text{ ft}^3$   
 Cubic-Yards of Concrete =  $120.2640939 \text{ ft}^3 \times (1 \text{ yd}^3 / 27 \text{ ft}^3) = 4.454226 \text{ yd}^3$

12. **Environmental:** A tractor fueled by No. 2 diesel burns 8.45 gallons per hour. When the same tractor is fueled with B20 biodiesel it burns 75 gallons of fuel in eight hours. Approximately what percentage does the gallons of fuel per hour (consumption) increase when the tractor is fueled by B20 biodiesel rather than No. 2 diesel?

- A. 9.95 percent
- B. 10.95 percent
- C. 11.95 percent
- D. 12.95 percent

Gallons Increase per hour =  $(75 \text{ gal} / 8 \text{ hrs}) - (8.45 \text{ gal/hr}) = 0.925 \text{ gallons/hr increase}$   
 $\% = 0.925 \text{ gal} / 8.45 \text{ gal} = 0.1094674556 = 10.94674556 \%$

13. **Machinery:** What is the approximate speed, in miles per hour, for a fertilizer spreader that travels 115 meters in 1 minute and 9 seconds?

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

- A. 2.7 miles per hour
- B. 3.2 miles per hour
- C. 3.7 miles per hour
- D. 4.2 miles per hour

$(115 \text{ m} / 69 \text{ sec}) \times (1 \text{ ft} / 0.3048 \text{ m}) \times (60 \text{ sec.} / \text{min.} \times 60 \text{ min.} / 1 \text{ hr}) \times (1 \text{ mi} / 5,280 \text{ ft})$   
 Speed = 3.728 mph

14. **Electrical:** A 240-volt air conditioning unit uses 124 kilowatt hours of power during 24 hours of operation. What is the approximate size of this air conditioning unit in tons of refrigeration (disregard efficiency)? One ton of air conditioning removes heat at the rate equivalent to melting one ton of ice during a period of 24 hours.

Information: British Thermal Unit (BTU): 3412.14 BTUs = 1 kilowatt hour  
 1 Ton of Refrigeration = 12,000 BTUs / hour (the rate of heat removal)

- A. Three-Quarter Ton
- B. One Ton
- C. One and One-Half Tons
- D. Two Tons

Ton Refrigeration =  $\frac{3412.14 \text{ BTUs}}{1 \text{ kwh}} \times \frac{1 \text{ Ton}}{12,000 \text{ BTUs} / \text{hr}} \times \frac{124 \text{ kwh}}{24 \text{ hrs}}$   
 $\gg = 1.46912 \text{ Ton Refrigeration or } 1.5 \text{ Ton Unit}$

15. **Compact Equipment:** An engine manual requires each head bolt to be torqued to 16 Newton meters (Nm) during reassembly. The torque wrench available is calibrated in foot pounds (ft. lbs.). What approximate torque in ft. lbs. is equivalent to 13 Nm?

4.44822 Newtons = 1 pound force    0.22481 pound force = 1 Newton  
 1 meter = 3.28084 feet    1 foot = 0.3048 meters

- A. 8.6 ft. lbs.
- B. 9.2 ft. lbs.
- C. 9.6 ft. lbs.
- D. 10.2 ft. lbs.

$13 \text{ Nm} \times 0.22481 \text{ lbs} / 1 \text{ N} \times 3.28084 \text{ ft} / 1 \text{ m} = 9.58835 \text{ ft. lbs.}$   
 Or  
 $13 \text{ Nm} \times 1 \text{ lbs} / 4.44822 \text{ N} \times 1 \text{ ft} / 0.3048 \text{ m} = 9.58835 \text{ ft. lbs.}$

You may write on this exam, but only the scan sheet is graded.



16. **Compact Equipment:** A gasoline mower’s power takeoff (PTO) produces 20 horsepower and turns at 540 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. 194.5 foot-pounds
- B. 204.3 foot-pounds
- C. 214.5 foot-pounds
- D. 224.3 foot-pounds

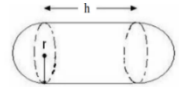
$$20 \text{ hp} \times 5252 \div 540 \text{ rpms} = 194.5185 \text{ ft-lbs}$$

17. **Structural:** A storage tank is shaped like a capsule with the following internal dimensions. The radius of the one-half spheres on each end are 21~9/32” and the height of the cylinder section is 6’ 9~15/16”. What is the approximate internal volume in gallons for this tank? diameter = (2 × radius)

$$\text{Volume of cylinder} = \pi \times (\text{cylinder radius})^2 \times \text{cylinder height} \quad \pi = 3.14 \quad 1 \text{ gallon} = 231 \text{ cubic inches}$$

- A. 642.1 gallons
- B. 679.1 gallons
- C. 742.1 gallons
- D. 779.1 gallons

$$\text{Volume of sphere} = 4/3 \times \pi \times (\text{cylinder radius})^3$$



$$r = 21\text{~}9/32'' = 21.28125'' \quad \text{and} \quad h = 6'\text{~}9\text{~}15/16'' = 81.9375''$$

$$\text{Vol. of Tank} = \{ [3.14 \times (21.28125'')^2 \times 81.9375''] + [4/3 \times 3.14 \times (21.28125'')^3] \} \times 1 \text{ gal}/231 \text{ in}^3$$

$$\text{Vol. of Tank} = (116,521.6496 \text{ in}^3 + 40,351.50947 \text{ in}^3) \times 1 \text{ gal}/231 \text{ in}^3$$

$$\text{Vol. of Tank} = 156,873.1591 \text{ in}^3 \times 1 \text{ gal}/231 \text{ in}^3$$

$$\text{Vol. of Tank} = 679.1045847 \text{ gal}$$

18. **Environmental:** A pesticide label specifies that 0.75 pint of pesticide concentration, mixed with 25 gallons of water, are to be applied per acre. Approximately how many gallons of pesticide concentration are required to treat a 522-acre field?

$$128 \text{ ounces} = 1 \text{ gal}$$

$$16 \text{ ounces} = 1 \text{ pint}$$

- A. 39 gallons
- B. 44 gallons
- C. 49 gallons
- D. 54 gallons

$$\text{Gallons} = [(0.75 \text{ pts} / \text{ac}) \times (16 \text{ oz} / \text{pt}) \times (1 \text{ gal} / 128 \text{ oz}) \times (522 \text{ acres})] = 48.9375 \text{ gallons}$$

19. A tractor produces 250 PTO horsepower at a rated power take-off speed of 1000 revolutions per minute. How much torque in foot-pounds does the tractor produce at the power take-off shaft?

$$\text{PTO Power} = \text{Torque} \times \text{Rotational Speed} \div 5252$$

- A. 1,182 lb-ft
- B. 1,313 lb-ft
- C. 1,461 lb-ft
- D. 1,592 lb-ft

$$\text{Torque} = 5252 \times 250 / 1000 = 1,313 \text{ lb-ft}$$

20. **Electrical:** A 120-volt electrical circuit will operate a 2400-watt resistance heater and ten 300-watt incandescent light bulbs. If the circuit is operated 10 hours each day for 300 days, how many kilowatt-hours will the electrical system use during the time period?

$$\text{Note: Kilowatt-hours} = \frac{\text{Total Watts} \times \text{Total hours}}{1000 \text{ Watts/Kilowatt}}$$

- A. 10,200 kilowatt-hours
- B. 12,200 kilowatt-hours
- C. 14,200 kilowatt-hours
- D. 16,200 kilowatt-hours

$$\text{Kilowatts-hours} = [(2400 \text{ Watts} + 3000 \text{ Watts}) \times 10 \text{ hours/day} \times 300 \text{ days}] / 1000 \text{ Watts/kilowatt} = 16,200 \text{ kwh}$$

You may write on this exam, but only the scan sheet is graded.

You may write on this exam, but only the scan sheet is graded.

21. **Electrical:** The monthly charge to operate an electric pump is 13.75 cents per kilowatt hour (kWh) for the first 1000 hours and 15.55 cents for each kWh greater than 1000 hours. If this pump uses 2779 kWhs of electricity during a single month, what is the approximate monthly cost to operate the pump? Information: 1 kilowatt = 1000 Watts 100 cents = \$1.00 1 hour = 60 minutes

- A. \$ 415
- B. \$ 438
- C. \$ 515
- D. \$ 538

$$\$ = (1000 \text{ hrs} \times \$0.1375 / \text{kWh}) + [(2779 \text{ Watts} - 1000 \text{ Watts}) \times \$0.1555 / \text{kWh}] = \$414.1345$$

22. **Compact Equipment:** A hydraulic cylinder that operates the arm of a skid steer loader has a bore diameter of 2.9 inches and a stroke of 36 inches. The tractor's hydraulic system produces a maximum pressure of 2,600 pounds per square inch. Approximately, what is the maximum force the cylinder can exert on the lift arm? Information: Area of a cylinder bore =  $(\pi) \times (\text{radius})^2$   $\pi = 3.14$   
Force = Pressure  $\times$  Area radius = (diameter  $\div$  2)

- A. 12,042 pounds
- B. 13,084 pounds
- C. 15,133 pounds
- D. 17,165 pounds

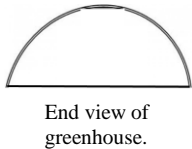
$$\text{Force} = \text{Pressure} \times \text{Area} = 2,600 \text{ lb/in}^2 \times 3.14 \times (2.9 \text{ in} / 2)^2 = 17,164.81 \text{ lbs}$$

23. **Structural:** An intake and/or exhaust fan should have the capacity in cubic feet per minute to completely exchange the air in a greenhouse every ten minutes. The rectangular floor of a greenhouse measures 30 feet by 60 feet and the walls and roof are made of plastic sheeting stretched over plastic pipe hoops positioned as half circles. The hoops give the greenhouse a perfect half cylinder shape with each hoop having a diameter of 30 feet. In cubic feet per minute, what is the approximate size fan needed to ventilate the greenhouse? Volume of a cylinder =  $(\pi) \times (\text{radius})^2 \times \text{length}$   
 $\pi = 3.14$  diameter =  $(2 \times \text{radius})$

- A. 2119.5 cubic feet per minute
- B. 2669.5 cubic feet per minute
- C. 3119.5 cubic feet per minute
- D. 3669.5 cubic feet per minute

$$\text{CFM} = 1/10 \times 1/2 [3.14 \times (30' \div 2)^2 \times 60']$$

$$\text{CFM} = 2119.5 \text{ ft}^3 / \text{min.}$$



24. **Environmental:** If the average weight of wheat is 62.5 pounds per bushel, approximately how many bushels of wheat can be transported in a rail car with a maximum carrying capacity of 90 tons? Information: 1 ton = 2000 pounds 1 bushel 2.44 cubic feet

- A. 2220 bushels
- B. 2440 bushels
- C. 2660 bushels
- D. 2880 bushels

$$\text{bu} = 1 \text{ bu} / 62.5 \text{ lb} \times 90 \text{ T} \times 2000 \text{ lb} / 1 \text{ T} = 2,880 \text{ bu}$$

25. **Machinery:** A utility tractor is re-equipped with high profile tires (larger diameter than the factory equipped tires). If the original tires had a 40.5-inch outside diameter and the new larger tires have a 43.9-inch outside diameter, what is the approximate speed of the tractor (miles per hour, with larger diameter tires) when the tractor's mechanical speedometer displays 10 miles per hour? Assume all tires are properly inflated, tires have no slippage, and the speedometer is still calibrated for the smaller diameter tires. Circumference of a circle =  $(2) \times (\pi) \times (\text{radius})$   $\pi = 3.14$  diameter of circle =  $(2) \times (\text{radius})$

- A. 7.62 mph
- B. 8.84 mph
- C. 9.62 mph
- D. 10.84 mph

Answer: Two step complicated method:  
 $\text{rpm} = 10 \text{ mi} / \text{hr} \div [(3.14 \times 40.5'' \times 1' / 12'') / \text{rev} \times 1 \text{ mi} / 5280' \times 60 \text{ min} / \text{hr}] = 83.03845244 \text{ rpm}$   
 $\text{mph} = [(3.14 \times 43.9'' \times 1' / 12'') / \text{rev}] \times 1 \text{ mi} / 5280' \times 60 \text{ min} / \text{hr} \times 83.03845244 \text{ rpm} = 10.8395 \text{ mph}$   
 Simple method:  $[43.9'' \div 40.5''] \times 10 \text{ mph} = 10.8395 \text{ mph}$

**2021 Examination for the  
National Agricultural Technology and  
Mechanical Systems  
Career and Leadership Development Event**

*You have 1.5 hours to complete this exam.*

**Answer Key**  
**Do Not Distribute**

**2021 Written Examination for the  
National Agricultural Technology & Mechanical Systems  
Career and Leadership Development Event**

1. **Machinery:** Approximately how many acres are in a rectangular area of land with adjacent sides that measure 6.5 kilometers and 0.75 miles? 1 acre = 43,560 square feet 1 mile = 5,280 feet 1 foot = 0.3048 meter Area of Rectangle = length x width 1000 meters = 1 kilometer

- A. 1938.7 acres
- B. 2447.6 acres
- C. 2954.5 acres
- D. 3384.4 acres

$$[6.5 \text{ km} \times (1000 \text{ m} / 1 \text{ km}) \times (1 \text{ ft} / 0.3048 \text{ m})] \times [0.75 \text{ mi} \times (5280 \text{ ft} / 1 \text{ mi})] \times (1 \text{ ac} / 43,560 \text{ ft}^2) = 1938.67812 \text{ ac}$$

2. **Electrical:** A rectangular farm building is poorly insulated and is located in a zone of the U.S. that typically requires 50 BTUs per square-foot of floor area to adequately heat the interior. If the interior floor dimensions of the rectangular building are 25.5 feet by 12 yards and the model of furnace being purchased is 77% efficient, what is the approximate size of the furnace required? Use the following formula to calculate the approximate furnace size (room height is not utilized in calculation). Furnace output is rated in British Thermal Units (BTUs) 1 yd = 3 ft  
Furnace Size in BTUs =  $\frac{\text{Square footage of floor} \times \text{number of BTUs recommended per square foot}}{\text{Furnace Efficiency}}$

- A. 40,000 BTUs
- B. 50,000 BTUs
- C. 60,000 BTUs
- D. 70,000 BTUs

$$\text{Furnace Size} = \frac{25.5' \times 12 \text{ yds} \times 3' / 1 \text{ yd} \times 50 \text{ BTUs} / \text{sq ft}}{0.77} = 59,610.39 \text{ BTUs}$$

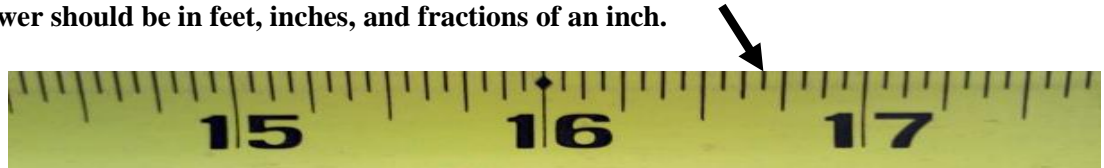
3. **Compact Equipment:** During the repair of an engine, a pilot-hole must be drilled to accommodate a 3/8" tap that will cut threads (for a 3/8" bolt) in the wall of the pilot-hole. The tap table indicates that the pilot-hole must have a 0.3125" diameter. All of the available twist drills have fractional rather than decimal measurements. What size twist drill should be used to drill the pilot-hole?

- A. 5/16 inch
- B. 11/32 inch
- C. 21/64 inch
- D. 12/32 inch

$$5/16'' = 0.3125''$$

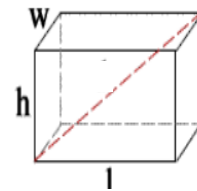
4. **Structural:** A small section of a tape measure with numerical values in inches is shown in the space below. The entire length of the tape measure is not shown. What length is indicated when measured from the end of the tape measure (not shown at the left of picture) to where the arrow touches the tape measure? Answer should be in feet, inches, and fractions of an inch.

- A. 1' 3~3/4"
- B. 1' 4~5/16"
- C. 1' 4~11/16"
- D. 1' 6~7/8"



5. **Environmental:** A rectangular shaped metal container with a lid is used to transport bulk livestock feed. This container is transported on a trailer with tandem axles and each axle has a 3500-pound load carrying capacity. The total weight of the trailer and the empty container is 970 pounds. The internal dimensions of the hopper are 5.25 feet wide, 8.5 feet long, and 3 feet deep. When the feed container is completely filled, what is the maximum weight in pounds per cubic foot (approximate value) of the bulk feed if the load is to be transported on the trailer within the load carrying limits of the axles?

1 cubic-foot = 1728 cubic-inches  
Volume of rectangular prism = Length × Width × Height



Picture of rectangular prism

- A. 25 lbs / ft<sup>3</sup>
- B. 35 lbs / ft<sup>3</sup>
- C. 40 lbs / ft<sup>3</sup>
- D. 45 lbs / ft<sup>3</sup>

$$(2 \text{ axles} \times 3500 \text{ lbs/axle}) - 970 \text{ lbs} = 6030 \text{ lbs}$$

$$6030 \text{ lbs} = 5.25' \times 8.5' \times 3' \times \text{??? lbs} / \text{ft}^3 \rightarrow 45.04201681 \text{ lbs}$$

6. **Environmental: If a center pivot irrigation system is 1320 feet long (has a 2640-foot diameter), approximately how many acres can be irrigated under 300 degrees of the pivot's travel?**

Area of a circle =  $(\pi) \times (\text{radius})^2$        $\pi = 3.14$       diameter =  $2 \times \text{radius}$   
 1 acre = 43,560 square feet      1 mile = 5,280 feet      Complete circle = 360 degrees

- A. 82.6 acres  
 B. 104.7 acres  
 C. 125.8 acres  
 D. 156.9 acres

$$\text{Acres} = 300^\circ/360^\circ \times 3.14 \times (1320)^2 \times 1 \text{ ac} / 43,560 \text{ ft}^2 = 104.66666667 \text{ ac}$$

7. **Machinery: Each cylinder in an eight cylinder tractor engine has a bore (diameter) of 5.65 inches and a piston stroke of 7.63 inches. What is the approximate total displacement of this engine in liters?**

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

- A. 15 liters  
 B. 20 liters  
 C. 25 liters  
 D. 30 liters

$$8 \text{ cyl} \times 3.14 \times (5.65 \text{ in} / 2)^2 \times 7.63 \text{ in} \times (1 \text{ L} / 61 \text{ in}^3) = 25.07559474 \text{ L}$$

8. **Electrical: The interior electrical lighting of a farm structure is being replaced with high efficiency LED lighting. There are 48 incandescent, 100-Watt lights that will be replaced with 30 LED, 45-Watt lights. The lights are operated 6 hours each day and 22 days each month. If electricity cost 13.15 cents per kilowatt-hour (kWh), what is the approximate reduction in electrical power costs during one year of operation?**      1000 Watts = 1 kilowatt      12 months = 1 year

- A. \$ 684.82  
 B. \$ 718.62  
 C. \$ 831.42  
 D. \$ 964.22

$$[(48 \text{ lights} \times 100 \text{ W}) - (30 \text{ lights} \times 45 \text{ W})] \times \$0.1315 / \text{kwh} \times 6 \text{ hrs/day} \times 22 \text{ days/mth} \times 12 \text{ months/yr} \times 1 \text{ kwh} / 1000 \text{ W} = \$ 718.6212 = \$ \text{ saving} / \text{yr}$$

9. **Compact Equipment: Which of the following has the greatest weight in pounds: 1.59 gallons of gasoline, 1.45 gallons of diesel, 1.36 gallons of 15W-40 engine oil, or 1.37 gallons of automatic transmission fluid?**

1 gallon of gasoline = 6.3 pounds      1 gallon of diesel = 6.943 pounds  
 1 gallon 15W-40 engine oil = 7.3 pounds      1 gallon automatic transmission fluid = 7.298 pounds

- A. gasoline  
 B. diesel  
 C. 15W-40 engine oil  
 D. automatic transmission fluid

$$\begin{aligned} 1.59 \text{ gals gas} \times 6.3 \text{ lbs} / 1 \text{ gal} &= 10.017 \text{ lbs} \\ 1.45 \text{ gals diesel} \times 6.943 \text{ lbs} / 1 \text{ gal} &= 10.06735 \text{ lbs} \\ 1.36 \text{ gals oil} \times 7.3 \text{ lbs} / 1 \text{ gal} &= 9.928 \text{ lbs} \\ 1.37 \text{ gals fluid} \times 7.298 \text{ lbs} / 1 \text{ gal} &= 9.99826 \text{ lbs} \end{aligned}$$

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

1 board-foot = 144 cubic inches      1 square foot = 144 square inches

- A. 6 boards measuring 2 inches by 6 inches by 16 feet  
 B. 5 boards measuring 2 inch by 8 inches by 14 feet  
 C. 9 boards measuring 1 inch by 10 inches by 12 feet  
 D. 11 boards measuring 1 inch by 10 inches by 10 feet

Nominal Measurement Comparison (same answer for actual)

$$\begin{aligned} 6 \times 2'' \times 6'' \times 16' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 &= 96 \text{ bd-ft} \\ 5 \times 2'' \times 8'' \times 14' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 &= 93.333 \text{ bd-ft} \\ 9 \times 1'' \times 10'' \times 12' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 &= 90 \text{ bd-ft} \\ 11 \times 1'' \times 10'' \times 10' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 &= 91.67 \text{ bd-ft} \end{aligned}$$

11. **Structural:** The round support column (cylinder) in a building is a vertical steel pipe with an outside diameter of 18 inches. The pipe has a wall thickness of 3/8" and will be filled with concrete. If the 20-foot tall pipe is to be completely filled, approximately how many cubic-yards of concrete are needed?  
 Volume of cylinder =  $(\pi) \times (\text{radius})^2 \times \text{height}$      $\pi = 3.14$     radius = (diameter  $\div$  2)    27 cubic feet = 1 cubic yard

- A. 0.8 cubic yards
- B. 1.2 cubic yards
- C. 1.5 cubic yards
- D. 1.9 cubic yards

Radius =  $(18'' - 3/8'' - 3/8'') \div 2 \rightarrow (18'' - 0.375'' - 0.375'') \div 2 = 8.625''$   
 Radius =  $8.625'' \times 1'/12'' = 0.71875'$   
 Vol. of Cylinder =  $\pi \times r^2 \times h = 3.14 \times (0.71875')^2 \times 20' = 32.44257813 \text{ ft}^3$   
 Cubic-Yards of Concrete =  $32.44257813 \text{ ft}^3 \times (1 \text{ yd}^3 / 27 \text{ ft}^3) = 1.201576968 \text{ yd}^3$

12. **Environmental:** A dairy's comprehensive nutrient management plan indicates that 20 tons of the dry manure should be applied to a crop field. If the wet manure being applied to the crop field has a 65% moisture content by weight, what is the approximate amount of wet manure that should be applied to be equivalent to the dry manure application weight?

- A. 22.67 tons
- B. 30.77 tons
- C. 38.25 tons
- D. 57.14 tons

$20 \text{ tons} / (1.00 - 0.65) = 57.142857 \text{ tons}$

13. **Machinery:** What is the approximate speed, in miles per hour, for a pesticide boom sprayer that travels 200 yards in 1 minute and 12 seconds?

5,280 ft = 1 mile    60 seconds = 1 minute    60 minutes = 1 hour    1 yard = 3 feet

- A. 4.2 miles per hour
- B. 4.7 miles per hour
- C. 5.2 miles per hour
- D. 5.7 miles per hour

$(200 \text{ yds} / 72 \text{ sec}) \times (3 \text{ ft} / 1 \text{ yd}) \times (60 \text{ sec.} / \text{min.} \times 60 \text{ min.} / 1 \text{ hr}) \times (1 \text{ mi} / 5,280 \text{ ft})$   
 Speed = 5.681818 mph

14. **Electrical:** A water pump for a stock tank has an electrical motor that operates at 120 volts and uses 9.8 amps of current. If it is a 1.25 horsepower motor and it operates with a power factor of 0.95, what is the approximate efficiency of the motor?    1 horsepower = 746 Watts

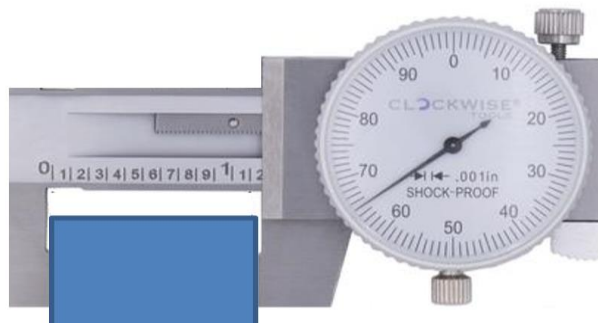
Horsepower =  $\frac{\text{voltage} \times \text{amperage} \times \text{power factor} \times \text{efficiency}}{746}$

- A. 73.5 %
- B. 78.5 %
- C. 83.5 %
- D. 88.5 %

$1.25 \text{ hp} = \frac{120 \text{ V} \times 9.8 \text{ A} \times 0.95 \times \text{Efficiency}}{746} \gggggg \text{ Eff.} = 0.8345759757$   
 Eff. = 83.5%

15. **Compact Equipment:** A partial picture of a 6-inch dial caliper is shown in the space below. The jaws of the dial caliper are closed on a solid object and the measurement is displayed on the face of the dial caliper. What is the measurement displayed on the dial caliper?

- A. 1.065 inches
- B. 1.165 inches
- C. 1.650 inches
- D. 1.265 inches



16. **Compact Equipment:** The operation of a walk-behind gasoline mower must generate sufficient income from cutting grass to generate a profit over purchase price, operating costs, and labor expenses. An \$890 mower is operated 760 hours annually for three years and then sold at an estimated salvage value of \$75. If total labor and operating costs are \$28 per hour and an average of 1850 square-feet of grass can be cut in an hour, what approximate amount should be charged for each hour of the mower's operation to produce a 50% profit margin?

- A. \$ 57
- B. \$ 63
- C. \$ 69
- D. \$ 75

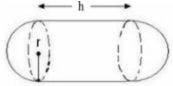
$$[ (\$890 - \$75) / (3 \text{ yrs} \times 760 \text{ hrs/yr}) ] + \$28/\text{hr} = \$28.357456$$

$$\$28.357456 / 0.50 = \$56.71491$$

17. **Structural:** A storage tank is shaped like a capsule with the following internal dimensions. The radius of the one-half spheres on each end are 23~5/8" and the height of the cylinder section is 9' 11~7/8". What is the approximate internal volume in gallons for this tank? diameter = (2 × radius)  
 Volume of cylinder =  $\pi \times (\text{cylinder radius})^2 \times \text{cylinder height}$      $\pi = 3.14$     1 gallon = 231 cubic inches

- A. 1148.46 gallons
- B. 1199.35 gallons
- C. 1246.24 gallons
- D. 1289.13 gallons

Volume of sphere =  $\frac{4}{3} \times \pi \times (\text{cylinder radius})^3$



$r = 23\text{~}5/8'' = 23.625''$     and     $h = 9'\text{~}11\text{~}7/8'' = 119.875''$

Vol. of Tank =  $\{ [3.14 \times (23.625'')^2 \times 119.875''] + [4/3 \times 3.14 \times (23.625'')^3] \} \times 1 \text{ gal}/231 \text{ in}^3$

Vol. of Tank =  $( 210,088.3173 \text{ in}^3 + 55,205.68922 \text{ in}^3 ) \times 1 \text{ gal}/231 \text{ in}^3$

Vol. of Tank =  $265,294.0065 \text{ in}^3 \times 1 \text{ gal}/231 \text{ in}^3$

Vol. of Tank = **1148.458903 gal**

18. **Environmental:** A pesticide label specifies that 0.25 pint of pesticide concentration, mixed with 20 gallons of water, are to be applied per acre. Approximately how many gallons of pesticide concentration are required to treat a 400-acre field?  
 128 ounces = 1 gal                      16 ounces = 1 pint

- A. 6.3 gallons
- B. 9.4 gallons
- C. 12.5 gallons
- D. 15.6 gallons

**Gallons =  $[(0.25 \text{ pts} / \text{ac}) \times (16 \text{ oz} / \text{pt}) \times (1 \text{ gal} / 128 \text{ oz}) \times (400 \text{ acres})]$**   
**= 12.5 gallons**

19. **Machinery:** A tractor's PTO produces 290 horsepower at a rated power take-off speed of 1000 revolutions per minute. How much torque in foot-pounds does the tractor produce at the power take-off shaft?

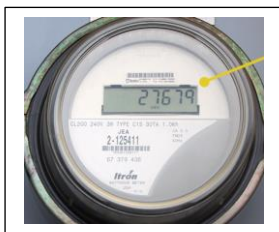
PTO Power = Torque x Rotational Speed ÷ 5252

- A. 1,124 lb-ft
- B. 1,325 lb-ft
- C. 1,426 lb-ft
- D. 1,523 lb-ft

**Torque =  $5252 \times 290 / 1000$**   
**= 1,523 lb-ft**

20. **Electrical:** A digital kilowatt-hour electric meter has the reading shown in the picture below. If last month's reading was 19778, and electric power cost 11.58 cents per kilowatt-hour, what is the approximate charge for the past month's electrical power?

- A. \$ 885
- B. \$ 915
- C. \$ 945
- D. \$ 975



**Kilowatts-hours =  $27679 - 19778 = 7901 \text{ kwh}$**   
 **$7901 \text{ kwh} \times \$0.1158 = \$914.9358$**

21. **Electrical:** The rooftop solar installation for a dairy has proven to reduce the monthly electric bill an average of \$30 for the four coldest months (winter) of the year, \$135 for one month in the fall, \$135 for one month in the spring, and \$270 per month during the six warmer months of the year. If the installation cost of the solar system was \$24,000, approximately how many years must the system be utilized to achieve the economic “breakeven” point?

$$\text{Breakeven in Years} = \text{Installation Cost} / (\$ \text{ savings/Year})$$

- A. 10 years
- B. 12 years
- C. 14 years
- D. 16 years

Annual Energy Savings =  $[(4 \text{ mth} \times \$30/\text{mth}) + (2 \text{ mth} \times \$135/\text{mth}) + (6 \text{ mth} \times \$270/\text{mth})] = \$2010 / \text{yr}$

Breakeven =  $\$24,000 / \$2010/\text{yr} = 11.94 \text{ yrs}$

22. **Compact Equipment:** A self-propelled fertilizer spreader for specialty crop production has a 12-foot swath width and an averages travel speed of 4.5 miles per hour. Fertilizer is applied to an area measuring 185 yards long and 145 yards wide, by an inexperience operator that is only 70% efficient. Approximately how long will it take the inexperienced operator to complete the fertilizer application?

Information: 5280 ft = 1 mile      1 yard = 3 feet      60 minutes = 1 hour      60 seconds = 1 minute

- A. 1 hours and 13 minutes
- B. 1 hours and 33 minutes
- C. 1 hours and 57 minutes
- D. 2 hours and 15 minutes

Hrs =  $\frac{185 \text{ yds} \times 145 \text{ yds} \times (9 \text{ ft}^2/\text{yd}^2)}{4.5 \text{ mi/hr} \times 5280 \text{ ft/mi} \times 12 \text{ ft}} \times \frac{1}{0.70} = 1.209641063 \text{ hrs}$

1 hour +  $(0.209641063 \text{ hrs} \times 60 \text{ min/hr}) = 1 \text{ hours and } 12.5784632 \text{ min}$

23. **Structural:** Over the past year the cost of framing lumber has increased significantly. The following table list the March 2020 prices and the April 2021 prices for common size lumber. Which one of the lumber sizes listed in the table exhibits the highest percentage increase in cost?

- A. 2” x 4” x 8’ lumber
- B. 2” x 6” x 10’ lumber
- C. 2” x 8” x 10’ lumber
- D. 2” x 10” x 10’ lumber

Lumber Size	Price in 2019	Price in 2021
2” x 4” x 8’	\$ 2.37	\$ 7.21
2” x 6” x 10’	\$ 5.37	\$ 15.29
2” x 8” x 10’	\$ 8.23	\$ 23.79
2” x 10” x 10’	\$ 10.81	\$ 29.37

$\$ 7.21 / \$ 2.37 = 304.22\%$

$\$ 15.29 / \$ 5.37 = 284.73\%$

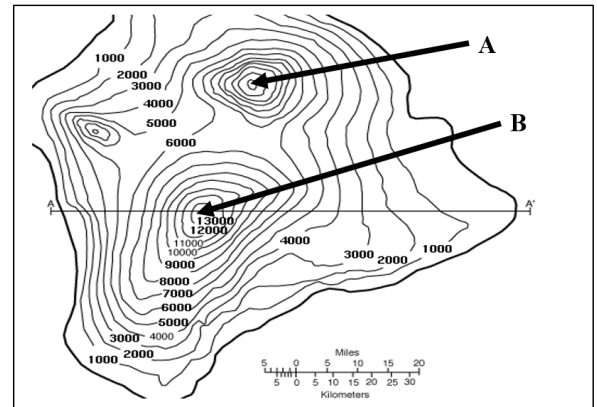
$\$ 23.79 / \$ 8.23 = 289.06\%$

$\$ 29.37 / \$ 10.81 = 271.69\%$

24. **Environmental:** A portion of a topographic map is shown below. Two mountain peaks, A and B are identified with arrows on the map. Which of the following statements about the map is correct?

- A. Elevation of point A cannot be determined.
- B. Elevation of point A is higher than point B.
- C. Elevation of point B is higher than point A.
- D. Elevation of point A equals elevation of point B.

Based on the information on the topo map, the amount of elevation change between the contour lines is 1000 feet. Both points are identified as peaks and there are 7 contour lines above the 6000-foot contour line for Peak A. This indicates 6000 feet plus 7000 feet or 13,000 feet for Peak A which makes it the same height as Peak B.



25. **Machinery:** To determine the wheel slippage in a loaded tractor’s operation the following measurements were made. The rear wheels of a tractor each have a diameter of 5.15 feet, the test distance is 100 feet long, and the loaded tractor’s rear wheels make 6.8 rotations while traveling the 100 feet. What is the approximate wheel slippage for this tractor during each rotation of the rear wheel?

Circumference of a circle =  $(2) \times (\pi) \times (\text{radius})$        $\pi = 3.14$       diameter of circle =  $(2) \times (\text{radius})$

- A. 0.28 feet/rotation, 1.73%
- B. 0.67 feet/rotation, 4.14%
- C. 1.08 feet/rotation, 6.68%
- D. 1.47 feet/rotation, 9.09%

Wheel circumference =  $[2 \times 3.14 \times 5.15/2] = 16.171 \text{ feet}$

6.8 rotations  $\times 16.171 \text{ feet} = 109.9628 \text{ feet in } 6.8 \text{ rotations}$

This represents 9.9629 feet slippage over 100 feet or

$9.9628 \text{ feet} / 6.8 \text{ revolutions} = 1.4651176 \text{ feet / rotation}$



**2022 (On-line) Written Examination**  
**for the**  
**National Agricultural Technology and Mechanical Systems**  
**Career and Leadership Development Event**

*You have **1.5** hours to complete this exam.*

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**2022 On-line Written Examination for the  
National Agricultural Technology & Mechanical Systems  
Career and Leadership Development Event**

- 1. Machinery: If a tractor travels at 28.5 kilometers per hour, what approximate length of time (in hours and minutes) is required to travel 29.5 miles?**

1 mile = 1.6 kilometers      1 hour = 60 minutes

- A. 1 hour and 2.1 minutes
- B. 1 hour and 16.8 minutes
- C. 1 hour and 39.4 minutes
- D. 2 hours and 11.7 minutes

- 2. Electrical: What is the approximate annual power consumption (kilowatt-hours = kWh) of a 120-volt electrical installation with 24 incandescent lights, with each light using 1.5 amps and operating 8 hours per day and 28 days per month? 1 year = 12 months      Kilowatt = 1000 Watts**

Watts = Volts  $\times$  Amps

Volts = Amps  $\times$  Resistance in Ohms

Kilowatt-hours = Kilowatts  $\times$  Hours

- A. 11,612 kWh
- B. 116,122 kWh
- C. 1,161,216 kWh
- D. 11,612,160 kWh

- 3. Compact Equipment: During the repair of an engine, a pilot-hole must be drilled to accommodate a 5/8" tap that will cut 'tight fit' threads (for a 5/8" bolt) in the wall of the pilot-hole. The tap table indicates that the pilot-hole must have a 0.6406" diameter. All of the available twist drills have fractional rather than decimal measurements. What approximate size twist drill should be used to drill the pilot-hole? 1/4" = 0.25"      1/2" = 0.5"      3/4" = 0.75"**

- A. 19/32 inch
- B. 41/64 inch
- C. 21/32 inch
- D. 43/64 inch

4. **Structural:** A small section of a tape measure with numerical values in inches is shown below. The entire length of the tape measure is not shown. What length is indicated when measured from the end of the tape measure (not shown at the left of picture) to where the arrow touches the tape measure? Answer should be in feet, inches, and fractions of an inch.

- A. 1' 3~3/4"  
 B. 1' 4~3/16"  
 C. 1' 4~11/16"  
 D. 1' 6~7/8"



5. **Environmental:** Approximately how many acres are in a rectangular field that has a length of 1109 meters and a width of 928 yards?

1 acre = 43,560 square feet      1 hectare = 2.47 acres      1 acre = 0.41 Hectare  
 Area of Rectangle = length  $\times$  width      1 yard = 3 feet      1 foot = 0.3048 meter

- A. 2.4 acres  
 B. 23.6 acres  
 C. 232.5 acres  
 D. 2325.4 acres

6. **Environmental:** An available electronic thermometer is calibrated in degrees Celsius ( $^{\circ}\text{C}$ ). A pesticide label specifies that the maximum allowable temperature for spray applications is 85 degrees Fahrenheit ( $^{\circ}\text{F}$ ). What is the approximate temperature equivalent in degrees Celsius?

$$^{\circ}\text{F} = (9/5 ^{\circ}\text{C}) + 32 \quad ^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

Water freezes at 32  $^{\circ}\text{F}$       Water boils at 212  $^{\circ}\text{F}$

- A. 11.7  $^{\circ}\text{C}$   
 B. 29.4  $^{\circ}\text{C}$   
 C. 61.7  $^{\circ}\text{C}$   
 D. 127.0  $^{\circ}\text{C}$

7. **Machinery:** Each cylinder in a eight cylinder tractor engine has a bore (diameter) of 4.75 inches and a piston stroke of 5.9 inches. What is the approximate total displacement of this engine in liters?

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

- A. 1.7 liters  
 B. 2.8 liters  
 C. 13.7 liters  
 D. 54.8 liters

- 8. Electrical:** A kilowatt-hour meter records 5.9 kilowatts of power being used by an eight-horsepower electric motor during one hour when it is operating at 230 volts and using 28 amps. What is the approximate power factor for this motor?

$$\text{Voltage} = \text{Amperage} \times \text{Resistance} \quad 1 \text{ kilowatt} = 1000 \text{ hours}$$

$$\text{Wattage} = \text{Voltage} \times \text{Amperage} \times \text{Power Factor}$$

- A. 0.92 power factor  
 B. 0.97 power factor  
 C. 1.09 power factor  
 D. 9.16 power factor
- 9. Compact Equipment:** What is the approximate speed, in miles per hour, for a riding mower that travels 80 meters in 39.5 seconds?  $5,280 \text{ ft} = 1 \text{ mile}$   
 $3600 \text{ seconds} = 1 \text{ hour}$   $1 \text{ foot} = 0.3048 \text{ meter}$

- A. 3.5 miles per hour  
 B. 4.5 miles per hour  
 C. 5.5 miles per hour  
 D. 6.5 miles per hour

- 10. Structural:** A round concrete column is fabricated using 5.8 cubic yard of concrete. If the concrete column is 40 inches in diameter, what is the approximate height of the column?

$$1 \text{ cubic yard} = 27 \text{ cubic feet} \quad 1 \text{ cubic foot} = 1728 \text{ cubic inches}$$

$$1 \text{ foot} = 12 \text{ inches} \quad \text{diameter} = (2 \times \text{radius}) \quad \pi = 3.14$$

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

- A. 17.95 feet  
 B. 18.45 feet  
 C. 18.95 feet  
 D. 19.45 feet
- 11. Structural:** Steel angle iron is sold for \$1.83 per linear foot, steel rod is sold for \$1.61 per linear foot, and steel pipe is sold for \$2.94 per linear foot. If 19.5 feet of angle iron, 15.5 feet of rod, and 12 feet of pipe are purchased, what is the approximate total price for the metal before taxes?
- A. \$ 9.59  
 B. \$ 95.92  
 C. \$ 959.92  
 D. \$ 9599.20

**12. Environmental:** A concrete slab will be installed to prevent contamination of the ground at a mixing and cleaning site for pesticide equipment. The inside dimensions of the slab's form boards are 24 feet wide by 14 feet long and the concrete forms provide an approximate depth of 5 inches. Order an additional 10 percent concrete to allow for the irregularity of the ground surface and note that pre-mixed concrete is sold/delivered in quarter-yard quantities (such as: 3 yd<sup>3</sup>, 6.25 yd<sup>3</sup>, 10.75 yd<sup>3</sup>, 15.5 yd<sup>3</sup>). Approximately how many cubic yards (yd<sup>3</sup>) of pre-mixed concrete should be ordered?

$$1 \text{ cubic yard} = 27 \text{ cubic feet}$$

$$1 \text{ cubic foot} = 1728 \text{ cubic inches}$$

$$1 \text{ foot} = 12 \text{ inches}$$

$$\text{Volume of rectangular prism} = \text{Length} \times \text{Width} \times \text{Height}$$

- A. 3.50 yd<sup>3</sup>
- B. 5.25 yd<sup>3</sup>
- C. 5.75 yd<sup>3</sup>
- D. 68.50 yd<sup>3</sup>

**13. Machinery:** There are 195 acres of corn with an average yield of 96.5 bushels per acre. Due to moisture content, a bushel has an average weight of 64.2 pounds. If the price is 14.2 cents per pound of harvested corn, what is the approximate income for the crop? 1 ton = 2000 pounds

$$\text{bushel} = 2.44 \text{ cubic feet}$$

- A. \$ 120,808
- B. \$ 171,548
- C. \$ 1,208,084
- D. \$ 1,715,479

**14. Electrical:** An inefficient electrical motor (identified as motor A) is to be replaced with a new high efficiency motor (identified as motor B). Motor A was operated 6 hours per day, 325 days each year, and its annual electrical bill averaged \$12,553. The purchase price for motor B is \$1,120 and the installation charge is \$345. Motor B will be operated the same number of hours as motor A and will have an average cost of \$6.07 per hour to operate. Approximately how many months will motor B need to operate to payback the purchase and installation cost of the new motor?

$$1 \text{ year} = 12 \text{ months}$$

$$1 \text{ day} = 24 \text{ hours}$$

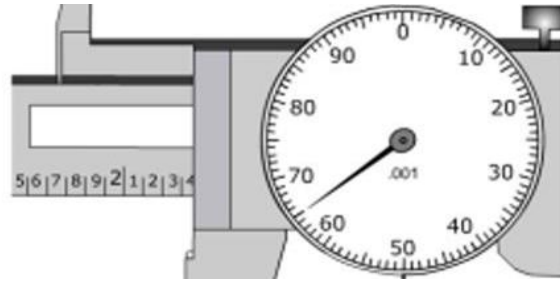
$$1 \text{ year} = 365 \text{ days}$$

$$\text{Payback} = \frac{\text{total cost for new high efficient equipment}}{\text{average saving in energy cost per month}}$$

- A. 24.5 months
- B. 96.2 months
- C. 125.3 months
- D. 294.4 months

- 15. Compact Equipment:** A partial picture of a 6-inch dial caliper is shown in the space below. The measurement displayed on the dial caliper is between 2 inches and 3 inches. What measurement is displayed on the dial caliper?

- A. 2.365 inches
- B. 2.465 inches
- C. 2.653 inches
- D. 2.654 inches



- 16. Compact Equipment:** Which of the following will have the greatest weight in pounds: 4.6 gallons of gasoline, 4.1 gallons of diesel, 3.8 gallons of 15W-40 engine oil, or 3.9 gallons of automatic transmission fluid?

1 gallon of gasoline = 6.3 pounds

1 gallon of diesel = 6.943 pounds

1 gallon 15W-40 engine oil = 7.3 pounds

1 gallon automatic transmission fluid = 7.298 pounds

- A. 4.6 gallons of gasoline
- B. 4.1 gallons of diesel
- C. 3.8 gallons of 15W-40 engine oil
- D. 3.9 gallons of automatic transmission fluid

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

1 board-foot = 144 cubic inches

1 square foot = 144 square inches

- A. 24 boards measuring 1 inches by 8 inches by 14 feet
- B. 27 boards measuring 2 inch by 4 inches by 12 feet
- C. 22 boards measuring 2 inches by 6 inches by 10 feet
- D. 20 boards measuring 1 inch by 8 inches by 16 feet

- 18. Environmental:** A pesticide label specifies that 0.5 pint of pesticide concentration is to be diluted (mixed) with 25 gallons of water for each acre treated (amount applied per acre). Approximately how many gallons of pesticide concentration are required to treat a 640-acre field?

128 ounces = 1 gal

16 ounces = 1 pint

- A. 25 gallons
- B. 30 gallons
- C. 35 gallons
- D. 40 gallons

- 19. Machinery:** A tractor's power takeoff produces 275 horsepower and turns at 1000 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. 1111 foot-pounds  
 B. 1222 foot-pounds  
 C. 1333 foot-pounds  
 D. 1444 foot-pounds
- 20. Electrical:** The interior electrical lighting of a farm structure is being replaced with high efficiency lighting. The 20 incandescent, 200-Watt lights will be replaced with 20 LED, 50-Watt lights. If the lights are operated 88 hours per month and electricity cost 10 cents per kilowatt-hour (kWh), what is the approximate reduction in electrical power costs each month?

$$1000 \text{ Watts} = 1 \text{ kilowatt}$$

- A. \$ 26.40  
 B. \$ 41.50  
 C. \$ 62.60  
 D. \$ 88.70
- 21. Electrical:** The monthly charge to operate an electrical water 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?

$$1 \text{ kilowatt} = 1000 \text{ Watts} \qquad 100 \text{ cents} = \$1.00$$

- A. \$ 196.30  
 B. \$ 236.20  
 C. \$ 274.10  
 D. \$ 314.00
- 22. Compact Equipment:** A 25 horsepower single-cylinder engine is operating at 3,480 feet above sea level. What approximate horsepower can be produced by the engine if the engine's power is reduced 1.5 percent for each 1000 feet of elevation above sea level?
- A. 23.1 horsepower  
 B. 23.7 horsepower  
 C. 24.3 horsepower  
 D. 24.9 horsepower

- 23. Structural:** A 21-foot length of unthreaded black pipe is to be cut into 13 pieces of equal length. Both ends of the 21-foot pipe are already cut square (90 degrees) and the 13 pieces will also have square cut ends. The metal saw being used cuts a kerf (material removed by saw blade) that is  $\frac{5}{32}$  inch wide. Other than the material lost by the saw kerf, none of the pipe is wasted or unused in cutting the 13 pieces of equal length. What is the approximate length (in feet, inches and fraction of an inch) of each piece of the pipe.

Information: 1 foot = 12 inches       $\frac{5}{32}$  inch = 0.15625 inch

- A. 1 foot, 6 and  $\frac{7}{16}$  inches  
 B. 1 foot, 6 and  $\frac{15}{32}$  inches  
 C. 1 foot, 7 and  $\frac{1}{4}$  inches  
 D. 1 foot, 7 and  $\frac{3}{8}$  inches
- 24. Environmental:** Water flows (horizontally) through 86 feet of pipeline that includes three 90-degree elbows. The water flow rate is 6.5 gallons per minute where the water exits the 86-foot pipeline. The pressure loss through the pipeline is equivalent to 6.2 vertical feet of head (pressure) loss per 100 feet of horizontal run. The head loss through each elbow is equivalent to that of 4.75 feet of additional horizontal length. Approximately, what is the vertical head (pressure) loss for this horizontal pipeline?

- A. 5.3 feet of head loss  
 B. 6.2 feet of head loss  
 C. 100.3 feet of head loss  
 D. 533.2 feet of head loss

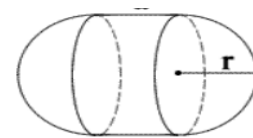
- 25. Machinery:** The center section of a fuel storage tank has a cylindrical shape (capsule) that is 6.5 feet long with an inside diameter of 3.5 feet. Each end of the tank has a half-sphere shape (two halves of a sphere), each with an internal radius of 21 inches. What is the approximate total storage capacity of the tank in gallons? 1 gallon = 231 cubic inches    1 foot = 12 inches     $\pi = 3.14$

Diameter =  $2 \times$  (radius)

Volume of a Cylinder =  $(\pi) \times (\text{radius})^2 \times (\text{length})$

Volume of Sphere =  $\frac{4}{3} \times (\pi) \times (\text{radius})^3$

- A. 515 gallons  
 B. 575 gallons  
 C. 635 gallons  
 D. 695 gallons



Picture of Capsule





# AGRICULTURAL TECHNICAL & MECHANICAL SYSTEMS

Created: Jul-23

## General Knowledge Exam Key

Question	Answer	Point Value	Standard	Standard	Standard
1.	C				
2.	A				
3.	B				
4.	B				
5.	C				
6.	B				
7.	C				
8.	A				
9.	B				
10.	A				
11.	B				
12.	C				
13.	B				
14.	A				
15.	A				
16.	A				
17.	D				
18.	D				
19.	D				
20.	A				
21.	B				
22.	B				
23.	C				
24.	B				
25.	C				