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

2018 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. <u>Do not round off intermediate answers</u> when using the calculator to solve these problems.***

Students are **<u>NOT allowed</u>** 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	6. Environmental	11. Structural	16. Compact Equipment	21. Electrical
2. Electrical	**7. Machinery**	12. Environmental	17. Structural	22. Compact Equipment
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**

This exam begins on the back of this sheet.

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

2018 Written Examination for the National Agricultural Technology & Mechanical Systems Career Development Event

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

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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 m x 1 ft / 0.3048 m x 2147 yds x 3 ft / 1 yd x 1 ac / 43,560 ft^2 = 477.3595 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?
Total Wattage = Voltage x Amperage

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

W = V x A
(6 x 150 Watts) + (2 x 300 Watts) + (12 x 40 Watts) = 120 volts x amps
amps = 16.5 amps

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 horsepower – [12 hp x 5,150 ft x (0.0175 / 1000 ft)] = 10.9185 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

112' x $ 1.79 / ft = $ 200.48
95' x $ 2.11 / ft = $ 200.45
12 x 20' x $ 0.38 / ft = $ 91.20 Total = $ 492.13
$ 492.13 x 1.0667 tax = $ 524.955071

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

loss = (5 elbows x 4.25 ft / elbow) + 119 ft x (6.5 ft loss / 100 ft) = 28.985 ft

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 × 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

Acres = 3.14 x (0.5 mi x 5280 ft / mi)^2 x 1 ac / 43,560 ft^2 = 502.4 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) x (π) x (radius) $\pi = 3.14$ diameter of circle = (2) x (radius)

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

Answer: **Two step complicated method:**
rpm = 25 mi / hr x 5280' / 1 mi x 1 hr / 60 min] ÷ [(3.14 x 38.9" x 1' / 12") / rev = 216.1347896 rpm
mph = [(3.14 x 44.6" x 1'/12") / rev] x 1 mi / 5280' x 60 min / hr x 216.1347896 rpm = 28,663239 mph
Simple method: [44.6" ÷ 38.9"] x 25 mph = 28.66324 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

kWh / month = 9.25 kW x 25 days / mth x 8 hrs / day = 1850 kWh / mth
$ = (1000 kWh/mth x $0.1275 / kWh) + [(1850 kWh/mth - 1000 kWh/mth) x $0.139 / 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: $\text{EFC} = \frac{\text{width of implement in feet x speed in miles per hour x efficiency}}{8.25}$

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 ac/hr = (24 ft x 5.25 mph x 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 ac-ft x 43,560 ft^3 / ac-ft x 62.43 lbs/ft^3 = 10,605.9 lbs
170 ft^3 x 62.43 lbs/ft^3 = 10,613.1 lbs
1275 gal x 8.34 lbs/gal = 10,633.5 lbs
4850 lit x 2.2 lbs/lit = 10,670 lbs

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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 × 2" × 10" × 10' × 12"/1 ft × 1bd-ft/144in^3 = 100 bd-ft
9 × 2" × 6" × 12' × 12"/1 ft × 1bd-ft/144in^3 = 108 bd-ft ***
12 × 1" × 8" × 12' × 12"/1 ft × 1bd-ft/144in^3 = 96 bd-ft
12 × 1" × 10" × 10' × 12"/1 ft × 1bd-ft/144in^3 = 100 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 %

Slope = (2255' - 1876') ÷ (1.58 miles x 5,280 ft. / mi.) x 100% / 1
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 yds / 43.5 sec) x (3 ft / 1 yd) x (60 sec. / min. x 60 min. / 1 hr) x (1 mi / 5,280 ft)
Speed = 9.404389 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 kWh /day x 60 days x 3412 Btus / kWh x 1 therm / 100,000 BTUs =
3910.152 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 x π x radius
Area of a cylinder bore = π x radius^2 π = 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 cyl x 3.14 x [11.6" ÷ (2 x 3.14)]^2 x 6.5" x 1 lit / 61 in^3 = 4.5663569 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?

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

A. 85.2 foot-pounds
B. 100.3 foot-pounds
C. 115.2 foot-pounds
D. 131.3 foot-pounds

25 hp x 5252 ÷ 1000 rpms = 131.3 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 × radius)

A. 16.33 inches
B. 19.55 inches
C. 22.33 inches
D. 25.55 inches

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

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

diameter = 22.329589"

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

Information: ºF = (9/5 ºC) + 32 ºC = 5/9 (ºF - 32) Water freezes at 32 ºF

A. 155.2 ºC
B. 175.6 ºC
C. 195.2 ºC
D. 115.6 ºC

ºC = 5/9 x (240ºF - 32º) ➔➔ 115.555556 ºC

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 = (diameter ÷ 2)

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

Force = 2 x Pressure x Area = 2 x 3,600 lb/in^2 x 3.14 x (3.25 in. / 2)^2 = 59,699.25 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 = $\frac{\text{Number of square feet x Number of BTUs per square foot}}{\text{Furnace Efficiency}}$

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

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

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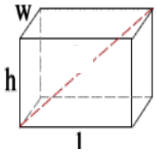
21. Electrical: The interior electrical lighting of a farm structure is being replaced with high efficiency lighting. The 36 incandescent, 100-Watt lights will be replaced with 36 LED, 40-Watt lights. If the lights are operated 100 hours per month and electricity cost 12.75 cents per kilowatt-hour (kWh), 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

$ saving / mth = (100 W - 40 W) x $0.1275 / kwh x 100 hrs/mth x 36 lights x 1 kwh / 1000 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

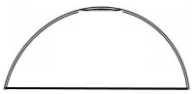
A. 16.7 lbs / ft^3
B. 19.6 lbs / ft^3
C. 23.7 lbs / ft^3
D. 27.6 lbs / ft^3

4500 lbs = lbs / ft^3 x 7.25' x 8.25' x 4.5' → lbs / ft^3 = 4500 lbs / 68.15625 ft^2 → 16.71891327 lbs / ft^3

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 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 $(\text{radius})^2$ x length
$\pi = 3.14$ 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

CFM = 1/3 x ½ [3.14 x (36' ÷ 2)^2 x 60']
CFM = 10,173.6 ft^3 / 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 feet × 12"/ft) - (10 cuts × 1/8" /cut)] ÷ 11 pieces = 22.79545455"
→ 1 foot 10 inches + 0. 79545455 inch → 1' 10" + ≈ 25/32"
→≈ 1' 10 ~ 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 in x 1150 rpms) = (**??** in x 1725 rpms) →→ diameter = 4.5"

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