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. <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 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.

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

2019 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.*

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 m x 1 ft / 0.3048 m x 486.7 yd x 3 ft / 1 yd x 1 ac / 43,560 ft^2 = 554.25587 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 x A
(2 x 200 Watts) + (4 x 100 Watts) + (5 x 60 Watts) = 120 volts x amps
amps = 9.16667 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

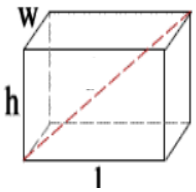
100 horsepower – [100 hp x 5400 ft x (0.015 / 1000 ft)] = 91.9 hp

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' x $ 1.16 / ft = $ 29.928
19' x $ 0.88 / ft = $ 16.72
231" x 1 ft / 12" x $ 2.44 / ft = $ 46.97 Total = $ 93.618
$ 93.618 x 1.07 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



Picture of rectangular prism

A. 7.3 lbs / ft^3
B. 7.7 lbs / ft^3
C. 8.1 lbs / ft^3
D. 9.4 lbs / ft^3

4500 lbs = lbs / ft^3 x 7.75' x 11.75' x 5.25 feet →→ lbs / ft^3 = 4500 lbs / 478.078125 ft^3 →→ 9.412688 lbs / 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 × 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

Acres = 3/4 x 3.14 x (0.25 mi x 5280 ft / mi)^2 x 1 ac / 43,560 ft^2 = 94.2 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 ÷ 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 cyl × 3.14 × (4.56 in / 2)^2 × 6.45 in × (1 L / 61 in^3) = 10.3557 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

$ saving / mth = [(36 lights x 150 W) – (24 lights x 60 W)] x $0.1174 / kwh x 105 hrs/mth x 1 kwh / 1000 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 gals gas x 6.3 lbs / 1 gal = 34.461 lbs
4.97 gals diesel x 6.943 lbs / 1 gal = 34.50671 lbs
4.71 gals oil x 7.3 lbs / 1 gal = 34.383 lbs
4.72 gals fluid x 7.298 lbs / 1 gal = 34.44656 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 × 1" × 10" × 10' × 12"/1 ft × 1bd-ft/144in^3 = 166.67 bd-ft
20 × 1" × 8" × 12' × 12"/1 ft × 1bd-ft/144in^3 = 160 bd-ft ***
14 × 2" × 6" × 12' × 12"/1 ft × 1bd-ft/144in^3 = 168 bd-ft
10 × 2" × 10"× 10' × 12"/1 ft × 1bd-ft/144in^3 = 166.67 bd-ft

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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 **o**f cylinder = (π) x (radius)^2 x height π = 3.14 radius = (diameter ÷ 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") ÷ 2 = (36" - 0.5" - 0.5") ÷ 2 = 17.5"
Radius = 17.5" x 1'/ 12" = 1.458333333'
Vol. of Cylinder = π x r^2 x h = π x (1.458333333')^2 x 18' = 120.2640939 ft^3
Cubic-Yards of Concrete = 120.2640939 ft^3 x (1 yd^3 / 27 ft^3) = 4.454226 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 gal / 8 hrs) - (8.45 gal/hr) = 0.925 gallons/hr increase

% = 0.925 gal / 8.45 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 m / 69 sec) x (1 ft / 0.3048 m) x (60 sec. / min. x 60 min. / 1 hr) x (1 mi / 5,280 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

$$\text{Ton}_{\text{Refrigeration}} = \frac{3412.14\ \text{BTUs}}{1\ \text{kwh}} \times \frac{1\ \text{Ton}}{12{,}000\ \text{BTUs / hr}} \times \frac{124\ \text{kwh}}{24\ \text{hrs}}$$

>> = 1.46912 $\text{Ton}_{\text{Refrigeration}}$ or 1.5 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 Nm x 0.22481 lbs / 1 N x 3.28084 ft / 1 m = 9.58835 ft. lbs.
Or
13 Nm x 1 lbs / 4.44822 N x 1 ft / 0.3048 m = 9.58835 ft. lbs.

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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?

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

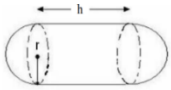
A. 194.5 foot-pounds
B. 204.3 foot-pounds
C. 214.5 foot-pounds
D. 224.3 foot-pounds

20 hp x 5252 ÷ 540 rpms = 194.5185 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)

Volume of cylinder = π × (cylinder radius)^2 × cylinder height π = 3.14 1 gallon = 231 cubic inches

Volume of sphere = 4/3 x π × (cylinder radius)^3



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

r = 21~9/32" = 21.28125" and h = 6' 9~15/16" = 81.9375"
Vol. of Tank = {[3.14 x (21.28125")^2 x 81.9375"] + [4/3 x 3.14 x (21.28125")^3]} x 1 gal/231 in^3
Vol. of Tank = (116,521.6496 in^3 + 40,351.50947 in^3) x 1 gal/231 in^3
Vol. of Tank = 156,873.1591 in^3 x 1 gal/231 in^3
Vol. of Tank = 679.1045847 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 ounces = 1 gal 16 ounces = 1 pint

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

Gallons = [(0.75 pts / ac) x (16 oz / pt) x (1 gal / 128 oz) x (522 acres)]
= 48.9375 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?

PTO Power = Torque x Rotational Speed ÷ 5252

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

Torque = 5252 x 250 / 1000
= 1,313 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?

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

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

Kilowatts-hours = [(2400 Watts + 3000 Watts) x 10 hours/day x 300 days] / 1000 Watts/kilowatt
= 16,200 kwh

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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 hrs x $0.1375 / kWh) + [(2779 Watts - 1000 Watts) x $0.1555 / 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 × Area radius = (diameter ÷ 2)

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

Force = Pressure x Area = 2,600 lb/in^2 × 3.14 x (2.9 in / 2)^2 = 17,164.81 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 = (π) x $(\text{radius})^2$ x length
$\pi = 3.14$ diameter = (2 × 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

CFM = 1/10 x ½ [3.14 x (30' ÷ 2)^2 x 60']
CFM = 2119.5 ft^3 / min.

End view of greenhouse.

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

bu = 1 bu / 62.5 lb x 90 T x 2000 lb / 1 T = 2,880 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) x (π) x (radius) $\pi = 3.14$ diameter of circle = (2) x (radius)

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

Answer: Two step complicated method:
rpm = 10 mi / hr ÷ [(3.14 x 40.5" x 1' / 12") / rev x 1 mi / 5280' x 60 min / hr] = 83.03845244 rpm
mph = [(3.14 x 43.9" x 1' / 12") / rev] x 1 mi / 5280' x 60 min / hr x 83.03845244 rpm = 10.8395 mph
Simple method: [43.9" ÷ 40.5"] x 10 mph = 10.8395 mph