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

2015 Examination for the

National Agricultural Technology and Mechanical Systems

Career Development Event

Name ____

Print Name Legibly

Answer Key for Examination

Order and Point Assignment for Exam Questions (2 points each)

1. Machinery	6. Environmental	11. Structural	16. Energy	21. Electrical
2. Electrical	**7. Machinery**	12. Environmental	17. Structural	22. Energy
3. Energy	8. Electrical	**13. Machinery**	18. Environmental	23. Structural
4. Structural	9. Energy	14. Electrical	**19. Machinery**	24. Environmental
5. Environmental	10. Structural	15. Energy	20. Electrical	**25. Machinery**

MACHINERY & EQUIPMENT SYSTEMS
ELECTRICAL SYSTEMS
ENERGY SYSTEMS
STRUCTURAL SYSTEMS
ENVIRONMENTAL & NATURAL RESOURCE SYSTEMS

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 Scantron sheet.

2015 Written Examination for the National Agricultural Technology & Mechanical Systems Career Development Event

Mark all answers on the Scantron sheet using a pencil. *Read each question carefully and mark the single correct answer on the Scantron 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: A tractor's power takeoff produces 325 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. 1652.4 foot-pounds
B. 1706.9 foot-pounds
C. 1841.2 foot-pounds
D. 1927.5 foot-pounds

325 hp x 5252 ÷ 1000 rpms = 1706.9 ft-lbs

2. Electrical: A water supply station used to refill pesticide tanks has a 4 horsepower electrical pump that operates at 120 volts. If the motor is 85 percent efficient and has a 0.9 power factor, what is the approximate amperage of the motor?

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

1 horsepower = 746 Watts

A. 8.1 amps
B. 27.6 amps
C. 32.5 amps
D. 253.6 amps

$4 \text{ hp} = \frac{120 \text{ V} \times ? \text{ A} \times 0.9 \times 0.85}{746}$ Amps = 32.50544662 amps

3. Energy: A 200 horsepower eight-cylinder engine is operating at 6865 feet above sea level. What approximate horsepower can be produced by the engine when the engine's power is reduced 2.45 percent for each 1000 feet of elevation above sea level?

A. 166.4 horsepower
B. 194.2 horsepower
C. 136.4 horsepower
D. 274.2 horsepower

200 horsepower – [200 hp x 6865 ft x (0.0245 / 1000 ft)] = 166.3615 hp

4. Structural: A pesticide spray tank has a cylindrical shape that is 7 feet 9 inches long with a radius of 2 feet. What is the approximate total storage capacity of the tank in gallons?

1 gallon = 231 cubic inches   1 foot = 12 inches π = 3.14   Diameter = 2 × (radius)

Volume of a Cylinder = (π) × $(\text{radius})^2$ × (length)   1728 cubic inches = 1 cubic foot

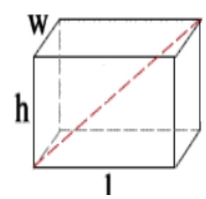
A. 97 gallons
B. 728 gallons
C. 972 gallons
D. 1,438 gallons

(3.14) x $(2')^2$ x (7.75') x 1728 in^3 / 1 ft^3 x 1 gal / 231 in^3 = 728.1537662 gal

5. Environmental: A rectangular shaped plastic hopper is used to transport granular pesticide in bulk. This hopper is transported on a trailer with a 5000-pound maximum load carrying capacity. The internal dimensions of the hopper are 6.5 feet wide, 8.75 feet long and 4.25 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. 20.7 lbs / ft^3
B. 23.6 lbs / ft^3
C. 27.1 lbs / ft^3
D. 99.2 lbs / ft^3

5000 lbs = lbs / ft^2 x 6.5' x 8.75' x 4.25 feet →→ lbs / ft^2 = 5000 lbs / 241.71875 ft^2 →→ 20.685197 lbs / ft^2

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6. Environmental: What is the approximate annual power consumption (kilowatt-hours, kWh) of a 240 volt electrical installation with 36 lights, each light using 0.95 amps and operating an average of 9 hours and 30 minutes each day, and 22.5 days per month? 1 year = 12 months Kilowatt = 1000 Watts
Watts = Volts × Amps Volts = Amps × Resistance in Ohms Kilowatt-hours = Kilowatts × Hours

A. 1,717.5 kWh
B. 2,169.3 kWh
C. 20,610.3 kWh
D. 21,053.5 kWh

240 volts x 0.95 amps / load x 36 loads x 9.5 hrs/day x 22.5 days/ mth x 12 mths / yr x 1 kWh / 1000 Watts = 21053.52 kWh

7. Machinery: Each cylinder in an eight cylinder tractor engine has a bore (diameter) of 4.85 inches and a piston stroke of 6.25 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 ÷ 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. 1.9 liters
B. 15.1 liters
C. 60.5 liters
D. 900.5 liters

8 cyl × 3.14 × (4.85 in / 2 $)^2$ × 6.25 in × (1 L / 61 in^3) = 15.135379 L

8. 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 8 hours and 30 minutes per day, 322 days each year, and its annual electrical bill averaged $18,983. The purchase price for motor B is $1,318 and the installation charge is $390. Motor B will be operated the same number of hours as motor A and will have an average cost of $5.87 per hour to operate. Approximately how many months must motor B operate to payback the purchase and installation cost of the new motor?
1 year = 12 months 1 day = 24 hours 1 year = 365 days

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

A. 7 months
B. 84 months
C. 125 months
D. 294 months

$$\text{Payback} = \frac{(\$1318 + \$390)}{(\$18{,}983/\text{yr} \times 1\text{yr} / 12 \text{ mths}) - (\$5.87/\text{hr} \times 8.5 \text{ hrs/day} \times 322 \text{ days/yr} \times 1\text{yr}/12 \text{ mths})} = 7.026854689 \text{ mths}$$

9. Energy: An available electronic thermometer is calibrated in degrees Celsius (ºC). A pesticide label specifies that the maximum allowable temperature for spray applications is 75 degrees Fahrenheit (ºF). What is the approximate temperature equivalent in degrees Celsius?
ºF = (9/5 ºC) + 32 ºC = 5/9 (ºF - 32) Water freezes at 32 ºF Water boils at 212 ºF

A. 9.7 ºC
B. 23.9 ºC
C. 41.7 ºC
D. 167.0 ºC

ºC = 5/9 x (75 ºF - 32) = 23.888888 ºC

10. Structural: Steel angle iron is sold for $2.11 per linear foot, steel rod is sold for $1.91 per linear foot, and steel pipe is sold for $3.19 per linear foot. If 28.5 feet of angle iron, 23 feet of rod, and 15.5 feet of pipe are purchased, what is the approximate total price for the metal before taxes?

A. $ 60.15
B. $ 93.36
C. $ 109.58
D. $ 153.51

28.5' x $ 2.11 / ft = $ 60.135
23' x $ 1.91 / ft = $ 43.93
15.5' x $ 3.19 / ft = $ 49.445 Total = $ 153.51

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. 52 boards measuring 1 inches by 6 inches by 14 feet
B. 27 boards measuring 2 inch by 8 inches by 10 feet
C. 45 boards measuring 2 inches by 6 inches by 8 feet
D. 46 boards measuring 1 inch by 8 inches by 12 feet

Nominal Measurement Comparison (same answer for actual)
$52 \times 1" \times 6" \times 14' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 364$ bd-ft
$27 \times 2" \times 8" \times 10' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 360$ bd-ft
$45 \times 2" \times 6" \times 8' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 360$ bd-ft
$46 \times 1" \times 8" \times 12' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 =$ 368 bd-ft

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 any inconsistencies in the ground surface and note that pre-mixed concrete is sold/delivered in quarter-yard quantities (such as: 3 yd3, 6.25 yd3, 10.75 yd3, 15.5 yd3). Approximately how many cubic yards (yd^3) of pre-mixed concrete should be ordered?
1 cubic yard = 27 cubic feet　　1 cubic foot = 1728 cubic inches　　1 foot = 12 inches
Volume of rectangular prism = Length × Width × Height

A. 3.50 yd^3
B. 5.25 yd^3
C. 5.75 yd^3
D. 68.50 yd^3

24' x 14' x 5" x (1 ft/12") x (1 yd^3/27 ft^3) x (1.10) = 5.7037 yd^3 → 5.75 yd^3

13. Machinery: Approximately how many acres are in a rectangular field measuring 1109 meters by 928 yards?
1 acre = 43, 560 square feet　　1 hectare = 2.47 acres　　1 acre = 0.4045 Hectares
Area of Rectangle = length × 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

1109 m x 1 ft / 0.3048 m x 928 yds x 3 ft / 1 yd x 1 ac / 43,560 ft^2 = 232.5401474 ac

14. Electrical: A pesticide boom sprayer with eight spray nozzles is mounted on the back of an ATV (4-wheeler) and the pump motor is powered by the 12 volt battery of the vehicle. The spray pump's range of operation for spraying applications is 20 to 45 pounds per square inch (PSI), but there is a 20% loss in pressure due to the spray system's components. If each nozzle must deliver a range of 0.02 to 0.04 gallons per minute (GPM), which of the following motors is most economical to purchase and also has the appropriate capacity and specifications for this boom sprayer.
VDC = direct current voltage　　VAC = alternating current voltage

A. Motor A, rated at 12 VDC, cost $219, and delivers up to 5 GPM at 100 PSI
B. Motor B, rated at 12 VDC, cost $149, and delivers up to 2 GPM at 65 PSI
C. Motor C, rated at 12 VDC, cost $119, and delivers up to 3.2 GPM at 45 PSI
D. Motor D, rated at 12 VAC, cost $93, and delivers up to 2.1 GPM at 65 PSI

Max volume required = 8 nozzles x 0.04 GPM = 0.32 GPM
Must be DC voltage and requires at least 1.2% x 45 PSI = 54 PSI to allow for system pressure losses at max pressure

15. Energy: A hot waterline is used 6 hours and 45 minutes each day, has three different water leaks, and the amount of water lost at each leak has been measured during a 30 minute time period. The three quantities of water from the leaks are (a) 75 ounces, (b) 68 ounces, and (c) 111 ounces. Approximately how many gallons of water will be lost from the waterline during 100 days of operation? 1 gallon = 128 ounces　　24 hours = 1 day　　60 minutes = 1 hour

A. 2,679 gallons
B. 13,395 gallons
C. 44,648 gallons
D. 342,900 gallons

[(75 oz + 68 oz + 111 oz) ÷ 30 min] × (60 min/1 hr) × (6.75 hrs/day) × 100 days x (1 gal/128 oz)
= 2678.90625 gals / 100 days

16. Energy: A water pump has a 4.75-inch diameter pulley that must turn at 800 revolutions per minute (rpm). The shaft of a 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 800 rpms? Pulley Size Formula: (Diameter of Pulley 1 x Speed of Pulley 1) = (Diameter of Pulley 2 x Speed of Pulley 2)

A. 2.2 inches
B. 3.3 inches
C. 4.4 inches
D. 5.5 inches

(4.75 in x 800 rpms) = (**??** in x 1725 rpms) ➔➔ diameter = 2.2"

17. Structural: There is concern that the numerical values marked on a 500 gallon pesticide spray tank are inaccurate and water weight will be used to determine and confirm tank volume values. The weight of the empty tank is 92 pounds. What should the approximate combined weight (pounds, lbs) be for the tank and water if the test weights are done at 100 gallons, 250 gallons and 500 gallons?
1 gallon of water = 8.34 pounds

A. 834 lbs for 100 gallons; 2085 lbs for 250 gallons; 4170 lbs for 500 gallons
B. 926 lbs for 100 gallons; 2177 lbs for 250 gallons; 4170 lbs for 500 gallons
C. 926 lbs for 100 gallons; 2177 lbs for 250 gallons; 4262 lbs for 500 gallons
D. 1018 lbs for 100 gallons; 2269 lbs for 250 gallons; 4262 lbs for 500 gallons

92 gal + (100 gal x 8.34 lb/gal) = 926 lbs
92 gal + (250 gal x 8.34 lb/gal) = 2177 lbs
92 gal + (500 gal x 8.34 lb/gal) = 4262 lbs

18. Environmental: If the delivery rate (gallons per minute) of a worn or damaged spray tip on a boom sprayer exceeds 10% (higher or lower) of the average for all of the nozzles, then that nozzle's spray tip should be replaced. The following delivery rates (in ounces; oz) were measured during a 20-second time period. Which if any nozzle spray tips should be replaced?
Tip 1 = 13.5 oz; Tip 2 = 12 oz; Tip 3 = 10.5 oz; Tip 4 = 12.5 oz; Tip 5 = 13 oz; Tip 6 = 14 oz

A. Replace tips 1 and 4
B. Replace tips 2 and 5
C. Replace tips 3 and 6
D. All tips are within 10%

?? oz /20 sec x (1 gal/128 oz) x 60 sec/1 min) = GPM **But is not necessary!**
Average of oz/20 sec = $\frac{13.5 + 12 + 10.5 + 12.5 + 13 + 14}{6} = \frac{75.5}{6}$ = 12.5833333 oz / 20 sec
90% = 0.90 → 0.90 x 12.583333333 = 11.325 oz / 20 sec lowest allowed
110% = 1.10 → 1.10 x 12.583333333 = 13.841666 oz / 20 sec highest allowed

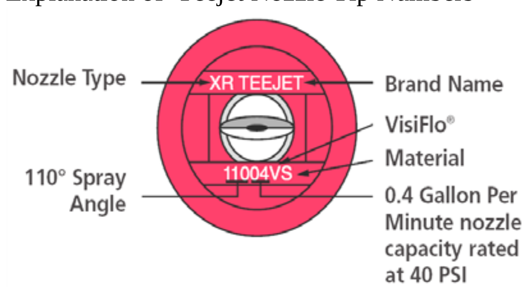
19. Machinery: A tractor mounted pesticide sprayer has 36 Teejet nozzles uniformly spaced along a spray boom. The applicator prefers to travel at 5 miles per hour (MPH) and wants to apply the pesticide and water mixture at a rate of 20 gallons per acre (GPA) to provide good coverage of the target site. Which of the following combinations of nozzle tip sizes and nozzle spacing will provide the approximate coverage required given the above parameters? This spray equipment is operated at 40 pounds per square inch (PSI) as recommended by Teejet. The Teejet number coding appears in the box.

$$\frac{\textbf{Gallons Per Minute}}{\textbf{Nozzle}} = \frac{\textbf{GPA x MPH x Nozzle Spacing in Inches}}{\textbf{5940}}$$

A. XR Teejet 8001VS with 20 inch nozzle spacing
B. XR Teejet 11002VS with 22 inch nozzle spacing
C. XR Teejet 8004VS with 24 inch nozzle spacing
D. XR Teejet 11008VS with 26 inch nozzle spacing

$GPM_C = \frac{20 \text{ GPA x } 5 \text{ MPH x } 24"}{5940}$ GPM_C = 0.404040
GPM_A = 0.336700 GPM_B = 0.370370 GPM_D = 0.437710

Explanation of Teejet Nozzle Tip Numbers



20. Electrical: The interior electrical lighting of a farm structure is being replaced with high efficiency lighting. The 24 incandescent, 200-Watt lights will be replaced with 24 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 Watts = 1 kilowatt

A. $ 10.56
B. $ 31.68
C. $ 42.40
D. $ 68.82

$ saving / mth = (200 W - 50 W) x $0.10 / kwh x 88 hrs/mth x 24 lights x 1 kwh / 1000 W = $31.68

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21. Electrical: Three incandescent light bulbs (100 Watts, 200 Watts, 300 Watts) are operating in a 120 volt circuit. If each bulb operates at its rated wattage, which of the following statements is correct in regard to the operation of the bulbs? Wattage = Voltage × Amperage
Voltage = Amperage × Resistance

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

0.833 Amps = 100 Watts / 120 volts
R = 120 volts / 0.833 = 144 ohms

22. Energy: An electric water heaters uses 880 kilowatt-hours (kWh) of power each day. If electric power cost 11.5 cents per kWh, approximately how much energy (in therms) does this water heater use during 22 days of operation? British Thermal Unit = BTU
1 kWh = 3412.3 BTUs of energy 1 therm of energy = 100,000 BTUs of energy

A. 306.0 therms
B. 660.6 therms
C. 933.6 therms
D. 7507.0 therms

880 kWh /day x 22 days x 3412.3 Btus / kWh x 1 therm / 100,000 Btus = 660.62128 therms

23. Structural: A round concrete column is fabricated using 2.25 cubic yards of concrete. If the concrete column is 2 feet 4 inches in diameter, what is the approximate height of the column?
1 cubic yard = 27 cubic feet 1 cubic foot = 1728 cubic inches 1 foot = 12 inches
Volume of cylinder = $\pi \times (\text{cylinder radius})^2 \times$ cylinder height $\pi = 3.14$ diameter = (2 × radius)

A. 5.4 feet
B. 9.7 feet
C. 11.9 feet
D. 14.2 feet

2.25 yd^3 = 3.14 × (28" ÷ 2 x 1' / 12")^2 × height ft × (1 yd^3 / 27 ft^3)
height = 2.25 yd^3 ÷ [(3.14 x $(1.166667)^2$ × (1 yd^3 /27 ft^3)] = **14.2142126'**

24. Environmental: A large volume of water contaminated with liquid pesticide (water and liquid pesticide) was collected from the runoff of a mixing and loading concrete pad. Initially the liquid is 6% pesticide and 94% water. Over the summer much of the water evaporates and only 42% of the water remains. All of the pesticide still remains. What is the approximate percentage of pesticide in the remaining liquid?

A. 9.9 % pesticide
B. 11.4 % pesticide
C. 12.1 % pesticide
D. 13.2 % pesticide

Initially waste water mixture = 0.06 P + 0.94 W = 1.00 (P & W)
After evaporation mixture = (0.06 P + 0.94 W) - (0.58 x 0.94 W)
= 0.06 P + (0.94 W - 0.5452 W) = 0.06 P + 0.3948 W
% P in P&W = 0.06 P ÷ (0.06 P + 0.3948 W) = 0.06 P ÷ 0.4548 (P&W)
% P = 0.1319261214 x 100%/1 = 13.2%

25. Machinery: A tractor powered herbicide boom sprayer with 24 spray nozzles, spaced 20 inches apart, is setup and calibrated to spray weeds in forage crops. The sprayer delivers a herbicide and water mixture at a uniform rate of 17.5 gallons per acre, travels at 4.75 miles per hour (MPH), and operates at a spray pressure of 30 pounds per square inch (PSI). An unusually high weed infestation requires an increase in the application of the herbicide mixture to 20 gallons per acre (GPA). Which of the following changes to one of the sprayer's operating parameters will most closely achieve 20 GPA?

$$\frac{\text{Gallons Per Minute}}{\text{Nozzle}} = \frac{\text{GPA x MPH x Nozzle Spacing in Inches}}{5940}$$

Pressure Formula: New PSI = (Original PSI) x (New GPM ÷ Original GPM)^2

A. Decrease speed from 4.75 MPH to 4.5 MPH
B. Decrease speed from 4.75 MPH to 4.25 MPH
C. Increase pressure from 30 PSI to 34 PSI
D. Increase pressure from 30 PSI to 39 PSI

Simplest/fastest way is to try each of the four answers. Reviewing answers prior to starting solution might save time because B and D are highest of the two types of answers.
?? Original GPM per Nozzle = 17.5 GPA x 4.75 MPH X 20" ÷ 5940 = **0.2798821549 Original GPM**
0.2798821549 GPM_A per Nozzle = ?? GPA_A x 4.5 MPH x 20" ÷ 5940 = **18.47222 GPA_A**
0.2798821549 GPM_B per Nozzle = ?? GPA_B x 4.25 MPH x 20" ÷ 5940 = **19.55 GPA_B**
34 PSI = 30 PSI x (New ?? GPM ÷ 0.2798821549 GPM)^2 → New GPM_C = 0.2979573068
0.2979573068 GPM_C per Nozzle = **?? GPA_C x** 4.75 x 20" ÷ 5940 = **18.63017266** GPA_C
39 PSI = 30 PSI x (New ?? GPM ÷ 0.2798821549 GPM)^2 → New GPM_C = 0.3191147549
0.3191147549 GPM_D per Nozzle = **?? GPA_D x** 4.75 x 20" ÷ 5940 = **19.95306994 GPA_D**