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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.

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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?

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

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?

1 horsepower = 746 Watts

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

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

4 hp = $\frac{120 \text{ V x ? A x } 0.9 \text{ x } 0.85}{746}$ 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 = $(\pi) \times (\text{radius})^2 \times (\text{length})$ 1728 cubic inches = 1 cubic foot

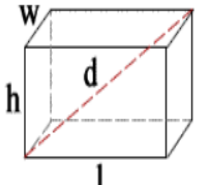
A. 97 gallons
B. 728 gallons
C. 972 gallons
D. 1,438 gallons

$(3.14) \times (2')^2 \times (7.75') \times 1728 \text{ in}^3 / 1 \text{ ft}^3 \times 1 \text{ gal} / 231 \text{ in}^3 = 728.1537662 \text{ gal}$

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

$8 \text{ cyl} \times 3.14 \times (4.85 \text{ in} / 2)^2 \times 6.25 \text{ in} \times (1 \text{ L} / 61 \text{ in}^3) = 15.135379 \text{ L}$

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

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

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 × 1" × 6" × 14' × 12"/1 ft × 1bd-ft/144in^3 = 364 bd-ft
27 × 2" × 8" × 10' × 12"/1 ft × 1bd-ft/144in^3 = 360 bd-ft
45 × 2" × 6" × 8' × 12"/1 ft × 1bd-ft/144in^3 = 360 bd-ft
46 × 1" × 8"× 12' × 12"/1 ft × 1bd-ft/144in^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

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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

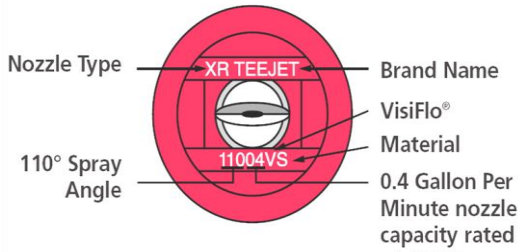
19. Machinery: A tractor mounted pesticide sprayer has 36 Teejet nozzles uniformly spaced along a spray boom. The applicator prefers to travel at 5 miles per hour (MPH) and wants to apply the pesticide and water mixture at a rate of 20 gallons per acre (GPA) to provide good coverage of the target site. 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.

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

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 = π × (cylinder radius)^2 × cylinder height π = 3.14 diameter = (2 × radius)

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

$2.25\ yd^3 = 3.14 \times (28" \div 2 \times 1'/12")^2 \times height\ ft \times (1\ yd^3 / 27\ ft^3)$

$height = 2.25\ yd^3 \div [(3.14 \times (1.166667)^2 \times (1\ yd^3 / 27\ ft^3)] =$ **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

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1. Machinery: Approximately how many acres are in a rectangular field measuring 1094 meters by 1.25 miles? 1 acre = 43, 560 square feet 1 hectare = 2.47 acres 1 acre = 0.4045 Hectares
Area of Rectangle = length × width 1 mile = 5,280 feet 1 foot = 0.3048 meter

A. 321.6 acres
B. 391.7 acres
C. 463.5 acres
D. 543.8 acres

1094 m x 1 ft / 0.3048 m x 1.25 mi x 5280 ft / 1 mi x 1 ac / 43,560 ft^2 = 543.824067 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 ten 60-watt lights, eight 100-watt lights, and four 200-watt lights. What is the amperage of the circuit with all of these light operating?
Total Wattage = Voltage x Amperage

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

W = V x A
(10 x 60 Watts) + (8 x 100 Watts) + (4 x 200 Watts) = 120 volts x amps
amps = 18.333333 amps

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

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

180 horsepower – [180 hp x 4870 ft x (0.0225 / 1000 ft)] = 160.2726 hp

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

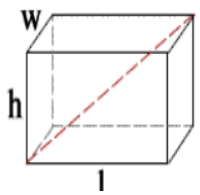
A. 11,700 psi
B. 65,000 psi
C. 260,000 psi
D. 292,500 psi

(1,170,000 lbs/4 bars) ÷ (1.5" x 3") = 65,000 psi

5. Environmental: In order to protect ground water from animal waste contaminants a concrete slab will be poured using forms that have inside dimensions of 34 feet, 9 inches by 23 feet, 3 inches. The forms allow for a concrete slab that is 6 inches deep. What is the approximate quantity of concrete that will be needed to pour this slab? 1 cubic yard = 27 cubic feet
1 gallon = 231 cubic inches 1 cubic-foot = 1728 cubic-inches
Volume of rectangular prism = Length × Width × Height

A. 13 yd^3
B. 15 yd^3
C. 17 yd^3
D. 19 yd^3

? yds^3 = 34.75' x 23.25' x 0.5' x 1 yd^3 / 27 ft^3 14.9618



Picture of rectangular prism

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

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 1 foot = 0.3048 meter

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

Acres = 3.14 x (500 m x 1 ft / 0.3148 m)^2 x 1 ac / 43,560 ft^2 = 181.849595 ac

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

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

6 cyl × 3.14 × (4.62 in / 2)^2 × 6.1 in × (1 L / 61 in^3) = 10.0532 L

8. Electrical: A water pump for stock tanks has an electrical motor that operates at 120 volts and uses 20 amps of current. If the motor is 87.5 percent efficient and has a 0.89 power factor, what is the approximate horsepower of the motor? 1 horsepower = 746 Watts

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

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

$$\text{? hp} = \frac{120\ \text{V} \times 20\ \text{A} \times 0.89 \times 0.875}{746} = 2.5\ \text{hp}$$

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

ºF = (9/5 ºC) + 32 ºC = 5/9 (ºF - 32) Water freezes at 32 ºF Water boils at 212 ºF

A. 100 ºF
B. 140 ºF
C. 180 ºF
D. 220 ºF

ºF = (9/5 x 82 ºC) + 32 = 179.6 ºF

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

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

60' x $ 1.79 / ft = $ 107.40
20' x $ 0.92 / ft = $ 18.40
63' x $ 2.91 / ft = $ 183.33 Total = $ 309.13
$ 309.13 x 1.07 tax = $ 330.7691

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

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

Nominal Measurement Comparison (same answer for actual)
$13 \times 1" \times 6" \times 12' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 78$ bd-ft
$11 \times 1" \times 8" \times 12' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 88$ bd-ft
$12 \times 2" \times 4" \times 10' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 80$ **bd-ft**
$9 \times 2" \times 6" \times 8' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 72$ bd-ft

12. Environmental: If a animal waste storage tank measures 60 feet wide by 33 yards long. Approximately how deep must the container be to hold 200,500 gallons of liquid?
1 gallon = 0.133681 cubic feet 1 yard = 3 feet 1 cubic foot = (1 foot x 1 foot x 1 foot)

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

250,000 gal = 1gal/ 0.133681 ft^2 x 60 ' x 33 yds x 3 ft/yd x depth ? feet
Depth ? feet = 250,000 gal x 0.133681/1 gal ÷ (60' x 33 yds x 3 ft/yd)
Depth = 5.6263047 ft

13. Machinery: What is the approximate speed, in miles per hour, for a planter that travels 100 meters in 39.5 seconds? 5,280 ft = 1 mile 3600 seconds = 1 hour 1 foot = 0.3048 meter

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

mph = (100 m / 39.5 sec) x (1 ft / 0.3048 m) x (3600 sec / 1 hr) x (1 mi / 5,280 ft)
= 5.66313 mph

14. **Electrical: Three incandescent light bulbs (100 Watts, 200 Watts, 300 Watts) are operating properly in a 120 volt electrical circuit. If each bulb operates at 120 volts, which of the following statements is correct in regard to the operation of the bulbs?**
Information: 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 less electrical resistance (ohms) than the 200- or 300-Watt light bulbs.
D. The 100-watt light bulb has more electrical resistance (ohms) than the 200- or 300-Watt light bulbs.

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

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

A. $ 0.79 per ft^3
B. $ 0.86 per ft^3
C. $ 24.08 per ft^3
D. $ 29.35 per ft^3

$ / ft^3 = $343.14 / 399 ft^3 = $ 0.86 / ft^3

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

NATURAL GAS CONSUMPTION			SERVICE FEES	Cost
Current Meter Reading (cubic-feet)	1932		Gas Consumption Charge	$ 301.60
Previous Meter Reading (cubic-feet)	1533		Monthly Connection Fee	$ 13.50
Meter Difference (cubic-feet)	399		Subtotal	$ 315.10
Average Consumption (cubic-feet / day	14.25		City/State/Energy Taxes (8.9%)	$ 28.04
*Volume Multiplier	0.088894		Current Total Due	$ 343.14

1 kWh = 3412.3 Btus 1 therm = 100,000 Btus (approximate, varies seasonally)
*Volume Multiplier: Converts gas volume (cubic-feet read on meter) to therms of gas consumed (value varies seasonally).
A British thermal unit (Btu) is the heat required to raise the temperature of one pound of water one degree Fahrenheit.
Therm: Unit of measurement used by gas companies to convert the volume of gas to its heat equivalent (actual energy).

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

16. Energy: A water pump has a 3.5-inch diameter pulley that must turn at 1000 revolutions per minute (rpm). The shaft of a electric motor rotates at 1725 rpm and powers the belt that turns the pump's pulley. What is the approximate diameter of the pulley needed on the motor shaft to turn the pump at 1000 rpms? Pulley Size Formula: (Diameter of Pulley 1 x Speed of Pulley 1) = (Diameter of Pulley 2 x Speed of Pulley 2)

A. 1.0 inches
B. 1.3 inches
C. 1.7 inches
D. 2.0 inches

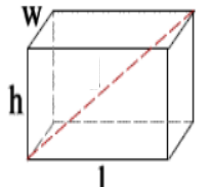
(3.5 in x 1000 rpms) = (?? in x 1725 rpms) ➔➔ diameter = 2.0289855”

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

Volume of rectangular prism = Length × Width × Height

A. 40 inches
B. 44 inches
C. 48 inches
D. 52 inches

2050 lbs/box ÷ 42.5 lbs / block = 48 blocks /box
48" length & width - 6" for wood sides = 42" inside space length & width
4 blocks x 4 blocks per layer = 16 blocks per layer
4 x 10" / block = 40" to fit inside 42" space
4 x 14" on a layer will not work with only 42" of space
48 blocks / box ÷ 16 blocks /layer = 3 layers
3 layers x 14" per layer = 42" 42" for blocks + 6" for wood = 48"



Picture of rectangular prism

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

A. 8.2 feet of head loss
B. 12.4 feet of head loss
C. 69.2 feet of head loss
D. 109.0 feet of head loss

head loss = [109 ft + (4 elbows x 4.85 ft / elbow)] x (6.4 ft loss / 100 ft) = 8.2176 ft

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

Force = Pressure × Area radius = (diameter ÷ 2)

A. 11,099 pounds
B. 14,811 pounds
C. 17,644 pounds
D. 20,488 pounds

Force = Pressure x Area = 2,900 lb/in^2 × 3.14 x (3in / 2)^2 = 20,488 lbs

20. Electrical: The monthly charge to operate an electric pump is 12.75 cents per kilowatt hour (kwh) for the first 1000 hours and 13.9 cents for each kwh greater than 1000 hours. If the pump uses 6.75 kilowatts per hour and it operates 22 days each month for 12 hours each day, what is the approximate monthly kwh charge to operate the pump?

Information: 1 kilowatt = 1000 Watts 100 cents = $1.00

A. $ 196.30
B. $ 236.20
C. $ 274.10
D. $ 314.00

kwh / month = 6.75 kw x 22 days / mth x 12 hrs / day = 1782 kwh / mth
$ = (1000 kwh/mth x $0.1275 / kWh) + [(1782 kwh/mth - 1000 kwh/mth) x $0.139 / kWh]
kwh/mth = $ 236.198

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21. Electrical: An old electrical motor has 'burned' out and must be replaced. The old motor operated an average of 10.5 hours each day, 27 days each month, and its average annual electrical bill was $11,895. The replacement cost for a motor (identified as A) that is identical to the old motor sells for $789 dollars and the installation charge is $276. An energy efficient motor (identified as B) sells for $1,092 and the installation charge is $314. Motor B will have an average cost of $3.39 per hour to operate. Approximately how many months must motor B operate to make up (payback) the higher cost to purchase and install an energy efficient motor rather than motor A? 1 year = 12 months

Motor Burnout Payback Period = (total cost for high efficient equipment B) - (total cost for identical equipment A) / (average saving in energy cost per month)

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

Payback = [($1,092 + $314) - ($789 + $276)] / [($11,895/yr × 1yr/12 mths) - ($3.39./hr × 10.5 hrs/day × 27 days/mths)] = 11.297 mths

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

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

$/therm = $301.60 / (399 ft3 x 0.088894) = $8.503270 / therm

23. Structural: A round concrete column (cylinder) is fabricated using 1. 5 cubic yards of concrete. If the concrete column is 15 feet 6 inches in height, what is the approximate diameter of the column?

1 cubic yard = 27 cubic feet 1 cubic foot = 1728 cubic inches 1 foot = 12 inches

Volume of cylinder = π × (cylinder radius)^2 × cylinder height π = 3.14 diameter = (2 × radius)

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

1.5 yd^3 = 3.14 x (diameter ÷ 2 x 1' / 12")^2 x 15.5' x (1 yd^3 / 27 ft^3)

diameter = $\sqrt{(1.5\ yd^3 \times 27\ ft^3 / 1\ yd^3 \div (3.14 \times 15.5'))}$ x 2 x 12"/1'

diameter = 21.893141 31"

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

1.00 = 100%

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

Manure Content at time of application:
MC = [(1.00 - 0.19 Moisture Remaining) x 0.90 Moisture] + 0.10 Solids = 0.829
% Solids at time of application:
Solids = 0.10 / 0.829 = 0.12062726 = 12.1%

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

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

% Solids = 12.1% from question 24
lbs = 4800 gal/spreader application x 8.43 lbs / gal x 12.1% = 4896.144 lbs

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. <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.

2017 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 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 m x 1 ft / 0.3048 m x 0.75 mi x 5280 ft / 1 mi x 1 ac / 43,560 ft^2 = 578.621 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 x A
(4 x 100 Watts) + (5 x 150 Watts) + (6 x 60 Watts) = 120 volts x amps
amps = 12.5833333 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 horsepower – [25 hp x 3480 ft x (0.015 / 1000 ft)] = 23.695 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?

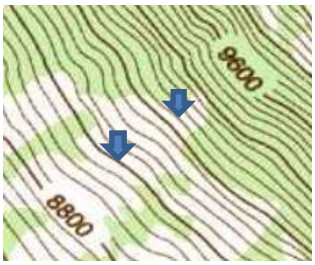
A. $ 78.14
B. $ 86.11
C. $ 92.14
D. $ 100.11

35.5' x $ 1.46 / ft = $ 51.83
12' x $ 0.94 / ft = $ 11.28
100" x 1 ft / 12" x $ 2.76 / ft = $ 23 Total = $ 86.11
$ 86.11 x 1.07 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') ÷ 20 = 40 ft
Each space between lines represents 40' of elevation change.
There are six spaces between arrows so: 6 x 40' = 240' in elevation change.



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

Pump HP = 10 hp x 1.12 x 1.10 = 12.32 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 in x 400 rpms) = (**??** in x 540 rpms) ➔➔ 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

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

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

$$1.5\text{ hp} = \frac{120\text{ V x }13.8\text{ A x }0.92\text{ x Efficiency}}{746} \quad >>>>> \quad \text{Eff.} = 0.7344833 \quad \text{Eff.} = 73.4\%$$

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 of15W-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)
$10 \times 1" \times 10" \times 10' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 83.33\text{ bd-ft}$
$10 \times 1" \times 8" \times 12' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 80\text{ bd-ft}$ ***
$7 \times 2" \times 6" \times 12' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 84\text{ bd-ft}$
$5 \times 2" \times 10" \times 10' \times 12"/1\text{ ft} \times 1\text{bd-ft}/144\text{in}^3 = 83.33\text{ bd-ft}$

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

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 ÷ 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 ÷ Run x (100% / 1)

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

Slope = (1875' - 1384') ÷ (1.24 miles x 5,280 ft. / mi.) x 100% / 1
Slope = 7.499389%

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

(110 m / 66.5 sec) x (1 ft / 0.3048 m) x (60 sec. / min. x 60 min. / 1 hr) x (1 mi / 5,280 ft)
Speed = 3.7002 mph

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

$$\text{Ton}_{\text{Refrigeration}} = \frac{3412.14 \text{ BTUs}}{1 \text{ kwh}} \times \frac{\text{Ton}}{12{,}000 \text{ BTUs / hr}} \times \frac{63 \text{ kwh}}{24 \text{ hrs}}$$

$$>> = 0.746 \text{ or } 3/4 \text{ Ton}_{\text{Refrigeration}}$$

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.

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 = 9.58831 ft. lbs.

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?

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

A. 142.4 foot-pounds
B. 153.3 foot-pounds
C. 164.2 foot-pounds
D. 175.1 foot-pounds

18 hp x 5252 ÷ 540 rpms = 175.06667 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 = π × (cylinder radius)^2 × cylinder height π = 3.14 diameter = (2 × radius)

A. 18.6 inches
B. 19.9 inches
C. 20.2 inches
D. 21.5 inches

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

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

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

loss = [97.5 ft + (3 els. x 4.9 ft / el.)] x (6.6 ft loss / 100 ft) = 7.4052 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 = (π) x (radius)^2 π = 3.14

Force = Pressure x Area radius = (diameter ÷ 2)

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

Force = 2 x Pressure x Area = 2 x 3,200 lb/in^2 x 3.14 x (2.75 in. / 2)^2 = 37,994 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 = $\frac{\text{Number of square feet x Number of BTUs per square foot}}{\text{Furnace Efficiency}}$

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

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

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

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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 ½	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			

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

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

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 ÷ 2)
Volumetric displacement of a single cylinder = (length of piston stroke) x (the area of the cylinder bore)

A. 1.2 liters
B. 1.8 liters
C. 2.5 liters
D. 2.9 liters

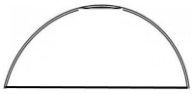
1 liter = 61 cubic inches 1 cubic inch = 0.0164 liter

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

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 × radius)

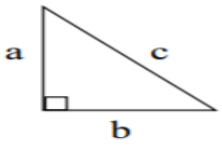
A. 16,750 cubic feet per minute
B. 17,250 cubic feet per minute
C. 17,750 cubic feet per minute
D. 18,250 cubic feet per minute

$\text{CFM} = 1/3 \times ½ [3.14 \times (40' \div 2)^2 \times 80']$
$\text{CFM} = 16{,}746.66667 \text{ ft}^3 / \text{min.}$



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 Pythgorean 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

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) x (π) x (radius) $\pi = 3.14$ diameter of circle = (2) x (radius)

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

Answer: Two step complicated method:
rpm = 15 mi / hr ÷ [(3.14 x 38.5" x 1' / 12") / rev x 1 mi / 5280' x 60 min / hr] = 131.0282075 rpm
mph = [(3.14 x 44.8" x 1' / 12") / rev] x 1 mi / 5280' x 60 min / hr x 131.0282075 rpm = 17.454546 mph
Simple method: [44.8" ÷ 38.5"] x 15 mph = 17.454546 mph

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

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.*

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 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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Mark all answers on the scan sheet.

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

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

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

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

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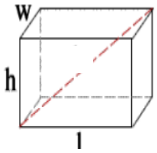
21. Electrical: The interior electrical lighting of a farm structure is being replaced with high efficiency lighting. The 36 incandescent, 100-Watt lights will be replaced with 36 LED, 40-Watt lights. If the lights are operated 100 hours per month and electricity cost 12.75 cents per kilowatt-hour (kWh),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

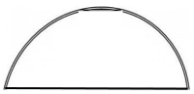
A. 16.7 lbs / ft^3
B. 19.6 lbs / ft^3
C. 23.7 lbs / ft^3
D. 27.6 lbs / ft^3

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"

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

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

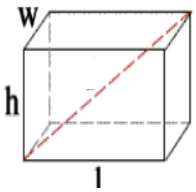
100 horsepower – [100 hp x 5400 ft x (0.015 / 1000 ft)] = 91.9 hp

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

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 **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.

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?

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

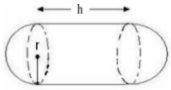
A. 194.5 foot-pounds
B. 204.3 foot-pounds
C. 214.5 foot-pounds
D. 224.3 foot-pounds

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

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

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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