

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

You have 1.5 hours to complete this exam.

**Answer Key
Do Not Distribute**

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

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

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

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

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

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

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

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

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

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

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

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

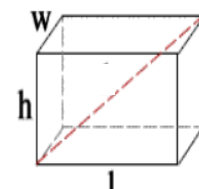


5. **Environmental:** A rectangular shaped metal container with a lid is used to transport bulk livestock feed. This container is transported on a trailer with tandem axles and each axle has a 3500-pound load carrying capacity. The total weight of the trailer and the empty container is 970 pounds. The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

1 cubic-foot = 1728 cubic-inches

Volume of rectangular prism = Length $\times$ Width $\times$ Height

- A. 25 lbs / ft³
B. 35 lbs / ft³
C. 40 lbs / ft³
D. 45 lbs / ft³



Picture of
rectangular
prism

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\begin{array}{l} \text{Nominal Measurement Comparison (same answer for actual)} \\ 6 \times 2'' \times 6'' \times 16' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 96 \text{ bd-ft} \\ 5 \times 2'' \times 8'' \times 14' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 93.333 \text{ bd-ft} \\ 9 \times 1'' \times 10'' \times 12' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 90 \text{ bd-ft} \\ 11 \times 1'' \times 10'' \times 10' \times 12''/1 \text{ ft} \times 1 \text{ bd-ft}/144 \text{ in}^3 = 91.67 \text{ bd-ft} \end{array}$$

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

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

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

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

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

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

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

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

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

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

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

1 horsepower = 746 Watts

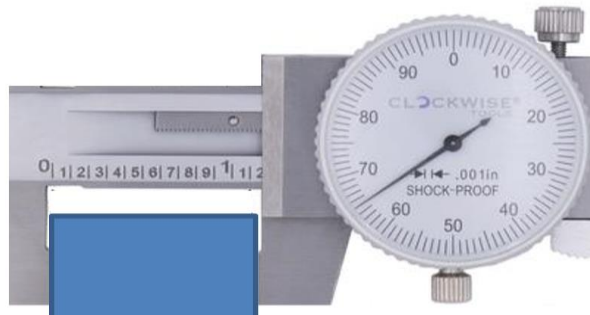
$$\text{Horsepower} = \frac{\text{voltage} \times \text{amperage} \times \text{power factor} \times \text{efficiency}}{746}$$

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

$$\begin{aligned}1.25 \text{ hp} &= \frac{120 \text{ V} \times 9.8 \text{ A} \times 0.95 \times \text{Efficiency}}{746} \ggggg \text{ Eff.} = 0.8345759757 \\ & \text{Eff.} = 83.5\%\end{aligned}$$

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

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



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

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

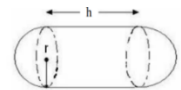
$$[(\$890 - \$75) / (3 \text{ yrs} \times 760 \text{ hrs/yr})] + \$28/\text{hr} = \$28.357456$$

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

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

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

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



$$r = 23\sim5/8'' = 23.625'' \text{ and } h = 9' 11\sim7/8'' = 119.875''$$

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

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

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

$$\text{Vol. of Tank} = 1148.458903 \text{ gal}$$

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

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

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

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

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

$$= 12.5 \text{ gallons}$$

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

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

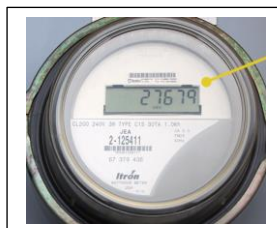
A. 1,124 lb-ft
B. 1,325 lb-ft
C. 1,426 lb-ft
D. 1,523 lb-ft

$$\text{Torque} = 5252 \times 290 / 1000$$

$$= 1,523 \text{ lb-ft}$$

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

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



$$\text{Kilowatts-hours} = 27679 - 19778 = 7901 \text{ kwh}$$

$$7901 \text{ kwh} \times \$0.1158 = \$914.9358$$

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

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

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

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

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

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

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

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

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

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

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

- A. 2" x 4" x 8' lumber
 B. 2" x 6" x 10' lumber
 C. 2" x 8" x 10' lumber
 D. 2" x 10" x 10' lumber

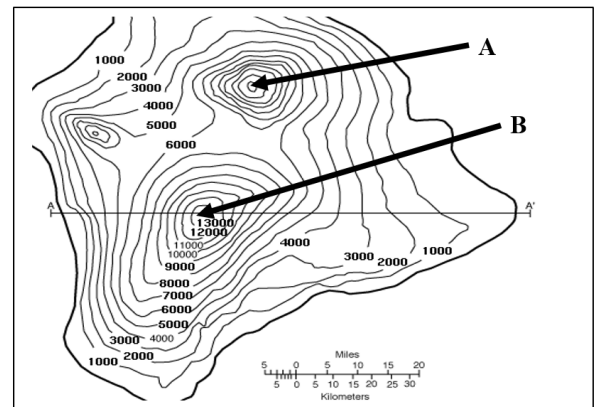
Lumber Size	Price in 2019	Price in 2021
2" x 4" x 8'	\$ 2.37	\$ 7.21
2" x 6" x 10'	\$ 5.37	\$ 15.29
2" x 8" x 10'	\$ 8.23	\$ 23.79
2" x 10" x 10'	\$ 10.81	\$ 29.37

$$\begin{aligned} \$7.21 / \$2.37 &= 304.22\% \\ \$15.29 / \$5.37 &= 284.73\% \\ \$23.79 / \$8.23 &= 289.06\% \\ \$29.37 / \$10.81 &= 271.69\% \end{aligned}$$

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

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

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



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

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

$$\pi = 3.14$$

$$\text{diameter of circle} = (2) \times (\text{radius})$$

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

$$\begin{aligned} \text{Wheel circumference} &= [2 \times 3.14 \times 5.15/2] = 16.171 \text{ feet} \\ 6.8 \text{ rotations} \times 16.171 \text{ feet} &= 109.9628 \text{ feet in 6.8 rotations} \\ \text{This represents } 9.9629 \text{ feet slippage over } 100 \text{ feet or} \\ 9.9628 \text{ feet} / 6.8 \text{ revolutions} &= 1.4651176 \text{ feet / rotation} \end{aligned}$$

2022 (On-line) Written Examination
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*You have **1.5** hours to complete this exam.*

Directions for completing this on-line exam: *T Y P E H E R E*

**2022 On-line Written Examination for the
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- 1. Machinery: If a tractor travels at 28.5 kilometers per hour, what approximate length of time (in hours and minutes) is required to travel 29.5 miles?**

1 mile = 1.6 kilometers 1 hour = 60 minutes

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

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

Watts = Volts $\times$ Amps

Volts = Amps $\times$ Resistance in Ohms

Kilowatt-hours = Kilowatts $\times$ Hours

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

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

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

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

- A. 1' 3 $\frac{3}{4}$ "
 B. 1' 4 $\frac{3}{16}$ "
 C. 1' 4 $\frac{11}{16}$ "
 D. 1' 6 $\frac{7}{8}$ "



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

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

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

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

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

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

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

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

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

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

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

Voltage = Amperage $\times$ Resistance 1 kilowatt = 1000 hours

Wattage = Voltage $\times$ Amperage $\times$ Power Factor

- A. 0.92 power factor
- B. 0.97 power factor
- C. 1.09 power factor
- D. 9.16 power factor

- 9. Compact Equipment:** What is the approximate speed, in miles per hour, for a riding mower that travels 80 meters in 39.5 seconds? 5,280 ft = 1 mile

3600 seconds = 1 hour 1 foot = 0.3048 meter

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

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

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

1 foot = 12 inches diameter = (2 $\times$ radius) $\pi = 3.14$

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

- A. 17.95 feet
- B. 18.45 feet
- C. 18.95 feet
- D. 19.45 feet

- 11. Structural:** Steel angle iron is sold for \$1.83 per linear foot, steel rod is sold for \$1.61 per linear foot, and steel pipe is sold for \$2.94 per linear foot. If 19.5 feet of angle iron, 15.5 feet of rod, and 12 feet of pipe are purchased, what is the approximate total price for the metal before taxes?

- A. \$ 9.59
- B. \$ 95.92
- C. \$ 959.92
- D. \$ 9599.20

- 12. Environmental:** A concrete slab will be installed to prevent contamination of the ground at a mixing and cleaning site for pesticide equipment. The inside dimensions of the slab's form boards are 24 feet wide by 14 feet long and the concrete forms provide an approximate depth of 5 inches. Order an additional 10 percent concrete to allow for the irregularity of the ground surface and note that pre-mixed concrete is sold/delivered in quarter-yard quantities (such as: 3 yd³, 6.25 yd³, 10.75 yd³, 15.5 yd³). Approximately how many cubic yards (yd³) 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 $\times$ Width $\times$ Height

- A. 3.50 yd³
- B. 5.25 yd³
- C. 5.75 yd³
- D. 68.50 yd³

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

1

bushel = 2.44 cubic feet

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

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

1 year = 12 months

1 day = 24 hours

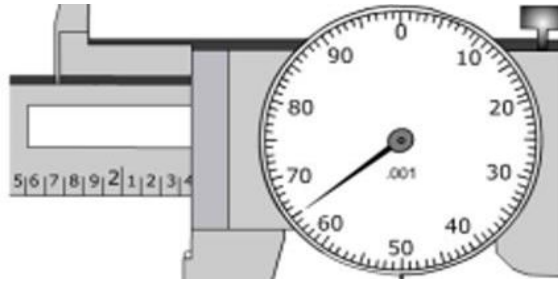
1 year = 365 days

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

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

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

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



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

1 gallon of gasoline = 6.3 pounds

1 gallon of diesel = 6.943 pounds

1 gallon 15W-40 engine oil = 7.3 pounds

1 gallon automatic transmission fluid = 7.298 pounds

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

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

1 board-foot = 144 cubic inches

1 square foot = 144 square inches

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

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

128 ounces = 1 gal

16 ounces = 1 pint

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

- 19. Machinery:** A tractor's power takeoff produces 275 horsepower and turns at 1000 revolutions per minute. Approximately how much torque, in foot-pounds, can this PTO produce?

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

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

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

- A. \$ 26.40
 - B. \$ 41.50
 - C. \$ 62.60
 - D. \$ 88.70
- 21. Electrical:** The monthly charge to operate an electrical water pump is 12.75 cents per kilowatt hour (kwh) for the first 1000 hours and 13.9 cents for each kwh greater than 1000 hours. If the pump uses 6.75 kilowatts per hour and it operates 22 days each month for 12 hours each day, what is the approximate monthly kwh charge to operate the pump?

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

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

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

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

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

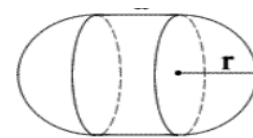
- A. 1 foot, 6 and $\frac{7}{16}$ inches
 B. 1 foot, 6 and $\frac{15}{32}$ inches
 C. 1 foot, 7 and $\frac{1}{4}$ inches
 D. 1 foot, 7 and $\frac{3}{8}$ inches
- 24. Environmental:** Water flows (horizontally) through 86 feet of pipeline that includes three 90-degree elbows. The water flow rate is 6.5 gallons per minute where the water exits the 86-foot pipeline. The pressure loss through the pipeline is equivalent to 6.2 vertical feet of head (pressure) loss per 100 feet of horizontal run. The head loss through each elbow is equivalent to that of 4.75 feet of additional horizontal length. Approximately, what is the vertical head (pressure) loss for this horizontal pipeline?
- A. 5.3 feet of head loss
 B. 6.2 feet of head loss
 C. 100.3 feet of head loss
 D. 533.2 feet of head loss
- 25. Machinery:** The center section of a fuel storage tank has a cylindrical shape (capsule) that is 6.5 feet long with an inside diameter of 3.5 feet. Each end of the tank has a half-sphere shape (two halves of a sphere), each with an internal radius of 21 inches. What is the approximate total storage capacity of the tank in gallons? 1 gallon = 231 cubic inches 1 foot = 12 inches $\pi = 3.14$

Diameter = $2 \times (\text{radius})$

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

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

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



Picture of Capsule



AGRICULTURAL TECHNICAL & MECHANICAL SYSTEMS

Created: Jul-23

General Knowledge Exam Key

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

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

2024 Examination for the National FFA Agricultural Technology and Mechanical Systems Career Development Event

Answer Key Do Not Distribute

- *If a diagram, picture, or table is needed to answer a question, the question will refer to the appropriate figure/page.*
- *Read each question carefully and determine the single correct answer.*
- *If a mark on the scan sheet needs to be changed, completely erase the incorrect answer and clearly mark the appropriate answer on the answer sheet.*
- *Each student needs a calculator to complete this examination, but calculators may not be shared between students.*
- *Formulas and conversion values are provided. Do not round off intermediate answers when using the calculator to solve these problems.*

Students are **NOT allowed** to use any type of electronic communication device, including but not limited to cellular telephones, pagers, two-way radios, or PDAs, during the CDE on Wednesday or Thursday. If a student uses, handles, or accesses any type of electronic communication device, she or he may be disqualified. If a personal emergency should arise during the CDE, students should contact a CDE official immediately for assistance.

Order, Point Assignment, and AFNR Alignment* for Exam Questions (2 points each)

1. Machinery (math) PST.03.03	6. Environmental (knowledge) ESS.05.01	11. Structural (knowledge) PST.04.01.02.c.	16. Compact Equipment (math) PST.03.01	21. Electrical (math) PST.03.02.01.c
2. Electrical (Knowledge) PST.05.02	7. Machinery (knowledge) PST.03.03	12. Environmental (math) ESS.03.02	17. Structural (math) PST.04.03	22. Compact Equipment (math) CS.03.02
3. Compact Equipment (Knowledge) PST.03.03.02.b.	8. Electrical (math) PST.04.04	13. Machinery (math) PST.03.03	18. Environmental (knowledge) CS.04.01	23. Structural (math) PST.04.02.
4. Structural (math) PST.04.02.01.b.	9. Compact Equipment (math) PST.03.01	14. Electrical (knowledge) PST.04.04	19. Machinery (knowledge) PST.01.03	24. Environmental (math) ESS.05.01
5. Environmental (math) NRS.03.02	10. Structural (knowledge) PST.04.02.02.c.	15. Compact Equipment (knowledge) PST.03.01	20. Electrical (math) PST.05.02	25. Machinery (math) PST.02.02

*Competency numbers (PST.02.02.) accompanying each question coincides with numbered AFNR performance indicators listed in the ATMS Handbook.

This exam begins on the back of this sheet.

2024 Written Examination for the National FFA Agricultural Technology & Mechanical Systems Career Development Event

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

1. **Machinery:** The John Deere 6M series 105HP utility tractor is equipped with an AutoPower/IVT transmission-hydraulic system that requires a fluid change at 1500 hours. The fluid capacity for the system is 60 liters. As a dealership manager, you have four tractors to service. Which purchase option is the least expensive with the least amount of fluid left over? 1 liter = 0.264172 gallon

One gallon = \$26.00 Five Gallon Container = \$123.00 Fifty-five Gallon Drum = \$1,247

- A. (1) fifty-five-gallon barrel and (9) one-gallon containers
B. (2) fifty-five-gallon barrel
C. (1) fifty-five-gallon barrel, (1) five-gallon container, and (4) one-gallon containers
D. (12) five-gallon containers and (1) one-gallon container

60 liters x 0.264172 gal = 15.85032 gallons
15.85032 gal x 4 tractors = 63.40128 gallons need

2. **Electrical:** A technician needs to install an electronic device to determine the volumetric output of a water pump operating a center pivot irrigation system. What device does the technician install?

- A. temperature sensor
B. flow sensor
C. pressure sensor
D. photoelectric sensor

pg. 560 ch. 21 Agricultural Technical Systems and Mechanics book

3. **Compact Equipment:** When using a bench grinder safely, what is the maximum tool rest spacing?

- A. 1/8"
B. 1/4"
C. 1/2"
D. 3/4"

Pg. 203 chapter 8 AMTS book GW, tool rest must be adjusted to less than or equal to 1/8" to prevent the workpiece from becoming trapped between the stone and the rest.

4. **Structural:** A large pasture needs to be sectioned into four smaller equal-sized square fields to allow for rotational grazing. The dimensions of the pasture include a length of 4350 feet and a width of 3582 feet. Three strands of four-point barb wire will be installed. Wire costs \$120 per roll. Each roll has 1,320 feet of wire. Tax is 6.5% of the purchase price. Assume that you will need an additional 10% wire for any errors. A single 16-foot gate will be installed for the main pasture perimeter and a 16-foot gate for each of the four sections to allow livestock to rotate. No wire is needed where gates are installed. What is the cost of the barbed wire, including tax, for the project?

Perimeter of Rectangle = 2(Length + Width)

- A. \$ 4,474.96
B. \$ 5,493.00
C. \$ 6,524.00
D. \$ 7,668.00

Perimeter Large pasture = 2(4350ft + 3582ft) = 15,864 feet
Dividing the field will require approximately 4350ft for length and 3582ft for width
16ft * 5 = 80 ft
15,864 + 4350 + 3582 - (80ft) = 23716 * 3 = 71,148 ft of wire * 1.10 = 78,262.8 ft of wire needed
78,263 / 1320 = 59.29 rolls or 60 rolls * \$120 = \$7,200 * 1.065 = \$7,668 for the wire with tax

5. **Environmental:** During the silking stage, a corn variety has an evapotranspiration rate of 0.32 inches per day. The sandy loam soil has an available water storage capacity of 2.1 inches. The farmer would like to know when to schedule the next irrigation. How long (in days) will it take before the crop exhibits stress due to insufficient moisture?

Day until crop stress = Water Storage Capacity ÷ Evapotranspiration rate

- A. 4.0 days
B. 6.5 days
C. 7.5 days
D. 8.0 days

2.1 inches ÷ .32 in/day = 6.5625 or 6.5 days, page 638 Chapter 25 Agricultural mechanics and technology systems

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

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

Mark all answers on the scan sheet.

6. **Environmental:** Using the NFPA symbol to the right, what is the level of health hazard for the fertilizer?

A. 0
B. 1
C. 3
D. 4

page 36 Chapter 2 Agricultural technical systems and mechanics



7. **Machinery:** For a hydraulic system, what is the result when a constant fluid flow rate encounters a reduction in the diameter of a hose?

A. Increase in fluid pressure
B. Decrease in fluid pressure
C. Decrease in fluid velocity
D. Decrease in flow rate

pg 944 chapter 37 hydraulic and pneumatic power Bernoulli's principle Agricultural Mechanics and technology systems

8. **Electrical:** If the electric company charges \$0.86 per kilowatt-hour, what is the cost to operate an electric water heater to raise the water temperature of 500 gallons from 60°F to 180°F over a three-hour period?

$$\text{Power in kilowatts} = \frac{\text{Gallons of water} \times \text{Temperature Rise in degrees fahrenheit}}{325 \times \text{Time to heat in hours}}$$

A. \$52.92
B. \$62.92
C. \$92.87
D. \$158.77

Pg. 539 chapter 21 Agricultural technical systems and mechanics book.
 $(500 \times 120) \div (325 \times 3) = 61.53846154 \text{ Kilowatts} \times 3 \times \$0.87 = \$158.7692308$

9. **Compact Equipment:** You have been asked to fabricate an engine mounting bracket. What is the approximate tap-drill bit size to make a 1/4-28 threaded hole?

$$\text{Tap-drill bit size} = \text{major diameter} - (1 \div \text{number of threads per inch})$$

A. 0.123"
B. 0.214"
C. 0.234"
D. 0.250"

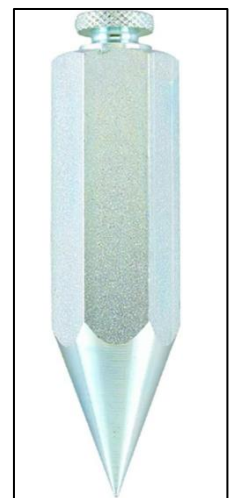
page 91 chapter 3 hand tools agricultural technical systems and mechanics

$$0.25'' - (1 \div 28) = .2142857''$$

10. **Structural:** What is the common name for the layout tool provided in the picture below?

A. Plumb Bob
B. Plate Level
C. Line Level
D. Carpenter's Level

pg 66 chapter 3 hand tools agricultural technical systems and mechanics



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

11. **Structural:** What is the in-line device designed and constructed to provide a liquid seal that prevents the back passage of sewer gas into the adjoining spaces where it is installed?

A. plumbing fixture trap
B. sanitary drainage system
C. sewer cleanout
D. sewer vent pipe

pg 426 ch 17 agricultural technical systems and mechanics

12. **Environmental:** If a center pivot irrigation system is 1220 feet long (has a 2440-foot diameter), approximately how many acres can be irrigated under 260 degrees of the pivot's travel?

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

A. 72.6 acres
B. 75.4 acres
C. 77.5 acres
D. 87.5 acres

$$\text{Acres} = 260^\circ / 360^\circ \times 3.14 \times (1220)^2 \times 1 \text{ ac} / 43,560 \text{ ft}^2 = 77.48761351 \text{ ac}$$

13. **Machinery:** Your current tractor produces 35 PTO-horsepower at a rated power take-off speed of 540 revolutions per minute. What horsepower is needed to operate a John Deere round baler that requires a PTO speed input of 540 rpm and a torque of 535 lb-ft? Does the 35 HP tractor have the capacity to operate the baler?

$$\text{Torque} = \text{PTO Horsepower} \times 5252 \div \text{PTO RPM}$$

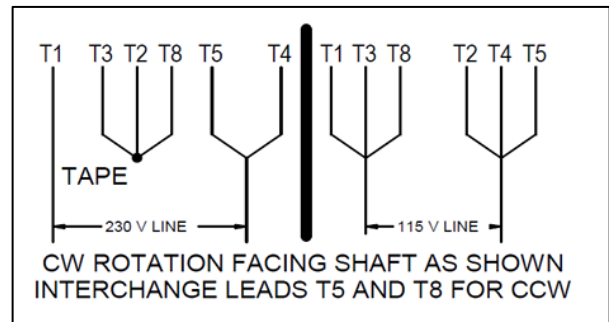
A. 25 HP, no
B. 35 HP, yes
C. 55 HP, yes
D. 55 HP, no

$$\begin{aligned} \text{PTO Horsepower} &= \text{Torque} \times \text{PTO RPM} \div 5252 \\ \text{PTO HP} &= 535 \text{ lb-ft} \times 540 \div 5252 \\ \text{PTO HP} &= 55.0076161 \end{aligned}$$

14. **Electrical:** Use the motor wiring diagram provided. Which wires must be connected but isolated from the power supply line for 230 V operation with counterclockwise shaft rotation?

A. T3, T2, T5
B. T5, T4
C. T3, T2, T8
D. T1, T3, T5

Chapter 23 Ag Mech and
Tech Systems, page 592



15. **Compact Equipment:** What OSHA safety color designates machines or energized equipment that may cut, crush, or shock and emphasizes such hazards when a guard is removed?

A. Red
B. Orange
C. Yellow
D. Green

Ch. 2 page 21 Ag Tech systems and mechanics.

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

16. **Compact Equipment:** A ride-behind gasoline mower must generate sufficient income from cutting grass to generate a profit over the purchase price, operating costs, and labor expenses. A \$1,200 mower operates 760 hours annually for three years and then sells at an estimated salvage value of \$675. If total labor and operating costs are \$32 per hour and an average of 1850 square-feet of grass can be cut in an hour, what approximate amount should be charged for each hour of the mower's operation to produce a 50% profit margin?

Straight Line Depreciation = (Purchase Price – Salvage Value) ÷ (useful life of the equipment)

- A. \$ 55
B. \$ 60
C. \$ 65
D. \$ 75

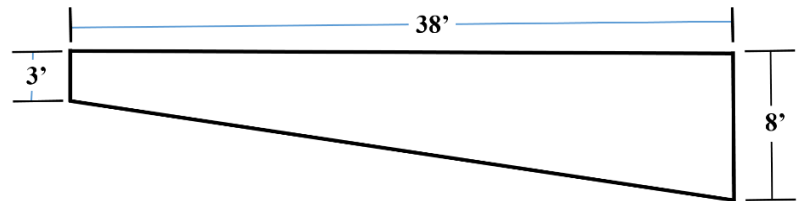
$$[(\$1800 - \$675) / (3 \text{ yrs} \times 760 \text{ hrs/yr})] + \$32/\text{hr} = \$32.49342105$$

$$\$32.49342105 / 0.50 = \$64.98684211$$

17. **Structural:** A concrete retaining wall shown below is 30" thick. Because of the sloping ground, the bottom of the concrete wall is angled, and the top is horizontal. An additional 5% concrete is ordered to allow for measurement errors. The Minimum concrete order is three yards, and concrete can only be ordered in half yard amounts above three yards. How much concrete will be needed to complete this pour?

1 cubic yard = 27 cubic feet 1 cubic foot = 1728 cubic inches 1 foot = 12 inches
Volume of rectangular prism = (length) x (width) x (height) $\pi = 3.14$
Volume of triangular prism = $0.5 * b * h * \text{length}$

- A. 19.5 cubic yards
B. 20.5 cubic yards
C. 25.5 cubic yards
D. 30.5 cubic yards



Divide the shape into a rectangular prism and a triangular prism

Convert the 30 inches to feet ($30/12$) = 2.5 ft width

Volume (cubic yards) of rectangular prism = $(38 * 3 * 2.5) \div 27 = 10.55555556 \text{ cu. yds.}$

Volume (cubic yards) of triangular prism = $(0.5 * 38 * 5 * 2.5) \div 27 = 8.796296296 \text{ cu. yds.}$

$10.5555556 + 8.796296296 = 19.35185186 \text{ cubic yards} * 1.05 \text{ for errors} = 20.31944445 \text{ cubic yards}$

18. **Environmental:** Using 2017 preliminary data, what percentage of the U.S. Energy consumption relies on renewable sources?

- A. 10 percent
B. 25 percent
C. 30 percent
D. 40 percent

Figure 22-1 Chapter 22 sustainable energy systems Ag Tech Systems and mechanics book pg 568

19. **Machinery:** For a 1.5" nominal pipe that is schedule 80, what is the inside diameter of the pipe?

- A. 1.900"
B. 1.689"
C. 1.610"
D. 1.500"

Pg 949 ch 37 Ag Mech and tech systems book

20. **Electrical:** A water pump for a stock tank has an electrical motor that operates at 120 volts and uses 5.8 amps of current. If it is a 0.50 horsepower motor and operates with a power factor of 0.90, what is the approximate efficiency of the motor?

1 horsepower = 746 Watts

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

746

- A. 59.5%
B. 73.5%
C. 83.5%
D. 88.5%

$$0.5\text{hp} = \frac{120 \text{ V} \times 5.8 \text{ A} \times 0.90 \times \text{Efficiency}}{746} \ggggg \text{ Eff.} = .59546661558$$

$$\text{Eff.} = 59.5\%$$

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

Mark all answers on the scan sheet.

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

21. **Electrical:** The rooftop solar installation for a hog finishing barn has proven to reduce the monthly electric bill by an average of \$80 for the four coldest months (winter) of the year, \$145 for one month in the fall, \$145 for one month in the spring, and \$280 per month during the six warmer months of the year. If the installation cost of the solar system was \$45,000, excluding sales tax, approximately how many years must the system be utilized to achieve the economic “breakeven” point?

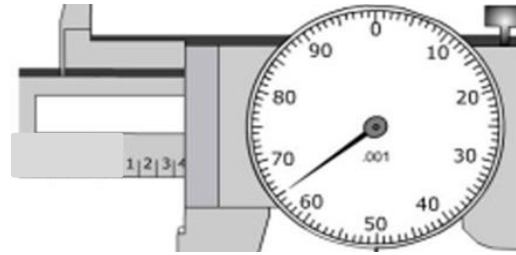
$$\text{Breakeven in Years} = \text{Installation Cost} / (\$ \text{ savings/Year})$$

- A. 14 years
B. 15 years
C. 19 years
D. 20 years

$$\text{Annual Energy Savings} = [(4 \text{ mth} \times \$80/\text{mth}) + (2 \text{ mth} \times \$145/\text{mth}) + (6 \text{ mth} \times \$280/\text{mth})] = \$2290/\text{yr}$$

$$\text{Breakeven} = \$45,000 / \$2290/\text{yr} = 19.65 \text{ yrs}$$

22. **Compact Equipment:** A partial picture of a 6-inch dial caliper is shown in the space below. The jaws of the dial caliper are closed on a solid object and the measurement is displayed on the face of the dial caliper. The measurement displayed on the dial caliper is between 3 inches and 4 inches. What measurement is displayed on the dial caliper?



- A. 3.365 inches
B. 3.465 inches
C. 4.365 inches
D. 4.465 inches

23. **Structural:** Building material costs often fluctuate. The following table lists the prices for common size framing lumber in March 2020 and April 2024. Which one of the lumber sizes listed in the table exhibits the highest percentage increase in cost?

- A. 2" x 4" x 8' lumber
B. 2" x 6" x 10' lumber
C. 2" x 8" x 10' lumber
D. 2" x 10" x 10' lumber

Lumber Size	Price in 2020	Price in 2024
2" x 4" x 8'	\$ 2.37	\$ 2.42
2" x 6" x 10'	\$ 5.37	\$ 18.98
2" x 8" x 10'	\$ 8.23	\$ 13.75
2" x 10" x 10'	\$ 10.81	\$ 18.98

$\$ 2.42 / \$ 2.37 = 102.11\%$
$\$ 18.98 / \$ 5.37 = 353.45\%$
$\$ 13.75 / \$ 8.23 = 167.10\%$
$\$ 18.98 / \$ 10.81 = 175.60\%$

24. **Environmental:** A vertical distance of 400 ft is measured between the intake and discharge of a hydroelectric energy system. The water flow rate is approximately 900 gallons per hour. How many kilowatt-hours can be potentially generated in a 12-hour period?

$$60 \text{ gallons per hour} = 1 \text{ gallon per minute}$$

$$\text{Head in Feet} \times \text{flow rate (gpm)} \div 12 = \text{Kilowatts}$$

- A. 24,000 Kilowatt-hours
B. 18,000 Kilowatt-hours
C. 6,000 Kilowatt-hours
D. 2,400 Kilowatt-hours

$$400 \text{ feet of head} \times 15 \text{ gpm} \div 12 \times 12 = 6000 \text{ kilowatt-hours}$$

25. **Machinery:** The following measurements were taken to determine the wheel slippage in a loaded tractor's operation. Each rear wheels have a diameter of 4.15 feet, the test distance is 100 feet long, and the loaded tractor's rear wheels make 8.75 rotations while traveling 100 feet. What is the approximate wheel slippage for this tractor during each rear wheel rotation?

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

$$\pi = 3.14$$

$$\text{diameter of circle} = (2) \times (\text{radius})$$

- A. 1.28 feet/rotation, 1.73%
B. 1.37 feet/rotation, 4.14%
C. 1.48 feet/rotation, 6.68%
D. 1.60 feet/rotation, 12.30%

$$\text{Wheel circumference} = [2 \times 3.14 \times (4.15' \div 2)] = 13.031 \text{ feet}$$

$$8.75 \text{ rotations} \times 13.031 \text{ feet} = 114.02125 \text{ feet in 8.75 rotations}$$

$$114.02125 \text{ ft} (-) 100 \text{ ft} \div 114.02125 = .1229704 \times 100 = 12.29704\%$$

$$\text{This represents } 14.02125 \text{ feet slippage over 100 feet or } 14.02125 \text{ feet} / 8.75 \text{ revolutions} = 1.602428571 \text{ feet} / \text{rotation}$$

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2025 Examination for the
National FFA Agricultural Technology and
Mechanical Systems
Career Development Event

Name _____
Print Name Legibly

READ THE FOLLOWING INSTRUCTIONS:

Mark all answers on the scan-sheet using a pencil.

- You have one hour to complete this exam.
- You may write on this exam, but information on this exam is not graded. Blank sheets of paper are provided if additional calculation space or scratch paper is needed.
- If a diagram, picture, or table is needed to answer a question, the question will refer to the appropriate figure/page.
- Read each question carefully and determine the single correct answer.
- If a mark on the scan sheet needs to be changed, completely erase the incorrect answer and clearly mark the appropriate answer on the answer sheet.
- Each student needs a calculator to complete this examination, but calculators may not be shared between students.
- Formulas and conversion values are provided. Do not round off intermediate answers when using the calculator to solve these problems.

Students are **NOT allowed** to use any type of electronic communication device, including but not limited to cellular telephones, pagers, two-way radios, or PDAs, during the CDE on Wednesday or Thursday. If a student uses, handles, or accesses any type of electronic communication device, she or he may be disqualified. If a personal emergency should arise during the CDE, students should contact a CDE official immediately for assistance.

The exam begins on the back of this sheet.

Answer Key

Do Not Distribute

Order, Point Assignment, and AFNR Alignment* for Exam Questions (2 points each)

1. Machinery (math) PST.02.02	6. Environmental (knowledge) PST.02.02	11. Structural (knowledge) PST.04.02.01a.	16. Compact Equipment (knowledge) PST.03.01	21. Electrical (math) PST.03.02.01.c
2. Electrical (math) PST.04.04	7. Machinery (math) PST.03.01.01b	12. Environmental (math) ESS.05.01	17. Structural (math) PST.04.03	22. Compact Equipment (knowledge) PST.02.02
3. Compact Equipment (Knowledge) PST.03.01	8. Electrical (math) PST.04.04	13. Machinery (knowledge) PST.03.03	18. Environmental (math) CS.04.01	23. Structural (math) PST.04.02.
4. Structural (knowledge) PST.04.01.01.b.	9. Compact Equipment (knowledge) PST.03.01	14. Electrical (knowledge) PST.04.04	19. Machinery (math) PST.03.01	24. Environmental (math) ESS.01.01.01.c
5. Environmental (knowledge) NRS.03.02	10. Structural (math) PST.04.02.01b	15. Compact Equipment (knowledge) PST.03.01	20. Electrical (knowledge) PST.05.02	25. Machinery (knowledge) PST.02.02

*Competency numbers (e.g. PST.02.02.) accompanying each question coincides with numbered AFNR performance indicators listed in the ATMS Handbook.

2025 Written Examination for the National FFA Agricultural Technology & Mechanical Systems Career Development Event

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

1. A farmer has 2,000 acres to spray. He measured the time it takes to travel with the tractor and sprayer. He can cover 1,000 feet in 1 minute and 45 seconds. His sprayer has 60 nozzles spaced 18 inches apart. Considering refilling the sprayer, turning around, etc. his efficiency is 70 percent. Which of the following is the closest estimate to the number of hours he should budget for spraying his crop?

1 foot = 12 inches

1 mile = 5,280 feet

1 acre = 43,560 square feet

Speed = (feet traveled ÷ minutes) ÷ 88

Theoretical field capacity = (Speed (in MPH) x Width (in feet)) ÷ 8.25

Effective field capacity = theoretical field capacity x effectiveness

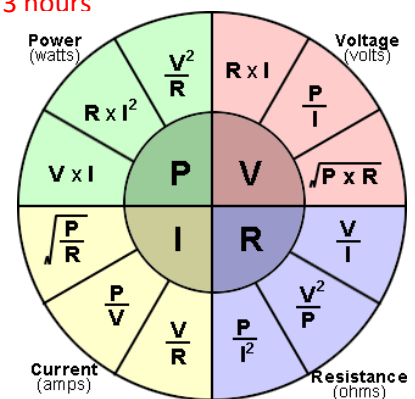
- A. 23 hours
- B. 28 hours
- C. 33 hours
- D. 40 hours**

Speed = (feet traveled ÷ minutes) ÷ 88 = 1,000 ÷ 1.75 ÷ 88 = 6.49 miles per hour
 Width = 60 nozzles x 18 inch spacing ÷ 12 inches per foot = 90 feet
 Theoretical field capacity = (6.49 mph x 90 feet wide) ÷ 8.25 = 70.8 acres per hour
 Effective field capacity = theoretical field capacity x efficiency = 70.8 x 0.70 = 49.56
 Hours = 2,000 acres ÷ 49.56 acres per hour = 40.3 hours

2. Three 60-watt incandescent light bulbs are connected in a 120-volt circuit in a parallel fashion. All three light bulbs are rated at 60 watts and 120 volts. What is the total amperage for this circuit?

- A. 0.17 amps
- B. 0.50 amps
- C. 1.50 amps**
- D. 6.00 amps

60 watts ÷ 120 volts = 0.5 amps
 In parallel, total amps = the sum of amps.
 0.5 amps x 3 = 1.50 amps



3. For a naturally aspirated gasoline engine, where in the carburetor is the fuel and air brought together and mixed?

- A. In the fuel bowl
- B. In the venturi**
- C. At the choke
- D. At the throttle

The venturi is a restriction in the air passage through the carburetor. This restriction speeds up the air and creates a low-pressure area. This low pressure draws in fuel that mixes with the air, creating an air-fuel mixture.

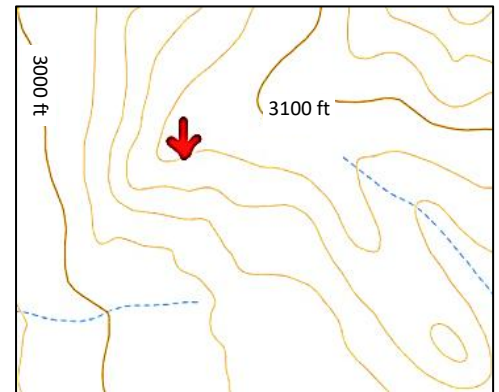
4. There is a dot on the line at 16 inches on a tape measure. What is the significance of this location?



- A. This is the standard width of a piece of plywood
 B. This is the standard length of one board foot of lumber
 C. This is the standard O.C. spacing between studs
 D. This is the standard width of a 2 x 16
5. Refer to the map contour lines (in feet) on the topographic map at the right of the page. What is the elevation of the line marked by the arrow?

- A. 3080 feet
 B. 3040 feet
 C. 2960 feet
 D. 2920 feet

The two labeled contour lines are 3000 feet and 3100 feet. There are four lines between these (five spaces). Therefore, the lines are 200 feet apart. One line lower than 3100 feet is 3080 feet.



6. Using the NFPA symbol to the right, what is the level of flammability hazard for the fertilizer?

- A. 0
 B. 1
 C. 3
 D. Not identified

The top diamond (1) is flammability hazard.
 The left diamond (3) is health hazard.
 The right diamond (0) is reactivity hazard.
 The bottom diamond (blank) is specific hazard.
 Flammability hazard of 1 has a flashpoint below 73°F
 At Tech Systems and Mechanics text (p. 36)



7. A John Deere 4010 diesel tractor has a six-cylinder engine. Each cylinder has a bore (diameter) of 4.125 inches and a piston stroke of 4.75 inches. The compression ratio for each cylinder is 16.4:1. What is the approximate clearance volume for each cylinder in cubic inches?

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

Volumetric displacement of a single cylinder =

(the area of the cylinder bore) x (length of piston stroke)

Clearance volume = Volumetric displacement $\div$ (Compression ratio – 1)

- A. 1.88 cubic inches
 B. 2.00 cubic inches
 C. 3.87 cubic inches
 D. 4.12 cubic inches

Piston displacement = $\pi \times (\text{bore} \div 2)^2 \times \text{stroke}$

$63.479 = \pi \times (4.125 \div 2)^2 \times 4.75$

Clearance Volume = PD $\div$ (CV -1)

$4.12 = 63.479 \div (16.4 - 1)$

8. A kilowatt-hour meter records 4.8 kilowatts of power being used by an eight-horsepower electric motor for one hour when it is operating at 240 volts and using 23 amps. What is the approximate power factor for this motor?

Voltage = Amperage $\times$ Resistance 1 kilowatt = 1000 watts

Wattage = Voltage $\times$ Amperage $\times$ Power Factor

- A. 0.87 power factor
- B. 1.00 power factor
- C. 1.15 power factor
- D. 10.43 power factor

Rearranging the wattage formula,
 Power factor = wattage $\div$ (volts $\times$ amps)
 0.87 = 4,800 $\div$ (240 $\times$ 23)

9. Which of the following is found on a small engine four-stroke cycle engine but not on a small engine two-stroke cycle engine?

- A. Flywheel
- B. Crankshaft
- C. Intake Valve
- D. Reed Valve

Both have a flywheel
 Both have a crankshaft
 A 4-stroke has an intake valve, a 2-stroke does not (it has ports)
 A 2-stroke has a reed valve, a 4-stroke does not

10. Which of the following quantities of lumber has the largest number of board-feet?

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

- A. 8 boards measuring 2 inches by 6 inches by 16 feet
- B. 7 boards measuring 2 inches by 8 inches by 14 feet
- C. 13 boards measuring 1 inch by 10 inches by 12 feet
- D. 11 boards measuring 1 inch by 12 inches by 12 feet

$8 \times 2 \times 6 \times 16 \div 12 = 128$
 $7 \times 2 \times 8 \times 14 \div 12 = 130.67$
 $13 \times 1 \times 10 \times 12 \div 12 = 130$
 $11 \times 1 \times 12 \times 12 \div 12 = 132$

11. This illustration is a stamp found on a piece of dimension lumber. Which of these statements do you know to be true?

- A. This lumber is 12 feet long
- B. This lumber is a hardwood
- C. This lumber was dried prior to being surfaced
- D. This lumber is a 1 x 12



12 is the mill number.

STAND and BTR is the lumber grade. (Standard and better)

WWP is the lumber company (Western Wood Products)

S-Dry means the lumber was surfaced (planed) when the moisture content was dry (19% or less).

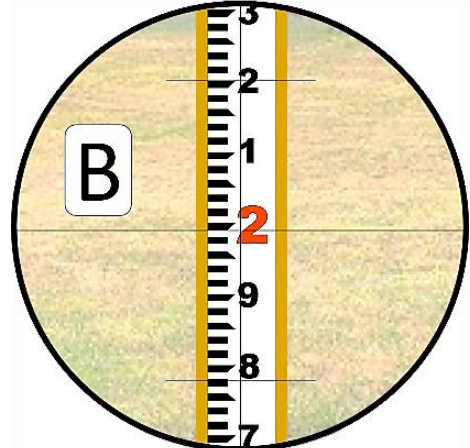
D-FIR means the tree species is Douglas Fir

12. How far is the surveying rod from the instrument in this illustration?

- A. 42 feet
- B. 178 feet
- C. 199 feet
- D. 220 feet

$$\text{Distance} = \text{Top stadia hair} - \text{bottom stadia hair} \times 100$$

$$(2.20 - 1.78) \times 100 = 42$$



13. Illustrated is a top view and a side view of a bolt. What is the grade of this bolt?

- A. SAE Grade 1
- B. SAE Grade 5
- C. SAE Grade 7
- D. SAE Grade 8

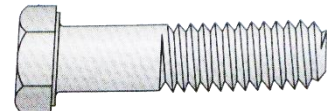
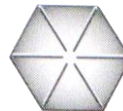
No points = Grade 1 or 2

3 points = Grade 5

5 points = Grade 7

6 points = Grade 8

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14. Suppose you are working on an electrical motor that has a dual voltage rating of 115 volts and 230 volts. This motor is currently configured for 115 volts. How would you change this motor to configure it for 230 volts?

- A. Disconnect the starting windings
- B. Change the running windings from parallel to series
- C. Add an additional hot (ungrounded) wire to the motor
- D. Replace the overload fuse with a higher amperage fuse

In parallel, volts are the same. Hence, each winding has 115 volts. In series, volts plus volts equals total volts. So, 115 volts at each winding equals 230 total volts. Therefore, you must change the windings from parallel to series.

15. A partial picture of a 6-inch dial caliper is shown in the space below. What measurement is displayed on the dial caliper?

- A. 3.691 inches
- B. 3.791 inches
- C. 3.689 inches
- D. 3.789 inches



Largest inch reading on the scale is three inches.

Largest tenths reading is six. The number seven is visible but the line following seven-tenths is not visible.

The dial reading is at 0.089.

Therefore, the reading is 3.689 inches.

16. What does the “W” stand for in an SAE 5W-30 multi-viscosity oil?

- A. Weight
- B. Wearability
- C. Watts
- D. Winter

Many people think W is for weight. However, it is the cold engine rating and stands for winter.

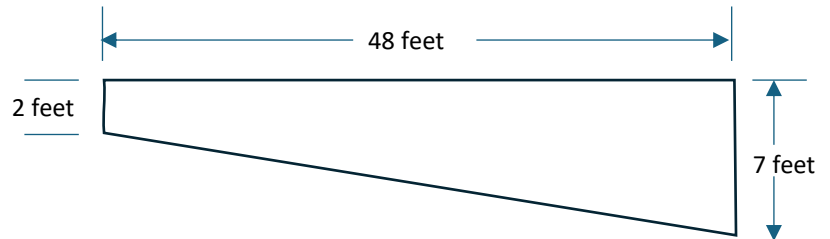
17. A concrete retaining wall shown below is 30” thick. Because of the sloping ground, the bottom of the concrete wall is angled, but the top is horizontal. An additional 5% concrete is ordered to allow for measurement errors. The minimum concrete order is three yards, and concrete can only be ordered in half yard amounts above three yards. How much concrete will be needed to complete this pour?

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

1 foot = 12 inches

Volume of rectangular prism = (length) x (width) x (height)

Volume of triangular prism = $0.5 \times b \times h \times \text{length}$



- A. 20.0 cubic yards
- B. 21.0 cubic yards
- C. 24.0 cubic yards
- D. 25.2 cubic yards

Volume of a rectangle prism = length x width x height = $2 \times 48 \times 2.5 = 240$ cubic feet

Volume of a triangular prism = $\frac{1}{2} \times \text{length} \times \text{width} \times \text{height} = \frac{1}{2} \times 5 \times 48 \times 2.5 = 300$ cubic feet

Cubic yards = cubic feet $\div 27 = (240 + 300) \div 27 = 20$

Cubic yards to order = yards + overage = $20 + (20 \times 0.05) = 21$ cubic yards

18. A pesticide label specifies that 0.5 pint of pesticide concentration is to be diluted (mixed) with 25 gallons of water for each acre treated (amount applied per acre). Approximately how many gallons of pesticide concentration are required to treat a 160-acre field?

128 ounces = 1 gal 16 ounces = 1 pint

- A. 5 gallons
- B. 10 gallons
- C. 25 gallons
- D. 50 gallons

Gallons = acres x rate (pints) $\div 8$ pints per gallon

10 gallons = $160 \text{ acres} \times 0.5 \text{ pints} \div 8 \text{ pints per gallon}$

19. A scale placed between a tractor drawbar and a tillage implement indicates a force of 15,000 pounds. The tractor is traveling at a speed of 5.5 miles per hour. What is the drawbar horsepower?

Horsepower formulas

$$HP = \text{torque} \times \text{rpm} \div 5252$$

$$HP = (\text{force [in pounds]} \times \text{distance [in feet]} \div \text{minutes}) \div 33,000 \text{ foot-pounds per minute}$$

$$HP = (\text{force [in pounds]} \times \text{speed [in miles per hour]}) \div 375$$

$$HP = (\text{force [in pounds]} \times \text{distance [in feet]} \div \text{time in seconds}) \div 550 \text{ foot-pounds/second}$$

- A. 260
- B. 240
- C. 220
- D. 200

$$\text{Horsepower} = (\text{drawbar force} \times \text{mph}) \div 375$$

$$220 = (15,000 \times 5.5) \div 375$$

20. When wiring to control the same light from three locations, what switch combination must be used?

- A. three-way switch → four-way switch → three-way switch
- B. single pole switch → three-way switch → single pole switch
- C. three-way switch → three-way switch → three-way switch
- D. four-way switch → three-way switch → four-way switch

21. A digital kilowatt-hour electric meter has the reading shown in the picture below. If last month's reading was 098640, and electric power cost 17.5 cents per kilowatt-hour, what is the approximate charge for the past month's electrical power?

- A. \$ 144
- B. \$ 177
- C. \$ 321
- D. \$ 441

$$\text{Kilowatt-hours} = \text{ending reading} - \text{beginning reading}$$

$$2522 = 101162 - 098640$$

$$\text{Cost} = \text{kilowatt-hours} \times \text{price per kilowatt-hour}$$

$$\$441.36 = 2522 \times \$ 0.175$$



22. What does the pictorial represent?

- A. safety alert
- B. slow moving vehicle alert
- C. service alert
- D. tire pressure alert



23. Kerry purchased lumber at four locations. The table below lists the sizes and prices paid for the lumber. Which lumberyard had the lowest price for lumber based on a price per board foot?

Location	Number of pieces	Lumber size	Amount paid
Menards	10	2" x 4" x 8'	\$42.35
Lowes	5	2" x 10" x 12'	\$74.36
Home Depot	25	2" x 6" x 14'	\$263.73
Eastman Cartwright	12	2" x 8" x 10'	\$122.50

- A. Menards
- B. Lowes
- C. Home Depot
- D. Eastman Cartwright

Menards: $42.35 \div (10 \times 2 \times 4 \times 8 \div 12) = \$0.79$

Lowes: $74.36 \div (5 \times 2 \times 10 \times 12 \div 12) = \$0.74$

Home Depot: $263.73 \div (25 \times 2 \times 6 \times 14 \div 12) = \$0.75$

Eastman Cartwright: $112.50 \div (12 \times 2 \times 8 \times 10 \div 12) = \$0.77$

24. An irrigation ditch runs along a piece of land that is a half mile long and 330 feet wide. Two-inch syphon tubes are set every 100 feet along the ditch. Each tube will flow 30 gallons of water per minute. The tubes were left in the ditch for two hours. How many inches of water was applied to the field?

$1 \text{ acre-inch} = 27,154 \text{ gallons}$

$1 \text{ acre} = 43,560 \text{ square feet}$

$1 \text{ mile} = 5,280 \text{ feet}$

- A. 1.5 inches
- B. 1.75 inches
- C. 2.25 inches
- D. 3.5 inches

$\text{Acres} = (2,640 \text{ feet} \times 330 \text{ feet}) \div 43,560 \text{ sq. ft./acre} = 20 \text{ acres}$

$\text{Number of tubes} = 2,640 \text{ ft.} \div 10 \text{ ft. spacing} = 264 \text{ tubes}$

$\text{Gallons per minute} = 264 \text{ tubes} \times 30 \text{ gallons per tube} = 7,290 \text{ gallons/min}$

$\text{Total gallons} = 7,290 \times 2 \text{ hours} \times 60 \text{ min/hour} = 950,400 \text{ gallons}$

$\text{Inches} = 950,400 \div 27,154 \text{ gallons/acre inch} \div 20 \text{ acres} = 1.75 \text{ inches}$

25. When driving agricultural machinery traveling at speeds 25 miles per hour or less on public roads, what must be visible from at least 500 feet from the rear of the equipment?

- A. Speed Identification Sign
- B. Flashing Lights
- C. Slow Moving Vehicle Emblem
- D. Registration and License Plate

