Practice Examination, Morning Session

I. Engineering Principles and Professional Practices

Question 101 I.A. Circuits, Controls and Sensors: 1. Electrical circuits and controls

The overcurrent protection rating (amps) required for conductors in a circuit containing only a 50 hp three-phase, 460V electric irrigation pump motor is most nearly:

(A) 55
(B) 65
(C) 75
(D) 85

Question 102 I.A. Circuits, Controls and Sensors: 2. Sensors, instrumentation, data loggers, and control circuits

The flow rate of ethanol at 68°F (49.2 lb/ft^3) through a horizontal pipeline (inside diameter of 10.0 in) in a processing plant is to be measured with an ASME long-radius flow nozzle. The anticipated range of flow rates is between 500 and 1000 gal/min. Assume a velocity coefficient for the flow nozzle of 0.98. The range of pressure drop associated with this range of flow rates is to be within the 5 to 50 inches of water range of a differential pressure transducer. The throat (restriction) diameter of flow nozzle that will most nearly match the flow rate range to the pressure drop range is:

(A) 2.5 in
(B) 3 in
(C) 5 in
(D) 8 in

Question 103 I.B. Codes, Graphics, and Safety: 1. Codes, regulations, and standards in specific areas of practice OR 2. Health and safety

Based on information contained in Annex C of ASABE/ISO 15077:2008 Standard (see below), the color that shall be used for a fog lights hand control on a piece of agricultural equipment is:

(A) pewter

(B) yellow

(C) red

(D) orange

Colour		Controls
C.2.1	Red	Single-function engine stop controls. Where key switches, ignition switches or hand throttles are used to stop the engines, the "off" or "stop" positions shall be indicated with red lettering and/or symbols.
C.2.2	Orange	Machine ground motion controls only. EXAMPLE Engine speed controls, transmission controls, parking brakes, park-locks, independent emergency brakes. Exceptions: — where the engine speed and engine stop controls are combined, the controls may be red; — steering wheels or steering controls may be black or any colour other than red or yellow.
C.2.3	Yellow	Function controls which involve the engagement of mechanisms only. EXAMPLE PTO, separators, cutterheads, feed rolls, picking units, elevators, unloading augers.
C.2.4	Black or any other colour except red, orange or yellow	All controls not covered by C.2.2, C.2.2 or C.2.3. EXAMPLE 1 Component lift or position such as implement hitch, header height, blade shift and reel lift. EXAMPLE 2 Control for unloading components such as spout cap, unloading auger swing and bin dump. EXAMPLE 3 Setting and adjustment mechanisms such as chokes, cylinder speed, concave space, seat adjustment, steering column, transmission disconnect, concave lock, lift stops, rockshaft stops, reel speed, and flow dividers. EXAMPLE 4 Machine lights such as headlights, work lights or floodlights, taillights, flashers, and turn signals. EXAMPLE 5 Cabin comfort such as pressurizer, cooling, heating and windshield wipers.

Question 104. I.C. Economics and Statistics: 1. Engineering economics analysis

As manager of a large fleet of farm equipment, you are contracting with an outside mechanics shop to have all complete engine overhauls for tractors, combines, and harvesters at the rate of $7,200 per engine. You have determined the investment needed to construct a new building and equip it to overhaul the equipment yourself would be $180,000. The estimated annual cost for taxes and insurance for the facilities and equipment is 1.25% of the purchase price. The operating cost to perform engine overhauls at a facility that you own would be $5,500 per engine. The equipment and facilities are assumed to have a life of 12 years with a salvage value of $35,000. Interest rate is 7% per year. The minimum number of engines to be overhauled per year to make the investment in equipment and facilities economically feasible is:

(A) 7

(B) 12

(C) 14

(D) 17

Question 105. I.C. Economics and Statistics: 2. Statistics application

You have been tasked with determining the coefficient of variation (C_v) for water discharge for a prototype microirrigation system emitter. Provided the information in the table below, the C_v for the prototype emitter is most nearly:

(A) 0.049

(B) 0.054

(C) 0.237

(D) 0.280

Water Discharge (gph) from Six Prototype Microirrigation System Emitters		
Emitter No.	x_i, Discharge Rate (gph)	$(x_i - x_{ave})^2$, Square of Deviation from Mean (gal^2/hr^2)
1	4.1	0.09
2	4.3	0.01
3	4.5	0.01
4	4.8	0.16
5	4.4	0
6	4.3	0.01
Mean	4.4	0.05

Question 106. I.D. Physical Operations: 1. Mass and energy balances

A biomass gasification facility is taking in 2 ton/hr of 42% moisture content (wet basis) switchgrass to gasify. Removal rate (lb/hr) of residual ash from the gasifier to balance with incoming ash in the biomass is most nearly:

(A) 810
(B) 140
(C) 80
(D) 40

Elemental Analysis (% wt, dry basis) of Different Biomass Fuel Sources						
Biomass	C	H	O	N	S	Ash
Bagasse (sugarcane)	44.8	5.3	39.6	0.38	0.01	9.8
Barley straw	45.7	6.1	38.3	0.4	0.1	6
Cotton stalk	43.6	5.8	43.9	-	-	6.7
Corn grain	44.0	6.1	47.2	1.2	0.14	1.3
Corn stover	43.7	5.6	43.3	0.61	0.01	6.3
Rice straw	41.8	4.6	36.6	0.7	0.08	15.9
Switchgrass	47.5	5.8	42.4	0.74	0.08	3.5
Wheat straw	43.2	5.0	39.4	0.61	0.11	11.4

Question 107. I.D. Physical Operations: 2. Applied psychometric processes

A gas-fired batch dryer is to be used for drying barley. Drying air is blown directly into a cavity below a perforated floor in the dryer and then forced upward through the barley kernels as they rest on the perforated floor. Assuming outside air conditions during the drying period are 40°F (dry bulb) and 50% relative humidity, and outdoor air is blown in at a rate of 1,000 ft^3/min, an estimate of the sensible heat (Btu/min) that must be added to the outside air to raise the temperature of the drying air to 60°F (dry bulb) is most nearly:

(A) 380
(B) 1,000
(C) 1,375
(D) 4,800

Question 108. I.D. Physical Operations: 3. Pump principles

Two identical pumps that each discharge 20 gpm at 150 ft of head are installed in parallel. The discharge head (ft) from the two pumps is most nearly:

(A) 75
(B) 150
(C) 225
(D) 300

II. Facility Engineering: Plant, Animal, and Commodity Environments and Structures

Question 109. II.A. Environment: 1. Air-quality requirements

Air quality in a 1,000-head swine nursery is to be kept at 2,500 ppm or below. Incoming air has a carbon dioxide concentration of 345 ppm. If the pigs weigh 20 kg each and have a total heat production of 4.8 W/kg, the required ventilation rate is most nearly:

(A) 0.09 m^3/s

(B) 1.4 m^3/s

(C) 1.8 m^3/s

(D) 44.5 m^3/s

Question 110. II.A. Environment: 3. Hazardous materials handling and storage

Financial backers of a proposed 5,000-head swine farrowing facility are considering siting the facility in one of the following states. They would like to use an anaerobic lagoon for treating the manure. From the perspective of volatile solids loading rates only, the state requiring the smallest lagoon treatment volume is:

(A) Florida

(B) Kansas

(C) North Carolina

(D) Idaho

Question 111 II.A. Environment: 5. Ventilation system requirements

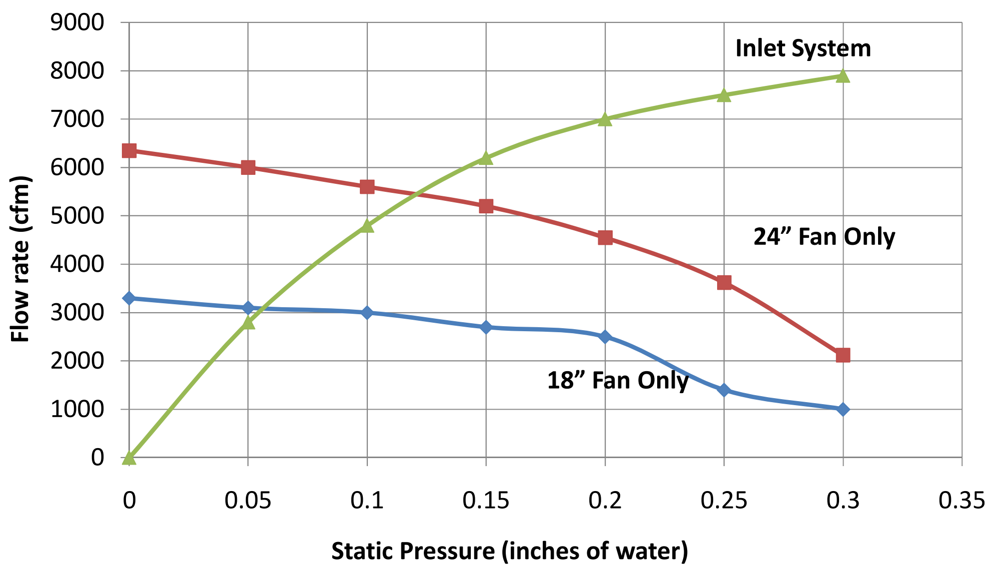
A livestock facility ventilation system is designed with an 18" fan that operates continuously. A second stage, 24" fan is activated as temperature rises. Given the individual fan curves and inlet system curve shown in the figure, what would be approximate the system operating pressure when BOTH fans are operating, in cfm?

(A) 0.05

(B) 0.12

(C) 0.17

(D) 0.21



Question 112. II.B. Structures: 1. Construction materials

A concrete structure is being designed to store materials that may be high in sulfates. The type of concrete that would be suited to this application is:

(A) Type I

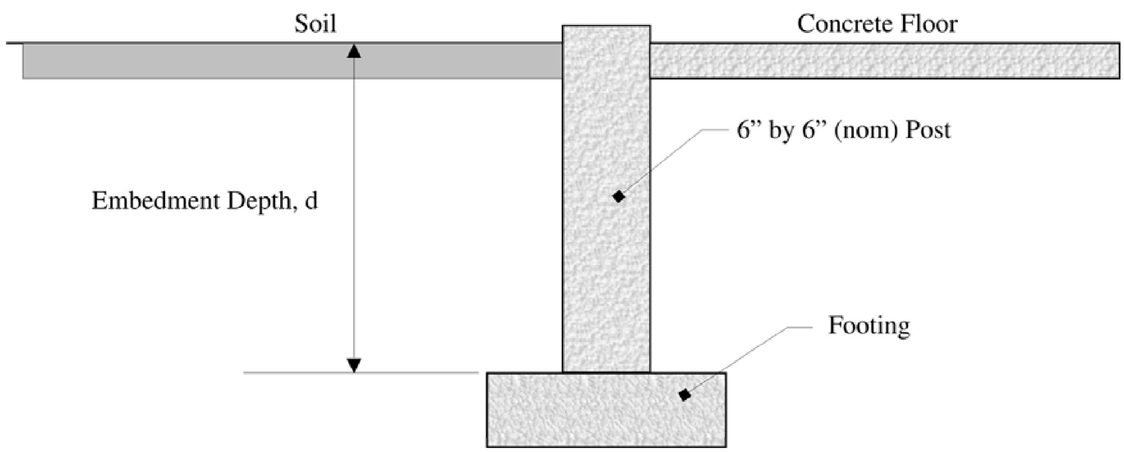
(B) Type III

(C) Type IV

(D) Type V

Question 113. II.B. Structures: 3. Post-frame building design

A post-frame building is designed using nominal 6 in × 6 in posts. The building has a concrete floor that constrains the post at the ground surface, but is not attached to the post. The moment applied to the foundation at the ground surface, M_a, is found to be 2,800 ft-lbs for wind load conditions. The posts are considered isolated from one another. The soil is considered a medium density, silty clay soil. The footing only serves as a bearing surface and does not restrain the post.



The required embedment depth, d (ft), of the post is most nearly:

(A) 3.7

(B) 4.1

(C) 4.6

(D) 5.1

Question 114. II.B. Structures: 5. Structural specification/codes and standards

A machine storage is constructed with a low slope roof (<5 degrees) in an area with a ground snow load (p_g) of 40 psf. The building is classified as an agricultural building with low occupancy. The area of construction is open and fully exposed, so it is classified a Terrain Category “C”. The building is unheated. The flat roof snow load (p_f) in psf is most nearly:

(A) 35

(B) 27

(C) 24

(D) 20

III. Machine Systems: Power, Electrical/Electronic, Machines, Controls, and Sensors

Question 115 III.A. Agricultural Machines: 1. Field and farmstead agricultural machines

An engine consumes 37 L/hr of No. 2 diesel. The brake thermal efficiency (%) of this engine as it creates 135 kW of brake power when operating at 2,200 rpm is most nearly:

(A) 30

(B) 32

(C) 35

(D) 38

Question 116 III.A. Agricultural Machines: 2. Stability analysis

A tractor with a wheel base of 8 feet and rear tire radius of 2 feet is pulling a load of 10,000 pounds acting at a downward 30 degree angle from horizontal. The load hitch point is three feet behind the rear axle and 1.5 feet above the ground surface. The tractor is 9,000 pounds total with the center of mass acting at a point 3 feet in front of the rear axle. The minimum amount of additional weight (lb) that must act upon the front axle in order to maintain static equilibrium is most nearly:

[Question corrected 14 October 2010]

(A) 124

(B) 665

(C) 810

(D) 2,125

Question 117 III.A. Agricultural Machines: 1. Field and Farmstead Agricultural Machines OR 2. Stability Analysis

A three-phase electric motor is direct connected and delivering 42.6 hp of power to drive a conveying system. The voltage at the system panel is 460V, and the motor power factor and efficiency are determined to be 0.847 and 0.90, respectively. Ignoring power loss in the conductors from the lines of the electric supplier to the panel, the current (amps) delivered to the motor is most nearly:

(A) 47

(B) 52

(C) 70

(D) 90

Question 118 III.B. Machine System Design: 1. Machine component design

The design of a deep tillage implement includes a SAE grade 5 bolt functioning in double shear. To adequately protect the implement, the shear bolt may be subjected to a maximum shear force of 78,000 pounds. Specify a shear bolt diameter assuming the shear force occurs at the shank of the bolt.

(A) $^1/_2$"

(B) $^9/_{16}$"

(C) $^3/_4$"

(D) $^7/_8$"

Question 119 III.B. Machine System Design: 3. Stress/strain relationships

A hollow structural square tube has outside dimensions of 8 inches × 12 inches. The square tube thickness is 0.5 inches all around. When positioned for use in bending, the maximum moment of inertia (in^4) is most nearly:

(A) 198

(B) 376

(C) 775

(D) 1,152

Question 120 III.B.1or2or3or4 Machine System Design: 1. Machine component design OR 2. Materials selection OR 3. Stress/strain relationships OR 4. Structural analysis of machines

A solid steel shaft with a diameter of 0.500 in receives power from a belt pulley and transmits it to the load. The tight-side belt tension is 70 lb, and the slack-side belt tension is 20 lb. The belt pulley has a pitch diameter of 9.75 in. The maximum shear stress from torsion on the shaft between the belt pulley and the load is most nearly:

(A) 10,000 psi

(B) 14,000 psi

(C) 20,000 psi

(D) 30,000 psi

Question 121 III.C. Power Systems: 1. Combustion and fuels

A 3,500 lb vehicle is annually driven 10,000 miles and averages 15 mpg. Assume a gasoline density of 5.8 lb/gal and that gasoline is 85% carbon by weight. An estimate of the annual carbon dioxide emissions (lb CO_2/yr) is most nearly:

(A) 3,300

(B) 7,700

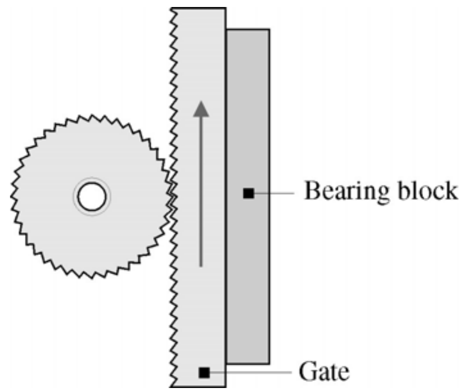
(C) 8,800

(D) 12,100

Question 122 III.C. Power Systems: 3. Power requirement analysis

The rack-and-pinion gear drive shown below is raising a 60,000 lb flood gate. The steel gate must be raised 20 ft in 10 min using the pinion spur gear which has 4 pitch, 40 teeth, and a 20° pressure angle. The gate is held against the gear by a stationary steel bearing block. Assume a coefficient of friction of $f = 0.2$ between the block and gate. The power (hp) required to raise the gate is most nearly:

(A) 3.5
(B) 4.0
(C) 4.5
(D) 5.5

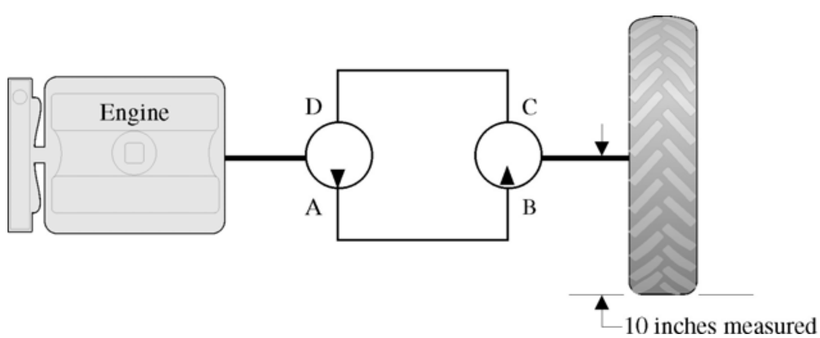


Question 123 III.D. Power Transmission Systems: 1. Hydraulic power circuits

Using the information in the table below including the desired condition of pressure and flow, the maximum tractive effort (lb), assuming no mechanical resistance, that can be expected from a JT04 hydraulic motor with a displacement of 4.0 in^3/rev, and the tire on the right, is most nearly:

Desired Condition of Pressure and Flow*					
Condition at Desired Output	Q_A (gal/min)	P_A (lb/in^2)	P_B (lb/in^2)	P_C (lb/in^2)	P_D (lb/in^2)
1	20	3,000	2,800	300	100
* Reference: Srivastava, A.J., C.E. Goering, and R.P. Rohrbach. 1993. *Engineering Principles of Agricultural Machines,* p. 97. ASAE.					

(A) 80
(B) 150
(C) 200
(D) 300



Question 124. III.D. Power Transmission Systems: 2. Mechanical power transmission

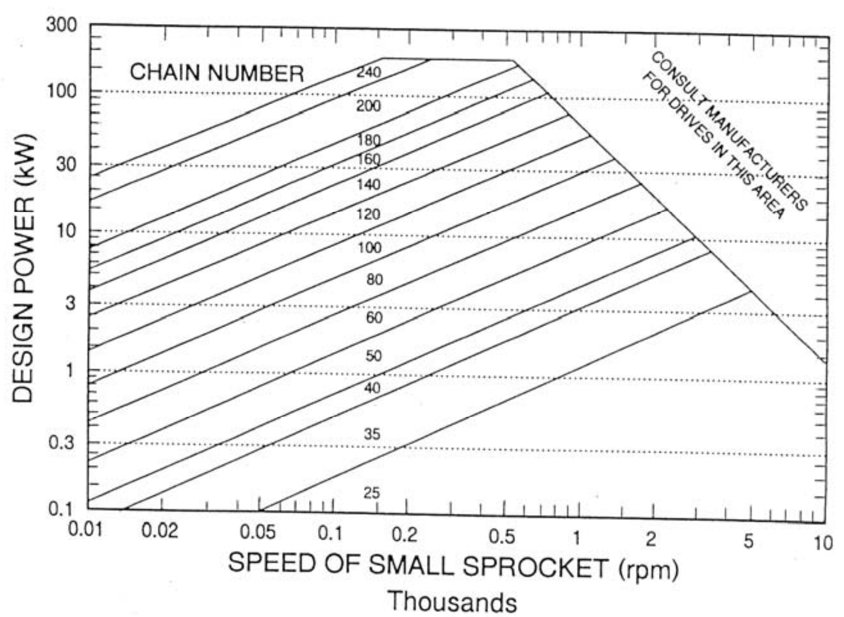
Select the appropriate preliminary drive chain number for application on the following skid steer loader. The chain drive must transmit 3 kW of power supplied by an internal combustion engine through a hydraulic drive. The chain drive will experience heavy shock loads. The drive sprocket has 17 teeth and the driven sprocket has 90 teeth. For the design tire size, the driven sprocket must operate at 58 rpm to obtain the desired working speed. The most appropriate drive chain number (single strand) for the application is:

Service Factors for Roller Chains*			
	Type of Input Power		
Type of Driven Load	Internal Combustion Engine with Hydraulic Drive	Electric Motor or Turbine	Internal Combustion Engine with Mechanical Drive
Smooth	1.0	1.0	1.2
Moderate shock	1.2	1.3	1.4
Heavy shock	1.4	1.5	1.7

*Taken from Table 3.5, page 76 I Srivastava et al. (1993), which is reproduced from *Chains for Power Transmission and Material Handling* by permission of the American Chain Association, Rockville, MD.

Pitch Selection Chart for Roller Chains

Redrawn from Figure 3.10, page 77 of Srivastava, et al. (1993), which is reproduced from *Chains for Power Transmission and Material Handling* by permission of the American Chain Association, Rockville, MD.



(A) 50

(B) 60

(C) 80

(D) 100

IV. Natural Resource Engineering questions

Question 125. IV.A.1 Soil, Water, and Plant Systems, Applications, Environmental Assessment Techniques

ASABE Standard S526.3 defines silt as a soil separate consisting of particles between 2 and 50 µm (micrometers) in diameter, using what soil classification system?

(A) AASHTO

(B) FAA

(C) USCS

(D) USDA

Question 126. IV.A.2 Soil, Water, and Plant Systems, Applications, Irrigation Principles

A Class A pan is located in the middle of an 18-ha field of soybeans. This pan indicates a loss of 6 mm of water per day. The average daily temperature of this field is 90°F (dry bulb) with a relative humidity of 80%. The wind speed is less than 2 m/s. The estimated amount of evapotranspiration (mm/day) from this field of soybeans is most nearly:

(A) 4.5

(B) 5.1

(C) 7.1

(D) 8.0

Question 127. IV.A.3 Soil, Water, and Plant Systems, Applications, Open-Channel Hydraulics

Assuming Manning's $n = 0.012$ and a flow depth of 3.4 feet, what most nearly is the critical slope, in percent, of a 10-ft wide rectangular concrete channel is to be built to convey water at a rate of 300 cfs?

(A) 0.019%

(B) 0.278%

(C) 0.352%

(D) 0.445%

Question 128. IV.A.4 Soil, Water, and Plant Systems, Applications, Surface and Subsurface Drainage

A corrugated plastic tubing main is used to drain six (6) laterals; each lateral is 1000 m long and the lateral spacing is 30 m. The design slope of the main is 1 m / 100 m and the drainage coefficient is 10 mm/day. The minimum standard size of the inside diameter of the mainline is most nearly:

(A) 102 mm

(B) 152 mm

(C) 203 mm

(D) 254 mm

Question 129. IV.A.1 Soil, Water, and Plant Systems, Applications, Environmental Assessment Techniques OR 2 Irrigation Principles OR 3 Open-Channel Hydraulics OR 4 Surface and Subsurface Drainage

A common rectangular weir with end contractions is used to measure the final effluent from a chlorine contact chamber for a beef processing plant in Nebraska. The weir is 0.8 m wide and the average flow depth is 0.265 m. The daily capacity (m^3) of the weir is most nearly:

(A) 0.20

(B) 723.

(C) 17,350.

(D) 29,230.

Question 130.IV.B.1 Soil, Water, and Plant Systems, Fundamentals, Hydrology

A municipality is in need of assistance in the design of a water control structure. The designer is using a 50 year-24 hour storm rainfall depth of 4.0 inches. The probability of the design storm being exceed in any given year is most nearly:

(A) less than 1%

(B) 2%

(C) 50%

(D) 100%

Question 131. IV.B.1 Soil, Water, and Plant Systems, Fundamentals, Hydrology OR 2 Soil Mechanics Principles OR 3 Soil Physics Principles OR 4 Soil-Water Relationships

As part of a geotechnical analysis for the construction of a runoff retention pond in Texas, it is determined that the soil material to be used for the earthen liner is highly calcareous and is classified as a CL (Unified Soil Classification System) soil. The soil amendment able to swell up to 10-15 times its dry volume when exposed to water and able to decrease the permeability of the soil is:

(A) bentonite

(B) soda ash (Na_2CO_3)

(C) sodium tripolyphosphate (STPP)

(D) tetrasodium pyrophosphate (TSPP)

Question 132. IV.B.3 Soil, Water, and Plant Systems, Fundamentals, Soil Mechanics Principles

Given the following data for a soil sample, the moisture content (dry basis) of the sample is most nearly:

Mass of sample can	16.09 g
Mass of sample can and wet soil	31.32 g
Mass of sample can and dry soil	29.28 g

(A) 7.0%

(B) 12.7%

(C) 13.4%

(D) 15.5%

Question 133. IV.C.1 Soil, Water, and Plant Systems, Interactions among Natural Resources, Ecological Processes

Compute the wetland area required to reduce the nitrate nitrogen concentration of a surface inflow stream of 10,000 m^3/yr by 60% to a wetland. The inflow concentration to the surface flow wetland is 150 mg/L and the background concentration of nitrate nitrogen in the wetland is 20 mg/L.

(A) 177 m^2

(B) 337 m^2

(C) 536 m^2

(D) 655 m^2

Question 134. IV.C.2 Soil, Water, and Plant Systems, Interactions among Natural Resources, Erosion Control and Slope Stabilization

Assuming a 100-year, 24-hour rainfall of 8.5 inches, the change in percent runoff from a watershed with an RCN of 75 in the pre-development condition to 80 in the post-development condition will most nearly be:

(A) a decrease of 27%

(B) a decrease of 11%

(C) an increase of 11%

(D) an increase of 27%

Question 135. IV.C.3 Soil, Water, and Plant Systems, Interactions among Natural Resources, Nutrient Management/Loading Rates in Soils

Using a nitrogen-based nutrient management strategy, the yearly land base required for manure application from a continually operated 1,000-head swine finishing barn described below is most nearly:

(A) 64 acres

(B) 75 acres

(C) 96 acres

(D) 160 acres

Pigs enter the barn at 50 lbs and are marketed when they reach 250 lbs.
Intended crop to grow is corn (in continuous rotation) with needs of 185 lbs/acre of total nitrogen.
Assume the fields receiving manure application have no residual nitrogen.
Assume a 40% storage and application loss.

Question 136. IV.C.4 Soil, Water, and Plant Systems, Interactions among Natural Resources, Sediment Processes

A flood control reservoir is being designed for a 40-square-mile watershed. The average annual soil loss is 8 tons/acre. The design includes flood storage of 350 acre-feet, sediment storage of 127 acre-feet and permanent pool storage of 300 acre-feet. The sediment delivery ratio is expected to be 17% with an average density of 127 lbs/cubic foot. The life of the reservoir based on sediment capacity is most nearly:

(A) 10 years

(B) 25 years

(C) 35 years

(D) 50 years

V. Process Engineering: Food, Feed, Fiber, and Fuel Products

Question 137. V.A. Energy Sources

A 500,000-Btu/hr biomass boiler is being incorporated into the heating system for a machine shed. Available biomass fuels for firing the boiler are listed in the table below.

Bulk and Energy Density for Residual Biomass Materials		
Biomass	Bulk Density (lb/ft^3)	Energy Density (Btu/lb)
Wheat straw	3.2	7,480
Switchgrass	6.6	7,990
Sugarcane bagasse	7.0	8,150
Corn stover	4.1	7,700

Based on the properties provided for the biomass fuels, the minimum volume (ft^3) of storage capable of holding a 3-week supply of any of the four fuels for use in the boiler is most nearly:

(A) 4,420
(B) 4,780
(C) 7,980
(D) 10,530

Question 138. V.C. Mass Transfer between Phases

Soybeans at 9% moisture (wet basis) are aerated using air at 10°C (dry bulb) and 80% relative humidity. If aeration is continued until equilibrium is reached, the moisture content (% wet basis) of the soybeans will most nearly be:

(A) 7
(B) 9
(C) 17
(D) 23

Question 139. V.C. Mass Transfer between Phases

Twenty-five kilograms per minute of 87% moisture content (wet basis) diced beets are dried in a concurrent flow, single-pass tunnel dryer on a conveyor belt. Outside air at 20°C (dry bulb) and 40% relative humidity is heated to 90°C in a preheater using a resistance element before being passed over the beets. An intake fan delivers 500 m^3/min (595 kg/min) of outside air to the preheater while exhaust air exits the dryer at 53°C (dry bulb). Assuming steady-state conditions at any point within the dryer and no heat losses from the dryer to the environment except for the exiting beets and air stream, the moisture content (% wet basis) of the exiting beets is most nearly:

(A) 49
(B) 55
(C) 73
(D) 79

Question 140. V.D. Materials Properties: 1. Biological Materials

Given the information below, the density (kg/m3) of a 0.41 (vol/vol) aqueous ethanol solution at 25°C is most nearly:

(A) 941

(B) 933

(C) 929

(D) 925

Densities of Aqueous Ethanol Solutions at Various Concentrations at 25°C	
Ethanol Concentration (wgt/wgt)	Density (kg/m^3)
0	997.08
0.10	980.43
0.20	966.39
0.30	950.67
0.40	931.48
0.50	909.85
0.60	886.99
0.70	863.40
0.80	839.11
0.90	813.62
1.0	785.06
(wgt/wgt) = [(vol/vol)(ρ_{EtOH})]/[{(vol/vol)(ρ_{EtOH})}+{(1-(vol/vol))(ρ_{H2O})}]	

Practice Examination, Morning Session

Answers

I. Engineering Principles and Professional Practices

Question 101. Correct answer (D)

Reference: *Fundamentals of Electricity for Agriculture* by Gustafson and Morgan

From reference tables, full load for a 50 hp, 460 V, three-phase induction type AC motor is 65 A. NEC requires 125% of full load for conductors, 65 × 1.25 = 82 A.

Common mistakes:

(A) Dividing by 1.25 to get 52 amps

(B) Not applying a full load factor

(C) Using a factor of 1.15 instead of 1.25

Question 102. Correct answer (C)

Reference: Beckwith, T.G., R.D. Marangoni, and J.H. Lienhard. 2007. *Mechanical Measurements.* (6th ed). Prentice Hall.

A fast way to solve this problem is to rearrange the equation for flow rate through a flow nozzle to solve for the pressure drop and plug in the answers for flow nozzle throat diameters and see which throat diameter gives pressure drops in the desired range.

$$Q_a = \frac{C_v A_2}{\sqrt{1-\left(A_2/A_1\right)^2}}\sqrt{2g\left(\frac{P_1-P_2}{\gamma}\right)} \quad \text{so} \quad \left(P_1-P_2\right)=\frac{\gamma}{2g}\left(\frac{Q_a}{C_v A_2}\right)^2\left[1-\left(\frac{A_2}{A_1}\right)^2\right]$$

For a differential pressure transducer: $(P_1 - P_2) = \gamma_{pt}\, h$ or $h = (P_1 - P_2)/\gamma_{pt}$

For 500 gpm with the 5 in throat diameter:

$$\left(P_1-P_2\right)=\frac{49.2\frac{\text{lb}}{\text{ft}^3}\left(\frac{\text{ft}}{12\text{in}}\right)^3}{2\left(32.2\frac{\text{ft}}{\text{s}^2}\right)\left(\frac{12\text{in}}{\text{ft}}\right)}\left(\frac{500\frac{\text{gal}}{\text{min}}\left(\frac{231\text{in}^3}{\text{gal}}\right)\frac{\text{min}}{60\text{s}}}{0.98\left(\frac{\pi\cdot(5\text{in})^2}{4}\right)}\right)^2\left[1-\left(\frac{\left(\frac{\pi\cdot(5\text{in})^2}{4}\right)}{\left(\frac{\pi\cdot(10\text{in})^2}{4}\right)}\right)^2\right]=0.3457\frac{\text{lb}}{\text{in}^2}$$

and

$$h=\frac{0.3457\frac{\text{lb}}{\text{in}^2}}{62.4\frac{\text{lb}}{\text{ft}^3}\left(\frac{\text{ft}}{12\text{in}}\right)^3}=9.57\text{in}$$

Similarly, for 1000 gpm with the 5 in throat diameter: h = 38.3 in, which meets the selection criteria.

Common mistakes:

(A) 2.5 in; used πD^2 for A_2 instead of πr^2

(B) 3 in; left out one conversion from ft to inches

(D) 8 in; included an extra conversion from ft to inches

Question 103. Correct answer (A)

Since the fog light indicator does not control engine stop (red), does not control ground motion nor is a steering control (orange), nor is a component lift control (yellow), the fog light control could be black or any other color. Thus the fog light is covered by C.2.4 of the standard.

Common mistakes:

Answers (B),(C),(D) all represent failure to read carefully and/or properly apply guidelines as required.

Question 104. Correct answer (C)

References: *Engineering Economic Analysis* by Newnan and Eschenbach

Cost comparisons must be made on an equal time basis. Convert both costs to an annual basis. Determining the annual cost of the investment for the building and equipment:

$$A_1 = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] - S\left[\frac{i}{(1+i)^n - 1}\right] = \$180{,}000\left[\frac{0.07(1.07)^{12}}{(1.07)^{12} - 1}\right] - \$35{,}000\left[\frac{0.07}{(1.07)^{12} - 1}\right]$$

$$A_1 = \$180{,}000(0.1259) - \$35{,}000(0.0559) = \$20{,}705.79$$

The annual costs for overhauling X engines per year with your own equipment and facilities is

$$\$20{,}705.79 + 0.0125(\$180{,}000) + \$5{,}500\,X = \$22{,}955.79 + \$5{,}500\,X$$

By comparison, the annual costs for having X engines per year overhauled by the outside mechanic shop is \$7,200X. Solving for the number of engines at which these two costs are equal:

$$\$22{,}955.79 + \$5{,}500X = \$7{,}200X$$

$$X = \frac{\$22{,}955.79}{(\$7{,}200 - \$5{,}500)} = 13.50 \rightarrow 14 \text{ engines}$$

Rounding up, the minimum number of engines to make the investment economically feasible is 14.

Common mistakes:

(A) 7; used 0.0559 × (\$180,000 - \$35,000) giving 6.09 engines

(B) 12; used 0.1259 × (\$180,000 - \$35,000) giving 12.06 engines, rounded to nearest engine instead of rounding up

(D) 17; using tables, used A/P factor for 10 years instead of 12, changing 0.1259 to 0.1423

Question 105. Correct answer (B)

Reference: *ASABE Standards*

Coefficient of variation, according to ASAE EP405.1, is defined as standard deviation of the discharge of the emitters (s) divided by the mean discharge of the emitters ($\bar{x}$) in the sample as noted below.

$$C_v = \frac{s}{\bar{x}} = \frac{\left[\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}\right]^{1/2}}{\bar{x}} = \frac{\left[\frac{0.28}{5}\right]^{1/2}}{4.4} = 0.054$$

Common mistakes:

(A) 0.049; divided population variance (σ) by sample mean = 0.216/4.4 = 0.049

(B) 0.237; used the sample variance (s)

(D) 0.280, used the sum of the deviations

Question 106. Correct answer (C)

References: *Introduction to Environmental Engineering* by Davis and Cornwell, and *Transport Processes and Separation Process Principles* by Geankoplis

Ash removal rate has to equal ash input rate. Ash input rate can be found by multiplying ash content of dry biomass by dry biomass input rate.

2 tons per hour of wet switchgrass × 2,000 lb/ton = 4,000 lb/h of wet switchgrass

4,000 lb wet switchgrass/h × (1 – 0.42) lb dry switchgrass/lb wet switchgrass = 2,320 lb dry switchgrass/h

2,320 lb dry switchgrass/h × 0.035 lb ash/lb dry switchgrass = 81 lb ash/h

Common mistakes:

(A) Factor of 10 error

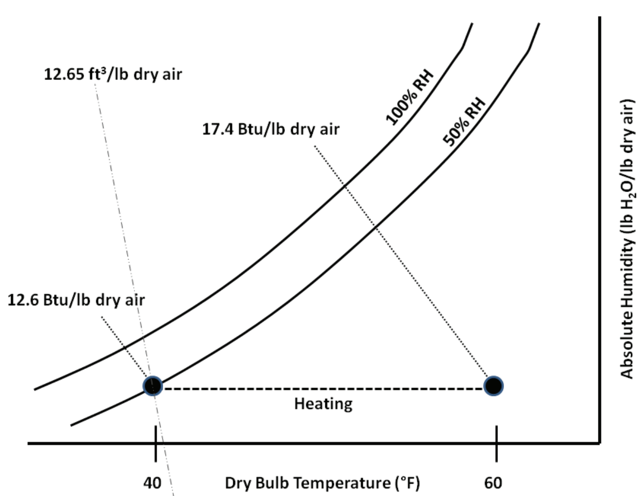
(B) Forgetting to correct for moisture

(D) 1,000 lb/ton instead of 2,000 lb/ton

Question 107. Correct answer (A)

Reference: *Principles of Process Engineering* by Henderson, Perry, and Young.

Solved with the aid of a psychrometric chart by recognizing energy per time (P) needed is found by multiplying change in enthalpy (Δh) of air-water mixture by air flowrate (m_{dot}). Relevant state points are shown in chart below.



$V_{air\ in} = 12.65\ ft^3/lb_{da}$

m_{dot} = mass flow air = $Q/V_{air\ in} = (1{,}000\ ft^3/min)/(12.65\ ft^3/lb_{da}) = 79\ lb_{da}/min$

$h_1 = 12.6\ BTU/lb_{da}$

$h_2 = 17.4\ BTU/lb_{da}$

$\Delta h = 4.8\ BTU/lb_{da}$

$P = m_{dot} \times \Delta h = 79\ lb_{da}/min \times 4.8\ BTU/lb_{da} = 379\ BTU/min$

Common mistakes:

(B) ($h_1 \times m_{dot}$) for 1,000

(C) ($h_2 \times m_{dot}$) for 1,375

(D) ($\Delta h \times Q$) for 4,800

Question 108. Correct answer (B)

Reference: Hoffman, et al. 2007. Design and Operation of farm Irrigation systems, ASABE.

For identical pumps operating in parallel, flow rate from each pump is added to others for total flow rate whereas the total head remains as the head for each of the individual pumps, or 150 ft.

Common mistakes:

(A) Guessed by saying that the head reduces by half with two parallel pumps

(C) Guessed by adding half the head of 150 ft (i.e., 75 ft) to 150 ft to get a total

(D) Used the head for two identical pumps in series

II. Facility Engineering: Plant, Animal, and Commodity Environments and Structures

Question 109. Correct answer (C)

Reference: *Environment Control for Plants and Animals* by Albright (1990)

$$THP = 1000\ pigs \times 20\ kg \times 4.8\ W/kg = 96{,}000\ W \text{ or } 96\ kW$$

1 liter of CO_2 is produced for each 24.6 kJ of total heat production (page 167).

$$CO_2 \text{ produced} = 96\ kW \times 1liter\ CO_2 / 24.6\ kJ = 3.9\ liter\ CO_2/s$$

$$Q\ (CO_2\ out - CO_2\ in) = CO_2 \text{ produced}$$

$$Q\ (2500\ liters\ CO_2 - 345\ liters\ CO_2)/(1{,}000{,}000\ liters\ air) = 3.9\ liters\ CO2/s$$

$$Q = 1810\ liters\ air/s = 1.8\ m^3/s$$

Question 110. Correct answer (A)

References: *Agricultural Waste Management Field Handbook* by NRCS

State	Anaerobic Lagoon Loading Rate (lbs VS/1000 cu ft/dy)
Florida	6.5 – 7
North Carolina	5.5 – 6.26
Kansas	4.6 – 5.4
Idaho	3.7 – 5

The highest loading rate yields the lowest treatment volume required for a given volatile solids production.

Question 111. Correct answer (D)

Reference: *Environment Control for Plants and Animals* by Albright (1990)

Compare the combined fan flow rate to inlet flow rate at each static pressure. Where they are approximately equal is the system operating point.

Static Pressure	Combined Fan Flow Rate	Inlet Flow Rate
0	3300 + 6300 = 9600	0
0.05	3100 + 6000 = 9100	2800
0.1	3000 + 5600 = 8600	4800
0.15	2700 + 5200 = 7900	6200
0.20	**2500 + 4600 = 7100**	**7000**
0.25	1400 + 3600 = 5000	7500
0.30	1000 + 2100 = 3100	7900

Question 112. Correct answer (D)

Reference: *Civil Enginering Reference Manual for the PE Exam* by Lindeburg (2008)

Question 113. Correct answer (A)

Reference: ASAE Standard EP486 (R2005)

Use Section 6.6.2:

$d^3 = 4\ M_a/(S \times b)$

$M_a = 2800$ ft lbs

S = allowable lateral soil pressure = (lateral pressure, table 1) × 2 × LDF_{wind}

= (130 psf /ft) 2 (1.33) = 345 psf/ft

Section 4.2.2.1 and 4.2.2.2 allow for an increase for isolated posts (× 2) and an increase of 1/3 for wind load conditions.

b = effective width of the post, $b = 2^{0.5} \times$ width

= 1.41 (5.5 inches) = 7.8 inches = 0.65 ft

Thus:

d^3 = 4. (2,800 ft-lbs) / (345 psf/ft × 0.65 ft)
= 49.9 ft^3
d = 3.7 ft

Question 114. Correct answer (C)

References: *Minimum Design Loads for Buildings and Other Structures: SEI/ASCE 7-05 (ASCE Standard No. 7-05)* and *Design of Wood Structures—ASD/LRFD* by Breyer et al.

From Breyer et al. page 2.15 or ASCE section 7.3:

$p_f = 0.7\ C_e\ C_t\ I\ p_g$

C_e = exposure factor for Category C that is fully exposed = 0.9 (ASCE table 7-2)

C_t = thermal factor for unheated structure = 1.2 (ASCE table 7-3)

I = importance factor for agricultural building with low occupancy = 0.8 (ASCE table 7-4)

p_f = 0.7 (0.9) (1.2) (0.8) 40 psf = 24 psf

III. Machine Systems: Power, Electrical/Electronic, Machines, Controls, and Sensors

Question 115. Correct answer (C)

Reference: *Engine and Tractor Power,* by Goering

Common mistakes:
(A) 30; misused density of water instead of diesel fuel.
(B) 32; misused density and heat value for heating oil.
(D) 38; misused density and heat value for gasoline.

Question 116. Correct answer (A)

Reference: *Engine and Tractor Power,* by Goering

Common mistakes:
(B) 665; used wheel diameter for lever arm for drawbar load instead of hitch point
(C) 810; incorrectly resolved x and y vector components
(D) 2,125; not resolved vector components, used only drawbar load

Question 117. Correct answer (B)

Reference: *Electricity in Agriculture,* by Gustafson

Common mistakes:
(A) 47; not used efficiency at all
(C) 70; not convert hp to KW
(D) 90; incorrectly assumed 1 phase and not apply $3^{0.5}$

Question 118. Correct answer (C)

Reference: *Shigley's Mechanical Engineering Design,* 8th ed., by Budynas and Nisbet

Common mistakes:
(A) $^{1}/_{2}$"; not taking into consideration only bolt tensile strength
(B) $^{9}/_{16}$"; used grade 8 bolt by mistake
(D) $^{7}/_{8}$"; found required bolt diameter, but sized up instead of down for shear protection

Question 119. Correct answer (B)

Reference: *Shigley's Mechanical Engineering Design,* 8th ed., by Budynas and Nisbet

Common mistakes:
(A) 198; calculated about weaker axis
(C) 775; used only moment of inertia for inner wall
(D) 1,152; used only moment of inertial for outer wall

Question 120. Correct answer (A)

Reference: *Shigley's Mechanical Engineering Design,* 8th ed., by Budynas and Nisbet

Common mistakes:
(B) 14,000 psi; forgot to subtract slack-side tension in calculating shaft torque
(C) 20,000 psi; used diameter instead of radius in numerator of torsion shear stress
(D) 30,000 psi; forgot to multiply by pi in equation for J

Question 121. Correct answer (D)

Reference: *Engine and Tractor Power,* 4th ed., by Goering and Hansen, p.115, table 6.1

Common mistakes:
(A) 3,300; pounds of carbon, without converting to carbon dioxide
(B) 7,700; used only one O instead of two in calculation for carbon dioxide.
(C) 8,800; forgot to include C in calculation for carbon dioxide

Question 122. Correct answer (B)

Reference: *Shigley's Mechanical Engineering Design,* 8th ed., by Budynas and Nisbet

Common mistakes:
(A) 3.5; ignored friction
(C) 4.5; used sin instead of tan
(D) 5.5; forgot to use friction coefficient

Question 123. Correct answer (B)

Common mistakes:
(A) 80; used D instead of r calculating force from torque
(C) 200; used 3000 psi instead of 2800-300 for motor pressure drop
(D) 300; forgot to divide by 2 calculating motor torque output.

Question 124. Correct answer (B)

Common mistakes:
(A) 50; didn't use service factor, or used wrong speed line (580 rpm) on chain size chart

(C) 80; didn't use service factor, and used wrong speed line (58 rpm) on chain size chart

(D) 100; wrong speed line on chain size chart (58 rpm)

IV. Natural Resource Engineering

Question 125. Correct answer (D)

USDA 0.002 - 0.05 mm (2 - 50 µm) from the standard "705. silt: a. A soil separate consisting of particles between 2 and 50 µm in diameter; USDA textural soil classification...."

Common mistakes:

(A) AASHTO: 0.005 - 0.075 mm (5 µm - #200 sieve)

(B) FAA: 0.005 - 0.05 mm (5 - 50 µm)

(C) USCS: *0.005 - 0.075 mm (5 µm - #200) *silt and clay defined by PI and LL relationship

Question 126. Correct answer (B)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 59, table 4-1

$ET = K_{pan} \times E_{pan} = 6.0 \times 0.85 = 5.1$ mm/day

Common mistakes:

(A) $6.0 \times 0.75 = 4.5$ mm/day

(C) $6.0 / 0.85 = 7.1$ mm/day

(D) $6.0 / 0.75 = 8.0$ mm/day

Question 127. Correct answer (B)

Reference: *Engineering Field Handbook,* chapter 3, eq. 3-20

$S_c = 14.56 \times n^2 \times D_m / (r^{4/3})$

$S_c = 14.56 \times 0.012^2 \times 3.4 / (2.02^{4/3})$

Common mistakes:

(A) $S_c = 0.012^2 \times 3.4 / (2.02^{4/3})$

(C) $S_c = 14.56 \times 0.012^2 \times 3.4 / (2.02)$

(D) $S_c = 14.56 \times 0.012^2 \times 3.4 / (2.02^{2/3})$

Question 128. Correct answer (C)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 322, figure 14-9

Read nomograph correctly using 10 mm coefficient and 1% slope:
$1000 \text{ m} \times 6 \times 30 \text{ m} / 10{,}000 = 18 \text{ ha}$

Common mistakes:

(A) $1000 \times 30 \text{ m} / 10000 = 3$ ha. Read nomograph using 10 mm coefficient and 1% slope.

(B) $1000 \times 30 \text{ m} / 10000 = 3$ ha. Read nomograph using 10 mm coefficient and 0.1% slope.

(D) $1000 \text{ m} \times 6 \times 30 \text{ m} / 10000 = 18$ ha. Read nomograph using 13 mm coefficient and 1% slope.

Question 129. Correct answer (C)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 129

Capacity $= 1.84 \times L \times h^{3/2} \times 3600 \times 24 \text{ m}^3 / \text{day}$

Common mistakes:

(A) Capacity $= 1.84 \times L \times h^{3/2} \text{ m}^3 / \text{second}$

(B) Capacity $= 1.84 \times L \times h^{3/2} \times 3600 \text{ m}^3 / \text{hour}$

(D) Capacity $= 3.1 \times L \times h^{3/2} \times 3600 \times 24 \text{ m}^3 / \text{day}$. Used US Customary System equation with metric inputs.

Question 130. Correct answer (B)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 38

$T = 100 / P$

$(50 / 100)^{-1} = 100/50 = 2$. This is commonly referred to as a 2% probability of occurrence.

Common mistakes:

(A) $[(50 \times 24) / 100]^{-1} = 100/(50 \times 24) = 0.08$ or 0.08% probability, or other errors.

(C) Used return period as percentage, 50 years or 50%.

(D) The design storm will be exceeded some time, forgot yearly chance.

Question 131. Correct answer (A)

Reference: *Agricultural Waste Management Field Handbook* (AWMFH), chapter 10D

Common mistakes:

(B), (C), and (D) are dispersant additives

Question 132. Correct answer (D)

Reference: *ASABE Standards,* specifically EP419.1, S501, and S358 in addition to various other references.

%MC (dry basis) = [H_2O mass/dry matter mass] × 100%

[(31.32 – 29.28) g H_2O / (29.28 – 16.09) g dry soil] × 100% = 15.47% ≈ 15.5%

Common mistakes:

(A) [(31.32 – 29.28) g H_2O / (29.28) g can and dry soil] × 100% = 6.97% ≈ 7.0 %
(B) [(31.32 – 29.28) g H_2O / (16.09) g can] × 100 % = 12.68% ≈ 12.7%
(C) [(31.32 – 29.28) g H_2O / (31.32-16.09) g wet soil] × 100 % = 13.39% ≈ 13.4%

Question 133. Correct answer (B)

Reference *Soil and Water Conservation Engineering* by Fangmeier, p. 285-6, including table 12-3

Area = A = $-Q/k \{\ln[(c_2-c^*)/(c_1-c^*)]\}$ = 10,000/35 {ln[60-20)/(150-20)]} = 337 m^2

Common mistakes:

(A) 177 m^2, reduced by 40% instead of 60%
(C) 536 m^2, used total nitrogen instead of nitrate nitrogen (k = 22 vs. 35)
(D) 655 m^2, used ammonia nitrogen instead of nitrate nitrogen (k = 18 vs. 35)

Question 134. Correct answer (C)

Reference: NRCS Engineering Field Manual, chapter 2

A rainfall of 8.5 inches yields runoff of 5.5 inches for an RCN of 75, and 6.1 inches for an RCN of 80, for an increase of 0.6 inches: 0.6 / 5.5 = 0.109 or 11% increase.

Common mistakes:

Answer (B) Change in sign

Answer (A) and (D) Misread the table using 8 inches for an RCN of 70 and 80. A rainfall of 8.0 inches yields runoff of 4.4 inches for an RCN of 70 and 5.6 inches for an RCN of 80 for a difference of 1.2 inches. 1.2 / 4.4 = 0.273 or 27%. (D) also has sign change.

Question 135. Correct answer (C)

Reference: *Agricultural Waste Management Field Handbook* (AWMFH)

Page 4-17 of current AWMFH 3/2008: Pigs grow from 50 lbs to 250 lbs; average is 150 lbs; 10 pound N / pig / 120 days or 0.54 lbs N/day / AU. Also page 11-26 and 11-27 in AWFMH.

(50+250) / 2 = 150 lbs avg. weight
1000 animals × 150 lbs animal weight × 0.54 lbs N/day/1000 lbs × 365 days = 29,565 lbs N per year
40% is lost, so multiply by 0.6 = 17,739 lbs N/year
Need 185 lbs N per acre per year so 17,739 / 185 = 95.9 acres

Common mistakes:

(A) Used 0.4 instead of 0.6 to figure losses
1000 animals × 150 lbs animal weight × 0.54 lbs N/day/1000 lbs × 365 days = 29,565 lbs N per year
40% is lost, so multiply by 0.4 (*error*) = 11,826 lbs N/year
Need 185 lbs N per acre per year so 11,826 / 185 = 63.9 acres

(B) Used old data, page 4-12 of AWMFH 7/1996

1000 animals × 150 lbs animal weight × 0.42 lbs N/day/1000 lbs × 365 days = 22,995 lbs N per year
40% is lost, so multiply by 0.6 = 13,797 lbs N/year
Need 185 lbs N per acre per year so 13,797 / 185 = 74.6 acres

(D) Used maximum swine size
1000 animals × 250 lbs animal weight × 0.54 lbs N/day/1000 lbs × 365 days = 49,275 lbs N per year
40% is lost, so multiply by 0.6 = 29,565 lbs N/year
Need 185 lbs N per acre per year so 29,565 / 185 = 159.8 acres

Question 136. Correct answer (A)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 149-150

40 sq mile × 640 acres/sq mile × 8 tons/acre/year × 0.17 delivery ratio × 2000 lbs/ton × (1 acre / 43,560 ft^2) × (1 /v127 lbs/ft^3) = 12.6 acre-ft per year

Planned sediment capacity is 127 acre-ft.

127 acre-ft / 12.6acre-ft / year = 10.1 years

Common mistakes:

(B) Used flood storage instead of sediment storage: 350 acre-ft/12.6 acre-ft/year = 27.8 years

(C) Used flood storage and sediment storage: (350 + 127)acre-ft/ 12.6 acre-ft/year = 37.9 years OR used permanent pool storage with sediment storage (300 + 127) acre-ft/12.6 acre-ft/year = 33.9 years

(D) Used permanent pool storage and flood storage (300 + 350) acre-ft / 12.6 acre-ft/year = 51.6 years

This problem addresses the concept that sediment (soil) will erode from a watershed and fill a flood control reservoir, making it ineffective for flood storage over a period of time. Designers plan for a certain life of the structure by including sediment storage at the lowest elevations of the reservoir so that the impoundment can provide flood control for many years before the sediment blocks the outflow structure. Flood storage is the capacity allowed in the event that a large storm needs to be held to avoid downstream damages to property. Permanent pool storage is the volume of water to be held in the reservoir most of the time to have a "lake" for such things as recreational activities. The sediment storage is what is designed to be filled by sediment over the reservoir's life.

V. Process Engineering: Food, Feed, Fiber, and Fuel Products

Question 137. Correct answer (D)

Reference: *ASABE Standards*

Wheat straw has the lightest bulk density and the smallest energy density so it will require the greatest volume to hold a 3-week supply. This volume will be the minimum volume to hold all four biomasses. Volume = (500,000 Btu/hr × 24 hr/day × 7 days/week × 3 weeks)/(3.2 lb/ft^3 × 7,480 Btu/lb) = 10,528 ft^3

Common mistakes:

(A) Volume based on holding only sugarcane bagasse

(B) Volume based on holding sugarcane bagasse and switchgrass

(C) Volume based on holding sugarcane bagasse, switchgrass, and corn stover

Question 138. Correct answer (C)

Reference: *ASABE Standards*

Soybeans as a biological material will reach an equilibrium state between storage relative humidity and bean moisture content. The equilibrium relationship has been empirically described visually using a graphical isotherm such as seen in Figure 8 from ASAE Standard D245.5 and mathematically described using an expression such as the Modified Halsey equation, Modified Chung-Pfost equation, Modified Henderson equation, or GAB equation. Reading off moisture content (% wet basis) on Figure 8 at 10°C (dry bulb) and 80% relative humidity finds a value of ≈16%. Using a rewritten expression such as the Modified Halsey equation for USA soybeans using A, B, and C values of 2.87, -0.0054, and 1.38, respectively, as given in Table 2 of ASAE Standard D245.5, finds:

$$\%MC_D = \left[\frac{-e^{(A+[B\times T])}}{\ln RH}\right]^{\frac{1}{C}} = \left[\frac{-e^{(2.87+[-0.0054\times 10])}}{\ln 0.8}\right]^{\frac{1}{1.88}} = 22.8\%$$

$$\%MC_W = \frac{\%MC_D}{100\% + \%MC_D} = 18.6\%$$

Common mistakes:

(A) 0.8 × 0.09 = 0.072 or ≈7%

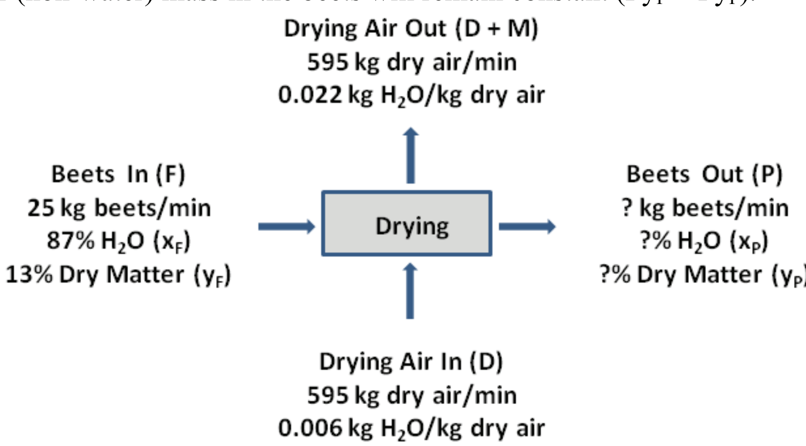
(B) Assumes no change in moisture content from 9%

(D) Fails to convert moisture content on dry basis as estimated by Modified Halsey equation to moisture content on wet basis

Question 139. Correct answer (D)

Reference: *Transport Processes and Separation Process Principles* by Geankoplis

Using a high-temperature, SI-unit psychrometric chart, the air heating (enthalpy increase with no moisture change) and subsequent drying (adiabatic humidification and cooling) processes are sketched on the chart as depicted below to find relevant state conditions. Additionally, a mass balance around the drying process indicates moisture gain/min (M) by the drying air has to equal moisture loss/min from the beets (F – P). Dry matter (non-water) mass in the beets will remain constant ($Fy_F = Py_P$).

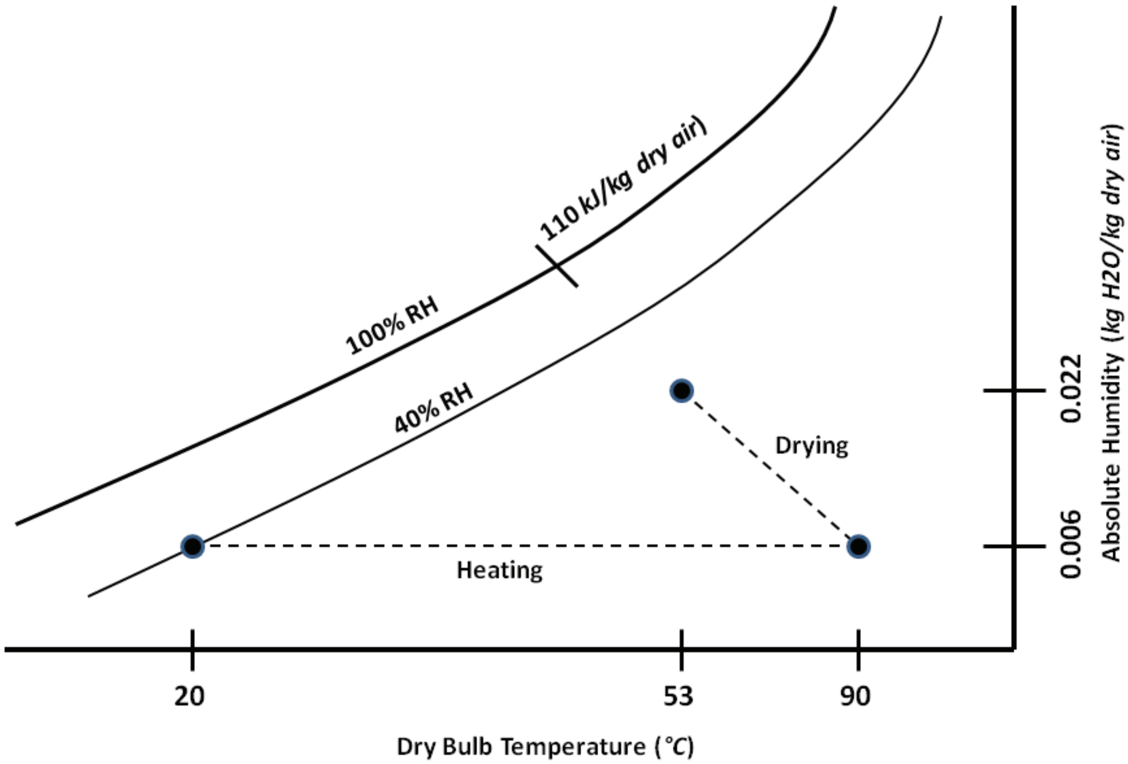


Moisture gain (kg H_2O/kg dry air) by drying air = 0.022 – 0.006 = 0.016 kg H_2O/kg dry air

Mositure gain (kg H_2O/min) by drying air = M = 0.016 kg H_2O/kg dry air × 595 kg dry air/min = 9.52 kg H_2O/min

Dry matter flow rate (kg dry matter/min) in beets entering/exiting dryer = Fy_F = Py_P = 25 kg beets/min × 0.13 kg dry matter/kg beets = 3.25 kg dry matter/min

Moisture loss rate (kg H_2O/min) from beets = F – P = M = 9.52 kg H_2O/min



Initial moisture mass flow rate (kg H_2O/min) in beets entering dryer = Fx_F = 25 kg beets/min × 0.87 kg H_2O/kg beets = 21.75 kg H_2O/min

Final moisture mass flow rate (kg H_2O/min) in beets exiting dryer= Px_P = 21.75 kg H_2O/min – 9.52 kg H_2O/min = 12.23 kg H_2O/min

$$\%MC_W = \frac{Px_p}{Px_p + Py_p} \times 100\% = \frac{12.23}{12.23 + 3.25} \times 100\% = 79\%$$

Common mistakes:

(A) Dividing remaining water mass in exiting beets by entering beet mass

(B) Assuming exit air relative humidity is still 40% as entering air and using the associated difference in entering and exiting air absolute humidities (moisture contents)

(C) Using exiting air absolute humidity (moisture content) rather than difference between entering and exiting air absolute humidities (moisture contents)

Question 140. Correct answer (A)

Reference: *Principles of Process Engineering,* by Henderson, Perry, and Young

The ethanol concentration of the solution is given as a volume ratio which must be converted to a weight ratio in order to use the table for interpolation. Conversion of the volume ratio to weight ratio can be completed using the equation provided below the table. Using information in the table, ethanol density is assumed to be 785.06 kg/m^3 at a weight ratio of 1.0 and water density is assumed to be 997.08 kg/m^3 at a weight ratio of 0.

$$^{wgt}/_{wgt} = \frac{\left[\left(^{vol}/_{vol}\right) \times (\rho_{EtOH})\right]}{\left[\left(\left[^{vol}/_{vol}\right] \times [\rho_{EtOH}]\right) + \left(\left[1 - \left(^{vol}/_{vol}\right)\right] \times [\rho_{H_2O}]\right)\right]} = 0.354$$

Once weight ratio of ≈0.35 is determined, observation indicates the density of the aqueous ethanol solution will be approximately halfway between the 0.30 and 0.40 densities or approximately at 941 kg/m^3.

Common mistakes:

(B) Not converting (vol/vol) to (wgt/wgt) and interpolating on wrong side of 0.41

(C) Not converting (vol/vol) to (wgt/wgt)

(D) Reversing the values for ethanol and water densities in the equation below the table

Practice Examination, Afternoon Session

I. Engineering Principles and Professional Practices

Question 501. I.A. Circuits, Controls and Sensors: 1. Electrical circuits and controls

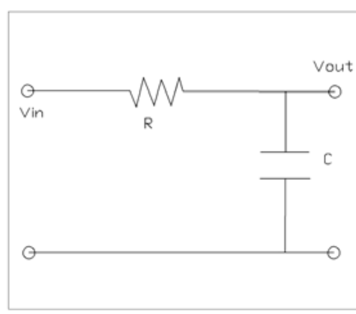
A 12-V mobile vehicle system has a changeover circuit to use its two 12-V batteries in series during starting to get 24 V. The starter motor requires 6 kW at cranking at 40°C ambient temperature. Assuming an intermittent load, an allowed temperature rise of 150°C and a current to conductor cross-sectional area ratio of 13.82 A/mm^2, the minimum diameter (mm) of copper conductor cables between the batteries and starter motor for safe starting is most nearly:

(A) 2.59 - (10 AWG)
(B) 5.19 - (4 AWG)
(C) 5.76 - (3 AWG)
(D) 7.35 - (1 AWG)

Question 502. I.A. Circuits, Controls and Sensors: 2. Sensors, instrumentation, data loggers, and control circuits

A high-pass filter as depicted in the diagram allows high-frequency signals (f) to pass through, but blocks low-frequency elements. For a high-pass filter, the cut-off frequency (f_c) defines the frequency below which all input signals are attenuated. The equation for a high-pass filter as a function of input (V_{in}) and output voltage (V_{out}) is:

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{\left(\frac{f}{f_c}\right)}{\sqrt{1+\left(\frac{f}{f_c}\right)^2}}$$



A filter to remove 60 Hz noise from pulses being transmitted at 2,000 Hz for a stepping motor is to be designed. Pulse amplitudes are not to be reduced by more than 3 dB with a critical frequency of 2 Hz in the filter. The voltage attenuation for this high pass filter is most nearly:

(A) 0.1%
(B) 0.3%
(C) 3.0%
(D) 3.3%

Question 503. I.B. Codes, Graphics, and Safety: 2. Health and safety OR 3. Preparation and interpretation of engineering graphics

Which of the following pictorials provides the best representation to warn of arm entanglement in feed rolls?


A


B


C


D

(A) A

(B) B

(C) C

(D) D

Question 504. I.C. Economics and Statistics: 1. Engineering economics analysis

A company is considering the purchase of several new gas-fired ovens for its processing facility with a total initial capital cost of $900,000, a useful life of 5 years for each oven, and a total salvage value of $100,000. Anticipated hourly operating costs for the plant for 5,000 hours of annual operation are:

Fuel	2,280,000 Btu/hr @ $3.80/million Btu
Labor	4 operators @ $14/hr/operator
Electricity	$0.70/hr
Maintenance	$1.50/hr

Assuming the company will produce saleable product at a rate of 200 units per hour, the price ($) per unit the company needs to charge to cover annual capital and operating costs is most nearly:

(A) 0.16

(B) 0.34

(C) 0.50

(D) 1.14

Question 505. I.C. Economics and Statistics: 2. Statistics application

Your company manufactures a line of small, general-purpose implements. The forecasted demand for the first three months of next year is shown below.

Month	Unit Demand
January	50
February	55
March	60

You would like to estimate the time requirements for your assembly department. The only data available for this task are the units assembled and time expended in a recent five-month period as shown below.

Month	Units Assembled	Time Expended (hours)
June	40	1,500
July	30	1,500
August	50	2,000
September	40	1,750
October	60	2,350

Assuming a linear model is appropriate for forecasting time needed for assembly given demand for units, the total forecasted time (hours) needed for the next three months is most nearly:

(A) 6,825

(B) 6,525

(C) 5,460

(D) 2,165

Question 506. I.D. Physical Operations: 1. Mass and energy balances

A break in a retaining wall has occurred and allows wastewater to enter a nearby creek at the rate of 225 gpm. The BOD_5 concentration of the wastewater is 375 mg/L. The upstream creek flow is at 32 cfs with a BOD_5 concentration of 3.2 mg/L. The BOD_5 (mg/L) in the downstream creek after the wastewater enters the upstream flow and thoroughly mixes is most nearly:

(A) 9

(B) 42

(C) 183

(D) 378

Question 507. I.D. Physical Operations: 3. Pump principles

A motor is to be sized for pumping within an aqueous waste slurry system as described with the following parameters.

Pumping rate	80 gpm
Slurry density, ρ	62.4 lbm/ft^3
Slurry viscosity, μ	0.000672 lbm/ft·s
Pipe size	2.5 in ID
Pipe length	500 ft
Elevation difference	15 ft (liquid level to highest point in system)
Pipe material	stainless steel
Pump efficiency	60%
Motor efficiency	90%

Assuming minor system head losses (i.e., elbows, valves, fittings, etc) can be ignored, the minimum motor rating (hp) for the pump in the system is most nearly:

(A).0.75

(B) 0.50

(C) 0.33

(D) 0.25

Question 508. I.D. Physical Operations: 2. Applied psychometric processes

Water, at a rate of 86.2 kg/min, is being removed from shiitake mushrooms as they dry in a tunnel dryer. An intake fan brings in 50 m^3/sec of outside air at 20°C (dry bulb) and 40% relative humidity for heating to 90°C (dry bulb) in a pre-heater, and then passing over the mushrooms. Assuming steady-state conditions at any point within the dryer and no heat losses from the dryer to the environment except through the exiting mushrooms and air stream, the humidity ratio of the air (kg water/kg dry air) exiting the dryer is most nearly:

(A) 0.006

(B) 0.024

(C) 0.030

(D) 0.040

II. Facility Engineering: Plant, Animal, and Commodity Environments and Structures

Question 509 II.A. Environment: 2. Animal and plant facilities

A 600-head swine gestation facility is 60 ft by 220 ft and has an under-slat pit to store manure for one year. Sows average 440 lbs. Washwater usage can be assumed as 0.1 gal/sow-day and wasted water from the drinkers is 10 percent above the excreted manure value. Freeboard between the lower edge of the slats and manure surface should be 1.5 ft to allow for the support structure. Using manure production values from ASABE Standard D384, the required depth of the pit in feet is most nearly:

(A) 3.0

(B) 3.5

(C) 4.5

(D) 5.0

Question 510 II.A. Environment: 4. Ventilation rate requirements

A negative pressure swine nursery facility holds 1,000 pigs weighing 17 kg each. Pigs produce sensible heat at the rate of 3.5 W/kg of body weight. The UA value for the building has been found to be 224 W/°C. Indoor conditions are to be kept at 18°C and 60% relative humidity. Heat losses from evaporation and gains from equipment are negligible. The heat balance ventilation rate to achieve a steady state without adding supplemental heat when the outdoor temperature is -20°C in m^3/min is most nearly:

(A) 106

(B) 94

(C) 78

(D) 30

Question 511. II.A. Environment: 1. Air quality requirements

Ventilation requirements for swine housing are designed to remove toxic gases from manure pits. The maximum hydrogen sulfide concentration for pig housing before pigs exhibit a fear of light, loss of appetite, and nervousness is most nearly:

(A) 1.2 mg/m^3

(B) 10 mg/m^3

(C) 24 mg/m^3

(D) 100 mg/m^3

Question 512. II.B. Structures: 2. Foundation design

A post is vertically loaded with 5,000 lb. It rests on a circular footing that is 14 inches thick. If the adjusted allowable vertical soil pressure is 1,000 lb/ft^2 and concrete has a density of 150 lb/ft^3, the footing has a diameter in inches most nearly:

(A) 30

(B) 33

(C) 36

(D) 39

Question 513. II.B. Structures: 4. Structural analysis of buildings

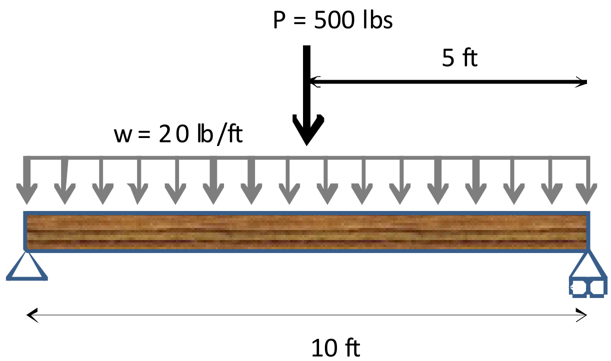
A 2 in. × 8 in. wooden beam is simply supported. There is a point load (P) of 500 lbs in the center of the 10 ft long beam and a uniformly distributed load (w) of 20 lbs/ft. The actual bending stress (f_b) at the center of the beam in psi is most nearly:

(A) 910

(B) 1,140

(C) 1,370

(D) 1,650



Question 514. II.B. Structures: 1. Construction materials

The most important factor influencing design (compressive) strength concrete is:

(A) temperature of water

(B) size of aggregate

(C) water to cement ratio

(D) mixing time

III. Machine Systems: Power, Electrical/Electronic, Machines, Controls, and Sensors

Question 515. III.A. Agricultural Machines: 1. Field and farmstead agricultural machines

An 8-shank chisel plow with 10-cm twisted shovels is pulled through a field at a typical speed of 8 km/h in medium-textured soil. Assuming a draft of 24.7 kN and a depth of 20 cm the drawbar power in kW to pull the implement is most nearly:

(A) 25

(B) 35

(C) 45

(D) 55

Question 516. III.A. Agricultural Machines: 2. Stability analysis

Consider a tractor having a 270-cm wheel base and static (no load) front and rear axle weights of 25 kN and 50 kN, respectively. This tractor has a hitch point 60 cm behind the rear axle and 50 cm above ground level. How much load, in kN, will be on the front axle if there is a rearward horizontal load on the hitch of 35 kN?

(A) 16

(B) 18

(C) 20

(D) 22

Question 517. III.B. Machine System Design: 1. Machine component design

If a $^{3}/_{4}$-inch diameter, grade 8 bolt is used as a hitch pin in double shear, what is the maximum permissible horizontal load in pounds if a shock factor of 3.0 is assumed for dynamic loading? Assume maximum shear stress theory and a tensile strength of 120,000 psi.

(A) 26,000

(B) 35,000

(C) 51,000

(D) 106,000

Question 518. III.B. Machine System Design: 2. Materials selection

The engineering stress in a solid member for an implement frame section part in tension during testing was found to be 43,000 lbf/in at failure. The cross-sectional area of the part was 5 in^2 before the test and necks down to 4.25 in^2 before breaking after the test. The true stress at failure was most nearly:

(A) 32,250 lbf/in^2

(B) 36,549 lbf/in^2

(C) 50,588 lbf/in^2

(D) 286,666 lbf/in^2

Question 519. III.B. Machine System Design: 4. Structural analysis of machines

Rollover protective structures for wheel-type agricultural tractors are designed to minimize the frequency and severity of injury from accidental upsets. Which of the following is **not** a testing requirement for rollover protective structures for wheel-type agricultural tractors?

(A) side impact test

(B) dynamic test

(C) crush test

(D) field upset test

Question 520. III.C. Power Systems: 1. Combustion and fuels

One consideration for use of other fuels is the emissions in the products of combustion. The atomic weight of carbon (C) is 12, of hydrogen (H) is 1, of oxygen (O) is 16, and of nitrogen (N) is 14. Air is assumed to contain 3.76 molecules of N_2 for every molecule of O_2. The combustion equation for ethanol (C_2H_6O) is:

$$C_2H_6O + 3O_2 + 11.28N_2 \rightarrow 2CO_2 + 3H_2O + 11.28N_2$$

Assuming stoichiometric combustion of ethanol the mass of nitrogen in the emissions per kJ of fuel heat energy (in kg of N/kJ) is most nearly:

(A) 0.00012

(B) 0.00018

(C) 0.00024

(D) 0.00030

Question 521. III.C. Power Systems: 3. Power requirement analysis

A sprayer manufacturer wants to produce a small sprayer for acreages. The sprayer will have a 200 L tank with recirculation nozzles inside the tank using some of the flow to keep the spray solution in the tank well mixed. The maximum flow rate is to be 76 L/min and the maximum pressure at the pump is to be 410 kPa. If the overall mechanical efficiency of the pump is expected to be 60%, the input power required to operate the pump will be most nearly:

(A) 0.3 kW

(B) 0.5 kW

(C) 0.9 kW

(D) 9.0 kW

Question 522. III.D Power Transmission Systems: 1. Hydraulic power circuits

A hydraulic cylinder with a bore diameter of 4.0 in. and a rod diameter of 2.0 in. has a 24 in. long stroke. The minimum flow rate in gallons per minute from the pump that will allow the cylinder to be cycled (extended and then retracted) continuously at a rate of 5 cycles in 4 minutes is most nearly:

(A) 3.3

(B) 2.9

(C) 1.6

(D) 0.4

Question 523. III.D. Power Transmission Systems: 2. Mechanical power transmission

The power to be transmitted to a component on a peanut digger with a two-sheave open belt drive is 7.0 kW. The service factor for the component is 1.3. The drive sheave has a pitch diameter of 4.65 in. and will operate at 1,850 rpm. The slack-side tension for the drive is 150 N. The tight-side tension (in N) on the drive is most nearly:

(A) 550

(B) 760

(C) 950

(D) 2,170

Question 524. III.D. Power Transmission Systems: 1. Hydraulic power circuits OR 2. Mechanical power transmission

A fluid power hydraulic system is being designed to move a cylinder at constant speed. The maximum operating pressure of the system is 1,200 psi and the maximum operating load on the cylinder is 14,500 lb, requiring a rod diameter of 1.75 in. When the cylinder is being extended against the resistive load, the maximum pressures in the cap and rod ends of the cylinder are 1,080 and 65 psi, respectively. Selecting from standard cylinder bore diameters, the required cylinder bore diameter in inches is:

(A) 6

(B) 5

(C) 4

(D) 3.25

IV. Natural Resource Engineering

Question 525. IV. A. Applications: 1. Environmental assessment techniques

The soil cone penetrometer is recommended as a measuring device to provide a standard uniform method of characterizing the penetration resistance of soils. The rate, in mm/s, at which the cone should be pushed into the soil is most nearly:

(A) 30

(B) 40

(C) 50

(D) 72

Question 526. IV. A. Applications: 2. Irrigation principles

Where are thrust blocks **not** required during the installation of PVC irrigation piping with rubber gasket joints?

(A) at pipe enlargements

(B) at pipe size reductions

(C) at "in-line" valves

(D) at the end of a pipeline

Question 527. IV. A. Applications: 3. Open-channel hydraulics

A 10 foot wide rectangular concrete channel (Manning's n = 0.01) is to be built to convey water. The design discharge is 100 cfs and flows at a velocity of 7.34 ft/sec. The slope in percent grade (%) of this channel is most nearly?

(A) 0.18

(B) 0.22

(C) 1.36

(D) 4.72

Question 528. IV. A. Applications: 4. Surface and subsurface drainage

A commercial grower in southeastern Virginia has hired your company to design and construct a drip irrigation system for one of their 250-acre fruit tree orchards. The orchard has a slope of 1% and the trees are spaced every 25 feet, on-center. What is an acceptable design emission (emitter) uniformity percentage for the designed system?

(A) 78

(B) 81

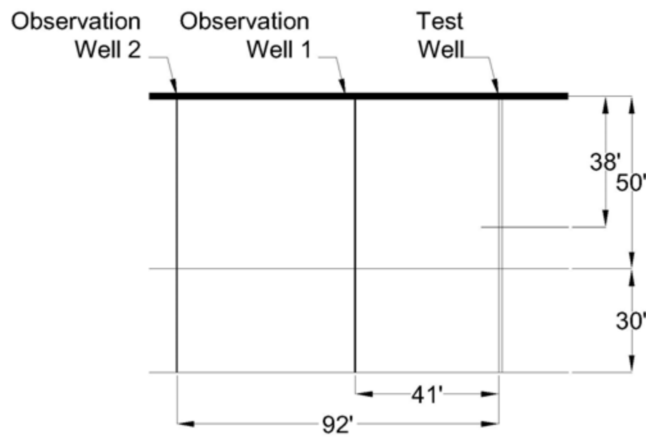
(C) 86

(D) 91

Question 529. IV. B. Fundamentals: 1. Hydrology

A 1-ft diameter test well is constructed into the confined aquifer shown below in the figure. The aquifer has a uniform thickness at 30 ft overlaid by an impermeable layer 50 ft deep. The initial piezometric surface is 38 ft below the ground surface datum of the test well and observation wells. After water was pumped for several days (from the test well) at 0.3 ft^3/s, the water levels stabilized at the following drawdowns:

Test Well	24 ft
Observation Well 1	16.1 ft
Observation Well 2	9.2 ft



The permeability (ft/s) of the aquifer is most nearly:

(A) 1.9×10^{-4}

(B) 3.7×10^{-4}

(C) 5.9×10^{-4}

(D) 1.1×10^{-2}

Question 530. IV. B. Fundamentals: 2. Soil mechanics principles

Using the Unified Soil Classification System, what group symbol is given to a soil with the following description?

- plasticity index of 15
- liquid limit of 43
- 60% of the soil passes the #200 sieve
- minimal organic matter

(A) ML

(B) CH

(C) CL

(D) SC

Question 531. IV.B. Fundamentals: 4. Soil-water relationships

Determine the saturated water content (%) of the soil described below, which is to be compacted to 95% of maximum standard proctor density. It is most nearly:

- standard Proctor maximum dry density: 101 pcf
- optimum water content: 19%
- in situ water content 21%
- coefficient of permeability: 1×10^{-6} cm/s
- specific gravity of soil solids: 2.70

(A) 18

(B) 20

(C) 25

(D) 28

Question 532. IV. C. Interactions among Natural Resources: 1. Ecological processes

Vertical transport of pathogens, out of the root zone, from surface application of manures depends mostly on:

(A) the amount of macro pores and micro pores in the soil matrix

(B) the amount of microorganisms in the manure

(C) the size of the microorganisms

(D) the cation exchange capacity of the soil

Question 533. IV. C. Interactions among Natural Resources: 2. Erosion control and slope stabilization

An open channel is being designed using the tractive force method. The straight channel is to be lined with 50 mm gravel (on a 2% slope). The critical shear in Pascals is most nearly?

(A) 16

(B) 32

(C) 64

(D) 96

Question 534. IV. C. Interactions among Natural Resources: 3. Nutrient management/loading rates in soils

The amount of nitrogen, in pounds/ac, that a ten ton per acre hay crop (total dry harvested weight) of Bermudagrass removes is most nearly:

(A) 50

(B) 200

(C) 250

(D) 350

Question 535. IV. C. Interactions among Natural Resources: 4. Sediment processes

The horizontal interval (HI) in meters for conservation terraces on 5% land in northern Iowa given Y = 0.9 is most nearly?

(A) 2

(B) 10

(C) 20

(D) 40

Question 536. IV. C. Interactions among Natural Resources: 3. Nutrient management/loading rates in soils

A manure storage pond is planned for a dairy herd. What runoff from the pond's drainage area and precipitation event on the surface of the pond is the minimum required based on ASABE standards?

(A) 25-year 12-hour storm

(B) 10-year 24-hour storm

(C) 25-year 24-hour storm

(D) 50-year 24-hour storm

V. Process Engineering: Food, Feed, Fiber, and Fuel Products

Question 537. V. B. Energy Sources

The level full storage capacity (bu) of an 18-ft diameter hopper bin with a 60 degree sloped hopper (measured from horizontal), a 20 degree roof (peak), and an eave height of 20 ft is most nearly:

(A) 4,100
(B) 5,100
(C) 5,400
(D) 6,400

Question 538. V. C. Mass Transfer between Phases

Water-soluble vitamins begin to leach from fish food pellets upon contact with pond water. The level of pantothenic acid (vitamin B_5) in pellets is estimated to be reduced at a rate of 40% for every 30 seconds in pond water. Assuming initial pantothenic acid level is 80 mg/kg dry food, the maximum time allowable (seconds) between spreading pellets upon the pond surface and consumption by fish before pantothenic acid level drops below 18 mg/kg dry food is most nearly:

(A) 2.9
(B) 49
(C) 88
(D) 130

Question 539. V. D. Materials Properties: 2. Bulk Solids Characterization

A building with an 8-foot high wall is storing grain. Grain was placed into the storage building and leveled until it was within 6 inches of the top of the wall. Assuming grain bulk density is 56 lb_m/bu, the lateral force per unit length (lb_f/ft) at the base of the wall is most nearly:

(A) 1,270
(B) 790
(C) 720
(D) 630

Question 540. V. D. Materials Properties: 1. Biological materials

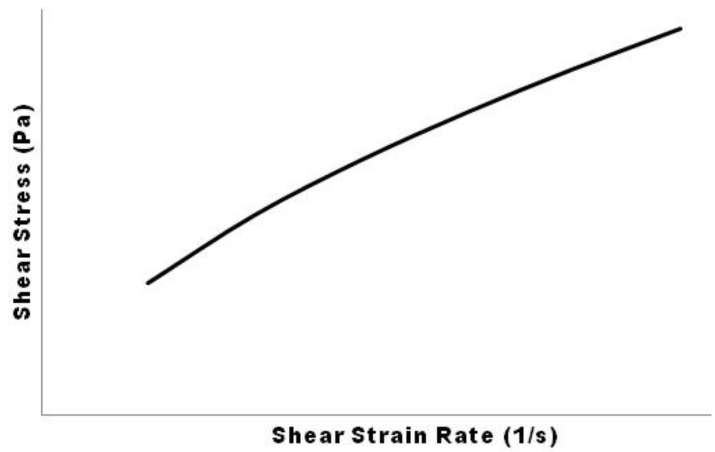
Swine manure with 13% total solids at 25°C has a density of 1,045 kg/m^3, a consistency coefficient of 3.9 $Pa{\cdot}s^n$, a flow behavior index of 0.6, and no yield stress. Assuming the properties described above and shear stresses observed over the range of shear strain rates depicted in the figure, which term below best describes the rheological behavior of the manure?

(A) Newtonian

(B) Bingham

(C) Pseudoplastic

(D) Dilatant



Practice Examination, Afternoon Session *Answers*

I. Engineering Principles and Professional Practices

Question 501. Correct answer (B)

Reference: *Off-Road Vehicles Engineering Principles,* Chapter 10 Electrical and electronic systems, by Goering, Stone, Smith, and Turnquist

Recognize P = VI and conductor cross-sectional area = $(\pi \times D^2)/4$, therefore

$$I = \frac{P}{V} = \frac{6000\ \mathrm{W}}{24\ \mathrm{V}} = 250\ \mathrm{A}$$

$$\text{Area} = \frac{250\mathrm{A}}{13.82 \dfrac{\mathrm{A}}{\mathrm{mm}^2}} = \frac{\pi \times D^2}{4} = 18.09\ \mathrm{mm}^2$$

$$D = \sqrt{\frac{18.09\,\mathrm{mm}^2 \times 4}{\pi}} = 4.8\ \mathrm{mm}^2$$

which means that the minimum diameter of AWG copper cable that would be appropriate is 4 AWG with a diameter of 5.19 mm.

Common mistakes:

(A) calculated radius value instead of diameter value

(C) failed to take square root of radius

(D) used 12 V instead of 24 V

Question 502. Correct answer (C)

Reference: *Sensors and Actuators: Control System Instrumentation* by De Silva (note: this reference or a similar reference on instrumentation is likely to be added to the approved reference list; problem is solvable with most instrumentation texts)

Recognize $f = 60$ Hz since frequencies at and below are to be blocked and $f_c = 2{,}000$ Hz, so that

$$\left|\frac{V_{out}}{V_{in}}\right| = \frac{\left(\dfrac{f}{f_c}\right)}{\sqrt{1+\left(\dfrac{f}{f_c}\right)^2}} = \frac{\left(\dfrac{60}{2000}\right)}{\sqrt{1+\left(\dfrac{60}{2000}\right)^2}} = 0.02999 \text{ or } 3.0\%$$

Common mistakes:

(A) used f = 2 instead of $f = 60$

(B) solution off by a factor of 10

(D) used f = 2 instead of f = 60 and $f_c = 60$ instead of $f_c = 2{,}000$

Question 503. Correct answer (D)

Reference: ASABE Standard S441.3 Safety signs, Section 7, Mechanical-entanglement hazards

Common mistakes:

(A) arms and upper torso entangled in spreader beater

(B) fingers and hand entangled in rotating gears

(C) arms entangled in rotating gears

Question 504. Correct answer (C)

Reference: *Engineering Economic Analysis,* 10th ed., by Newnan et al.

Annual operating costs		
Fuel	2.28 million Btu/hr × $3.80/million Btu × 5,000 hr/yr =	$43,320
Labor	4 opr × $14/hr/opr × 5,000 hr/yr =	$280,000
Electricity	$0.70/hr × 5,000 hr/yr =	$3,500
Maintenance	$1.50/hr × 5,000 hr/yr =	$7,500
	Total Annual Operating Costs	$334,320

Annual capital costs:

(Initial Cost - Salvage Value) ÷ Years of Useful Life = Annual Capital Costs

or ($900,000 - $100,000) ÷ 5 years = $160,000

Total annual costs:

Annual Operating Costs + Annual Capital Costs = Total Annual Costs

or $334,320 + $160,000 = $494,320

Price per unit:

$$\frac{\text{Total}\,\frac{\text{costs}}{\text{year}}}{\frac{\text{units}}{\text{year}}} = \frac{\frac{\$494{,}320}{\text{year}}}{200\,\frac{\text{units}}{\text{hr}} \times 5000\,\frac{\text{hr}}{\text{year}}} = \frac{\$0.49432}{\text{unit}}$$

Common mistakes:

(A) price based on only capital costs

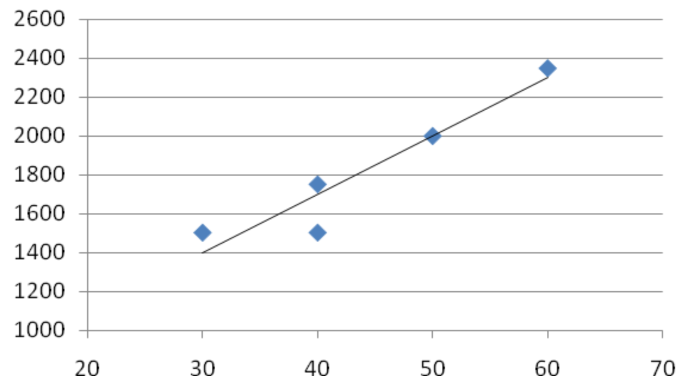
(B) price based on only operating costs

(D) failed to divide difference between initial cost and salvage value by 5 years

Question 505. Correct answer (B)

Reference: Your favorite statistics book

A solution can be arrived at through several ways but two typical ways may include roughing out a plot as depicted below and eyeballing the number of hours at 55 units (i.e., the three-month average) or plugging the *units assembled* and *time expended* data into the linear regression program in one of the NCEES-allowed calculators.



Using the rough plot, a value slightly less than 2,200 hours/month is found or for three months, the time expended would be near 6,600 hours. From regression, an equation of $y = 30x + 500$ would calculate 2,150 hours/month or 6,450 hours for three months. Average of these extreme values (6,600 and 6,450 hours) is 6,525 hours.

Common mistakes:

(A) hours based on 5-mon hours/unit ave × 55 units/month ave × 3 months

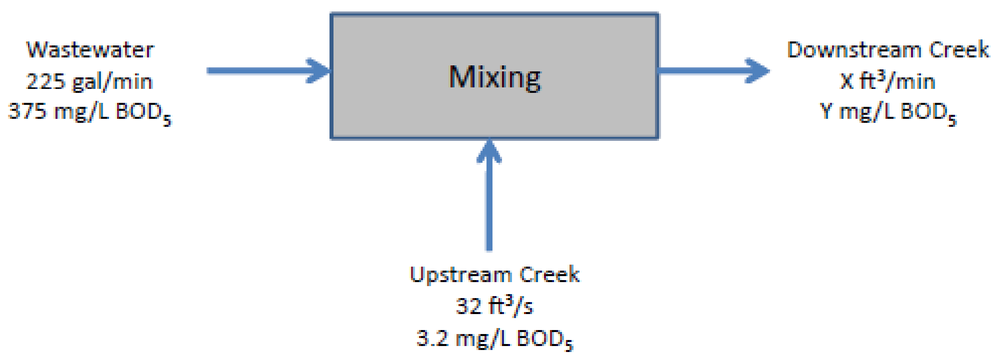
(C) hours based on 5-mon hours/month ave × 3 months

(D) failing to multiply regressed hours/month by 3 months

Question 506. Correct answer (A)

Reference: Your favorite book covering thermodynamic principles

Recognize *mass in* = *mass out* but no need to convert volume to mass since density of all flows is essentially the same (i.e., all are dilute water where $\rho \approx 62.4\ lb_m/ft^3$).



Total mass (volume) balance

$$(225\ \text{gal/min} \div 7.481\ \text{gal/ft}^3) + (32\ \text{ft}^3/\text{s} \times 60\ \text{s/min}) = X$$
$$X = 30 + 1{,}920 = 1{,}950\ \text{ft}^3/\text{min}$$

BOD_5 mass balance

$$[(375\ \text{mg/L} \times 30\ \text{ft}^3/\text{min}) + (3.2\ \text{mg/L} \times 1{,}920\ \text{ft}^3/\text{min}) = (X \times Y)] \times 28.316\ \text{L/ft}^3$$
$$Y = (11{,}280 + 6{,}144) \div 1{,}950 = 8.9\ \text{mg/L}$$

Common mistakes:

(B) failing to convert gallons to cubic feet

(C) failing to convert seconds to minutes

(D) adding given upstream and wastewater BOD_5 levels together

Question 507. Correct answer (A)

Reference: *Principles of Process Engineering* by Henderson, Perry, and Young

Recognize that a mechanical energy balance based on the *Bernoulli Equation* (see below) will estimate theoretical energy (*EP*) that can be used to calculate actual motor horsepower.

$$E_p = \frac{g(z_2 - z_1)}{g_c} + \frac{(u_2^2 - u_1^2)}{2 \propto g_c} + \frac{(P_2 - P_1)}{\rho} + \frac{\Delta P_f}{\rho}$$

Assumptions and parameters to use include:

$P_2 = P_1$, $u_2 = u_1$ $\quad$ $z_2 - z_1 = 15$ ft $\quad$ $g = 32.2$ ft/s^2 $\quad$ $g_c = 32.2$ lb$_m$·ft/lb$_f$·s^2

Therefore,

$$E_p = \frac{g(z_2 - z_1)}{g_c} + f\frac{L}{D}\frac{2u^2}{g_c}$$

$$u = \frac{\frac{80\text{gal}}{\text{min}} \times \frac{1\text{ft}^3}{7.481\text{gal}} \times \frac{1\text{min}}{60\text{s}}}{\frac{\pi \times \left(\frac{2.5\text{in}}{12\frac{\text{in}}{\text{ft}}}\right)^2}{4}} = 5.23\frac{\text{ft}}{\text{sec}}$$

From Moody's Chart, Fanning friction factor (f) ≈ 0.0045

$$P = \frac{\left(18.35\frac{\text{ft} \cdot \text{lb}_f}{\text{lb}_m}\right)\left(\frac{80\text{gal}}{\text{min}} \times \frac{1\text{ft}^3}{7.481\text{gal}} \times \frac{62.4\text{lb}_m}{\text{ft}^3} \times \frac{1\text{min}}{60\text{s}}\right)}{(0.6)(0.9)} \times \frac{1\text{ hp}}{550\frac{\text{ft} \cdot \text{lb}_f}{\text{s}}} = 0.7\text{ hp}$$

Common mistakes:

(B) ignored efficiencies

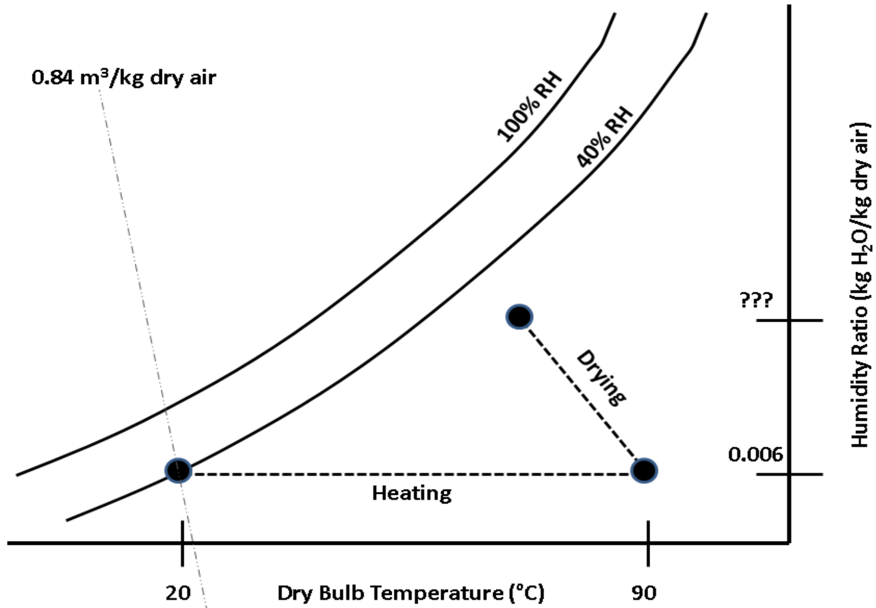
(C) ignored efficiencies and straight-pipe friction losses

(D) failed to multiply actual energy input by mass flow rate

Question 508. Correct answer (C)

Reference: *Principles of Process Engineering* by Henderson, Perry, and Young or *Transport Processes and Separation Process Principles* by Geankoplis

Recognize that entering air has an initial humidity ratio (i.e., dry basis moisture content) which will increase as water is added from the drying mushrooms as the air passes through the dryer. The initial humidity ratio (0.006 kg water/kg dry air) and specific volume (0.84 m^3/kg dry air) of the air can be found using a psychrometric chart as depicted below.



Moisture is coming off the mushrooms at a rate of 86.2 kg water/min and mixing with air moving at a rate of

$$[(50\ m^3/sec \times 60\ sec/min) \div 0.84\ m^3/kg\ dry\ air] = 3{,}571\ kg\ dry\ air/min.$$

$$0.006 \frac{kg\,water}{kg\,dry\,air} + \frac{86.2 \frac{kg\,water}{min}}{3571 \frac{kg\,dry\,air}{min}} = 0.030 \frac{kg\,water}{kg\,dry\,air}$$

Common mistakes:

(A) initial absolute humidity value by itself

(B) added absolute humidity value by itself

(D) multiplied by specific volume instead of dividing by specific volume

II. Facility Engineering: Plant, Animal, and Commodity Environments and Structures

Question 509. Correct answer (D)

Reference: ASABE Standard D384

From Table 1.b, manure production is 0.18 ft^3/sow-day

$$\text{Total manure} = 0.18\ ft^3/\text{sow-day} \times 600\ \text{sows} \times 365\ \text{days} = 39{,}420\ ft^3$$

$$\text{Wasted water} = 10\% \times 39{,}420\ ft^3 = 3{,}942\ ft^3$$

$$\text{Washwater} = 0.1\ \text{gal/sow-day} \times 600\ \text{sows} \times 365\ \text{days} \times 0.13368\ ft^3/\text{gal} = 2{,}928\ ft^3$$

$$\text{Total volume} = 39{,}420 + 3{,}942 + 2{,}928 = 46{,}290\ ft^3$$

$$\text{Depth of liquid} = 46{,}290\ ft^3 / (60\ ft \times 220\ ft) = 3.5\ ft$$

$$\text{Depth of pit} = 3.5\ ft + \text{freeboard} = 5\ ft$$

Question 510. Correct answer (C)

Reference: ASABE Standard EP270.5

$$Q_S + Q_E + Q_{supp} = Q_M + Q_B + Q_V + Q_{stored} \quad \text{(equation 3.3.1-1)}$$

$Q_E = 0$ due to neglecting equipment gains

$Q_{supp} = 0$ no supplemental heat added

$Q_M = 0$ due to neglecting evaporation

$Q_{stored} = 0$ due to steady state

becomes $Q_S = Q_B + Q_V$

Q_S = No. of animals × wt × sensible heat = 1,000 pigs × 17 kg/pig × 3.5 W/kg = 59,500 W

$Q_B = UA\,\Delta T$ = 224 W/°C × (18°C – (-20°C)) = 8,512 W

$Q_V = Q_S – Q_B$ = 59,500 – 8,512 = 50,988 W

$Q_V = M\, c_p\, \Delta T$

M = 50,988 W / (1,005 J/kg °K × (18°C – (-20°C))) = 1.3 kg/s

$q_v = M\, \nu\, 60$

From psychrometric chart: ν = 1.00 m^3/kg at 18°C and 60%

q_v = 1.3 kg/s × 1.00 m^3/kg × 60 s / minute = 78 m^3/min

Question 511. Correct answer (C)

Reference: ASABE Standard EP270.5, Section 6.1.4.3.

Question 512. Correct answer (B)

Reference: ASABE Standard EP486

First approximation:

A = P/S = 5,000 lb/1,000 lb/ft^2 = 5 ft^2

Account for footing weight:

use 5.5 ft^2 as a guess

weight of footer = 5.5 ft^2 × 14 in/12 in/ft × 150 lb/ft^3 = 962 lbs

A = (5,000 lbs + 962 lbs)/1,000 lb/ft^2 = 5.96 ft^2

Adjust footing estimate:

weight of footer = 6 ft^2 × 14 in/12 in/ft × 150 lb/ft^3 = 1,050 lbs

A = (5,000 lbs + 1,050 lbs)/1,000 lb/ft^2 = 6.05 ft^2

Convert to circular area:

diameter = $(4 \times 6.05\ ft^2 /3.14)^{0.5}$ = 2.77 ft = 33 in.

Question 513. Correct answer (C)

References: *Design of Wood Structures—ASD/LRFD,* by Breyer et al.

$M_{max,p}$ = PL/4 for point load, at center = 500 lbs × 10 ft /4 = 1,250 ft lbs = 15,000 in. lbs

$M_{max,w} = wL^2/8$ for distributed load, at center = 20 lbs/ft × (10 ft)^2/8 = 250 ft lbs = 3,000 in. lbs

Combining by superposition:

$$M_{max} = 15{,}000 + 3{,}000 = 18{,}000 \text{ inch lbs}$$

$$S \text{ for 2 in.} \times \text{8 in. lumber} = 13.14 \text{ in}^3$$

$$f_b = M_{max}/S = 18{,}000 \text{ in. lbs}/13.14 \text{ in}^3 = 1{,}370 \text{ psi}$$

Question 514. Correct answer (C)

Many factors affect concrete strength but w:c ratio is by far the most important.

III. Machine Systems: Power, Electrical/Electronic, Machines, Controls, and Sensors

Question 515. Correct answer (D)

Reference: ASABE Standard EP 496.3 Agricultural machinery management

Section 4.1.1.3, $P_{db} = Ds/3.6$

$$P_{db} = 24.7 \times 8/3.6 = 55 \text{ kW}$$

Question 516. Correct answer (B)

From no-load condition: $X_{cg} = 270(25)/75 = 90$ cm

Loaded condition (sum moments around rear axle contact point):

$$F_{db}(Y_{db}) = Wt(X_{cg}) - F_f(WB)$$

$$F_f = [(Wt)(X_{cg}) - F_{db}(Y_{db})]/WB$$

$$F_f = [75(90) - 35(50)]/270 = 18.5 \text{ kN}$$

Question 517. Correct answer (C)

Reference: *Machine Design for Mobile and Industrial Equipment*

Load strength is 120,000 psi (tensile); assuming max shear stress theory, proof shear strength would be 60,000 psi ($\tau_y = 60{,}000$ psi).

$$\tau = F/A$$

$$60{,}000 = F/(\pi d^2/4)$$

$$F = 26{,}000 \text{ lb}$$

In double shear, $F \times 2 = 53{,}000$ lb

Question 518. Correct answer (C)

Reference: Civil Engineering reference manual

Reduction in area: $1 - 4.25/5 = 0.15$

$$\sigma = s / 1 - \text{reduction in area}$$

$$\sigma = 43{,}000 / 1 - 0.15 = 50{,}588 \text{ lbf/in}^2$$

Also: $43{,}000 \times 5/4.25 = 50{,}588 \text{ lbf/in}^2$

Common mistakes:

(A) used improper equation: $43{,}000 \times 1/0.75 = 32{,}250 \text{ lbf/in}^2$

(B) used improper equation: $43{,}000/5 - 4.25 = 36{,}549 \text{ lbf/in}^2$

(D) improper reduction of area calculation yields 286,666 lbf/in^2

Question 519. Correct answer (D)

Reference: ASABE Standard 383.1, SAE J1194.

Section 6.4.1.1 states that the field upset test may be omitted if the static or dynamic results indicate compliance at an energy application of 115% or more of the requirements defined in 6.1.2 or 6.2.2 and the ROPS meet the temperature-material requirements.

Question 520. Correct answer (C)

Reference: *Engine and Tractor Power,* 4th ed., by Goering and Hansen.

Balancing the combustion equation:

$$C_2H_6O + 3O_2 + 11.28N_2 \rightarrow 2CO_2 + 3H_2O + 11.28N_2$$

Molecular weight of ethanol consumed = 2(12) + 6(1) + 1(16) = 46 g/mole

Molecular weight of the nitrogen produced = (11.28)2(14) = 315.84 g/mole

From Table 6.6, p. 135, the high heat value (HHV) for ethanol is given as 29,700 kJ/kg.

Calculating the mass of nitrogen per kJ of heat energy:

$$\left(\frac{315.84 \text{ kg } N_2}{46 \text{ kg ethanol}}\right) \cdot \left(\frac{\text{kg ethanol}}{29{,}700 \text{ kJ}}\right) = 0.000231 \frac{\text{kg } N_2}{\text{kJ from ethanol}}$$

Question 521. Correct answer (C)

Reference: *Engineering Principles of Agricultural Machines* by Srivastava, Goering, and Rohrbach, pp. 284-289.

Equation 7.1, p. 288:

$$\text{Pwr} = \frac{Q \cdot P}{\left(60{,}000 \dfrac{L \cdot kPa}{min \cdot kW}\right)\eta_m}$$

Pwr = input power to the pump, kW

Q = flow rate from the pump, L/min

P = pressure at the pump, kPa

η_m = overall mechanical efficiency of the pump, decimal

$$\text{Pwr} = (76 \text{ L/min})(410 \text{ kPa})/(60{,}000 \text{ L·kPa/(min·kW)})(0.60) = 0.866 \text{ kW}$$

Question 505. Correct answer (B)

Reference: *Engineering Principles of Agricultural Machines* by Srivastava, Goering, and Rohrbach, pp. 96-107.

Volume of fluid pump must deliver to cap end of cylinder to extend cylinder:

$$V_{ext.} = \frac{\pi}{4}B^2L = \frac{\pi}{4}(4.0\text{ in})^2 24\text{ in} = 301.6\frac{\text{in}^3}{\text{extension}}$$

Volume of fluid pump must deliver to rod end of cylinder to retract cylinder:

$$V_{retr.} = \frac{\pi}{4}\left(B^2 - d_r^2\right)L = \frac{\pi}{4}\left[(4.0\text{ in})^2 - (2.0\text{ in})^2\right]24\text{ in} = 226.2\frac{\text{in}^3}{\text{retraction}}$$

Total volume of fluid pump must deliver to circuit to cycle the cylinder:

$$V_{cycle} = V_{ext.} + V_{retr.} = 301.6\frac{\text{in}^3}{\text{extension}} + 226.2\frac{\text{in}^3}{\text{retraction}} = 527.8\frac{\text{in}^3}{\text{cycle}}$$

Required minimum pump flow rate:

$$Q_{pump} = \frac{5\text{ cycles}}{4\text{ min}}V_{cycle} = \frac{5\text{ cycles}}{4\text{ min}}\left(527.8\frac{\text{in}^3}{\text{cycle}}\right)\frac{1\text{ gal}}{231\text{ in}^3} = 2.86\frac{\text{gal}}{\text{min}}$$

Question 523. Correct answer (C)

Reference: *Engineering Principles of Agricultural Machines* by Srivastava, Goering, and Rohrbach, pp. 64-65.

Calculating the sheave radius: $r = \frac{d}{2} = \left(\frac{4.65\text{ in}}{2}\right)\left(\frac{2.54\text{ cm}}{\text{in}}\right)\left(\frac{\text{m}}{100\text{ cm}}\right) = 0.05906\text{ m}$

Calculating the sheave speed: $\omega = \left(1{,}850\frac{\text{rev}}{\text{min}}\right)\left(2\pi\frac{\text{rad}}{\text{rev}}\right)\left(\frac{\text{min}}{60\text{ s}}\right) = 193.7\frac{\text{rad}}{\text{s}}$

Calculating the belt speed: $v = r\omega = (0.05906\text{ m})\left(193.7\frac{\text{rad}}{\text{s}}\right) = 11.44\frac{\text{m}}{\text{s}}$

Calculating the design power: $P_d = P(\text{S.F.}) = (7.0\text{ kW})(1.3)\left(\frac{1000\text{ W}}{\text{kW}}\right) = 9{,}100\text{ W}$

Formula for belt power: $P = (T_1 - T_2)v$

Solving for the belt tight-side tension: $T_1 = \frac{P}{v} + T_2 = \left(\frac{9100\text{ W}}{11.44\text{m/s}}\right)\left(\frac{\text{N}\cdot\text{m}}{\text{s}\cdot\text{W}}\right) + 150\text{ N} = 945.5\text{ N}$

Question 524. Correct answer (B)

Reference: *Engineering Principles of Agricultural Machines* by Srivastava, Goering, and Rohrbach, p. 97.

The area at the rod end of the cylinder with a rod diameter of 1.75 in:

$$A_{rod\ end} = A_{cap} - A_{rod}$$

$$A_{rod} = \frac{\pi}{4} d_r^2 = \frac{\pi}{4}(1.75 in)^2 = 2.405 in^2$$

Using a force balance on the cylinder:

$$P_{cap} A_{cap} - F_{load} - P_{rod} A_{rod\ end} = 0$$

Working through the algebra: $P_{cap} A_{cap} - F_{load} - P_{rod} (A_{cap} - A_{rod}) = 0$

$$(P_{cap} - P_{rod}) A_{cap} = F_{load} - P_{rod} A_{rod} \quad \text{so} \quad A_{cap} = \frac{F_{load} - P_{rod} A_{rod}}{(P_{cap} - P_{rod})} = \frac{\pi}{4} B^2$$

$$B = \sqrt{\left(\frac{4}{\pi}\right) \frac{F_{load} - P_{rod} A_{rod}}{(P_{cap} - P_{rod})}} = \sqrt{\left(\frac{4}{\pi}\right) \frac{14{,}500\ lb - (65\ psi)(2.405\ in^2)}{(1080\ psi - 65\ psi)}} = 4.242\ in$$

As this is the minimum diameter, the next larger bore diameter, 5 in. (answer B), must be selected.

IV. Natural Resource Engineering

Question 525. Correct answer (A)

Reference: ASABE Standard EP542, Section 5.1

Common mistakes:

(B) fill the spread within the range

(C) manual readings should be made at depth increments of 50 mm

(D) 30 mm/s approximately 72 in./min

Question 526. Correct answer (A)

Reference: ASAE Standard S376.2

Thrust blocks are required at the following locations.

8.4.1.1 Where the pipe changes the direction of the water (i.e., ties, elbows, crosses, wyes and tees).

8.4.1.2 Where the pipe size changes (i.e., reducers, reducing tees and crosses).

8.4.1.3 At the end of the pipeline (i.e., caps and plugs).

8.4.1.4 Where there is an in-line valve.

Question 527. Correct answer (B)

Reference: *Engineering Field Handbook,* chapter 3, eq. 3-15

$$V = 1.486 / n r^{2/3} S^{1/2}$$

$$A = Q/V = 100 / 7.34 = 13.6 \text{ sq ft}$$

$$Dm = A/T = 13.6 / 10 = 1.36 \text{ ft}$$

$$r = A/WP = 13.6 / (1.36 + 10 + 1.36) = 1.07 \text{ sq ft / ft}$$

$$S = [Vn / (1.486\, r^{2/3})]^2$$

$$S = [7.34 \times 0.01 / (1.486 \times 1.07^{2/3})]^2 = 0.0022 \text{ or } 0.22\%$$

Common mistakes:

(A) solved for critical depth

$S_c = 14.56 \times n^2 \times D_m / (r^{4/3})$

$S_c = 14.56 \times 0.01^2 \times 1.36 / (1.07^{4/3})$

(C) used flow depth

(D) forgot S was square root

$S = [V \times n / (1.486 \times r^{2/3})]$

$S = 7.34 \times 0.01 / (1.486 \times 1.07^{2/3}) = 0.0472$ or 4.72%

Question 528. Correct answer (D)

Reference: ASAE Standard EP405.1

Required knowledge: Orchard drip irrigation is point source, not line source, with emitters spacing approximately equal to the given tree spacing, therefore use Table 2 of the referenced ASAE standard. Using point source on perennial crops; (emitter) spacing >4 m (13.1 ft.); (field) slope of <2% (given), yields a recommended design emission (emitter) uniformity in the range of 90 to 95 percent. Choice (D) is the only value within this range.

Question 529. Correct answer (A)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 259, eq 11.2

$$K = \frac{Q}{2\prod b(h2 - h1)} \ln\frac{r2}{r1}$$

Datum:

$h0 = 80 - 38 = 42$ ft

$hw = 42 - 24 = 18$ ft

$h1 = 42 - 16.1 = 25.9$ ft

$h2 = 42 - 9.2 = 32.8$ ft

$$K = \frac{0.3\text{cfs}}{2\prod(30\text{ft})(32.8 - 25.9)} \ln\left(\frac{92}{41}\right)$$

$K = 1.86 \times 10^{-4}$ ft/s

Common mistakes:

(B) 0.000372845, forgot 2

(C) 0.000585664, forgot pi

(D) 0.011185361, used unconfined equation 11.1

Question 530. Correct answer (C)

Reference: *Engineering Field Handbook,* Chapter 4 (Soils), pp. 9, 10, 14

Common mistakes: A, B, and D result from incorrectly reading the chart.

Question 531. Correct answer (D)

Reference: *Engineering Field Handbook,* Chapter 4, page 4-7

$$W_{sat},\% = \left(\frac{\gamma_{water}}{\gamma d} - \frac{1}{G_s}\right)(100) \Rightarrow W_{sat},\% = \left(\frac{62.4}{0.95(101)} - \frac{1}{2.70}\right)(100) = 28\%$$

Common mistakes:

(A) (0.95)19 = 18.05%

(B) used 0.95 of 21% = 20%

(C) did not use 95% of the maximum standard proctor density; used 101 pcf in the denominator instead of 0.95(101)

Question 532. Correct answer (A)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 80, and other soils science textbooks. Physical transport of pathogens in soils is a function of the macro pores in the soil transported by water.

Common mistakes:

(B) the amount of microorganisms in the manure has no impact on their mobility

(C) the size of the microorganisms has no impact

(D) the cation exchange capacity is an irrelevant factor

Question 533. Correct answer (B)

Reference: *Soil and Water Conservation Engineering* by Fangmeier, p. 119

Common mistakes:

(A) read 25 mm diameter shear

(C) doubled correct critical shear

(D) read 150 mm diameter shear

Question 534. Correct answer (D)

Reference: *National Engineering Handbook. Part 651, Agricultural Waste Management Field Handbook*, Chapter 6, Table 6-6

$$10 \text{ tons} \times (2{,}000 \text{ lbs/ton}) \times 0.0188 = 376 \text{ lbs/ac}$$

Common mistakes:

(A) used the % dry weight of P at 0.19 instead of 1.88 for N

$$10 \text{ tons} \times (2{,}000 \text{ lbs/ton}) \times 0.0019 = 38 \text{ lbs/ac}$$

(B) Used the % dry weight N = 1.0 % for Indiangrass

$$10 \text{ tons} \times (2{,}000 \text{ lbs/ton}) \times 0.01 = 200 \text{ lbs/ac}$$

(C) Used the % dry weight N = 1.25 % for Guineagrass

$$10 \text{ tons} \times (2{,}000 \text{ lbs/ton}) \times 0.0125 = 250 \text{ lbs/ac}$$

Question 535. Correct answer (D)

Reference: ASABE Standard S268.4, Section 3.1.1.3, or *Soil and Water Conservation Engineering* by Fangmeier, p. 167

$$HI = VI / S = [(5 \times 0.21) + 0.9]/0.05 = 39 \text{ M}$$

Common mistakes:

(A) did not convert VI to HI; $HI = VI / S = (5 \times 0.21)+0.9 = 1.95$ M

(B) $HI = VI / S = [(5 \times 0.21) + 0.9] \times 5 = 10$ M

(C) forgot to use Y factor; $HI = VI / S = (5 \times 0.21)/0.05 = 21$ M

Question 536. Correct answer (C)

Reference: ASABE Standard EP393

Common mistakes:

(A) used 12-hour instead of 24-hour precipitation

(B) used precipitation commonly for sizing farm culverts

(D) precipitation event sometimes used to design conservation engineering practices that impound water

V. Process Engineering: Food, Feed, Fiber, and Fuel Products

Question 537. Correct answer (B)

Reference: ASABE Standard S413.1 Procedure for establishing volumetric capacities of cylindrical grain bins

Volume can be estimated using the equation given in Section 3.5.1 of the Standard for level full (no peaking of grain occurs so $\varphi = 0$) storage capacity for a hopper bottom bin:

$$V = \left(\frac{\prod D^2}{4}\right)(EH) + \left(\frac{\prod D^2}{4}\right)\left(\frac{(D/2)\tan\phi}{3}\right) + \left(\frac{\prod D^2}{4}\right)\left(\frac{(D/2)\tan\delta}{3}\right)$$

$$V = \left(\frac{\prod 18^2}{4}\right)(20) + 0 + \left(\frac{\prod 18^2}{4}\right)\left(\frac{(18/2)\tan 60}{3}\right)$$

$$V = 6{,}408\ ft^3$$

$$V = 6{,}408\ ft^3/(1.244\ ft^3/bu) = 5{,}151\ bu$$

Common mistakes:

(A) volume based on only cylindrical portion of bin

(C) volume based on using 20° instead of 60° and failing to convert ft^3 to bu

(D) failed to convert volume from ft^3 to bu

Question 538. Correct answer (C)

Reference: *Transport Processes and Separation Process Principles* by Geankoplis

Leaching of water-soluble vitamins into water as presented is recognized as a first-order decay/destruction/loss reaction and that each unit time period is 30 s in length. Therefore, k and allowable time can be determined using:

$$\ln\frac{C_o}{C} = kt$$

where C_0 is initial concentration, C is concentration at t, t is time period and k is reaction velocity constant.

Calculating k at t = 1 30-s period with C_0 = 80 mg/kg dry food and C = 48 mg/kg dry food (i.e., 100% - 40% or 60% of 80 mg/kg dry food after one time period).

$$k = \frac{\ln\frac{80}{48}}{1} = 0.511\ \text{time period}^{-1}$$

$$t = \frac{\ln\frac{80}{18}}{0.511} = 2.92\ \text{time periods}$$

allowable time = 2.92 time periods × (30 s/time period) = 88 s

Common mistakes:

(A) failed to convert number of 30-s time periods to allowable time

(B) allowable time based on 60% rather than 40%

(D) allowable time based on dividing 80 by 18 for 4.44 time periods and then multiplying by 30 s/time period

Question 539. Correct answer (D)

Reference: ASABE Standard EP545 Loads exerted by free-flowing grain on shallow storage structures

Using Eq. 6 from Section 5.9.1 and recognizing $\beta = 0$,

$$P_H = L(H)\left(\frac{H}{2}\right) = L(z)\left(\frac{H}{2}\right) = kV(z)\left(\frac{H}{2}\right) = kWG(z)\left(\frac{H}{2}\right)$$

where $k = 0.5$ = lateral-to-pressure ratio, $W = 56$ lb_m/bu, $H = 8$ ft – 0.5 ft = 7.5 ft, and $z = 7.5$ ft down from top of grain to base of wall, so:

$$P_H = (0.5)\left(\frac{56\ lb_m}{bu}\right)\left(\frac{1\ bu}{1.244\ ft^2}\right)\left(\frac{1\ lb_f}{1\ lb_m}\right)(7.5\ ft)\left(\frac{7.5\ ft}{2}\right) = 633\ lb_f/ft$$

Common mistakes:

(A) force per length using $k = 1$

(B) failed to convert bu to ft^3

(C) force per length using $H = z = 8$ ft

Question 540. Correct answer (C)

Reference: *Principles of Process Engineering* by Henderson, Perry, and Young or *Transport Processes and Separation Process Principles* by Geankoplis

Recognize flow behavior index (i.e., b value as denoted by Henderson, Perry, and Young) is less than 1, which describes a pseudoplastic fluid, or comparing given curve to curve in Figure 2.5 of Henderson, Perry, and Young (1997) (note Figure 2.5 axes are switched from convention used in many other references) or Figure 3.5.1 of Geankoplis (2003), which is denoted for pseudoplastic fluids.

Common mistakes:

(A) failing to recognize manure at higher total solids concentrations no longer exhibits Newtonian behavior (i.e., flow behavior index $b \neq 1$)

(B) assuming curve is linear and crosses y axis above origin

(D) reversing description of curve concavity where $b > 1$