Solutions to Practice Examination #2: Afternoon Session

Question 501: Principles of irrigation (Answer D)

References: *ASAE Standards, EP405.1* or general drip (micro-) irrigation texts –

Required Knowledge:

Orchard drip irrigation is point source, not line source, with emitters spacing approx. equal to the given tree spacing, therefore use Table 2 of the referenced ASAE standard, with:

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 502: subsurface drainage (Answer B)

References: Soil Mechanics texts (e.g. Principles of Geotechnical Engineering – Das, 1994) and/or Fluid Mechanics texts:

$u = P_H * \gamma_w$, where:

u = pore water pressure at a given point of interest (lbs/ft^2),
P_H = pressure head at the given point of interest (ft.), and,
γ_w = unit weight of water (lbs/ft^3).

As water is flowing, the pore water pressure must be determined from a seepage analysis. Twelve (12) feet of head is lost over six (6) equipotential lines (drops), each equipotential line (square) represents two (2) feet of total head loss.

Point A is one drop above the seepage exit, therefore, the total head (T_H) at Point A is:

T_H = 238.0 ft. + (1/6) * 12 ft. = 240 ft.

Given an elevation head (E_H) of 230 ft., the pressure head (P_H) is found by subtracting the elevation head (E_H) from the total head (T_H):

P_H = 240 ft. – 230 ft. = 10 ft, therefore:

u_A = 10 ft. * 62.4 lbs/ft^3 = 624.0 62.4 lbs/ft^2 ; Ans. (b)

Question 503: Soil Mechanics (Answer A)

References: General knowledge of soil sealing amendments.

Question 504: Principles of surface or subsurface drainage (Answer A)

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References: Elementary Soil and Water Engineering (Schwab et.al.), 1971 –
Based on a 25-year return period peak runoff rate of 2.0 m^3/s (71 cfs) and a water surface area of 0.81 hectares (2 acres) at the design (normal) water level, a 10 inch CMP principal spillway would be appropriate. However, since the project specifications for this job state that a Schedule 40 PVC pipe is to be used, we can reduce the size of our pipe to the next smallest diameter because the PVC pipe has a lower roughness coefficient (smooth wall), therefore we select 8 inches.

Question 505: Water Quality. (Answer D)
<u>References:</u> *Water Quality*, Novotny & Olem (1994) or other Water Quality texts –v

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Question 516: Unit Operations. (Answer A)
Key is: (a) 4.99 bars

To find the pressure drop across the bed we will use the Ergun equation.

$$\Delta p = \left(\frac{1-\varepsilon}{\varepsilon^3}\right)\left(\frac{\rho v_s^2 L}{D_p}\right)\left(\frac{150(1-\varepsilon)}{\mathrm{Re}_p}+1.75\right)$$

where

ε – void fraction

ρ – air density

D_p – characteristic particle diameter

L – bed depth

Re_p – Reynolds number for the particle

v_s – superficial air velocity

Since the particles are cubes, the characteristic diameter is determined by

$$D_p = \frac{6V_p}{A_p} = \frac{(6)(0.5\mathrm{cm})^3}{(6)(0.5\mathrm{cm})^2}\left(\frac{1\,\mathrm{m}}{100\,\mathrm{cm}}\right) = 0.005\,\mathrm{m}$$

The superficial air velocity is calculated using:

$$v_s = \frac{G}{\rho}, \text{ where G is the mass flow rate per unit area}$$

$$v_s = \frac{3000\,\frac{\mathrm{kg}}{\mathrm{hr}\cdot\mathrm{m}^2}}{5.239\,\frac{\mathrm{kg}}{\mathrm{m}^3}}\left(\frac{1\,\mathrm{hr}}{3600\,\mathrm{sec}}\right) = 0.159\,\frac{\mathrm{m}}{\mathrm{sec}}$$

The pressure drop is calculated using the Ergun equation:

$$\Delta p = \left(\frac{1-0.45}{0.45^3}\right)\left(\frac{\left(5.239\frac{kg}{m^3}\right)\left(0.159\frac{m}{sec}\right)^2 3m}{0.005m}\right)\left(\frac{150(1-0.45)}{225.1}+1.75\right)\left(\frac{1bar}{10^5\frac{N}{m^2}}\right)$$

$$\Delta p = (6.036)(79.468)(2.117)\left(\frac{1}{10^5}\right) = 0.0102$$

$$p_{exit} = p_{entrance} - \Delta p = 5 - 0.0102 \text{ bar} = 4.99 \text{ bars}$$

References:

a) Transport Process and Unit Operations by Geankoplis

Question 517. Mass Transfer between phases. (Answer B)
Key is: (b) 4.62 kg / m^3

Since the inlet and discharge conditions of the air are different we would characterize the system by the average density of the air. As we are not given the exit pressure, assume that the pressure drop across the bed is insignificant, and therefore, we will only take into account the change in temperature.

$$P = 5 \text{ bar}\left(\frac{10^5\frac{N}{m^2}}{1bar}\right) = 5x10^5\frac{N}{m^2}$$

$$\rho_{in} = \frac{P}{RT_{in}} = \frac{5x10^5\frac{N}{m^2}}{\left(287\frac{J}{kg\cdot K}\right)(313K)}$$

$$\rho_{in} = 5.566\frac{kg}{m^3} \quad \text{(Note: that J = N}\cdot\text{m)}$$

$$\rho_{out} = \frac{P}{RT_{out}} = \frac{5x10^5\frac{N}{m^2}}{\left(287\frac{J}{kg\cdot K}\right)(473K)}$$

$$\rho_{out} = 3.683\frac{kg}{m^3}$$

$$\rho_{avg} = \frac{\rho_{in}+\rho_{out}}{2} = \frac{5.566+3.683}{2} = 4.62\frac{kg}{m^3}$$

References:

Solutions to Practice Examination #2: Afternoon Session

Transport Process and Unit Operations by Geankoplis

Question 519: Particle characterization and dynamics (Answer D)
Key is: (d) turbulent

Since the particles are cubes, the characteristic diameter is determined by:

$$D_p = \frac{6V_p}{A_p} = \frac{(6)(0.5\text{cm})^3}{(6)(0.5\text{cm})^2}\left(\frac{1\,\text{m}}{100\,\text{cm}}\right) = 0.005\,\text{m}$$

The Reynolds number for the particle is

$$Re_p = \frac{D_p v_s \rho}{\mu} = \frac{(0.005\,\text{m})\left(0.450\frac{\text{m}}{\text{sec}}\right)\left(8.711\frac{\text{kg}}{\text{m}^3}\right)}{2.31\,\text{x}\,10^{-5}\,\frac{\text{N}\cdot\text{sec}}{\text{m}^2}} = 848.5$$

$$\text{Note: } N = \frac{\text{kg}\cdot\text{m}}{\text{sec}^2} \;\&\; Pa = \frac{N}{\text{m}^2}$$

$$Re = \frac{Re_p}{1-\varepsilon} = \frac{848.5}{1-0.45} = 1542 > 1000$$

Therefore, the flow is turbulent.

References:

1. Transport Process and Unit Operations by Geankoplis
Unit Operations of Chemical Engineering by McCabe and Smith

Question 521: Air Quality standards in ag buildings/confined spaces (Answer D)

Question 522: Standards for post-frame building design (Answer C)
Diaphragm design distributes the horizontal loads based on frame and cladding stiffness.

Question 523: Electrical wiring/lighting devices (Answer A)
Dust and moisture are the primary adverse environmental factors which are of a concern regarding the electrical system. While there may be some flammable or explosive gases produced in livestock housing, it is considered to be so rare that explosion proof electrical fixtures are not justified. It is generally recommended that electrical wiring be place on wall or ceiling surfaces and not hidden in wall cavities. Metal fixtures tend to corrode in livestock housing.

Question 524: Structural Analysis (Answer B)
The top flange is prone to buckling and causing failure before the beam load has reached its capacity. Bracing can prevent this premature failure.

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Question 525: Ventilation System Requirements (Answer B)
References: Albright
$V_x = V_o(h_x/h_o)^a = 10(4/10)^{.4} = 6.93$ m/s
$V = EAV_w = 0.55 * 40 * 6.93$ m^3/s

Question 526: Ventilation System Requirements/Rate Requirements (Answer D)
References: Albright
$P_1 – P_2 = C_d(\rho/2)(v_2^2 – v_1^2) = 0.6(1.2 \text{ kg/m}^3/2)(5^2\text{m/s} – 0^2) = 7.5$ Pa

Question 527:Structural loads and standards (Answer D)
References: ASCE-7
Flat open country = exposure C; agricultural facility = category I, I = 0.87
$q_z = 0.00256K_zK_{zl}K_dV^2I$; $K_{zl} = K_d = 1.0$; $K_z = 1.225$
$q_z = 0.00256(1.225)90^2(0.87) = 22.1$ psf
$F = q_zGC_fA_f$; $G = 0.85$ $C_f = 1$
$F = 22.1(0.85)(42/12)72 = 4734$ lb force

Question 528: Aerobic and Anaerobic Processes (Answer A)
$V = (W \times L \times D) – (S \times D^2) \times (L + W) + (4 \times S^2 \times D^3)/3$

Question 529: Environmental Assessment Techniques (Answer B)
References: Handbook of Hydrology (Maidment, 1993) and many other Hydrology and Hydrogeology texts –

Flow time is important to determining the response time and locations required to remediate the source of potential pollution, but it is unrelated to characterizing the pollutant source.

Question 530: Awareness of ecological processes (Answer A)
References: Culligan (or any other Manufacturer/Supplier of) Water Treatment Systems
Ion Exchange systems can reduce (treat) nitrate-nitrogen concentration levels specified at the peak flow rate used at this facility. Typically, Ion Exchange systems can treat flows up to several hundred gallons per minute. Charcoal filters do not reduce nitrate-nitrogen concentration levels in water. UV filters/sterilizers do not reduce nitrate-nitrogen concentration levels in water. Reverse Osmosis systems do reduce nitrate-nitrogen concentration levels in water, but they are not designed to treat peak flow rates of approx. 40 gpm.

Question 531:

Question 532: Structural and materials analysis (Answer C)
References:
The design load for a building is the maximum load that might be expected to occur during the design life of the building. The load combinations that need to be considered

are the weight of materials (D), the load due to occupancy (L), and the weather related loads. It is not expected that the maximum snow load will occur when the wind force is greatest.

Question 533: Psychometrics (Answer C)
References:
$M_w = (w_2 - w_1)v$; $v = Q/v$
$w_2 = 10.0$; $w_2 = 4.4$ [from psyc chart]
$M_w = (10 - 4.4)(4/0.85) = 26.4$

Question 534: Heat Transfer applications (Answer A)
References:
$Q = (A/R)dt = [\{(20x30)/30\} + \{(2x12)x(20 + 30)-24\}/24 + (24/4)] (50+10)$
$= [20 + 49 + 6]60 = 4500$ Btu/h

Question 535: Heat Transfer applications (Answer D)
References:
$R_t = R_1 + R_2*t_2 + R_3*t_3 + R_4 = 0.4 + 42 \times 0.05 + 14 \times 0.012 + 0.02 = 2.688\ m^2C/W$