Fe exam reference handbook 9.5 pdf pdf download 2017 full

where dx = x-axis distance between the two axes in question dy = y-axis distance between the two axes in question 109 Statics Friction The largest frictional force is called the limiting friction. 110 Figure Area & Centroid y A = bh/2 h C yc = h/3 x b y A = bh/2 h C xc = b/3 yc = h/3 x b y C a xc = 2b/3 A = bh/2 h xc = (a + b)/3 yc = h/3 x b C A = bh h b xc = b/2 yc = h/2 x C b rx2c = h 2 18 Ix = bh3/12 Iy = b3h/4 rx2 = h 2 6 ry2 = b 2 2 ry2c = b 2 18 I yc = b 3h/36 = bh3/12 Iy = bh3/12 2 Iyc = bh b − ab + a 2 3 I x = bh 12 [(2 I y = bh b + ab + a 2 A = h(a + b) 2 h(2a + b) yc = 3(a + b) h x)] 36)] 12 A = ab sin θ C b a x xc = (b + a cos θ)/2 yc = (a sin θ)/2 (2 = b − ab + a (rx2 = h 2 3 ry2 = b 2 3 [(( )] (I xc = h 3 a 2 + 4ab + b 2 36(a + b) Ix = h 3 (3a + b) 12 Ix [2) I xy [ ] = [Ah(2a + b)] 12 = bh 2 (2a + b) 24 I xc y c = 0 I xy = Abh 4 = b 2 h 2 4) (h 2 a 2 + 4ab + b 2 18(a + b) 2 h (3a + b) rx2 = 6(a + b) rx2c = rx2c = (a sinθ)2 12 (I y = ab sinθ (b + a cosθ) 2]3)) ry2c = b 2 + a 2 cos 2 θ 12 2 3 ( ] rp2 = b 2 + h 2 12 ( ) = [ab sinθ (b + a cos θ)] 12 = (a b sin θ) 3 2 [= bh 2 (2a − b) 72) I x = bh 3 3 I y = b3h 3 3) 18 ry2c = b 2 12 I yc = b 3 h 12 = Abh 12 = b 2 h 2 24 I xc yc = [Ah(2a − b)] 36 =h 6 = b 2 + ab + a 2 6 rx2c = h 2 12 I yc 2 2 I xc = b h 3 12 I xc = a 3b sin 3θ 12 y I xy rx2c = h 2 18 ry2c rx2 ry2 = Abh 4 = b 2 h 2 8 I xc yc = − Abh 36 = − b 2 h 2 72 rx2 = h 2 6 ry2 = b 2 6 I xc = bh 3 36 [(Ixy rx2c = h 2 18 Ix c = bh 3 /36 Ix Ixc yc = Abh 36 = b 2 h 2 72 ry2c = b 2 18 I yc = b 3h/36 J = bh b 2 + h 2 12 a y Ix c = bh 3 /36 Product of Inertia) − a 2b 2 sinθ cosθ 6 rx2 ry2 = (a sinθ) 3 2 = (b + a cosθ) 3 − (ab cosθ) 6 2 Housner, George W., and Donald E. The RSA Public-Key Cryptosystem n=p*q where p and q are both primes. No code can give immediate and mechanical answers to all ethical and professional problems that an engineer may face. Rule 3: All zeros in the decimal portion are significant. Organic chemistry (e.g., nomenclature, functional group reactions) D. It also produces oxygen. Zone Flatness Cylindrical boundary, within which the axis of the feature must lie (derived median line) Parallel planes, within which the elements of a surface must lie 0.1 R 0.1 Tol. 428 Industrial and Systems Engineering Ergonomics—Hearing The average shifts with age of the threshold of hearing for pure tones of persons with "normal" hearing, using a 25-year-old group as a reference group. Particle and rigid-body kinematics B. Ferrous chloride 3 FeCl2 + 2 PO43– → Fe3(PO4)2 (↓) + 6 Cl– 3. A function represented as a product of maxterms only is said to be in canonical product of sums (POS) form. SQL Injection(SQLi) – injection attack, by inserting SQL query via input data from the client to the application for execution. Water distribution systems E. R. (Former Class E network.) 255.255.255.255/32 255.255.255.255 1 Subnet Reserved for the "limited broadcast" destination address. Processing (e.g., crushing, grinding, crystallization) C. H7/h6 Loose running fit: for wide commercial H11/c11 tolerances or allowances on external members Close running fit: for running on accurate H8/f7 machines and for accurate location at moderate speeds and journal pressures Transition Locational transition fit: for accurate location, H7/k6 a compromise between clearance and interference Locational transition fit: for more accurate H7/n6 location where greater interface is permissible Interference Location interference fit: for parts requiring rigidity and alignment with prime accuracy of location but without special bore pressure requirements. 870-872. Hazard communications (e.g., SDS, proper labeling, concentrations, fire ratings, safety equipment) 6–9 7. Psychrometrics J. Basic dynamics (e.g., friction, force, mass, acceleration, momentum) B. Appleton-Century Company, Inc. 17 mA−99 mA Extreme pain, respiratory arrest, severe muscular contractions. CPU CORE AND L1 CACHES CPU CORE AND L1 CACHES BACK SIDE BUS INTERFACE AND L2 CACHES FRONT SIDE Generic dual-core processor, with CPU-local level 1 caches, and a shared, on-die level 2 cache Threading In computer science, a thread of execution is the smallest sequence of programmed instructions that can be managed independently by a scheduler, which is typically a part of the operating system. 95 Materials Science/Structure of Matter Mechanical Strain is defined as change in length per unit length; for pure tension the following apply: Engineering strain DL f= L 0 where ε = engineering strain ΔL = change in length L0 = initial length True strain dL fT = L where εT = true strain dL = differential change in length L = initial length εT = ln (1 + ε) 96 Materials Science/Structure of Matter Proper�es of Metals Metal Symbol Aluminum Antimony Arsenic Barium Beryllium Bismuth Cadmium Caesium Calcium Cerium Chromium Cobalt Copper Gallium Gold Indium Iridium Iron Lead Lithium Magnesium Manganese Mercury Molybendum Nickel Niobium Osmium Palladium Platinum Potassium Rhodium Rubidium Ruthenium Silver Sodium Strontium Tantalum Thallium Thorium Tin Titanium Tungsten Uranium Vanadium Zinc Zirconium Al Sb As Ba Be Bi Cd Cs Ca Ce Cr Co Cu Ga Au In Ir Fe Pb Li Mg Mn Hg Mo Ni Nb Os Pd Pt K Rh Rb Ru Ag Na Sr Ta Tl Th Sn Ti W U V Zn Zr Density ρ Atomic (kg/m3) Weight Water = 1000 26.98 121.75 74.92 137.33 9.012 208.98 112.41 132.91 40.08 140.12 52 58.93 63.54 69.72 196.97 114.82 192.22 55.85 207.2 6.94 24.31 54.94 200.59 95.94 58.69 92.91 190.2 106.4 195.08 39.09 102.91 85.47 101.07 107.87 22.989 87.62 180.95 204.38 232.04 118.69 47.88 183.85 238.03 50.94 65.38 91.22 2,698 6,692 5,776 3,594 1,846 9,803 8,647 1,900 1,530 6,711 7,194 8,800 8,933 5,905 19,281 7,290 22,550 7,873 11,343 533 1,738 7,473 13,547 10,222 8,907 8,578 22,580 11,995 21,450 862 12,420 1,533 12,360 10,500 966 2,583 16,670 11,871 11,725 7,285 4,508 19,254 19,050 6,090 7,135 6,507 Melting Point (°C) Melting Point (°F) Specific Heat (J/(kg˙K)) Electrical Resistivity (10−8 Ω˙m) at 0°C (273.2 K) 660 630 subl. v P v v P v v v Vennard, J.K., Elementary Fluid Mechanics, 6th ed., J.K. Vennard, 1954. Ethers may also be named as alkoxy derivatives of hydrocarbons. Straight Line The general form of the equation is Ax + By + C = 0 The standard form of the equation is y = mx + b, which is also known as the slope-intercept form. Thus, mv = ωout /ωin. Instrumental Methods of Analysis Method Atomic absorption spectrometry Atomic emission spectrometry (AES) Capillary electrophoresis (CE) Electrochemistry Gas Chromatography (GC) ICP-mass spectrometry(ICP MS) Infrared spectroscopy (IS) Ion chromatography Liquid chromatography (LC) Mass spectrometry (MS) Nuclear Magnetic Resonance (NMR) Raman spectroscopy Thermal analysis (TA) UV and visible (UV/VIS) spectrophotometry UV absorption UV fluorescence X-ray absorption X-ray diffraction (XRF) X-ray fluorescence Qualitative Quantitative Elemental Molecular Elemental Molecular No Yes Yes Yes No Yes No Yes No Yes No No No Yes No No Yes No Yes No No Yes Yes Yes No Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes Yes No Yes No Yes Yes Yes Yes No Yes No Yes No Yes No No No Yes No No Yes No Yes No No Yes Yes Yes No Yes Yes Yes Yes Yes Yes Yes Yes Yes No Yes No Adapted from Robinson, James W., Eileen M. 255 O(+) O(–) I O(+) HYDROCYCLONE I O(–) O(+) * M: Mechanical transport of sands to discharge N : Nonmechanical (gravity or pressure) discharge of underflow S : Sedimentation classifier O(–) = Liquid Flow Out O(+) = Solid Flow In I = Slurry Flow In Perry, Robert H., and Don Green, Perry's Chemical Engineers' Handbook, 7 ed, New York: McGraw-Hill, 1997. Electricity and electrical circuits 4–6 3. Head Loss Through Clean Bed Rose Equation Monosized Media 1.067 `vs j LCD hf = gh 4 d 2 Carmen-Kozeny Equation Monosized Media f l L `1 − h j vs2 = hf h3 gd Multisized Media 1.067 `vs j L CDijxij / hf = dij gh 4 2 Multisized Media L `1 − h j vs2 f li j xi j / = hf di j h3 g 1−h f l = friction factor = 150 d Re n + 1.75 where hf L η vs g = head loss through the clean bed (m of H2O) = depth of filter media (m) = porosity of bed = void volume/total volume = filtration rate = empty bed approach velocity (m/s) = Q/Aplan = gravitational acceleration (m/s2) v td Re = Reynolds number = sn dij, d = diameter of filter media particles; arithmetic average of adjacent screen openings (m) i = filter media (sand, anthracite, garnet) j = filter media particle size xij = mass fraction of media retained between adjacent sieves f lij = friction factors for each media fraction CD = drag coefficient as defined in settling velocity equations Bed [illegible] used in this Act, shall mean the jurisdiction board of licensure for professional engineers and professional surveyors, hereinafter provided by this Act. R V A DW S A B C G A T = SB E W A== D E F SS W C FW T X Inverse [ ]–1 The inverse B of a square n × n matrix A is B = A −1 = adj ^ Ah A where adj(A) = adjoint of A (obtained by replacing AT elements with their cofactors) A = determinant of A [A][A]–1 = [A]–1[A] = [I] where I is the identity matrix. Linear motion (e.g., force, mass, acceleration) C. Vibrations (e.g., natural frequency) 9–14 Strength of Materials A. It occurs over an infinitesimal distance. Flip-flops and counters F. Network topologies (e.g., mesh, ring, star) C. 448 Mechanical Engineering Kinematics, Dynamics, and Vibrations Kinematics of Mechanisms Four-Bar Linkage The four-bar linkage shown above consists of a reference (usually grounded) link (1), a crank (input) link (2), a coupler link (3), and an output link (4). Electrodynamics (e.g., Maxwell equations, wave propagation) C. Usually coupled with a social engineering attack. a(c) = +1 if there is an even number (or zero) of factors in the group set at the low level (Level 1) in experimental condition c = 1, 2, ..., m a(c) = –1 if there is an odd number of factors in the group set at the low level (Level 1) in experimental condition c = 1, 2, ..., m It can be proved that the interaction effect E for the factors in the group and the corresponding sum of squares SSL can be determined as follows: E= L – 2n 1 m L = / a^chY ^ch c=1 SSL = rL2 2n Sum of Squares of Random Error The sum of the squares due to the random error can be computed as SSerror = SStotal – ΣiSSi – ΣiΣjSSij – ... – SS12 ...n where SSi is the sum of squares due to factor Xi, SSij is the sum of squares due to the interaction of factors Xi and Xj, and so on. The number of different combinations of n distinct objects taken r at a time is P ^ n, r h n! C ^n, r h = r! = 7r! ^ n - r h !A n nCr and e o are alternative notations for C(n,r) r 3. Rate-of-Return The minimum acceptable rate-of-return (MARR) is that interest rate that one is willing to accept, or the rate one desires to earn on investments. Perry, Perry's Chemical Engineers' Handbook, 8th ed., McGraw-Hill, 2008. Groundwater (e.g., flow, wells, drawdown) I. Perfect Form at MMC Not Required Where it is desired to permit a surface or surfaces of a feature to exceed the boundary of perfect form at MMC, a note such as PERFECT FORM AT MMC NOT REQUIRED is specified. Table reprinted by permission of G.W. Housner & D.E. Hudson. Aluminum sulfate (alum) Al2 (SO4)3 • 14 H2O + 2 PO43– → 2 AlPO4 (↓) + 3 SO42– + 14 H2O Common Radicals in Water Molecular Formulas CO32– CO2 Ca(OH)2 CaCO3 Ca(HCO 3)2 CaSO4 Ca2+ H+ HCO3– Mg(HCO3)2 Mg(OH)2 MgSO4 Mg2+ Na+ Na 2CO3 OH – SO42– Molecular Weight n # Equiv per mole Equivalent Weight 30.0 22.0 37.1 50.0 81.1 68.1 20.0 1.0 61.0 73.2 29.2 60.2 12.2 23.0 53.0 17.0 48.0 2 2 2 2 2 2 2 1 1 2 2 2 2 1 2 1 2 60.0 44.0 74.1 100.1 162.1 136.1 40.1 1.0 61.0 146.3 58.3 120.4 24.3 23.0 106.0 17.0 96.1 Typical Operating Ranges for Coagulation with Alum and Ferric Chloride 0 RE-STABILIZATION ZONE (BOUNDARY CHANGES WITH COLLOID) –4 –5 –6 OPTIMAL SWEEP COMBINATION (SWEEP AND ABSORPTION) CHARGE NEUTRALIZATION TO ZERO ZETA POTENTIAL With AI(OH)3 (s) ADSORPTION DESTABILIZATION AITOTAL –7 AI3+ 0 2 4 30 10 3 1 0.3 CHARGE NEUTRALIZATION TO ZERO ZETA POTENTIAL n+ With AIx(OH)y AI(OH)3(s) 4+ AI8(OH)20 –8 100 6 8 10 12 SWEEP COAGULATION 270 log [Fe], moI/L AI(OH)4 Fe3+ –2 300 ALUM AS AL2(SO4)3 •14.3 H20, mg/L –2 AI(OH) –3 log [AI], moI/L SWEEP COAGULATION 27 –4 2.7 –6 Fe(OH) RE-STABILIZATION ZONE (CHANGES WITH COLLOID OR SURFACE AREA) –8 – 10 – 12 14 pH OF MIXED SOLUTION 0 2 ADSORPTION DESTABILIZATION 2+ 0.27 FeTOTAL Fe(OH)4– Fe(OH)2+ 4 6 8 10 12 14 pH OF MIXED SOLUTION Metcalf and Eddy; AECOM, Wastewater Engineering: Treatment and Resource Recovery, 5th ed., New York: McGraw-Hill, 2014, p. These databases and software to manipulate them are commercially available. Select the job with the shortest time, from the list of jobs, and its time at each work center. For an n-bit binary word length, transmission of a pulse-code-modulated low-pass message m(t), with M(f) = 0 for f ≥ W, requires the transmission of at least 2nW binary pulses per second. Effective stress E. Force transmitted with the hands is counteracted at the foot. v12 P2 v 22 P1 + + = + + + + z z 1 2 c 2g c 2g h f h f, fitting P1 v12 P2 v 22 + + = + + z z tg 1 2g tg 2 2g + h f + h f, fitting where v2 h f, fitting = C 2g v2 2g = 1 velocity head 183 Fluid Mechanics Specific fittings have characteristic values of C, which will be provided in the problem statement. All hosts are required to be able to reassemble datagrams of size up to 576 bytes, but most modern hosts handle much larger packets. 4 1 34 2 1 1.0 1/2 3 1 Good: Gauges must be mounted at 45 degrees from centerline. The heat of reaction for a combustion process using oxygen is also known as the heat of combustion. Yes (Axis) Yes Not a refinement of size. Incomplete Combustion Some carbon is burned to create carbon monoxide (CO). ICMP and ICMPv6 Header Format Offsets Octet 0 Octet Bit 0 0 Type 4 32 Rest of Header 0 1 2 3 1 4 5 6 7 8 9 10 11 2 12 13 14 15 16 Code 17 18 19 3 20 21 22 23 24 25 26 Checksum Partial List of ICMP Type and Code Values (IPv4) ICMP Type ICMP Code 0 = Echo Reply 0 0 = net unreachable 1 = host unreachable 3 = Destination Unreachable 2 = protocol unreachable 4 = fragmentation needed and DF set 5 = source route failed 0 = Redirect Datagram for the Network 5 = Redirect Message 1 = Redirect Datagram for the Host 2 = Redirect Datagram for the ToS and network 3 = Redirect Datagram for the ToS and host 8 = Echo Request 0 9 = Router Advertisement 0 10 = Router Solicitation 0 0 = TTL expired in transit 11 = Time Exceeded 1 = Fragment reassembly time exceeded 403 27 28 29 30 31 Electrical and Computer Engineering Partial List of ICMPv6 Type and Code Values ICMPv6 Type ICMPv6 Code 0 = no router to destination 1 = communication with destination administratively prohibited 2 = Beyond scope of source address 3 = address unreachable 1 = Destination Unreachable 4 = port unreachable 5 = source address failed ingress/egress policy 6 = reject route to destination 7 = Error in Source Routing Header 2 = Packet Too Big 0 0 = hop limit exceeded in transit 3 = Time exceeded 1 = fragment reassembly time exceeded 0 = erroneous header field encountered 4 = Parameter problem 1 = unrecognized Next Header type encountered 2 = unrecognized IPv6 option encountered 128 = Echo Request 0 129 = Echo Reply 0 130 = Multicast Li stener Query 0 131 = Multicast lis tener Done 0 1 3 3 = R o u t e r So l i c i t a t i o n 0 134 = Router Advertisement 0 1 3 5 = N e i g h b o r So l i c i t a t i o n 0 136 = Neighbor Advertisement 0 137 = Redirect Message 0 0 = Router Renumbering Command 138 = Router Renumbering 1 = Router Renumbering Result 255 = Sequence Number Reset 0 = The Data field contains an IPv6 address which is the Subject of this Query 139 = ICMP Node Information Query 1 = The Data field contains a name which is the Subject of this Query, or is empty, as in the case of a NOOP. Smith; and Peter Harriott, Unit Operations of Chemical Engineering, 6 ed., New York: McGraw-Hill, 2001. Sub-Cooled Boiling – Temperature of liquid is below saturation temperature; bubbles forming at surface may condense in the liquid. Transmissivity, T: The product of hydraulic conductivity and thickness, b, of the aquifer (L2T –1). xmax = distance along plume centerline to the point of maximum concentration (Cu/Q)max = e [a + b lnH + c (lnH) 2 + d (lnH)3] H = effective stack height = stack height + plume rise (m) Turner, D.B., "Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modeling," 2nd ed., Lewis Publishing/CRC Press, Florida, 1994. Prime Implicant – An implicant which is not entirely contained in any other implicant. Oxidation – The loss of electrons. The following table contains equivalent codes for a four-bit binary value. Three-phase power (e.g., motor efficiency, balanced loads, power equation) 14. A planetary gearset has two independent inputs and one output (or two outputs and one input, as in a differential gearset). The pressure drop P1 – P2 is given by the following: P1 – P2 = γ hf = ρghf Bernoulli Equation The field equation is derived when the energy equation is applied to one-dimensional flows. The point-slope form is y – y1 = m(x – x1) Given two points: slope, m = (y2 – y1)/(x2 – x1) The angle between lines with slopes m1 and m2 is α = arctan [(m2 – m1)/(1 + m2·m1)] Two lines are perpendicular if m1 = –1/m2 The distance between two points is d= _ y2 - y1i + ^ x2 - x1h 2 2 Quadratic Equation ax2 + bx + c = 0 b ! b 2 - 4ac x = Roots = 2a Quadric Surface (SPHERE) The standard form of the equation is (x – h)2 + (y – k)2 + (z – m)2 = r2 with center at (h, k, m). Gaining Access 4. 412, Oxford University Press. When a mechanical force is applied, the material changes dimension and an electric field is produced. UNBRACED LENGTH 2 X8 14 X73 X68 W24 W21 7 X6 X68 6 W1 X62 W24 W 10 X8 X7 8X7 4 9 W21 10 X8 8 X7 14 W X68 1 4 X6 8 12 67 6X 73 W21X 68 2 X62 W21 X7 W1 W24X 11 14 5 8X6 X62 W1 W24 W 55 X55 0X 77 50 8X 0X 14 8 5 0 68 W21X 5 X6 8X6 W1 12 5 62 W24X 14 16 18 UNBRACED LENGTH (0.5-ft INCREMENTS) Steel Construction Manual, 14th ed., AISC, 2011. Traffic capacity and flow theory D. Examples: unit, integration, system, and acceptance testing. Equivalent force systems C. 222 Instrumentation, Measurement, and Control Strain Bridge Type Gauge Setup Sensitivity mV/V @ 1,000 με 1 0.5 1/4 Axial 1 2 1/2 1.0 Better: Rejects bending strain, but not temperature. Parallel-Axis Theorem The mass moments of inertia may be calculated about any axis through the application of the above definitions. Material/Energy Balances A. 395 Electrical and Computer Engineering IPv6 Special Address Blocks Address block (CIDR) First address Number of addresses Last address Usage Purpose 2128 Routing Default route. Other reactants are excess reactants. Humid Volume: Volume of moist air/mass of dry air. ARC LENGTH The symbolic means of indicating a dimension is an arch length measured on a curved outline. (Harris, C.E., M.S. Pritchard, & M.J. Rabins, Engineering Ethics: Concepts and Cases, Wadsworth Publishing company, pages 27–28, 1995.) The expertise possessed by engineers is vitally important to societal welfare. 231 Engineering Economics Benefit-Cost Analysis In a benefit-cost analysis, the benefits B of a project should exceed the estimated costs C. When reporting measurement results, it is necessary to provide an associated uncertainty so that those who use it may assess its reliability. Engineering Economics A. Submit five references acceptable to the board B. The last fragment has a non-zero Fragment Offset field, differentiating it from an unfragmented packet. Thermal properties of materials E. Baffling Description Guidance Manual LT1ESWTR Disinfection Profiling and Benchmarking, U.S. Environmental Protection Agency, 2003. Lost workday cases rate 5. It is given by A•B = axbx + ayby + azbz = A B cos i = B : A The cross product is a vector product of magnitude B A sin θ which is perpendicular to the plane containing A and B. Its efficiency is given by: ηc = (TH – TL)/TH where TH and TL = absolute temperatures (Kelvin or Rankine). These substances, such as plasticizers, improve formability during processing, while others

[illegible]

and surveying matters that are inspired or paid for by interested parties, unless they explicitly identify the interested parties on whose behalf they are speaking and reveal any interest they have in the matters. The atomic number is the number of protons in the atomic nucleus. For pipes in parallel, the head loss is the same in each pipe. 26 Safety Exposure Residential Exposure Equations for Various Pathways Ingestion in drinking water where ABS = absorption factor for soil contaminant (unitless) CDI = (CW)(IR)(EF)(ED) (BW)(AT) AD = absorbed dose (mg/[kg•day]) Ingestion while swimming AF = soil-to-skin adherence factor (mg/cm2) CDI = (CW)(CR)(ET)(EF)(ED) (BW)(AT) AT = averaging time (days) BW = body weight (kg) Dermal contact with water CA = contaminant concentration in air (mg/m3) AD = (CW)(SA)(PC)(ET)(EF)(ED)(CF) (BW)(AT) CDI = chronic daily intake (mg/[kg•day]) CF = volumetric conversion factor for water = 1 L/1,000 cm3 Ingestion of chemicals in soil CDI = (CS)(IR)(CF)(FI)(EF)(ED) (BW)(AT) = conversion factor for soil = 10–6 kg/mg CR = contact rate (L/hr) Dermal contact with soil CS = chemical concentration in soil (mg/kg) AD = (CS)(CF)(SA)(AF)(ABS)(EF)(ED) (BW)(AT) CW = chemical concentration in water (mg/L) Inhalation of airborne (vapor phase) chemicals ED = exposure duration (years) CDI = (CA)(IR)(ET)(EF)(ED) (BW)(AT) EF = exposure frequency (days/yr or events/year) ET = exposure time (hr/day or hr/event) Ingestion of contaminated fruits, vegetables, fish and shellfish CDI = (CF)(IR)(FI)(EF)(ED) (BW)(AT) FI = fraction ingested (unitless) IR = ingestion rate (L/day or mg soil/day or kg/meal) = inhalation rate (m3/hr) PC = chemical-specific dermal permeability constant (cm/hr) SA = skin surface area available for contact (cm2) Risk Assessment Guidance for Superfund. Turbines, Pumps, Compressors: Often considered adiabatic (no heat transfer). Heat is moved from low to high temperature requiring work, W. Catalysis (e.g., mechanisms, biocatalysis, physical properties) 13. Conviction of or entry of a plea of guilty or nolo contendere to any crime that is a felony, whether or not related to the practice of engineering or surveying; and conviction of or entry of a plea of guilty or nolo contendere to any crime, whether a felony, misdemeanor, or otherwise, an essential element of which is dishonesty or which is directly related to the practice of engineering or surveying 4. Mass Moment of Inertia The definitions for the mass moments of inertia are Ix = # ` y 2 + z 2 j dm Iy = # _ x 2 + z 2 i dm Iz = # ` x 2 + y 2 j dm A table listing moment of inertia formulas for some standard shapes is at the end of this section. Conductive heat transfer B. The Reply Data field may or may not be empty. Notes Skull and crossbones; Keep Out of Reach of Children Keep Out of Reach of Children Keep Out of Reach of Children From Regulating Pesticides, U.S. Environmental Protection Agency. 93 Materials Science/Structure of Matter Atomic Bonding Primary Bonds Ionic (e.g., salts, metal oxides) Covalent (e.g., within polymer molecules) Metallic (e.g., metals) Corrosion A table listing the standard electromotive potentials of metals is shown on the previous page. Measurements, Instrumentation, and Controls A. Strain Transducers Strain Gauge – a device whose electrical resistance varies in proportion to the amount of strain in the device. Reaction rates and order B. (N-S) Similar to cylindrical tank classifier, except tank is conical to eliminate need for rake. Rogers, Review for the Professional Engineers' Examination in Industrial Engineering, 2012. Aluminum sulfate plus soda ash Al2 (SO4)3 + 3 NaCO3 + 3 H2O ⇔ 2 Al (OH)3 + 3 NaSO4 + 3 CO2 3. When the equation is a homogeneous differential equation, f(x) = 0, the solution is yh ^ xh = C1e r1 x + C2e r 2 x + f + Cie r i x + f + Cne r n x where rn is the nth distinct root of the characteristic polynomial P(x) with P(r) = bnrn + bn–1rn–1 + ... + b1r + b0 If the root r1 = r2, then C2er2 x is replaced with C2xer1x. Reprinted by permission from ASHRAE. 129 Mechanics of Materials Uniaxial Stress-Strain STRESS, PSI STRESS, MPa Stress-Strain Curve for Mild Steel Flinn, Richard A., and Paul K. Mechanical energy balance (e.g., pipes, valves, fittings, pressure losses across packed beds, pipe networks) D. 0.060 0.080 0.10 30 -10 100. ALKALINE STEEL = < 0.002 IN. • If the SYN flag is clear (0), that a packet with Congestion Experienced flag set (ECN=11) in the IP header was received during normal transmission. Eutectic reaction (liquid → two solid phases) Eutectoid reaction (solid → two solid phases) Peritectic reaction (liquid + solid → solid) Peritectoid reaction (two solid phases → solid) Lever Rule L β+L α+L β α TEMPERATURE, °F TEMPERATURE, °C The following phase diagram and equations illustrate how the weight of each phase in a two-phase system can be determined: α+β A xα 0% B 100% A xβ x COMPOSITION, WT% (In diagram, L = liquid.) If x = the average composition at temperature T, then x -x wt % a = x b x # 100 b- a x - xa wt % b = x x # 100 b- a 105 B 100% B 0% A Materials Science/Structure of Matter Iron-Iron Carbide Phase Diagram Van Vlack, L.H., Elements of Materials Science and Engineering, 6th ed., ©1989. Mass and energy balances G. In determining mv, it is helpful to invert the mechanism by grounding the arm and releasing any gears that are grounded. Analytic geometry, logarithms, and trigonometry B. Geotechnical Engineering A. The lesser and greater sublists are then recursively sorted. 312 Environmental Engineering Downwind distance where the maximum concentration occurs, xmax, versus (Cu/Q)max as a function of stability class A – EXTREMELY UNSTABLE B – MODERATELY UNSTABLE C – SLIGHTLY UNSTABLE D – NEUTRAL E – SLIGHTLY STABLE F – MODERATELY STABLE EF FE CT IVE ST AC KH EIG HT ,H (Cu/Q)max, m–2 NOTES: Effective stack height shown on curves numerically. The SDS is product related and, usually, is not able to provide information that is specific for any given workplace where the product may be used. Zone 0.1 Ø10±0.2 Concentric circles, within which each circular element of the surface must lie Circularity 0.1 Concentric cylinders, within which all surface elements must lie R 0.1 Tol. This can be used when sending packets to a host that does not have resources to handle fragmentation. For an internal feature, it is equal to the MMC minus the related geometric tolerance. The sum of n terms is S. 160 ... We will also post errata on the website. Raising temperature causes (1) recovery (stress relief), (2) recrystallization, and (3) grain growth. It is defined when its (1) magnitude, (2) point of application, and (3) direction are known. Values of the coefficient Ccr for maximum heat flux (dimensionless parameter L* = L[g(ρl – ρv)/σ]1/2 Heater Geometry Large horizontal flat heater Small horizontal flat heater1 Large horizontal cyclinder Small horizontal cyclinder Large sphere Small sphere 1K = σ/[g(ρ 1 l Charac. Linear algebra (e.g., matrix operations) E. 192.168.0.0/16 192.168.0.0– 192.168.255.255 65536 Private network Used for local communications within a private network. Surface wind speed is measured at 10 m above the ground. If A = B = C = 0, a straight line is defined. Primary control for features of size. If the indicated sum is greater than unity, the mixture is above the lower flammable limit. There is no difference between the terms flammable and explosive as applied to the lower and upper limits of flammability. liquid vapor vf vg 0.6113 0.8721 1.2276 1.7051 2.339 3.169 4.246 5.628 7.384 9.593 12.349 15.758 19.940 25.03 31.19 38.58 47.39 57.83 70.14 84.55 0.001 000 0.001 000 0.001 000 0.001 001 0.001 002 0.001 003 0.001 004 0.001 006 0.001 008 0.001 010 0.001 012 0.001 015 0.001 017 0.001 020 0.001 023 0.001 026 0.001 029 0.001 033 0.001 036 0.001 040 0.101 35 0.120 82 0.143 27 0.169 06 0.198 53 0.2321 0.2701 0.3130 0.3613 0.4154 0.4758 0.5431 0.6178 0.7005 0.7917 0.8920 1.0021 1.1227 1.2544 1.3978 1.5538 1.7230 1.9062 2.104 2.318 2.548 2.795 3.060 3.344 3.648 3.973 4.319 4.688 5.081 5.499 5.942 6.412 6.909 7.436 7.993 8.581 9.202 9.856 10.547 11.274 12.845 14.586 16.513 18.651 21.03 22.09 0.001 044 0.001 048 0.001 052 0.001 056 0.001 060 0.001 065 0.001 070 0.001 075 0.001 080 0.001 085 0.001 091 0.001 096 0.001 102 0.001 108 0.001 114 0.001 121 0.001 127 0.001 134 0.001 141 0.001 149 0.001 157 0.001 164 0.001 173 0.001 181 0.001 190 0.001 199 0.001 209 0.001 219 0.001 229 0.001 240 0.001 251 0.001 263 0.001 276 0.001 289 0.001 302 0.001 317 0.001 332 0.001 348 0.001 366 0.001 384 0.001 404 0.001 425 0.001 447 0.001 472 0.001 499 0.001 561 0.001 638 0.001 740 0.001 893 0.002 213 0.003 155 MPa 206.14 147.12 106.38 77.93 57.79 43.36 32.89 25.22 19.52 15.26 12.03 9.568 7.671 6.197 5.042 4.131 3.407 2.828 2.361 1.982 1.6729 1.4194 1.2102 1.0366 0.8919 0.7706 0.6685 0.5822 0.5089 0.4463 0.3928 0.3468 0.3071 0.2727 0.2428 0.2168 0.194 05 0.174 09 0.156 54 0.141 05 0.127 36 0.115 21 0.104 41 0.094 79 0.086 19 0.078 49 0.071 58 0.065 37 0.059 76 0.054 71 0.050 13 0.045 98 0.042 21 0.038 77 0.035 64 0.032 79 0.030 17 0.027 77 0.025 57 0.023 54 0.021 67 0.019 948 0.018 350 0.016 867 0.015 488 0.012 996 0.010 797 0.008 813 0.006 945 0.004 925 0.003 155 Internal Energy kJ/kg Sat. Using IPv6 jumbograms, it is possible to have UDP packets of size greater than 65,535 bytes. Motors and generators (e.g., synchronous, induction, dc) 8–12 11. Work measurement (e.g., time study, predetermined time systems, work sampling, standards) C. Process design and optimization (e.g., sustainability, efficiency, green engineering, inherently safer design, evaluation of specifications, product design) E. Trade secrets offer little protection without a written agreement between the involved parties. Properties (e.g., chemical, electrical, mechanical, physical, thermal) B. State S0 S1 S2 S3 Input i1 i2 S1 S2 S2 S3 S3 S3 S3 S3 S3 i0 S0 S2 S3 S0 i3 S3 S3 S3 S3 Another way to represent a finite state machine is to use a state diagram, which is a directed graph with labeled edges. Time value of money (e.g., equivalence, present worth, equivalent annual worth, future worth, rate of return) B. Piezoresistive effect – a change in the intrinsic electrical conductivity of a material due to a mechanical strain. In practice, the field has become a hop count—when the datagram arrives at a router, the router decrements the TTL field by one. Rule 2: Any zeros between two significant digits are significant. Steady-state analysis using constant inputs based on the Final Value Theorem. The Option-Kind field indicates the type of option, and is the only field that is not optional. Engineering drawing interpretations and geometric dimensioning and tolerancing (GD&T) 491 10–15 Fundamentals of Engineering (FE) OTHER DISCIPLINES CBT Exam Specifications Effective Beginning with the July 2020 Examinations • The FE exam is a computer-based test (CBT). The program traceroute uses these ICMP Time Exceeded messages to print the routers used by packets to go from the source to the destination. 169 ft3/lbmol — 1.20 4.08 1.50 1.49 Thermodynamics SELECTED LIQUIDS AND SOLIDS cp Density Substance kJ/(kg·K) Btu/(lbm-° R) kg/m3 lbm/ft3 Liquids Ammonia Mercury Water 4.80 0.139 4.18 1.146 0.033 1.000 602 13,560 997 38 847 62.4 0.900 0.386 2.11 0.450 0.128 0.215 0.092 0.502 0.107 0.030 2,700 8,900 917 7,840 11,310 170 555 57.2 450 705 Solids Aluminum Copper Ice (0°C; 32°F) Iron Lead Howell, John, R. 286 W 77 1X5 W2 55 8X X57 W1 W21 8 X5 12 W 0 5 8X W1 50 12 8X6 W1 1 57 X6 6X 53 6X 10 W1 W W1 1X4 W2 X50 14X W W21 W1 4 1X4 W2 6 4 8X W1 8 W1 W24 8X W1 W1 X50 W21 W10X68 300 W W 5 60 57 8X 1X5 W1 8X7 1 W2 X6 14 W1 W 6X Available Moment φ Mn (foot-kips) 83 X7 14 X55 12 X57 8 W1 330 6 W X7 W12X65 345 315 7 6 W W 40 W21 1X4 360 W21X W24X7 1 55 W2 375 7 6 W1 2 W1 1X6 8X 390 00 12 W2 W1 W12X72 405 X1 W 65 5 7 1X5 8X W1 W2 X5 W21 W14X68 W10X88 420 W21 W12X79 W 450 435 TABLE 3-10 (CONTINUED) W SHAPES 20 22 Civil Engineering TABLE C-A-7.1 AISC APPROXIMATE VALUES OF EFFECTIVE LENGTH FACTOR, K BUCKLED SHAPE OF COLUMN IS SHOWN BY DASHED LINE. Multiplying matrix B by matrix A occurs as follows: R V SA BW H I G C = SC DW : = SS W J K E FW X RT V S_ A : H + B : J i _ A : I + B : K iW C = S_C : H + D : J i _C : I + D : K iW SS W _E : H + F : J i _E : I + F : K i W T X Matrix multiplication is not commutative. tα, n-1 corresponds to the appropriate probability under the t distribution with n-1 degrees of freedom for a given tvar. This field is optional in IPv4 and mandatory in IPv6. If f(x) has a continuous first derivative then the (j +1)st estimate of the root is aj+ 1 = aj - f ^ xh df ^ xh dx x a j = The initial estimate of the root a0 must be near enough to the actual root to cause the algorithm to converge to the root. [Source: ISO JCGM 200:2012 definition 2.16] Sources of errors in measurements arise from imperfections and disturbances in the measurement process, and added noise. . Kinematics of rigid bodies G. Two widely used abstract models for modern computer networks are the open systems interconnect (OSI) model and the TCP/IP model shown in the figure below. Chemical reactions (e.g., stoichiometry, equilibrium, bioconversion) 5–8 4. Columns become rows. Pi = Pyi = hxi where h Pi xi yi P = Henry's Law constant = partial pressure of a gas in contact with a liquid = mol fraction of the gas in the liquid = mol fraction of the gas in the vapor = total pressure Raoult's Law for Vapor-Liquid Equilibrium Valid for concentrations near 1; i.e., xi ≈1 at low pressure (ideal gas behavior) Pi = xi Pi* where Pi = partial pressure of component i xi = mol fraction of component i in the liquid Pi* = vapor pressure of pure component i at the temperature of the mixture 153 Thermodynamics Rigorous Vapor-Liquid Equilibrium For a multicomponent mixture at equilibrium ftiV = ftiL where tf V = fugacity of component i in the vapor phase i tf L = fugacity of component i in the liquid phase i Fugacities of component i in a mixture are commonly calculated in the following ways: For a liquid ftiL = xi γi f iL where xi = mole fraction of component i γi = activity coefficient of component i fiL = fugacity of pure liquid component i t P For a vapor ftiV = yi U i where yi = mole fraction of component i in the vapor t = fugacity coefficient of component i in the vapor U i P = system pressure The activity coefficient γi is a correction for liquid phase nonideality. Examples: code reviews and walkthroughs and compiler syntax and structure checks. For systems with time delay (dead time or transport lag) θ, the transfer function is - is Y ^ sh = xKe s+ 1 R ^ sh The step response for t ≥ θ to a step of magnitude M is where y ^ t h = 9 y0e - t - i /x + KM _1 - e - t - i /x iC u ^t - i h ^ h ^ h u(t) is the unit step function. Life-cycle engineering E. Smith; and Peter Harriott, Unit Operations of Chemical Engineering, 6 ed., New York: McGraw-Hill, 2001, p. c. Analysis (e.g., cost-benefit, trade-off, breakeven) 5–8 479 11–17 5. FE exam results are typically available 7–10 days after you take the exam. This material may be downloaded from ncees.org for personal use only. − d _ tan 1 u i = 1 du dx 1 + u 2 dx − d _cot 1 u i =− 1 du dx 25. To detect and correct errors, redundant bits need to be added to the transmitted data. Torsion Torsion stress in circular solid or thick-walled (t > 0.1 r) shafts: x = Tr J where J = polar moment of inertia Torsional Strain czz = limit r ^Dz/Dz h = r ^dz/dz h Dz " 0 The shear strain varies in direct proportion to the radius, from zero strain at the center to the greatest strain at the outside of the shaft. The first term on the right side of the equation is the linear momentum of a system of particles at time t1. Soil stabilization (e.g., chemical additives, geosynthetics) 10–15 13. Dynamics A. Space-velocity SV is the reciprocal of space-time, SV = 1/τ. (a) (b) THEORETICAL K VALUE AISC-RECOMMENDED DESIGN VALUE WHEN IDEAL CONDITIONS ARE APPROXIMATED 0.5 0.7 1.0 1.0 2.0 2.0 0.65 0.80 1.2 1.0 2.10 2.0 (c) END CONDITION CODE (d) (e) (f) ROTATION FIXED AND TRANSLATION FIXED ROTATION FREE AND TRANSLATION FIXED ROTATION FIXED AND TRANSLATION FREE ROTATION FREE AND TRANSLATION FREE FOR COLUMN ENDS SUPPORTED BY, BUT NOT RIGIDLY CONNECTED TO, A FOOTING OR FOUNDATION, G IS THEORETICALLY INFINITY BUT UNLESS DESIGNED AS A TRUE FRICTION-FREE PIN, MAY BE TAKEN AS 10 FOR PRACTICAL DESIGNS. X1 + X2 + f + Xn n X = X1+ X 2 + f + X k k R1 + R2 + f + Rk R= k X= The R Chart formulas are: CLR = R UCLR = D4R LCLR = D3R The X Chart formulas are: CLX = X UCLX = X + A2R LCLX = X - A2R Standard Deviation Charts n 2 3 4 5 6 7 8 9 10 A3 2.659 1.954 1.628 1.427 1.287 1.182 1.099 1.032 0.975 B3 0 0 0 0 0.030 0.119 0.185 0.239 0.284 B4 3.267 2.568 2.266 2.089 1.970 1.882 1.815 1.761 1.716 UCLX = X + A3 S CLX = X LCLX = X - A3 S UCLS = B4 S CLS = S LCLS = B3 S 82 Engineering Probability and Statistics Approximations The following table and equations may be used to generate initial approximations of the items indicated. When a dirty block is evicted from the cache (due to a replacement), the entire block must be written back to main memory. Licensee's Obligation to the Public 1. Frequency Modulation (FM) The phase deviation is t φ ^ t h = kF -#3 m ^λh dλ rad The frequency-deviation ratio is D= kF max m ^t h 2πW where W is the message bandwidth. 198.51.100.0/24 198.51.100.0– 198.51.100.255 256 Documentation Assigned as TEST-NET-2, documentation and examples. d u/v = v du/dx -2 u dv/dx dv v n n–1 8. Angle Modulation xAng ^t h = Ac cos 72rfct + z ^t hA The phase deviation φ(t) is a function of the message m(t). HexaPacked Binary Decimal decimal Octal BCD Base-2 Base-10 Base-16 Base-8 Code 0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 1010 1011 1100 1101 1110 1111 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 0 1 2 3 4 5 6 7 8 9 A B C D E F 0 1 2 3 4 5 6 7 10 11 12 13 14 15 16 17 389 0000 0001 0010 0011 0100 0101 0110 0111 1000 1001 ------------ Gray Code 0000 0001 0011 0010 0110 0111 0101 0100 1100 1101 1111 1110 1010 1011 1001 1000 Electrical and Computer Engineering Logic Operations and Boolean Algebra Three basic logic operations are the "AND (•)," "OR (+)," and "Exclusive-OR ⊕" functions. A. Similar definitions exist for LC10 and LD10, where the corresponding percentages are 10%. Hearing conservation program requires: (1) testing employee hearing, (2) providing hearing protection at employee's request, and (3) monitoring noise exposure. If a2 > 4b, the solution is of the form (overdamped) y = C1er1x + C2er2 x If a2 = 4b, the solution is of the form (critically damped) y = (C1+ C2x)er1x If a2 < 4b, the solution is of the form

[illegible]

its legal boundaries. Postorder Traversal 1. Trojan, Engineering Materials and Their Applications, 4th ed., Houghton Mifflin Company, 1990. Kinematics of particles B. 291 Civil Engineering Well Drawdown Unconfined aquifer Q ORIGINAL GROUNDWATER LEVEL r2 r1 PERMEABLE SOIL h2 h1 BOTTOM OF AQUIFER IMPERMEABLE Dupuit's Formula Q= where rK `h 22 - h12 j r ln d r2 n 1 Q = flowrate of water drawn from well (cfs) K = coefficient of permeability of soil; hydraulic conductivity (ft/sec) h1 = height of water surface above bottom of aquifer at perimeter of well (ft) h2 = height of water surface above bottom of aquifer at distance r2 from well centerline (ft) r1 = radius to water surface at perimeter of well, i.e., radius of well (ft) r2 = radius to water surface whose height is h2 above bottom of aquifer (ft) ln = natural logarithm Q/Dw = specific capacity Dw = well drawdown (ft) Confined aquifer ORIGINAL PIEZOMETRIC SURFACE H AQUITARD TOP OF AQUIFER PERMEABLE SOIL r1 h2 h1 r2 BOTTOM OF AQUIFER IMPERMEABLE 292 b Civil Engineering Theim Equation Q= T = Kb = transmissivity (ft2/sec) b = thickness of confined aquifer (ft) h1, h2 = heights of piezometric surface above bottom of aquifer (ft) r1, r2 = radii from pumping well (ft) ln = natural logarithm H = height of peizometric surface prior to pumping (ft) Sewage Flow Ratio Curves Ratio of Minimum or of Peak-to-Average Daily Sewage Flow where 2r T `h 2 − h1 j r ln d r2 n 1 P 0.2 Curve A 2: 5 14 + Curve B: 1 4+ P 18 + P Curve G: 4+ P Population in Thousands (P) Design and Construction of Sanitary and Storm Sewers, Water Pollution Control Federation and American Society of Civil Engineers, 1970. Phase equilibrium (e.g., fugacity, activity coefficient, Raoult's law) G. If the final load is P and the corresponding elongation of a tension member is δ, then the total energy U stored is equal to the work W done during loading. Note that the value in the IHL field must include enough extra 32-bit words to hold all the options (plus any padding needed to ensure that the header contains an integer number of 32-bit words). The averages of n observations tend to become normally distributed as n increases. Impersonating any licensee 6. Statically indeterminate systems 5–8 9–14 10–15 489 9–14 9. The integer following the slash indicates the number of leftmost bits that are common to all addresses on the network. Gain margin (GM), which is the additional gain required to produce instability in the unity gain feedback control system. Hypothesis testing and design of experiments (e.g., t-test, outlier testing, analysis of the variance) D. 221 Instrumentation, Measurement, and Control Alloy Combination and Color ANSI Code + Lead − Lead J IRON Fe (magnetic) White CONSTANTAN COPPER-NICKEL Cu-Ni Red K NICKELCHROMIUM Ni-Cr Yellow T COPPER Cu Blue E NICKELCHROMIUM Ni-Cr Purple NICKEL-ALUMINUM Ni-Al (magnetic) Red CONSTANTAN COPPER-NICKEL Cu-Ni Red CONSTANTAN COPPER-NICKEL Cu-Ni Red Outer Jacket Color Maximum Thermocouple Thermocouple Extension Temperature Range Leads Cable Environment Reducing, Vacuum, Inert. The Engineering Probability and Statistics section provides a high-level overview of measurement uncertainty. For an external feature, the virtual condition is equal to the MMC plus the related geometric tolerance. 115 Dynamics Plane Circular Motion A special case of radial and transverse components is for constant radius rotation about the origin, or plane circular motion. Abbreviation ACK Acknowledge ARQ Automatic request BW Bandwidth CRC Cyclic redundancy code DHCP Dynamic host configuration protocol IP Internet protocol LAN Local area network NAK Negative acknowledgement OSI Open systems interconnect TCP Transmission control protocol Protocol Definitions • TCP/IP is the basic communication protocol suite for communication over the Internet. The interest of the public f. Agreements and contracts C. 100 150 200 250 300 400 500 600 700 800 900 1000 1100 1200 1300 1.6940 1.6958 1.9364 2.172 2.406 2.639 3.103 3.565 4.028 4.490 4.952 5.414 5.875 6.337 6.799 7.260 Sat. McCabe's Cyclomatic Complexity c=e–n+2 where for a single program graph, n is the number of nodes, e is the number of edges, and c is the cyclomatic complexity. NCEES offers free institutions reports that break down the performance of students and graduates from their programs, comparing results on specific content areas to national averages. Heat-transfer equipment, operation, and design (e.g., double pipe, shell and tube, fouling, number of transfer units, log-mean temperature difference, flow configuration) 8–12 10. No (Surface) Straightness Ø10±0.2 Ø0.1 Tol. The number of different permutations of n objects taken n at a time, given that ni are of type i, where i = 1, 2, ..., k and ∑ni = n, is n! P _ n; n1, n2, f, nk i = n1!n2!fnk! Sets De Morgan's Law A,B= A+B A+B= A,B Associative Law A , ^ B , C h =] A , Bg , C A + ^ B + C h =] A + Bg + C Distributive Law A , ^ B + C h =] A , Bg + ^ A , C h A + ^ B , C h =] A + Bg , ^ A + C h Laws of Probability Property 1. The Reply Data field will be empty. 9. Pressure vessels and piping F. Cyclone 50% Collection Efficiency for Particle Diameter 0.5 9μW H dpc = > 2π NeVi `ρ p − ρg j dpc μ W Ne Vi ρp ρg = diameter of particle that is collected with 50% efficiency (m) = dynamic viscosity of gas (kg/m•s) = inlet width of cyclone (m) = number of effective turns gas makes in cyclone = inlet velocity into cyclone (m/s) = density of particle (kg/m3) = density of gas (kg/m3) Cyclone Collection Efficiency Cyclone Efficiency (%) where Particle Size Ratio dp d pc Adapted from Cooper, David C., and F.C. Alley, Air Pollution Control: A Design Approach, 2nd ed., Waveland Press, Illinois, 1986. The network interface layer of the TCP/IP model corresponds to the bottom two layers (data link and physical) of the OSI model. Predicting Lower Flammable Limits of Mixtures of Flammable Gases (Le Chatelier's Rule) Based on an empirical rule developed by Le Chatelier, the lower flammable limit of mixtures of multiple flammable gases in air can be determined. Analytic geometry B. Zone Symmetry Datum A A Ø5±0.2 0.1 A Ø10±0.2 Runout Circular Runout Datum A A Ø5±0.2 0.1 A Ø10±0.2 Total Runout Rule #1 Individual Feature of Size Where only a tolerance of size is specified, the limits of size of an individual feature prescribe the extent to which variations in its geometric form, as well as size, are allowed. To implement multiprocessing, the operating system may use hardware threads that exist as a hardware-supported method for better utilization of a particular CPU. The secretary of state of this jurisdiction shall not accept organizational papers nor issue a certificate of incorporation, organization, licensure, or authorization to any firm which includes among the objectives for which it is established or within its name, any of the words "engineer," "engineering," "surveyor," "surveying," or any modification or derivation thereof unless the board has issued for said applicant a certificate of authorization or a letter indicating the eligibility of such applicant to receive such a certificate. Flow measurement B. 44 Mathematics Conic Section Equation The general form of the conic section equation is Ax2 + Bxy + Cy2 + Dx + Ey + F = 0 where not both A and C are zero. 232 Engineering Economics Interest Rate Tables Factor Table - i = 0.50% n 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 30 40 50 60 100 n 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 30 40 50 60 100 P/F 0.9950 0.9901 0.9851 0.9802 0.9754 0.9705 0.9657 0.9609 0.9561 0.9513 0.9466 0.9419 0.9372 0.9326 0.9279 0.9233 0.9187 0.9141 0.9096 0.9051 0.9006 0.8961 0.8916 0.8872 0.8828 0.8610 0.8191 0.7793 0.7414 0.6073 P/F 0.9901 0.9803 0.9706 0.9610 0.9515 0.9420 0.9327 0.9235 0.9143 0.9053 0.8963 0.8874 0.8787 0.8700 0.8613 0.8528 0.8444 0.8360 0.8277 0.8195 0.8114 0.8034 0.7954 0.7876 0.7798 0.7419 0.6717 0.6080 0.5504 0.3697 P/A 0.9950 1.9851 2.9702 3.9505 4.9259 5.8964 6.8621 7.8230 8.7791 9.7304 10.6770 11.6189 12.5562 13.4887 14.4166 15.3399 16.2586 17.1728 18.0824 18.9874 19.8880 20.7841 21.6757 22.5629 23.4456 27.7941 36.1722 44.1428 51.7256 78.5426 P/A 0.9901 1.9704 2.9410 3.9020 4.8534 5.7955 6.7282 7.6517 8.5650 9.4713 10.3676 11.2551 12.1337 13.0037 13.8651 14.7179 15.5623 16.3983 17.2260 18.0456 18.8570 19.6604 20.4558 21.2434 22.0232 25.8077 32.8347 39.1961 44.9550 63.0289 P/G F/A A/P A/F 1.0000 0.4988

3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 Destination port C E U A P R S F N W C R C S S Y I Window Size S R E G K H T N N Urgent pointer (if URG set) Source Port (16 bits) Identifies the sending port Destination Port (16 bits) Identifies the receiving port. Thermodynamic processes (e.g., isothermal, adiabatic, isentropic, phase changes) E. A firm that practices or offers to practice engineering or surveying is required to obtain a certificate of authorization by the board in accordance with the Rules. d(sin u)/dx = cos u du/dx 17. Polar Coordinate System r y x = r cos θ; y = r sin θ; θ = arctan (y/x) r = x + jy = x 2 + y 2 θ x x + jy = r (cos θ + j sin θ) = re jθ [r1(cos θ1 + j sin θ1)][r2(cos θ2 + j sin θ2)] = r1r2[cos (θ1 + θ2) + j sin (θ1 + θ2)] (x + jy)n = [r (cos θ + j sin θ)]n = rn(cos nθ + j sin nθ) r1 `cosi1 + j sini1 j r1 = 9cos _i1 − i2 i + jsin _i1 − i2 iC r `cosi + j sini j r2 2 2 2 36 Mathematics Euler's Identity ejθ = cos θ + j sin θ e−jθ = cos θ - j sin θ cos i = Roots e ji + e -ji e ji - e -ji = , sin i 2 2j If k is any positive integer, any complex number (other than zero) has k distinct roots. economics may require judgments that are not fully addressed simply by application of the code. Piezoelectric effect-the electromechanical and the electrical state in crystalline materials. Rate constant (e.g., Arrhenius function) C. Organic vapors and dusts associated with grain handling often contain toxic yeasts or molds and have low oxygen contents. The heat of formation is defined as the enthalpy change associated with the formation of a compound from its atomic species as they normally occur in nature [i.e., O2(g), H2(g), C(solid), etc.] The heat of reaction varies with the temperature as follows: T DH%r ^T h = DH%r _Tref i + # DcpdT Tref where Tref is some reference temperature (typically 25°C or 298 K), and: Δcp = / νi cp, i − / νi cp, i products reactants and cp,i is the molar heat capacity of component i. For the two-source configuration with an ideal operational amplifier, R2 R1 va v0 = - vb v0 R2 R2 v d1 nv R1 a + + R1 b If va = 0, we have a non-inverting amplifier with R v 0 = d1 + 2 n v b R1 If vb = 0, we have an inverting amplifier with v0 = - R2 v R1 a Common Mode Rejection Ratio (CMRR) − v2 + − A(v1 − v2) − + v1 + − Equivalent Circuit of an Ideal Op Amp In the op-amp circuit shown the differential input is defined as: vid = v1 - v2 The common-mode input voltage is defined as: vicm = (v1 + v2)/2 381 + v0 − Electrical and Computer Engineering The output voltage is given by: vO = Avid + Acmvicm In an ideal op amp Acm = 0. Convective heat transfer (natural and forced) C. Total Length This 16-bit field defines the entire packet size in bytes, including header and data. Transmission Control Protocol TCP Header Offsets Octet Octet Bit 0 0 Source port 4 32 Sequence number 8 64 Acknowledgment number (if ACK set) 12 96 Data offset 16 128 Checksum 20 ... Medium peripheral-speed mills J. B. Surface Water Resources and Hydrology A. Consistency of the fine with past fines for similar offenses, or justification for the fine amount Model Law, Section 150.30 Grounds for Disciplinary Action—Unlicensed Individuals A. AT LEAST MATERIAL CONDITION (When applied to a tolerance value) AT LEAST MATERIAL BOUNDARY (When applied to a datum reference) An MMB and an LMB, where at least one boundary is a specified shape that is not a uniform offset from true profile. Engineering Management A. The second term on the right side of the equation is the angular impulse of the moment M0 from time t1 to t2. Law of Total Probability P(A + B) = P(A) + P(B) – P(A, B) where P(A + B) = the probability that either A or B occur alone or that both occur together = the probability that A occurs P(A) = the probability that B occurs P(B) P(A, B) = the probability that both A and B occur simultaneously 64 Engineering Probability and Statistics Property 3. Spring Material: The strength of the spring wire may be found as shown in the section on linear springs. Dx " 0 y l = the slope of the curve f (x) . Provides composite control of all surface elements. All rights reserved. Estimation for a single mean (e.g., point, confidence intervals) D. A has an inverse. OUTER JACKET + LEAD − LEAD Typical Thermocouple (TC) Cable From Convectronics Inc., as posted on www.convectronics.com, July 2013. An additional equation for velocity as a function of position may be written as v 2 = v02 + 2a0 _s - s0i For constant angular acceleration, the equations for angular velocity and displacement are a ^ t h = a0 ~ ^ t h = a0 _t − t0 j + ~0 i ^ t h = a0 _t − t0 j /2 + ~0 _t − t0 j + i0 2 where θ θ0 ω ω0 α0 t t0 = angular displacement = angular displacement at time t0 = angular velocity = angular velocity at time t0 = constant angular acceleration = time = some initial time An additional equation for angular velocity as a function of angular position may be written as ~ 2 = ~02 + 2a0 _i − i0 j 117 Dynamics Projectile Motion y v0 θ x The equations for common projectile motion may be obtained from the constant acceleration equations as ax = 0 vx = v0 cos(θ) x = v0 cos(θ)t + x0 ay = −g vy = −gt + v0 sin(θ) y = −gt2/2 + v0 sin(θ)t + y0 Non-constant Acceleration When non-constant acceleration, a(t), is considered, the equations for the velocity and displacement may be obtained from v ^ t h = # a ^x h dx + vt0 t t0 s ^ t h = # v ^x h dx + st0 t t0 For variable angular acceleration t ~ ^t h = # a ^xh dx + ~t0 t0 t i ^t h = # ~ ^xh dx + it0 t0 where τ is the variable of integration Concept of Weight W = mg where W = weight (N or lbf) m = mass (kg or lbf-sec2/ft) g = local acceleration of gravity (m/s2 or ft/sec2) 118 Dynamics Particle Kinetics Newton's second law for a particle is ΣF = d(mv)/dt where ΣF = sum of the applied forces acting on the particle m = mass of the particle v = velocity of the particle For constant mass, ΣF = m dv/dt = ma One-Dimensional Motion of a Particle (Constant Mass) When motion exists only in a single dimension then, without loss of generality, it may be assumed to be in the x direction, and ax = Fx /m where Fx = the resultant of the applied forces, which in general can depend on t, x, and vx. 0.85 0.81 0.75 0.65 0.55 0.45 ≤ 2 hr /day V < 30 in. 126 Dynamics Torsional Vibration kt I θ For torsional free vibrations it may be shown that the differential equation of motion is where θp + ` kt I j θ = 0 θ = angular displacement of the system kt = torsional stiffness of the massless rod I = mass moment of inertia of the end mass The solution may now be written in terms of the initial conditions i ^0h = i0 and io ^0h = io 0 as i ^t h = i cos _~ t i + _io /~ i sin _~ t i 0 n 0 n n where the undamped natural circular frequency is given by ~n = kt /I The torsional stiffness of a solid round rod with associated polar moment-of-inertia J, length L, and shear modulus of elasticity G is given by kt = GJ/L Thus the undamped circular natural frequency for a system with a solid round supporting rod may be written as ~n = GJ/IL Similar to the linear vibration problem, the undamped natural period may be written as 2r 2r = xn = 2r/~n = GJ kt IL I 127 Dynamics Figure Mass & Centroid y c z L x c = ρLA = L/2 =0 =0 = cross-sectional area of rod ρ = mass/vol. # block offset bits = log2(block size) = log2(B) 408 Electrical and Computer Engineering Microprocessor Architecture – Harvard ALU INSTRUCTION MEMORY CONTROL UNIT DATA MEMORY I/O Multicore A multicore processor is a single computing component with two or more independent actual processing units (called cores), which are the units that read and execute program instructions. The board may designate a professional engineer, on the basis of education, experience, and examination, as being licensed in a specific discipline or branch of engineering signifying the area in which the engineer has demonstrated competence. Host Used for loopback addresses to the local host. The first term on the right side of the equation is the angular momentum of a system of particles at time t1. Static Loading Failure Theories Brittle Materials Maximum-Normal-Stress Theory The maximum-normal-stress theory states that failure occurs when one of the three principal stresses equals the strength of the material. Transportation and storage (e.g., belts, pneumatic, slurries, tanks, hoppers) 12. It provides for full-duplex, half-duplex, or simplex operation, and establishes checkpointing, adjournment, termination, and restart procedures. Turbines Turbines produce power by extracting energy from a working fluid. However, the SDS information enables the employer to develop an active program of worker protection measures, including training, which is specific to the individual workplace, and to consider any measures that may be necessary to protect the environment. Safety is also the control of known threats to attain an acceptable level of risk. z' c M = rR2ts xc = yc = zc = 0 ts = mass/area y THIN CIRCULAR DISK z V = 2 π R3 3 c 3 8 R y' R x 3 M = 2 rR t 3 xc = yc = 0 3 zc = 8 R t = mass/vol. Leveling (e.g., differential, elevations, percent grades) 10. Structural Engineering A. Model Law, Section 160.70 Grounds for Disciplinary Action—Firms Holding a Certificate of Authorization A. IEEE 1284 is a common interface. Blowers (e.g., power, inlet/outlet pressure, efficiency, operating point, parallel, series) G. Examples include: Bubble Sort: continuously steps through a list, swapping items until they appear in the correct order. An object can have a heat capacity that would be expressed as energy/degree. Ideal-Impulse Sampling xd ^ t h = m ^ t h / d _t - nTs i = / m _nTs i d _t - nTs i n =+3 n =+3 n =-3 n =-3 k =+3 Xd _ f i = M _ f i) < fs / d _f - kfs iF k =-3 = fs / M _f - kfs i k =+3 k =-3 The message m(t) can be recovered from xδ (t) with an ideal low-pass filter of bandwidth W if fs > 2 W. First-Order Linear Nonhomogeneous Differential Equations x dy + y = Kx ^t h dt y ^0h = KA x ^t h =) A t0 τ is the time constant K is the gain 51 Mathematics The solution is y ^t h = KA +] KB - KAg c1 - exp b -xt l m or t KB - KA x = 1n < KB - y F Second-Order Linear Homogeneous Differential Equations with Constant Coefficients An equation of the form y″+ ay′+ by = 0 can be solved by the method of undetermined coefficients where a solution of the form y = Cerx is sought. The efficiency η of a heat engine is given by: η = W/QH = (QH − QL)/QH The most efficient engine possible is the Carnot Cycle. Ma ≡ Vc V ≡ mean fluid velocity Isentropic Flow Relationships In an ideal gas for an isentropic process, the following relationships exist between static properties at any two points in the flow. Flow through a pipe is generally characterized as laminar for Re < 2,100 and fully turbulent for Re > 10,000, and transitional flow for 2,100 < Re < 10,000. Where feature control frames contain the same datums in the same order of precedence with the same modifying symbols, they are considered a single composite pattern. Data is processed in the order it entered the buffer. Vector operations D. Minor Losses in Pipe Fittings, Contractions, and Expansions Head losses also occur as the fluid flows through pipe fittings (i.e., elbows, valves, couplings, etc.) and sudden pipe contractions and expansions. If y is kept fixed, the function z = f (x, y) becomes a function of the single variable x, and its derivative (if it exists) can be found. Minimum Heat Flux Minimum heat flux, which occurs at the Leidenfrost point, it represents the lower limit for the heat flux in the film boiling regime. E., "Engineering Anthropometry," Ergonomics, Vol. V z = Vactual ideal Thermodynamics COMMON THERMODYNAMIC CYCLES Carnot Cycle Reversed Carnot Otto Cycle (Gasoline Engine) η=1−r q=0 1−k r = v 1 /v 2 Rankine Cycle Refrigeration q wT q wc q q p2 = p3 h4 = h 3 p2 = p3 η= (h3 − h 4) − (h 2 −h 1) COP ref = h3 − h 2 172 h 1 − h4 h 2 − h1 COP HP = h2 − h3 h 2 − h1 Thermodynamics Refrigeration and HVAC Cycles Refrigeration and HVAC Two-Stage Cycle out in, 1 in, 2 in T 2 6 3 7 4 8 1 5 s The following equations are valid if the mass flows are the same in each stage. where A′ = area above the layer (or plane) upon which the desired transverse shear stress acts y l = distance from neutral axis to area centroid b = width or thickness or the cross-section Transverse shear flow: q = VQ/I Deflection of Beams Using 1/ρ = M/(EI), d 2y = M, differential equation of deflection curve dx 2 d 3y EI 3 = dM ^ x h /dx = V dx d 4y EI 4 = dV ^ x h /dx =− w dx Determine the deflection curve equation by double integration (apply boundary conditions applicable to the deflection and/or slope). Power Screws Square Thread Power Screws: The torque required to raise, TR, or to lower, TL, a load is given by Fμ d Fd l + πμd TR = 2 m e πd − μl o + 2c c m Fμ d Fd πμd − l TL = 2 m e πd m+ μl o + 2c c m where dc dm l F μ μc = mean collar diameter = mean thread diameter = lead = load = coefficient of friction for thread = coefficient of friction for collar The efficiency of a power screw may be expressed as η = Fl/(2πT) Power Transmission Shafts and Axles Static Loading: The maximum shear stress and the von Mises stress may be calculated in terms of the loads from 1 2 2 9_ i ^ h2C 3 8M + Fd + 8T rd 1 2 2 4 vl = 3 9_8M + Fd i + 48T 2C rd xmax = where M F T d 2 = bending moment = axial load = torque = diameter 433 Mechanical Engineering Fatigue Loading: Using the maximum-shear-stress theory combined with the Soderberg line for fatigue, the diameter and safety factor are related by 2 where 2 1 2 rd3 = >f Mm + K f Ma p + f Tm + K fsTa p H 32 n Sy Se Sy Se d = diameter n = safety factor Ma = alternating moment Mm = mean moment Ta = alternating torque Tm = mean torque Se = fatigue limit Sy = yield strength Kf = fatigue strength reduction factor Kfs = fatigue strength reduction factor for shear Gearing Involute Gear Tooth Nomenclature Circular pitch pc = πd/N Base pitch pb = pc cos φ Module m = d/N Center distance C = (d1 + d2)/2 where N = number of teeth on pinion or gear d = pitch circle diameter φ = pressure angle Gear Trains: Velocity ratio, mv, is the ratio of the output velocity to the input velocity. (1998) Chin, David, Water-Resources Engineering, 2nd ed., Pearson, 2006, p. Media mills I. d(u + v − w)/dx = du/dx + dv/dx – dw/dx 5. 256–261. DeWitt, Introduction to Heat Transfer, 4th ed., John Wiley and Sons, 2002, pp. Economics A. Laminar and turbulent flow D. Also controls surface flatness. Compressible flow (e.g., Mach number, isentropic flow relationships, normal shock) G. In a three-dimensional space, the distance between two points is d= ^ x2 - x1h + _ y2 - y1i + ^ z2 - z1h 2 2 2 Logarithms The logarithm of x to the Base b is defined by logb (x) = c c where b = x Special definitions for b = e or b = 10 are: ln x, Base = e log x, Base = 10 To change from one Base to another: logb x = (loga x)/(loga b) e.g., ln x = (log10 x)/(log10 e) = 2.302585 (log10 x) 35 Mathematics Identities logb bn = n log xc = c log x; xc = antilog (c log x) log xy = log x + log y logb b = 1; log 1 = 0 log x/y = log x – log y Algebra of Complex Numbers Complex numbers may be designated in rectangular form or polar form. Rmo i `hi + Vi2 /2 + gZi j − Rmo e `he + Ve2 /2 + gZe j + Qo in − Woout = 0 and Rmo i = Rmo e where mo = mass flowrate (subscripts i and e refer to inlet and exit states of system) g = acceleration of gravity Z = elevation V = velocity Qo in = net rate of heat transfer into the system Woout = net rate of work out of the system 148 Thermodynamics Special Cases of Steady-Flow Energy Equation Nozzles, Diffusers: Velocity terms are significant. The severity of the violation and the risk of harm to the public d. 64:ff9b::/96 64:ff9b::0.0.0. 0 64:ff9b::255.255.255.255 232 Global Internet IPv4/IPv6 translation. Injury rate 2. Abbreviation Name Jurisdiction ANSI CGA CSA FAA IEC ITSNA MSHA NFPA NIOSH OSHA RCRA UL USCG USDOT USEPA American National Standards Institute Compressed Gas Association Canadian Standards Association Federal Aviation Administration International Electrotechnical Commission Intertek Testing Services NA (formerly Edison Testing Labs) Mine Safety and Health Administration National Fire Protection Association National Institute for Occupational Safety and Health Occupational Safety and Health Administration Resource Conservation and Recovery Act Underwriters Laboratories United States Coast Guard United States Department of Transportation United States Environmental Protection Agency Nonprofit standards organization Nonprofit trade association Nonprofit standards organization Federal regulatory agency Nonprofit standards organization Nationally recognized testing laboratory Federal regulatory agency Nonprofit trade association Federal regulatory agency Federal regulatory agency Federal law Nationally recognized testing laboratory Federal regulatory agency Federal regulatory agency Federal regulatory agency Safety and Prevention A traditional preventive approach to both accidents and occupational illness involves recognizing, evaluating, and controlling hazards and work conditions that may cause physical or other injuries. TAG INDEX BLOCK OFFSET • Tag – These are the most significant bits of the address, which are checked against the current row (the row that has been retrieved by index) to see if it is the one needed or another, irrelevant memory location that happened to have the same index bits as the one wanted. Time value of money (e.g., present value, future value, annuities) B. Impulse and momentum (e.g., linear, angular) F. Deformations (e.g., axial, torsion, bending, thermal) D. Sampling (e.g., aliasing, Nyquist theorem) B. GHS LABEL ELEMENTS Product Name or Identifier (Identify Hazardous Ingredients, where appropriate) Signal Word Physical, Health, Environmental Hazard Statements Supplemental Information Precautionary Measures and Pictograms First Aid Statements Name and Address of Company Telephone Number Occupational Safety and Health Administration, A Guide to The Globally Harmonized System of Classification and Labelling of Chemicals (GHS), United States Department of Labor, 15 Safety GHS PICTOGRAMS AND HAZARD CLASSES • FLAMMABLES • SELF-REACTIVES • PYROPHORICS • SELF-HEATING • EMITS FLAMMABLE GAS • ORGANIC PEROXIDES • EXPLOSIVES • SELF-REACTIVES • ORGANIC PEROXIDES • ACUTE TOXICITY (SEVERE) • CORROSIVES • GASES UNDER PRESSURE • CARCINOGEN • RESPIRATORY SENSITIZER • REPRODUCTIVE TOXICITY • TARGET ORGAN TOXICITY • MUTAGENICITY • ASPIRATION TOXICITY • ENVIRONMENTAL TOXICITY • IRRITANT • DERMAL SENSITIZER • ACUTE TOXICITY (HARMFUL) • NARCOTIC EFFECTS • RESPIRATORY TRACT IRRITATION • OXIDIZERS Occupational Safety and Health Administration, A Guide to The Globally Harmonized System of Classification and Labelling of Chemicals (GHS), United States Department of Labor, 16 Safety TRANSPORT PICTOGRAMS FLAMMABLE LIQUID FLAMMABLE GAS FLAMMABLE AEROSOL FLAMMABLE SOLID SELF-REACTIVE SUBSTANCES PYROPHORICS (SPONTANEOUSLY COMBUSTIBLE) SELF-HEATING SUBSTANCES 1 SUBSTANCES, WHICH IN CONTACT WITH WATER, EMIT FLAMMABLE GASES (DANGEROUS WHEN WET) OXIDIZING GASES OXIDIZING LIQUIDS OXIDIZING SOLIDS EXPLOSIVE DIVISIONS 1.1, 1.2, 1.3 1.4 1.5 1.6 1 1 1 EXPLOSIVE DIVISION 1.4 EXPLOSIVE DIVISION 1.5 EXPLOSIVE DIVISION 1.6 ACUTE TOXICITY (POISON): ORAL, DERMAL, INHALATION CORROSIVE 2 COMPRESSED GASES MARINE POLLUTANT MARINE POLLUTANT 5.2 ORGANIC PEROXIDES Occupational Safety and Health Administration, A Guide to The Globally Harmonized System of Classification and Labelling of Chemicals (GHS), United States Department of Labor, 17 Safety ACUTE ORAL TOXICITY LD50 CATEGORY 1 CATEGORY 2 CATEGORY 3 CATEGORY 4 CATEGORY 5 ≤ 5 mg/kg > 5 < 50 mg/kg ≥ 50 < 300 mg/kg ≥ 300 < 2,000 mg/kg ≥ 2,000 < 5,000 mg/kg PICTOGRAM SIGNAL WORD NO SYMBOL DANGER HAZARD STATEMENT FATAL IF SWALLOWED DANGER DANGER WARNING WARNING FATAL IF SWALLOWED TOXIC IF SWALLOWED HARMFUL IF SWALLOWED MAY BE HARMFUL IF SWALLOWED Safety Data Sheet (SDS) The SDS provides comprehensive information for use in workplace chemical management. EI (dy/dx) = ∫M(x) dx EI EIy = ∫[∫M(x) dx] dx The constants of integration can be determined from the physical geometry of the beam. The following area ratio holds for any Mach number. Storativity or storage coefficient of an aquifer, S: The volume of water taken into or released from storage per unit surface area per unit change in potentiometric (piezometric) head. GHS is a comprehensive approach to: • Defining health, physical, and environmental hazards of chemicals • Creating classification processes that use available data on chemicals for comparison with the defined hazard criteria • Communicating hazard information, as well as protective measures, on labels and Safety Data Sheets (SDSs), formerly called Material Safety Data Sheets (MSDSs). P = pressure γ = specific weight of fluid h = height g = acceleration of gravity ρ = fluid density Another device that works on the same principle as the manometer is the simple barometer. Magnesium non-carbonate hardness removal MgSO4 + Ca(OH)2 + Na2CO3 → CaCO3(s) + Mg(OH)2(s) + 2Na+ + SO42− 6. The element aij refers to row i and column j. Network Optimization Assume we have a graph G(N, A) with a finite set of nodes N and a finite set of arcs A. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without the prior written permission of NCEES. Other symbols are defined as before. ny = n and the standard deviation vy = v n 67 Engineering Probability and Statistics t-Distribution Student's t-distribution has the probability density function given by: v+1 v+1 Cc 2 m 2 − 2 c1 + t m f^ t h = v v vr C a 2 k where v = number of degrees of freedom n = sample size v=n-1 Γ = gamma function xr - n t= s/ n -∞ ≤ t ≤ ∞ A table later in this section gives the values of tα, v for values of α and v. Also controls flatness of each individual surface. ECN is an optional feature that is only used when both endpoints support it and are willing to use it. Roll crushers E. U = overall heat-transfer coefficient based on area A and the log mean temperature difference [W/(m2•K)] ΔTlm = log mean temperature difference (K) Log Mean Temperature Difference (LMTD) For counterflow in tubular heat exchangers DTlm = _THo - TCi i - _THi - TCoi ln d THo - TCi n THi - TCo For parallel flow in tubular heat exchangers ΔTlm = `THo − TCo j − `THi − TCi j T −T ln e THo − TCo o Hi where Ci ΔTlm = log mean temperature difference (K) THi = inlet temperature of the hot fluid (K) THo = outlet temperature of the hot fluid (K) TCi = inlet temperature of the cold fluid (K) TCo = outlet temperature of the cold fluid (K) 215 Heat Transfer Heat Exchanger Effectiveness, ε Qo actual heat transfer rate f= o = maximum possible heat transfer rate Qmax f= where C _T - TCi i CH _THi - THoi or f = C Co Cmin _THi - TCi i Cmin _THi - TCi i C = mc o P = heat capacity rate (W/K) Cmin = smaller of CC or CH Number of Transfer Units (NTU) NTU = UA Cmin Effectiveness-NTU Relations C Cr = min = heat capacity ratio Cmax For parallel flow concentric tube heat exchanger f= 1 - exp 8- NTU ^1 + Cr hB 1 + Cr NTU = - ln 81 - f ^1 + Cr hB 1 + Cr For counterflow concentric tube heat exchanger f= 1 - exp 8- NTU ^1 - Cr hB 1 - Crexp 8- NTU ^1 - Cr hB f = NTU 1 + NTU 1 ln f - 1 NTU = Cr - 1 c fCr - 1 m NTU = f 1- f ^Cr< 1h ^Cr = 1h ^Cr< 1h ^Cr = 1h Overall Heat-Transfer Coefficient for Concentric Tube and Shell-and-Tube Heat Exchangers D ln e Do o R R fi fo i 1 = 1 + + + + 1 Ao hoAo UA hiAi Ai 2rkL where Ai = inside area of tubes (m2) Ao = outside area of tubes (m2) Di = inside diameter of tubes (m) Do = outside diameter of tubes (m) hi = convection heat-transfer coefficient for inside of tubes [W/(m2•K)] ho = convection heat-transfer coefficient for outside of tubes [W/(m2•K)] k = thermal conductivity of tube material [W/(m•K)] Rfi = fouling factor for inside of tube [(m2•K)/W] Rfo = fouling factor for outside of tube [(m2•K)/W] 216 Heat Transfer Radiation Types of Bodies Any Body For any body α+ρ+τ=1 where α = absorptivity (ratio of energy absorbed to incident energy) ρ = reflectivity (ratio of energy reflected to incident energy) τ = transmissivity (ratio of energy transmitted to incident energy) Opaque Body For an opaque body α + ρ = 1 Gray Body A gray body is one for which where α = ε, (0 < α < 1; 0 < ε < 1) ε = the emissivity of the body For a gray body ε+ρ=1 Real bodies are frequently approximated as gray bodies. Carboxylic Acids The name of each linear carboxylic acid is unique to the number of carbon atoms it contains. The centroid and then the moment of inertia are found on the transformed section for use in the bending stress equations. Licensee's Obligation to Other Licensees 1. This layer interacts with software applications that implement a communicating component. Reproduced with permission of John Wiley & Sons, Inc. Average 0.5 Baffled inlet or outlet with some intra-basin baffles. Traverse the right sub-tree. 1 + sT2 227 Instrumentation, Measurement, and Control First-Order Control System Models The transfer function model for a first-order system is where Y^ s h K = xs + 1 ^ h R s K = steady-state gain τ = time constant The step response of a first-order system to a step input of magnitude M is y ^t h = y0e- t x t x + KM _1 - e- i In the chemical process industry, y0 is typically taken to be zero, and y(t) is referred to as a deviation variable. Aiding or assisting another person in violating any provision of this Act or the rules or regulations of the board 9. τN-reactors = Nτindividual 1 N C = N >e A0 o k CAN where − 1H N = number of CSTRs (equal volume) in series CAN = concentration of A leaving the Nth CSTR Two Irreversible Reactions in Parallel kD A " D ^desired h kU A " U ^undesired h x y − rA =− dcA/dt = kD C A + k U C A x r D = dcD/dt = kD C A y r U = dcU /dt = kU C A Y D = instantaneous fractional yield of D = d C D / _− d C A i Y D = overall fractional yield of D = N D f / ` N A0 − N A f j where NAf and NDf are measured at the outlet of the flow reactor. The statements usually insert, select, delete or update stored data in the SQL database. The values are shared with those used for the IPv4 protocol field, as both fields have the same function. When the system pressure is 1 atm, an ideal-gas mixture is assumed. Engineering 1. Both version 4 (IPv4) and version 6 (IPv6) are used and can co-exist on the same network. Linear algebra H. Transmission lines (high frequency) 480 4–6 11–17 4–6 12. a= where f DT α = thermal expansion coefficient ε = engineering strain ΔT = change in temperature 104 Materials Science/Structure of Matter Specific heat (also called heat capacity) is the amount of heat required to raise the temperature of something or an amount of something by 1 degree. Source Address This field is the IPv4 address of the sender of the packet. The economic benefits gained by the violator as a result of noncompliance 5. Diffusion Diffusion Coefficient D = Do e−Q/(RT) where D = diffusion coefficient Do = proportionality constant Q = activation energy R = gas constant [8.314 J/(mol•K)] T = absolute temperature Thermal and Mechanical Processing Cold working (plastically deforming) a metal increases strength and lowers ductility. Hardenability: The "ease" with which hardness can be obtained. Providing false testimony or information to the board 13. 5 Ethics and Professional Practice Model Law, Section 110.20 Definitions A. Instrumentation, Measurement, and Control Wheatstone Bridge – an electrical circuit used to measure changes in resistance. P0 = 1 - ρ Lq = (λ2σ2 + ρ2)/[2 (1 − ρ)] L = ρ + Lq Wq = Lq / λ W = Wq + 1/μ Poisson Input—Erlang Service Times, σ2 = 1/(kμ2) Lq = [(1 + k)/(2k)][(λ2)/(μ (μ− λ))] = [λ2/(kμ2) + ρ2]/[2(1 − ρ)] Wq = [(1 + k)/(2k)]{λ /[μ (μ − λ)]} W = Wq + 1/μ 419 Industrial and Systems Engineering Multiple Server Model (s > 1) Poisson Input—Exponential Service Times Because calculations for P0 and Lq can be time consuming, the following table gives formulas for 1, 2, and 3 servers. Σ FH = 0 and Σ FV = 0 where FH = horizontal forces and member components FV = vertical forces and member components Plane Truss: Method of Sections The method consists of drawing a free-body diagram of a portion of the truss in such a way that the unknown truss member force is exposed as an external force. Bearing capacity H. Algebra and trigonometry B. Sauer, Jr., Principles of Heating, Ventilating and Air Conditioning, 6th ed., American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2009, p. Health Hazards and Risk Assessment A. Flammability is further defined with lower and upper limits: LFL = lower flammability limit (volume % in air) UFL = upper flammability limit (volume % in air) The LFL is also known as the lower explosive limit (LEL). In particular, the threads of a process share its instructions (executable code) and its context (the values of its variables at any given moment). Component Direct costs Purchased equipment-delivered (including fabricated equipment and process machinery such as pumps and compressors) Purchased-equipment installation Range 100 39–47 Instrumentation and controls (installed) 9–18 Piping (installed) 16–66 Electrical (installed) 10–11 Buildings (including services) 18–29 Yard improvements 10–13 Service facilities (installed) 40–70 Land (if purchase is required) 6 Total direct plant cost 264–346 Indirect costs Engineering and supervision 32–33 Construction expenses 34–41 Total direct and indirect plant costs 336–420 Contractor's fee (about 5% of direct and indirect plant costs) 17–21 Contingency (about 10% of direct and indirect plant costs) 36–42 Fixed-capital investment 387–483 Working capital (about 15% of total capital investment) Total capital investment 68–86 455–569 257 Chemical Engineering Scaling of Equipment Costs The cost of Unit A at one capacity related to the cost of a similar Unit B with X times the capacity of Unit A is approximately Xn times the cost of Unit B. Bridging may occur at the top surface due to condensation and resulting spoilage creating a crust. If the shortest job time is the time at the first work center, schedule it first, otherwise schedule it last. Loads, load combinations, and load paths (e.g., dead, live, lateral, influence lines and moving loads, tributary areas) G. Incineration DRE = Win - Wout # 100% Win where DRE = destruction and removal efficiency (%) Win = mass feed rate of a particular POHC (kg/h or lb/h) Wout = mass emission rate of the same POHC (kg/h or lb/h) POHC = principal organic hazardous contaminant CO2 CE = # 100% CO2 + CO where CO2 = volume concentration (dry) of CO2 (parts per million; volume, ppmv) CO = volume concentration (dry) of CO (ppmv) CE = combustion efficiency Kiln Formula t= where 2.28 L/D SN t = mean residence time (min) L/D = internal length-to-diameter ratio S = kiln rake slope (in./ft of length) N = rotational speed (rev/min) Energy Content of Waste Typical Waste Values Food Waste Paper Cardboard Plastics Wood Glass Bi-metallic Cans Moisture, % 70 6 5 2 20 2 3 317 Energy, Btu/lb 2,000 7,200 7,000 14,000 8,000 60 300 Environmental Engineering Indoor Air Quality Material Balance where dC V dt i = QCo + S − QCi − kCiV V = volume of the room (m3) ng o m3 ng Co = concentration of the pollutant in the outside air e 3 o m 3 m d n Q = ventilation rate hr ng S = source emission rate inside the room d n hr k = removal reaction rate constant (assumed here to be first order) (hr –1) Ci = indoor concentration of this pollutant e where Ci = indoor concentration of pollutant = Ciss _1 − e −t τ i+ Coe −t τ S Ciss = steady state concentration of indoor pollutant = x c ACo + V m τ A = time constant = (A + k)–1 Q = air exchange rate = V , air changes per hour (ach) Air Infiltration Rates into Homes with Windows Closed Layout of Room No windows or exterior doors Windows or exterior doors on one wall Windows or exterior doors on two walls Windows or exterior doors on three walls Air Exchange Rate (air changes per hour, ach) 0.5 1.0 1.5 2.0 Approximate Volume Flow Rate of Outdoor Air where 13, 000 n QOA . If a Fourier series representing a periodic function is truncated after term n = N the mean square value FN2 of the truncated series is given by Parseval's relation. Limited Use in Oxidizing at High Temperatures. Addition of Two Matrices A+G B+H C+I A B C G H I = G+= G=> H D+J E+K F+L D E F J K L Identity Matrix The matrix I = (aij) is a square n × n matrix with 1's on the diagonal and 0's everywhere else. However, once the moments of inertia have been determined about an axis passing through a body's mass center, it may be transformed to another parallel axis. Electronics A. 2 Full 4 1 0.5 1/4 Bending 1.0 1/2 2 2 2.0 Full Torsional and Shear 3 Good: Simplest to implement, but must use a dummy gauge if compensating for temperature. The instructions are ordinary CPU instructions such as Add, Move Data, and Branch, but the multiple cores can run multiple instructions at the same time, increasing overall speed for programs amenable to parallel computing. Flow measurement (e.g., pitot tube, venturi meter, weir) J. Zone R 0.1 Tol. C iB iC iB B Same as for NPN with current directions and voltage polarities reversed. Entropy ds = _1 T i dqrev 2 s2 − s1 = #1 _1 T i dqrev Inequality of Clausius # _1 T i dqrev # 0 #1 2 _1 T i dq # s2 - s1 Isothermal, Reversible Process Δs = s2 – s1 = q/T Isentropic Process Δs = 0; ds = 0 A reversible adiabatic process is isentropic. Can the employee strain muscles by pushing, pulling, or lifting? Dual Linear Program Associated with the above linear programming problem is another problem called the dual linear programming problem. Construction Engineering A. Adapted from ASME Y14.5–2018, American Society of Mechanical Engineers, 2018. If M is an N-digit value of base-r, the radix complement R(M) is defined by R(M) = r N – M The 2's complement of an N-bit binary integer can be written 2's Complement (M) = 2N – M This operation is equivalent to taking the 1's complement (inverting each bit of M) and adding one. 542. However, an increase in water without a corresponding increase in cement reduces the concrete strength. Power Systems A. Occupational health (e.g., PPE, noise pollution, safety screening) 8. Pumps (e.g., power, operating point, parallel, series) E. Water quality (e.g., ground and surface, basic water chemistry) J. D UI VOLUME LIQ SSS GLA L STA CRY Tg Tm TEMPERATURE The volume temperature curve as shown above is often used to show the difference between amorphous and crystalline solids. Expected value and expected error in decision making C. The payback period is the period of time required for the profit or other benefits of an investment to equal the cost of the investment. In the absence of known effects, use ke = 1. Radiation D. No licensee granted inactive status may practice or offer to practice engineering in this jurisdiction unless otherwise exempted in this Act. Human factors (e.g., displays, controls, usability, cognitive engineering) B. The Impulse-Momentum Principle The resultant force in a given direction acting on the fluid equals the rate of change of momentum of the fluid. hfg Sat. DeWitt, Fundamentals of Heat and Mass Transfer, 3rd ed., Wiley, 1990. 2 = The Data field contains an IPv4 address which is the Subject of this Query 0 = A successful reply. Ethers Ethers are generally designated by naming the alkyl groups and adding the word ether. The vector form of a force is F = Fx i + Fy j Resultant (Two Dimensions) The resultant, F, of n forces with components Fx,i and Fy,i has the magnitude of 2 2 1 2 F = >e / Fx, i o + e / Fy, i o H n i=1 n i=1 The resultant direction with respect to the x-axis is i = arctan e ! Fy, i n i=1 ! Fx, i o n i=1 Resolution of a Force Fx = F cos θx Fy = F cos θy Fz = F cos θz cos θx = Fx /F cos θy = Fy /F cos θz = Fz /F Separating a force into components when the geometry of force is known and R = Fx = (x/R)F Fy = (y/R)F x2 + y2 + z2 Fz = (z/R)F Moments (Couples) A system of two forces that are equal in magnitude, opposite in direction, and parallel to each other is called a couple. Any further increase in applied forces will cause motion. Linear programming and optimization (e.g., formulation, solution, interpretation) C. There are significant work terms and a single-mass stream. If σ1 ≥ σ2 ≥ σ3, then the theory predicts that yielding will occur whenever τmax ≥ Sy /2 where Sy is the yield strength. When h = k = 0, Eccentricity: e = 1 + _b 2/a 2i = c/a b = a e 2 - 1; Focus: (± ae, 0); Directrix: x = ± a/e Brink, R.W., A First Year of College Mathematics, D. Thermoplastic polymers are either semicrystalline or amorphous. Xn is approximately normal. Case 2: Allowances are based on workday. # dx = + ax bx + c 2 2ax + b − tan 1 2 4ac − b 4ac − b 2 27b. SODIUM HYDROXIDE 0 CONCENTRATION, % METHANOL 0 ACID, NITRIC 100 AMMONIA, AQUEOUS 200 ACID, HYDROCHLORIC 300 ACID, ACETIC TEMPERATURE, °F KEY TO CHARTS HYDROGEN PEROXIDE Detailed Corrosion Data on Construction Materials DRY AERATED 600°F AERATED OR AIR-FREE 12½ 25 37½ NEOPRENE = SATISFACTORY = FOR LIMITED USE ONLY = UNSATISFACTORY POLYETHYLENE = COMPLETE RESISTANCE = SOME ATTACK = ATTACK OR DECOMPOSITION RUBBER, BUTYL = SATISFACTORY = SATISFACTORY FOR LIMITED USE = GENERALLY UNSATISFACTORY STAINLESS STEEL, TYPE 316 = < 0.002 IN. This reference provides materials drawn from the ASME Y14.5 standard: "GD&T is an essential tool for communicating design intent—that parts from technical drawings have the desired form, fit, function and interchangeability." GD&T helps the designer provide information about the size, geometry, and location of features for mechanical parts. Manufacturing processes (e.g., machining, casting, welding, forming, dimensioning, new technologies) B. Calculus (e.g., single-variable, integral, differential) C. Therefore, one must distinguish the pound-force (lbf) from the pound-mass (lbm). Stresses and strains (e.g., diagrams, axial, torsion, bending, shear, thermal) C. The length is set to zero when a Hop-by-Hop extension header carries a Jumbo Payload option. This value is decremented by one at each forwarding node and packet discarded if it becomes 0. A confined space has limited or restricted means for entry or exit and is not designed for continuous employee occupancy. This serves as an indication of network congestion (or impending congestion) to the TCP sender. 496. However, there may be situations in which applying the code may raise more difficult issues. 396 Electrical and Computer Engineering IPv4 Header Format Offsets Octet Octet Bit 0 0 4 32 8 64 0 0 1 2 3 1 4 Version 5 6 7 8 9 IHL 10 11 2 12 DSCP 13 14 15 17 18 ECN 19 3 20 21 22 23 24 25 26 27 28 29 30 31 Total Length Identification Time To Live 16 Flags Protocol Fragment Offset Header Checksum 12 96 Source IP Address 16 128 Destination IP Address 20 160 24 192 28 224 32 256 Options (if IHL > 5) Version The first header field in an IP packet is the four-bit version field. The cofactor of this element is the value of the minor of the element (if i + j is even), and it is the negative of the value of the minor of the element (if i + j is odd). If, in addition, the density is constant, then Q is constant. Errata To report errata in this book, send your correction using our chat feature or your account on NCEES.org. Cation – Positive ion Anion – Negative ion Standard Oxidation Potentials for Corrosion Reactions* Potential, Eo, Volts Corrosion Reaction vs. The dose below which there are no harmful effects Reference Dose Reference dose (RfD) is determined from the Noncarcinogenic Dose-Response Curve using NOAEL. As of June 1, 2015, the HCS requires new SDSs to be in a uniform format, and include the section numbers, the headings, and associated information under the headings below: Section 1, Identification: Includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use Section 2, Hazard(s) identification: Includes all hazards regarding the chemical; required label elements Section 3, Composition/information on ingredients: Includes information on chemical ingredients; trade secret claims Section 4, First-aid measures: Includes important symptoms/effects, acute, and delayed; required treatment Section 5, Fire-fighting measures: Lists suitable extinguishing techniques, equipment; chemical hazards from fire Section 6, Accidental release measures: Lists emergency procedures; protective equipment; proper methods of containment and cleanup Section 7, Handling and storage: Lists precautions for safe handling and storage, including incompatibilities Section 8, Exposure controls/personal protection: Lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE) Section 9, Physical and chemical properties: Lists the chemical's characteristics Section 10, Stability and reactivity: Lists chemical stability and possibility of hazardous reactions Section 11, Toxicological information: Includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity Section 12, Ecological information* Section 13, Disposal considerations* Section 14, Transport information* Section 15, Regulatory information* Section 16, Other information: Includes the date of preparation or last revision *Note: Since other Agencies regulate this information, OSHA will not be enforcing Sections 12 through 15 (29 CFR 1910.1200(g)(2)). Also, a, c, and n represent constants. Finite State Machine A finite state machine consists of a finite set of states Si = {s0, s1, ..., sn} and a finite set of inputs I; and a transition function f that assigns to each state and input pair a new state. An organization may develop its own database of normal element durations, and normal times for new or changed tasks may be predicted if the tasks consist entirely of elements whose normal times are already in the database. DIMENSION ORIGIN The symbolic means of indicating a toleranced dimension between two features originates from one of these features and not the other. Scanning 3. Care must be exercised during computations to correctly compute the algebraic sign of the work term. Bernoulli equation (hydrostatic pressure, velocity head) E. 224.0.0.0/4 224.0.0.0– 239.255.255.255 268435456 Internet In use for IP multicast. The change in kinetic energy is the work done in accelerating the rigid body from ω0 to ω i Iq ~ 2/2 = Iq ~02 /2 + # Mqdi i0 Kinetic Energy In general the kinetic energy for a rigid body may be written as T = mv 2/2 + Ic ~ 2/2 For motion in the xy plane this reduces to 2 2 2 T = m ` vcx + vcy j /2 + Ic ~ z /2 For motion about an instant center, T = IICω2/2 Principle of Angular Impulse and Momentum Rigid Body (Plane Motion) (Hc)1 + Σ∫Mc dt = (Hc)2 where Hc = Icω (H0)1 + Σ∫M0 dt = (H0)2 where H0 = I0ω Subscript c indicates center of mass. An axis to surface control. Equivalent Spring Constant Springs in series: 1 k1 /1 keq = i ki Springs in parallel: k2 ki k1 k2 keq = / ki i ki Spring Material: The minimum tensile strength of common spring steels may be determined from Sut = A/d m where Sut is the tensile strength in MPa, d is the wire diameter in millimeters, and A and m are listed in the following table: Material Music wire Oil-tempered wire Hard-drawn wire Chrome vanadium Chrome silicon ASTM m A A228 A229 A227 A232 A401 0.163 0.193 0.201 0.155 0.091 2060 1610 1510 1790 1960 Maximum allowable torsional stress for static applications may be approximated as Ssy = τ = 0.45Sut cold-drawn carbon steel (A227, A228, A229) Ssy = τ = 0.50Sut hardened and tempered carbon and low-alloy steels (A232, A401) 431 Mechanical Engineering Compression

ACWP = Actual cost of work performed (Actual) BCWP = Budgeted cost of work performed (Earned) Variances CV = BCWP - ACWP (Cost variance = Earned - Actual) SV = BCWP - BCWS (Schedule variance = Earned - Planned) Indices BCWP CPI = ACWP = Cost Performance Index = Earned m Actual Planned BAC = Original project estimate (Budget at completion) ETC = BAC - BCWP CPI EAC = _ ACWP + ETC i _Estimate to complete i _Estimate at completion i 309 EARLY FINISH ACTIVITY DESCRIPTION DURATION FLOAT LATE START Forecasting B LATE FINISH Environmental Engineering Air pollution Nomenclature where P _ MW i ng = ppb # RT m3 ppb = parts per billion P = pressure (atm) R = ideal gas law constant = 0.0821 L•atm/(mole•K) T = absolute temperature (K) = 273.15 + °C MW = molecular weight (g/mole) Atmospheric Dispersion Modeling (Gaussian) σy and σz are a function of downwind distance and stability class. OSI MODEL TCP/IP MODEL APPLICATION PRESENTATION APPLICATION SESSION TRANSPORT TRANSPORT NETWORK INTERNET DATA LINK NETWORK INTERFACE PHYSICAL Tanenbaum, Andrew S., Computer Networks, 3rd ed., Prentice Hall, 1996, p. Fundamental Principles A. If a2 + b2 – c equals zero, a point at (–a, –b). Basic hydrogeology (e.g., aquifer properties, soil characteristics, subsurface) B. Societal Considerations "Creating a sustainable world that provides a safe, secure, healthy life for all peoples is a priority of the US engineering community. International tolerance (IT) grade numbers designate groups of tolerances such that the tolerance for a particular IT number will have the same relative accuracy for a basic size. Internet Protocol version 4 Header The IPv4 packet header consists of 14 fields, of which 13 are required. Materials Science A. Certification or Licensure 1. Remember that the applicant is considered as minimum evidence that the applicant is qualified for certification as an engineer intern. The following shall be considered as minimum evidence that ... needed to solve exam questions—such as the cover, introductory material, index, and exam specifications—will not be included in the PDF version. Biological processes (e.g., activated sludge, fixed film, lagoons, phytoremediation, aerobic, anaerobic, anoxic) F. Statistics (e.g., distributions, mean, mode, standard deviation, confidence interval, regression and curve fitting) 8–12 2. Merge Sort: divides the list into the smallest unit (e.g., 1 element), then compares each element with the adjacent list to sort and merge the two adjacent lists. Disciplinary action by another jurisdiction, foreign country, or the United States government, if at least one of the grounds for discipline is the same or substantially equivalent to those contained in this Act 6. Single-variable calculus C. Statistical control (e.g., control limits) 4–6 3. In the sliding window protocol, each outbound frame contains a sequence number. P ten n5 num ags prote Plati . AC circuit analysis (e.g., resistors, capacitors, inductors) D. Risk always involves both probability and severity elements. As a 4-bit field, the maximum value is 15 words (15 × 32 bits, or 480 bits = 60 bytes). Maximum, Mi – A sum term which contains an occurrence of every variable in the function. Unfortunately, there is no scientific basis for predicting element times without breaking them down into motion-level parts. d(uvw)/dx = uv dw/dx + uw dv/dx + vw du/dx ^ h 7. Any other use requires prior permission of ASCE. A binary tree is a special case of a tree in which each node can have no more than two children nodes. * FOR SATURATED LIQUID AT –40°F 80 R-410A 1000 800 600 80 70 0 60 –40 –100 2000 Refrigerant 410A [R-32/125 (50/50)] Properties of Liquid on Bubble Line and Vapor on Dew Line Pressure, psia Temp.,* °F Bubble Dew Density, lb/ft3 Volume, ft3/lb Liquid Vapor Enthalpy, Btu/lb-°F Liquid Vapor Entropy, Btu/lb-°F Liquid Vapor Specific Heat cp Btu/lb-°F Liquid Vapor Cp/Cv Vapor Thermal Conductivity Btu/hr-ft-°F Liquid Vapor Pressure, psia –135.16 –134.98 92.02 47.6458 –30.90 100.62 –0.08330 0.32188 0.3215 0.1568 1.228 0.1043 0.00421 1 1.5 –126.03 –125.87 91.10 32.5774 –27.97 101.90 –0.07439 0.31477 0.3213 0.1600 1.227 0.1023 0.00431 1.5 2.5 –119.18 –119.02 90.41 24.8810 –25.76 102.86 –0.06786 0.30981 0.3213 0.1626 1.227 0.1008 0.00439 2 2.5 –113.63 –113.48 89.84 20.1891 –23.98 103.63 –0.06267 0.30602 0.3214 0.1648 1.228 0.0996 0.00446 2.5 3 –108.94 –108.78 89.36 17.0211 –22.47 104.27 –0.05834 0.30296 0.3216 0.1668 1.228 0.0985 0.00451 3 4 –101.22 –101.07 88.57 13.0027 –19.98 105.33 –0.05133 0.29815 0.3220 0.1702 1.229 0.0968 0.00461 4 5 –94.96 –94.81 87.92 10.5514 –17.96 106.18 –0.04574 0.29455 0.3226 0.1733 1.230 0.0954 0.00469 5 6 –89.63 –89.48 87.36 8.8953 –16.24 106.89 –0.04107 0.29162 0.3231 0.1760 1.232 0.0942 0.00476 6 7 –84.98 –84.83 86.87 7.6992 –14.74 107.50 –0.03704 0.28916 0.3236 0.1785 1.233 0.0931 0.00482 7 8 –80.83 –80.68 86.43 6.7935 –13.40 108.05 –0.03349 0.28704 0.3241 0.1807 1.234 0.0922 0.00488 8 10 –73.70 –73.56 85.67 5.5105 –11.08 108.97 –0.02743 0.28356 0.3251 0.1848 1.237 0.0905 0.00498 10 12 –67.62 –67.48 85.02 4.6434 –9.10 109.75 –0.02235 0.28075 0.3261 0.1884 1.240 0.0891 0.00507 12 14 –62.31 –62.16 84.44 4.0168 –7.36 110.42 –0.01795 0.27840 0.3270 0.1917 1.243 0.0879 0.00515 14 14.70b –60.60 –60.46 84.26 3.8375 –6.80 110.63 –0.01655 0.27766 0.3274 0.1928 1.244 0.0875 0.00517 14.70b 16 –57.56 –57.42 83.93 3.5423 –5.80 111.01 –0.01407 0.27638 0.3279 0.1947 1.246 0.0868 0.00522 16 18 –53.26 –53.12 83.47 3.1689 –4.39 111.54 –0.01059 0.27461 0.3288 0.1975 1.248 0.0858 0.00528 18 20 –49.34 –49.19 83.02 2.8684 –3.09 112.01 –0.00743 0.27305 0.3297 0.2002 1.251 0.0849 0.00535 20 22 –45.70 –45.56 82.61 2.6225 –1.89 112.45 –0.00452 0.27164 0.3305 0.2027 1.254 0.0841 0.00540 22 24 –42.32 –42.18 82.23 2.4151 –0.77 112.85 –0.00184 0.27037 0.3313 0.2050 1.256 0.0833 0.00546 24 26 –39.15 –39.01 81.87 2.2386 0.28 113.22 0.00067 0.26919 0.3321 0.2073 1.259 0.0826 0.00551 26 28 –36.17 –36.02 81.54 2.0865 1.27 113.56 0.0030 0.26811 0.3329 0.2094 1.261 0.0819 0.00556 28 30 –33.35 –33.20 81.21 1.9540 2.22 113.88 0.0052 0.26711 0.3337 0.2115 1.264 0.0813 0.00561 30 32 –30.68 –30.53 80.91 1.8375 3.11 114.18 0.0073 0.26617 0.3344 0.2135 1.266 0.0807 0.00566 32 34 –28.13 –27.98 80.62 1.7343 3.97 114.47 0.0093 0.26530 0.3352 0.2154 1.269 0.0801 0.00570 34 36 –25.69 –25.54 80.33 1.6422 4.79 114.74 0.0112 0.26448 0.3360 0.2173 1.272 0.0795 0.00574 36 Thermodynamics 166 I * F Refrigerant 410A [R-32/125 (50/50)] Properties of Liquid on Bubble Line and Vapor on Dew Line Pressure, psia Temp.,* °F Bubble Dew Density, lb/ft3 Liquid Volume, ft3/lb Vapor Enthalpy, Btu/lb-°F Liquid Vapor Entropy, Btu/lb-°F Liquid Vapor Specific Heat cp Btu/lb-°F Liquid Vapor Cp/Cv Vapor Thermal Conductivity Btu/hr-ft-°F Liquid Vapor Pressure, psia 38 –23.36 –23.20 80.05 1.5598 5.57 115.00 0.0130 0.26371 0.3368 0.2191 1.274 0.0790 0.00578 38 40 –21.12 –20.96 79.79 1.4857 6.33 115.24 0.0147 0.26297 0.3374 0.2208 1.277 0.0785 0.00582 40 42 –18.96 –18.81 79.54 1.4168 7.06 115.47 0.0163 0.26228 0.3382 0.2226 1.279 0.0780 0.00586 42 44 –16.89 –16.73 79.29 1.3558 7.77 115.68 0.0179 0.26162 0.3389 0.2242 1.282 0.0775 0.00590 44 46 –12.94 –12.79 78.82 1.2460 9.11 116.10 0.0209 0.26038 0.3403 0.2275 1.287 0.0766 0.00597 48 –11.07 –10.91 78.59 1.1979 9.75 116.30 0.0223 0.25980 0.3410 0.2290 1.290 0.0762 0.00601 48 ... 117.16 0.0288 0.25722 0.3445 0.2365 1.301 0.0743 0.00619 60 65 1.43 1.60 77.06 0.9287 14.05 117.53 0.0317 0.25610 0.3462 0.2400 1.308 0.0734 0.00628 65 70 5.10 5.27 76.60 0.8... 0.00645 75 80 11.88 12.06 75.73 0.7576 17.70 118.49 0.0395 0.25316 0.3512 0.2499 1.326 0.0711 0.00653 80 85 15.03 15.21 75.32 0.7135 18.81 118.77 0.0418 0.25231 0.3528 0.253... 119.26 0.0461 0.25072 0.3561 0.2592 1.345 0.0692 0.00677 95 100 23.71 23.89 74.17 0.6070 21.90 119.48 0.0482 0.24999 0.3578 0.2622 1.352 0.0685 0.00684 100 110 28.96 29.14 ... 0.0664 0.00715 120 130 38.46 38.65 72.13 0.4655 27.25 120.56 0.0589 0.24618 0.3678 0.2795 1.392 0.0654 0.00730 130 140 42.80 42.99 71.51 0.4314 28.85 120.83 0.0621 0.24508 ... 0.3755 31.85 121.29 0.0679 0.24304 0.3781 0.2965 1.435 0.0628 0.00775 160 170 54.56 54.76 69.75 0.3523 33.27 121.48 0.0706 0.24210 0.3816 0.3022 1.451 0.0620 0.00791 170 18... Properties of Liquid on Bubble Line and Vapor on Dew Line (con't) Pressure, psia Temp.,* °F Bubble Dew Density, lb/ft3 Liquid Volume, ft3/lb Vapor Enthalpy, Btu/lb-°F Liquid Vapor Entropy, Btu/lb-°F Liquid Vapor ...

[illegible]

Kenyon, Fluid Mechanics, Wiley, 1980. Flammability Flammable describes any solid, liquid, vapor, or gas that will ignite easily and burn rapidly. If σ1 ≥ σ2 ≥ σ3, then the theory predicts that failure occurs whenever σ1 ≥ Sut or σ3 ≤ – Suc where Sut and Suc are the tensile and compressive strengths, respectively. Helmholtz Free Energy, ΔA Energy released or absorbed in a reaction occurring reversibly at constant volume and temperature. Conversely, licensees serving as members, advisors, or employees of a government body or department, who are the principals or employees of a private concern, shall not participate in decisions with respect to professional services offered or provided by said concern to the governmental body that they serve. Violating any terms of any Order imposed or agreed to by the board or using a seal or practicing engineering or surveying while the firm's certificate of authorization is inactive or restricted 10. H)2 Free and Forced Vibration A single degree-of-freedom vibration system, containing a mass m, a spring k, a viscous damper c, and an external applied force F can be diagrammed as shown: EQUILIBRIUM POSITION x c k m 125 F Dynamics The equation of motion for the displacement of x is: mxp =− kx − cxo + F or in terms of x, mxp + cxo + kx = F One can define ~n = k m c 2 km 1 K= k g= Then: 1 + 2g + = xp ~ xo x KF n ~ 2n If the externally applied force is 0, this is a free vibration, and the motion of x is solved as the solution to a homogeneous ordinary differential equation. Van Nostrand Co./Wadsworth Publishing Co., 1949. 224 Instrumentation, Measurement, and Control Examples of Common Chemical Sensors Sensor Type Principle Materials Analyte Semiconducting oxide sensor Conductivity impedance SnO2, TiO2, ZnO2, WO3, polymers O2, H2, CO, SOx, NOx, combustible hydrocarbons, alcohol, H2S, NH3 Electrochemical sensor (liquid electrolyte) Amperiometric composite Pt, Au catalyst H2, O2, O3, CO, H2S, SO2, NOx, NH3, glucose, hydrazine Ion-selective electrode (ISE) Potentiometric glass, LaF3, CaF2 pH, K+, Na+, Cl–, Ca2, Mg2+, F–, Ag+ Solid electrode sensor Amperiometric Potentiometric YSZ, H+-conductor YSZ, β-alumina, Nasicon, Nafion O2, H2, CO, combustible hydrocarbons, O2, H2, CO2, CO, NOx, SOx, H2S, Cl2 H2O, combustible hydrocarbons Piezoelectric sensor Mechanical w/ polymer film quartz combustible hydrocarbons, VOCs Catalytic combustion sensor Calorimetric Pt/Al2O3, Pt-wire H2, CO, combustible hydrocarbons Pyroelectric sensor Calorimetric Pyroelectric + film Vapors Optical sensors Colorimetric fluorescence optical fiber/indicator dye Acids, bases, combustible hydrocarbons, biologicals Reprinted with permission from Journal of The Electrochemical Society, 150 (2),

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diameter 1.20 Tray, sieve, c.s. 3- to 10-ft diameter 0.86 Motor, squirrel cage, induction, 440 volts, explosion proof Classification of Cost Estimates Class of Estimate Level of Project Definition (as % of Complete Definition) Class 5 0% to 2% Class 4 1% to 15% Class 3 10% to 40% Class 2 30% to 70% Class 1 50% to 100% Methodology (Estimating Method) Typical Purpose of Estimate Stochastic or Judgement Primarily Stochastic Mixed but Primarily Stochastic Primarily Deterministic Screening or Feasibility Concept Study or Feasibility Budget, Authorization, or Control Control or Bid/Tender Check Estimate or Bid/Tender Deterministic Expected Accuracy Range (+/– Range Relative to Best Index of 1) Preparation Effort (Relative to Lowest Cost Index of 1) 4 to 20 1 3 to 12 2 to 4 2 to 6 3 to 10 1 to 3 5 to 20 1 10 to 100 (From AACE Recommended Practice No. 17R-97 [4], AACE International, 209 Prairie Ave., Morgantown, WV;) Whiting, Wallace B., Turton, Richard, Shaeiwitz, Joseph A., Bhattacharyya, Debangsu, and Bailie, Richard C., Analysis, Synthesis and Design of Chemical Processes, 4th ed., Prentice Hall, 2012, p. D. The possible options that can be put in the header are as follows: Size (bits) Field Copied Description 1 Set to 1 if the options need to be copied into all fragments of a fragmented packet. 451 Mechanical Engineering HVAC Nomenclature h = specific enthalpy hf = specific enthalpy of saturated liquid mo a = mass flowrate of dry air mo w = mass flowrate of water Qo = rate of heat transfer Twb = wet bulb temperature ω = specific humidity (absolute humidity, humidity ratio) HVAC—Pure Heating and Cooling MOIST AIR ma 1 2 Q ω 1 2 or 2 1 Qo = mo a _h2 - h1 i T 452 Mechanical Engineering Cooling and Dehumidification Qout MOIST AIR ma 2 1 3 LIQUID OUT Qo out = mo a 9_h1 − h 2 i − h f3 _~1 − ~ 2 iC mw mo w = mo a _~1 − ~ 2 i ω 1 2 T Heating and Humidification mw 3 Qin WATER OR STEAM MOIST AIR ma 2 1 4, 4' ω 4 4' 2 1 T Qo in = mo a_ h2 - h1i mo w = mo a_~4l - ~2i or mo w = mo a_~4 - ~2i 453 Mechanical Engineering Adiabatic Humidification (evaporative cooling) MOIST AIR ma 1 2 WATER 3 mw ω 2 T wb = C ON ST AN T 1 T h2 = h1 + h3 _~2 − ~1 i mo w = mo a _~2 − ~1 i h3 = h f at Twb Adiabatic Mixing MOIST AIR ma1 3 1 2 MOIST AIR ma2 ω 2 3 1 mo a3 = mo a1 + mo a2 mo h + mo a2h2 h3 = a1 1 mo a3 mo ~ + mo a2 ~2 ~3 = a1 1 mo a3 T 454 ma3 Mechanical Engineering Cycles and Processes Internal Combustion Engines Diesel Cycle P 2 3 s=C s=C 4 1 v T 3 P=C 2 r = V1 V2 rc = V3 V2 h = 1− r k−1 > k = cp cv 1 r ck − 1 H ^cold air standardh k _rc − 1 j 4 v=C 1 s Brake Power R N where F Wob = 2πTN = 2πFRN Wo b T N F R = brake power (W) = torque (N•m) = rotation speed (rev/s) = force at end of brake arm (N) = length of brake arm (m) 455 Mechanical Engineering Indicated Power Woi = Wob + Wo f where Wo i = indicated power (W) Wo f = friction power (W) Brake Thermal Efficiency Wob ηb = mo f ^ HV h where ηb = brake thermal efficiency mo f = fuel consumption rate (kg/s) HV = heating value of fuel (J/kg) Indicated Thermal Efficiency Wo i hi = mo f ^ HV h Mechanical Efficiency h Wo hi = ob = hb i Wi Displacement Volume B Vc Cylinder Piston S 2 Vd = rB S , m3 for each cylinder 4 Total volume (m3) = Vt = Vd + Vc Vc = clearance volume (m3) Compression Ratio rc = Vt /Vc 456 Mechanical Engineering Mean Effective Pressure (mep) o s Wn mep = V n N d c where ns = number of crank revolutions per power stroke nc = number of cylinders Vd = displacement volume per cylinder mep can be based on brake power (bmep), indicated power (imep), or friction power (fmep). d. The energy loss shows up as a decrease in fluid pressure (head). A × B = A B n sin θ where n = unit vector perpendicular to the plane of A and B Gradient, Divergence, and Curl dz = c 2 i + 2 j + 2 k m z 2x 2y 2z d : V = c 2 i + 2 j + 2 k m : _V1i + V2j + V3k i 2x 2y 2z d # V = c 2 i + 2 j + 2 k m # _V1i + V2j + V3k i 2x 2y 2z 59 Mathematics The Laplacian of a scalar function φ is d2 z = Identities 22 z 22 z 22 z + + 2x 2 2y 2 2z 2 A • B = B • A; A • (B + C) = A • B + A • C A • A = |A|2 i•i=j•j=k•k=1 i•j=j•k=k•i=0 If A • B = 0, then either A = 0, B = 0, or A is perpendicular to B. unbraced length 286 W shapes dimensions and properties 284 X Y yield 155 yielding 281 U Z ultimate bearing capacity 264 ultrafiltration 345 uniaxial loading and deformation 131 uniaxial stress-strain 130 unified design provisions 277 Unified Soil Classification System 267 unit hydrograph 291 unit normal distribution 76 units in FE exam 1 unsaturated acyclic hydrocarbons 89 user datagram protocol 402 z-transforms 370 V Vadose zone penetration 323 vaporized liquids 29 vapor-liquid equilibrium (VLE) 153, 246 variable loading failure theories 447 variances 309 vectors 59 vectors: gradient, divergence, and curl 59 vectors: identities 60 velocity pressure exposure coefficient 274 Venturi meters 196 vertical curve formulas 308 vertical curves 300 vertical stress profiles 264 vertical stress profiles with surcharge 264 vibrations 449 viscosity 177 470 Appendix: FE Exam Specifications

471 Fundamentals of Engineering (FE) CHEMICAL CBT Exam Specifications Effective Beginning with the July 2020 Examinations • The FE exam is a computer-based test (CBT). Risk Assessment Guidance for Superfund. In IPv6 only the source port field is optional. Normality of Solutions – The product of the molarity of a solution and the number of valence changes taking place in a reaction. 149 Thermodynamics Upper limit of COP is based on reversed Carnot Cycle: COPc = TH /(TH – TL) for heat pumps and COPc = TL /(TH – TL) for refrigeration. # sin x dx = – cos x 11. Holbrow, J. e. Analytical chemistry (e.g., wet chemistry and instrumental chemistry) D. Visit the root node. 152 Thermodynamics Combustion Processes First, the combustion equation should be written and balanced. Any fraud or deceit in obtaining or attempting to obtain or renew a certificate of authorization 2. Use an inflation adjusted interest rate per interest period d for computing present worth values P. Concurrent force systems C. Henry Rushton, 1952, v. 345 Environmental Engineering Typical Removal Credits and Inactivation Requirements for Various Treatment Technologies Process Conventional Treatment Resulting Typical Log Disinfection Log Removal Credits Inactivation Requirements Giardia Viruses Giardia Viruses 0.5 2.0 2.5 2.0 Direct Filtration 2.0 1.0 1.0 3.0 Slow Sand Filtration 2.0 2.0 1.0 2.0 Diatomaceous Earth Filtration 2.0 1.0 1.0 3.0 0 0 3.0 4.0 Unfiltered Guidance Manual LT1ESWTR Disinfection Profiling and Benchmarking, U.S. Environmental Protection Agency, 2003. The pound-force is that force which accelerates one pound-mass at 32.174 ft/sec2. Identification This field is an identification field and is primarily used for uniquely identifying the group of fragments of a single IP datagram. For direct central impact with no external forces m1v1 + m2v2 = m1vl1 + m2vl2 where m1, m2 = masses of the two bodies v1, v2 = velocities of the bodies just before impact v l1, v l2 = velocities of the bodies just after impact For impacts, the relative velocity expression is e= where _vl2 in − _vl1 in _v1 in − _v2 in = coefficient of restitution e (vi)n = velocity normal to the plane of impact just before impact _ v li in = velocity normal to the plane of impact just after impact 121 Dynamics The value of e is such that 0 ≤ e ≤ 1, with limiting values e = 1, perfectly elastic (energy conserved) e = 0, perfectly plastic (no rebound) Knowing the value of e, the velocities after the impact are given as ^v l1hn = ^v l2hn = m2 ^v2hn ^1 + eh + ^m1 - em2h ^v1hn m1 + m2 m1 ^v1hn ^1 + eh - ^em1 - m2h ^v2hn m1 + m2 Friction The Laws of Friction are 1. Properties data and phase diagrams of pure components and mixtures (e.g., steam tables, psychrometric charts, T-s, P-h, x-y, T-x-y) C. This is also expressed as: the curvature of a curve at a given point is the rate-of-change of its inclination with respect to its arc length. It has the following format: Offsets Octet Octet Bit 0 0 4 32 8 64 12 96 16 128 20 160 24 192 28 224 32 256 36 288 0 0 1 2 3 1 4 Version 5 6 7 8 9 10 11 2 12 13 14 15 16 17 18 19 3 20 21 22 23 24 25 26 27 28 29 30 31 Flow Label Traffic Class Payload Length Next Header Hop Limit Source Address Destination Address Version (4 bits) The constant 6 (bit sequence 0110). Using the same basic formula with only minor substitutions, safety managers can calculate the following types of incidence rates: 1. k t P2 T ^ k - 1h d 2n = d t2 n P1 = T1 1 k The stagnation temperature, T0, at a point in the flow is related to the static temperature as follows: 2 T0 = T + V 2 : cp Energy relation between two points: V2 V2 h1 + 21 = h2 + 22 Vennard, J.K., Elementary Fluid Mechanics, 6th ed., J.K. Vennard, 1954. This number is a key design parameter. Worker Deaths by Electrocution; A Summary of NIOSH Surveillance and Investigative Findings, U.S. Health and Human Services, (NIOSH), 1998. Codes of ethics (e.g., NCEES Model Law, professional and technical societies, ethical and legal considerations) B. A power series, which is convergent in the interval –R < x < R, defines a function of x that is continuous for all values of x within the interval and is said to represent the function in that interval. Societal impacts (e.g., economic, sustainability, life-cycle analysis, environmental, public safety) 5–8 492 8–12 6. Professional Surveyor (Professional Land Surveyor, Professional Surveyor and Mapper, Geomatics Professional, or equivalent term); See Model Law. Licensees shall undertake assignments only when qualified by education or experience in the specific technical fields of engineering or surveying involved. Corresponds to a fall afternoon, or a cloudy summer day, or clear summer day with the sun 15-35°. Internal flow E. Limited Use in Vacuum or Reducing. 50 Mathematics Taylor's Series ^ h 2 n f l^a h f m^ a h f n ^a h f ^ x h = f ^a h + 1! _ x − a i + 2! _ x − a i + ... Over time, sufficient experience with common situations has resulted in the development of a standard. If a row of piezometers were placed at intervals along the pipe, the grade line would join the water levels in the piezometer water columns. • CWR (1 bit): Congestion Window Reduced (CWR) flag is set by the sending host to indicate that it received a TCP segment with the ECE flag set and had responded in congestion control mechanism. (ΔL/L)1 = (ΔL/L)2 where ΔL = change in length of the composite L = original length of the composite Hardenability Hardness: Resistance to penetration. Nodal Processing Delay – It takes time to examine the packet's header and determine where to direct the packet to its destination. 9 Ethics and Professional Practice D. Power screws H. At constant pressure the amount of heat (Q) required to increase the temperature of something by ΔT is CpΔT, where Cp is the constant pressure heat capacity. The number of different permutations of n distinct objects taken r at a time is n! P ^n, r h = ^n - rh ! nPr is an alternative notation for P(n,r) 2. Expenses do not include capital items, which should be depreciated. A constant of integration should be added to the integrals. Mass balance and loading rates (e.g., removal efficiencies) C. Measuring devices (e.g., voltmeter, ammeter, wattmeter) E. 15. Principles and tools (e.g., planning, organizing, motivational theory, organizational structure) B. Phase relations C. The figure above shows how W/C expressed as a ratio of weight of water and cement by weight of concrete mix affects the compressive strength of both air-entrained and non-air-entrained concrete. 200 250 300 350 400 500 600 700 800 900 1000 1100 1200 1300 0.2404 0.2608 0.2931 0.3241 0.3544 0.3843 0.4433 0.5018 0.5601 0.6181 0.6761 0.7340 0.7919 0.8497 0.9076 Superheated Water Tables u h kJ/kg kJ/kg p = 0.01 MPa (45.81oC) s kJ/(kg·K) v m3/kg 2437.9 2443.9 2515.5 2587.9 2661.3 2736.0 2812.1 2968.9 3132.3 3302.5 3479.6 3663.8 3855.0 4053.0 4257.5 4467.9 4683.7 2584.7 2592.6 2687.5 2783.0 2879.5 2977.3 3076.5 3279.6 3489.1 3705.4 3928.7 4159.0 4396.4 4640.6 4891.2 5147.8 5409.7 8.1502 8.1749 8.4479 8.6882 8.9038 9.1002 9.2813 9.6077 9.8978 10.1608 10.4028 10.6281 10.8396 11.0393 11.2287 11.4091 11.5811 2506.1 2506.7 2582.8 2658.1 2733.7 2810.4 2967.9 3131.6 3301.9 3479.2 3663.5 3854.8 4052.8 4257.3 4467.7 4683.5 2675.5 2676.2 2776.4 2875.3 2974.3 3074.3 3278.2 3488.1 3704.4 3928.2 4158.6 4396.1 4640.3 4891.0 5147.6 5409.5 7.3594 7.3614 7.6134 7.8343 8.0333 8.2158 8.5435 8.8342 9.0976 9.3398 9.5652 9.7767 9.9764 10.1659

10.3463 10.5183 0.8857 2553.6 2564.5 2646.8 2726.1 2804.8 2884.6 2964.4 3129.2 3300.2 3477.9 3662.4 3853.9 4052.0 4256.5 4467.0 4682.8 2738.6 2752.8 2860.5 2964.2 3066.8 3170.1 3273.4 3484.9 3702.4 3926.5 4157.3 4395.1 4639.4 4890.2 5146.8 5408.8 5408.8 6.8959 6.9299 7.1706 7.3789 7.5662 7.7324 7.8985 8.1913 8.4558 8.6987 8.9244

Mathematics Given: f(t) 2 V0 t T 2T T 0 2 then f 2 "t n = f 2 ^t h = V0 x 2V0 x 3 in ... Question: What is the Fourier Transform and its Inverse ... Duality X (t) x(-f) x(t) ... Modulation ... Multiplication x(t) y(t) ... Convolution x(t)*y(t) ... Differentiation ... Integration ...

Properties of Single-Component Systems ... CONTENTS Units and Conversion Factors ... Ethics and Professional Practice ... Safety, Health, and Environment ... Mathematics ... Engineering Probability and Statistics ... Chemistry ... Materials Science/Structure of Matter ... Statics ... Dynamics ... Mechanics of Materials ... Thermodynamics ... Fluid Mechanics ... Heat Transfer ... Instrumentation, Measurement, and Control ... Engineering Economics ... Chemical Engineering ... Civil Engineering ... Environmental Engineering ... Electrical and Computer Engineering ... Industrial and Systems Engineering ... Mechanical Engineering ...

Units and Conversion Factors. Distinguishing pound-force from pound-mass. The FE exam and this handbook use both the metric system of units and the U.S. Customary System (USCS).

Elemental Fluid Mechanics ... Hydraulic Radius ... Shear Stress ... Reynolds Number ... Bernoulli Equation ... Energy Equation ... Continuity Equation ... Momentum ... Pump Power Equation ... Fan Characteristics ... Compressible Flow ... Mach Number ...

Chemical Engineering ... Chemical Reaction Engineering ... Mass Transfer ... Distillation ... Kinetics: Reaction rate, rate constant, order ... Arrhenius Equation ... Batch Reactor ... Plug-Flow Reactor ... Continuous-Stirred Tank Reactor ...

Environmental Engineering ... Air Pollution ... Atmospheric Dispersion Modeling (Gaussian) ... Cyclone ... Baghouse ... Electrostatic Precipitator ... Incineration ... Fate and Transport ... Microbial Kinetics ... Monod Kinetics ... Water and Wastewater Technologies ... Sludge Age ... Activated Sludge ...

Civil Engineering ... Geotechnical ... Structural ... Transportation ... Traffic Flow Relationships ... Highway Pavement Design ... Construction ...

Electrical and Computer Engineering ... Electromagnetic Dynamic Fields ... AC Circuits ... Fourier Series ... Transmission Lines ... Communication Theory and Concepts ... Amplitude Modulation ... Angle Modulation ... Digital Systems ... Computer Networking ...

Industrial and Systems Engineering ... Linear Programming ... Statistical Quality Control ... Queueing Models ... Ergonomics ...

Mechanical Engineering ... Mechanical Design and Analysis ... Springs ... Gearing ... Refrigeration and HVAC ... Cycles and Processes ...

239 Chemical Engineering Reactions of Shifting Order ... rA = ln k1CA1 + k2CA ... Ao - CA This form of

the rate equation is used for elementary enzyme-catalyzed reactions and for elementary surfaced-catalyzed reactions. Simplex A single channel where communications is one direction only. The allowable stress σ is then given by Sy = σ = 0.78Sut cold-drawn carbon steel (A227, A228, A229) Sy = σ = 0.87Sut hardened and tempered carbon and low-alloy steel (A232, A401) Bearings Ball/Roller Bearing Selection The minimum required basic load rating (load for which 90% of the bearings from a given population will survive 1 million revolutions) is given by where C = PL1 C P L a a = minimum required basic load rating = design radial load = design life (in millions of revolutions) = 3 for ball bearings, 10/3 for roller bearings 432 Mechanical Engineering When a ball bearing is subjected to both radial and axial loads, an equivalent radial load must be used in the equation above. 220 Instrumentation, Measurement, and Control Thermistors – Typically manufactured from a semiconductor, with a negative temperature coefficient. DeWitt, Fundamentals of Heat and Mass Transfer, 3rd ed., Wiley, 1990, p. Linear Systems A. Intellectual Property Intellectual property is the creative product of the intellect and normally includes inventions, symbols, literary works, patents, and designs. Phasors G. The velocities in a planetary set are related by ωL − ωarm = ωf − ωarm ! my where ωf = speed of the first gear in the train ωL = speed of the last gear in the train ωarm = speed of the arm Neither the first nor the last gear can be one that has planetary motion.

[illegible]

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1 dx − d _csc 1 u i=− 1 du 27. They shall not misrepresent or exaggerate their degree of responsibility in prior assignments nor the complexity of said assignments. The flow upstream of a normal shock wave is always supersonic and the flow downstream is always subsonic as depicted in the figure. Traffic Class (6+2 bits) The bits of this field hold two values. • Write-through: Write to both the cache's copy and the main memory's copy. Graduating from an engineering program of four years or more accredited by the Engineering Accreditation Commission of ABET (EAC/ABET), or graduating from an engineering master's program accredited by EAC/ABET, or meeting the requirements of the NCEES Engineering Education Standard. Modified Accelerated Cost Recovery System (MACRS) MACRS FACTORS Recovery Period (Years) Year 3 5 7 10 Recovery Rate (Percent). Decision nodes D1 … Decision node D2 Decision maker chooses 1 of the available paths. Statics A. The lift coefficient CL can be approximated by the equation $C_L = 2\pi k_1 \sin(\alpha + \beta)$, which is valid for small values of α and β where k1 = constant of proportionality α = angle of attack (angle between chord of airfoil and direction of flow) β = negative of angle of attack for zero lift. The drag coefficient CD may be approximated by $C_D = C_{D\infty} + \frac{C_L^2}{\pi AR}$ where CD∞ = infinite span drag coefficient. The aspect ratio AR is defined $AR = \frac{b^2}{A_p} = \frac{A_p}{c^2}$ where b = span Ap = plan area c = chord length. The aerodynamic moment M is given by $M = \frac{C_M \rho v^2 A_p c}{2}$ where the moment is taken about the front quarter point of the airfoil. The complete solution for the differential equation is $y(x) = y_h(x) + y_p(x)$, where $y_p(x)$ is any particular solution with f(x) present. Area properties (e.g., centroids, moments of inertia, radius of gyration, parallel axis theorem) G. Polymer Additives Chemicals and compounds are added to polymers to improve properties for commercial use. Materials Science/Structure of Matter Amorphous Materials Amorphous materials such as glass are non-crystalline solids. Z. An unit normal distribution table is included at the end of this section. Safety. Multiplexing (e.g., time division, frequency division, code division) D. Break-Even Analysis. Coagulation Equations. Insoluble products are shown in italics. Zone at LMC. Tol. Tree Traversal There are three primary algorithms that are used to traverse a binary tree data structure. Place on probation, fine, recover costs from, and/or reprimand. Fluid Mechanics Moving Blade. The Ideal Gas Law. Bessel's Correction. Electromagnetics. Determinants. A matrix is an ordered rectangular array of numbers with m rows and n columns. The integral equations can be used along with the following methods of integration. A3. Engineering Probability and Statistics Permutations and Combinations A permutation is a particular sequence of a given set of objects. Refrigeration. The term "Person," as used in this Act, shall mean an individual or firm. Molar Volume of an Ideal Gas (at 0°C (32°F) and 1 atm (14.7 psia)). Microprocessors B. Cost analysis (e.g., incremental, average, sunk, life-cycle, minimum cost). Heat Transfer There are three modes of heat transfer: conduction, convection, and radiation. The simplest alkynes have a single carbon-carbon triple bond with the general formula of C_nH_{2n-2}. Isentropic Efficiency (turbine). Throttling Valves and Throttling Processes: No work, no heat transfer, and single-mass stream. Intellectual property (e.g., copyright, trade secrets, patents, trademarks). Licensee—The term "Licensee," as used in this Act, shall mean a professional engineer or a professional surveyor. In the USCS system of units, both force and mass are called pounds. Surveying incidental to the practice of engineering excludes the surveying of real property for the establishment of land boundaries, rights of way, easements, and the dependent or independent surveys or resurveys of the public land survey system. Steel and moment diagrams. B. AISC Figure C-A-7.1 AISC Figure C-A-7.2 Alignment chart, sidesway inhibited (braced frame) Alignment chart, sidesway uninhibited (moment frame). Unit Weight of Water. Pi-Theorem. Process Control. Acids and bases. Fuel Cells. Pressure. Electromagnetics. Transfer functions. Lumped Parameter Systems. Capacitors and Inductors. Design Standards. Torsion. Convex and concave mirrors. Beam Deflection Formulas. Heat Exchangers. Sampling Theorem. Hydrology. Mass Transfer. Transportation Engineering. Traffic Flow Relationships (q = kv). Highway Capacity Manual. Freeway Level of Service. Stopping Sight Distance. Vertical Curves. Spiral Curves. Superelevation. Horizontal Curves. Pavement Design. Structural Numbers for Flexible Pavements. Geotechnical Engineering. Phase Relationships. Permeability. Consolidation. Effective Stress. Rankine Earth Pressure Coefficients. Bearing Capacity. Slope Stability. Environmental Engineering. Biochemical Oxygen Demand. Reactor Design. Activated Sludge. Filtration. Settling. Electrical and Computer Engineering. AC Circuits. Complex Power. Three-Phase Circuits. Transformers. Electric Machines. Operational Amplifiers. Solid-State Electronics and Devices. Diodes. Bipolar Junction Transistors. Field Effect Transistors. Number Systems and Codes. Logic Operations and Boolean Algebra. Flip-Flops. Computer Networks. Communication Theory and Concepts. Industrial and Systems Engineering. Linear Programming. Queueing Models. Simulation. Forecasting. Experimental Design. Statistical Quality Control. Ergonomics. Facilities Planning. Mechanical Engineering. Refrigeration and HVAC. Cycles. Psychrometrics. Fans, Pumps, and Compressors. Vibrations. Material Handling. Chemical Engineering. Chemical Reaction Engineering. Mass Transfer. Distillation. Biomedical Engineering. Instrumentation and Controls. [remainder of dense text illegible at this resolution]

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