ERRATA for
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Errata below will be corrected in *FE Reference Handbook*, 9.5. The exam will be administered using the updated version of the handbook.

CONVERSION FACTORS

p. 2, Conversion Factor Chart
Added two factors to the chart:

Multiply	By	To Obtain
ft-lbm	2	slug-ft/s^2
slug	32.174	pound-mass (lbm)

ETHICS

p. 4, Model Law (new)
The seven new sections of the NCEES Model Law may be downloaded from the online *FE Reference Handbook*.

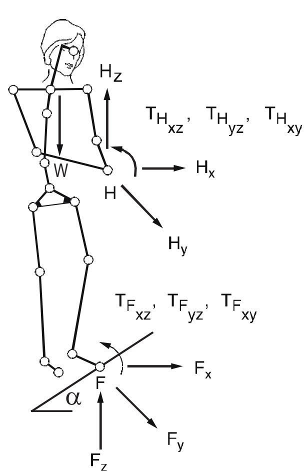
SAFETY

p. 10, Acute Oral Toxicity Pictorgrams

ACUTE ORAL TOXICITY

	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5
LD_{50}	≤ 5 mg/kg	$> 5 < 50$ mg/kg	$\geq 50 < 300$ mg/kg	$\geq 300 < 2{,}000$ mg/kg	$\geq 2{,}000 < 5{,}000$ mg/kg
PICTOGRAM					NO SYMBOL
SIGNAL WORD	DANGER	DANGER	DANGER	WARNING	WARNING
HAZARD STATEMENT	FATAL IF SWALLOWED	FATAL IF SWALLOWED	TOXIC IF SWALLOWED	HARMFUL IF SWALLOWED	MAY BE HARMFUL IF SWALLOWED

p. 20, Biomechanics of the Human Body
The slope angle should be shown and defined as follows:



With the slope angle α

$$F_x = \mu F_z \cos \alpha$$

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MATHEMATICS

p. 30, col 2, Properties of Series

Added the definition of Π to the end of the list:

$$\sum_{i=1}^{n} c = nc; \qquad c = \text{constant}$$

$$\sum_{i=1}^{n} cx_i = c\sum_{i=1}^{n} x_i$$

$$\sum_{i=1}^{n} \left(x_i + y_i - z_i\right) = \sum_{i=1}^{n} x_i + \sum_{i=1}^{n} y_i - \sum_{i=1}^{n} z_i$$

$$\sum_{x=1}^{n} x = \left(n + n^2\right)/2$$

$$\prod_{i=1}^{n} x_i = x_1 x_2 x_3 \ldots x_n$$

p. 34, col 2, MATRICES

Expanded the definition of *matrix* to include the following:

The rank of a matrix is equal to the number of rows that are linearly independent.

CHEMISTRY

p. 54, col 2, DEFINITIONS

Added the Nernest equation:

Nernst Equation

$$\Delta E = \left(E_2^0 - E_1^0\right) - \frac{RT}{nF}\ln\left[\frac{M_1^{n+}}{M_2^{n+}}\right]$$

E_1^0 = half-cell potential (volts)

R = ideal gas constant

n = number of electrons participating in either half-cell reaction

T = absolute temperature (K)

M_1^{n+} and M_2^{n+} = molar ion concentration

p. 55, Periodic Table of Elements

The current periodic table may be downloaded from the online *FE Reference Handbook*.

MECHANICS OF MATERIALS

p. 84, MATERIAL PROPERTIES

The subtitle of Table 2 should read as follows:

(Use these values for the specific alloys and temper listed. For all other materials refer to Table 1 above.)

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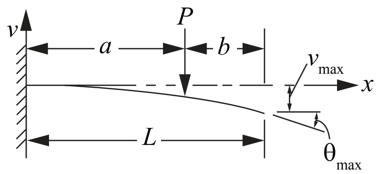
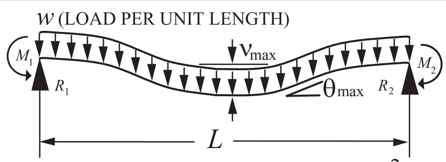
p. 86, Cantilevered Beam Slopes and Deflections

BEAM	SLOPE	DEFLECTION	ELASTIC CURVE
	$\theta_{max} = \frac{-Pa^2}{2EI}$	$v_{max} = \frac{-Pa^2}{6EI}(3L - a)$	$v = \frac{-Pa^2}{6EI}(3x - a)$, for $x > a$ $v = \frac{-Px^2}{6EI}(-x + 3a)$, for $x \le a$

p. 86, Piping Segment Slopes and Deflections

PIPE	SLOPE	DEFLECTION	ELASTIC CURVE
 $R_1 = R_2 = \frac{wL}{2}$ and $M_1 = M_2 = \frac{wL^2}{12}$	$\lvert\theta_{max}\rvert = 0.008\frac{wL^3}{24EI}$ at $x = \frac{1}{2} \pm \frac{L}{\sqrt{12}}$	$\lvert v_{max}\rvert = \frac{wL^4}{384EI}$ at $x = \frac{L}{2}$	$v(x) = \frac{wx^2}{24EI}(L^2 - 2Lx + x^2)$

THERMODYNAMICS

p. 89, col 1, Open Thermodynamic System

Polytropic process (ideal gas):

Pv^n = constant

Closed system

$w_{rev} = (P_2v_2 - P_1v_1)/(1 - n)$

One-inlet, one-exit control volume

$w_{rev} = n\,(P_2v_2 - P_1v_1)/(1 - n)$

FLUID MECHANICS

p. 106, col 2, Open-Channel Flow and/or Pipe Flow of Water

Defined Q for Manning's equation and Hazen-Williams equation:

Manning's Equation

$Q = (K/n)AR_H^{2/3}S^{1/2}$

Hazen-Williams Equation

$Q = k_1CAR_H^{0.63}S^{0.54}$

p. 111, col 1, Turbines

For a turbine where ΔKE is included:

$$\dot{W}_{turb} = \dot{m}\left(h_i - h_e + \frac{V_i^2 - V_e^2}{2}\right)$$

$$= \dot{m}\left(c_p\left(T_i - T_e\right) + \frac{V_i^2 - V_e^2}{2}\right)$$

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INSTRUMENTATION, MEASUREMENT, AND CONTROLS

p. 125

The table of strain gauges is shown in the online *FE Reference Handbook*.

ENGINEERING ECONOMICS

p. 131, col 1, NOMENCLATURE AND DEFINITIONS

Added two definitions:

EV...........Expected value

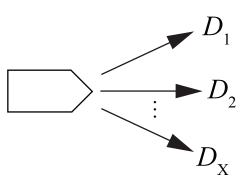
MARR....Minimum acceptable/attractive rate of return

p. 132, ECONOMIC DECISION TREES (new)

Added an economic decision tree:

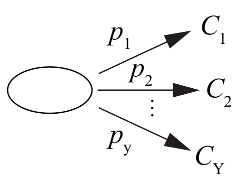
The following symbols are used to model decisions with decision trees:

Decision node



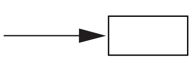
Decision maker chooses 1 of the available paths.

Chance node



Represents a probabilistic (chance) event. Each possible outcome (C_1, C_2,..., C_Y) has a probability (p_1, p_2,..., p_y) associated with it.

Outcome node



Shows result for a particular path through the decision tree.

Expected Value: $EV = (C_1)(p_1) + (C_2)(p_2) + \ldots$

CIVIL ENGINEERING

p. 149, col 1, Horizontal Stress Profiles and Forces

Added the following to the end of the section:

At rest forces on wall per unit length of wall

K_0 = at rest earth pressure coefficient (smooth wall, C = 0, level backfill)

$K_0 \approx 1 - \sin\phi$ for normally consolidated soil

$K_0 = (1 - \sin\phi)\, OCR^{\sin\phi}$ for overconsolidated soil where

OCR = overconsolidation ratio

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p. 149, col 2, Retaining Walls (new)

Added a retaining wall section to bottom of page:

$$FS_{overturning} = \frac{\Sigma M_R}{M_O}$$

$$FS_{sliding} = \frac{\Sigma F_R}{\Sigma F_D}$$

$$FS_{sliding} = \frac{(\Sigma V)\tan\delta + BC_a + P_p}{P_a\cos\alpha}$$

$$FS_{bearing\ capacity} = \frac{q_{ULT}}{q_{toe}}$$

$$q_{toe} = \frac{\Sigma V}{B}\left(1 + \frac{6e}{B}\right)$$

$$e = \frac{B}{2} - \left(\frac{\Sigma M_R - M_O}{\Sigma V}\right)$$

e = eccentricity
B = width of base
M_R = resisting moment
M_O = overturning moment
F_R = resisting forces
F_D = driving forces
V = vertical forces
$\delta = k_1\phi_2$
$C_a = k_2C_2$
k_1 and k_2 are given, ranging from 1/2 to 2/3

p. 153, col 1, STRUCTURAL DESIGN/Live Load Reduction

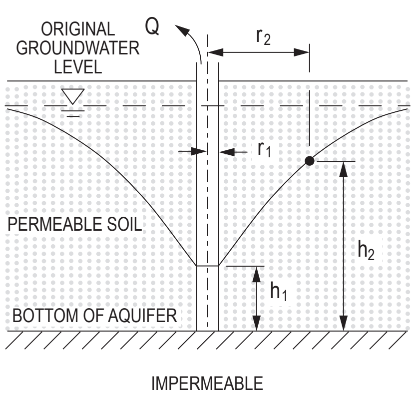
For members supporting one floor:

$$L_{reduced} = L_{nominal}\left(0.25 + \frac{15}{\sqrt{K_u A_T}}\right) \geq 0.5L_{nominal}$$

For members supporting two or more floors

$$L_{reduced} = L_{nominal}\left(0.25 + \frac{15}{\sqrt{K_{LL} A_T}}\right) \geq 0.4L_{nominal}$$

p. 165, col 2, Well Drawdown



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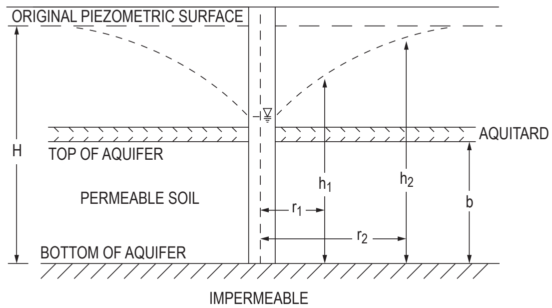
p. 165, col 2, DuPuit's Formula



p. 165, col 2, Theim Equation
Defined *H* as follows:

H = height of peizometric surface prior to pumping (ft)

p. 167, col 2, Manning's Equation
Defined *V* in Manning's Equation:

Manning's Equation

$$Q = (K/n)AR_H^{2/3}S^{1/2}$$

$$V = (K/n)R_H^{2/3}S^{1/2}$$

Q = discharge (ft^3/sec or m^3/s)
V = velocity (ft/sec or m/s)
K = 1.486 for USCS units, 1.0 for SI units
A = cross-sectional area of flow (ft^2 or m^2)
R_H = hydraulic radius = A/P (ft or m)
P = wetted perimeter (ft or m)
S = slope (ft/ft or m/m)
n = roughness coefficient

p. 168, col 1, Hazen-Williams Equation
Defined *Q* for Hazen-Williams equation:

Hazen-Williams Equation

$$V = k_1 C R_H^{0.63} S^{0.54}, \text{ where}$$

$$Q = k_1 C A R_H^{0.63} S^{0.54}$$

C = roughness coefficient
k_1 = 0.849 for SI units
k_1 = 1.318 for USCS units
R_H = hydraulic radius (ft or m)
S = slope of energy grade line
= h_f/L (ft/ft or m/m)
V = velocity (ft/sec or m/s)
Q = discharge (ft^3/sec or m^3/s)

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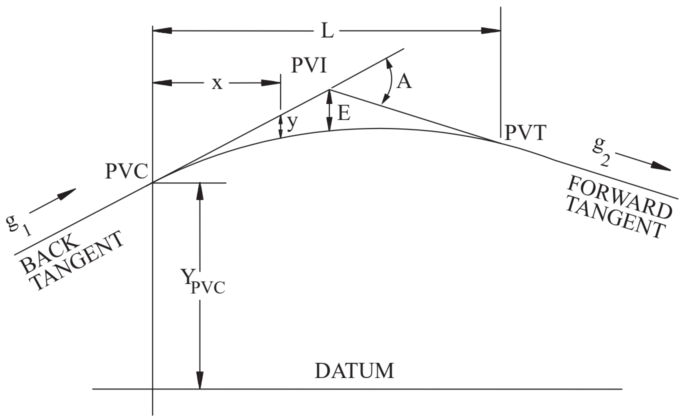
p. 176, AREA FORMULAS

The vertical curve formulas and definitions should be shown as follows:



VERTICAL CURVE FORMULAS
NOT TO SCALE

PVC = Point of vertical curvature, or beginning of curve

PVI = Point of vertical intersection, or vertex

PVT = Point of vertical tangency, or end of curve

L = Length of curve

y = Tangent offset

x = Horizontal distance from *PVC* to point on curve

x_m = Horizontal distance to min/max elevation on curve

g_1 = Grade of back tangent

g_2 = Grade of forward tangent

A = Algebraic difference in grades

a = Parabola constant

E = Tangent offset at *PVI*

r = Rate of change of grade

K = Rate of vertical curvature

Tangent elevation = $Y_{\text{PVC}} + g_1x = Y_{\text{PVI}} + g_2\,(x - L/2)$

Curve elevation = $Y_{\text{PVC}} + g_1x + ax^2 = Y_{\text{PVC}} + g_1x + [(g_2 - g_1)/(2L)]x^2$

ENVIRONMENTAL ENGINEERING

p. 179, col 2, Selected Properties of Air

Added the Lapse Rate equation:

$$\text{Lapse rate} = \Gamma = -\frac{\Delta T}{\Delta z}$$

where ΔT is the change in temperature and Δz is the change in elevation.

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p. 185, col 1, Mass Calculations

Mass balance: $\frac{dM}{dt} = \frac{dM_{in}}{dt} + \frac{dM_{out}}{dt} \pm r$

M = CQ = CV

Continuity equation = Q = vA

M = mass
M_{in} = mass in
M_{out} = mass out
r = reaction rate = kC^n
k = reaction rate constant (1/time)
n = order of reaction
C = concentration
Q = flowrate
V = volume
v = velocity
A = cross-sectional area of flow

M (lb/day) = C (mg/L) × Q (MGD) × 8.34 [lb-L/(mg-MG)]

where:
MGD = million gallons per day
MG = million gallons

p. 185, col 1, Microbial Kinetics

<u>BOD Exertion</u>

$$BOD_t = L_o\left(1 - e^{-kt}\right)$$

where
k = BOD decay rate constant (base e, $days^{-1}$)
L_o = ultimate BOD (mg/L)
t = time (days)
BOD_t = the amount of BOD exerted at time t (mg/L)

p. 186, col 1, Kinetic Temperature Corrections

$k_T = k_{20}\,(\theta)^{T-20}$

BOD (k): θ = 1.135 (T = 4 – 20°C)
θ = 1.056 (T = 20 – 30°C)
Reaeration (k_r) θ = 1.024

p. 196, col 1, Rapid Mix and Flocculator Design

Updated definition of γ:

γ = specific weight of water (lb/ft^3 or N/m^3)

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p. 197, col 1, Disinfection

Updated nomenclature and definitions:

CT_{calc} = $C \times t_{10}$
CT_{calc} = calculated CT value (mg • mm/L)
C = residual disinfectant concentration measured during peak hourly flow (mg/L)
t_{10} = time it takes 10% of the water to flow through the reactor measured during peak hourly flow (min)
= can be determined from traces study data or the following relationship
$t_{10(\text{approx})} = \theta \times \text{BF}$
θ = hydraulic residence time (min)
BF = baffling factor

Adapted from *Guidance Manual LT1ESWTR Disinfection Profiling and Benchmarking*, U.S. Environmental Protection Agency, 2003.

ELECTRICAL AND COMPUTER ENGINEERING

p. 205, col 2, Voltage Regulation (new)

The percent voltage regulation of a power supply is defined as

$$\% \text{ Regulation} = \frac{|V_{NL}| - |V_{FL}|}{|V_{FL}|} \times 100\%$$

where

V_{NL} = voltage under no load conditions

V_{FL} = voltage under full load conditions

p. 206, col 2, line 8, LOSSLESS TRANSMISSION LINES

Updated the equation for the reflection coefficient:

$$\Gamma = \frac{\boldsymbol{V}^-}{\boldsymbol{V}^+} = \frac{\mathbf{Z}_L - \mathbf{Z}_0}{\mathbf{Z}_L + \mathbf{Z}_0}$$

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p. 216, N-Channel Junction Field Effect Transistors (JFETs)
The mathematical relationships column should read as follows:

Mathematical Relationships

Cutoff Region: $v_{GS} < V_p$
$i_D = 0$

Triode Region: $v_{GS} > V_p$ and $v_{GD} > V_p$
$i_D = (I_{DSS}/V_p^2)[2v_{DS}(v_{GS} - V_p) - v_{DS}^2]$

Saturation Region: $v_{GS} > V_p$ and $v_{GD} < V_p$
$i_D = I_{DSS}(1 - v_{GS}/V_p)^2$
where
I_{DSS} = drain current with $v_{GS} = 0$ (in the saturation region)
$= KV_p^2$,
K = conductivity factor
For JFETs,
V_p = pinch-off voltage
For MOSFETs,
$V_p = V_T$ = threshold voltage

p. 221, col 1, Protocol Definitions

- TCP/IP is the basic communication protocol suite for communication over the Internet.
- Internet Protocol (IP) provides end-to-end addressing and is used to encapsulate TCP or UDP datagrams. Both version 4 (IPv4) and version 6 (IPv6) are used and can co-exist on the same network.
- Transmission Control Protocol (TCP) is a connection-oriented protocol that detects lost packets, duplicated packets, or packets that are received out of order and has mechanisms to correct these problems.
- User Datagram Protocol (UDP), is a connectionless-oriented protocol that has less network overhead than TCP but provides no guarantee of delivery, ordering, or duplicate protection.
- Internet Control Message Protocol (ICMP) is a supporting protocol used to send error messages and operational information.

p. 221, col 1, Local Area Network (LAN)
There are different methods for assigning IP addresses for devices entering a network.

- Dynamic host configuration protocol (DHCP) is a networking protocol that allows a router to assign the IP address and other configuration information for all stations joining a network.
- Static IP addressing implies each station joining a network is manually configured with its own IP address.
- Stateless address autoconfiguration (SLAAC) allows for hosts to automatically configure themselves when connecting to an IPv6 network.

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MECHANICAL ENGINEERING

p. 245, col 1, HVAC—Pure Heating and Cooling