ERRATA for

FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4
Third printing June 2015
Errata posted June 2016

Errata below will be corrected in *FE Reference Handbook*, 9.4. The exam will be administered using the updated version of the handbook.

ETHICS

p. 4, INTELLECTUAL PROPERTY (new section)

The new page of definitions may be downloaded from the online FE Reference Handbook.

SAFETY

p. 10, Flammability

LFL and UFL should be defined as follows:

The LFL is also known as the lower explosive limit (LEL). The UFL is also referred to as the upper explosive limit (UEL). There is no difference between the terms *flammable* and *explosive* as applied to the lower and upper limits of flammability.

A table identifying the LFL and UFL of various mixtures should be shown as follows:

Gas/Compound	LFL	UFL
Acetone	2.6	13.0
Acetylene	2.5	100.0
Ammonia	15.0	28.0
n-butane	1.8	8.4
Carbon disulfide	1.3	50.0
Carbon monoxide	12.5	74.0
Cycloheptane	1.1	6.7
Cyclohexane	1.3	7.8
Cyclopropane	2.4	10.4
Diethyl ether	1.9	36.0
Ethane	3.0	12.4
Ethyl acetate	2.2	11.0
Ethyl alcohol	3.3	19.0
Ethyl ether	1.9	36.0
Ethyl nitrite	3.0	50.0
Ethylene	2.7	36.0
Gasoline 100/130	1.3	7.1
Gasoline 115/145	1.2	7.1
Hydrazine	4.7	100.0
Hydrogen	4.0	75.0
Hydrogen sulfide	4.0	44.0
Isobutane	1.8	8.4
Methane	5.0	15.0
Propane	2.1	9.5

From *SFPE Handbook of Fire Protection Engineering*, 4 ed., Society of Fire Protection Engineers, 2008.

p. 11, Electrical Safety

The probable effect of >2000 mA of current on the human body should read as follows:
Cardiac arrest (stop in effective blood circulation), internal organ damage, and severe burns. Death is probable.

p. 13, col 2, Reference Dose

The definition of W should read as follows:
W = the weight of the adult male

ERRATA for

FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4
Third printing June 2015
Errata posted June 2016

ENGINEERING PROBABILITY AND STATISTICS

p. 39, col 1, LINEAR REGRESSION AND GOODNESS OF FIT

Least Squares

$\hat{y} = \hat{a} + \hat{b}x$, where

$\hat{b} = S_{xy}/S_{xx}$

$\hat{a} = \bar{y} - \hat{b}\bar{x}$

$$S_{xy} = \sum_{i=1}^{n} x_i y_i - (1/n)\left(\sum_{i=1}^{n} x_i\right)\left(\sum_{i=1}^{n} y_i\right)$$

$$S_{xx} = \sum_{i=1}^{n} x_i^2 - (1/n)\left(\sum_{i=1}^{n} x_i\right)^2$$

$$\bar{y} = (1/n)\left(\sum_{i=1}^{n} y_i\right)$$

$$\bar{x} = (1/n)\left(\sum_{i=1}^{n} x_i\right)$$

where

n = sample size
S_{xx} = sum of squares of x
S_{yy} = sum of squares of y
S_{xy} = sum of x-y products

Residual (new section)

$$e_i = y_i - \hat{y} = y_i - \left(\hat{a} + \hat{b}x_i\right)$$

p. 39, col 2, HYPOTHESIS TESTING

Let a "dot" subscript indicate summation over the subscript. Thus:

$$y_{i\bullet} = \sum_{j=1}^{n} y_{ij} \quad \text{and} \quad y_{\bullet\bullet} = \sum_{i=1}^{a}\sum_{j=1}^{n} y_{ij}$$

One-Way Analysis of Variance (ANOVA)

Given independent random samples of size n_i from k populations, then:

$$\sum_{i=1}^{k}\sum_{j=1}^{n_i}\left(y_{ij} - \bar{y}_{\bullet\bullet}\right)^2 = \sum_{i=1}^{k} n_i\left(\bar{y}_{i\bullet} - \bar{y}_{\bullet\bullet}\right)^2 + \sum_{i=1}^{k}\sum_{i=1}^{n_i}\left(y_{ij} - \bar{y}_{i\bullet}\right)^2$$

$$SS_{\text{total}} = SS_{\text{treatments}} + SS_{\text{error}}$$

If N = total number observations

$= \sum_{i=1}^{k} n_i$, then

$$SS_{\text{total}} = \sum_{i=1}^{k}\sum_{j=1}^{n_i} y_{ij}^2 - \frac{y_{\bullet\bullet}^2}{N}$$

$$SS_{\text{treatments}} = \sum_{i=1}^{k} \frac{y_{i\bullet}^2}{n_i} - \frac{y_{\bullet\bullet}^2}{N}$$

$$SS_{\text{error}} = SS_{\text{total}} - SS_{\text{treatments}}$$

ERRATA for

FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4

Third printing June 2015

Errata posted June 2016

Randomized Complete Block Design

For k treatments and b blocks

$$\sum_{i=1}^{k}\sum_{j=1}^{b}\left(y_{ij}-\overline{y}_{\bullet\bullet}\right)^2 = b\sum_{i=1}^{k}\left(\overline{y}_{i\bullet}-\overline{y}_{\bullet\bullet}\right)^2 + \mathrm{k}\sum_{j=1}^{b}\left(\overline{y}_{\bullet j}-\overline{y}_{\bullet\bullet}\right)^2$$

$$+\sum_{i=1}^{k}\sum_{j=1}^{b}\left(\overline{y}_{ij}-\overline{y}_{\bullet j}-\overline{y}_{i\bullet}+\overline{y}_{\bullet\bullet}\right)^2$$

$$SS_{\text{total}} = SS_{\text{treatments}} + SS_{\text{blocks}} + SS_{\text{error}}$$

$$SS_{\text{total}} = \sum_{i=1}^{k}\sum_{j=1}^{b} y_{ij}^2 - \frac{y_{\bullet\bullet}^2}{kb}$$

$$SS_{\text{treatments}} = \frac{1}{b}\sum_{i=1}^{k} y_{i\bullet}^2 - \frac{y_{\bullet\bullet}^2}{bk}$$

$$SS_{\text{blocks}} = \frac{1}{k}\sum_{j=1}^{b} y_{\bullet j}^2 - \frac{y_{\bullet\bullet}^2}{bk}$$

$$SS_{\text{error}} = SS_{\text{total}} - SS_{\text{treatments}} - SS_{\text{blocks}}$$

From Montgomery, Douglas C., and George C. Runger, *Applied Statistics and Probability for Engineers*, 4th ed., Wiley, 2007.

Two-factor Factorial Designs

For a levels of Factor A, b levels of Factor B, and n repetitions per cell:

$$\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n}\left(y_{ijk}-\overline{y}_{\bullet\bullet\bullet}\right)^2 = bn\sum_{i=1}^{a}\left(\overline{y}_{i\bullet\bullet}-\overline{\mathrm{y}}_{\bullet\bullet\bullet}\right)^2 + an\sum_{j=1}^{b}\left(\overline{y}_{\bullet\mathrm{j}\bullet}-\overline{y}_{\bullet\bullet\bullet}\right)^2$$

$$+n\sum_{i=1}^{a}\sum_{j=1}^{b}\left(\overline{y}_{ij\bullet}-\overline{y}_{i\bullet\bullet}-\overline{y}_{\bullet j\bullet}+\overline{y}_{\bullet\bullet\bullet}\right)^2 + \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n}\left(y_{ijk}-\overline{y}_{ij\bullet}\right)^2$$

$$SS_{\text{total}} = SS_{\text{A}} + SS_{\text{B}} + SS_{\text{AB}} + SS_{\text{error}}$$

$$SS_{\text{total}} = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n} y_{ijk}^2 - \frac{y_{\bullet\bullet\bullet}^2}{abn}$$

$$SS_{\text{A}} = \sum_{i=1}^{a}\frac{y_{i\bullet\bullet}^2}{bn} - \frac{y_{\bullet\bullet\bullet}^2}{abn}$$

$$SS_{\text{B}} = \sum_{j=1}^{b}\frac{y_{\bullet j\bullet}^2}{an} - \frac{y_{\bullet\bullet\bullet}^2}{abn}$$

$$SS_{\text{AB}} = \sum_{i=1}^{a}\sum_{j=1}^{b}\frac{y_{ij\bullet}^2}{n} - \frac{y_{\bullet\bullet\bullet}^2}{abn} - SS_{\text{A}} - SS_{\text{B}}$$

$$SS_{\text{error}} = SS_{\text{T}} - SS_{\text{A}} - SS_{\text{B}} - SS_{\text{AB}}$$

From Montgomery, Douglas C., and George C. Runger, *Applied Statistics and Probability for Engineers*, 4th ed., Wiley, 2007.

ERRATA for

FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4
Third printing June 2015
Errata posted June 2016

p. 40, Two-Way ANOVA Table
The table has been renamed and should be shown as follows:

Randomized Complete Block ANOVA Table

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F
Between Treatments	$k-1$	$SS_{\text{treatments}}$	$MST = \dfrac{SS_{\text{treatments}}}{k-1}$	$\dfrac{MST}{MSE}$
Between Blocks	$n-1$	SS_{blocks}	$MSB = \dfrac{SS_{\text{blocks}}}{n-1}$	$\dfrac{MSB}{MSE}$
Error	$(k-1)(n-1)$	SS_{error}	$MSE = \dfrac{SS_{\text{error}}}{(k-1)(n-1)}$	
Total	$N-1$	SS_{total}		

CHEMISTRY

p. 53, col 2, ACIDS, BASES, and pH (aqueous solutions)

$$\text{pH} = \log_{10}\left(\frac{1}{[H^+]}\right), \text{ where}$$

$[H^+]$ = molar concentration of hydrogen ion, in gram moles per liter. *Acids* have pH < 7. *Bases* have pH > 7.

$$HA \longleftrightarrow A^- + H^+$$

$$K_a = \frac{[A^-][H^+]}{[HA]}$$

$$pK_a = -\log(K_a)$$

For water $[H^+][OH^-] = 10^{-14}$

$[\ \ ]$ denotes molarity

p. 54, Periodic Table of Elements
An updated table may be downloaded from the online FE Reference Handbook.

STATICS

p. 67, col 1, Moment of Inertia Parallel Axis Theorem
The parallel axis theorem equation and new free-body diagram should be shown as follows:

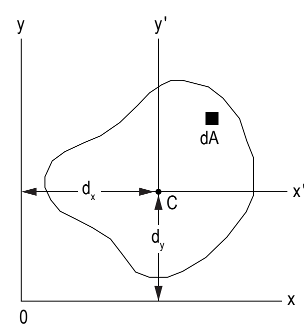
$$I'_x = I_{x_c} + d_y^2 A$$

$$I'_y = I_{y_c} + d_x^2 A, \text{ where}$$

d_x, d_y = distance between the two axes in question

I_{x_c}, I_{y_c} = the moment of inertia about the centroidal axis

I'_x, I'_y = the moment of inertia about the new axis



ERRATA for

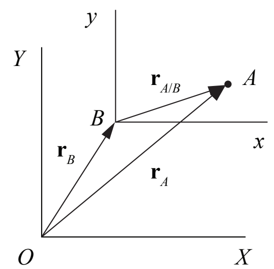
FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4
Third printing June 2015
Errata posted June 2016

DYNAMICS

p. 71, col 2, Relative Motion/*Translating Axes x-y*

The equations that relate the absolute and relative position, velocity, and acceleration vectors of two particles *A* and *B*, in plane motion, and separated at a constant distance, should be shown as follows:

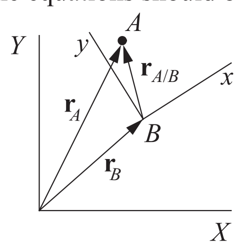


$$\mathbf{r}_A = \mathbf{r}_B + \mathbf{r}_{A/B}$$
$$\mathbf{v}_A = \mathbf{v}_B + \boldsymbol{\omega} \times \mathbf{r}_{A/B} = \mathbf{v}_B + \mathbf{v}_{A/B}$$
$$\mathbf{a}_A = \mathbf{a}_B + \boldsymbol{\alpha} \times \mathbf{r}_{A/B} + \boldsymbol{\omega} \times (\boldsymbol{\omega} \times \mathbf{r}_{A/B}) = \mathbf{a}_B + \mathbf{a}_{A/B}$$

Adapted from Hibbeler, R.C., *Engineering Mechanics*, 10th ed., Prentice Hall, 2003.

p. 72, col 1, *Rotating Axis*

The equations should be shown as follows:

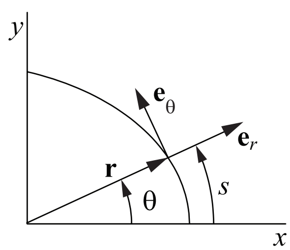


$$\mathbf{r}_A = \mathbf{r}_B + \mathbf{r}_{A/B}$$
$$\mathbf{v}_A = \mathbf{v}_B + \boldsymbol{\Omega} \times \mathbf{r}_{A/B} + (\mathbf{v}_{A/B})_{xyz}$$
$$\mathbf{a}_A = \mathbf{a}_B + \dot{\boldsymbol{\Omega}} \times \mathbf{r}_{A/B} + \boldsymbol{\Omega} \times (\boldsymbol{\Omega} \times \mathbf{r}_{A/B}) + 2\boldsymbol{\Omega} \times (\mathbf{v}_{A/B})_{xyz} + (\mathbf{a}_{A/B})_{xyz}$$

where $\boldsymbol{\Omega}$ and $\dot{\boldsymbol{\Omega}}$ are, respectively, the total angular velocity and acceleration of the relative position vector $\mathbf{r}_{A/B}$.

p. 72, col 1, Plane Circular Motion

A special case of radial and transverse components is for constant radius rotation about the origin, or plane circular motion.



Here the vector quantities are defined as

$\mathbf{r} = r\mathbf{e}_r$

$\mathbf{v} = r\omega\mathbf{e}_\theta$

$\mathbf{a} = \left(-r\omega^2\right)\mathbf{e}_r + r\alpha\mathbf{e}_\theta$, where

r = the radius of the circle

θ = the angle from the x axis to $\mathbf{r}$

ERRATA for
FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4
Third printing June 2015
Errata posted June 2016

The values of the angular velocity and acceleration, respectively, are defined as

$$\omega = \dot{\theta}$$
$$\alpha = \dot{\omega} = \ddot{\theta}$$

Arc length, transverse velocity, and transverse acceleration, respectively, are

$$s = r\theta$$
$$v_\theta = r\omega$$
$$a_\theta = r\alpha$$

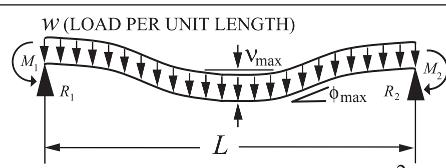
p. 74, col 1, PRINCIPLE OF WORK AND ENERGY
This section has been moved to the previous page and includes Kinetic Energy, Work, and Power and Efficiency. The two reordered pages may be downloaded from the online FE Reference Handbook.

MECHANICS OF MATERIALS

p. 82, col 1, Composite Sections
The definition of y should read as follows:
y = distance from the neutral axis to the fiber location above or below the neutral axis

p. 85, Piping Segment Slopes and Deflections (new figure)
A piping segment was added and should be shown as follows:

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 $x = \frac{1}{2} \pm \frac{L}{\sqrt{12}}$	$\lvert\nu_{max}\rvert = \frac{wL^4}{384EI}$ at $x = \frac{L}{2}$	$\nu_{max}(x) = \frac{wx^2}{24EI}(L^2 - Lx + x^2)$

Adapted from Crandall, S.H. and N.C. Dahl, *An Introduction to Mechanics of Solids*, McGraw-Hill, New York, 1959.

FLUID MECHANICS

p. 108, col 2, FLUID FLOW MACHINERY/Centrifugal Pump Characteristics
The definition of g should read as follows:
g = acceleration due to gravity

INSTRUMENTATION, MEASUREMENT, AND CONTROLS

p. 125, col 1, Piezoelectric Transducers
The definition of piezoelectric transducers has been added and should read as follows:

Piezoelectric Transducers – often comprised of a special ceramic that converts the electrical energy to mechanical energy, or electrical voltage to mechanical force, and vice versa. When an electric field is applied to the material, it will change dimension. Conversely, when a mechanical force is applied to the material, an electric field is produced. Piezoelectric transducers can have multiple layers and many different geometries.

ERRATA for

FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4
Third printing June 2015
Errata posted June 2016

CHEMICAL ENGINEERING

p. 143, Capital Cost Estimation (new section)

The first table in the new section should be shown as follows:

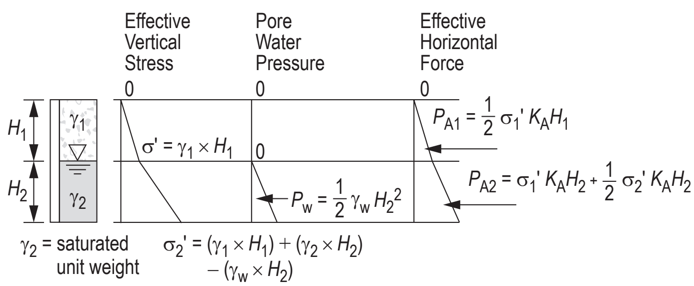
	Lang factors	
Type of plant	**Fixed capital investment**	**Total capital investment**
Solid processing	4.0	4.7
Solid-fluid processing	4.3	5.0
Fluid processing	5.0	6.0

From Green, Don W., and Robert H. Perry, *Perry's Chemical Engineers' Handbook,* 8th ed., McGraw-Hill, 2008.
Adapted from M. S. Peters, K. D. Timmerhaus, and R. West, *Plant Design and Economics for Chemical Engineers*, 5th ed., McGraw-Hill, 2004.

CIVIL ENGINEERING

p. 148, col 1, Horizontal Stress Profiles and Forces

The horizontal force formula should be shown as follows on the figure:



p. 168, TRANSPORTATION

The eight pages in this section were reordered and updated as shown in the online FE Reference Handbook.

ENVIRONMENTAL ENGINEERING

p. 188, SAMPLING AND MONITORING/Data Quality Objectives (DQO) for Sampling Soils and Solids

The mean μ_S and μ_B have been defined as follows:

μ_S = mean of pollutant concentration of the site of the contamination
μ_B = mean of pollutant concentration of the site before contamination or the noncontaminated area (background)

ELECTRICAL AND COMPUTER ENGINEERING

p. 201, col 1, CAPACITORS AND INDUCTORS

The inductance L (henrys) of a coil of N turns wound on a core with cross-sectional area A (m^2), permeability μ and flux ϕ with a mean path of l (m) should be given as follows:

$$L = N^2 \mu A / l = N^2 / \Re$$
$$N\phi = Li$$

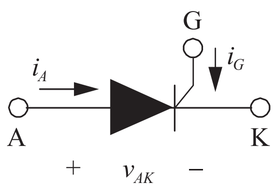
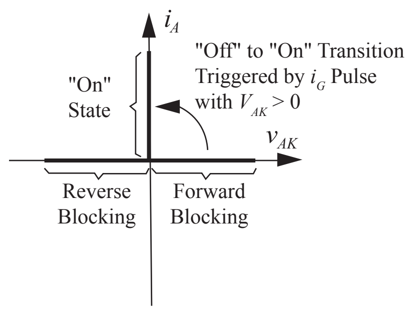
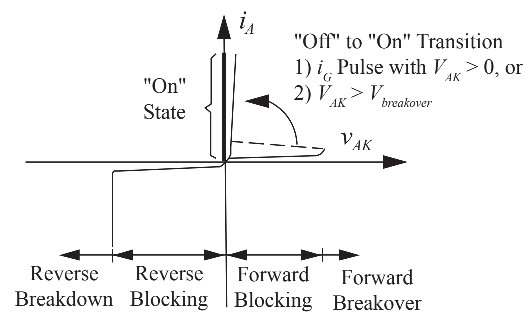
where $\Re$ = reluctance = $l/\mu A$ (H^{-1}). μ is sometimes given as $\mu = \mu_r \bullet \mu_o$ where μ_r is the relative permeability and $\mu_o = 4\pi \times 10^{-7}$ H/m.

ERRATA for

FE Reference Handbook, 9.3

ISBN: 978-1-932613-67-4
Third printing June 2015
Errata posted June 2016

p. 214, Thyristor or Silicon Controlled Rectifier (SCR) (new figure)
The new figure should be shown as follows:

<table>
<tr><th colspan="3">Thyristor or Silicon Controlled Rectifier (SCR)</th></tr>
<tr><th>Schematic Symbol</th><th>Ideal I-V Relationship</th><th>Piecewise-Linear Approximation of the I-V Relationship</th></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
</table>

p. 218, col 2, COMPUTER NETWORKING, COMPUTER SYSTEMS, and SOFTWARE DEVELOPMENT (new sections)
The nine new pages may be downloaded from the online FE Reference Handbook.

INDUSTRIAL AND SYSTEMS ENGINEERING

p. 221, col 2, RANDOMIZED BLOCK DESIGN
This section has been deleted.

MECHANICAL ENGINEERING

p. 230, col 2, Dynamics of Mechanisms
The formulas for stresses in spur gears have been deleted.

INDEX

p. 251
The index was recreated and may be downloaded from the online FE Reference Handbook.