Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

SKU: 9781305081567-SOLUTIONS

Chapter 2

2.1 d. $\gamma = \dfrac{(87.5)(9.81)}{(1000)(0.05)} = \mathbf{17.17\ kN/m^3}$

c. $\gamma_d = \dfrac{\gamma}{1+w} = \dfrac{17.17}{1+0.15} = \mathbf{14.93\ kN/m^3}$

a. Eq. (2.12): $\gamma = \dfrac{G_s\gamma_w}{1+e}$. $14.93 = \dfrac{(2.68)(9.81)}{1+e}$; $e = \mathbf{0.76}$

b. Eq. (2.6): $n = \dfrac{e}{1+e} = \dfrac{0.76}{1+0.76} = \mathbf{0.43}$

e. Eq. (2.14): $S = \dfrac{V_w}{V_v} = \dfrac{wG_s}{e} = \left[\dfrac{(0.15)(2.68)}{0.76}\right](100) = \mathbf{53\%}$

2.2 a. From Eqs. (2.11) and (2.12), it can be seen that,

$$\gamma_d = \frac{\gamma}{1+w} = \frac{20.1}{1+0.22} = \mathbf{16.48\ kN/m^3}$$

b. $\gamma = 16.48\ \text{kN/m}^3 = \dfrac{G_s\gamma_w}{1+e} = \dfrac{G_s(9.81)}{1+e}$

Eq. (2.14): $e = wG_s = (0.22)(G_s)$. So,

$$16.48 = \frac{9.81G_s}{1+0.22G_s}; \quad G_s = \mathbf{2.67}$$

2.3 a. $\gamma = \dfrac{G_s\gamma_w(1+w)}{1+e}$. $18.79 = \dfrac{(2.65)(9.81)(1+0.12)}{1+e}$; $e = \mathbf{0.55}$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

b. $n = \dfrac{0.55}{1+0.55} = \mathbf{0.355}$

c. $S = \dfrac{wG_s}{e} = \dfrac{(0.12)(2.65)}{0.55} \times 100 = \mathbf{57.8\%}$

d. $\gamma_d = \dfrac{\gamma}{1+w} = \dfrac{18.79}{1+0.12} = \mathbf{16.78\ kN/m^3}$

2.4 a. $G_s = \dfrac{e}{w}$. $\gamma_d = \dfrac{\left(\dfrac{e}{w}\right)(\gamma_w)}{1+e}$. $18.43 = \dfrac{\left(\dfrac{e}{0.36}\right)(9.81)}{1+e}$; $e = \mathbf{0.97}$

b. $n = \dfrac{e}{1+e} = \dfrac{0.97}{1+0.97} = \mathbf{0.49}$

c. $G_s = \dfrac{e}{w} = \dfrac{0.97}{0.36} = \mathbf{2.69}$

d. $\gamma_{sat} = \dfrac{(G_s+e)\gamma_w}{1+e} = \dfrac{(2.69+0.97)(9.81)}{1+0.97} = \mathbf{18.23\ kN/m^3}$

2.5 From Eqs. (2.11) and (2.12): $\gamma_d = \dfrac{18.34}{1+0.08} = 16.98\ \text{kN/m}^3$

Eq. (2.12): $\gamma_d = \dfrac{G_s\gamma_w}{1+e}$; $16.98 = \dfrac{(2.65)(9.81)}{1+e}$; $e = 0.53$

Eq. (2.23): $D_r = 0.82 = \dfrac{e_{max}-e}{e_{max}-e_{min}} = \dfrac{e_{max}-0.53}{e_{max}-0.44}$; $e_{max} = \mathbf{0.94}$

$\gamma_{d\,(min)} = \dfrac{G_s\gamma_w}{1+e_{max}} = \dfrac{(2.65)(9.81)}{1+0.94} = \mathbf{13.4\ kN/m^3}$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

2.6 Refer to Table 2.7 for classification.

Soil A: **A-7-6(9)** (*Note*: PI is greater than LL – 30.)

$$GI = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(PI - 10)$$
$$= (65 - 35)[0.2 + 0.005(42 - 40)] + 0.01(65 - 15)(16 - 10)$$
$$= 9.3 \approx \mathbf{9}$$

Soil B: **A-6(5)**

$$GI = (55 - 35)[0.2 + 0.005(38 - 40)] + 0.01(55 - 15)(13 - 10)$$
$$= 5.4 \approx \mathbf{5}$$

Soil C: **A-3-(0)**

Soil D: **A-4(5)**

$$GI = (64 - 35)[0.2 + 0.005(35 - 40)] + 0.01(64 - 15)(9 - 10)$$
$$= 4.585 \approx \mathbf{5}$$

Soil E: **A-2-6(1)**

$$GI = 0.01(F_{200} - 15)(PI - 10) = 0.01(33 - 15)(13 - 10) = 0.54 \approx \mathbf{1}$$

Soil F: **A-7-6(19)** (PI is greater than LL – 30.)

$$GI = (76 - 35)[0.2 + 0.005(52 - 40)] + 0.01(76 - 15)(24 - 10)$$
$$= 19.2 \approx \mathbf{19}$$

2.7 Soil A: Table 2.8: 65% passing No. 200 sieve.
Fine grained soil; LL = 42; PI = 16
Figure 2.5: **ML**
Figure 2.7: Plus No. 200 > 30%; Plus No. 4 = 0
% sand > % gravel – **sandy silt**

Soil B: Table 2.8: 55% passing No. 200 sieve.
Fine grained soil; LL = 38; PI = 13
Figure 2.5: Plots below A-line – **ML**
Figure 2.7: Plus No. 200 > 30%
% sand > % gravel – **sandy silt**

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

Soil C: Table 2.8: 8% passing No. 200 sieve.
% sand > % gravel – sandy soil – SP
Figure 2.6: % gravel = 100 – 95 = 5% < 15% – **poorly graded sand**

Soil D: Table 2.8: 64% passing No. 200 sieve
Fine grained soil; LL = 35, PI = 9
Figure 2.5 – **ML**
Figure 2.7: % sand (31%) > % gravel (5%) – **sandy silt**

Soil E: Table 2.8: 33% passing No. 200 sieve; 100% passing No. 4 sieve.
Sandy soil; LL = 38; PI = 13
Figure 2.5: Plots below A-line – **SM**
Figure 2.6: % gravel (0%) < 15% – **silty sand**

Soil F: Table 2.8: 76% passing No. 200 sieve; LL = 52; PI = 24
Figure 2.5: **CH**
Figure 2.7: Plus No. 200 is 100 – 76 = 24%
% gravel > % gravel – **fat clay with sand**

2.8 $$\gamma_d = \frac{G_s\gamma_w}{1+e};\quad e = \frac{G_s\gamma_w}{\gamma_d} - 1 = \frac{(2.68)(9.81)}{18.39} - 1 = 0.43$$

Eq. (2.37): $$\frac{k_1}{k_2} = \frac{\left(\frac{e_1^3}{1+e_1}\right)}{\left(\frac{e_2^3}{1+e_2}\right)};\quad \frac{0.22}{k_2} = \frac{\left(\frac{0.63^3}{1+0.63}\right)}{\left(\frac{0.43^3}{1+0.43}\right)};\quad k_2 = \mathbf{0.08\ cm/s}$$

2.9 From Eq. (2.41):

$$\frac{k_1}{k_2} = \left(\frac{1+e_2}{1+e_1}\right)\left(\frac{e_1}{e_2}\right)^n;\quad \text{or}\ \frac{0.2\times10^{-6}}{0.91\times10^{-6}} = \left(\frac{2.9}{2.2}\right)\left(\frac{1.2}{1.9}\right)^n;\quad 0.1667 = (0.6316)^n$$

$$n = \frac{\log(0.1667)}{\log(0.6316)} = \frac{-0.778}{=0.1996} = 3.898$$

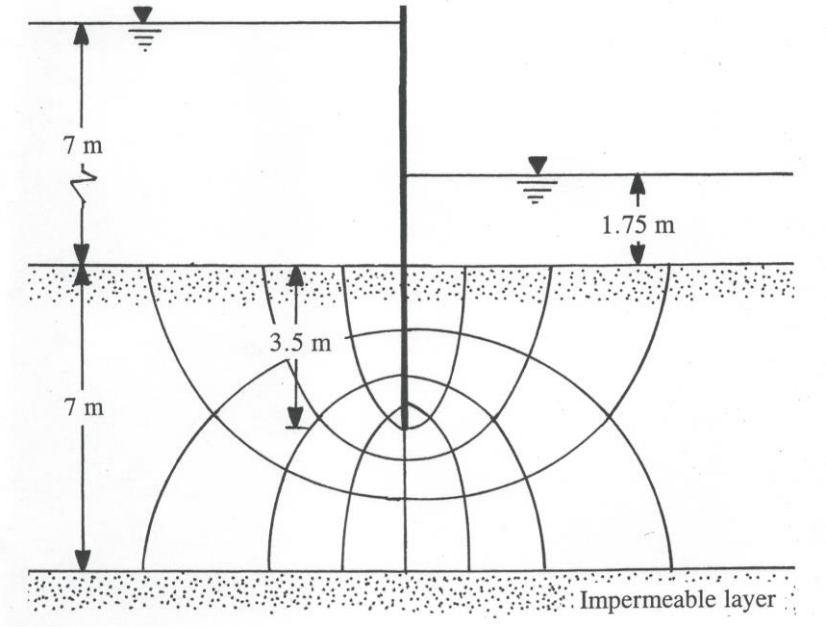
© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

$$C = \frac{k_1(1+e_1)}{e_1^n} = \frac{(0.2\times10^{-6})(2.2)}{1.2^{3.998}} = 0.216\times10^{-6}$$

$$k_3 = C\left(\frac{e^n}{1+e}\right) = \left(\frac{0.9^{3.998}}{1.9}\right)(0.216\times10^{-6}) = \mathbf{0.075\times10^{-6}\ cm/s}$$

2.10 The flow net is shown.



$k = 6.5\times10^{-4}$ cm/s; $h_{max} = H_1 - H_2 = 7 - 1.75 = 5.25$ m. So,

$$q = \left(\frac{6.5\times10^{-4}}{10^2}\right)\left[\frac{(5.25)(4)}{8}\right] = \mathbf{17.06\times10^{-6}\ m^3/m/s}$$

2.11 a. $$k = 2.4622\left[D_{10}^2\frac{e^3}{(1+e)}\right]^{0.7825} = 2.4622\left[(0.2)^2\left(\frac{0.6^3}{1+0.6}\right)\right]^{0.7825} = \mathbf{0.041\ cm/s}$$

b. $$k = 35\left(\frac{e^3}{1+e}\right)C_u^{0.6}(D_{10})^{2.32} = (35)\left(\frac{0.6^3}{1+0.6}\right)\left(\frac{0.4}{0.2}\right)^{0.6}(0.2)^{2.32} = \mathbf{0.171\ cm/s}$$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

2.12 $$\gamma_{dry(sand)} = \frac{G_s\gamma_w}{1+e} = \frac{(2.66)(9.81)}{1+0.55} = 16.84\ \text{kN/m}^3$$

$$\gamma_{sat(sand)} = \frac{G_s\gamma_w + e\gamma_w}{1+e} = \frac{(9.81)(2.66+0.48)}{1+0.48} = 20.81\ \text{kN/m}^3$$

$$\gamma_{sat(clay)} = \frac{G_s\gamma_w(1+w)}{1+wG_s} = \frac{(2.74)(9.81)(1+0.3478)}{1+(0.3478)(2.74)} = 18.55\ \text{kN/m}^3$$

At A: $\sigma = \mathbf{0}$; $u = \mathbf{0}$; $\sigma' = \mathbf{0}$

At B: $\sigma = (16.84)(3) = \mathbf{50.52\ kN/m^2}$
$u = \mathbf{0}$
$\sigma' = \mathbf{50.52\ kN/m^2}$

At C: $\sigma = \sigma_B + (20.81)(1.5) = 50.52 + 31.22 = \mathbf{81.74\ kN/m^2}$
$u = (9.81)(1.5) = \mathbf{14.72\ kN/m^2}$
$\sigma' = 81.74 - 14.72 = \mathbf{67.02\ kN/m^2}$

At D: $\sigma = \sigma_C + (18.55)(5) = 81.74 + 92.75 = \mathbf{174.49\ kN/m^2}$
$u = (9.81)(6.5) = \mathbf{63.77\ kN/m^2}$
$\sigma' = 174.49 - 63.77 = \mathbf{110.72\ kN/m^2}$

2.13 Eq. (2.54): $C_c = 0.009(\text{LL} - 10) = 0.009(42 - 10) = 0.288$

Eq. (2.65):

$$S_c = \frac{C_cH_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'}{\sigma'_o} = \frac{(0.288)(3.7\times1000\ \text{mm})}{1+0.82}\log\left(\frac{155}{110}\right) = \mathbf{87.2\ mm}$$

2.14 Eq. (2.69):

$$S_c = \frac{C_sH_c}{1+e_o}\log\left(\frac{\sigma'_c}{\sigma_o}\right) + \frac{C_cH_c}{1+e_o}\log\frac{\sigma'_o + \Delta\sigma'}{\sigma'_c}$$

$$= \frac{\left(\frac{0.288}{5}\right)(3700\ \text{mm})}{1+0.75}\log\left(\frac{128}{110}\right) + \frac{(0.288)(3700)}{1+0.82}\log\left(\frac{155}{128}\right) = \mathbf{56.69\ mm}$$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

2.15 a. Eq. (2.53): $C_c = \dfrac{e_1 - e_2}{\log\left(\dfrac{\sigma'_2}{\sigma'_1}\right)} = \dfrac{0.91 - 0.792}{\log\left(\dfrac{300}{150}\right)} = 0.392$

From Eq. (2.65): $S_c = \dfrac{C_c H_c}{1 + e_o} \log \dfrac{\sigma'_o + \Delta\sigma'}{\sigma'_o}$

Using the results of Problem 2.12,

$$\sigma'_o = (3)(16.84) + 1.5(20.81 - 9.81) + \frac{5}{2}(18.55 - 9.81) = 88.87 \text{ kN/m}^2$$

$$e_o = wG_s = (0.3478)(2.74) = 0.953$$

$$S_c = \frac{(0.392)(5000 \text{ mm})}{1 + 0.953} \log\left(\frac{88.87 + 50}{88.87}\right) = \mathbf{194.54 \text{ mm}}$$

b. Eq. (2.73): $T_v = \dfrac{C_v t}{H^2}$. For $U = 50\%$, $T_v = 0.197$ (Table 2.11). So,

$$0.197 = \frac{9.36 \times 10^{-4} t}{(500 \text{ cm})^2}; \quad t = 5262 \times 10^4 \text{ sec} = \mathbf{609 \text{ days}}$$

2.16 a. Eq. (2.53): $C_c = \dfrac{e_1 - e_2}{\log\left(\dfrac{\sigma'_2}{\sigma'_1}\right)} = \dfrac{0.82 - 0.64}{\log\left(\dfrac{360}{120}\right)} = \mathbf{0.377}$

b. $C_c = \dfrac{e_1 - e_2}{\log\left(\dfrac{\sigma'_2}{\sigma'_1}\right)}$; $0.377 = \dfrac{0.82 - e_2}{\log\left(\dfrac{200}{120}\right)}$; $e_2 = \mathbf{0.736}$

2.17 Eq. (2.73): $T_v = \dfrac{C_v t}{H^2}$. For 60% consolidation, $T_v = 0.286$ (Table 2.11).

Lab time: $t = 8\frac{1}{6} \text{ min} = \dfrac{49}{6} \text{ min}$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

$$0.286 = \frac{C_v\left(\frac{49}{6}\right)}{(3.8\,\text{cm})^2}; \quad C_v = 0.5057\,\text{cm}^2/\text{min}$$

Field: $U = 50\%$; $T_v = 0.197$

$$0.197 = \frac{(0.5057)t}{\left(\frac{3.05\times 100}{2}\,\text{cm}\right)^2}; \quad t = 9060\,\text{min} = \mathbf{6.29\ days}$$

2.18 $$U = \frac{30}{60} = 0.5$$

$$T_{v(1)} = \frac{C_{v(1)}t}{H_1^2} = \frac{(2)(t)}{\left(\frac{2\times 1000}{2}\right)^2} = 2\times 10^{-6}t$$

$$T_{v(2)} = \frac{C_{v(2)}t}{H_2^2} = \frac{(2)(t)}{\left(\frac{1\times 1000}{2}\right)^2} = 8\times 10^{-6}t$$

So, $T_{v(1)} = 0.25T_{v(2)}$. The following table can be prepared for trial and error procedure.

$T_{v(1)}$	$T_{v(2)}$	U_1 (Figure 2.22)	U_2 (Figure 2.22)	$\frac{U_1H_1 + U_2H_2}{H_1 + H_2} = U$
0.05	0.2	0.26	0.51	0.34
0.10	0.4	0.36	0.70	0.473
0.125	0.5	0.40	0.76	0.52
0.1125	0.45	0.385	0.73	0.50

So, $T_{v(1)} = 0.1125 = 2 \times 10^{-6}t$; $t = 56{,}250$ min = **39.06 days**

2.19 Eq. (2.84): $T_c = \frac{C_v t_c}{H^2}$. $t_c = 60$ days $= 60 \times 24 \times 60 \times 60$ sec; $H = \frac{2}{2}$ m = 1000 mm.

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

$$T_c = \frac{(8\times10^{-3})(60\times24\times60\times60)}{(1000)^2} = 0.0415$$

After 30 days: $T_v = \dfrac{C_v t}{H^2} = \dfrac{(8\times10^{-3})(30\times24\times60\times60)}{(1000)^2} = 0.0207$

From Figure 2.24 for $T_v = 0.0207$ and $T_c = 0.0415$, $U = 5\%$. So

$S_c = (0.05)(120) =$ **6 mm**

After 100 days: $T_v = \dfrac{C_v t}{H^2} = \dfrac{(8\times10^{-3})(100\times24\times60\times60)}{(1000)^2} = 0.069$

From Figure 2.24 for $T_v = 0.069$ and $T_c = 0.0415$, $U \approx 23\%$. So

$S_c = (0.23)(120) =$ **27.6 mm**

2.20 $\phi' = \tan^{-1}\left(\dfrac{S}{N}\right)$

Normal force, N (N)	Shear force, S (N)	$\phi' = \tan^{-1}\left(\dfrac{S}{N}\right)$ (deg)
222.4	193.5	41.02
489.3	424.8	40.96
667.2	587.1	41.35

From the graph, $\phi' \approx$ **41°**

2.21 Normally consolidated clay; $c' = 0$.

$$\sigma_1' = \sigma_3' \tan^2\left(45 + \frac{\phi'}{2}\right); \quad 207 + 662.4 = 207\tan^2\left(45 + \frac{\phi'}{2}\right); \quad \phi' = \mathbf{38°}$$

2.22 $\sigma_1' = \sigma_3' \tan^2\left(45 + \dfrac{\phi'}{2}\right)$; $138 + 276 = 138\tan^2\left(45 + \dfrac{\phi'}{2}\right)$; $\phi' = \mathbf{30°}$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

2.23 $c' = 0$. Eq. (2.91): $\sigma_1' = \sigma_3' \tan^2\left(45 + \frac{\phi'}{2}\right) = 140 \tan^2\left(45 + \frac{28}{2}\right) = \mathbf{387.8\ kN/m^2}$

2.24 Eq. (2.91): $\sigma_1' = \sigma_3'\left(45 + \frac{\phi'}{2}\right) + 2c' \tan\left(45 + \frac{\phi'}{2}\right)$

$$368 = 140 \tan^2\left(45 + \frac{\phi'}{2}\right) + 2c' \tan\left(45 + \frac{\phi'}{2}\right) \quad \text{(a)}$$

$$701 = 280 \tan^2\left(45 + \frac{\phi'}{2}\right) + 2c' \tan\left(45 + \frac{\phi'}{2}\right) \quad \text{(b)}$$

Solving Eqs. (a) and (b), $\phi' = \mathbf{24°}$; $c' = \mathbf{12\ kN/m^2}$

2.25 $\phi = \sin^{-1}\left(\frac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3}\right) = \sin^{-1}\left(\frac{220.8 - 89.7}{220.8 + 89.7}\right) = \mathbf{25°}$

$$\phi' = \sin^{-1}\left(\frac{\sigma_1' - \sigma_3'}{\sigma_1' + \sigma_3'}\right)$$

$\sigma_3' = 220.8 - 37.95 = 182.85\ \text{kN/m}^2$; $\sigma_3' = 89.7 - 37.95 = 51.75\ \text{kN/m}^2$

$$\phi' = \sin^{-1}\left(\frac{182.85 - 51.75}{182.85 + 51.75}\right) = \mathbf{34°}$$

Normally consolidated clay; $c = \mathbf{0}$ and $c' = \mathbf{0}$

2.26 $\sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\phi}{2}\right)$. $\sigma_1 = 150 \tan^2\left(45 + \frac{20}{2}\right) = 305.9\ \text{kN/m}^2$

$$\frac{\sigma_1'}{\sigma_3'} = \tan^2\left(45 + \frac{\phi'}{2}\right); \quad \frac{305.9 - u}{150 - u} = \tan^2\left(45 + \frac{28}{2}\right); \quad u = \mathbf{61.9\ kN/m^2}$$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

2.27 a. $\phi' = 26° + 10D_r + 0.4C_u + 1.6\log(D_{50})$

$= 26° + (10)(0.53) + (0.4)(2.1) + (1.6)[\log(0.13)] = \mathbf{30.7°}$

b. $\phi' = \dfrac{1}{ae + b}$

$a = 2.101 + 0.097\left(\dfrac{D_{85}}{D_{15}}\right) = 2.101 + 0.097\left(\dfrac{0.21}{0.09}\right) = 2.327$

$b = 0.845 - 0.398a = 0.845 - (0.398)(2.327) = -0.081$

$\phi' = \dfrac{1}{(2.327)(0.68) - 0.081} = \mathbf{33.67°}$

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual

© 2016 Cengage Learning. All Rights Reserved. May not be scanned, copied or duplicated, or posted to a publicly accessible website, in whole or in part.

Principles of Foundation Engineering SI Edition 8th edition Das Solutions Manual