Chapter 2 Solutions

2-1. Precision = 0.27/4826.55 = 1/17,876

2-2 Precision = 0.38/6432.81 = 1/16,928

2-3. A probable error or 50% error is the magnitude of an error for which there is a 50% chance that a particular measurement contains an error of lesser magnitude and a 50% chance that it contains a larger one.

2-4. When a single quantity is measured several times or when a series of quantities is measured, random errors will tend to accumulate in proportion to the square root of the number of measurements. This is referred to as the Law of Compensation.

2-5.

Measured Values	Residual v	v^2
3.462	0.0008	0.000001
3.467	0.0058	0.000034
3.465	0.0038	0.000014
3.458	-0.0032	0.000010
3.463	0.0018	0.000003
3.457	-0.0042	0.000018
3.468	0.0068	0.000046
3.452	-0.0092	0.000085
3.464	0.0028	0.000008
3.456	-0.0052	0.000027
Avg = 3.4612		Σv^2 = 0.000246

a. Most probable value of the measured quantity

Mean = 3.461

b. Probable error of a single measurement.

$E_{50} = \pm 0.6745*(0.000246/(10-1))^{(1/2)} = \pm 0.0035$ ft

c. 90% error.

$E_{90} = \pm 1.6449*(0.000246/(10-1))^{(1/2)} = \pm 0.0086$ ft

d. 95% error.

$E_{95} = \pm 1.9599*(0.000246/(10-1))^{(1/2)} = \pm 0.0102$ ft

2-6.

Measured Values	Residual v	V^2
154.70	0.052	0.002756
154.67	0.022	0.000506
154.68	0.032	0.001056
154.69	0.042	0.001806
154.62	-0.028	0.000756
154.66	0.012	0.000156
154.60	-0.048	0.002256
154.74	0.093	0.008556
154.55	-0.097	0.009506
154.58	-0.067	0.004556
154.65	0.002	0.000006
154.63	-0.018	0.000306
Avg = 154.648		**Σv^2 = 0.0322**

a. Most probable value of the measured quantity
   Mean = 154.65
b. Probable error of a single measurement.
   $E_{50} = \pm\ 0.6745*(0.0322/(12-1))^{(1/2)} = \pm\ 0.04$ ft
c. 90% error.
   $E_{90} = \pm\ 1.6449*(0.0322/(12-1))^{(1/2)} = \pm\ 0.09$ ft
d. 95% error.
   $E_{95} = \pm\ 1.9599*(0.0322/(12-1))^{(1/2)} = \pm\ 0.11$ ft

2-7.

a. Most Probable Error = (0.6745)(±0.21)= ±0.14 ft

b. Error @ 2σ = (2.00)(±0.21)= ±0.42 ft
   Estimated Precision = 0.42/916.45=1/2182

c. Error @ 3σ = (3.00)(±0.21)= ±0.63 ft
   Estimated Precision = 0.63/916.45=1/1454

2-8.

Measured Values	Residual v	V^2
736.352	-0.0072	0.000052
736.363	0.0038	0.000014
736.375	0.0158	0.000250
736.324	-0.0352	0.001239
736.358	-0.0012	0.000001
736.383	0.0238	0.000566
Avg = 736.3592		**Σv^2 = 0.00212**

a. Most probable value of the measured quantity
   Mean = 736.359 ft
b. Standard Deviation = $\pm(0.004/(6-1))^{1/2} = \pm 0.0206$ ft
c. Error @ 3.29σ = (±0.028 ft)(3.29) = ±0.0678 ft

2-9.

Measured Values	Residual v	V^2
201.658	-0.019	0.000342
201.642	-0.035	0.001190
201.660	-0.017	0.000272
201.732	0.055	0.003080
201.649	-0.028	0.000756
201.661	-0.016	0.000240
201.730	0.053	0.002862
201.680	0.004	0.000012
Avg = 201.677		**Σv^2 = 0.008756**

a. Most probable value of the measured quantity
Mean = 201.677 ft
b. Standard Deviation = ±(0.008756/(8-1))$^{1/2}$ = ±0.035 ft
c. Error @ 3.29σ = (±0.035 ft)(3.29) = ±0.115 ft

2-10.

Measured Values	Residual v	V^2
155.35	-0.09	0.0074
155.42	-0.02	0.0003
155.30	-0.14	0.0186
155.58	0.14	0.0207
155.47	0.03	0.0011
155.32	-0.12	0.0135
155.61	0.17	0.0302
155.44	0.00	0.0000
Avg = 155.44		**Σv^2 = 0.0918**

a. Most probable value of the measured quantity
Mean = 155.44 ft
b. Standard Deviation = ±(0.0918/(8-1))$^{1/2}$ = ±0.11 ft
c. Error @ 3.29σ = (±0.11 ft)(3.29) = ±0.36 ft

2-11.

Measured Values	Residual v	V^2
613.27	-0.04	0.0012
613.24	-0.07	0.0042
613.34	0.03	0.0012
613.29	-0.02	0.0002
613.43	0.12	0.0156
613.22	-0.09	0.0072
613.39	0.08	0.0072
613.40	0.09	0.0090
613.26	-0.05	0.0020
613.21	-0.10	0.0090
Avg = 613.31		**$\Sigma v^2 = 0.0570$**

a. Most probable value of the measured quantity
Mean = 613.31 ft

b. Standard Deviation = $\pm(0.0570/(12-1))^{1/2} = \pm 0.07$ ft

c. Error @ 3.29σ = (±0.07 ft)(3.29) = ±0.23 ft

2-12. $E_{total} = \pm 0.008*(32)^{1/2} = \pm 0.045$ ft

2-13. a) $E_{total} = \pm 0.007*(24)^{1/2} = \pm 0.034$ ft
b) $E_{total} = \pm 0.004*(24)^{1/2} = \pm 0.020$ ft

2-14. $E_{total} = \pm 0.020*(15.2744)^{1/2} = \pm 0.0781$ ft
$E_{total} = \pm 0.020*(18.1237)^{1/2} = \pm 0.0851$ ft
E for both sides = $[(0.0781)^2 + (0.0851)^2]^{1/2} = 0.116$ ft

2-15. $E_{total} = \pm 0.004*(25)^{1/2} = \pm 0.020$ ft

2-16. n = # of tape lengths = 1500/30= 50
$E_{total} = \pm 0.003*(50)^{1/2} = \pm 0.0212$ m

2-17. Area = (158.46)*(212.71) = 33,706.03 sq ft
$E_{product} = \pm[(158.46)^2*(0.04)^2 + (212.71)^2*(0.03)^2]^{1/2} = 8.99$ sq ft
Say 9 sq ft

2-18. a) n=22 tape lengths
$\pm E\ (22)^{1/2} = \pm 0.20$
E = ±0.04 ft / tape length
b) n=40 tape lengths
$\pm E_{95}\ (40)^{1/2} = \pm 0.24$
$E = \pm 0.0379 = 1.9599*\sigma = 1.9599*E_{standard}$
$E_{standard} = \pm 0.0194$ ft   Say ±0.02 ft

2-19. $E_{series} = \pm E *n^{1/2}$
$\pm 1' = \pm E *9^{1/2}$
E = ± (1/3)' = 20"

Chapter 3 Solutions

3-1.

a) Pacing (convenient for estimating distances and for checking distances measured by other methods—very inaccurate.)
b) Odometers (convenient for measuring on smooth surfaces such as pavements and for initial route location surveys—quite inaccurate.)
c) Stadia (convenient for locating details for maps and for estimating other distances—poor accuracy.)
d) Subtense bar (convenient for measuring across rough terrain and for relatively short distances under about 500 ft. Has been made obsolete by the far more accurate and quickly used EDMs.)
e) Taping (convenient and quite accurate for short distances up to a few hundred feet but tedious and slow compared to EDMs. May have to make quite a few corrections as for temperature, slope sag, pull, etc.)
f) Electronic distance measuring instruments (EDMs) (quick and accurate for short and long distances. May have to make corrections for humidity and slopes.)

3-2.

a) Pacing (estimating distances as for lots and checking distances made by more precise means.)
b) Odometer (measurements of amounts of paving for roads and parking lots. Initial location surveys and quick checks on other measurements.)
c) Stadia (locating details for maps, making rough surveys and for checking more precise surveys.)
d) Taping (short distances, accurate work.)
e) EDMs (quick, accurate, long or short distances, difficult terrain.)

3-3. Avg. # of paces = (95+93+97+98+92) / 5 = 95 paces
Avg. pace = 250 / 95 = 2.632 ft
Avg. # of paces for unknown dist. = (115+118+116+117) / 4 = 116.5 paces
Dist. Paced = (116.5 paces)(2.632 ft / pace) = 306.63 say 307 ft

3-4. Avg. # of paces = (140+143+141+142) / 4 = 141.5 paces
Avg. pace = 400 / 141.5 = 2.827 ft
# of paces req'd. for 525 ft = 525 / 2.827 = 185.7 say 186 paces

3-5. a) (632.18 m)(3.280840 ft / m) = 2074.08 ft
b) (895.49 m)(3.280840 ft / m) = 2937.96 ft
c) (1254.3 m)(3.280840 ft / m) = 4115.16 ft

3-6. a) 24°19′12″ = 24°19′ + 12′/60 = 24°19.2′ = 24° + 19.2°/60 = 24.32°
b) 59°44′37″ = 59°44′ + 37′/60 = 59°44.616666′ = 59° + 44.616666°/60 = 59.7436°
c) 123°10′09″ = 123°10′ + 9′/60 = 123°10.15′ = 123° + 10.15°/60 = 123.1692°

3-7. a) 99.4871° = 99° + (0.4871)(60′) = 99°29.226′ = 99°29′ + (0.226)(60″) = 99°29′13.6″
b) 51.9534° = 51° + (0.9534)(60′) = 51°57.204′ = 51°57′ + (0.204)(60″) = 51°57′12.2″
c) 148.6736° = 148° + (0.6736)(60′) = 148°40.416′ = 148°40′ + (0.416)(60″) = 148°40′25″

3-8. Avg. angle reading on the subtense bar =

$$\frac{0°44'20'' + 0°44'18'' + 0°44'21'' + 0°44'19''}{4}$$

Avg.= 0°44′20″

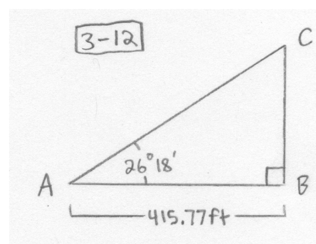
Horizontal length of line = cot α / 2 = cot(0°44′20″ / 2) = cot(0°44.333333′ / 2)
= cot(0.73888888° / 2) = 155.08 m

3-9. Distance = 83.00 – 0.48 = 82.52 ft

3-10. Cross-sectional area of tape
= (1/40)(5/16) = 0.0078125 sq. in.
Volume of tape in cubic ft.
= (0.0078125 / 144)(100) = 0.0054253472222 ft^3
Wt. of tape = (0.0054253472222)(490) = 2.66 lb

3-11. Cross-sectional area of tape
= (0.030)(3/8) = 0.01125 sq. in.
Volume of tape in cubic ft.
= (0.01125 / 144)(100) = 0.0078125 ft^3
Wt. of tape = (0.0078125)(490) = 3.83 lb

3-12. Changing angle A to decimal form
=26° + (18/60) ° = 26.3°
Cos(26.3°) = 415.77 ft / L_{AC}
L_{AC} = 415.77 / 0.896486430 = 463.78 ft
$L_{BC} = [(463.78)^2 – (415.77)^2]^{½}$ = 205.49 ft



3-13. Sin A = 126.42 / 82.83 = 0.655196963
Angle A = 40°56.075′