18.0 USEFUL INFORMATION

18.1 CONVERSION FACTORS

To convert from this	into this To convert this back	multiply by this divide by this
atmosphere	millibar	1013.25
atmosphere	pascal	101.325
cubic foot	cubic metre	0.028317
cubic inch	cubic millimetre	16387.1
cubic yard	cubic metre	0.764555
foot	metre	0.3048
foot per minute	metre per minute	0.3048
foot per minute	metre per second	0.00508
foot per second	metre per second	0.3048
foot pound force per second	watt	1.35582
gallon (Imp)	litre	4.54609
gallon (US)	litre	3.785 41
inch	metre	0.0254
inch	millimetre	25.4
inch mercury	kilopascal	3.38638
inch water gauge	kilopascal	0.248642
knot	kilometre per hour	1.852
mile	kilometre	1.609 344
mile per hour	kilometre per hour	1.609 344
millimetre mercury	kilopascal	0.133322
millimetre water gauge	pascal	9.78904
ounce	gram	28.3495
ounce per square foot	gram per square metre	305.152
ounce per square yard	gram per square metre	33.9057
pound	kilogram	0.45359237
pound force	newton	4.44822
pound force foot	newton.metre	1.35582
pound force inch	newton.metre	0.112985
pound force per square inch	bar	0.69
pound force per square inch	pascal	6894.76
pound force per square inch	kilopascal	6.89476
pound force per square foot	kilopascal	0.0479
pound force per square inch	megapascal	0.006895
pound per cubic foot	kilogram per cubic metre	16.0185
pound per foot	kilogram per metre	1.48816
pound per square foot	kilogram per square metre	4.882
square foot	square metre	0.092 903
square foot per ton	square metre per tonne	0.091436
square inch	square millimetre	645.16
square mile	square kilometre	2.59
square yard	square metre	0.836127

To convert from this	into this To convert this back	multiply by this divide by this
ton	tonne	1.01605
ton, freight (40 ft^3)	cubic metre	1.13267
ton force foot	kilonewton metre	3.03703
ton force per square inch	megapascal	15.4443
ton per cubic yard	tonne per cubic metre	1.32894
yard	kilometre	0.000914

1 knot	= 1 nautical mile/h = 6080 ft/h = 1.853 km/h = 0.515 m/s
1 km/h	= 0.539 knots
Head of water	= 9.8 kPa per m

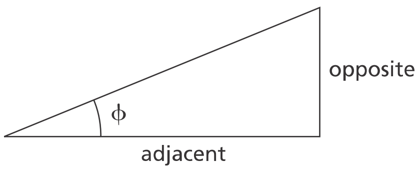
Water 0° – 100° increases in volume by 4.4%

1 litre	= 1 kg = 0.001 m^3
1 m^3	= 1000 litres
Weight of steel kgs/m^2	= thickness in mm x 7.85
1 kN	= 102 kg
1 kip	= 6.895 MPa

18.2 ROOF PITCH

The relationship between the pitch, fall or rise and the horizontal, is the relationship between the opposite and the adjacent sides of a right angled triangle.

This is known as the tangent of the angle. (tan ϕ) with the opposite side being the rise and the adjacent side the horizontal distance.



TAN .25°	=	.0044	approximating	1 in 225
TAN .5°	=	.0087	approximating	1 in 115
TAN 1°	=	.0175	approximating	1 in 60
TAN 1.5°	=	.0262	approximating	1 in 40
TAN 2°	=	.0349	approximating	1 in 30
TAN 2.5°	=	.0437	approximating	1 in 25
TAN 3°	=	.0524	approximating	1 in 20
TAN 4°	=	.0699	approximating	1 in 14
TAN 5°	=	.0875	approximating	1 in 12
TAN 6°	=	.1051	approximating	1 in 10
TAN 7°	=	.1228	approximating	1 in 8
TAN 8°	=	.1405	approximating	1 in 7
TAN 9°	=	.1584	approximating	1 in 6.5
TAN 10°	=	.1763	approximating	1 in 6
TAN 11°	=	.1944	approximating	1 in 5
TAN 12°	=	.2126	approximating	1 in 4.75
TAN 13°	=	.2309	approximating	1 in 4.5
TAN 14°	=	.2493	approximating	1 in 4
TAN 15°	=	.2679	approximating	1 in 3.75
TAN 16°	=	.2867	approximating	1 in 3.5
TAN 17°	=	.3057	approximating	1 in 3.25
TAN 18°	=	.3249	approximating	1 in 3
TAN 19°	=	.3443	approximating	1 in 3
TAN 20°	=	.3640	approximating	1 in 2.75
TAN 21°	=	.3839	approximating	1 in 2.5
TAN 22°	=	.4040	approximating	1 in 2.5
TAN 23°	=	.4245	approximating	1 in 2.5
TAN 24°	=	.4452	approximating	1 in 2.25
TAN 25°	=	.4663	approximating	1 in 2
TAN 30°	=	.5774	approximating	1 in 1.75
TAN 35°	=	.7002	approximating	1 in 1.5
TAN 45°	=	1	approximating	1 in 1
TAN 60°	=	1.732	approximating	1 in 0.6
TAN 75°	=	3.732	approximating	1 in 0.3

18.3 MATERIAL DENSITY, MELTING POINT, EXPANSION AND MODULUS

Material	Density kg/m³	Melting point °C	Expansion mm/10m/100°C	Youngs modulus Gpa
Air	1.29			
Air acetylene		2500*		
Aluminium, rolled	2710	658	24	69
Brass	8330	900	18	
Carbon Dioxide 0°C	1. 99			
Cement	1281			
Concrete, reinforced 2% steel	2420			
Copper	8938	1083	17	131
Glass	2787	850	9	
Gold	19290	1063	14	
Hydrogen 0°C	.0897			
Helium 0°C	.178			
Ice	913	0		
Iron, cast	7208	1530	12	179
Lead, rolled	11325	327	29	16
Nitrogen 0°C	1.25			
Oxygen 0°C	1.43			
Oxy acetylene		4400*		
Pinus Radiata	609			6
Polycarbonate	1244	133	64	
Polyester	1299	245	80#	
P.V.C.	1465	86	140	
Silver	10500	960	19	
Silver solder		735		
Easy-flo		630		
Solder Lead 50%/tin 50%	9302	210		
(Eutectic) Lead 33%/tin 67%	8615	180		
Snow: fresh	96	1		
wet compact	320			
Stainless Steel 304	8080	1425	17	193
Stainless Steel 316	8080	1385	16	193
Steel, low carbon	7850	1350	12	200
Tin	7280	231	27	
Water: fresh 4°C	1000			
Water: fresh 20°C	988			
Water: fresh 100°C	958			
Water: salt	1009-1201			
Zinc: rolled	7192	419	29	

* max flame temperature

glass reinforced polyester GRP expansion = 22

To convert Centigrade to Farenheit. C° = F° - 32° x .56

To convert Farenheit to Centigrade. F° = C° x 1.8 + 32°

18.3.1 THERMAL CONDUCTIVITY K

Material	W/mK	Material	W/mK
Copper	385	Water (20˚C)	.56
Aluminium	205	Timber (Pine)	.14
Zinc	108	Snow	.1
Steel	50	Kraft building paper	.07
Lead	35	Fibreglass	.035
Stainless Steel	16	Rockwool	.035
Ice	2	Polystyrene	.035
Glass	1.05	Air (20˚C)	.025
Concrete	.94	Polyurethane (Rigidised)	.016
Brick	.8		

Thermal conductivity values will vary with density, temperature and moisture content. (when applicable)

Electrical conductivity values generally follow thermal conductivity.

K = Kelvin = Absolute scale. i.e. 0˚ C = 273 K The degrees are equal i.e. 100˚ C = 373 K

18.4 DECADIC NUMBER SYSTEM

Symbol	Designation	Long Measure			Multiplier
T	Tera	Billion (Trillion USA)			10^{12}
G	Giga	Milliard (Billion USA)			10^{9}
M	Mega	Million			10^{6}
ma	Myria	Ten thousand	mam	Myriametre	10^{4}
k	Kilo	Thousand	km	Kilometre	10^{3}
h	Hecto	Hundred	hm	Hectometre	10^{2}
da	Deca	Ten	dam	Decametre	10
		One	m	Metre	1
d	Deci	Tenth	dm	Decimetre	10^{-1}
c	Centi	Hundredth	cm	Centimetre	10^{-2}
m	Milli	Thousandth	mm	Millimetre	10^{-3}
µ	Micro	Millionth		Micrometre (Micron)	10^{-6}
n	Nano	Milliardth (billionth USA)	nm	Nanometre	10^{-9}
p	Pico	Billionth (trillionith USA)	pm		10^{-12}

18.4.1 INTERNATIONAL SYMBOLS

The Greek Alphabet

Upper		Lower		Greek
A	Α	a	α	alpha
B	Β	b	β	beta
G	Γ	g	γ	gamma
D	Δ	d	δ	delta
E	Ε	e	ϵ	epsilon
Z	Ζ	z	ζ	zeta
H	Η	h	η	eta
Q	Θ	q	ϑ	theta
I	Ι	i	ι	iota
K	Κ	k	κ	kappa
L	Λ	l	λ	lambda
M	Μ	m	μ	mu
N	Ν	n	ν	nu
J	Ξ	j	ξ	xi
O	Ο	o	ο	omicron
P	Π	p	π	pi
R	Ρ	r	ρ	rho
S	Σ	s	σ	sigma
T	Τ	t	τ	tau
Y	Υ	y	υ	upsilon
F	Φ	f	ϕ	phi
X	Χ	x	χ	chi
C	Ψ	c	ψ	psi
V	Ω	v	ω	omega

18.5 GEOMETRY AND MENSURATION

a	= area
b	= base
d	= diameter
h	= height
l	= length
r	= radius
c	= circumference
π	= 3.1416
c	= $2\pi r$ or 22/7 d

Areas

Circle	= πr^2 or 0.7854 d^2
Square, rectangle, rhombus or rhomboid	= bh
Triangle	= .5 bh
Trapezoid	= .5 two parallel sides x h
Side of square of area equal to circle	= 0.8862 d
Diameter of circle equal in area to square	= 1.1284 side of square
Parabola	= .66 bh
Ellipse	= 0.7854 d^1 d^2

Area of any figure of four or more unequal sides is found by dividing it into triangles, finding areas of each and adding together.

Surface area

Cube	= $6b^2$
Sphere	= πd^2
Lateral surface area of regular figure	= .5 cbh (slant height)
Cylinder (Lateral surface area)	= πdh
Cylinder (Total surface area)	= $\pi dh + 2\pi r^2$
Cone (Total surface area)	= ab + c of base x .5h (slant height)

Volume

Cube	= b^3
Sphere	= 0.5236 d^3
Pyramid or Cone	= .33 abh
Cylinder	= $\pi r^2 h$

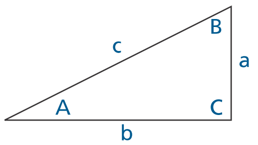
Table of polygons

S	= side of polygon.
R	= Radius of circumscribed circle.
r	= Radius of inscribed circle.
A	= Angle formed by the intersection of the sides.

Name	No of sides	Angle
Trigon	3	60˚
Pentagon	5	108˚
Hexagon	6	120˚
Octagon	8	135˚
Decagon	10	144˚

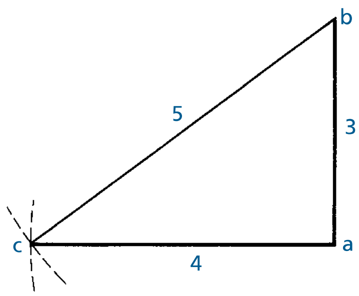
Area of any regular polygon = Radius of inscribed circle x 1/2 number of sides x length of one side.

Right angle triangles



Find	Given	Solution
A	a, b	tan A = a / b
	a, c	sin A = a /c
	b, c	cos A = b / c
B	a, b	tan B = b / a
	a, c	cos B = a / c
	b, c	sin B = b / c
a	A, b	b tan A
	A, c	c sin A
	b, c	$\sqrt{c^2 - b^2}$
b	A, a	a / tan A
	A, c	c / cos A
	a, c	$\sqrt{c^2 - a^2}$
c	A, a	a / sin A
	A, b	b / cos A
	a, b	$\sqrt{a^2 + b^2}$
Area	a, b	ab / 2

To find a right angle:
Draw a line ab 3x long. At point a scribe an arc 4x long.
At point b scribe an arc 5x long to intersect a c.
Join ac and b, ac and ab are at 90^0.



18.6 VELOCITIES

Unit	m/s	kms/h	mile/h
mile / hour	0.44704	1.60934	1
m/s	1	3.6	2.23694
km/h	0.277778	1	0.62137

Velocity is the distance travelled in one second (m/s).

The following speeds are approximate and are assumed to be constant and in a straight direction and therefore are also the velocity.

Description marked *R* are speed records.

	m/s	km/h	mile/hour	Beaufort Scale	
Calm	0	<1	0		Smoke rises vertically
Light Air	0.8	3	2	1	Smoke rises on angle
Man walking	1.5	5.5.	3.5		
Light breeze	2.5	9	5.6	2	Feel wind on face
Gentle breeze	4.5	16	10	3	Flags extend
Moderate breeze	7	25	15.5	4	Raises dust
Fresh breeze	10	35	22	5	Trees sway, waves
Runner 100m *R*	10	35	22		
Strong breeze	12.5	45	28	6	Telegraph wires whistle
Racehorse trotting *R*	15	54	33		
Moderate gale	15.5	56	35	7	Difficult to walk
Fresh gale	18.5	67	42	8	Branches break
Racehorse *R*	19	68	42.5		
Ostrich	20	72	45		
Racing cyclist *R*	22	79	49		
Strong gale	23	82	51	9	Slight building damage
Whole gale	26.5	96	60	10	Trees uprooted
N.Z. Road speed limit	28	100	62.5		
Skier downhill	28	100	62.5		
Storm	31	111	69	11	Widespread damage
Low wind speed NZS 3604	32	115	71		
Hurricane	33.5	120	75	12	Severe damage
Medium wind speed NZS 3604	37	133	83		
High wind speed NZS 3604	44	158	98		
AS/NZS 1170	45	162	101		
Swift - fastest bird	47	169	105		
Very high wind speed NZS 3604	50	180	111		
AS/NZS 1170 (Cook Strait)	51	184	114		
Moderate cyclone	55	198	153		
Tennis serve *R*	66	238	148		
Bullet train (Japan)	69	248	154		
Severe tropical cyclone	70	252	157		
TGV express train	77	277	172		
Wind *R*	103	371	230		

	m/s	km/h	mile/hour	
Boeing 747	256	920	572	
Sound in air	333	1199	743	
Land speed *R*	341	1228	763	
Rotation of earth at equator	465	1674	1040	
Concorde	649	2336	1452	
303 Bullet	792	2851	1772	
Lockheed Blackbird *R*	981	3529	2193	
Moon round the earth	1000	3600	2237	
Sound through steel	5100	18360	11408	
To escape earth's gravity	7823	28,163	17,500	
Fastest man has travelled	11,176	40,234	25,000	
Earth round the sun	29,700	106,920	66,437	
Pioneer space probe	66,720	240,192	149,248	
Light and electric waves	299,388,000	1,077,614,064	669,600,000	186,000 miles/sec

18.7 CONVERSION WIND SPEED TO PRESSURE

To convert metres a second into Pascals.

Dynamic pressure q (Pa)

V, m/s	0	1.0	2.0	3.0	4.0	5.0	6,0	7.0	8.0	9.0
10	61	74	88	104	120	138	157	177	199	221
20	245	270	297	324	353	383	414	447	481	516
30	552	589	628	668	709	751	794	839	885	932
40	981	1030	1080	1130	1190	1240	1300	1350	1410	1470
50	1530	1590	1660	1720	1790	1850	1920	1990	2060	2130
60	2210	2280	2360	2430	2510	2590	2670	2750	2830	2920
70	3000									

$q_z = 0.6\, V_{d(z)}{}^2 \times 10^{-3}$ kPa

$p_e = C_{pe} \pm C_{pi}\ k_l\ q_z$

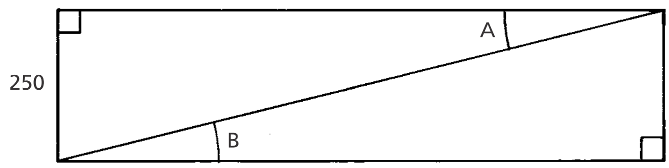
1 km/h = .278m/s

1m/s = 3.6 kms/h

18.8 CRICKET PENETRATION PATTERNS

When cricket and diverter penetration flashings are used the pitch of the cricket valley will always be less than the pitch of the roof.

To find the pitch of a roof or valley, a simple method is to use a level measuring stick 1.000m long and measure the rise as shown in drawing 15.8.A. The relationship between the rise and the horizontal distance, is known as the tangent of the angle and is is calculated by using tan ϕ = O/A (being the opposite side divided by the adjacent side). ***(see section 18.2.)***



Drawing 18.8.A

250/1000 = 0.25 = 14° (1 in 4)

N.B. Angles A and B are equal.

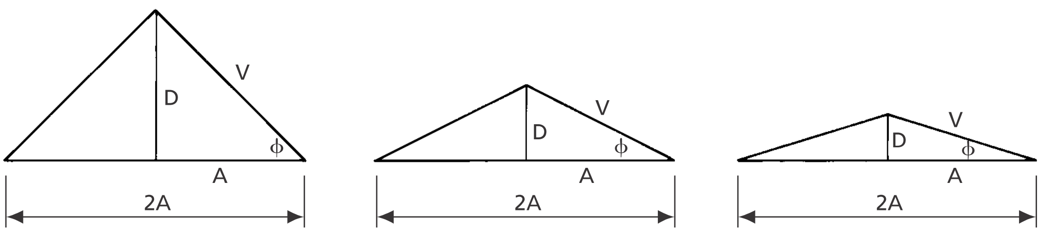
It is possible to obtain the length of the hypotenuse by using $\sqrt{a^2 + b^2}$

Cricket flashings as described in section 6 can be made to suit any penetration width, any cricket flashing depth to width ratio and roof pitch down to 3°. For simplicity three angles ϕ have been selected

ϕ X = 45°
ϕ Y = 27°
ϕ Z = 18°

VARIATION OF CRICKET VALLEY DESIGN DEPENDENT ON DEPTH AND ROOF PITCH

Penetration Width = 2A
Depth = D
Valley = V



ϕ X = 45°	ϕ Y = 27°	ϕ Z = 18°
D = A	D = 1/2A	D = 1/3A
V = $\sqrt{2}$ = 1.42	V = $\sqrt{1.25}$ = 1.118	V = $\sqrt{1.11}$ = 1.054

Drawing 18.8.B

To find the cricket valley pitch when the roof pitch is known, it is necessary to find the depth (D) of the cricket. If the depth of the cricket is half of the width of the penetration, as shown for 'Cricket X' the angles are at 45˚ and there is a defined relationship between the length of the valley of the cricket and the width of the penetration and also between the pitch of the valley of the cricket and the pitch of the roof.

This is $1 : \sqrt{2} = 1.42$ which means that to maintain the desired 3˚ fall in the cricket valley, the minimum roof pitch (4˚) can be calculated using table 15.8.

If the depth of the cricket is a quarter or a sixth of the width of the penetration, there are also defined relationships between the pitch of the valley of the cricket and the pitch of the roof.

These are described in table 15.8 as 'Cricket Y' and 'Cricket Z'.

All figures comply with the minimum fall of 1.5˚, but all the bold figures will provide a 3˚ cricket valley pitch.

This methodology is valid for all sizes of penetration, however there is a point at which, having a design with a wide penetration and a low pitch, it becomes uneconomic to pursue the ideal 3˚ fall in the cricket valley. When the roof pitch is known, the minimum allowable fall of the cricket valley pitch (1.5˚) can then be read from table 15.8.

It is permissible to lower the valley pitch because 1.5˚ allows sufficient fall to clear debris from the valley and therefore qualifies as a warrantable flashing.

A diverter flashing without a cricket design only shifts the position of the cricket to the top overflashing of the penetration as shown on drawing 6.2.1.C, unless the penetration is rotated 45˚ as shown on drawing 6.3.D. ***(see section 6.0.)***

ROOF PITCH	3˚	4˚	5˚	6˚	7˚	8˚	9˚	10˚
TANGENT	.0524	.0699	.0875	.1051	.1228	.1405	.1584	.1763
CRICKET X	2˚	**3˚**	**3.5˚**	**4.5˚**				
CRICKET Y	1.5˚	1.75˚	2.25˚	2.75˚	**3.25˚**			
CRICKET Z	*n/a*	*n/a*	1.5˚	2˚	2.25˚	2.5˚	**3˚**	**3.5˚**

Table 18.8.

PROCEDURE TO MAKE A HALF PATTERN FOR A CRICKET PENETRATION FLASHING

Example:

A net penetration width is 550mm wide and gross width to the flat of the pans is 620mm (2A)
The back curb is required to have a fall of 3˚.
The roof pitch is 7˚.
From Table 15.8. select the cricket - Type Y

Given:

Half the width of the cricket	A = 310mm
Depth of the Y cricket from drawing 15.8.B (D=1/2A)	D = 155mm
Height of the side curb	H = 130mm
Height to the top of the cricket	Hc = 70mm
H - Hc = Hr	Hr = 60mm

From Drawing 15.8.C
Find length of V, S and R.

Right angle triangle therefore the length of V $V = \sqrt{A^2 + D^2}$

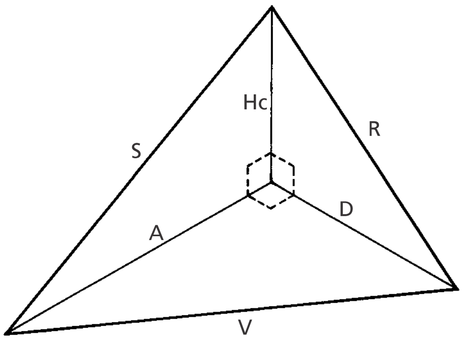
$= 346$ mm

Right angle triangle therefore the length of R $R = \sqrt{Hc^2 + D^2}$

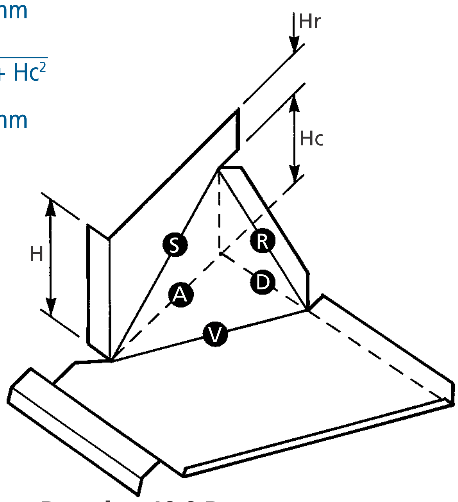
$= 170$ mm

Right angle triangle therefore the length of S $S = \sqrt{A^2 + Hc^2}$

$= 318$ mm



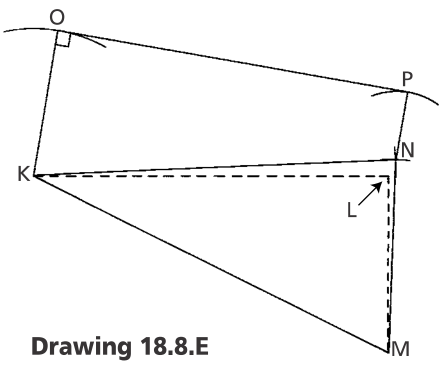
Drawing 18.8.C



Drawing 18.8.D

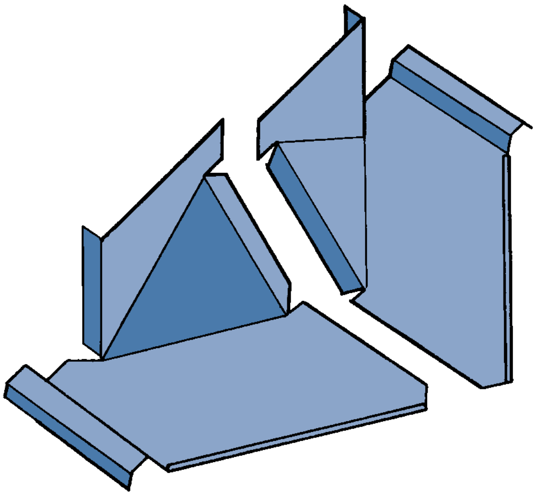
DRAW A HALF PATTERN

1. Draw a dotted line K - L length equal to A
2. From L draw a dotted line at right angles L - M length equal to D
3. Draw the line K - M (length equal to V)
4. With centre M scribe an arc length equal to R
5. With centre K scribe an arc length equal to S
6. From their point of intersection N draw a line to K and also to M
7. With centre K scribe an arc length equal to H.
8. With centre N scribe an arc length equal to Hr.
9. Draw a line as a tangent to the two arcs
10. From point K draw a line at right angles to intersect this line at O.
11. From O measure length A to a point P
12. The shape K-M-N-P-O is the net cricket pattern



Drawing 18.8.E

The back flashing and all tabs are added to this pattern, and then repeat the procedure for the other hand.



Drawing 18.8.F

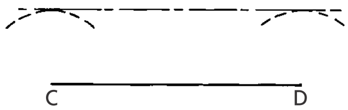
18.9 SHEET METAL WORK FOR ROOFING CONTRACTORS.

When forming various flashings in sheet-metal the Roofing Contractor is required to know how to cut his material in order to obtain the desired shape.

A basic knowledge of geometrical drawing and mensuration is required and this section explains the methods which are employed to ensure accurate results.

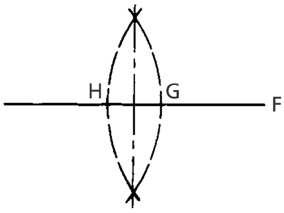
A straight line. A straight line is a line drawn in the shortest manner between two given points, so any other line between these points is a curved line.

Parallel lines. Parallel lines are lines which, when extended, do not touch. Given a line CD, to draw a parallel line set a compass to the required distance apart and with C and D as centres, describe two arcs. A line drawn as a tangent to both arcs will be a parallel line to CD.



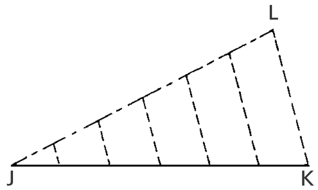
To draw a perpendicular line. Given a straight line EF, set a compass to any distance more than half the distance EF and, with E and F as centres, describe arcs of radius EG and FH.

A line drawn through the points of intersection of these arcs is perpendicular to EF, and bisects the distance EF.



To divide a line into any number of equal parts. Given a straight line J K, draw another line J L at any suitable angle and no particular length. Set off on JL, at any reasonable distance apart, a number of equal spaces similar in number to the parts into which JK is to be divided.

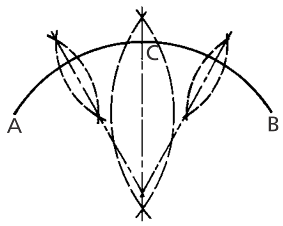
Connect L and K with a line, and parallel to this draw other lines through points on JL. These divide JK into the required number of equal parts.



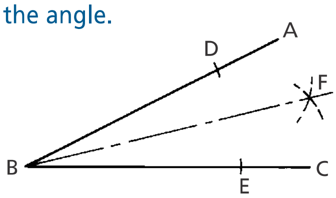
To bisect an arc. Given an arc AB, set a compass to a distance a little more than half that between the ends and with A and B as centres, describe arcs of equal radii.

A line drawn through the points of intersection will bisect AB. This method can be employed to divide the arc into any number of even parts by repetition. Further, the method may be used to find the centre of any given arc by further bisecting AC and CB.

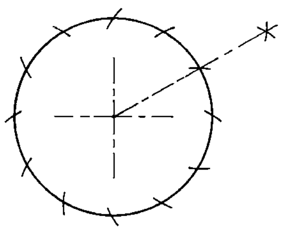
Lines taken through the intersecting points of these latter arcs, when produced, will intersect at the centre of the arc AB.



To bisect an angle. Given an angle ABC, set off equal distances BD and BE and with D and E as centres and a compass set at any reasonable radius, describe arcs to intersect in F. A line drawn through B and F bisects the angle.



To divide a circle into six equal parts. Set a compass to the radius of the circle and step this distance off along the circumference. Further division into 12 parts may be done by bisecting one part, and again stepping-off with the radius of the circle



Development of the frustrum of a true cone.

Draw the elevation X with base diameter AB, the vertical height CD to the desired cone angle and add the section line EF to the elevation. With centre D and radius DA describe a semicircle Y on the base, and divide the circumference of this into six equal parts.

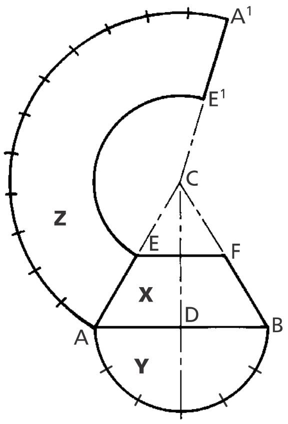
To draw the development Z:

With centre C and radius CB, describe an arc AA^1 whose length equals the circumference of cone base.

This may be obtained by marking off along the arc from A spaces equal to parts in the semicircle Y but double in number.(12)

With C as centre and radius CE, draw the arc EE^1 and add the line CA^1.

The figure AA^1E^1E is the development Z of the frustrum.



Development of a square base to a circular top.

Draw the elevation X, making the base AB, vertical height CD, and diameter of top EF.

Draw a half plan Y on the base, drawing the semicircle E^1F^1 and dividing one half of this into a number of equal parts, F^1G, GH, HJ, and JK.

Through points F^1, G, H, J, and K, draw lines to B^1.

Before proceeding to the development it is necessary to find the true lengths of B^1K, B^1J, B^1H, B^1G, and B^1F^1.

To do this, drop a perpendicular from F to F^1 and extend the base line AB.

An offset diagram is now made by measuring distances B^1F^1, B^1G, and B^1H, setting these off from F^1 on base line AB and drawing lines to F.

The lengths FF^1, FG, and FH, etc., are now true lengths.

To draw the development Z:

Draw a centre line C^1O. At right angles to C^1 draw A^2B^2 equal to AB.

From C^1, set off distance C^1F^1, equal to FB.

Join A^2 and B^2 to F^1. With centre A^2 and radius F^1G, draw a short arc to be cut by an arc of F^1G radius struck from F^1 to obtain point G^1.

Similarly, with A^2 as centre and radius FH, draw an arc, to be cut by an arc of GH radius struck from point G^1, thus obtaining point H^1.

Draw a line through, A^2 and H^1 and produce same to intersect the centre line C^1O at O.

Repeat the process with. B^2 as centre for long radii, thus completing one quarter of the whole development.

To complete the pattern, draw a curve through points $H^1G^1F^1$ and repeat in the other sections of the development.