The Length Of Drive Belts

The drive belt is measured at halfway through its radial thickness, as shown in Figure 1.

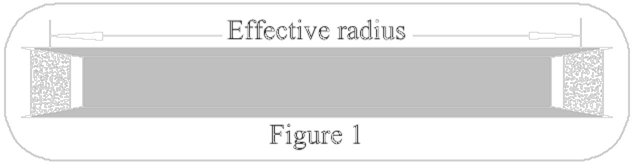

Figure 1

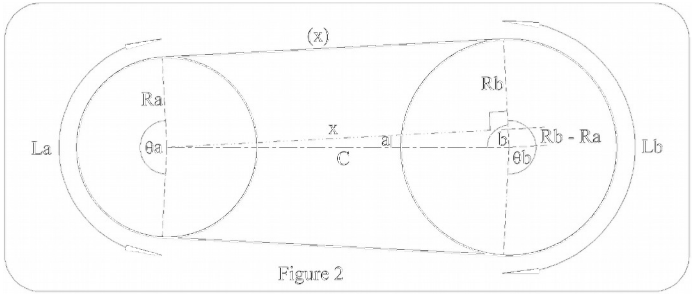

Figure 2

The simplest case is for two pulleys; see Figure 2.
In triangle C, x, Rb-Ra:
$x^2 = C^2 - (Rb-Ra)^2$
$x = \sqrt{[C^2 - (Rb-Ra)^2]}$
$a = \sin^{-1}(Rb-Ra)/C$ $\quad$ $b = \cos^{-1}(Rb-Ra)/C$
$\theta a = 360 - 180 - 2a$ $\quad$ $\theta b = 360 - 2b$
$La = 2.\pi.Ra.\theta a/360$ $\quad$ $Lb = 2.\pi.Rb.\theta b/360$
$Ltotal = 2.x + La + Lb$

Most cars thease days have the crankshaft pulley driving an alternator pulley & an air conditioner pulley, as in Figure 3.
$\alpha = \sin^{-1}(R1-R3)/P1$
$L1 = \cos \sin^{-1}(R1-R3)/P1$

$\beta = \sin^{-1}(R1-R2)/P2$
$L2 = \cos \sin^{-1}(R1-R2)/P2$
Allowing for O to the longest of the Ls, in this case L2:
(The book says O = 0•016P, in this case P2.)
$2.E = 2\sqrt{(O^2 + L2^2/4)} = 2\sqrt{\{O^2 + [\cos \sin^{-1}(R1-R2)/P2]^2 / 4\}}$

$\gamma = \sin^{-1}(R3-R2)/P3$
$L3 = \cos \sin^{-1}(R3-R2)/P3$

$\zeta = \cos^{-1}(P1^2 + P2^2 - P3^2) / 2.P1.P2$

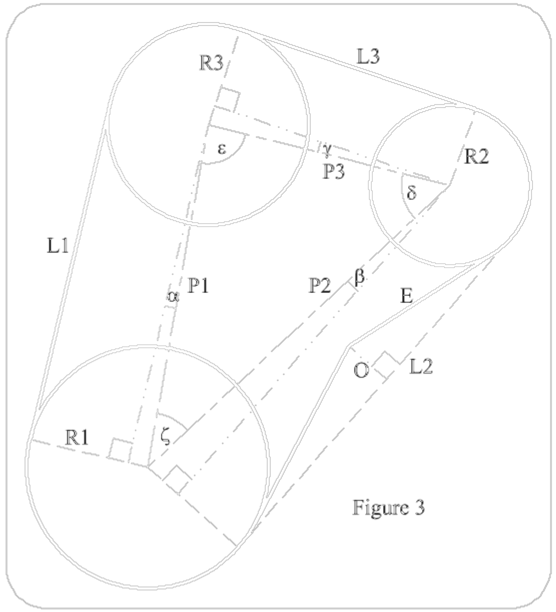

Figure 3

Angle between L1 & L2 = $\zeta + \alpha + \beta$

$= \cos^{-1}(P1^2 + P2^2 - P3^2) / 2.P1.P2 + \sin^{-1}(R1-R3)/P1 + \sin^{-1}(R1-R2)/P2$

R1 contact length = $2.\pi.R1[\cos^{-1}(P1^2 + P2^2 - P3^2) / 2.P1.P2 + \sin^{-1}(R1-R3)/P1 + \sin^{-1}(R1-R2)/P2] / 360$

$\delta = \cos^{-1}(P2^2 + P3^2 - P1^2) / 2.P2.P3$

Angle between L2 & L3 = $\gamma + \beta + \delta$

$= \sin^{-1}(R3-R2)/P3 + \sin^{-1}(R1-R2)/P2 + \cos^{-1}(P2^2 + P3^2 - P1^2) / 2.P2.P3$

R2 contact length = $2.\pi.R2[\sin^{-1}(R3-R2)/P3 + \sin^{-1}(R1-R2)/P2 + \cos^{-1}(P2^2 + P3^2 - P1^2) / 2.P2.P3] / 360$

$\varepsilon = \cos^{-1}(P1^2 + P3^2 - P2^2) / 2.P1.P3$

Angle between L3 & L1 = $\varepsilon + \delta + \alpha$

$= \cos^{-1}(P1^2 + P3^2 - P2^2) / 2.P1.P3 + \cos^{-1}(P2^2 + P3^2 - P1^2) / 2.P2.P3 + \sin^{-1}(R1-R3)/P1$

R3 contact length = $2.\pi.R3[\cos^{-1}(P1^2 + P3^2 - P2^2) / 2.P1.P3 + \cos^{-1}(P2^2 + P3^2 - P1^2) / 2.P2.P3 + \sin^{-1}(R1-R3)/P1] / 360$

So the belt length = $\cos \sin^{-1}(R1-R3)/P1 + 2\sqrt{\{O^2 + [\cos \sin^{-1}(R1-R2)/P2]^2 / 4\}} + \cos \sin^{-1}(R3-R2)/P3$

$+ 2.\pi.R1[\cos^{-1}(P1^2 + P2^2 - P3^2) / 2.P1.P2 + \sin^{-1}(R1-R3)/P1 + \sin^{-1}(R1-R2)/P2] / 360$

$+ 2.\pi.R2[\sin^{-1}(R3-R2)/P3 + \sin^{-1}(R1-R2)/P2 + \cos^{-1}(P2^2 + P3^2 - P1^2) / 2.P2.P3] / 360$

$+ 2.\pi.R3[\cos^{-1}(P1^2 + P3^2 - P2^2) / 2.P1.P3 + \cos^{-1}(P2^2 + P3^2 - P1^2) / 2.P2.P3 + \sin^{-1}(R1-R3)/P1] / 360$

Simple. Now you’ve got the hang of it, try the belt & chains in figures 4 & 5.

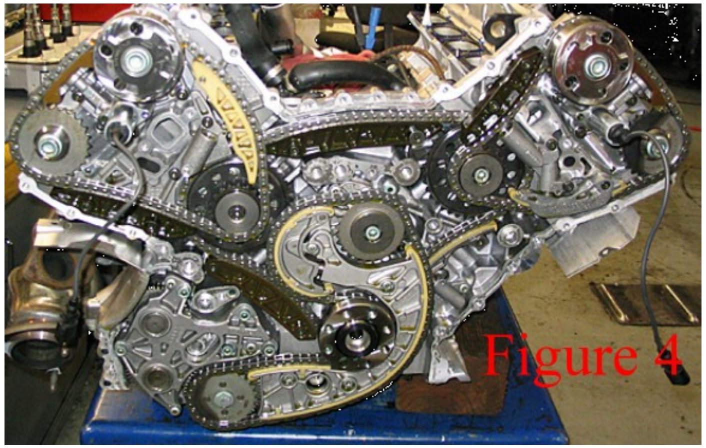

Figure 4

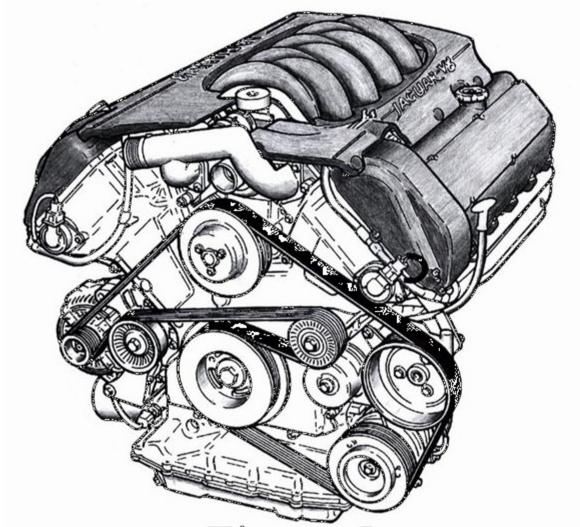

Figure 5

Some notes on belt drives

Tq   Torque on the driven shaft

$Tq = (T1 - T2).Dn / 2$

$Power = (T1 - T2).N.DN / 2$

Belt slip is a function of total tension & differential tension.

$Efficiency = A + Be^{C.Tq} + D.Tq$

A, B, C & D are constants, +ve or -ve real numbers.

Traction coefficient is an indicator of how hard a belt is working.

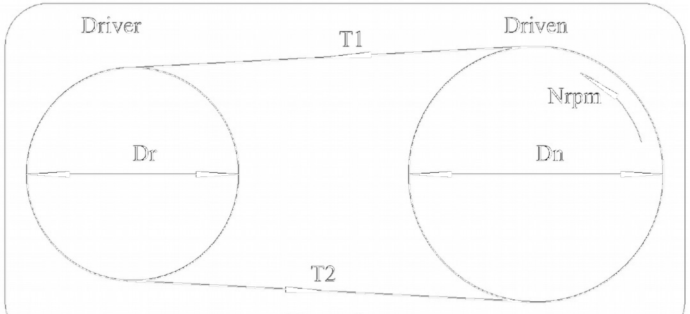

Figure 6