



Dwell-Rise-Fall-Dwell and Dwell-Fall-Rise-Dwell cam laws Sections 9 to 13: segments having asymmetric rise and fall periods

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item which was monitored and guided by the Mechanisms Committee, which has the following membership:

Chairman	
Dr C.W. Stammers	— University of Bath
Vice-Chairman	
Dr G. Druce	— Independent, Hampshire
Members	
Dr C. Burvill	— The University of Melbourne, Australia
Mr P.J. Carden	— Ricardo Consulting Engineers Ltd, Shoreham-by-Sea
Mr A.A. Fogarasy	— Independent, Tyne & Wear
Prof F. Freudenstein*	— Columbia University, New York, USA
Dr M.J. Gilmartin	— Liverpool John Moores University
Dr M.R. Smith†	— University of Newcastle-upon-Tyne (Member Emeritus)
Prof Zhonghe Ye*	— Fuzhou University, P.R. China
* Corresponding Member	
† Member Emeritus	

The technical work involved in the assessment of the available information and the construction and subsequent development of the Data Item was carried out under contract to ESDU by a Member of the Mechanisms Committee

Dr G. Druce.

The person with overall responsibility for the work in this subject area is Mr C.J. Loughton, Head of the Mechanical Motion and System Dynamics Group.

The Mechanisms Committee, which first met in 1975, is continuing the work that previously was the responsibility of the former Gearing and Mechanisms Committee, which first met in November 1964. Like the earlier Committee it has the cooperation of many engineers and scientists in industry, research establishments and universities from whom much assistance and information is being received.

DWELL-RISE-FALL-DWELL AND DWELL-FALL-RISE-DWELL CAM LAWS. SECTIONS 9 TO 13: SEGMENTS HAVING ASYMMETRIC RISE AND FALL PERIODS

Data Items in the series on Dwell-Rise-Fall-Dwell cam laws are:

- Item 06002^[15] - Sections 1 to 8: segments having equal rise and fall periods,
- Item 06003^[16] - Sections 9 to 13: segments having asymmetric rise and fall periods,
- Item 06004^[17] - Sections 14 to 23: examples,
- Item 06005^[18] - Computer program.

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DWELL-RISE-FALL-DWELL AND DWELL-FALL-RISE-DWELL CAM LAWS. SECTIONS 9 TO 13: SEGMENTS HAVING ASYMMETRIC RISE AND FALL PERIODS

9. NOTATION AND UNITS

The units used in this Item are predominantly SI but any coherent system of units may be used. All angles are measured positively in an anticlockwise sense and the cam is considered to rotate in an anticlockwise direction.

Equations, sketches, tables, appendices, *etc.* identified by section numbers not found in this Item are to be found in: Sections 1 to 8 and Appendices A to D in Item 06002^[15] and Sections 14 to 23 in Item 06004^[17].

		Units
a, b, c, d	coefficients (see Equations (11.20a) to (11.20d))	—
D	distance from cam centre, O, to pivot point of swinging arm, measured in positive sense to right of cam centre	m
H	total lift of translating follower corresponding to one motion segment	m
k_A	acceleration ratio (see Equations (4.2a) and (4.2b))	—
L	distance between follower arm pivot and follower datum centre	m
$N1$	component blending with dwell	—
$N2$	component controlling reversal of velocity	—
O	cam centre of rotation and origin of co-ordinate axis system	—
R_a	prime circle radius	m
R_b	reference circle radius	m
R_r	roller radius	m
u	normalised cam angle (see Equation (3.2a) or (3.2b))	—
w	normalised follower displacement (see Equation (3.3a) or (3.3b))	—
w'	non-dimensional follower velocity	—
w''	non-dimensional follower acceleration	—
w'''	non-dimensional follower jerk	—
X_c, Y_c	axes fixed in, and rotating with, cam with origin at cam centre O	—
X_m, Y_m	axes fixed in machine, with origin at cam centre O	—

y	linear displacement of translating follower	–
y_m	height of translating follower datum above X_m -axis	m
y_b	height of follower datum above X_m -axis at innermost position of travel	m
y_0	height of translating follower datum above X_m -axis at start of motion segment	m
$\dot{y}$	linear velocity of translating follower	m/s
$\ddot{y}$	linear acceleration of translating follower	m/s ²
$\dddot{y}$	linear jerk of translating follower	m/s ³
Z_3, Z_4	intermediate calculation parameters (for Z_3 see Equation (11.10) and for Z_4 see Equation (11.32))	–
Φ	total angle of cam rotation corresponding to one motion segment	degree
ϕ	intermediate angle of cam rotation from start of motion segment	degree
ϕ_0	angle of cam rotation at start of motion segment	degree
Ψ	total angle of follower swing associated with one motion segment	degree
ψ	angular displacement of swinging follower	degree
ψ_b	angle between X_m -axis and swinging follower at innermost position	degree
ψ_m	angle between X_m -axis and swinging follower datum	degree
ψ_0	angle between X_m -axis and swinging follower at start of motion segment	degree
$\dot{\psi}$	angular velocity of swinging follower	rad/s
$\ddot{\psi}$	angular acceleration of swinging follower	rad/s ²
$\dddot{\psi}$	angular jerk of swinging follower	rad/s ³
ω_c	angular velocity of cam	rad/s

Subscripts

B	refers to value at blending point
$fall$	refers to fall motion of follower
max	indicates maximum magnitude
$N1$	refers to notional dimension of component blending with dwell
$N2$	refers to notional dimension of component controlling reversal of velocity

<i>rev</i>	refers to follower acceleration at reversal of velocity
<i>rise</i>	refers to rise motion of follower
<i>sec</i>	refers to secondary motion segment (see Section 10)
<i>V</i>	refers to location of maximum follower velocity for single law motions
<i>V1</i>	refers to location of maximum follower velocity (Component <i>N1</i>)
<i>V2</i>	refers to location of maximum follower velocity (Component <i>N2</i>)

Definition of terms and acronyms

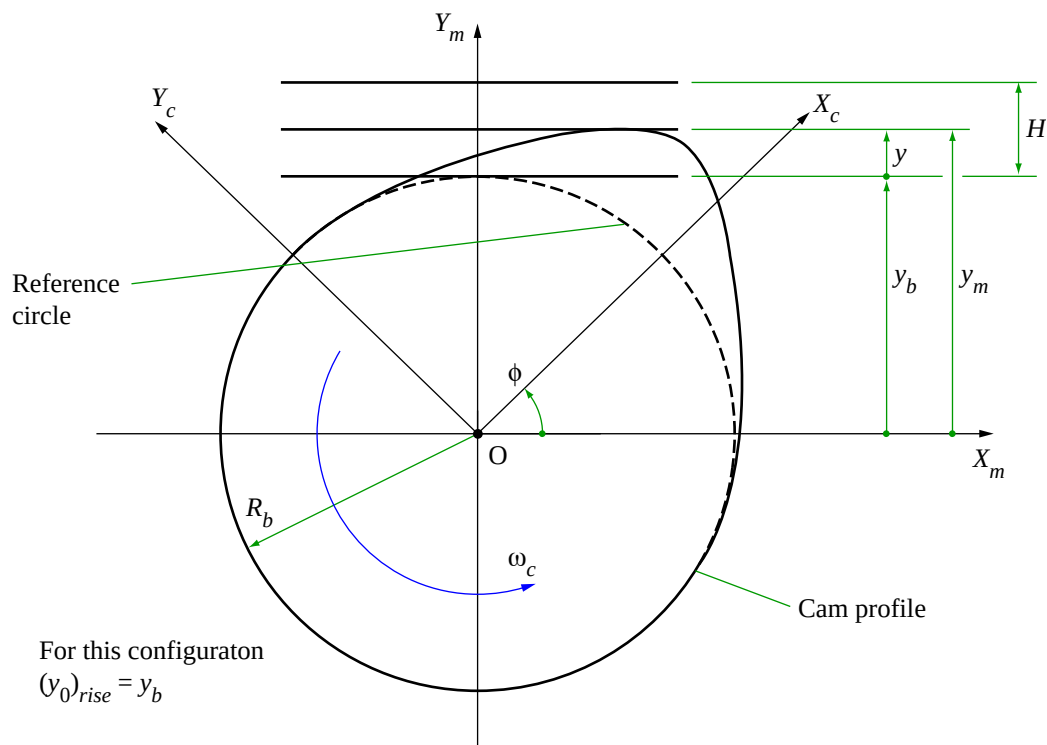
CCCA	Constant-Cosine-Constant-Acceleration
DFD	Dwell-Fall-Dwell [†]
DHM	Double Harmonic Motion
DRD	Dwell-Rise-Dwell
DFRD	Dwell-Fall-Rise-Dwell
DRFD	Dwell-Rise-Fall-Dwell
Jerk	third derivative of the displacement equation with respect to time
SHM	Simple Harmonic Motion
THM	Triple Harmonic Motion

[†] DRD may also refer to Dwell-Return-Dwell in other Data Items in the cam series.

10. INTRODUCTION

This Data Item[†] provides guidance upon the analysis and selection of cam laws suitable for Dwell-Rise-Fall-Dwell (DRFD) and Dwell-Fall-Rise-Dwell (DFRD) follower motions having asymmetric rise and fall segments and forms part of a series of Items on DRFD and DFRD laws. In this type of output motion the follower is held stationary (dwells) whilst in contact with a constant radius segment of the cam profile concentric with the axis of rotation. It rises (or falls) during the subsequent motion segment through the maximum displacement (the lift) and then immediately falls (or rises) to be restored to the original dwell position. For the purpose of this series of Data Items, a motion segment is defined as that part of a cam motion cycle during which the follower moves from one position of zero follower velocity to the next position of zero follower velocity. The content applies to all configurations of the cam mechanism[‡] (see Item 82024^[7]), such as the disc cam driving a sliding translating follower shown in Sketch 10.1, or a disc cam driving a swinging roller follower shown in Sketch 10.2. The terminology and dimensions used in this Data Item are defined in the Notation and superimposed on the drawings.

Besides the applications of cam laws to conventional cam mechanisms used throughout this series of Data Items, the laws given are equally applicable to the definition of the output motion of “electronic cams”. (See Items 82006^[6], 06002^[15], 06004^[17] and 06005^[18].)

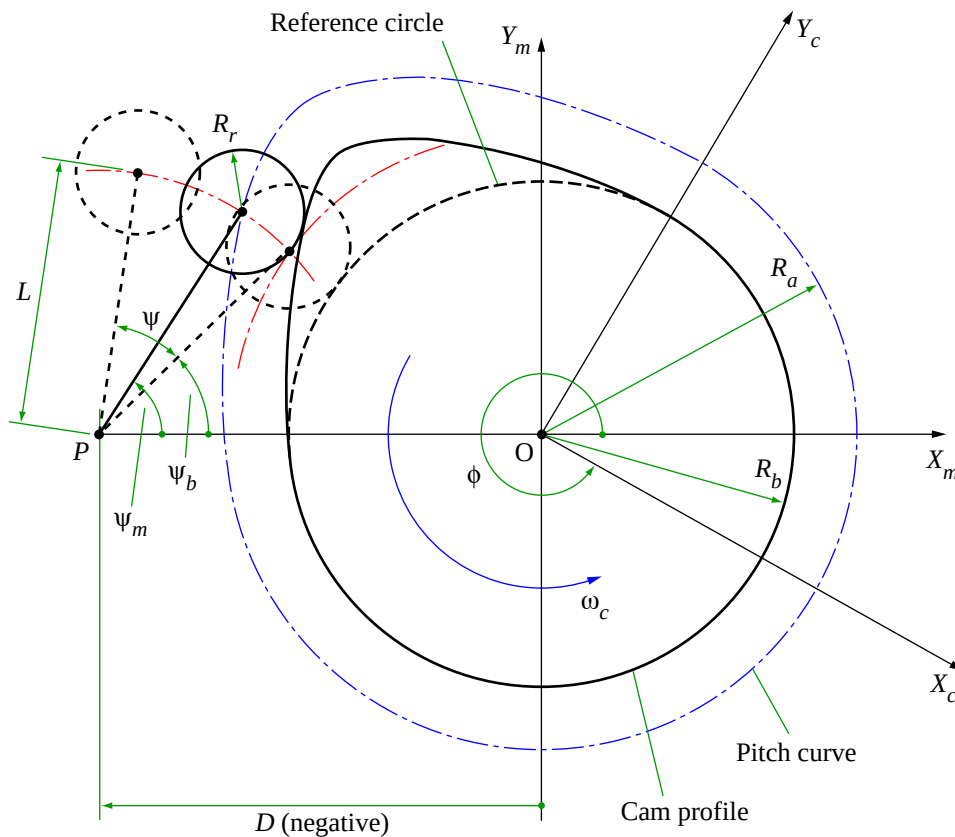


Sketch 10.1 Disc cam for asymmetric DRFD motion driving sliding translating follower

[†] Equations, sketches, tables, appendices, *etc.* identified by section numbers not found in this Item are to be found in: Sections 1 to 8 and Appendices A to D in Item 06002^[15] and Sections 14 to 23 in Item 06004^[17].

† Flat-faced sliding followers are unsuitable for DFRD cams.

Asymmetric cam motions have different rise and fall motions with different periods. By implication, the functions of the two actions differ. For example, the rise of a DRFD motion could control a feed operation requiring a constant velocity drive to the end effector (a general term for the output drive member of any mechanism or actuator) during an intermediate part of that movement and succeeded immediately by an idle fall motion to restore the follower rapidly to the dwell position in preparation for the next working cycle (see Example 2 of Item 03010^[14]). Hence the segment angle and the follower lift, velocity and acceleration during the rise and fall actions can be radically different, provided the conditions for a smooth blend at the reversal of follower velocity are met (see Tables 10.1 to 10.4). Unlike a DRFD action having equal rise and fall periods, an asymmetric motion requires a blend to be inserted in the cam profile at the reversal of follower velocity. At this position both the velocity and jerk of the follower are zero: for good dynamic performance, the acceleration must be continuous through the blend.



Sketch 10.2 Disc cam for asymmetric DRFD motion driving swinging roller follower

In all asymmetric cam motions, the portion of the cam profile driving the more critical, more complex action is designated the 'Primary Motion Segment' and that controlling the reverse follower movement is designated the 'Secondary Motion Segment', hence the terminology does not define the sequence of these components.

In all cases, design the Primary Motion Segment first, using the procedures contained in the associated Item 06002^[15]† and the accompanying ESDU computer program (see Item 06005^[18]). The process is then continued by determining the motion of the Secondary Motion Segment using the procedures given in this Data Item and the same ESDU computer program, Item 06005^[18].

† The design procedures given in Data Item 93002^[10] should be used if the Primary Motion Segment involves a precision point, using that associated ESDU computer program and then exporting the completed data file to the ESDU computer program in Item 06005^[18]. The cam laws used must meet the criteria specified in this Item and Items 06002^[15] and 06005^[18].