

OSCAM. Computer-aided cam mechanism design: user manual

Associated software: OSCAM

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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.

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OSCAM. COMPUTER-AIDED CAM MECHANISM DESIGN: USER MANUAL

1. INTRODUCTION

1.1 Synopsis

OSCAM is a general-purpose cam design program for use on PCs running Microsoft Windows 95 or later. For a full description of the installation details, hardware requirements and configuration details, Data Item 00013 (Reference 18) should be consulted.

OSCAM can model plane cam mechanisms composed of a cam, follower and return spring. Cams driving either translating or rotating followers can be modelled and the program can interface with the computer-aided mechanism design software OSMEC (see References 15, 16 and 17). OSCAM performs the lengthy, expensive and error-prone process of calculation and drawing when designing a cam/follower mechanism. The follower motion and the cam/follower dimensions, inertial properties and load forces can all be altered easily and quickly. The effects of these alterations are analysed and displayed.

OSCAM complements other Data Items and software relating to cams within the Mechanisms Series and is used for the rapid design analysis of cam mechanisms and produces graphs and tables of:

linear or angular follower rise, velocity, acceleration and jerk,

pressure angle,

follower contact point excursion,

bearing forces,

cam shaft torque,

cam profile and tool cutter co-ordinates

and prints timed and dated reports of all dimensions and motion parameters of the mechanism. Data defining the cam profile shape can be sent to a plotter or printer, or sent to a file for use in any program that can read HPGL^{*} files. The program can produce a drawing of the cam profile to be exported as a DXF[†] file format to CAD (Computer-Aided Design/Drafting) software so that the detail design of the constituent parts can be carried out.

OSCAM includes cams driving both translating and swinging followers whose motion may be specified in one of three ways. (For an overview of cam terminology, see Section 4.)

- (i) The first is used for single-lobe cam mechanisms for which the motion profile consists of one rise and one return motion segment, optionally separated by dwell motion segments. The follower motion is defined by one of six commonly used cam laws available in OSCAM.
- (ii) The second method is used for more complex multi-lobe cam mechanisms, in which the follower motion can be defined by up to 20 motion segments of type rise, return or dwell. The motion of the cam during each active motion segment is modelled using one of the six commonly-used cam laws available.

* Hewlett Packard Graphics Language File defined by Hewlett Packard Corporation.

† Drawing Exchange File Format defined by Autodesk Inc.

- (iii) The final method is to import a data file supplied by the user or generated by other software in the ESDU cam series of Data Items.

There are five options for entry of external load applied to the follower. Forces or torques resulting from the spring and follower inertia may also be included in the analysis.

For a cam with a swinging follower, either a left- or a right-hand assembly mode can be specified and the cam shaft may be considered to rotate either clockwise or counterclockwise (see Section 5.3).

If the size of the cutting tool used to manufacture the cam is specified, OSCAM can check if profile errors, including undercutting, can occur. The program gives an error message if the spring does not maintain contact between the cam and follower.

1.2 Modelling Cam Mechanisms using OSCAM

A disc cam is a mechanical component which by direct contact transmits a desired motion to a follower by virtue of its profile shape. In general the cam and follower constitute a conjugate pair and for most practical purposes must be considered together. OSCAM models disc cams in which the input motion is rotary and the output motion may be either translating or swinging. There is a choice between curved foot (usually roller) followers and flat-faced followers. Alternative configurations are given in Section 2 of Data Item 82024 (Reference 2). See Appendix D for sketches of the six cam/follower mechanisms.

Having decided on a particular cam and follower configuration, the user must then specify the desired follower motion. The follower motion for each rotation of the cam consists of motion segments when

- (a) the follower is moving away from the cam shaft centre (rise),
- (b) the follower is moving towards the cam shaft centre (return)

or (c) the follower is stationary relative to the cam shaft centre (dwell).

A cam law must then be chosen to obtain the correct follower output motion during an active motion segment (*i.e.* rise or return). The term cam law is given to a mathematical expression which defines follower motion as a function of cam shaft angle and hence is a major factor in determining the shape of the cam profile. However, it must be noted that for the same cam law different followers will require different profile shapes. If a particular cam law only gives the required performance over part of the motion segment, other cam laws can be used as required for other parts of the motion segment to meet the complete requirement. Data Items 86026, 92014 and 93002 (References 5, 8 and 10) give a comprehensive approach to blending cam laws.

For a cam and follower configuration to achieve its desired performance, contact must be maintained at all operating speeds. There are two means available: body closure and force closure. Body closure is provided by having contact between the cam and follower for both directions of their relative motion (see Data Item 82024, Reference 2).

Force/torque analysis in OSCAM assumes force closure, *i.e.* continuous contact between the cam and follower, provided by an external force applied to the follower by gravity or more commonly by a preloaded spring of constant stiffness.

For further information, refer to the following Data Items in the Mechanisms Series.

- For a guide to the selection of cam and follower type, see Data Item 82024 (Reference 2).
- For a full description of the kinematic analysis of disc cams, see Data Item 95001 (Reference 14).
- For a guide to the selection of DRD cam laws, see Data Item 82006 (Reference 1).
- For examples of the design of disc cams and their followers, see Data Item 85013 (Reference 4).

1.3 Assumptions

When considering the kinematic and kinetostatic relationships between the constituent parts of a cam mechanism modelled using OSCAM, it is assumed that

- (a) no out-of-plane motion or forces occur,
 - (b) the motion of the follower is defined throughout a complete rotation of the cam shaft,
 - (c) all parts of the mechanism are stiff enough to be considered rigid bodies,
 - (d) there is no clearance in the bearings
- and (e) the effects of friction at all bearings are negligible.

1.4 Document Syntax in this Item

When software menu items are described they are italicised, for example *Edit*, whereas keyboard entries are enclosed in quotes, e.g. 'Esc'.

1.5 Installation

The procedure for installing OSCAM and notes on the copyright and fitness for purpose are described in Data Item 00013 (Reference 18).

1.6 Acknowledgements

The Mechanisms Committee and ESDU International gratefully acknowledge the original contribution of Dr S. Molian, who conceived and developed previous versions of OSCAM.

OSCAM uses the INTERACTER graphics library produced by Interactive Software Services Limited and their file conversion programs INTPRINT and INTCONV are included with OSCAM, under licence from Interactive Software Services Limited.

2. UNITS

Output units are specified automatically on the graphs. The units for entering the data are as follows:

Angle [*]	degree
Cam shaft speed	rev/min
Force	N
Helical spring rate	N/m
Length	mm
Mass	kg
Mass moment of inertia [†]	kg m ²
Torque	N m
Torsional spring rate	Nm/rad

* All angles are positive when measured in a counterclockwise sense.

† The mass moment of inertia of a swinging follower must include the roller and any other attached driven components must be calculated about the axis perpendicular to the plane of motion that passes through the mass centre of the follower. Note that this differs from the analysis given in Data Item 91026 (Reference 6) where mass moment of inertia is specified relative to the swinging follower pivot.

3. USING OSCAM

This section gives a brief overview of OSCAM and the typical menu and form structure, including overall program control using either the keyboard or the mouse. A full description of the OSCAM menu structure is given in Sections 4 and 5.

3.1 Starting OSCAM

To run the program change to the appropriate directory (such as C:\OSCAM) and double click on the executable file* OSCAMV##.EXE. The introductory screen shown in Sketch 3.1 is displayed.



Sketch 3.1

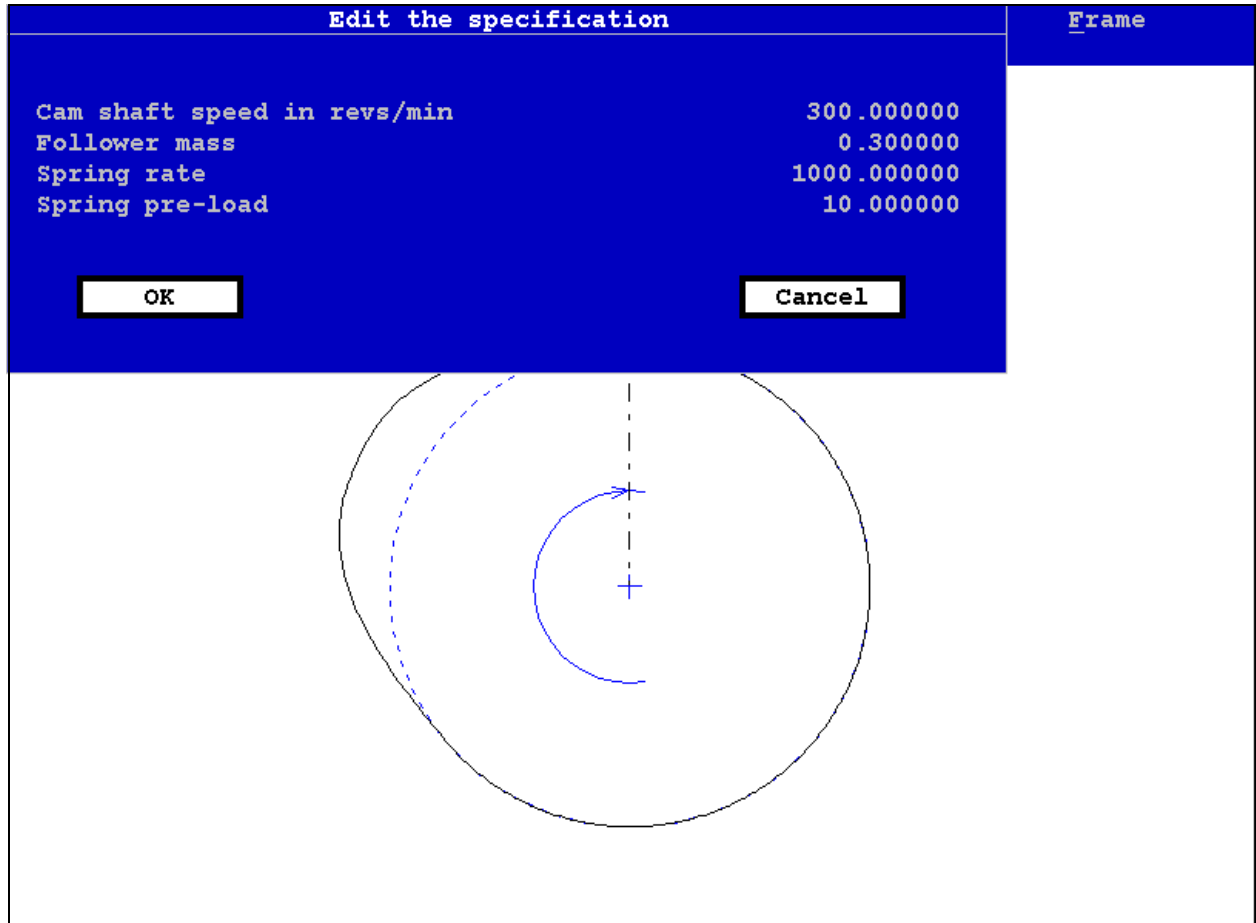
3.2 Menus and Forms

A menu is a list of options (such as *File*, *Select* and *Quit*) that appears along the top line of the screen. Sketch 3.1 shows a menu along the top line. As the cursor is moved along the top line by pressing the arrow keys or moving the mouse, an explanation of each option appears on the line below. This is called the help line. Selecting some options may lead to further sub-menus from which a further choice is made.

Sketch 3.2 shows a typical screen display where the *Dynamics* option has been selected from the *Edit* menu and a form for entering the relevant data occupies a window in the centre of the screen, partially obscuring

* The actual name of the OSCAM executable file depends on the current version of the program. Thus, for example, the full name of Version 5.0 of OSCAM will be OSCAMV50.EXE and must be used when accessing the file. The current version number of OSCAM is listed on the "Contents" page of the Volume in which the program resides.

the drawing and menu. The cam and part of the follower are shown and the direction of rotation of the cam is shown to be clockwise. A form is a rectangular area of the screen in which numerical values are entered and/or choices are made between certain options.



Sketch 3.2 Typical Screen Display showing *Dynamics* Form selected from *Edit* menu

3.2.1 Program control using the keyboard

When the program is activated, a summary of the ways in which the keys are used appears on the screen (see Sketch 3.1).

The horizontal arrow keys are used to move backwards and forwards along a menu of options to reach the desired choice. The space bar has the same effect but moves the cursor only to the right. If a menu has too many options to fit on the screen a row of dots will appear after the last one displayed. Continuing to press the right arrow key when that last entry is highlighted causes further options in the same menu to appear.

The 'Return' (or 'Enter') key is used to move forward through the program. When an option in the menu is highlighted the computer will not execute it until 'Return' is pressed. The option has then been selected. The word 'Select' is used throughout this Data Item to mean "Choose an option and press 'Return'".

Entering the highlighted letter of an option selects it automatically regardless of the current position of the cursor. If two or more items in a menu have the same initial letter pressing that letter will always select the first of them. The arrow keys or space bar must be used to select a later option with the same initial.

In a similar way to the use of 'Return' to move forward through the program, 'Esc' is used to move back through the hierarchy of menus.

Some additional keys are used when manipulating a form. Pressing the 'Tab' key moves the cursor to the right or downwards, while 'Shift' + 'Tab' (*i.e.* both keys pressed simultaneously) moves it to the left or upwards. The arrow keys are only used in a form to select options such as *Yes* or *No*. To change from *Yes* to *No*, or vice versa, press either horizontal arrow key.

The 'Page Up' or 'Page Down' keys are used in some forms to run through a list of items if there are too many to fit in the form simultaneously. The form will display a message if these keys are needed.

The main purpose of a form is to enter numerical data. This is done using the number keys. The 'Delete' and 'Backspace' keys are used in the usual way.

When all of the data have been entered in the form, press 'Return' to exit. The program will accept the data unless there is some incompatibility, in which case an error message will appear. Pressing 'Esc' also closes the form first opened, so that all changes made when it was open are lost.

When a form is displayed, it usually contains some numerical values. These are called default values. Default choices also appear for options such as *Yes/No* or *Left/Right*, and by default the cursor will appear at a particular position on a menu. The program is designed so that the default choices are those most likely to be selected.

3.2.2 Program control using the mouse

It is also possible to move through the hierarchy of menus in the program using the mouse. To select an option on any menu, move the cursor using the mouse until the desired item is highlighted and then press the left-hand button. To move back through the hierarchy of menus, use the right-hand button. In general, pressing the left- and right-hand mouse buttons has the same effect as pressing the 'Return/Enter' and 'Esc' keys (see Section 3.2.1), respectively.

3.3 Closing the Program

To close the program the cursor must be on the main menu. If necessary, press 'Esc' to go back through the menu hierarchy to the main menu. Then select *Quit* (or press 'Q').

3.4 Help

An explanation of each menu option appears beneath the line of menu options, summarising the action(s) that will result if the option currently highlighted by the cursor is selected. On selected screens, more comprehensive help is available by pressing the 'F1' key.

4. OSCAM MENU STRUCTURE

When the program is started, the main menu offers three options:

File Select Quit

File retrieves an existing cam mechanism model file (see Section 4.1).

Select presents the choice between the six types of cam/follower mechanism in OSCAM (see Section 4.2). Each type is a stored mechanism with typical dimensions that is loaded from OSCAM and edited to suit the user's requirements.

Quit closes the program.

Once a cam mechanism has been loaded or selected the number of options on the main menu changes.

The revised options are as follows.

File Select Run Edit Zoom Graphs Grid List Quit

File now provides the options of saving and loading a cam mechanism model file.

Run is used to display the mechanism, obtain hard copy and export a DXF file (see Section 4.3).

Edit displays the values of all parameters used to define the mechanism with the option of changing them if required (see Section 5).

Zoom alters the size of the display (see Section 4.4).

Graphs produces graphs and tables (see Section 4.5).

Grid puts a measuring grid on the screen (see Section 4.6).

List produces files containing information on the cam mechanism (see Section 4.7).

4.1 File

When the program is started the *File* option has the sole function of loading a cam mechanism data file. The prompt shows the directory path and

*.OSC

and if 'Return' is pressed a list box appears with the stored cam mechanism data files. This list may be examined using the vertical arrow keys. If 'Return' is pressed again, the file currently highlighted will be loaded and the cam displayed on the screen.

If other cam mechanism model files have been edited or created and stored as files they can also be retrieved from the same list box. Unless such files have the .OSC extension it is necessary to load them by replacing *.OSC in the prompt with the name of the required file, including the appropriate path if necessary. For example C:\WORKING\PLATECAM.MEC must be entered for a file called PLATECAM.MEC in the WORKING sub-directory on the C: hard disk drive or, A:\BACKUP\CAMI.NEW (for a file called CAMI.NEW in the BACKUP sub-directory on a disk in the A: drive).

Once a file has been loaded or a new mechanism created with the *Select* option (see Section 4.2), the *File* option produces a sub-menu with the options *Retrieve* and *Save*.

The *Retrieve* option is used to load a cam mechanism data file in the manner just described. However, if the current mechanism has been edited or created but not saved, a warning message will appear with the option to save, before a new file can be loaded.

The *Save* option requires a file name and path for the cam mechanism being saved. If the name of an existing file is entered, a warning message will appear but the option of overwriting the old file is retained.

4.2 Select

4.2.1 Types of cam/follower mechanism

The *Select* menu presents the six types of cam mechanism available as stored data with typical dimensions in OSCAM, distinguished by the type of follower as:

Type 1: Translating with roller (see Sketch 4.1),

Type 2: Translating with domed contact surface (see Sketch 4.2),

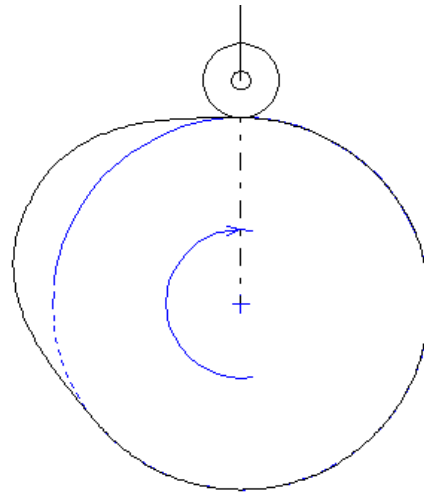
Type 3: Translating with flat-faced contact surface (see Sketch 4.3),

Type 4: Rotating with roller (see Sketch 4.4),

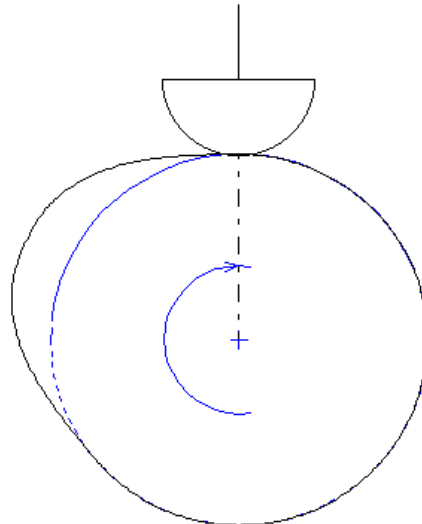
Type 5: Rotating with domed contact surface (see Sketch 4.5),

Type 6: Rotating with flat-faced contact surface (see Sketch 4.6).

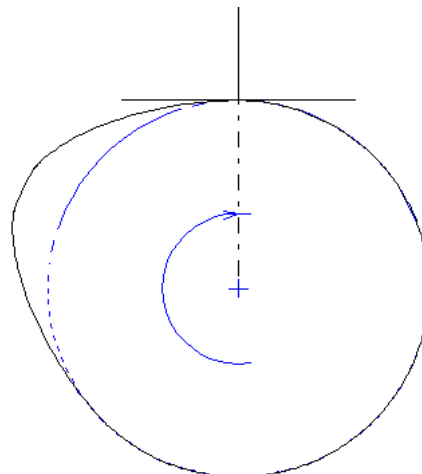
The relevant dimensions of these mechanism are shown respectively in Sketches D1.1, D1.2, D1.3, D1.4, D1.5 and D1.6.



Sketch 4.1 Type 1 – Cam with translating roller follower



Sketch 4.2 Type 2 – Cam with translating domed follower



Sketch 4.3 Type 3 – Cam with translating flat-faced follower