

OSMEC. Computer-aided linkage design: user manual

Associated software: OSMEC

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The Mechanisms Committee, which first met in 1975, is continuing the work that was previously 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.

OSMEC. COMPUTER AIDED LINKAGE DESIGN: USER MANUAL

CONTENTS

	Page
1. INTRODUCTION	1
1.1 Synopsis	1
1.2 Limitations on the Type of Mechanism	2
1.3 Assumptions	2
1.4 Document Syntax	2
1.5 Installation	2
1.6 Acknowledgment	2
2. TECHNICAL TERMINOLOGY AND UNITS	3
2.1 Technical Terminology	3
2.2 Units	4
2.2.1 Default System of Units used in OSMEC	5
2.2.2 User-defined System of Units	5
3. HOW MECHANISMS ARE MODELLED IN OSMEC	7
3.1 Introduction	7
3.2 Representation of Links	7
3.2.1 Offset/coupler points	10
3.2.2 Multiple Joints	10
3.3 Driving Entities	12
3.3.1 Crank	12
3.3.2 Piston in a fixed cylinder	12
3.3.3 Trunnion-mounted ram	13
3.4 Driven Entities	14
3.4.1 Dyad	14
3.4.2 Slider with connecting rod	14
3.4.3 Link carrying a slider	15
3.4.4 Springs	16
3.4.5 Gear trains	16
3.4.6 Shapes and frames	16
3.4.7 Markers	16
3.5 Modelling a Mechanism in OSMEC	16
3.5.1 Mechanism topology	17
3.5.2 Identification of OSMEC mechanism entities	18

4.	USING OSMEC	19
4.1	Starting the Program	19
4.2	Menus and Forms	19
4.3	Program Control	20
4.3.1	Program control using the keyboard	20
4.3.2	Program control using the mouse	20
4.4	An Outline of the Menu Structure	21
4.5	Closing the Program	21
4.6	Help	21
5.	NOTES ON MECHANISM DESIGN AND THE STORED MECHANISM DATA FILES	22
5.1	Introduction	22
5.2	Creating a Complicated Mechanism	22
5.3	Stored Mechanism Data Files	22
5.3.1	Crank	22
5.4	Four-Bar Linkages	23
5.5	Six-bar, Eight-bar and Ten-bar Linkages	28
5.5.1	Six-bar linkages	28
5.5.2	Eight-bar linkages	30
5.5.3	Ten-bar linkages	31
5.6	Slider-crank	31
5.7	Piston in a Fixed Cylinder driving a Dyad	34
5.8	Trunnion-mounted Rams	35
5.9	Quick Return Mechanisms	38
5.10	Pivoted Slider Mechanism	39
5.11	Mechanisms Using Springs	40
5.12	Mechanisms Using Gear Trains	41
5.13	Robot Manipulators	45
5.14	Additional Mechanisms	46
6.	USING THE EDIT MENU TO MODIFY MECHANISM DATA FILES	48
6.1	Introduction	48
6.2	Input	48
6.3	Dimension	48
6.4	Force	51
6.4.1	Link	51
6.4.2	Slider	51
6.5	Torque	52
6.6	Add	52
6.7	Shape	52
6.8	Frame	52
6.9	Mark	52
6.10	Units	52

7.	NUMERICAL OUTPUT - THE GRAPH MENU	53
7.1	Introduction	53
7.2	Query	53
7.3	Graphs	53
7.3.1	Angle	54
7.3.2	Distance	55
7.3.3	Velocity	55
7.3.4	Acceleration	55
7.3.5	Note on velocity and acceleration graphs	55
7.3.6	Force	56
7.3.7	Torque	56
7.3.8	Slider	56
7.3.9	Frame	56
7.3.10	Repeat	57
7.3.11	Balancing	57
7.4	Hard Copy and Tables	57
8.	THE RUN MENU	58
8.1	Continuous, Stepped, Trace and Set	58
8.2	Loci	58
8.2.1	Displaying loci	58
8.2.2	Tabulating loci	59
8.2.3	Loci option on the display menu	59
8.3	Delete	59
8.4	Restore	59
8.5	Print	59
8.6	DXF Export	60
9.	THE CREATE OPTION	61
9.1	The Create Process	61
9.2	Offset Points	61
9.3	Shape	62
9.4	Frames	62
9.5	Springs	62
9.6	Multiple Joints	62
9.7	Ending Create	62
9.7.1	Gear trains	62
9.7.2	Torsion springs	62
9.7.3	Specifying units	63
9.7.4	Input data	63
9.8	Program Restrictions - Memory Limits	63
10.	REFERENCES	64

APPENDIX A – INPUT DATA FILES AND THE MODELLING OF CAM-DRIVEN LINKAGES	65
APPENDIX B – LIST OF STORED MECHANISM DATA FILES	67
APPENDIX C – TUTORIAL ON FORCE ANALYSIS	69
C1. Introduction	69
C1.1 Exercise 1	69
C1.2 Exercise 2	70
C1.3 Exercise 3	70
C1.4 Exercise 4	70
C1.5 Solutions	70
APPENDIX D – MAIN MENU	72
D1. Introduction	72
D1.1 File	72
D1.2 Zoom	73
D1.3 Grid	73
D1.4 Setup	74
APPENDIX E – INDEX	75

OSMEC. COMPUTER AIDED LINKAGE DESIGN: USER MANUAL

1. INTRODUCTION

1.1 Synopsis

OSMEC is a general-purpose linkage design program. It can model plane linkages composed of links, pivoted and sliding joints, gear trains and springs. OSMEC can also model cam-driven mechanisms and can interface with the cam design program OSCAM (see Reference 1). OSMEC eliminates the lengthy, expensive and error-prone labour of drawing and calculation when laying out or modifying the basic design of a mechanism. OSMEC provides both static and animated drawings of the mechanism on the computer screen. Dimensions, masses, moments of inertia and load forces can be altered easily and quickly. The effects of these alterations are analysed and displayed.

OSMEC is used for the rapid design analysis of mechanisms. OSMEC produces graphs and tables of:

- positions of points,
- angles of links,
- linear/angular velocities,
- linear/angular accelerations,
- driving and bearing forces,
- drive torque

and prints timed and dated reports on all dimensions of the mechanism. Hard copy of any display can be sent to a plotter or printer, or sent to a file for use in any program that can read HPGL[†] files. OSMEC can export a DXF[‡] file to CAD (Computer-Aided Design/Drafting) software. The detail design of the constituent parts can then be carried out.

OSMEC performs force/torque calculations using two distinct methods and reports the position of the mechanism at which the maximum difference between the forces calculated using the two methods occurs. This information provides an indication of the accuracy of the predicted values.

OSMEC can be used to design mechanisms for applications involving high speeds and large forces. OSMEC is menu driven and has extensive on-line help.

OSMEC includes an extensive library of mechanism models representing the majority of planar linkages found in practice. The relevant data file may be easily edited to model the design parameters representing the user's mechanism. A series of tutorial examples is included in this Data Item that demonstrates this procedure, see Section 5.

Various motive power units can be specified for mechanisms capable of being modelled using OSMEC. Linear input motion may be provided by trunnion-mounted and fixed-axis rams or actuators. Rotary input motion from both motors and human input may be applied to cranks that either rotate fully or move through an arc. The specified motion may be either constant speed or user-defined by importing a file specifying the length, velocity and acceleration of the input actuator/ram or, in the case of a rotating crank, the equivalent angular quantities.

[†] Hewlett Packard Graphics Language File defined by Hewlett Packard corporation

[‡] Drawing Exchange File Format defined by Autodesk Inc.

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This page Amendment B

1



Documents

Document Sharing Hub

Loads may be applied to any link in the mechanism as external forces/torques or using linear/torsion springs. Inertial effects may also be included.

1.2 Limitations on the Type of Mechanism

OSMEC can only model mechanisms that can be built up from the entities provided. However most mechanisms used in practical applications can be modelled. A list of the mechanism data files is provided in Appendix B with typical applications suggested for each.

1.3 Assumptions

When considering the kinematic and kinetostatic relationships between the parts of a planar mechanism modelled using OSMEC, it is assumed that:

- (a) all joints connecting links have a single degree of freedom,
 - (b) no out-of-plane motion or forces occur,
 - (c) the motion of the input link is defined,
 - (d) there are no clearances at the joints,
 - (e) all parts of the mechanism are stiff enough to be considered rigid bodies
- and (f) the effects of friction at all bearings are negligible.

1.4 Document Syntax

Throughout this document links are labelled using numbers shown emboldened, *e.g.* **2**, while points are labelled using a letter *e.g.* B. Point letters and link numbers are discussed in Section 3. When software menu items are described they are italicised, for example *Create*, whereas keyboard entries are enclosed in quotes, *e.g.* 'Esc'.

1.5 Installation

The procedure for installing OSMEC, notes on the copyright and fitness for purpose are described in Data Item 97023 (Reference 2).

1.6 Acknowledgment

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

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

2. TECHNICAL TERMINOLOGY AND UNITS

2.1 Technical Terminology

Mechanisms are used in a very large number of different industries and different technical terms are therefore sometimes used that have the same meaning. To avoid confusion, the words that have come into common use in text-books and papers on mechanism theory are used in this document. Their meaning(s) are defined as follows.

A **plane** or **planar** mechanism is one in which every moving point moves in a plane and all of those planes are parallel to each other. The motion is consequently two-dimensional and such mechanisms are sometimes called 2-D mechanisms. For example, a pair of spur gears is a plane mechanism; a pair of bevel gears is not. Most of the mechanisms in common use are plane, and OSMEC is restricted to such plane mechanisms.

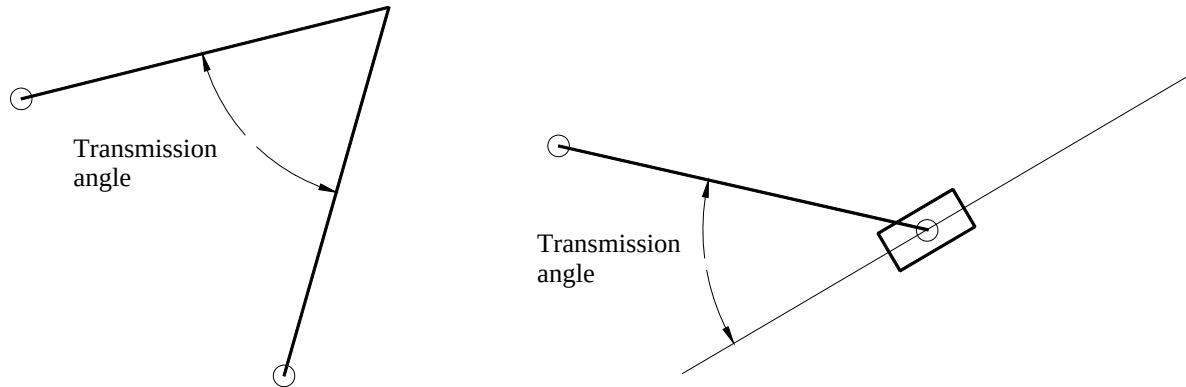
Each separate part of a mechanism, including the frame, is called a **link** or **bar**. Any arrangement of moving parts connected together so as to transmit motion is called a **mechanism**. This includes cam mechanisms, gear trains, *etc.* A mechanism using only pivoted and/or sliding joints is called a **linkage**. Thus, for example, a **four-bar linkage** (a very common and important mechanism) consists of three moving links and a frame connected together by pivoted joints. An example is provided in mechanism model file M02.OS (see Sketch 5.2).

The part of a link in contact with another link is called an **element**. The connections between links are made by elements coming into contact and these joints are therefore known as **kinematic pairs**. Considering only the planar mechanisms modelled by OSMEC, the kinematic pairs fall into two classes - **higher** and **lower** pairs. In higher pair joints the connection is at a line or point, as in gear-teeth or a cam and follower. Lower pair joints involve a surface contact, as in a journal/plane bearing or between a piston and cylinder. Lower pair joints are restricted to a single **degree of freedom** of movement whereas higher pairs allow two degrees of freedom of movement. OSMEC models mechanisms in which the links are connected by joints with a single degree of freedom. These joints are either **revolute**, in which only angular relative motion between the links is possible, or **sliding** in which only translation between two links can occur.

A link that rotates about a centre fixed to the frame is called a crank or a rocker. In this Data Item a link that drives the mechanism is referred to as a **crank**. If the link is driven by the motion of other input links it is referred to as a **rocker**. Note, however, that some references use the terms interchangeably. For example, the "double-crank" mechanism model file M06.OS (see Sketch 5.6) is a four-bar linkage with a driving crank and a driven rocker.

A link that has no fixed centres, such as the connecting rod of an engine or pump, is called a **coupler** or a **floating link**. When a floating link (or coupler) is connected to a rocker link (or another floating link) this two-link **entity** is known as a **dyad** (see Section 3.4.1). Note that a single driven link cannot be added to a mechanism model because its motion is not uniquely defined. Similarly a sub-assembly of links consisting of a connecting rod, a slider and its track must be added to a mechanism as a single **slider** entity. The entities available in OSMEC are described in Sections 3.3 and 3.4.

The **transmission angle** between two links at a pivoted joint is shown in Sketch 2.1a. It is of significance if one link is a coupler and the other is driven by it.



Sketch 2.1 Transmission angle

It is recommended that this angle should not be allowed to fall much below 45° or rise much above 135° . Beyond those limits there is a risk of jamming. The effect is sometimes deliberately used by arranging for the transmission angle to fall to (or near) zero so that the linkage will jam in a particular position; this is called a toggle action. A slider entity is shown in Sketch 2.1b. It is recommended that the transmission angle between the link and the slider track should be less than 30° or greater than 150° .

A mechanism consisting of a crank, connecting rod and piston or slider (such as a single-cylinder engine or pump) is called a **slider-crank mechanism**. An example, constructed from an OSMEC crank entity driving a slider entity, is provided in mechanism model file M19.OS (see Sketch 5.19). A complicated mechanism can consist of a simple mechanism, such as a four-bar linkage, with extra links connected to it. In such a case it is often useful to focus attention on the simple mechanism and this is then called a **four-bar group**.

The term **kinematics** is used to refer to all motion characteristics of the mechanism that affect only the relative motion of the links, ignoring the effects of forces. When forces are involved, the terms **dynamics**, **kinetostatics** or **force analysis** are used. See also Reference 4.

The concepts introduced in this section are discussed in detail in References 6 to 15 listed in Section 10.

2.2 Units

OSMEC offers a choice of units, between the "Default" or the "User-defined" system of units. When the program is activated it uses the default system. Immediately after a new mechanism has been created the program provides a choice between the two systems of units and the system can be changed at any time by a command on the *Edit* menu. The choice of system is recorded in the mechanism data file when a mechanism is saved, and when the file is retrieved the program will automatically use the appropriate system of units.

In both systems the positive sense for angular quantities is counter-clockwise. Angles are measured from the positive global x-axis (horizontally to the right on the screen). A moment of inertia must be specified about the axis perpendicular to the plane of motion that passes through the mass centre of the link concerned. The driving speed of a rotating input (crank) is measured in rev/min. Otherwise the units are as follows.

This page Amendment B

2.2.1 Default System of Units used in OSMEC

The default system is the system commonly used in the UK and on the European continent. Essentially it is the SI system except that lengths are in millimetres, angles in degrees and input speeds in rev/min.

TABLE 2.1 List of Default System of Units applicable to OSMEC computations

Parameter	Default unit
Distance	mm
Angle	degree
Velocity	m/s
Input speed	rev/min
Angular velocity (for output graphs/tables)	rad/s
Acceleration	m/s ²
Angular acceleration	rad/s ²
Mass	kg
Mass moment of inertia	kg m ²
Force	N
Torque	N m
Helical spring rate	N/m
Torsional spring rate	N m/rad

2.2.2 User-defined System of Units

Any dynamically consistent system of units is allowed except that angles are measured in degrees and input speeds in rev/min. OSMEC employs only one exception to this rule: to conform with common engineering practice, angles are measured in degrees and angular velocities and accelerations of driven links are measured using rad/s and rad/s², respectively.

When using a user-defined system of units, it is important that consistent units are selected if the results of the analysis are to be meaningful. For example, it is not acceptable to measure distances in millimetres and velocities in metres per second. Table 2.2 lists examples of units applicable to OSMEC computations for three commonly used systems.

TABLE 2.2 Examples of user-defined systems of units applicable to OSMEC computations

Units	SI	CGS	FPS
Distance	m	cm	ft
Angle	degree	degree	degree
Velocity	m/s	cm/s	ft/s
Rotational speed - input	rev/min	rev/min	rev/min
Angular velocity - output	rad/s	rad/s	rad/s
Acceleration	m/s ²	cm/s ²	ft/s ²
Angular acceleration	rad/s ²	rad/s ²	rad/s ²
Mass	kg	g	lb
Mass moment of inertia	kg m ²	g cm ²	lb ft ²
Force	N	dyne	pdl
Torque	N m	dyne cm	ft pdl
Helical spring rate	N/m	dyne/cm	pdl/ft
Torsional spring rate	N m/rad	dyne cm/rad	pdl ft/rad

3. HOW MECHANISMS ARE MODELLED IN OSMEC

The user is reminded that throughout this document link numbers are shown using a bold font, *e.g.* **2**, while points are labelled by letters, *e.g.* B. When software menu items are described they are italicised, for example *Create*, whereas keyboard entries are enclosed in quotes, *e.g.* 'Esc'.

Note that some complicated planar mechanisms cannot be modelled (see Section 5.5) using OSMEC. However the majority of mechanisms used in practical applications are provided in the stored mechanism model files listed in Appendix B. It is suggested that the original versions of these files are not overwritten and the modified mechanism is saved to a different file name on exit.

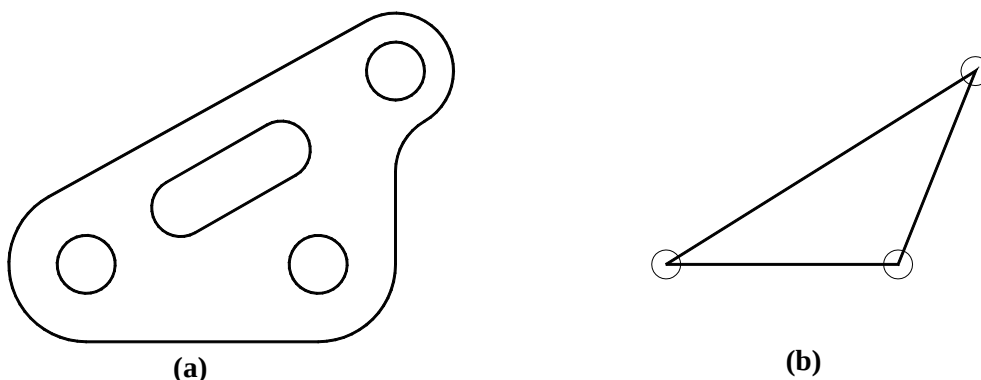
3.1 Introduction

To use OSMEC effectively it is important to understand how the constituent parts of a mechanism are represented and how a real mechanism is modelled in the abstract form that the program uses.

OSMEC produces diagrams similar to the layout drawings produced using computer-aided design/drafting (CAD) software or manually on a drawing board during basic design. These diagrams represent the links of the mechanism as straight lines joining their bearing centres. To make the diagrams more realistic OSMEC adds rectangles to indicate sliders and cylinders, and circles to indicate gears. A shape consisting of lines drawn by the user to represent features of the link may be attached to a moving link, see Section 3.4.6, in sufficient detail for layout purposes. Features of the fixed frame may also be included for reference purposes. Fixed bearing centres are indicated by small crosses and fixed slider guides by their centre-lines, both drawn in red when viewed on a colour monitor. Each link in the mechanism is assigned a number and each bearing or reference point is given a letter, displayed in yellow and green, respectively.

3.2 Representation of Links

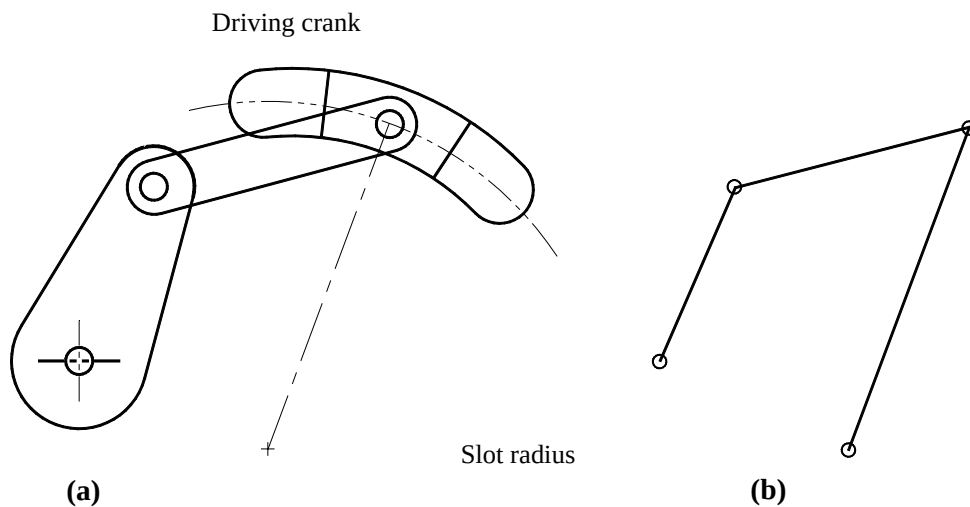
In a real mechanism, or a working drawing, the essential features that govern the kinematics and dynamics are usually surrounded by a great deal of detail. A typical machine link is shown in Sketch 3.1a. It comprises 3 bearing housings, 1 lightening hole and seatings to attach various other components. The representation of this link in OSMEC is shown in Sketch 3.1b in which the three bearing centres are joined by straight lines.



Sketch 3.1 Typical machine link (a) and its representation in OSMEC (b)

This defines the link completely for kinematic purposes. If inertial forces are significant, the location of the mass centre, the values of the mass and the moment of inertia taken about an axis through the mass centre perpendicular to the plane of motion must be specified.

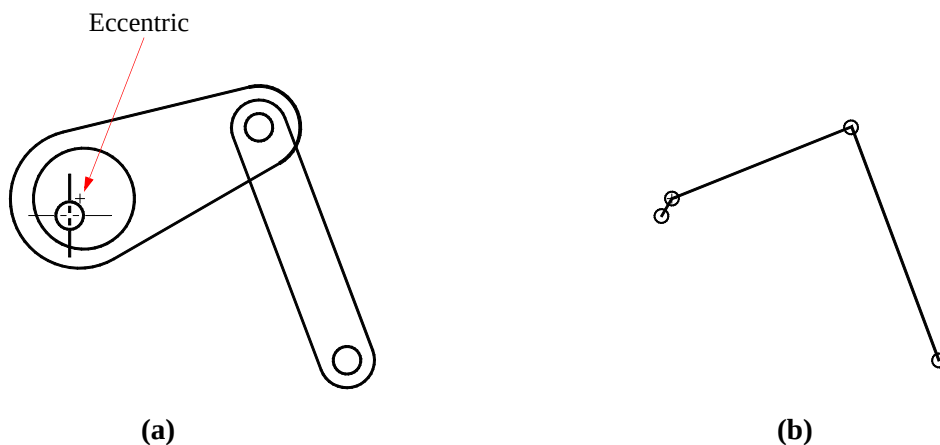
Sometimes the symbolic representation of parts of a mechanism are not obvious. Sketch 3.2a shows a mechanism in which a link is driven by a crank. The other end of the link is guided by a slider running in a curved slot, the slot being cut in the frame. The pivot-centre of the slider therefore moves along a circular arc struck from the same centre as the slot. The link is driven by the crank, as before, and guided by another link. This second link is pivoted at the centre from which the slot was struck and its length is equal to the pitch radius of the slot. The symbolic representation of the mechanism is shown in Sketch 3.2b.



Sketch 3.2 Link driven by crank with other end running in slot

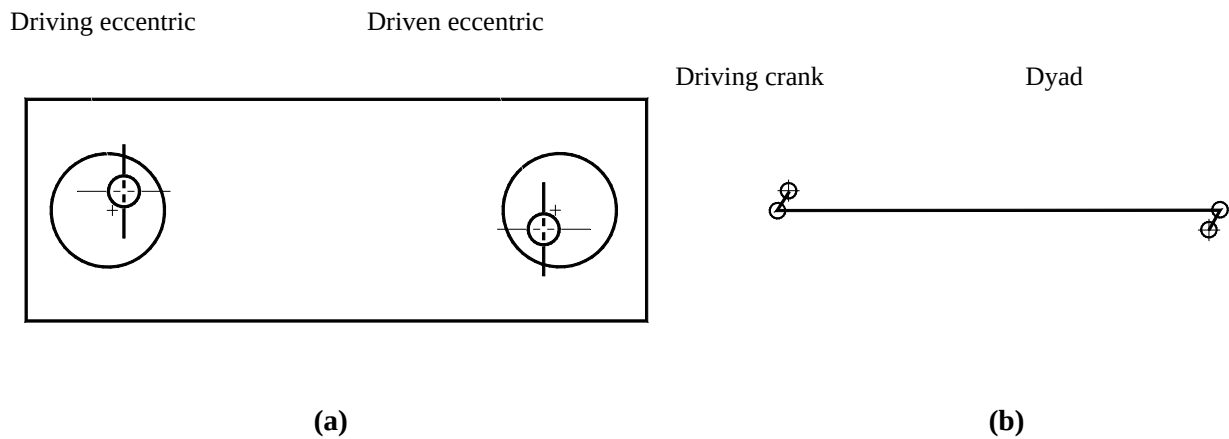
This representation is exact for kinematic purposes. It is also exact for force analysis if the mass, mass moment of inertia and the position of the mass centroid of the rocker link are equal to those of the slider.

An eccentric, as shown in Sketch 3.3a, is modelled in OSMEC as a very short crank whose length is equal to the eccentric, as shown in the symbolic representation of Sketch 3.3b.



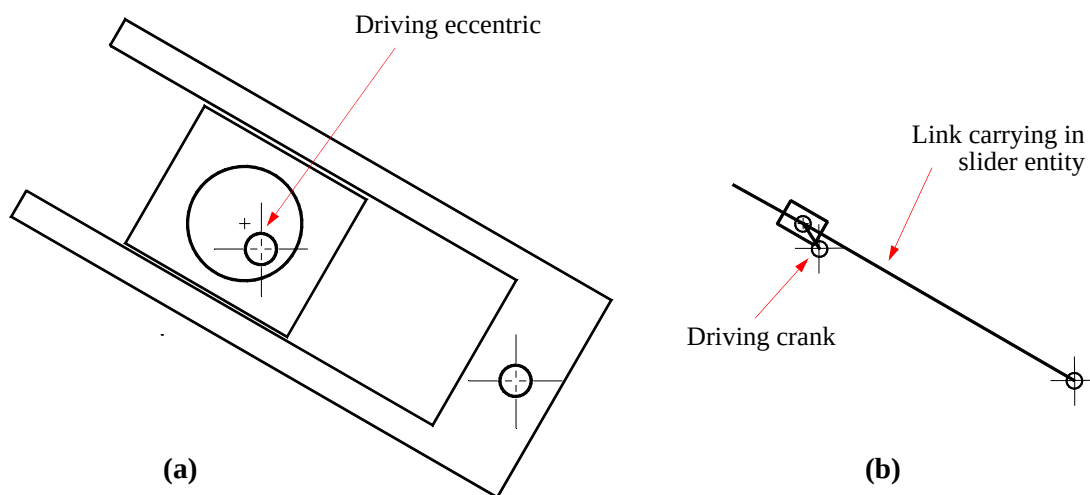
Sketch 3.3 Eccentric modelled by a very short link

Similarly a mechanism with two eccentrics, shown in Sketch 3.4a, is modelled symbolically in Sketch 3.4b.



Sketch 3.4 Mechanism with two eccentrics

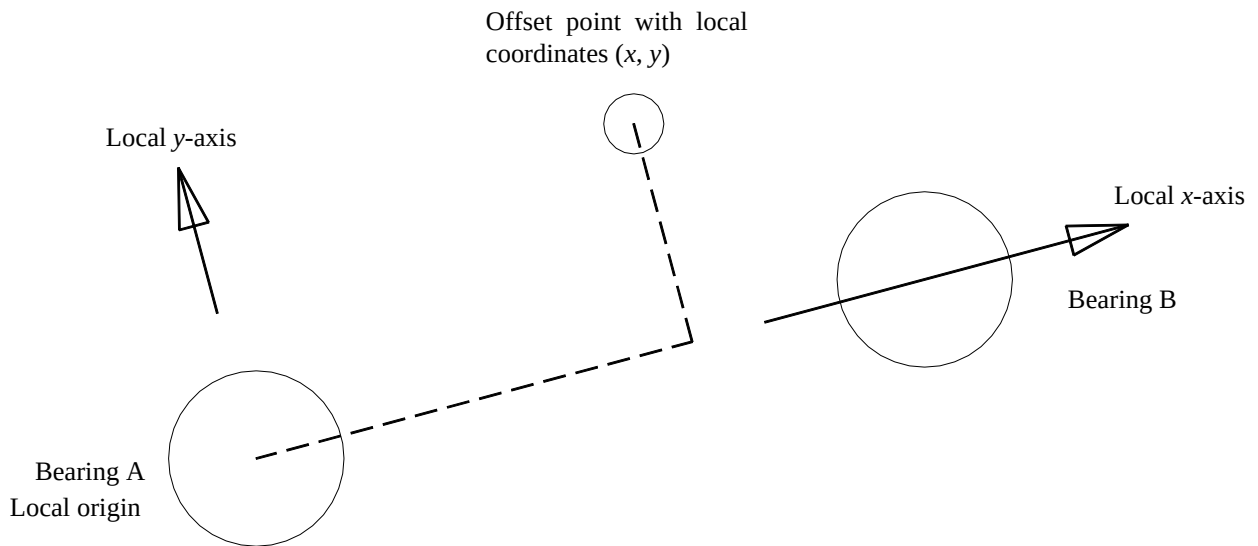
Sketch 3.5a shows a mechanism in which an eccentric drives a pivoted slider. Its symbolic representation is shown in Sketch 3.5b.



Sketch 3.5 Eccentric driving a pivoted slider

3.2.1 Offset/coupler points

Any link in a mechanism can carry additional points, either on the link axis or offset from it. Such points are called offset points and their location on the link is defined using local co-ordinates. See Sketch 3.6.



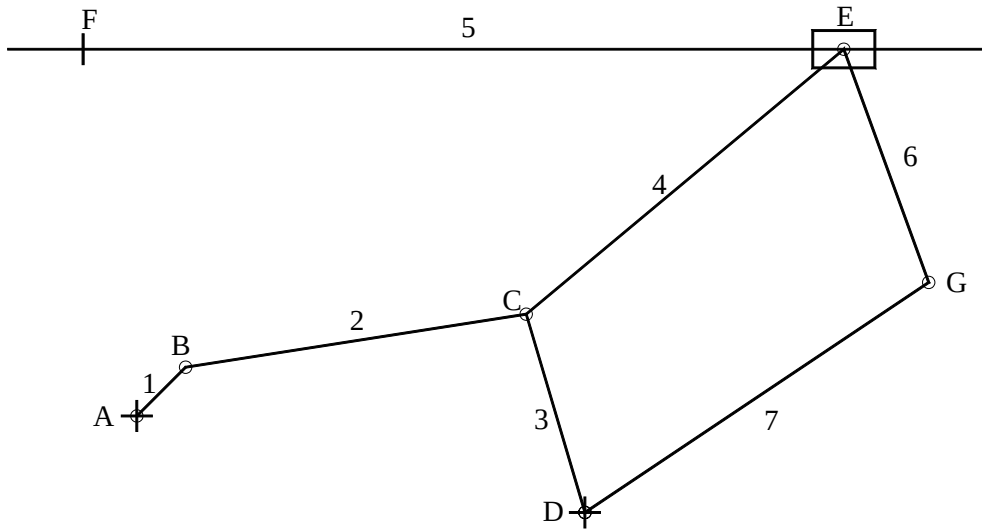
Sketch 3.6 Offset points on a link

An offset point on a coupler (floating link) is usually called a coupler point and the path followed by the coupler point as the mechanism moves is called the coupler curve. The complex paths followed by different coupler points on the same link are often quite distinct. Mechanism model file M05.OS (see Sketch 5.5) illustrates this point.

The origin of local co-ordinates is one of the end-points of the link, depending on which was selected during the original *Create* process. The positive local *x*-axis extends from the origin to the other end-point. The positive local *y*-axis extends perpendicularly from the origin to the left of this line when viewed along the positive local *x*-axis from the origin.

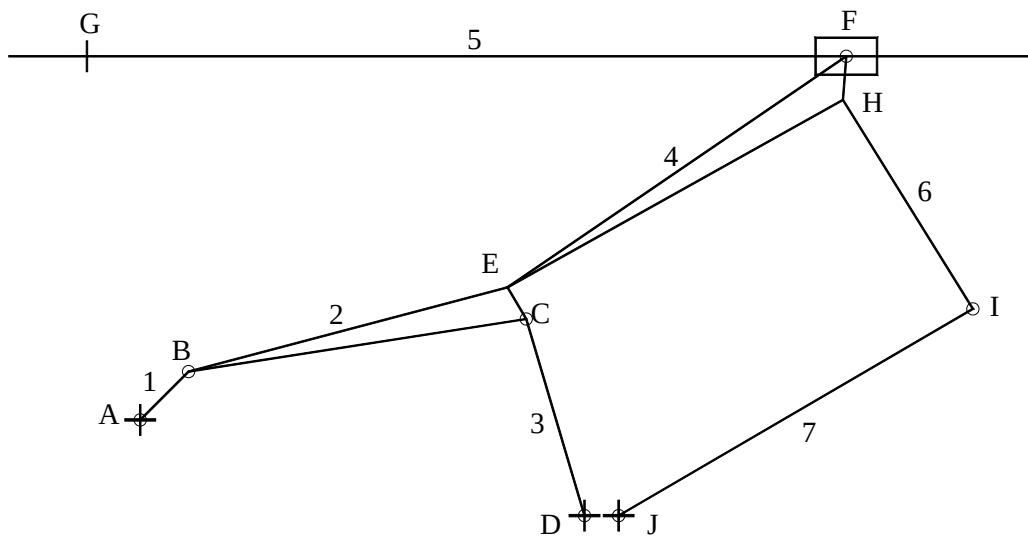
3.2.2 Multiple Joints

A multiple joint occurs where more than two entities are connected together. These entities can be links (including the frame) or helical springs. Sketch 3.7 shows a mechanism with two examples.



Sketch 3.7 Mechanism with multiple joints at points C, D and E

The connecting rod for the slider is connected to the central pivot of the dyad and a helical spring is connected to the slider pivot and anchored to one of the fixed pivots. The forces acting at a multiple joint can, however, be analysed by putting an offset point on one of the relevant links, as in Sketch 3.8.



Sketch 3.8 Simulating multiple joints for force analysis

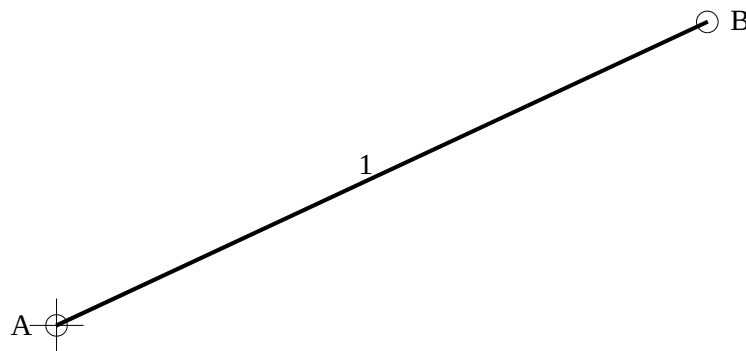
The local co-ordinates of the offset point are then set to zero after *Create* is ended by using the *Offset* option in the *Dimension* sub-menu of the *Edit* menu. Forces may be analysed and graphs drawn for these offset points.

3.3 Driving Entities

In OSMEC a mechanism is modelled from entities connected in the same sequence in which they would be drawn. A driving link is the first entity that provides the input; the first entity drives the second, and so on throughout the chain of entities that make up the mechanism. The driving entities currently available in OSMEC are described in the following Sections 3.3.1 to 3.3.3.

3.3.1 Crank

The OSMEC representation of a driving crank is shown in Sketch 3.9.

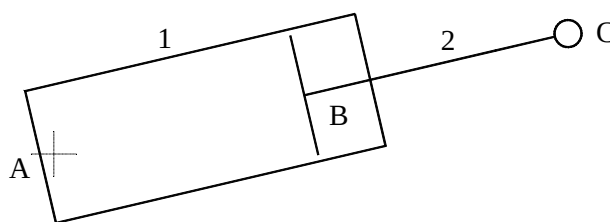


Sketch 3.9 Driving Crank

An example of this single-link entity is provided in the mechanism model file M01.OS that is also illustrated in Sketch 5.1. The crank angle is the input variable. The rotating point at the end of the crank drives all connected entities.

3.3.2 Piston in a fixed cylinder

A piston sliding in a cylinder with a fixed axis is shown symbolically in Sketch 3.10.

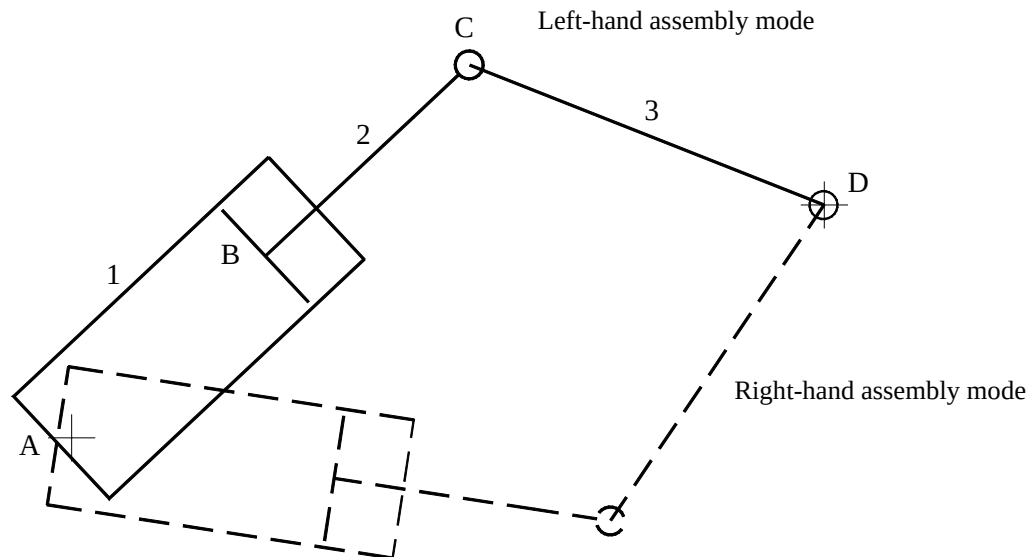


Sketch 3.10 Piston in a fixed axis cylinder

This entity is available in the mechanism model file M21.OS which is illustrated in Sketch 5.21. The fixed angle of inclination of the cylinder axis is defined by the vector joining point A to point B. The distance between these points is the input variable defining the piston displacement. Point C drives all connected entities.

3.3.3 Trunnion-mounted ram

Sketch 3.11 shows a trunnion-mounted ram (links 1 and 2) connected to a rocking link (3) that is usually attached to the frame.



Sketch 3.11 Trunnion-mounted ram

The cylinder length, link 1, measured along the centre-line between points A and B, acts as the input variable defining the piston displacement and drives the piston rod, link 2, measured between points B and C. The ram pivots about the trunnion bearing at point A and drives the rocker, link 3, connected by a revolute joint at point C. Point D is the pivot for the rocker link.

This entity is provided in the mechanism model file M22.OS illustrated in Sketch 5.22. Note that the trunnion-mounted ram has one of two possible assembly modes for given positions of the pivots A and D. In the left-hand mode (solid lines in Sketch 3.11) points B and C are on the left when viewed from A towards D. In the right-hand mode (broken lines) they are on the right. Both assembly modes are shown in the OSMEC representation in Sketch 3.11. The *Assembly* option (on the *Dimensions* sub-menu of the *Edit* menu) is used to set the assembly mode. A short exercise will demonstrate this procedure.

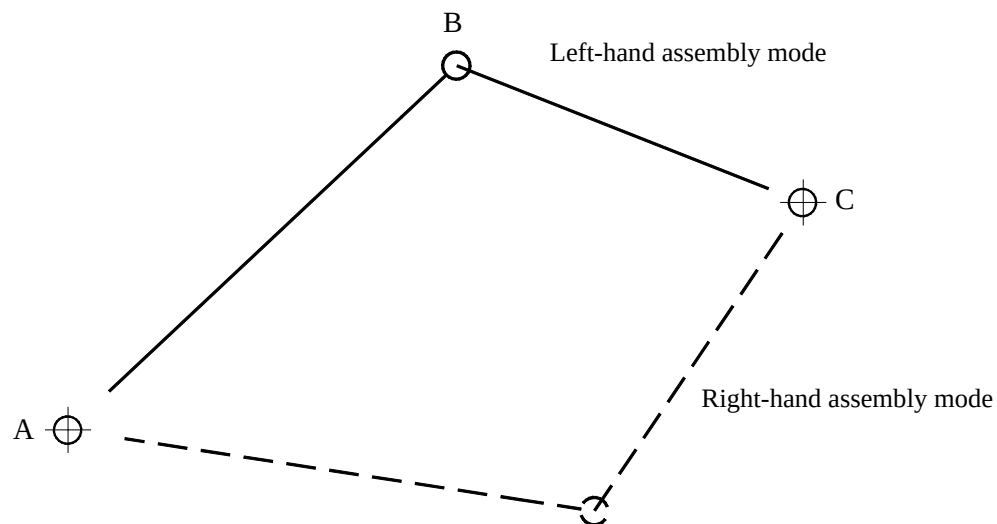
Load mechanism model file M22.OS using the *File* menu option of the main menu (see Section D1.1 of Appendix D) and select the *Dimensions* sub-menu of the *Edit* menu where the option *Assembly* is located. Select this option and a form will appear with a column labelled *Mode*. This column will contain the word *Left*, this being the current assembly mode of the trunnion-mounted ram. Press either of the horizontal arrow keys or the spacebar and the assembly mode will change to *Right*. Press the 'Return' or 'Enter' key and observe the changed assembly mode.

3.4 Driven Entities

Each of the entities described in Section 3.3 can be used as the first entity in a mechanism and can either serve as the complete mechanism or drive other entities. The additional driven entities are described in Sections 3.4.1 to 3.4.7.

3.4.1 Dyad

The layout for both assembly modes is included in the OSMEC representation of a dyad shown in Sketch 3.12.



Sketch 3.12 Pair of links connected by a central pivot – Dyad

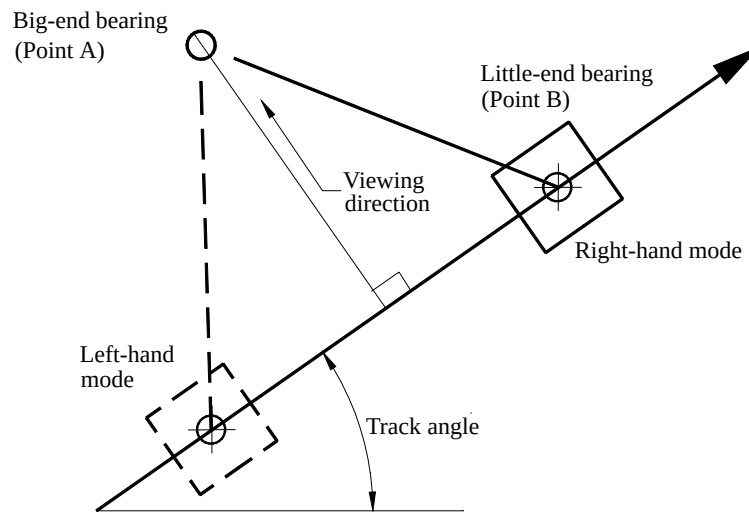
This entity is constructed from two links connected by a revolute pivot. The dyad must have one of the two possible assembly modes for given positions of end pivots A and C.

In the left-hand mode (solid lines in Sketch 3.12) the central pivot B is on the left when viewed from A towards C. In the right-hand mode (broken lines) it is on the right.

A four-bar linkage mechanism, constructed from a crank driving a dyad, is provided in the mechanism model file M02.OS as illustrated in Sketch 5.2. When this mechanism file is retrieved, the *Assembly* option (on the *Dimension* sub-menu of the *Edit* menu) can be used to observe the difference between the two modes.

3.4.2 Slider with connecting rod

The layout for both assembly modes is included in the OSMEC representation shown in Sketch 3.13.



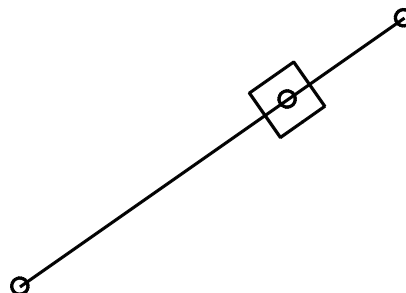
Sketch 3.13 Assembly mode of a slider with connecting rod

This entity consists of a link (the connecting rod) with big-end bearing point A and little-end (also called a gudgeon-pin or wrist-pin) bearing point B. The slider is pivoted with the link at B. The slider runs on a straight track, defined by its angle of inclination relative to the positive horizontal x-axis and the fact that it passes through the reference point C.

There are two possible assembly modes for this entity. In the right-hand mode (solid lines in Sketch 3.13) the slider (point B) is located to the right of the line drawn perpendicular to the track through point A, when viewed along that line in the direction 90° anticlockwise to the track. Therefore the assembly mode is unchanged regardless of which side of the track the big-end (point A) is located. In the left-hand mode (broken lines), the slider is on the left. A mechanism made up of a crank driving a slider entity (slider-crank mechanism) is provided in the mechanism model file M17.OS that is also illustrated in Sketch 5.17. By retrieving this mechanism using the *File* menu and changing the assembly mode using the *Assembly* option on the *Dimensions* sub-menu, the difference between the two modes may be observed.

3.4.3 Link carrying a slider

This entity, shown in Sketch 3.14, consists of a track (usually a bar) with a slider running freely along it. This entity is driven by one of the two end pivots (the first one that appears when the entity was selected in *Create*) and by the pivot point on the slider. The second end pivot point can be left free or used to drive another entity.



Sketch 3.14 Link carrying a slider

Typical applications are demonstrated by the mechanism model files M26.OS, M28.OS and M29.OS. In M26.OS the first end pivot is fixed and the slider pivot is driven by a crank (see Sketch 5.26). M28.OS has a similar arrangement except that the second end pivot is used to drive a slider via a connecting rod (see Sketch 5.28). Mechanism model file M29.OS provides a further example in which the first end pivot is driven by a crank and the slider pivots about a point on the frame, to which it is fixed (see Sketch 5.29).

3.4.4 Springs

Helical springs and torsion springs (displayed in OSMEC as dashed lines and broken circles, respectively) can be added to the mechanism. Examples of mechanisms that include springs are provided in mechanism model files M30.OS (see Sketch 5.30) and M31.OS (see Sketch 5.31). Note that in OSMEC a spring only applies a force (or torque) to a mechanism model and does not affect its kinematics.

3.4.5 Gear trains

A gear train can be introduced to connect any pair of cranks provided the second crank in the pair is capable of being used as an input link. Examples are given in mechanism model files M33.OS to M38.OS inclusive (see Sketches 5.33 to 5.40) and are discussed in Section 5. Note that force analysis for mechanisms which include gear trains is not possible in OSMEC.

3.4.6 Shapes and frames

As explained in Section 3.1, links are represented by straight lines joining their pivot centres. It is sometimes necessary to show links in more detail, for example in mechanism model file M25.OS (see Sketch 5.25) which shows an excavator. This is done by attaching "shapes" to the links. A shape consists of a series of lines that represent the outline of the actual component. When commands on the *Run* menu are selected, the shapes in the animated mechanism move with the link to which they are attached.

Offset points on a link are joined by straight lines between them and the two main pivot centres that locate the link. An example of a complicated mechanism represented in this way is shown in model file M16.OS (see Sketch 5.16). When a shape is added to a link the lines joining offset points are suppressed, to make the display clearer when there are several offset points, as in mechanism model file M05.OS (see Sketch 5.5). Note that a shape in OSMEC can consist of a single offset point.

A "frame" is included in the mechanism as a series of (purple) lines. These features are for reference only and do not affect the kinematics or move when the mechanism is animated.

3.4.7 Markers

Small static crosses can be added to the display to serve as guide marks during design work. (This is an option on the *Edit* menu only, it is not part of the *Create* process described in Section 9.)

3.5 Modelling a Mechanism in OSMEC

The starting point in design is often an existing mechanism that has to be analysed or modified. The mechanism is usually available as a drawing or as actual hardware. If a new mechanism is to be created the starting point is usually a rough sketch. In either event, to model the mechanism in OSMEC it is necessary to reduce it to a symbolic representation using the entities described in Sections 3.2 to 3.4.

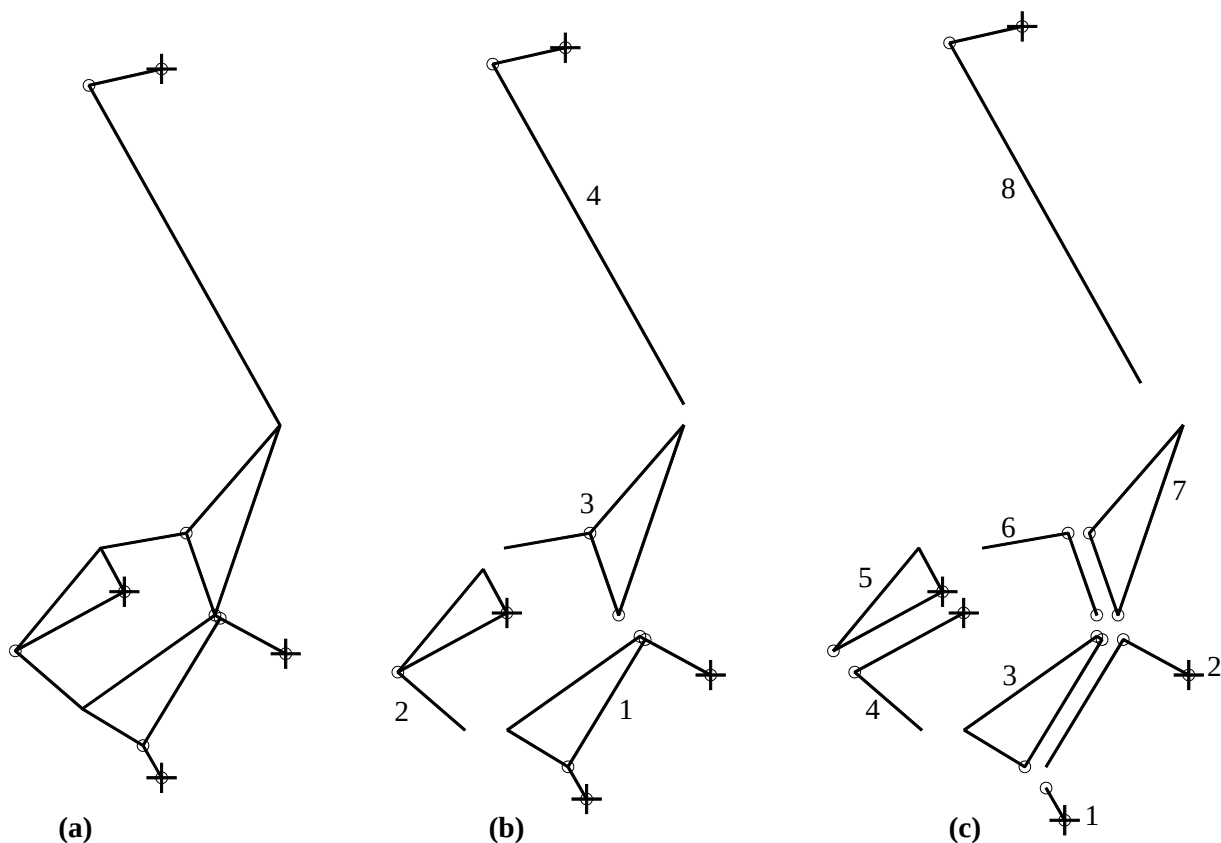
The first step in understanding a mechanism is to locate the pivot centres and make a sketch in which the centres are shown joined by lines to represent the (kinematic) links. It is particularly important that the fixed centres are clearly marked. This sketch and all subsequent sketches need not be very accurate.

3.5.1 Mechanism topology

Once the sketch has been made it is easier to decide whether the mechanism is an existing stored type, such as one of the .OS mechanism model files supplied with OSMEC. At this stage the dimensions are irrelevant, since they can be altered later using *Edit* commands. Any four-bar linkage with revolute joints, for example, can be represented by model file M02.OS, illustrated in Sketch 5.2.

The characteristics of a mechanism (apart from its dimensions) that define its type are called the topology. The topology is determined by the number of links, the number and types of joints and the order in which these links are connected together. All four-bar linkages, for example, have the same topology. In most practical cases a mechanism can be modelled by one of the .OS mechanism model files. New entities can be added but existing entities cannot be removed. If, because the required topology is not available in an existing .OS file, *Create* must be used.

It is easier to understand a complicated mechanism if a preliminary sketch is made showing it separated into distinct 'units' of links, sliders, offset points etc. For example, consider Sketch 3.15a, which shows the mechanism modelled in file M16.OS, and Sketch 3.15b, which shows the separate units.



Sketch 3.15 (a) Mechanism M16.OS (b) and (c) Mechanism M16.OS broken into its basic sub-assemblies

Referring to Sketch 3.15b, it can be seen that the driving unit is a four-bar group (unit 1). This drives a dyad (unit 2). Another dyad (unit 3) is then driven from points on units 1 and 2. Finally, unit 4 is driven by unit 3.

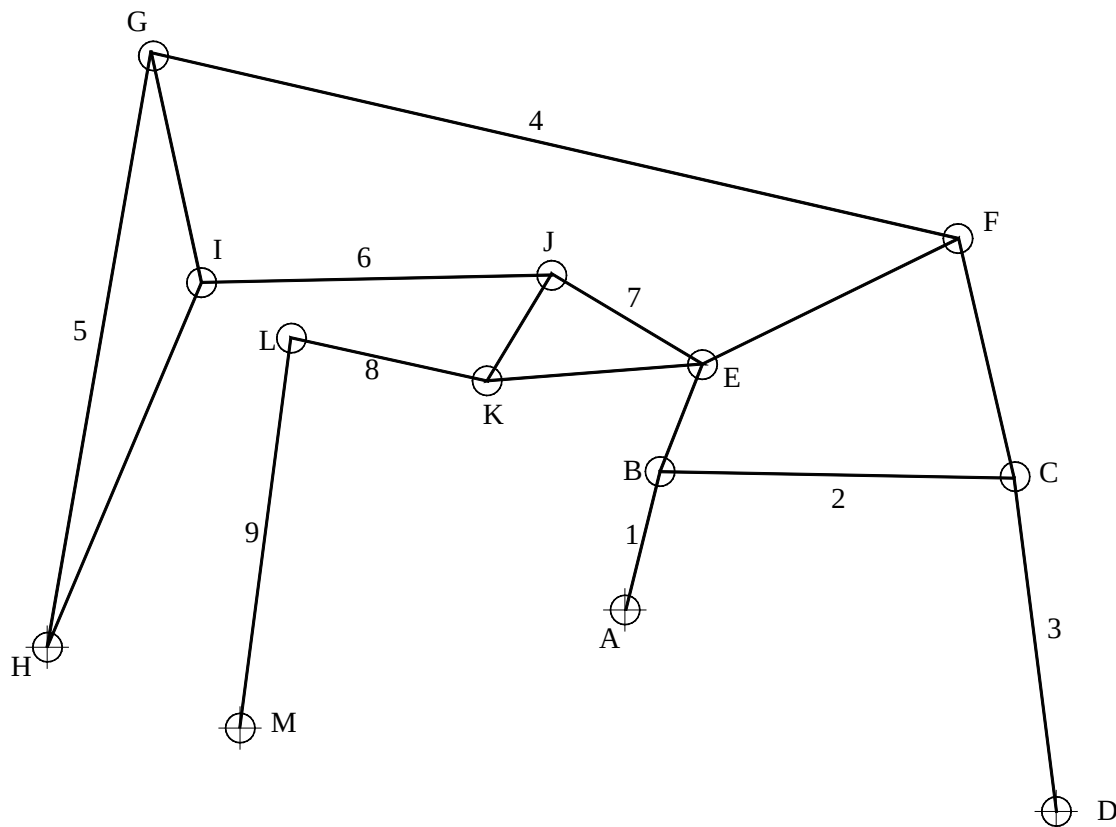
3.5.2 Identification of OSMEC mechanism entities

The next step is to reduce the units to a set of OSMEC entities. This is carried out, for example, by separating the four-bar group (unit 1) into a crank and dyad and then identifying the link with which each offset point is associated. This gives the symbolic representation shown in Sketch 3.15c. The mechanism can now be represented by a set of OSMEC entities and the *Create* process used to model it if an existing mechanism model file with the same chain of entities does not exist.

By using the *Delete* and *Restore* options in the main *Edit* menu, it is possible to see how a mechanism is constructed and how motion is transmitted through the kinematic chain of entities. It is instructive to try this procedure on a stored mechanism before reading further.

Load and run M16.OS and select *Delete* repeatedly until all of the links have been removed. Now select *Restore* repeatedly until the complete mechanism has been re-built. Run the mechanism after each *Restore* and its motion can be seen.

It is suggested that the user tries to separate the mechanism in Sketch 3.16 into entities in the same way. It will be seen that this mechanism has the same topology as the mechanisms shown in Sketch 3.15 despite its very different appearance.



Sketch 3.16 Mechanism with topology identical to Sketch 3.15

4. USING OSMEC

4.1 Starting the Program

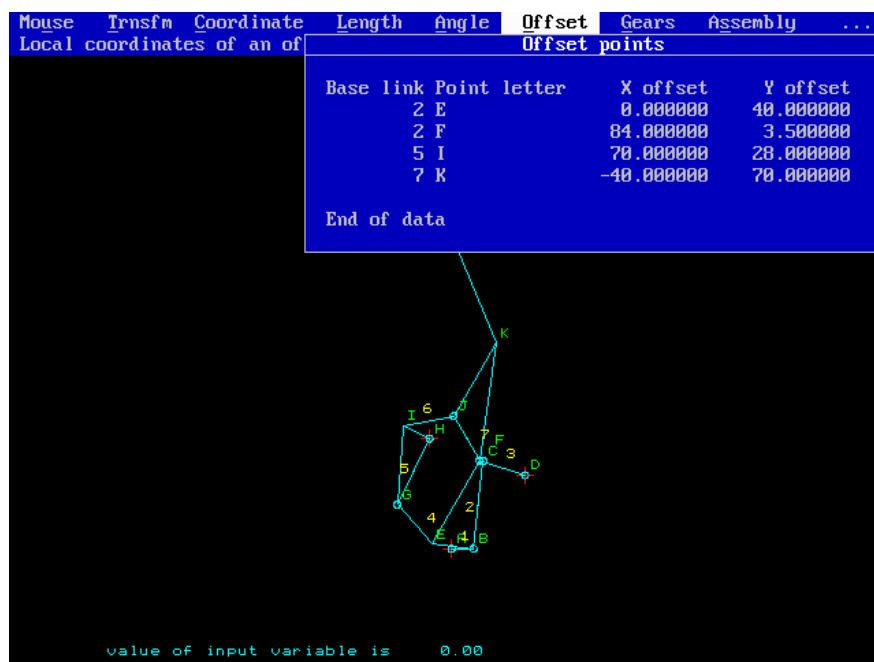
To run the program change to the appropriate directory (such as C:\OSMEC) and click on the file OSMECv##.EXE[†].

4.2 Menus and Forms

A menu is a list of options (such as "run the mechanism", "close the program", *etc.*) that appears along the top line of the screen. As the cursor is moved along the top line by pressing the arrow keys, an explanation of each option appears on the line below. In this Data Item, this is referred to as the help line.

A form is a rectangular area of the screen in which numerical values are entered and/or choices are made between certain options.

Sketch 4.1 shows a typical screen display with a menu along the top line. The *Offset* option has been selected and a form for entering the relevant data occupies a window in the top right-hand area of the screen, partially obscuring the menu help line and the mechanism display. The mechanism links are defined by the lines drawn between the bearing pivots that appear as small circles. On a colour monitor, the links are identified by yellow numbers positioned near the centre of the link. Bearings and offset points are defined by green letters located slightly to the right of the point. Offset points (see Section 3.2.1) on any given link are shown as a point joined by straight lines to two bearings.



Sketch 4.1 Typical screen display with menu along the top line

[†] The full name of the OSMEC executable file depends on the current version number of the program. Thus, for example, the full name of Version 7.0 of OSMEC will be OSMECv70.EXE and must be used when accessing the file.

4.3 Program Control

4.3.1 Program control using the keyboard

When the program is activated, a summary of the way the keys are used appears on the screen. In addition to the help line that appears automatically below the menu line, context-related on-line help is available. To use it at any point in the program press 'F1'.

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. If the arrow key is repeatedly pressed further options in the same menu will 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.

Sometimes the selection of a menu item causes a sub-menu to appear. Items in a sub-menu may have further sub-menus.

As 'Return' is used 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' and '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 via 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' closes the form and cancels any changes to the original data.

When a form is displayed it usually includes 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.

4.3.2 Program control using the mouse

The mouse is used when creating a new mechanism and for certain editing functions. This is explained in Section 6.3a.