Working Model®

Demonstration Guide
and
Tutorial

1. Introduction & Installation

Working Model - Fast and Powerful Engineering Analysis for Desktop PC's

Working Model is a powerful tool for engineering analysis, animation, and prototyping. It saves time and money in the design process by allowing you create and analyze dynamic physical systems on the computer prior to building costly prototypes.

Operating Concept

The operating concept of Working Model is straight-forward. First, define a set of rigid bodies and constraints (e.g., motors, springs, and joints) by drawing them with a mouse. Then set your system into motion by selecting "RUN" -- there is no pre-processing or post-processing. You immediately receive accurate results.

With Working Model, you create systems that are driven by physical laws. You can test, re-design, and re-test your mechanical system, speeding your time to market by seeing which designs work better before you build them.

Working Model allows you to fine-tune simulation parameters. You can define controllers to adjust properties of objects. You can create meters to plot the data that is taken during a simulation. You can design a model in your CAD program and import the data into Working Model. You can even use another application such as Excel or MATLAB® to control your simulations.

Designed with Ease -of-Use in Mind

Working Model was designed to be an integral tool in the design and analysis process for engineers of all types. Its highly intuitive interface makes it useful for engineers of all levels. An engineer can quickly test the performance of a shock absorber with a simple model, or create a highly complex dynamic model of an automobile engine. With its high degree of accuracy, Working Model can simulate almost any mechanical system.

Smart Editor ™

Working Model features the unique Smart Editor™. The Smart Editor shortens the design process by making it extremely easy to build and maintain complex designs as well as check for clearances, mechanism functionality, and tolerances. Interconnected objects can be moved by simply clicking and dragging—the Smart

Editor automatically moves each object based on existing constraints.

Import / Export

Working Model includes import/export options. With Working Model, users can import CAD drawings in DXF format from popular applications such as AutoCAD®, CADKEY and Vellum® and use them immediately in simulations.

Inter-Application Communication

Working Model uses Dynamic Data Exchange (DDE) on Windows and Apple® Events on Macintosh to communicate with other applications during a simulation. With this feature, users can specify physical models of real-life mechanical designs and then control them externally through other programs. For example, Microsoft® Excel can be used to calculate control signals. Data from Working Model is sent to the spreadsheet which calculates the control signals based on the current state of the system. New control information is then received by Working Model and used to calculate the next simulation frame.

About the Demonstration Version

These demonstration disks include a limited version of Working Model along with numerous example files. You will be able to build models, simulate their behavior, make measurements and interact with systems using the revolutionary Smart Editor™.

Several features, however, have been disabled in the demonstration version. In particular, file saving functionality has been removed (Save, Save As, Print, Export, Cut, Copy, Paste and Duplicate). This version also limits the number of measurements and bodies that can be created to one meter and five bodies per document.

The Demonstration Guide & Tutorial

This guide will provide you with information you will need to evaluate Working Model. It contains a 10 Minute Demo, two tutorials, and reference information on Working Model's tool palette and function language.

System Requirements

Working Model versions are available for both Macintosh and Windows personal computers. The following system configurations are needed to run Working Model:

Windows: A 486 microprocessor or better is required, Windows version 3.1 or greater, minimum of 8 megabytes of RAM and 8 megabytes of available hard disk space. More than 8MB of memory is strongly recommended for optimum performance. We also recommend a floating-point math co-processor.

Macintosh: A 68020-based computer or higher (Mac II or above) is required. Macintosh Plus, SE, Portable, Classic and Powerbook 100 are not supported. Working Model requires System 7 or later, approximately 8 megabytes of RAM and 8 megabytes of available hard drive space. A floating-point math co-processor is highly recommended. Working Model is compatible with PowerPC-based Macintosh computers.

Installation

The demonstration disk contains an automatic installer. To install:

On Macintosh: simply double-click on the icon named **Double-Click Me to Install**.

On Windows: run **SETUP** from within Windows.

Ordering Information

We hope you enjoy the demonstration version. To order your full copy of Working Model:

- call TOLL-FREE at **(800) 766-6615** or **(415) 574-7777** (8:00AM to 5:00PM Pacific Time),

- E-mail to us (internet) via info@krev.com, or

- print out the order form in the README file included on the demonstration disks and fax or mail it to Knowledge Revolution at:
  FAX: (415) 574-7541
  MAIL: Knowledge Revolution
  66 Bovet Road, Suite 200
  San Mateo, CA 94402

Working Model comes with a 30-day money-back guarantee!

2. The Ten Minute Demo

Working Model's graphical users interface allows users to model and analyze systems very rapidly. This 10 minute demo walks you through two simple examples - a ball bouncing down a ramp, and a 4-bar linkage.

A Ball Bouncing Down a Ramp

Creating simulations in Working Model is similar to drawing in any popular CAD package. Using the tools found in the toolbar, you first sketch bodies, then connect them together using Working Model's many different constraints.

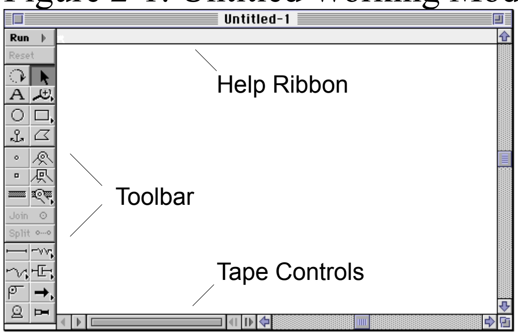
When all bodies and constraints are defined, the simulation is run. No pre-processing or post-processing is needed. You immediately see results.

Step 1 - Open Working Model

1. Double-click the Working Model icon to start the program.

Working Model starts up and opens a new, untitled window. Your screen will look like Figure 2-1.

Figure 2-1: Untitled Working Model Window



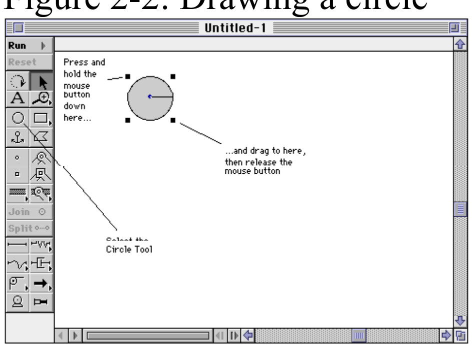
You will see the toolbar on the left and the tape controls along the bottom of the window. The toolbar contains tools you will use to create simulations. The tape controls give you more control for running and viewing simulations. You can use the tape controls to step through simulations, play simulations backwards, or move to a specific time in a simulation.

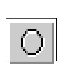
Step 2 - Draw a circle

The toolbar provides a variety of tools for setting up simulations. To choose a tool, click on the corresponding icon on the toolbar. The Help Ribbon located at the top of the window helps you identify the tools as you move the mouse pointer over the tool icons.

To draw a circle (see Figure 2-2):

Figure 2-2: Drawing a circle



1. Click the Circle tool. 

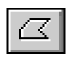
2. Position the pointer at any starting point in the blank area of the screen.

The pointer changes from an arrow to a crosshair. This means you are ready to create an object.

3. Press and hold down the mouse button (left button on a two-button mouse). Drag the mouse to draw a circle. When the circle reaches the size you want, release the mouse button.

A line appears inside the circle. During an animated sequence, this line indicates the circle's rotation.

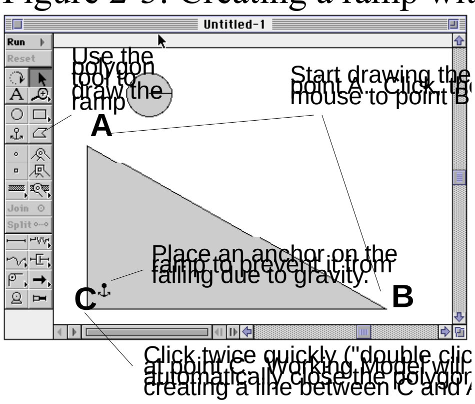
Step 3 - Draw a Ramp

1. Click the polygon tool. 

The pointer changes from an arrow to a crosshair. This means you are ready to create an object.

2. Position the pointer to draw the upper left point (point A) of the polygon as shown in Figure 2-3.

Figure 2-3: Creating a ramp with the polygon tool



3. Click the mouse button (left button on a two-button mouse) and release. Move the mouse to the lower right point (point B) of the polygon.

Refer to Figure 2-3. A line is drawn as the polygon is being created.

4. Click the mouse button again and release. Move the mouse to the bottom left point (point C) of the polygon.

Refer to Figure 2-3. A second line is drawn as the polygon is being created.

5. Double click (click twice quickly) on the mouse button.

The polygon is automatically closed by Working Model, creating a ramp.

6. Click the anchor tool. 

7. Position the anchor over the ramp with the mouse and click.

The anchor pins the ramp to the background, preventing gravity from dragging it downward.

Step 4 - Run The Simulation

You are now ready to run your simulation. To run the simulation:

1. Click Run in the toolbar. 

Watch your first simulation run. Because normal earth gravity is on by default in a new document, the circle drops and bounces down the ramp, with Working Model automatically handling all contacts and collisions. Note that Working Model also handles friction -- the ball spins as it rolls down the ramp.

2. Click once in an empty area of the workspace to stop the simulation.

Step 5 - Display a velocity meter

Working Model allows you to measure many physical properties such as velocity, acceleration, and energy by using meters and vectors. Meters and vectors provide visual representations of quantities you want to measure.

To display a digital meter that measures the velocity of the projectile, follow these steps:

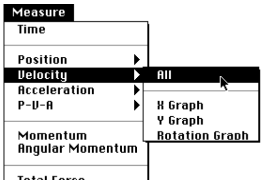
1. Click Reset in the toolbar. 

2. Select the circle drawn earlier by clicking on it.

3. Choose Velocity from the Measure menu at the top of the screen, and choose All from the Velocity sub menu (see Figure 2-4).

A digital velocity meter appears (Figure 2-5).

Figure 2-5: Choosing All from the Velocity submenu in the Measure menu



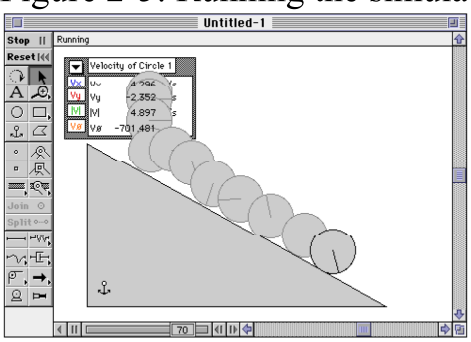
4. Click Run in the toolbar. 

See Figure 2-5. Tracking has also been turned on (by selecting Tracking, Every 8 Frames, under the World menu). Notice that Working Model handles contacts, collisions and frictions automatically.

5. Change simulation parameters.

Double click on the ball to open its properties window and change its mass, elasticity, and friction coefficient. Re-run the simulation. Similarly, change the properties of the ramp. Add other objects above the ramp and simulate multi-body collisions.

Figure 2-5: Running the simulation with tracking and a meter



Modeling a Four Bar Linkage

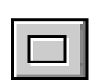
Creating mechanisms with Working Model is a snap. In this example, you will create a four-bar linkage using the Smart Editor.

Step 1 - Create the bars

To construct a linkage consisting of three bars:

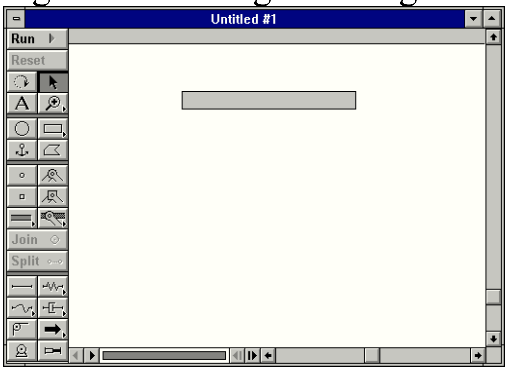
1. Close all open documents prior to starting this demo.

2. Create a new Working Model document by selecting New from the File menu.

3. Double click the rectangle tool on the toolbar. 

The tool will turn black, indicating that it can be used multiple times. Sketch a rectangle similar to the one in Figure 2-6.

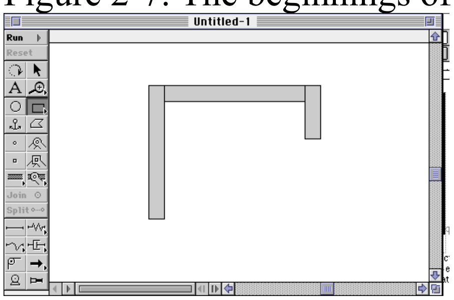
Figure 2-6: A single rectangle



4. Sketch two vertical rectangles below the horizontal rectangle.

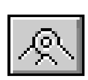
Your screen should resemble Figure 2-7. Note that the two vertical bars are placed on top of the horizontal bar.

Figure 2-7: The beginnings of a four-bar linkage



Step 2 - Pin the bars together with pin joints

You will now create pin joints. A pin joint acts as a hinge between two mass objects. The Smart Editor will prevent joints from breaking during a drag operation.

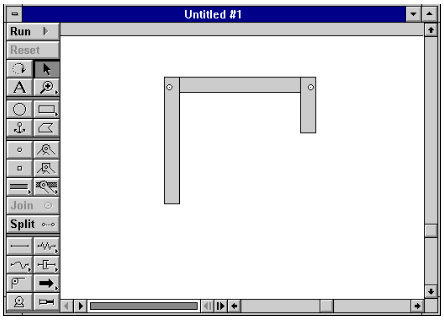
1. Double click on the Pin Joint tool. 

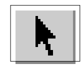
The tool will turn black, indicating that it can be used multiple times.

2. Sketch two pin joints by clicking once with the mouse for each joint.

Your screen should resemble Figure 2-8. Pin joints automatically connect the top two mass objects. If only one mass object lies beneath a pin joint, the pin joint joins the mass object to the background.

Figure 2-8: The beginnings of a four-bar linkage



3. Select the arrow tool by clicking on the toolbar. 

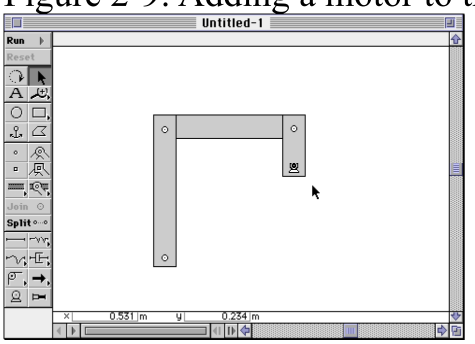
4. Drag the horizontal bar.

All three rectangles will follow the motion of the mouse, because the pin joints connect them. The Smart Editor does not allow joints to separate.

5. Add another pin joint at point B as indicated in Figure 29.

This pin joint will join the rectangle to the background.

Figure 2-9: Adding a motor to the linkage.



Step 3 - Adding a Motor to Drive the 4-Bar Linkage

1. Click the motor tool on the toolbox. 

The motor tool will become shaded, indicating that it has been selected. The cursor should now look like a small motor.

2. Place the cursor over the bottom of rectangle D (see Figure 2-9). Click the mouse.

A motor will appear on the 4-bar linkage as shown in Figure 2-9. Similar to a pin joint, a motor has two attachment points. A motor will automatically connect the top two mass objects. If only one mass object lies beneath the motor, it will join the *mass object to the background. A motor will then apply a torque between the two mass objects it is pinned to.*

3. Click Run on the toolbar. 

The 4-bar linkage will begin slowly cranking through its range of motion.

4. Click Reset in the toolbar. 

The simulation will stop and reset to frame 0.

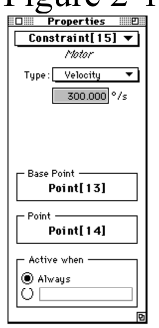
5. Double-click on the motor to open the properties box.

You can also select the motor and choose Properties from the Window menu to open the properties box.

6. Increase the velocity of the motor to 300 degrees/second by typing this value in the properties box as shown in Figure 2-10.

Users can define a motor to apply a certain torque, to move to a given rotational position, or to turn at a given velocity or acceleration. Rotation, velocity, and acceleration motors have built-in control systems that automatically calculate the torque needed. In this demo, we will stick with the velocity motor.

Figure 2-10: Properties window for a motor



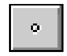
7. Click Run on the toolbar. 

The 4-bar linkage will once again begin cranking, this time at a much higher velocity.

Step 4 - Measuring a Point's Position

1. Click Reset in the toolbar. 

The simulation will stop and reset to frame 0.

2. Select the point tool from the toolbar. 

The point tool is located immediately to the left of the pin joint tool used earlier.

3. Place the cursor over the horizontal bar of the 4-bar linkage and press the mouse button.

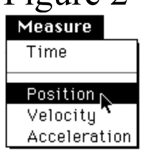
A point is attached to the bar. This is a single point, and does not attach the bar to the background.

If the point is not already selected (darkened), select it by clicking on it.

5. Create a meter to measure the position of this point by choosing Position from under the Measure menu (see Figure 2-11).

A new meter will appear. Position meters default to display digital (numerical) information. You can change a digital meter to a graph by clicking once on the triangle in the meter's upper left hand corner on Windows machines, or select the graph display from a pull down menu that appears when you click on the upper left hand corner of the meter in the Macintosh version.

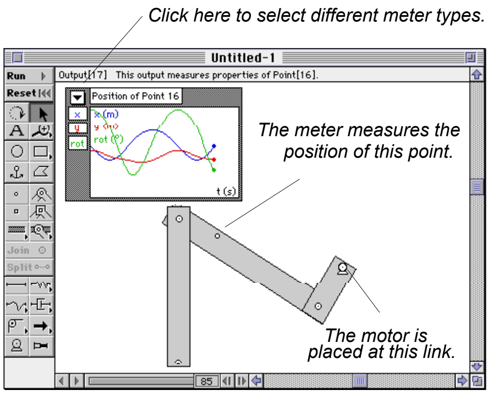
Figure 2-11: Creating a meter to measure a pin's position



6. Click Run on the toolbar. 

Your simulation will immediately begin running and measurement information will appear in the meter as shown in Figure 2-12. Meter data can be exported to an ascii file or copied onto the clipboard and pasted into a spreadsheet program for further analysis. In this case the spreadsheet would receive four columns of information: Time, X, Y, and Rotation. One row would appear for each integration time step calculated.

Figure 2-12: Running the simulation with a motor and a meter


Click here to select different meter types.
Untitled-1
Run
Reset
Join
Split
Output[17] This output measures properties of Point[16].
Position of Point 16
x (m)
rot
t (s)
The meter measures the position of this point.
The motor is placed at this link.
85

7. Modify your simulation and re-run.

Working Model's seamless integration between the editing of a model and the running of the dynamics engine allows you to quickly investigate many different simulation configurations. As an example, modify the mass of the horizontal beam using the properties box, and re-run the simulation. You can also modify pin joint locations, measure velocities and forces, or even investigate how this 4-bar linkage would run in zero gravity by turning gravity off under the World menu!

Applying What You Have Learned

You have now finished the 10 minute demo. This demo has shown you how to create and run simple simulations in Working Model. We encourage you to experiment with the simulations you have already created, or create your own mechanism from scratch. As you will find, Working Model has an incredible array of features that will allow you to model and analyze most complex mechanical devices.

Tutorials to help you explore the features in Working Model are available on disk. For a copy of the tutorials or more information on the toolbar or Working Model's built in function language, please call Knowledge Revolution at (800) 766-6615.

The Next Step

The demonstration version of the software permits you to create your own simulations of mechanisms with up to five bodies. We encourage you to model several of your own mechanical systems to understand how Working Model can help you design more accurately and efficiently. If you have any questions during this process, a sales representative will be happy to assist you.

We hope you have enjoyed this demonstration copy. Please pass it on to a colleague or a friend when you are finished. When you are ready to place your order, please call us at (800) 766-6615 or fax us at (415) 574-7541. We look forward to hearing from you.