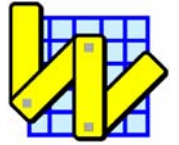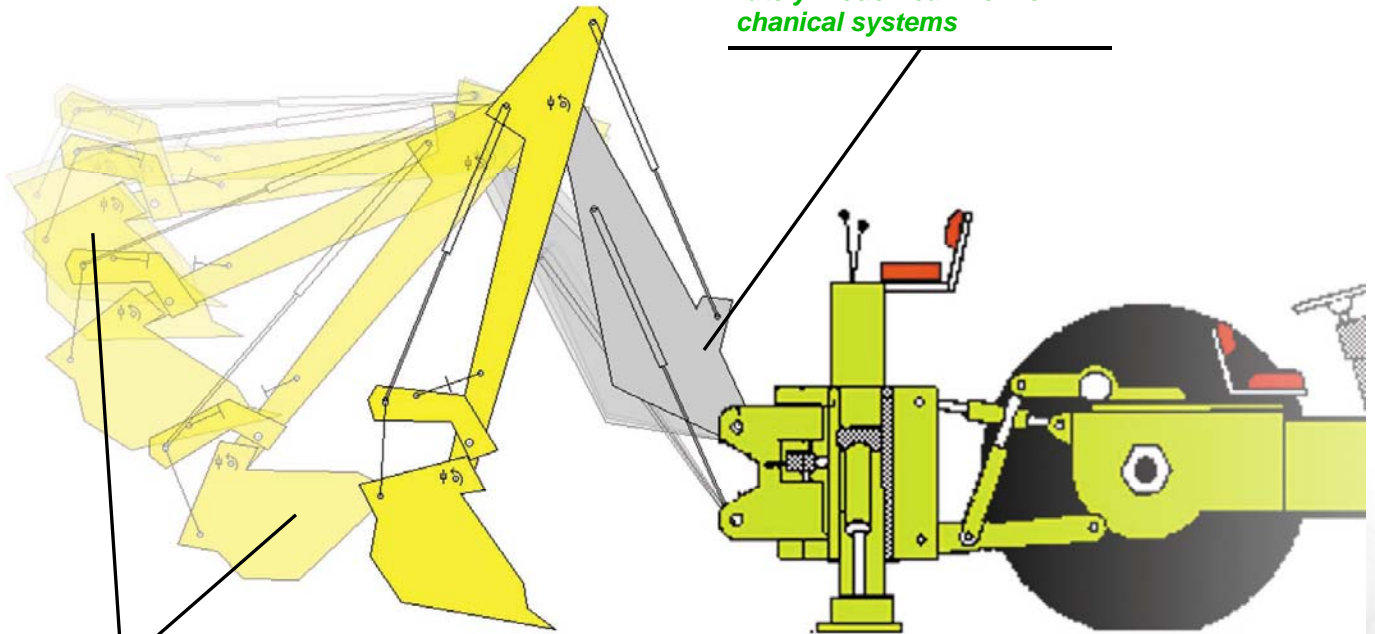# Working Model 2D

The world's most popular 2D computer aided engineering tool

Use automatic collision detection and friction to accurately model real-life mechanical systems
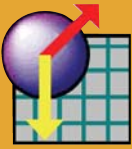
Track the motion of an object under specific simulation parameters

- Powerful physics-based 2D kinematic and dynamic motion simulation and analysis

- Provides accurate solutions to complex engineering motion simulation problems

- Save time and money by avoiding expensive prototyping and product failures
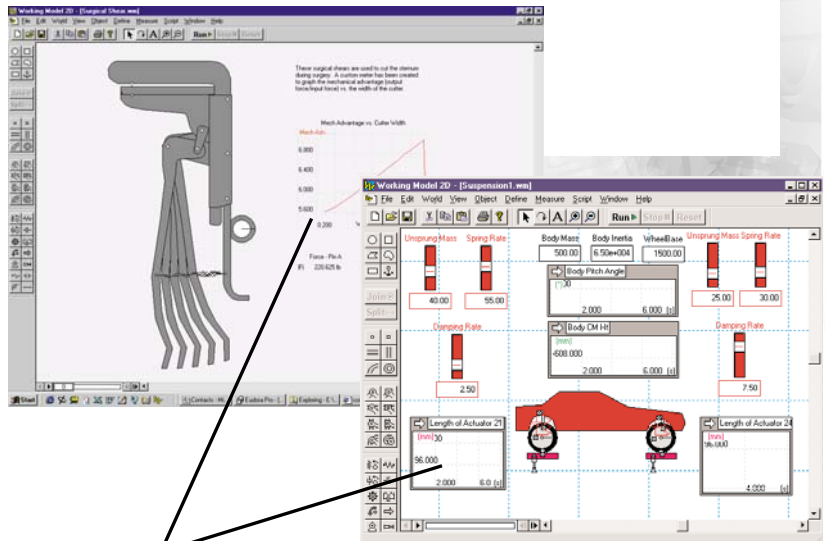
Record and display simulation data in realtime

SUPPORTED 2D FORMATS

- DXF file format

BODY PROPERTIES & FEATURES

- Body types: circle, box, polygon and smooth (b-Spline edges)
- Mass, density, geometry, center of mass, moment of inertia, velocity and angular velocity, electrostatic charge and more
- Track the motion path of a body
- Automatic collision detection and response
- Automatically applied static and kinetic friction

CONSTRAINTS

- Pin, rigid, slot, keyed slot and curved slot joints
- Rods, ropes, pulleys and gears
- Linear and rotational spring/ damper

MOTION DRIVERS

- Motor
- Acturator
- Force
- Torque

Constraints and drivers can be defined by numeric or equation input in the formula editor, or with tabular data.

UNITS SYSTEMS & FORMULAS

- SI, English, CGS and user-defined

MEASURABLE PARAMETERS

- Position
- Velocity
- Acceleration
- Momentum
- Angular momentum
- Constraint force and torque
- Gravity, electrostatic and air force
- Kinetic energy, gravitational potential energy and power

Record and display simulation data in real-time with graphical and digital meters.

SIMULATION CONTROL

- Run, stop, reset, single step, or pause the simulation at any time.
- Control the accuracy of your simulation by modifying integration and animation steps and configuration tolerances.
- Superimpose multiple simulations.

INTERACTIVE CONTROLS

- Connection to Excel and MatLab
- Complete "Visual Basic" style scripting language with built-in debugger
- Menu and script buttons
- "Player" mode for content creation

VISUALIZATION

- Track the motion path of a body or its center of mass
- Attach graphics to bodies
- Images on bodies rotate
- Display system center of mass
- Multiple, moving reference frames
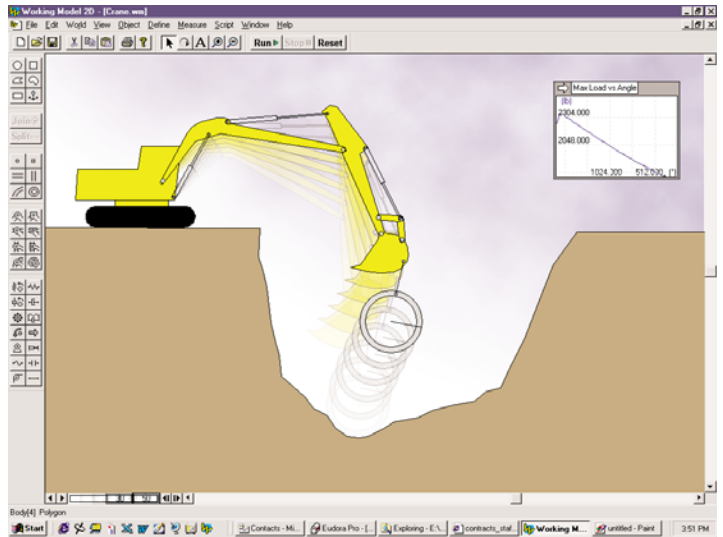
SCRIPTS

- Optimize
- Create constraint
- Document model
- Zoom to extents
- Measure distance between points
- Flip polygon
- Multiple file run
- Pin friction
- Slot friction
- Slot damper
- Flexbeam
- Shear and bending moment

OUTPUT

- AVI video files for playback
- Meter data from simulations to tabular data file

PRINTING

- Print an image of your simulation or meter data

WORKING MODEL 2D SYSTEM REQUIREMENTS

Window System

- Microsoft Windows 95/98/ ME/2000/XP/Vista/ Windows 7
- 1 GB RAM Minimum
- 60 MB disc space
- CD-ROM drive

Design Simulation
Technologies

Welcome to Working Model

Working Model is the result of a 15-year collaborative effort between professional engineers and software specialists. We are committed to providing you **easy-to-use**, engineering software that makes you more productive, and saves time and money on hardware prototyping, testing, and virtual product development.

To begin, install Working Model and go through each step of the demonstration described below.
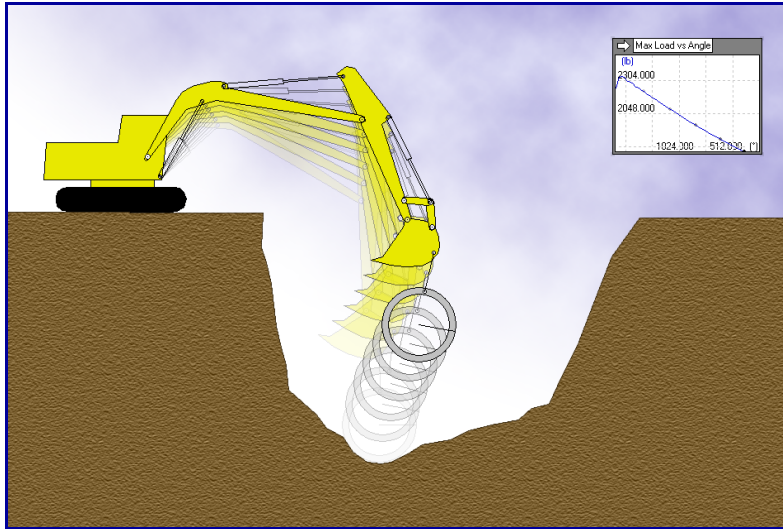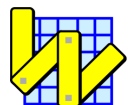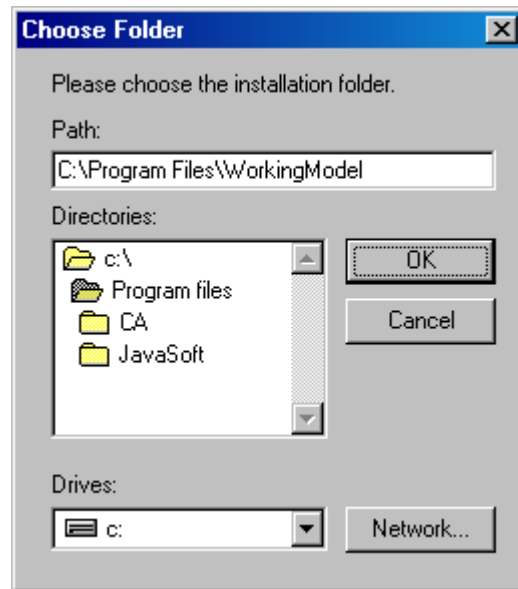

Installing Working Model

1. Insert the Working Model CD into the CD-Rom drive and follow the installation instructions
2. When prompted for a serial number, enter "**DEMO**" or enter your licensed serial number
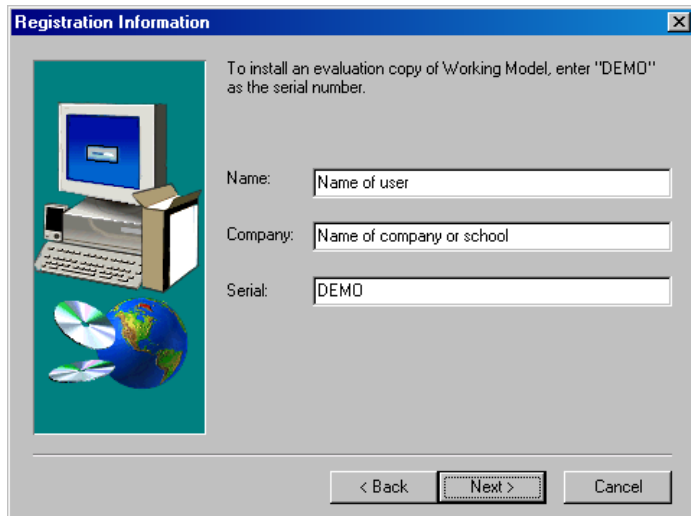
3. When the "Choose Folder" window appears, click [OK].
4. For a step-by-step introductory tutorial, turn to the next page.

Starting Working Model

1. Ensure that Working Model is installed on your computer.

2. From the Windows ⊞Start Menu, click on Programs, then Working Model, and then Working Model. This opens a simulation.

1 Creating a Falling Block

1. The first simulation is Newton's first experiment, dropping a block.
2. To draw a rectangle, click on the Rectangle tool, then click in the workspace and draw a long thin rectangular block.

3. To run the simulation and see the block fall due to gravity, click Run▶.

4. Click Reset to reset the simulation.
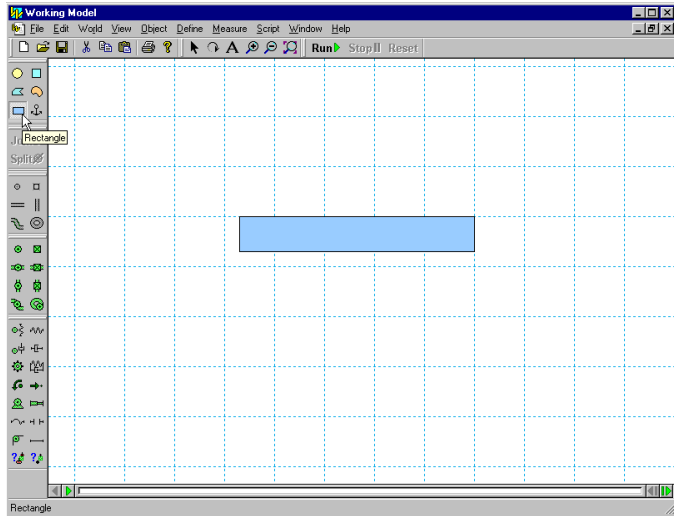
2 Adding a Velocity Vector

1. To add a velocity vector, click on the rectangle.
2. From the Define menu, click on Vectors and then Velocity.

3. Click Run▶ and observe that the vector changes magnitude as the block falls.

4. Click Reset.

Optional: To show the velocity vector's x and/or y component, click on the Define menu, select Vector Display, and check the X and/or Y box.

3 Making a Pendulum

1. To make a pendulum, click on the Pin joint tool and then click on the upper left-hand corner of the rectangle.

2. Click Run▶ and observe that the vector changes magnitude and direction as the pendulum moves. Click Reset.
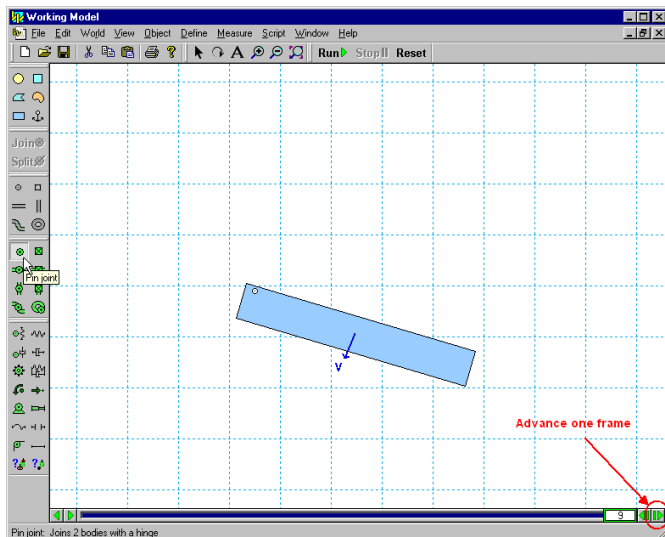
Optional: Each click on ▶▶ at the bottom of the screen advances one frame.

4 Graphing the Pendulum's Motion

1. To graph the pendulum's motion, click on the rectangle. Under the Measure menu, select Position, then select Rotation Graph.

2. To collect data, click Run▶. Note: Data can be displayed as a graph, bar chart, or number, and can be changed while running the simulation by clicking the ▷ on the top left-hand corner of the graph. Click Reset.

3. The graph shows the pendulum's amplitude and frequency. To make the graph larger, click on the graph and drag its lower right-hand corner to the right.
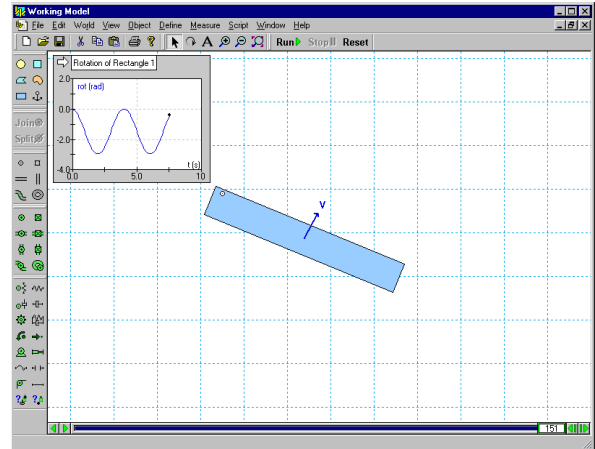

5 Changing Gravity

1. To change gravity, click on the World menu, select Gravity, type the value 20 m/sec^2 in the input box, and click [OK].

2. Click Run▶ and observe that, in agreement with theoretical and experimental predictions, the pendulum has a higher natural frequency. Click Reset.

*Note: Working Model was designed to be **easy-to-use**. For example, in this exercise, the only time you need to touch the keyboard is to enter the value 20.*
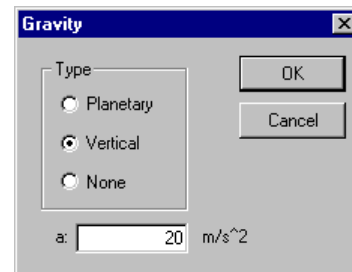

6 Adding Air Resistance

1. Under the World menu, select Air Resistance, click on Low Speed, and accept the default air resistance value of 0.3 kg/(m*s) by clicking [OK].

2. Click Run▶ and observe the exponentially decaying oscillations. Click Reset.
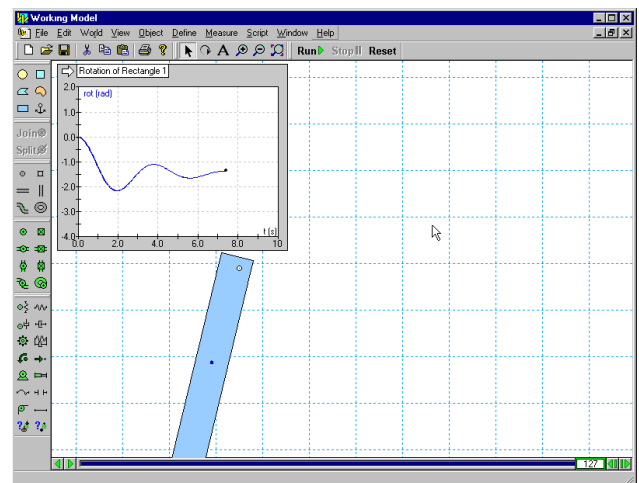
7 Adding a Spring

1. To add a spring, click on the Spring tool. Click on the upper right-hand corner of the block and stretch the spring up and to the right.

2. Click **Run ▶** and observe the pendulum's higher natural frequency and new equilibrium position. Click **Reset**.
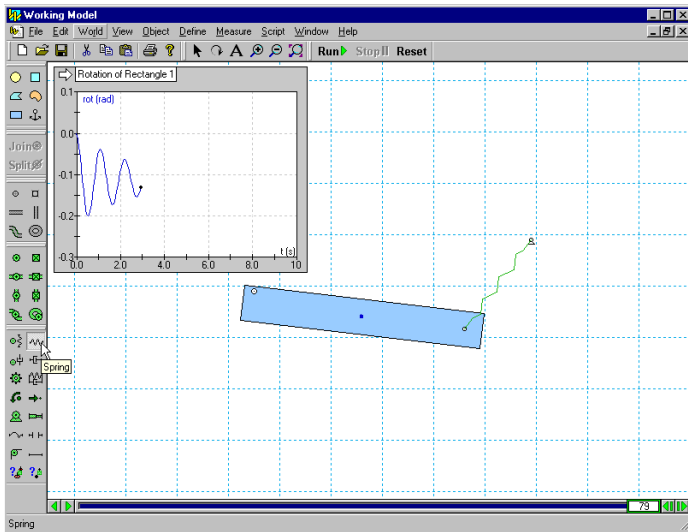
8 Controlling the Spring Constant

1. To control the spring constant, click on the spring. Under the Define menu, select New Control, then select Spring Constant.

2. The slider that controls the spring will appear in the left-hand side of the workspace. To move the slider's location closer to the spring, click on its **title** and drag it next to the spring.

3. To see the effect of varying the spring constant, click **Run ▶** and observe that the pendulum angle is a function of the spring-constant (move the slider up and down while the simulation is running). Click **Reset**.
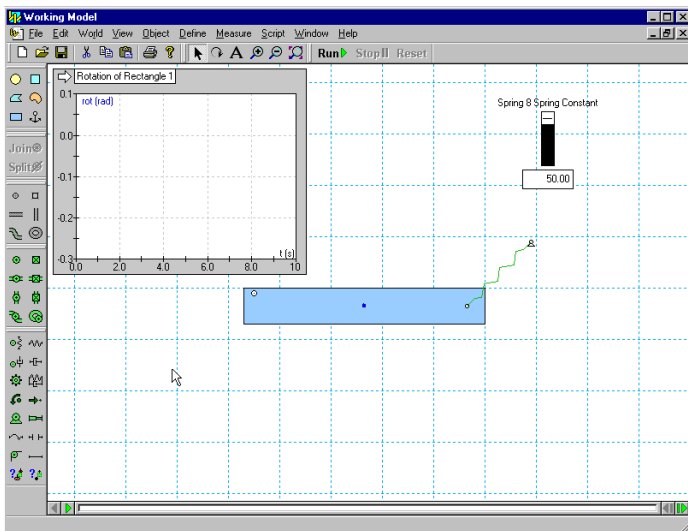

Optional: The properties of any object can be modified by double-clicking on any object (e.g., the rectangle, pin point, graph, spring, spring-constant control).
The appearance or geometry of an object can be modified by clicking on the object, selecting the Window menu and selecting Appearance or Geometry.

9 Collisions with a Smooth Polygon

1. To create a smooth polygon, click on the Curved Polygon tool, click in the workspace in a few locations. Double-click to close the polygon.

(If your rectangle is high on the screen, click 🔍 to zoom to extents.)

2. Click **Run ▶** to start the simulation and observe that the curved polygon bounces and rolls on top of the rectangle. Automatic collision and contact is a very useful feature in Working Model (even the elastic and frictional properties of objects may be varied). Click **Reset**.

Note: Collision sound/motion sound can be added to a simulation. To add a collision sound, click on the curved polygon, select the Measure menu, and choose Hear the Collision. (Windows only; computer speakers required)
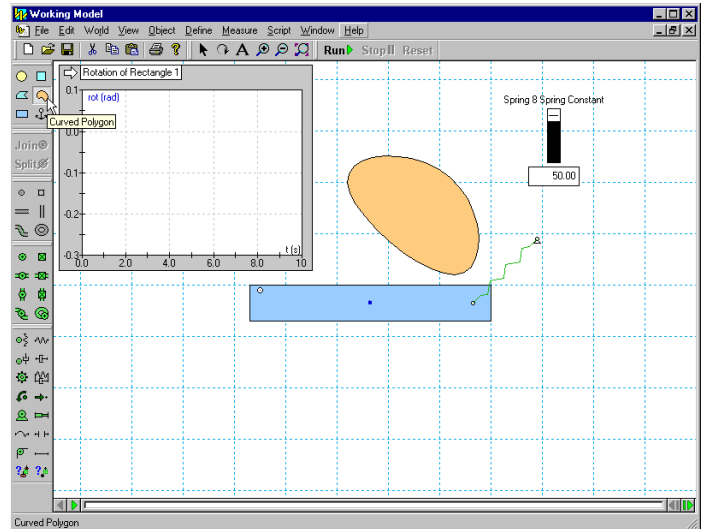

10 Smart Editor

1. Working Model's Smart Editor allows the user to change an object's position and orientation while keeping constraints intact.

2. To change the orientation of the rectangle, click on the rectangle and drag the mouse to rotate the rectangle counterclockwise so that it is nearly vertical as shown below. (If necessary, click 🔍 to view to extents.)

11 Creating a Cam-Follower Mechanism

1. To add a motor to the curved polygon, click on the Motor tool, and then click on the curved polygon.

2. Click **Run ▶** and observe that the rectangle's motion is determined by the shape of the curved polygon and the motor's speed. Click **Reset**.

3
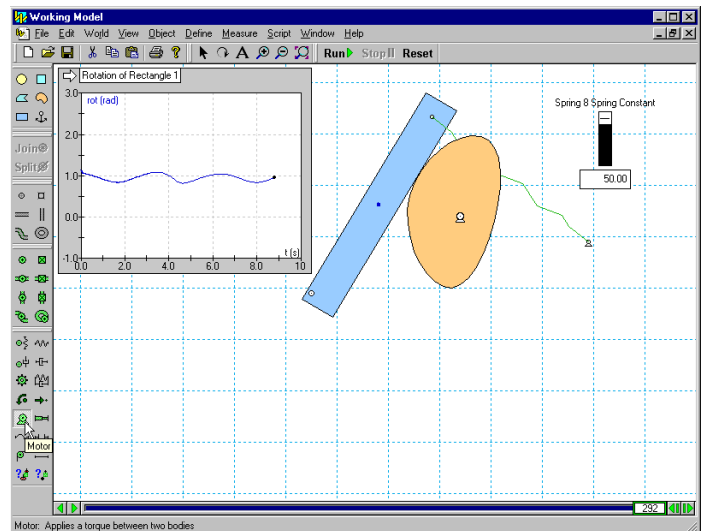
12 Creating a Flexible Beam

1. To convert the rectangle into a flexible beam (Flexbeam), click on the rectangle.
2. Under the Script menu, select Flexbeam.
3. In the "Flexible Body Information" dialog box, accept the default values and click [OK]. Click [OK] in the "No Flexbeam Undo" dialog Box.
4. Click **Run ▶** to start the simulation and observe that the formerly rigid rectangle is now acting as a Flexbeam. Change the values of the "EI" and 'Damping - Bending" sliders to change the Flexbeam's stiffness and damping. Click **Reset**.
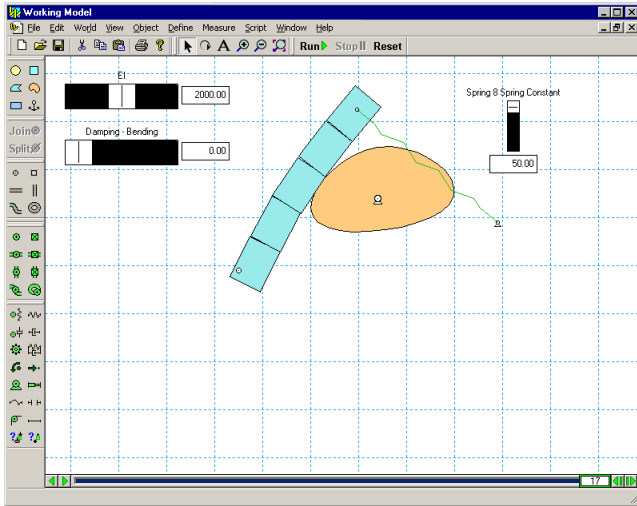

13 Animation Step and Integrator Error

1. To change accuracy, select the World menu and then Accuracy…
2. Select an Integrator Error small enough to meet your accuracy requirements.
3. Select an Animation Step that produces smooth visual results.

14 Importing DXF Files

1. Open a new simulation by selecting the File menu and clicking on New.
2. To import a DXF file, select the File menu and click on Import.
3. In the Import window, navigate to the directory where Working Model is installed, for example, C:\Program Files\WorkingModel and then select the sub-directory WMIntroduction.
4. Select the file WMDXFDemo.dxf and click [Import]. This imports the DXF objects (a crane, wrecking ball, a Working Model logo, and an abandoned building).
5. Click **Run ▶** and watch all the objects fall due to gravity. Click **Reset**.

15 Simulating a Building Demolition

1. To anchor the base of the building, click on the Rigid Joint tool, then click on the base of the building.
2. To anchor the crane, click on the Rigid Joint tool, then click on the crane.
3. To fix the Working Model logo to the crane, click on the Rigid Joint tool, then click on the Working Model logo.
4. To attach the wrecking ball to the crane with a rope, click on the Rope tool, then single-click on the ball, and then single-click on the crane to create a rope.
5. Click **Run ▶** and observe that Working Model detects the shape of the imported DXF objects and automatically calculates how they collide. Click **Reset**.
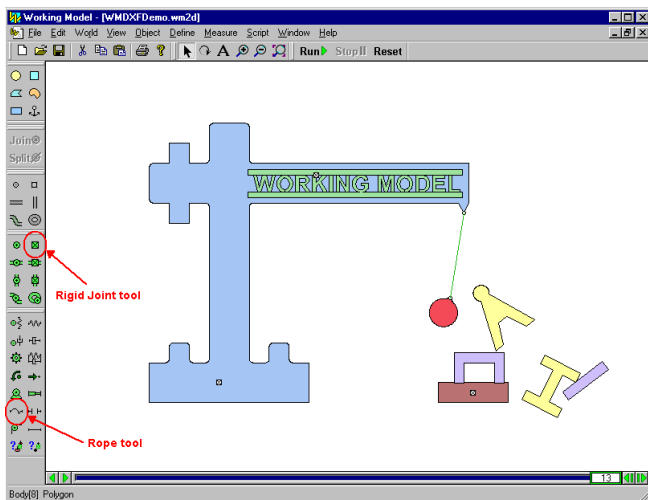

16 Adding Colors to DXF Objects

1. Objects that are imported from a DXF file are treated the same as objects created within Working Model. You can change their appearance, measure their velocity, acceleration, etc.
2. To add color to the crane, click on the crane.
3. Under the Window menu, click on Appearance.
4. In the Appearance window, note that the fill pattern is currently set as "no." Click on the drop-down menu and change it to another pattern.
5. Click on the fill color drop-down menu and change the fill color to blue.
6. Close the Appearance window.
7. To change the color of the other objects, repeat steps 2 to 6.
8. Click **Run ▶** to start the simulation. Click **Reset**.

## 17 Running Demo Files

1. Under the Script menu, click on "Run All Demo Files".
2. Sit back and enjoy a series of demos on a variety of engineering topics.
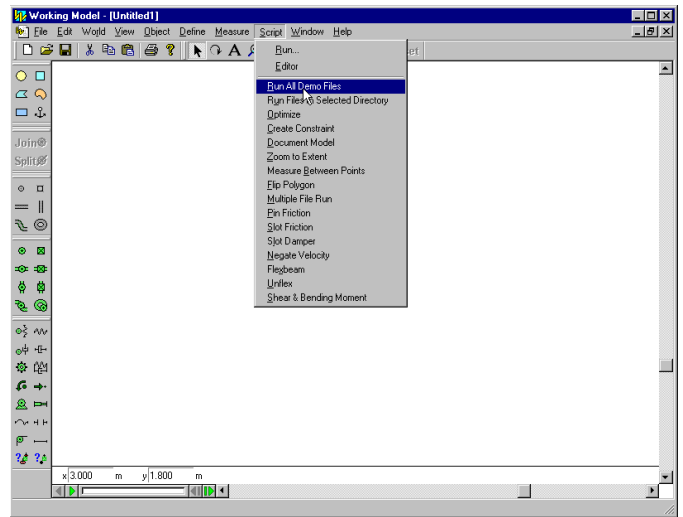
18 Creating a Movie

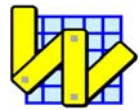1. You can create a movie from any Working Model simulation.
2. To see an example, select **Start** menu, then Programs, then WorkingModel, then WMIntroduction, and then double-click on WorkingModelMoneyBowl.avi.

4
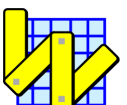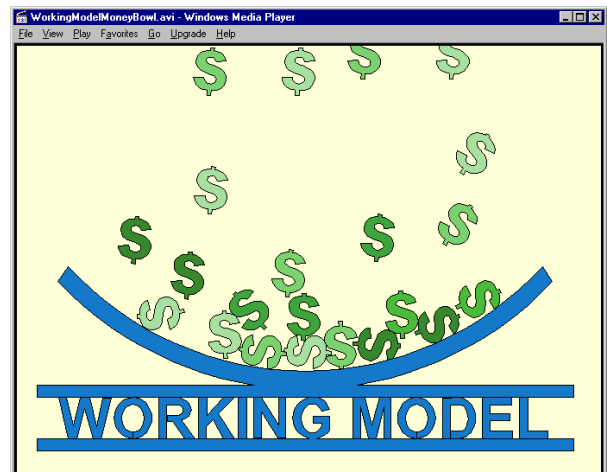
Working Model 2D Professional

The Americas Price List – February 1, 2009

http://www.workingmodel.com

Working Model® 2D (Windows Only)				
Description	Node Lock Dongle US$	Network US$	# of CDs[A]	# of Manuals[A]
Single User	2,995	4,995	1	1
2-User	5,495	6,995	1	2
3-User	7,495	8,495	1	2
4-User	9,495	9,995	1	2
5-User	11,495	11,495	1	2
10-User	18,495	18,495	1	3
20-User	33,495	33,495	1	4
30-User	48,495	48,495	1	5
Custom User	Call	Call	Call	Call
Training	Call	Call	Call	**Call**
[A] - A limited number of free additional CDs and/or manuals are available with original purchase				
Maintenance renewals are 20% of the Retail Price and are provided by Design Simulation Technologies or a certified reseller. The first year of technical support and maintenance is included with initial purchase.				

1	Orders to US and Canada: American Express, Visa, MasterCard, Discover, checks, purchase orders accepted.
2	International orders: American Express, Visa, MasterCard and bank wire transfers accepted. For orders less than $1,000 shipping charges will be added to the order or a UPS, DHL, or Fedex account must be provided.
3	Sales tax is extra
4	When possible, orders are shipped within 48 hours.
5	<u>All sales are final.</u> **If you are tentative about a purchase, ask for a demonstration copy.**
6	A copy of the customer's purchase order and/or purchasing information must accompany all orders.
7	Technical support is provided by Design Simulation Technologies or a certified reseller for the first year of ownership and is extended yearly upon maintenance renewal.
8	Prices and terms are subject to change without notice.