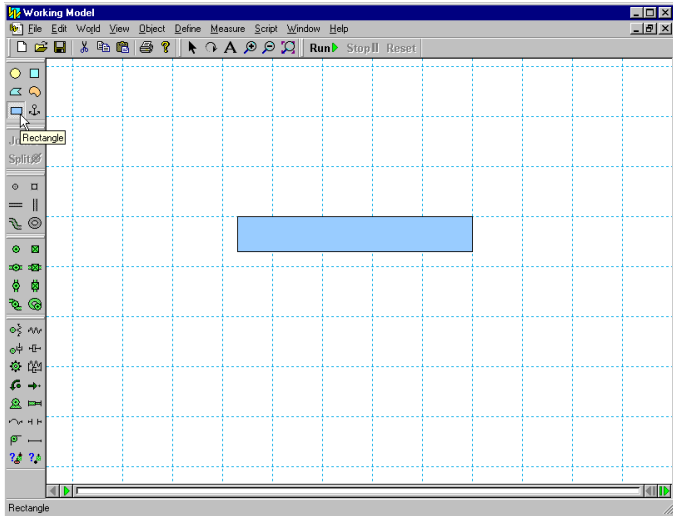


## Starting Working Model

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.



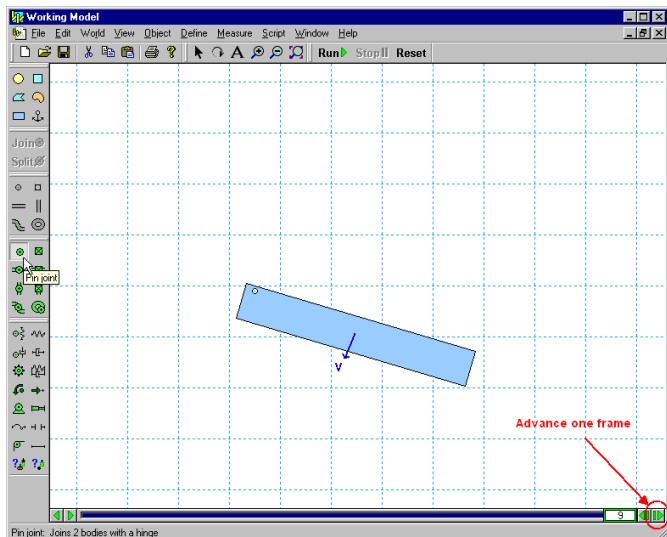
## 2 Adding a Velocity Vector

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

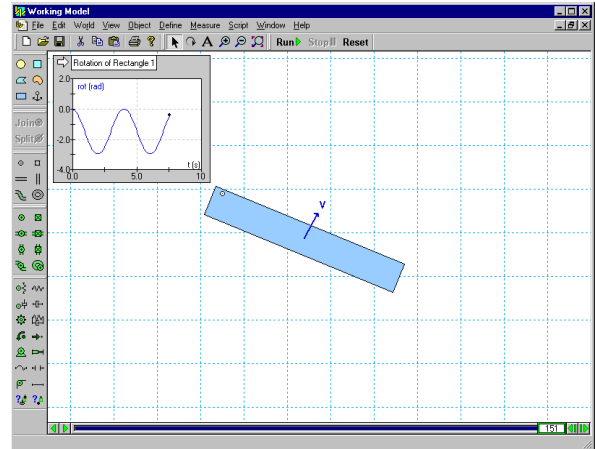
1. To make a pendulum, click on the Pin joint tool and then click on the upper left-hand corner of the rectangle.
2. Click **Run** and observe that the vector changes magnitude and direction as the pendulum moves. Click **Reset**.



Optional: Each click on **Advance one frame** at the bottom of the screen advances one frame.

## 4 Graphing the Pendulum's Motion

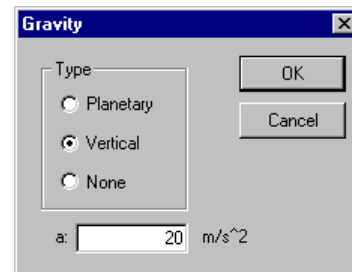
1. To graph the pendulum's motion, click on the rectangle. Under the Measure menu, select Position, then select Rotation Graph.
2. To collect data, click **Run**. Note: Data can be displayed as a graph, bar chart, or number, and can be changed while running the simulation by clicking the **Reset** on 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

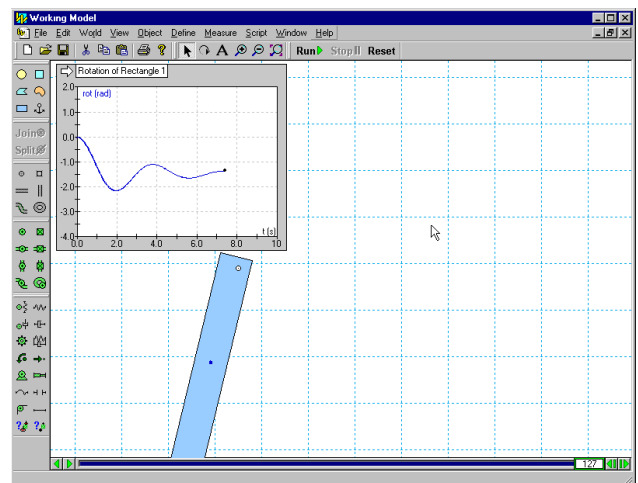
1. To change gravity, click on the World menu, select Gravity, type the value 20 m/sec<sup>2</sup> in the input box, and click [OK].
2. Click **Run** and observe that, in agreement with theoretical and experimental predictions, the pendulum has a higher natural frequency. Click **Reset**.

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.



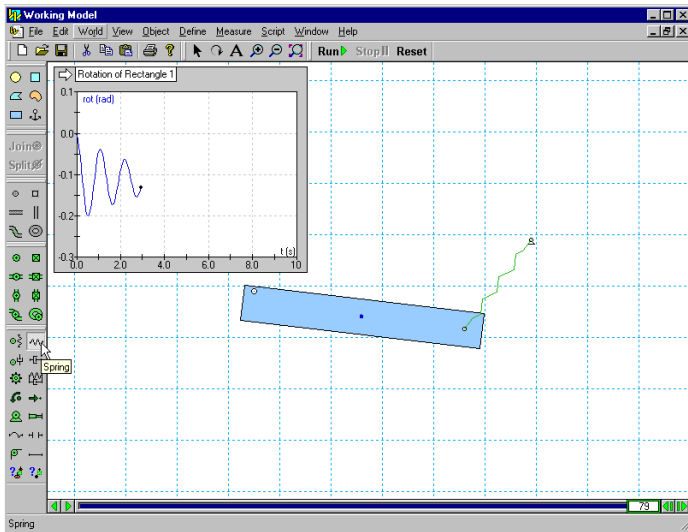
## 6 Adding Air Resistance

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**.



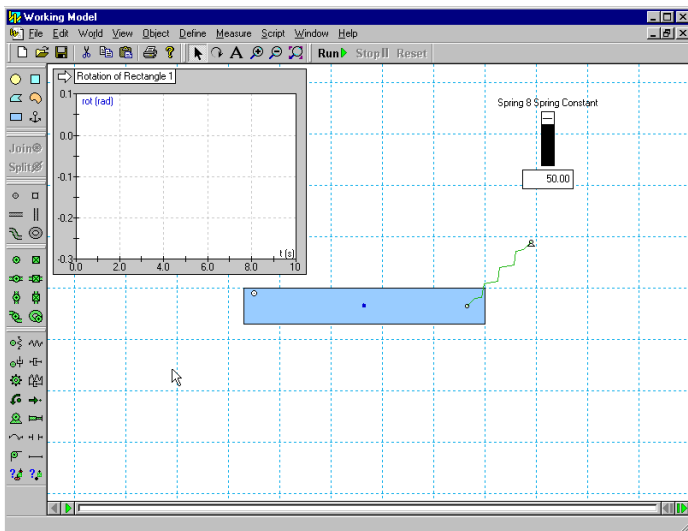
## 7 Adding a Spring

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**.

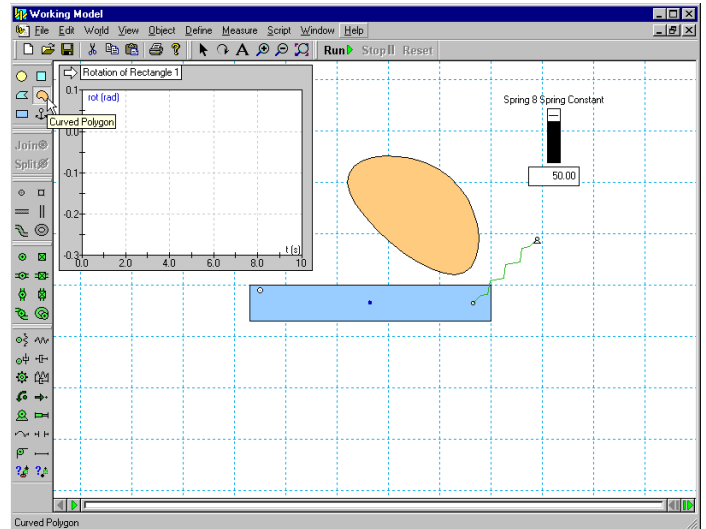


Optional: The properties of any object can be modified by double-clicking on any object (e.g., the rectangle, pin point, graph, spring, spring-constant control). The appearance or geometry of an object can be modified by clicking on the object, selecting the Window menu and selecting Appearance or Geometry.

## 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)*

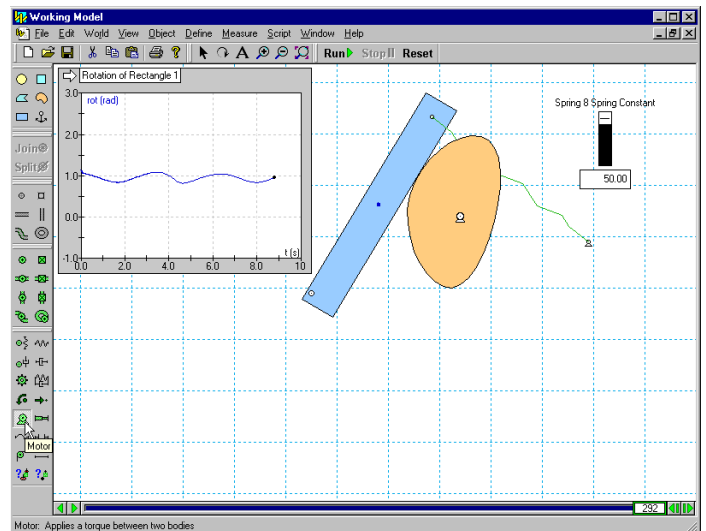


## 10 Smart Editor

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

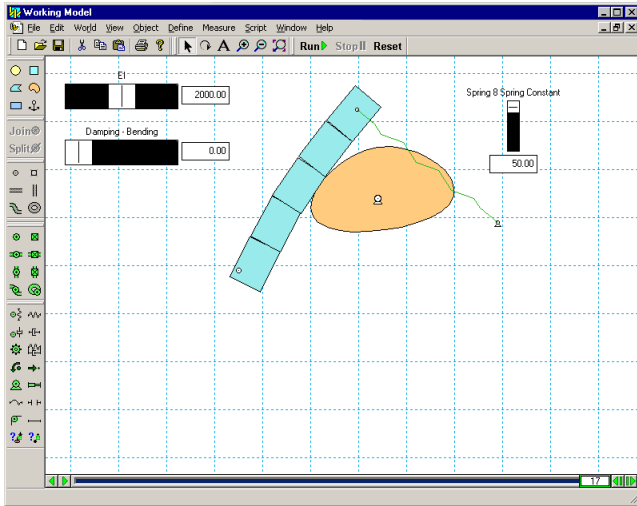
1. To add a motor to the curved polygon, click on the Motor tool, and then click on the curved polygon.
2. Click **Run ▶** and observe that the rectangle's motion is determined by the shape of the curved polygon and the motor's speed. Click **Reset**.



Motor: Applies a torque between two bodies

## 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

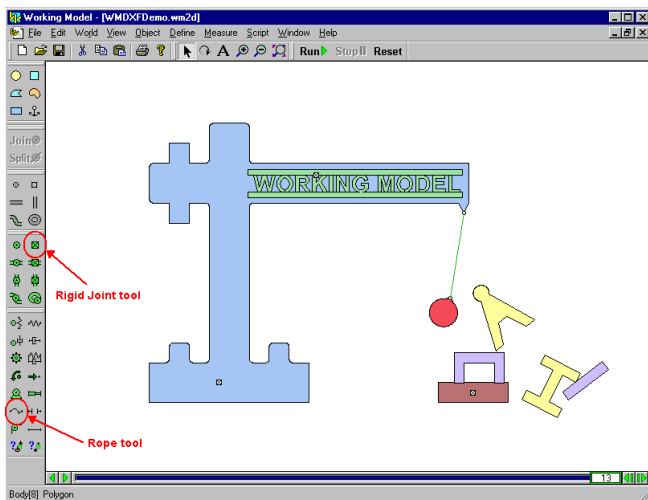
1. To change accuracy, select the World menu and then Accuracy...
2. Select an Integrator Error small enough to meet your accuracy requirements.
3. Select an Animation Step that produces smooth visual results.

## 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**.

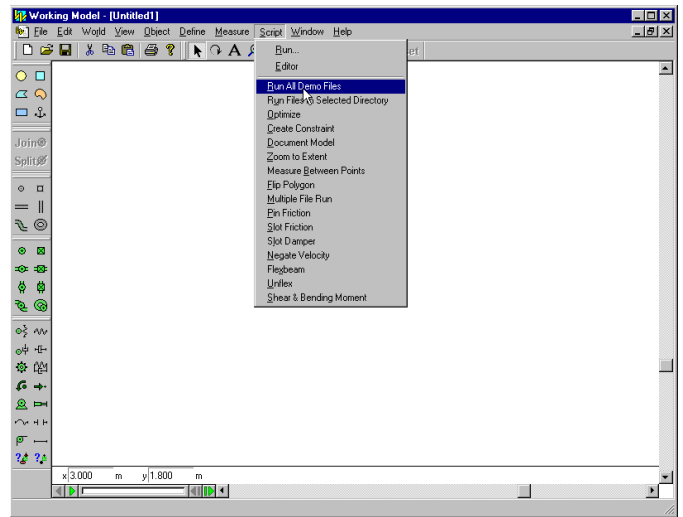


## 16 Adding Colors to DXF Objects

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.

