Gravity Help Index

Introduction

Welcome to Gravity 1.0!

Have you ever wondered if planets can have stable orbits around a binary sun? Have you ever wondered what it would be like if a Jupiter-sized planet were to pass through our solar system? Perhaps you feel that life on Earth would be more fun if only our planet's orbit were not so boring. Gravity is designed to let you explore all these possibilities; it is designed to give you an intuitive feel for how a system will behave. By simply placing planets and dragging vectors you will be able to create entire solar systems and watch them behave under the influence of gravity.

To start, open the file **solsys.grv**. This scenario shows the sun (in the center of the screen) and the first five planets of the Solar System (Mercury, Venus, Earth, Mars and Jupiter). The line sticking out of each of the worlds is its velocity vector, an indicator of the current speed and direction of the planet. Select Start from the Simulation menu and the worlds will start their orbits around the sun. Now stop the simulation (select Stop) and click on a world and drag its velocity vector so that it points in another direction. Now selected Start again.

That's all that you need to know to play with the scenarios that come with the program. If you want to do more sophisticated editing or create your own scenarios, look at the section on Using Gravity. If you'd like an overview of all the menu commands, look at the Commands sections.

Using Gravity

Commands

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About Gravity

I wrote Gravity so that I could get a feeling for the behavior of a planetary system. I knew that gravitational force increased proportionally to mass and inversely to distance squared, but I wanted to know what that meant in terms of actual planetary masses and distances. How close to the Earth would a planet have to pass to noticeably disturb the Earth's orbit? How stable is a planetary orbit around a binary star? I wanted to write a program in which one could set up a configuration of worlds, see the results, edit the configuration, and see the results of the new set up.

I chose an Euler method to calculate the orbits because it is fast and simple. Although it is not very accurate, the Euler method does have two advantages: it is relatively fast and it takes a constant time to calculate. Since the error in the simulation is proportional to the acceleration of a world, I thought that I could increase the time step (making the calculations more accurate) as the acceleration of a world increased. Unfortunately, that idea has the side-effect of slowing down the simulation just when the worlds are moving the fastest. Similarly, I could have used a more accurate Runge-Kutta method, but that involved many more calculations per time step, slowing down the simulation to unacceptable levels. In the end, I compromised accuracy for a more dynamic and intuitive simulation.

I wrote Gravity in Turbo Pascal for Windows using the Object Windows Library included in the package. Although the OWL class library makes programming for Windows remarkably easy, I did find it constraining at times. For example, I had to override the MessageLoop method (something that the manual says one should never do) so that I could get Gravity to run a simulation but still accept messages. Overall, however, I found it much easier to use the Turbo Pascal integrated environment than to use the Microsoft combination of C6 and the Windows SDK.

I hope that you enjoy playing with Gravity and I hope that it helps to give life to the gravity equations that you learned in college. If you have any comments, questions, or suggestions, please write to me at this address:

TMA
15 Whittier Rd.
Natick, MA 01760

Good luck!

-- George Moromisato

Calculations

The motion of the worlds is calculated using a simple Euler iterative method. The acceleration of each world is calculated using the Universal Law of Gravitation and Newton's F=ma equation. The world is then moved in a straight line for the current time step. At the new position, the acceleration is calculated again, and the world is moved in a straight line to the next time step.

For small time step values and small accelerations this is a reasonable approximation. But because the error is cumulative (and large compared to other numerical methods) one should not expect Gravity to produce results comparable to reality. You may increase the accuracy of the simulation by using smaller time step values (see Changing the Time Step), but that will also cause it to run slower.

Although Gravity uses floating-point numbers to do its calculations, it does not use a math coprocessor.

Source Code for Gravity

The source code to Gravity 1.0, written in Turbo Pascal for Window 1.0, is available from TMA for $15. Please fill in the following order form:

Name:
_____
Street:
_____
City, State, Zip:
_____

Disk Size: [ ] 3½ [ ] 5¼

Enclose a check or money order and mail it to:

TMA
15 Whittier Rd.
Natick, MA 01760

Selecting a World

Some menu commands act on the currently selected world. Click the mouse on the world that you want to select. Note that clicking the mouse on an empty place will create a new world. The currently selected world is outlined by a white square.

Creating a World

To create a world, simply click on the spot that you want the world to be placed. The Edit World dialog box will then appear allowing you to choose other parameters such as the mass and velocity.

Gravity is limited to 25 worlds; you will not be able to create more.

Editing a World

You may edit a world by either double-clicking on it or by choosing Edit World from the Simulation menu. The menu choice will edit the currently selected world. The Edit World dialog box allows you to change the mass, position, and velocity of the world.

You may change the velocity vector of a world by simply clicking on it and dragging a new vector.

You may delete the currently selected world by choosing Delete World from the Simulation menu.

Running the Simulation

To start a simulation running, select Start from the Simulation menu. You will see the worlds move around their orbits and you will see the timer in the lower left part of the screen start to count up. To stop the run, select Stop from the Simulation menu.

If you don’t like the results of the run, you may select Reset from the Simulation menu to restore the worlds to their state before you started the simulation. Note that you will not be able to select Reset if you edit any of the worlds after you stop the simulation.

Zooming and Framing

The Zoom In and Zoom Out options on the View menu allow you to increase and decrease the scale used to view the planets. Zooming is always focused on the center of the screen. The scale at the bottom of the screen gives you an idea of your current magnification.

The Frame option on the View menu allows you to choose a world to be in the center of the screen. When you select Frame, the currently selected world is placed in the center.

Changing the Time Step

The motion of the planets is computed by calculating the acceleration of all the bodies, letting them move for a given length of time, and then calculating accelerations at the new positions. The length of (simulation) time between calculation is given by the time step. Shorter time step as more accurate, but take longer to compute. The default time step is 24 (simulated) hours. See the section on Calculations for more details.

You can change the time step used for the simulation by selecting Time Step option from the Simulation menu. The time step is the amount of time between calculations when you run the simulation.

Loading and Saving

Gravity uses standard Windows conventions for loading and saving files. To load a file, select Open from the File menu. To save a file, select Save or Save As from the File menu. If you want to start a new scenario, select New from the File menu.

File New

The File New command clears the current scenario (asking first if you'd like to save it). Use this command when you want to start again with an empty universe.

File Open

This command opens a previously saved Gravity file.

File Save

This command saves the current scenario. If you have not yet chosen a filename for your scenario, it will put up a dialog box so that you may do so.

File Save As

The File Save As command saves the current scenario under a different name.

View Zoom In

The View Zoom In command increases the magnification used to show the worlds. It zooms in on the center of the screen. Use the View Zoom Out command to decrease the magnification. Use the View Frame command to center the screen on a particular world.

View Zoom Out

The View Zoom Out command decreases the magnification used to show the worlds. It zooms out from the center of the screen. Use the View Zoom In command to increase the magnification. Use the View Frame command to center the screen on a particular world.

View Frame

The View Frame command will center the screen on the currently selected world. Note that this command will actually change the x and y coordinates of each of the worlds so that the central world is at coordinates 0,0.

Simulation Start/Stop

This commands starts and stops the simulation. While the simulation is running, you will not be able to choose any other command except Stop.

After you've run a simulation, you may select Simulation Reset to restore the worlds to their state before the beginning of the run.

Simulation Reset

The Simulation Reset command will restore the parameters of all the worlds to their state before the beginning of a run. Use this command when the results of a run were not what you expected and you wish to change some parameters to correct them.

Note that after you have edited or created a world you will not be able to reset the simulation.

Simulation Time Step

You may change the time step used to run the simulation with this command. A dialog box will appear asking you to enter the new time step in hours. The initial time step is 24 hours.

Simulation Zero Timer

This command will set the simulation timer to zero. You can see the timer in the lower-left part of the screen.

Simulation Edit World

The Simulation Edit World command allows you to change the parameters of the currently selected world. The dialog box presented allows you to change the following values:

Mass: The mass of the world relative to the mass of the Earth. A few values are included for reference, including the mass of the Sun and the mass of Jupiter. Select one of the predefined values or time in your own.

x,*y*: The position of the world in Cartesian coordinates relative to the center of the screen. Positive x is to the left; positive y is up. Position is measured in Astronomical Units, the average distance from the Earth to the Sun.

vx,*vy*: The velocity vector of the world in kilometers per second.

Simulation Delete World

This command will delete the currently selected world.

The currently selected world is outlined by a white rectangle. You may click on a world to select it.