

# ***Mechanics Simulator 2014***

## **User Guide**

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# Introduction

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Welcome to Mechanics Simulator 2014! The purpose of this system is to help teachers teach Mechanics principles for the first time to students, as well as to act as an effective revision tool for students. This user guide is intended for the use of both teacher and student. The program is focused around three main sections:

- **Simulation** – Each simulation is completely unlocked, and students can experiment with the different variables to see how it affects the objects being simulated. As a teacher, you could set up demonstrations using this mode for teaching students
- **Test** – This is a chance for students to put their knowledge to the test for a chosen category. Test questions are randomly generated, so there are thousands of unique possibilities. After the student has answered the questions, they will be able to see the simulation running, revealing the answers to the questions
- **My Progress** – Users who have completed tests can look at statistics based on their own progress. Part of this is a graph of test score against test number for any particular category

# Installation

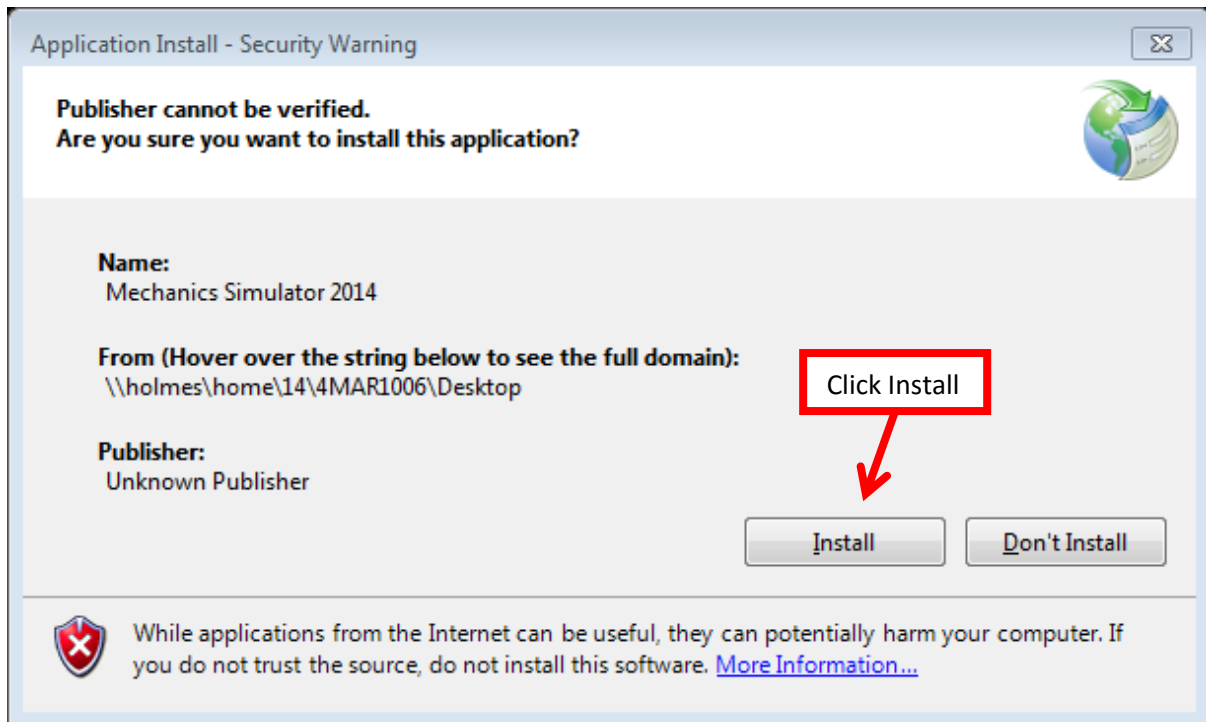
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Mechanics Simulator 2014 works on all recent Windows operating systems, although Windows 7 is recommended. You will need to use a monitor capable of a screen resolution of at least 990x750, since this is the fixed size of the program. Installing the program is very simple.

Three items are required for installation: a folder called “Application Files”, a ClickOnce Application called “Mechanics Simulator 2014” and an Application called “Setup”. These could be distributed with a USB flash drive or email. First ensure that these three items are all copied into the same directory (e.g. Downloads, Desktop, or a folder that you create). Then double-click to run the “Setup” Application (icon pictured below).



One of the prerequisites of Mechanics Simulator 2014 is the Microsoft .NET Framework 4.5. The Setup will detect if your computer already has this installed. If it does not, this should be downloaded and installed automatically, although you may need to click “Yes” to give the Setup application permission to do this. Note that you will need an internet connection should this prerequisite need to be installed, and that you may be asked to restart your computer after installing it. If the Setup detects that your computer **does** already have the Microsoft .NET Framework 4.5 installed, it will skip this step.



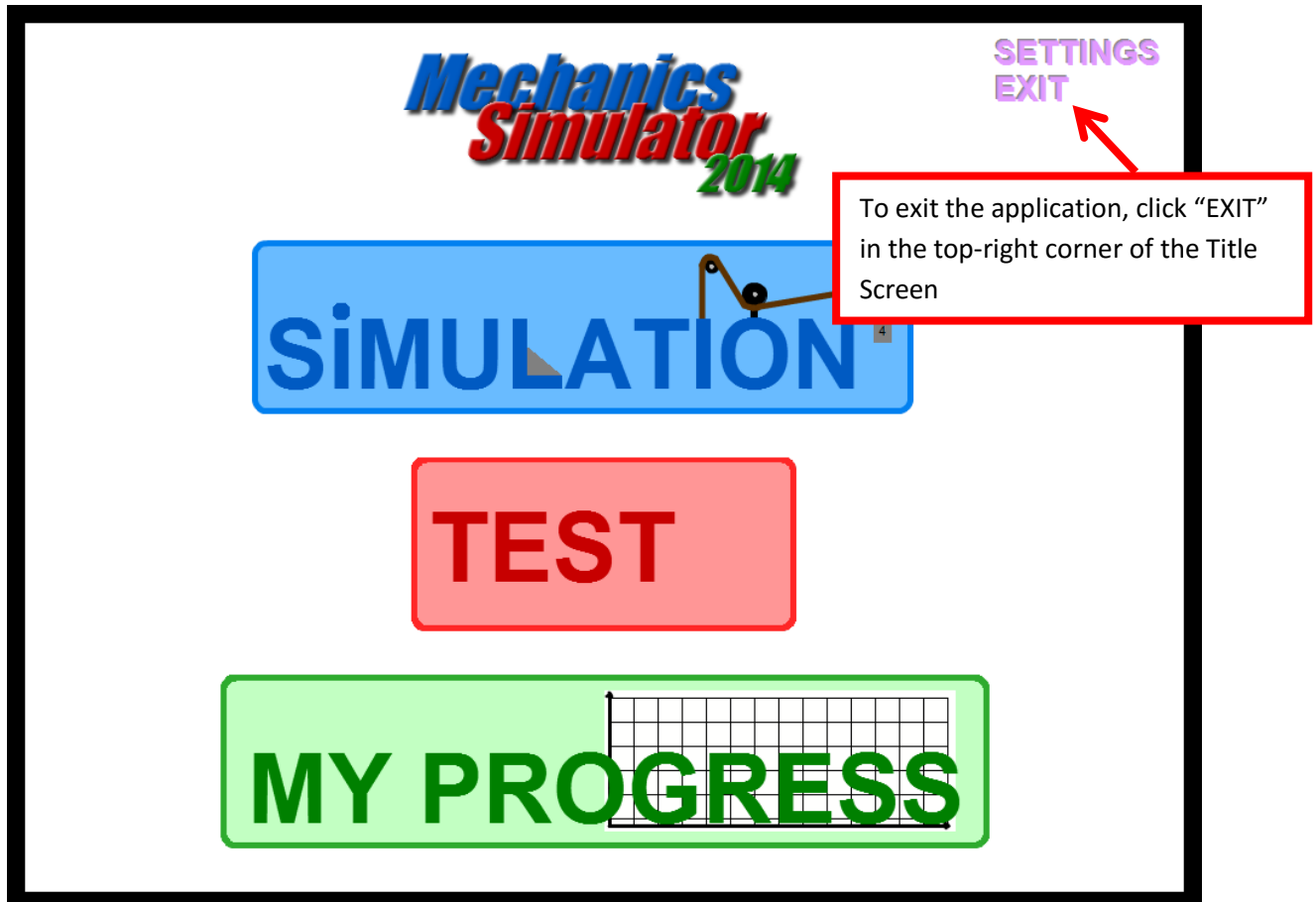
You will be prompted to verify that you wish to install the program with a message box similar to the one pictured above. After Mechanics Simulator 2014 has been installed, it will run for the first time automatically. If you wish to run the program again, you will find a shortcut to it on your Desktop which is automatically created during installation. Alternatively, you will find it in the "Mechanics Simulator 2014" folder found in "All Programs", which can be accessed from the Windows Start Menu. The program will have the same icon as is pictured below.



# How to use Mechanics Simulator 2014

## Getting Started

When you run Mechanics Simulator 2014, you will be presented with the Title Screen, which is pictured below.

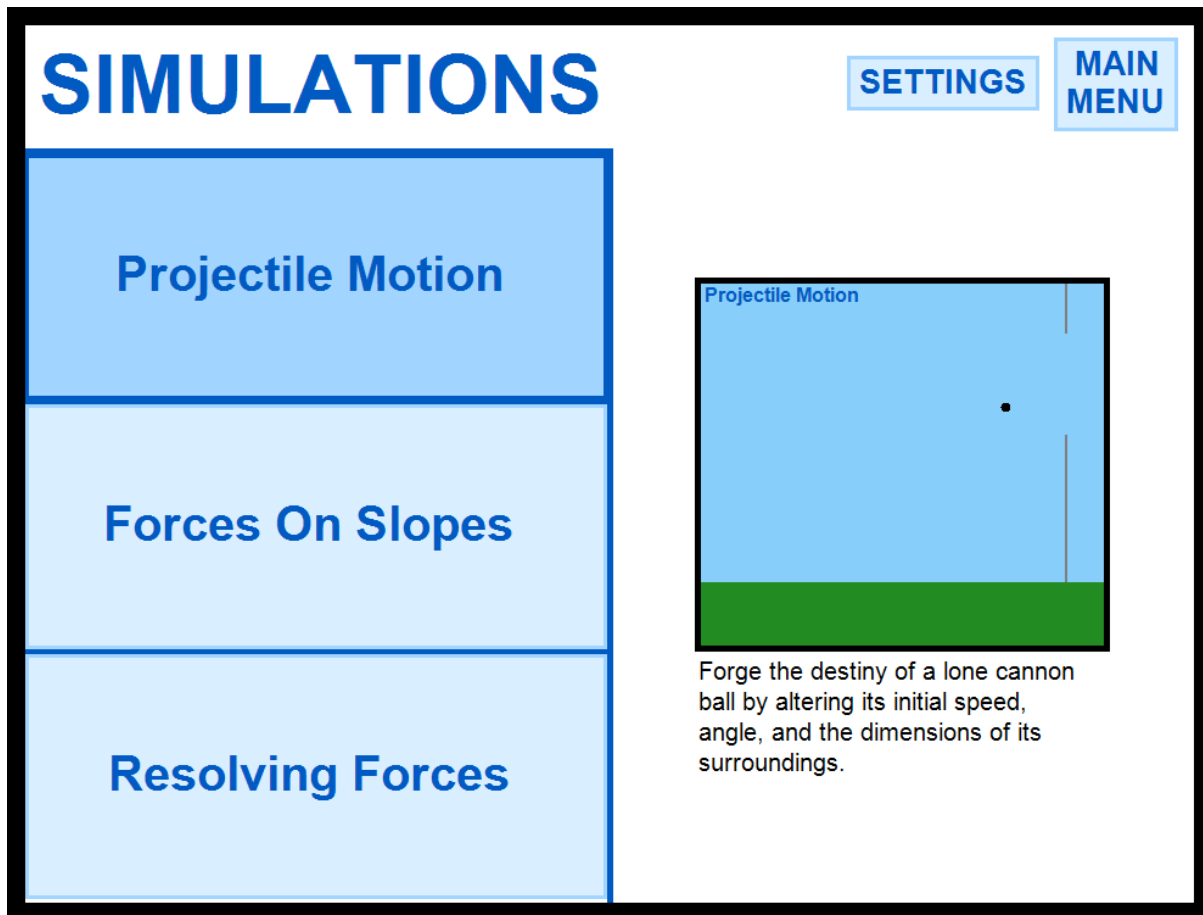


The three large buttons on this screen have an animation when your mouse cursor hovers over them and are used to navigate to the three main sections of the program: Simulation, Test and My Progress. Also on this screen is an "EXIT" button, and a "SETTINGS" button (program settings are explained in more detail later in this guide on page 21).

There is always a border surrounding the main content of the program. This border is black by default. The main window can be moved by holding a mouse button down on any part of this border and dragging.

## Simulation

Clicking the big Simulation button on the Title Screen will bring you to the Simulations Menu. From here, you can preview, and choose a Simulation.

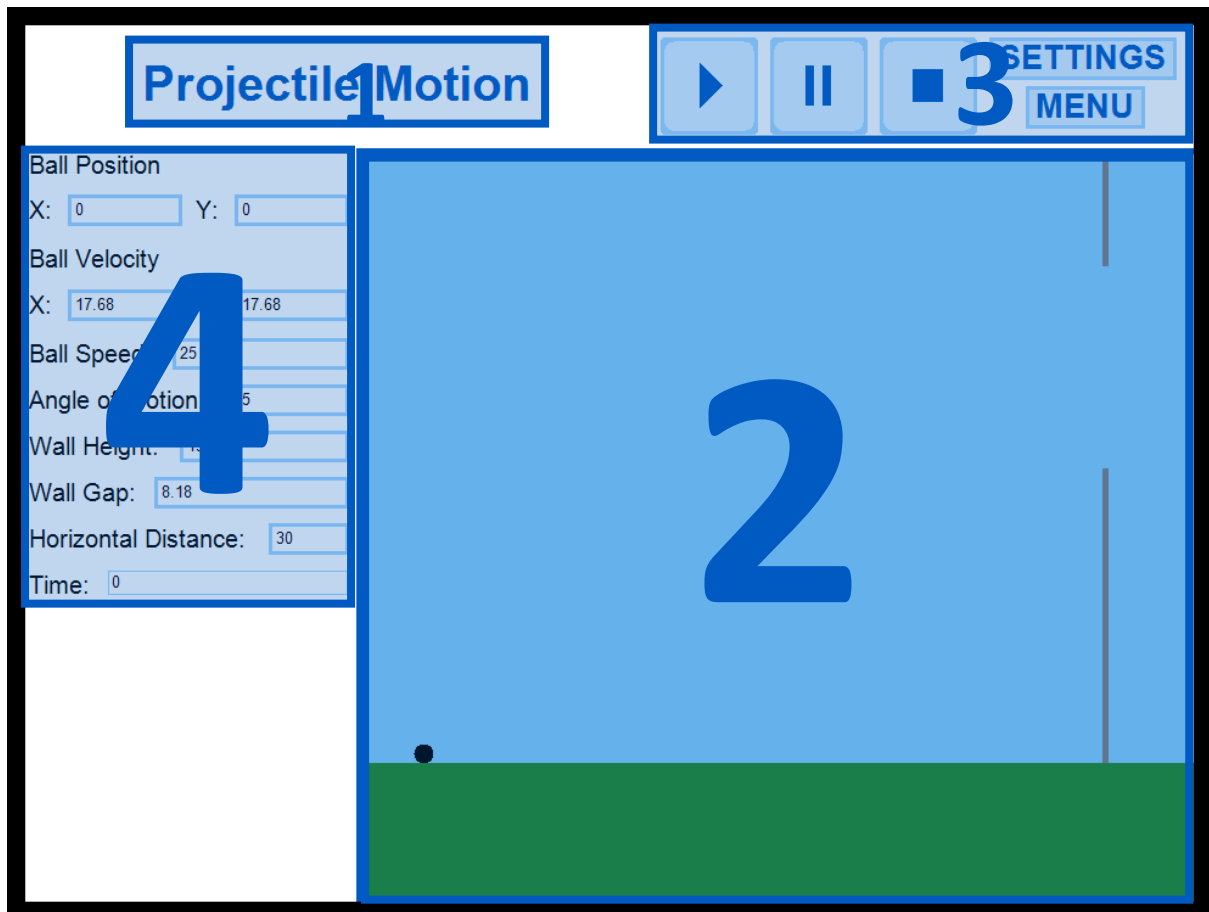


There are three big buttons down the left side, one for each Simulation. Hovering the mouse cursor over one of these buttons will display an animated preview and description of that Simulation on the right side.

You can select a Simulation to use simply by clicking on the button associated with that Simulation.

## Simulation Types

All Simulations have the same basic design. The picture below shows the four main sections, using the Projectile Motion Simulation as an example.

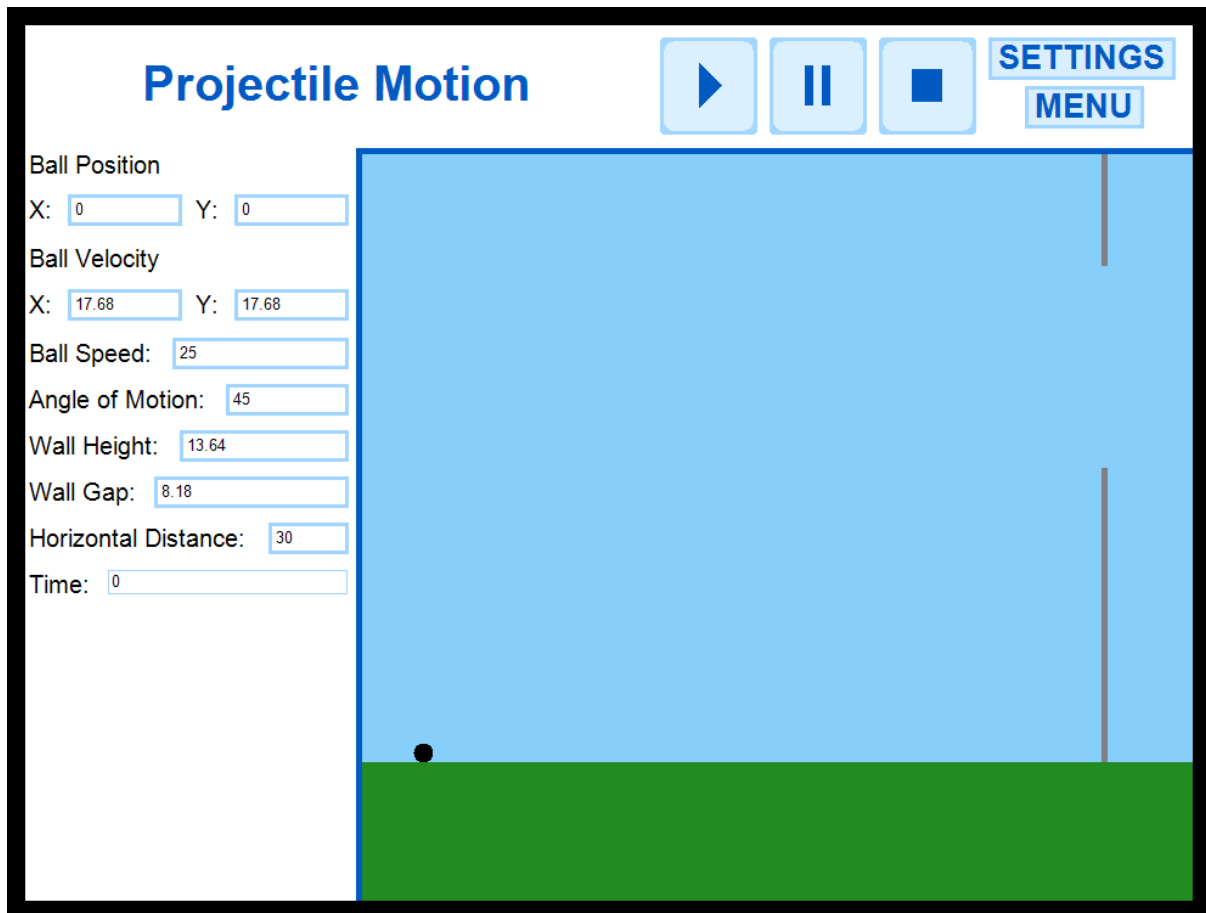


1. **Title** - This shows the name of the topic that the Simulation is about
2. **Animation** - This is where the Simulation is shown as a moving picture
3. **Control Bar** - This is the area for the Play, Pause and Stop buttons, as well as buttons to navigate to the Settings Menu and back to the Simulations Menu. This area is exactly the same for all Simulations
4. **Variables** - The numerical values associated with the Simulation. These can usually be edited before the Simulation starts and they change with the Simulation as it is running

From now on in this guide, parts of a Simulation screen may be referred to by their section number. For example, section 4 means the variables section.

### *Projectile Motion*

The scenario of the Projectile Motion Simulation is that a ball, which starts in the bottom left corner of the animation area, is fired up and to the right with a starting speed and angle. There is a wall ahead of the ball with a gap in it, and the ball could hit the wall, go through the gap or not reach the wall at all.



The following table explains each of the variables from section 4 of the Projectile Motion Simulation:

Variable Name	Description	Units	Can be edited?
<b>Ball Position: X</b>	Horizontal position of the ball. Increasing this moves the ball to the right	m	Yes
<b>Ball Position: Y</b>	Vertical position of the ball. Increasing this moves the ball up	m	Yes
<b>Ball Velocity: X</b>	Horizontal component of the ball's velocity	$\text{ms}^{-1}$	Yes
<b>Ball Velocity: Y</b>	Vertical component of the ball's velocity	$\text{ms}^{-1}$	Yes
<b>Ball Speed</b>	Magnitude of the ball's velocity	$\text{ms}^{-1}$	Yes
<b>Angle of Motion</b>	Angle of the ball's motion. This ranges from $-90^\circ$ (straight down) to $90^\circ$ (straight up). $0^\circ$ means horizontal motion	$^\circ$	Yes
<b>Wall Height</b>	Vertical distance from the ground to the gap in the wall	m	Yes
<b>Wall Gap</b>	Vertical distance between the two parts of the wall	m	Yes
<b>Horizontal Distance</b>	Distance between the point (0,0) and the wall	m	Yes
<b>Time</b>	Time elapsed since the Simulation started running	s	No



### Resolving Forces

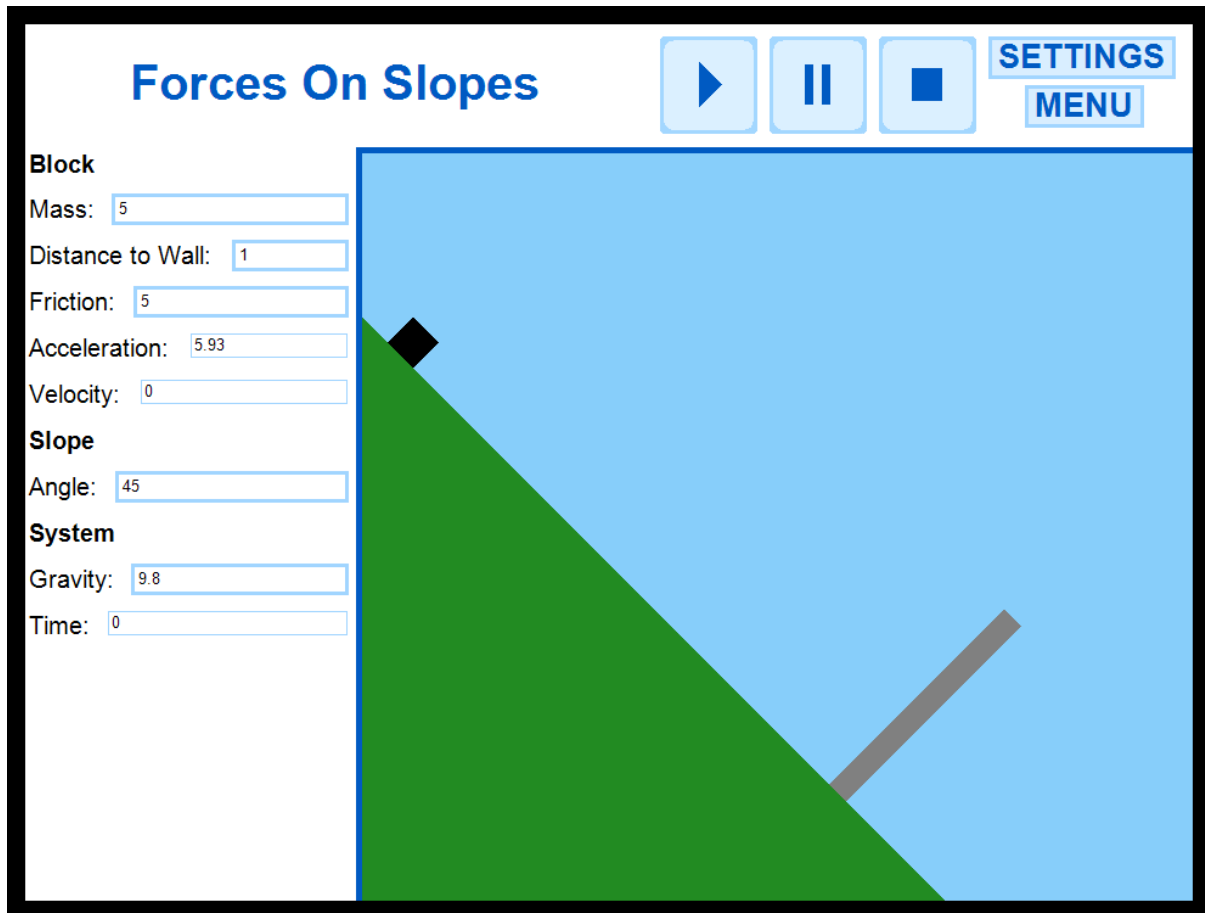
The scenario of the Resolving Forces Simulation is that there is a mass on a horizontal shelf with constant friction. This mass is connected by a light, inextensible string around a pulley to a vertically hanging mass. The whole system is released from rest. The first mass moves to the left and the second mass falls to the ground.

The following table explains each of the variables from section 4 of the Projectile Motion Simulation:

Variable Name	Description	Units	Can be edited?
<b>Mass 1: Mass</b>	Mass of the mass on the shelf	kg	Yes
<b>Mass 1: Distance to Pulley</b>	Horizontal distance between the left edge of Mass 1 and the pulley	m	Yes
<b>Mass 1: Friction</b>	Constant frictional force between Mass 1 and the shelf	N	Yes
<b>Mass 2: Mass</b>	Mass of the hanging mass	kg	Yes
<b>Mass 2: Distance to Ground</b>	Vertical distance between the bottom edge of Mass 2 and the ground	m	Yes
<b>Velocity</b>	Speed of motion of the whole system	$\text{ms}^{-1}$	No
<b>Acceleration</b>	Acceleration of motion of the whole system	$\text{ms}^{-2}$	Yes
<b>Gravity</b>	Acceleration due to gravity	$\text{ms}^{-2}$	Yes
<b>Time</b>	Time elapsed since the Simulation started running	s	No
<b>Tension</b>	Tension in the rope around the pulley	N	No

### Forces On Slopes

The scenario of the Forces On Slopes Simulation is a square block sliding down a slope with constant friction. The Simulation starts with the system being released from rest. There is a wall perpendicular to the slope ahead of the block. The block will slide down the slope and stop at the wall.



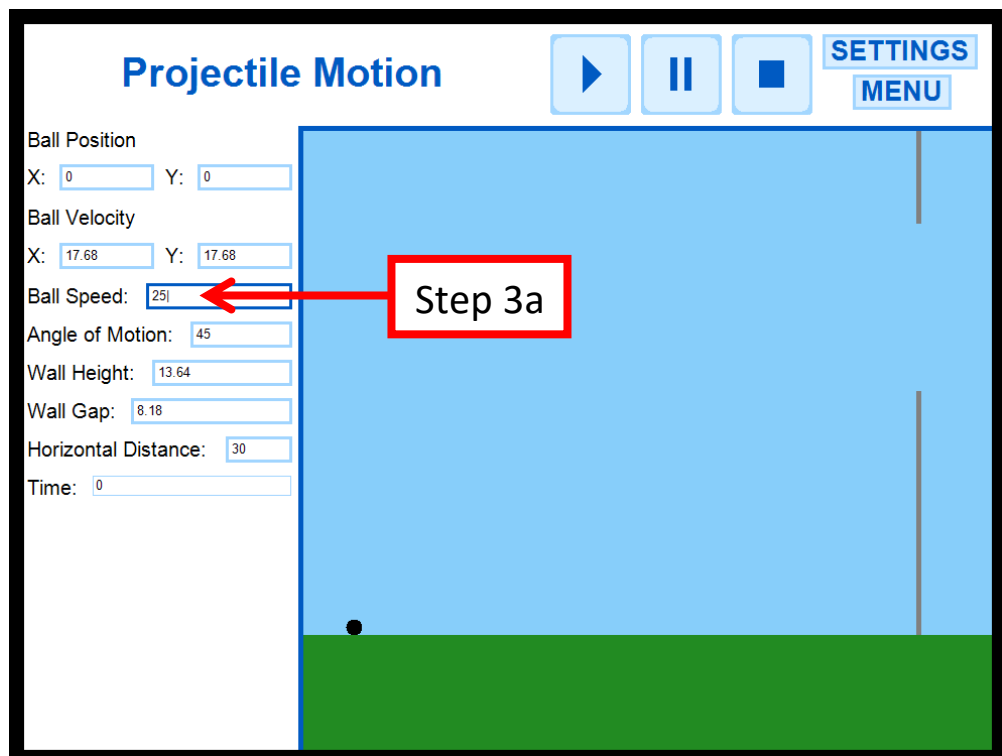
The following table explains each of the variables from section 4 of the Projectile Motion Simulation:

Variable Name	Description	Units	Can be edited?
<b>Block Mass</b>	Mass of the Block	kg	Yes
<b>Distance to Wall</b>	Magnitude of the displacement between the right edge of the Block and the Wall	m	Yes
<b>Friction</b>	Constant frictional force between the block and the slope	N	Yes
<b>Acceleration</b>	Acceleration of the block down the slope	$\text{ms}^{-2}$	No
<b>Velocity</b>	Velocity of the block down the slope	$\text{ms}^{-1}$	No
<b>Slope Angle</b>	Angle of the bottom right corner of the slope, from the horizontal. This ranges from $0^\circ$ (Flat) to $90^\circ$ (Vertical drop)	$^\circ$	Yes
<b>Gravity</b>	Acceleration due to gravity	$\text{ms}^{-2}$	Yes
<b>Time</b>	Time elapsed since the Simulation started running	s	No

## Using the Simulations

The following set of instructions is for choosing a Simulation, editing a variable, and running the Simulation, using the Projectile Motion Simulation as an example. It assumes that you are starting from the Title Screen:

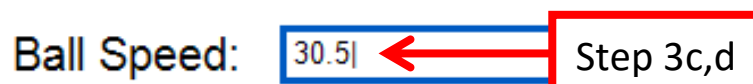
1. Click the big Simulation button on the Title Screen
2. Click the button for the Simulation that you want to use
3. To edit a variable:
  - a. Click anywhere inside that variable's text box. The border of the box will change to a darker blue and a flashing input cursor will appear



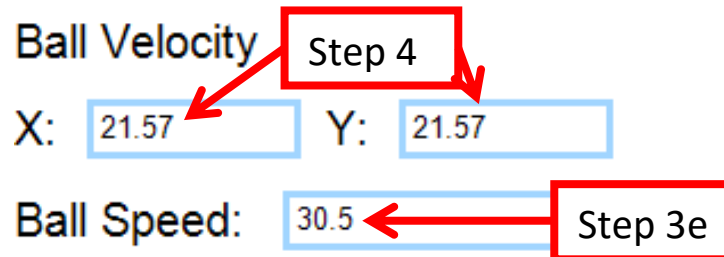
- b. Remove characters already in the text box by pressing the Backspace key once for each character



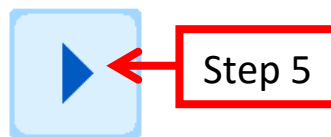
- c. Insert numbers by pressing a number key (either on the main keyboard, or on the NumPad)
    - d. You can insert one decimal point (a dot, or full stop) anywhere in a text box except from the beginning. No characters other than a point and numbers are allowed, and these cannot be inserted



- e. Press the Enter key once you have finished typing in the new value for the variable. This step is necessary, and your changes won't take effect unless you do this. This will cause the border of the text box to change back to its original colour, and the value you entered will, if possible, be rounded to two decimal places
4. Sometimes, different variables will change after you edit a variable. This would be because the variables are dependent on each other



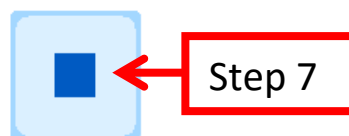
5. To start running the Simulation, click the Play button in Section 3 of the Simulation



6. While the Simulation is running, it can be paused by clicking the Pause button. Clicking the Play button again will resume running of the Simulation. Running of the Simulation can also be toggled on or off by pressing the Space Bar



7. To stop and reset the Simulation, click the Stop button. Variables can only be edited again once the Simulation has been reset



## User Selection

When trying to access the Test or My Progress sections of Mechanics Simulator 2014, you will always be prompted to select or create your user profile, since these sections cannot be accessed otherwise. The picture below shows the User Selection screen for the Test Section, although the My Progress one is identical (apart from being green instead of red).

**Already used this program?**  
Select your user name from the list:  
TestUser1  
TestUser2

**New User?**  
Create a new user name:  
 **Create**

Only letters and numbers can be used.  
User names cannot be longer than 10 characters.

**OR**

**Back to Main Menu**

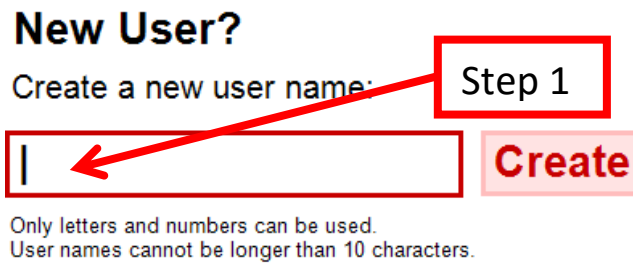
User profiles are designed to allow multiple users of Mechanics Simulator 2014 on a single machine. Users are distinguished by each having a unique User Name. This can be any combination of uppercase letters, lowercase letters, and numbers, up to a maximum of 10 characters.

If you have already used the program before on your machine, you will see the User Name that you created in the list on the left side. Continue to the Test or My Progress section by clicking your User Name on this list. If you are the first user of the program on your machine, the list of existing users will be empty, and the only way to progress is to create a new User Profile.

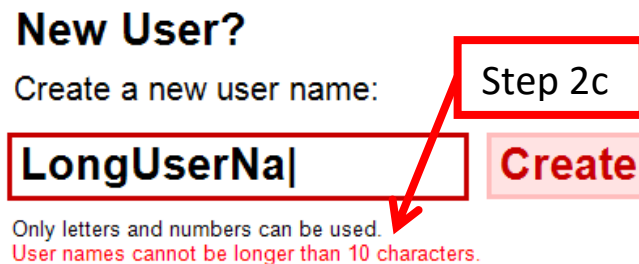
### Creating a new User Profile

If you are trying to access the Test or My Progress section of the program for the first time, do not select a User Name from the list that you do not recognise, or that isn't yours, unless you have permission to do so from the owner of that User Name. The following set of instructions is for creating a new User Profile and selecting it to continue with the program, using the Test section User Selection screen as an example:

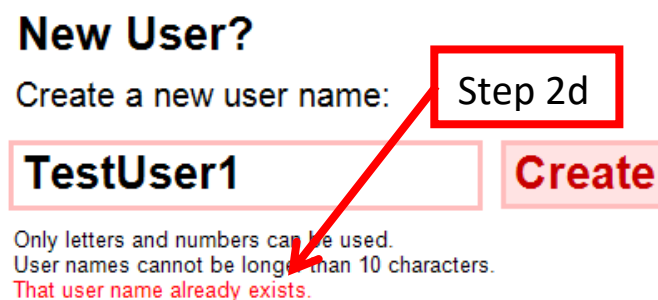
1. Click anywhere in the new User Name text box. This will make the border of the text box change to a darker colour and the input cursor will appear and start flashing



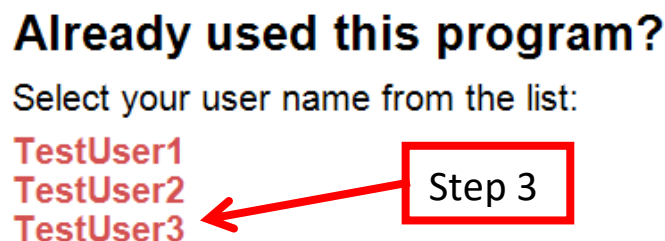
2. Type in your desired User Name and either press the Enter key or click the Create button
  - a. Pressing the Backspace key once will remove one character
  - b. You can only type in uppercase letters, lowercase letters, and numbers
  - c. Your User Name cannot be more than 10 characters long. If you try to type an 11<sup>th</sup> character, the warning message will turn red



- d. User Names on a machine must all be unique. You cannot enter a User Name which is identical to one that already exists on your machine



3. If your entered User Name was valid, it will instantly appear in the list on the left side of the screen

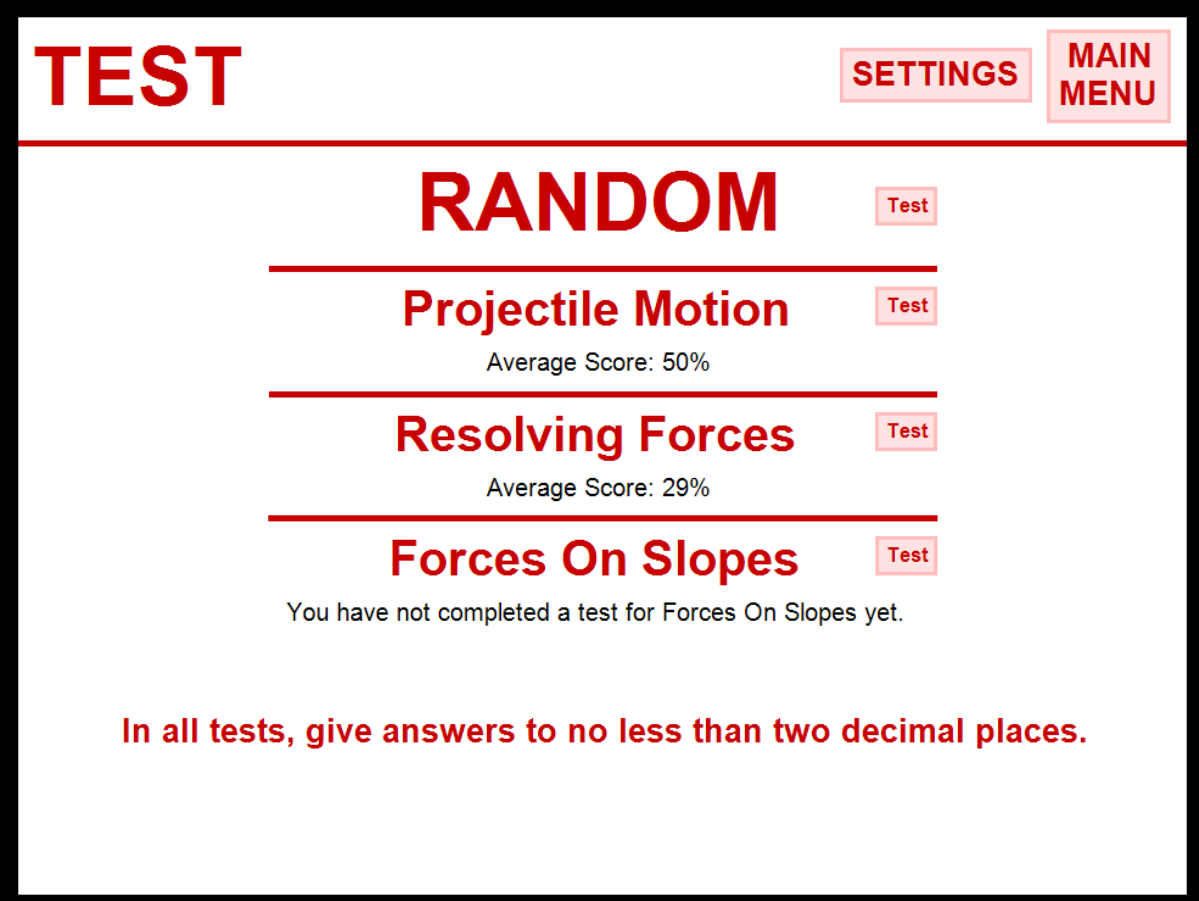


4. Click on your newly created User Name to continue to the Test or My Progress section of the program

For each User Profile on a machine, a text file is created which saves data associated with that user. The save files are located in the My Documents directory, inside a folder called Mechanics Simulation. It is highly recommended that you do not attempt to access/delete any of the contents of this folder, because this would probably result in the irreversible loss or corruption of user data. User data is encrypted, so attempting to access a user's progress file will not achieve anything, apart from potentially corrupting important user data.

## Test

The Test section of the program can be accessed by clicking the big Test button on the Title Screen. You will have to select a user to access this section, since it requires the access of user data. See the User Selection part of this guide for more information about selecting your User Profile, or creating a new one. The picture below shows the Tests Menu, which is shown after you have selected your User Name. It shows a list of all of the possible Test categories, as well as your current average percentage score for that category. There is a Test category for each Simulation type.



**TEST** **SETTINGS** **MAIN MENU**

**RANDOM** **Test**

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**Projectile Motion** **Test**  
Average Score: 50%

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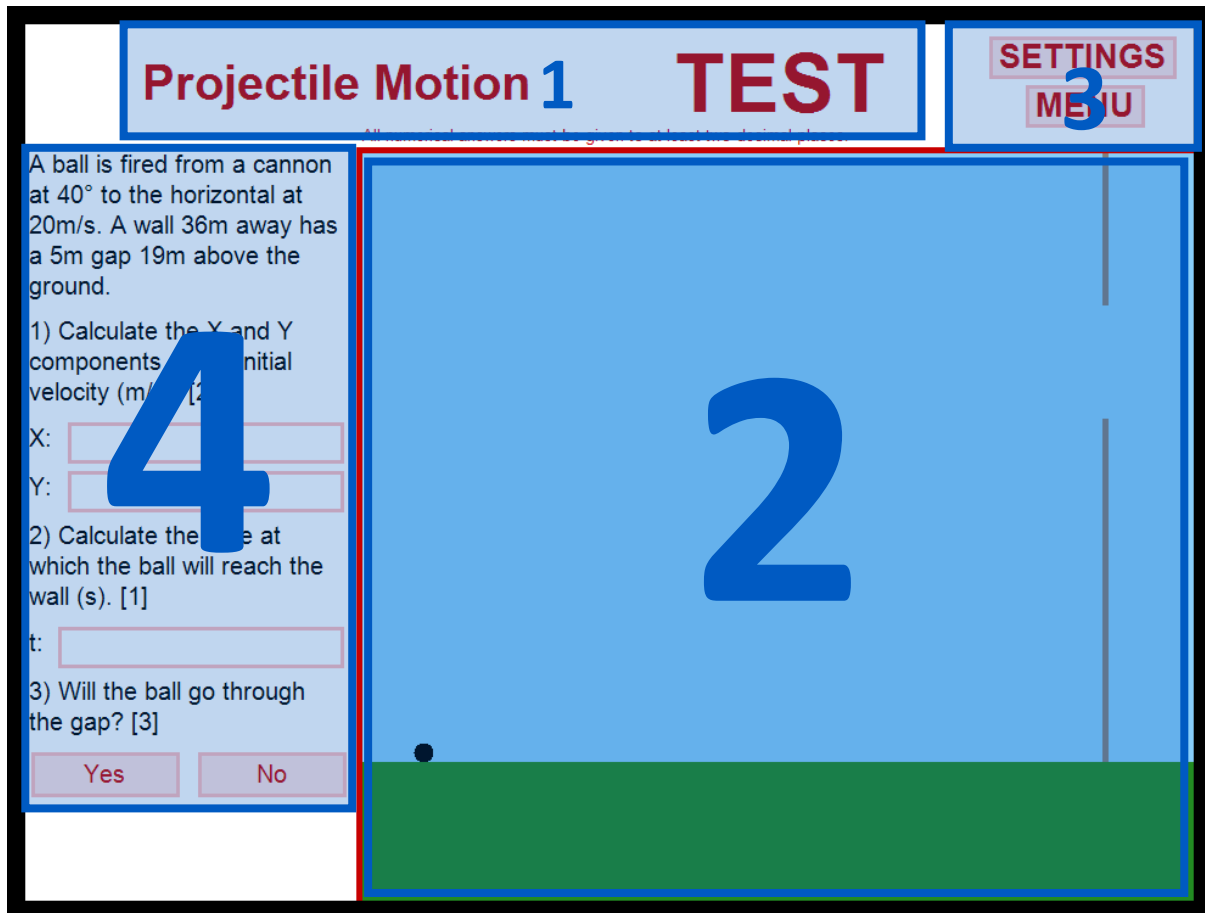
**Resolving Forces** **Test**  
Average Score: 29%

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**Forces On Slopes** **Test**  
You have not completed a test for Forces On Slopes yet.

**In all tests, give answers to no less than two decimal places.**

Much like for the Simulations, the Tests follow a similar general design. The picture below shows the four main sections of a Test, using the Projectile Motion Test as an example:



- 1. Title** - This section shows the category of the Test
- 2. Animation/Test Report** - This section shows the Simulation as a moving picture and runs when the user has submitted their answers. The animation is replaced with the Test Report once the Simulation has finished running
- 3. Control Bar** - This section has a Settings button, which navigates to the program settings screen, and a Menu button, which navigates back to the Tests Menu
- 4. Question** - This section is where the question for the Test is, along with all of the answer boxes/buttons

### How to take a Test

The following set of instructions is for choosing a test category, then carrying out that test, using the Projectile Motion Test category as an example. It assumes that you are starting at the Title Screen:

1. Click the big Test button on the Title Screen
2. Select your User Name from the list, or create a new User Profile, and select that one
3. Click the Test button next to the Test category that you want. You can click the Test button next to RANDOM to take a random Test from the list



4. Read the question and enter values for each part of the question. To enter a value for a part:

**Projectile Motion TEST** SETTINGS MENU

All numerical answers must be given to at least two decimal places.

A ball is fired from a cannon at  $48^\circ$  to the horizontal at  $22\text{m/s}$ . A wall  $28\text{m}$  away has a  $3\text{m}$  gap  $12\text{m}$  above the ground.

1) Calculate the X and Y components of the initial velocity (m/s). [2]

X:

Y:

2) Calculate the time at which the ball will reach the wall (s). [1]

t:

3) Will the ball go through the gap? [3]

Step 4

- a. Click anywhere inside the question part's text box. The text box's border will change to a darker red and a flashing input cursor will appear

1) Calculate the X and Y components of the initial velocity (m/s). [2]

X:

Y:

Step 4a

- b. Type your answer in to at least two decimal places. You can use only numbers and one decimal point per answer. Your answer cannot begin with a decimal point. All other keyboard characters will not be inserted into the text box

1) Calculate the X and Y components of the initial velocity (m/s). [2]

Step 4a

X: 14.72|

Y:

- c. Pressing the Backspace key once will remove one character  
d. Press the Enter key. The border colour will change back to what it was originally

1) Calculate the X and Y components of the initial velocity (m/s). [2]

Step 4d

X: 14.72

Y:

5. On the Projectile Motion Test, answer the last part to submit all of your answers. On the other two Test categories, click the Mark button to submit your answers
- a. If you try to submit numerical answers which are not given to two decimal places, the borders of the invalid answers will flash between light and dark red

1) Calculate the X and Y components of the initial velocity (m/s). [2]

Step 5a

X: 14.72

Y: 16.3

- b. Also, the two decimal places warning at the top of the screen will flash blue
- c. If you leave any answer boxes empty, just the warning message will flash blue

All numerical answers must be given to at least two decimal places.

Step 5b,c

- d. You would then need to correct the invalid answers, and try submitting again
6. If you submit valid answers, the Simulation will start running to show the outcome of the situation in the question
  7. After the Simulation has finished, Section 4 will be replaced with the Test Report screen. This shows the marks you achieved for each part of the question, along with what the correct answers were. The final test score is represented and saved as a percentage. The date and time of the Test's completion is also saved

## Projectile Motion Test Report

Part 1: 2/2

Correct Answer: X: 14.72m/s Y: 16.35m/s

Part 2: 1/1

Correct Answer: t: 1.9s

Part 3: 0/3

Correct Answer: Yes

Step 7

Total: 3/6 (50%)

Date: 30/03/2014

Time: 13:14

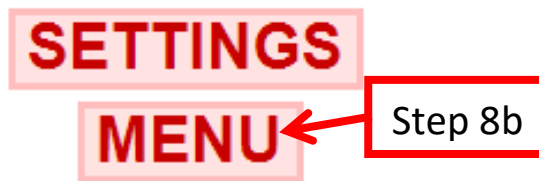
Take another  
Projectile Motion  
Test

8. Once you have taken note of your Test results, you can either:
  - a. Click the Take Another Test button, to take a new test of the same category

Take another  
Projectile Motion  
Test

Step 8a

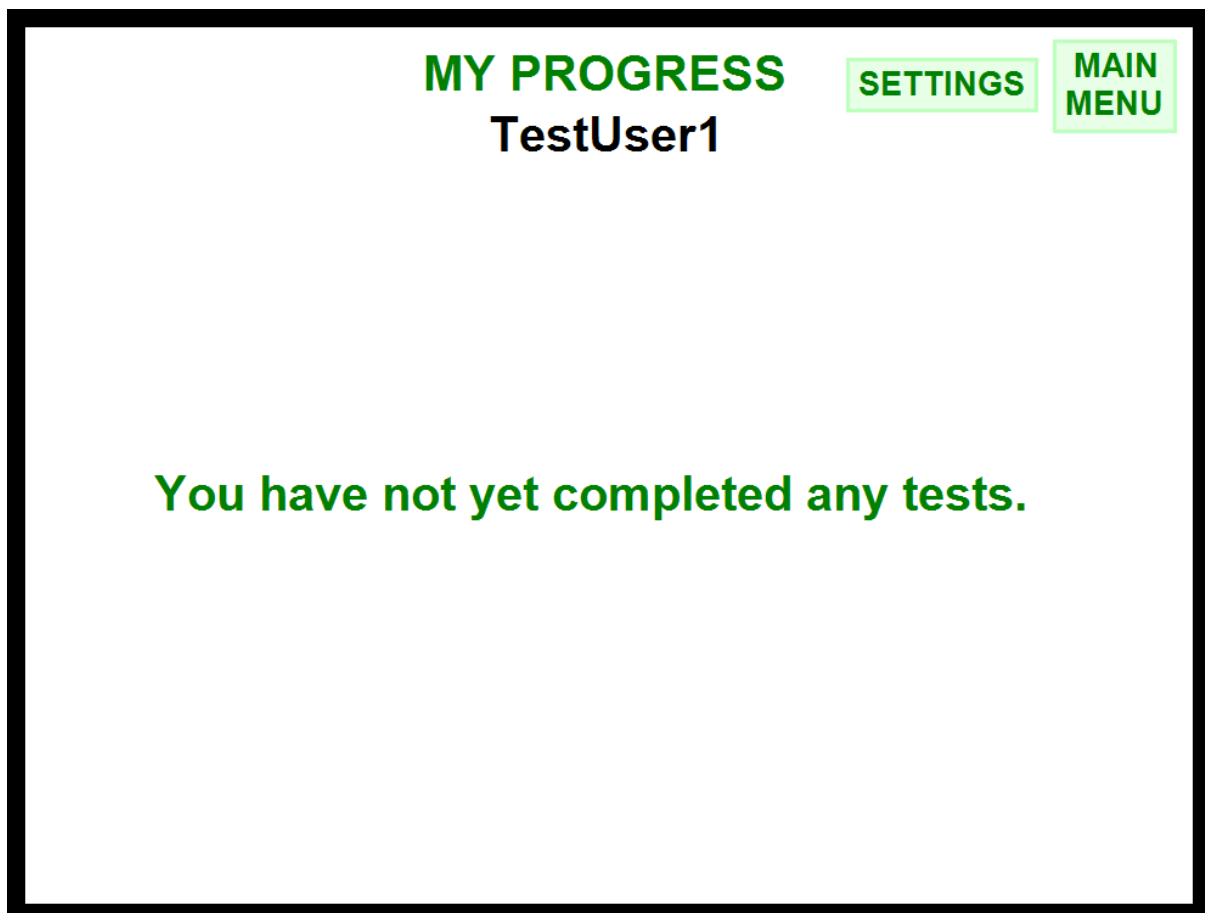
- b. Or click the MENU button to go back to the Tests Menu



## My Progress

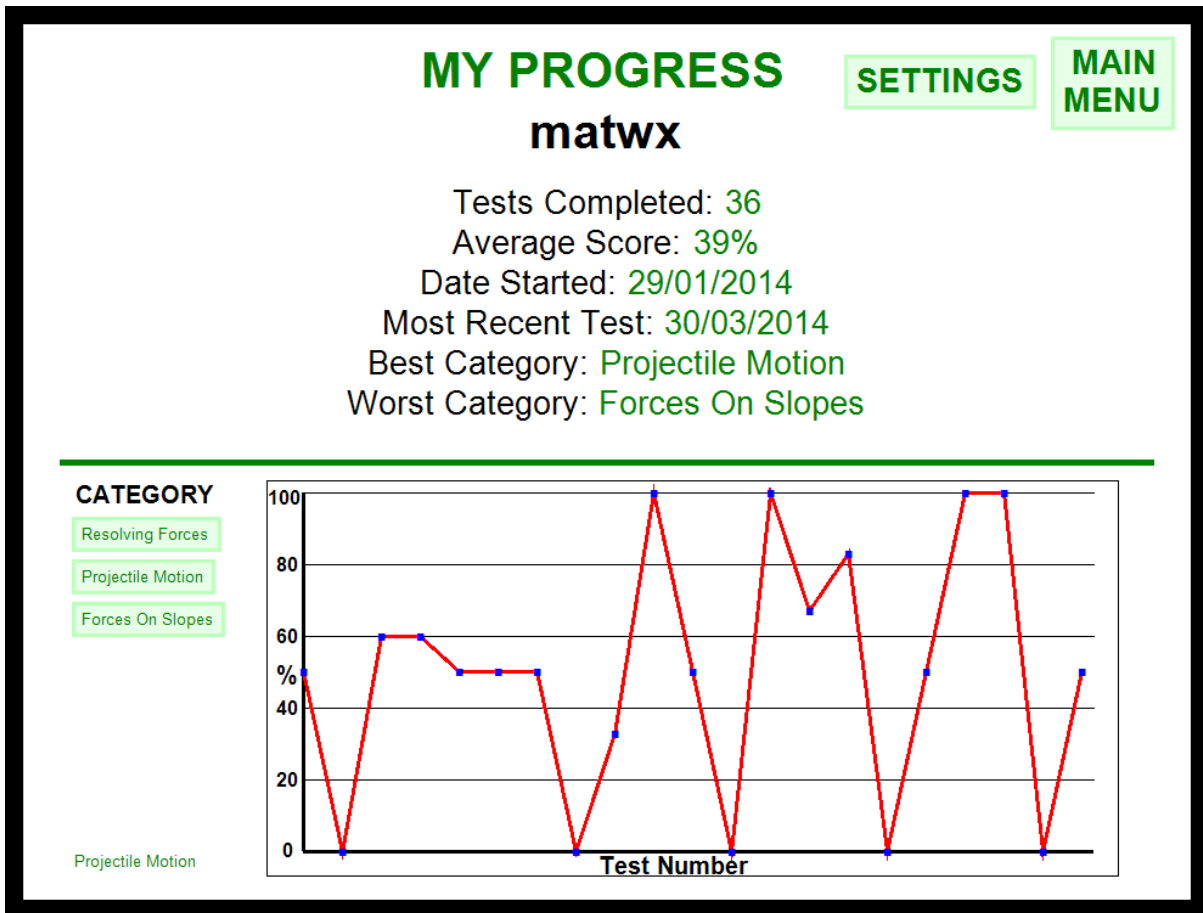
The My Progress section of Mechanics Simulator 2014 is for a user to see various statistics about their User Profile. It shows their progress over time in the Test section of the program. The My Progress section can be accessed by clicking the big My Progress button on the Title Screen. You will have to select your User Name from the list, or create a new User Profile if you do not have one already. See the User Selection part of this guide for more information about selecting your User Profile, or creating a new one.

The picture below shows what the My Progress screen would look like for a user who has not completed any Tests.



This is not particularly useful or interesting. However, once the user has completed at least one test, lots of information will be displayed about their User Profile.

The picture below shows what the My Progress screen would look like for a user who has completed some Tests.



There are two main sections of the My Progress screen: the Overall statistics and the Graphs.

### Overall Statistics

The first section of the My Progress screen is the top half, which shows statistics based on the user themselves, and overall Test information. The table below describes each of the six statistics in the first section.

Statistic Name	Description
Tests Completed	Number of Tests completed by the user
Average Score	Total percentage score of all tests completed (regardless of category) divided by the total number of Tests completed
Date Started	Date of the first Test that the user ever completed
Most Recent Test	Date of the most recent Test that the user completed
Best Category	Name of the category for which completed Tests have the highest average percentage score. This is the category that the user is currently performing best in
Worst Category	Name of the category for which completed Tests have the lowest average percentage score. This is the category that the user is currently performing worst in and may be the category which needs most work on revising

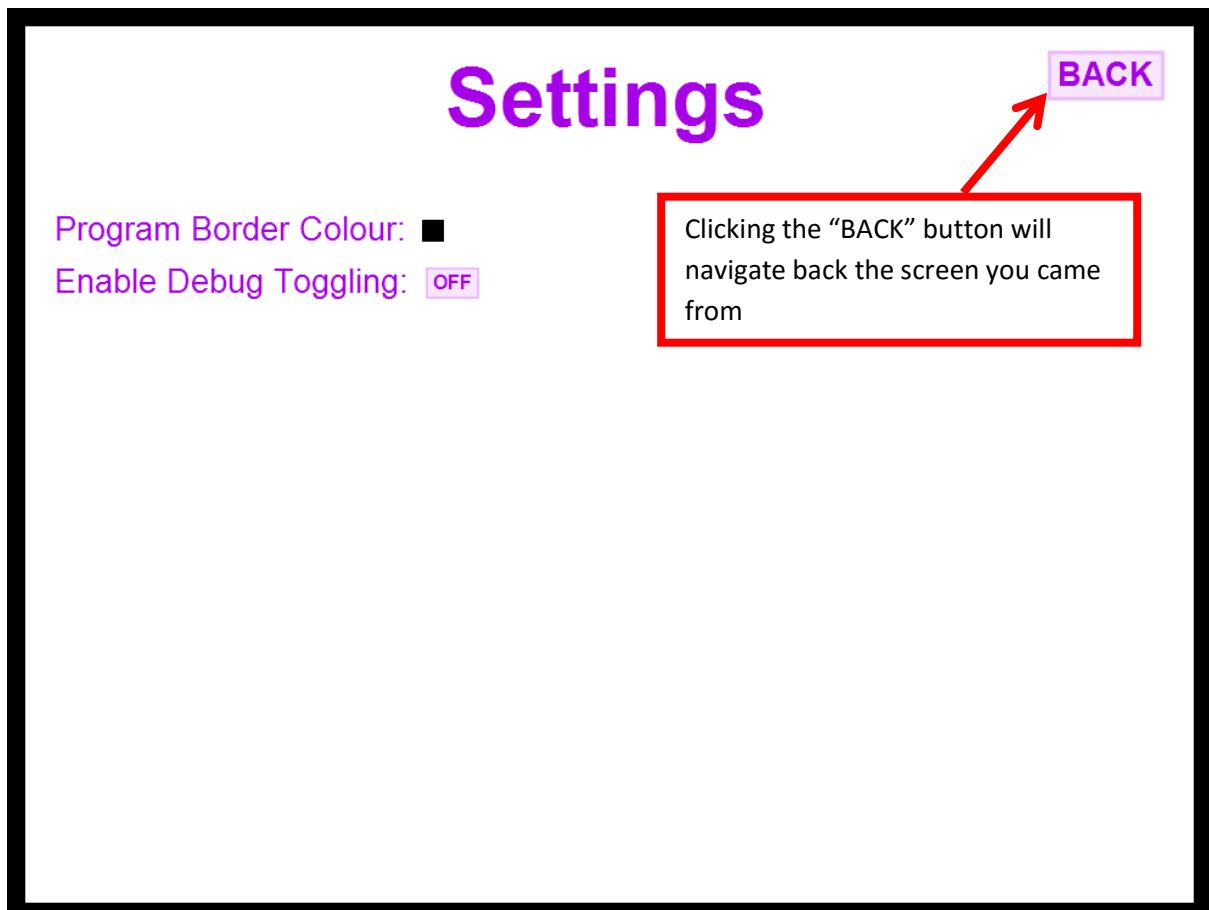
## Graphs

The second section of the My Progress screen is the bottom half. This shows a large graph where individual tests are plotted as blue points. The Tests' percentage scores are plotted in chronological order. Only the Tests from one particular category are plotted at one time, and this category is shown in the bottom left corner of the screen. The displayed category can be changed by clicking on the button associated with that category left of the graph.

The graph is intended to show you how you are progressing over time in each category, and to show you which categories that you may need to spend more time revising with.

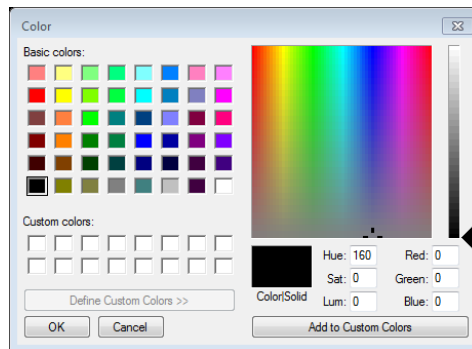
## Program Settings

Most of the screens of the program have a "Settings" button in the top-right corner. Clicking this will take you to the Settings Screen, as pictured below.



There are two available program settings:

1. **Program Border Colour:** Clicking on the coloured square will open a colour picker. Choosing a colour and clicking “OK” will update the program’s main border colour with your selected colour. The default border colour is black



2. **Enable Debug Toggling:** This setting is designed for the use of a programmer or developer. You will never need to use this setting, although using it will not harm the program in any way. It should be set to “OFF” and if you notice that it is set to “ON”, simply click the button to set it back to “OFF”

## Troubleshooting and FAQs

This troubleshooting section of the guide is intended to answer any popular queries or problems about Mechanics Simulator 2014, including any error messages which may occur.

**Q:** **When I start running a Simulation, the variable change I made doesn’t seem to have made any difference**

**A:** You need to press the Enter key once you have finished typing in the new value for the variable. This step is necessary, and your changes won’t take effect unless you do this. Pressing Enter will cause the border of the text box to change back to its original colour, and the value you entered will, if possible, be rounded to two decimal places.

Ball Speed:

**Q:** **I have stopped the Simulation, but I still can’t change any of the variables**

**A:** You won’t be able to edit any variables until the Simulation has been stopped **and reset**. You need to make sure that you don’t just pause the Simulation, but click the Stop button before you edit variables. You can then play the Simulation again after making your changes.



**Q:** The ball in the Projectile Motion Simulation should have gone off the screen, but a red arrow appeared instead

**A:** This arrow is an indicator that the ball has gone above the view of the animation. This can happen when the initial angle or speed of motion is quite high. The red number is how high, in metres, that the ball is above the top of the Simulation.



**Q:** On the Projectile Motion Simulation, the Angle of Motion has changed to “NaN”. What is this?

**A:** NaN stands for “Not a Number” and, in this case, is set as the Angle of Motion when the ball has landed and is stationary. Since the ball has no velocity in any direction, it is not in **motion** and therefore cannot have an angle of **motion**.

Ball Position

X:  Y:

Ball Velocity

X:  Y:

Ball Speed:

Angle of Motion:

Wall Height:

Wall Gap:

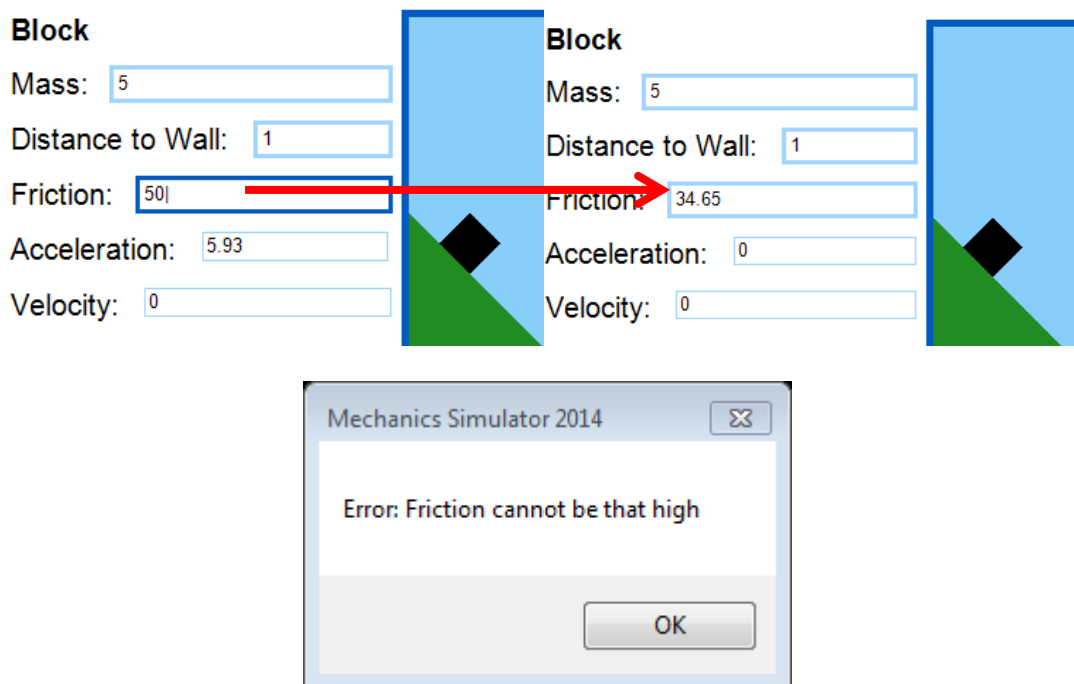
Horizontal Distance:

Time:





- Q:** When I try to change one of the variables for a Simulation, it gets set to a completely random value and I get a message box popping up saying “Error”
- A:** This value is not completely random. Some variables have maximum or minimum values, for example, the Block Friction in the Forces On Slopes Simulation (pictured below). In this example, with the currently set slope angle and gravity, the friction cannot exceed 34.65N because otherwise the resultant force would be up the slope. This wouldn’t make sense, because friction always opposes motion. There are other examples of variables where some values do not work, and the program will either set the variable to a maximum or minimum value, or set it back to its original value. A message box will pop up for each of these situations, and should explain why the value cannot be entered.



- Q:** When creating a new User Profile, I tried to enter my desired User Name, but I can’t type anything. Is my keyboard broken?
- A:** You should notice that there is a message just below the new User Name text box saying “Only letters and number can be used”. If you are trying to enter any characters other than uppercase letters, lowercase letters or numbers, your characters will not appear in the text box. To fix this problem, you should only use letters or numbers in your User Name.

## New User?

Create a new user name:

Only letters and numbers can be used.  
User names cannot be longer than 10 characters.

- Q:** When creating a new User Profile, I tried to enter my desired User Name, but I can't type anything anymore and the "User names cannot be longer than 10 characters" message has been highlighted in red
- A:** You cannot create a User Name that is longer than 10 characters. One character means one symbol, letter, or number. To fix this error, you could still press Enter to use the 10 characters displayed as your User Name, or you can press the Escape key to clear the text box, and think of a new User Name which is within the 10 character limit.

## New User?

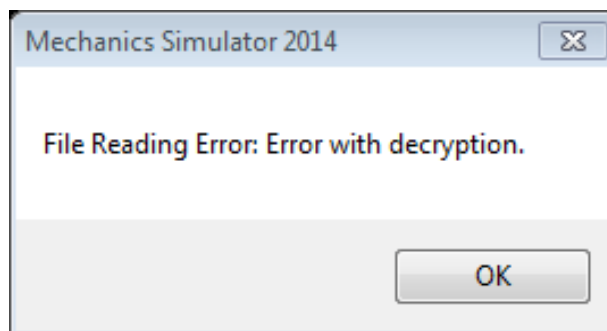
Create a new user name:

LongUserNa	Create
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Only letters and numbers can be used.  
User names cannot be longer than 10 characters.

- Q:** A message box popped up saying "File Reading Error: Error with Decryption" whenever I tried to select my User Name
- A:** This error means that your user save data has been corrupted. For each User Profile on a machine, a text file is created which saves data associated with that user. The save files are located in the My Documents directory, inside a folder called Mechanics Simulation. The most likely cause for this error is that someone has tried tampering with your user save file.

Unfortunately, there is no feasible fix. However, you can prevent it from happening again in the future by ensuring that other users of your machine do not try to access or edit any files inside the save file folder. This message will keep appearing when you try to select your User Name and the program will think that you have not yet completed any Tests. Completing a Test now will clear all of the old corrupted data associated with your user and insert only that Test's data, thus stopping this error message from appearing.



**Q:** When I tried to submit my answers in a Test, one of the answer boxes started flashing and a message at the stop flashed blue, but I am sure that my answer is correct

**A:** Even if your answer is correct, you need to give it to at least two decimal places. This means that there needs to be no less than two digits after the decimal point, even if one or both of these digits are 0. Clicking inside the answer box to edit it will stop the flashing, but you need to enter more digits for your answer to be accepted.

A ball is fired from a cannon at  $35^\circ$  to the horizontal at 32m/s. A wall 48m away has a 5m gap 23m above the ground.

1) Calculate the X and Y components of the initial velocity (m/s). [2]

X:

Y:

2) Calculate the time at which the ball will reach the wall (s). [1]

t:

3) Will the ball go through the gap? [3]

All numerical answers must be given to at least two decimal places.