AN INTRODUCTION TO FREE FALL MOTION
Using the ClassPad 300

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When an object is released in space and falls to the surface of the earth, the motion of this falling object is called **free fall motion**. This motion is governed by Newton's second law of motion which states that $F = ma$ where F is the sum of the forces acting on the object, m is the mass of the object, and a is the acceleration of the object.

As the object is falling, there are two forces which affect its motion: air resistance and gravity. Air resistance is too mathematically complicated for a first year calculus student to handle so in this introduction to free fall motion air resistance will be ignored.

However, gravity is something we can deal with. The gravitational force acting on the object is $-mg$, where g is the acceleration due to gravity. (The minus sign is there because this is a downward force.) Near the surface of the earth, $g = 32 \text{ ft/s}^2 = 9.8 \text{ m/s}^2$.

Since we are assuming that gravity is the only force acting on the object, $F = ma = -mg$. Thus the acceleration of the free falling object is $a = -g$. Even though this acceleration is constant, it is still a function of time. So it would be better to write it as:

$$a(t) = -g \quad \text{where } g = 32 \text{ ft/s}^2 = 9.8 \text{ m/s}^2.$$

Since $a(t) = v'(t)$, we see that $v(t) = \int a(t)\,dt = \int -g\,dt = -gt + C$. Evaluating this at time $t = 0$, we see that $C = v_0$, the initial velocity of the object. Hence velocity is:

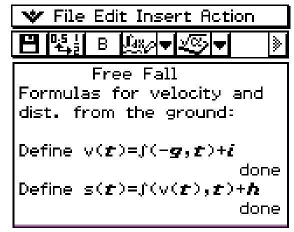
$$v(t) = -gt + v_0.$$

And since $v(t) = s'(t)$ where $s(t)$ is the distance of the object from the earth at time *t*, we see that $s(t) = \int (-gt + v_0)\,dt = -\tfrac{1}{2}gt^2 + v_0 t + D$. Evaluating this at time $t = 0$ shows us that the constant of integration is $D = s_0$, the initial distance of the object from the ground. Hence the distance function is:

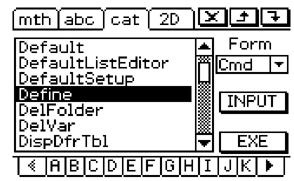
$$s(t) = \tfrac{1}{2}gt^2 + v_0 t + s_0.$$

But you don't have to memorize these three equations in order to solve free fall problems. All you need to know is the acceleration due to gravity. The rest can be found by integrating. In fact, if you are going to solve many free fall problems you can create and save an eActivity that does the integrating for you. Here's how:

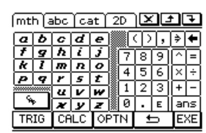
- Start a new eActivity.



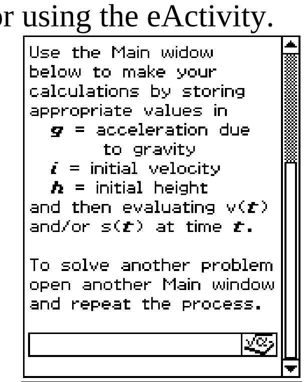
- Add instructions such as the first three lines in the figure at the right. (optional)
- Define the velocity and distance functions as shown at the right.
    - The **Define** command is housed in the Catalog. To place it on the screen:
        - Tap (on the soft Keyboard.
        - Select **Cmd** from the **Form** drop down menu on the right.
        - Tap the letter **D** at the bottom of the screen.
        - Tap the **Define** command in the left column.
        - Tap **INPUT** in the column on the right.



    - Use the 0 keyboard to enter the letters v (for velocity) and s (for distance). Use the VAR submenu on the 9 menu of the Soft keyboard to enter the variables ***t***, ***g***, ***i***, and ***h***.

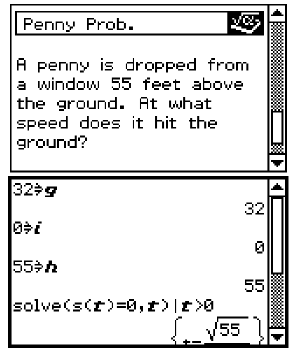



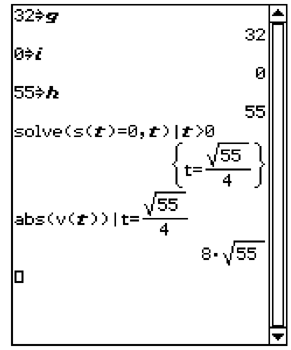
- Add instructions such as those in the figure at the right for using the eActivity. This is optional, but highly recommended so that when you use the eActivity at a later date you'll know how to use it.



- Open a Main Window in which to do your work. To do this tap **Insert** and then tap **Main**. This is optional but useful if you want to solve several free fall problems.
- Save the eActivity for future use. To do this, tap the eActivity screen, tap **File** on the Menu bar, and then tap **Save** in the drop down menu. Then enter the name of the eActivity and tap **Save**.
- To use this eActivity in the future, simply select eActivity from the Main menu, tap **File/Open**, and select the file you just saved.

Example: The first figure shows the eActivity with the solution to the problem displayed in its Main window. The second figure shows the Main window expanded to fill the screen. (To expand the Main window, tap r on the Icon panel. To return to the split window displaying both the eActivity and the Main window, tap r again.)



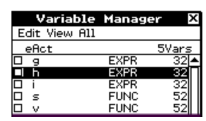


CAUTION: If you have stored a value in one of the letters ***g***, ***i***, or ***h*** and then at a later time you want to use that letter as a variable instead a constant containing its stored value, you must delete that letter from the Variable Manager in the eActivity. For example, when you worked the Penny Problem (above example) you turned ***h*** into a constant by storing a value in it. But when you then want to solve a free fall problem where you need to find the initial height ***h*** (such as in the first exercise below), you must turn ***h*** back into a variable by deleting it from the Variable Manager. Doing such will not effect any work you've already done, such as the solution to the Penny Problem. Here's how you delete a variable such as ***h*** from the Variable Manager:

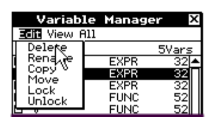
- Tap O on the Menu bar. Tap **Settings** and then tap **Variable Manager**.

- Tap **eAct** two times to display the variables for this eActivity.

- Tap the letter you want to delete to highlight it, as illustrated at the right for the letter ***h***.



- Tap **Edit** on the Menu bar and then tap **Delete**.



- When the **Delete** window appears, tap **OK**.
- Then tap **Close** at the bottom of the first and second screens.

Exercises:

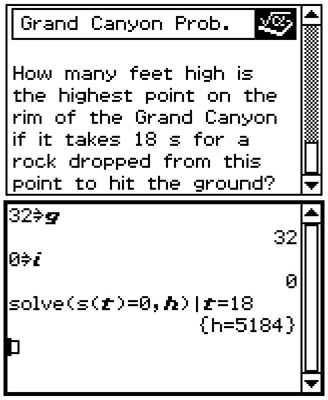
1. How many feet high is the highest point on the rim of the Grand Canyon if it takes 18 seconds for a rock dropped from this point to hit the ground?

2. Find the acceleration due to gravity on the moon given that it takes 20 seconds for a stone dropped from a height of 320 meters to land on the moon.

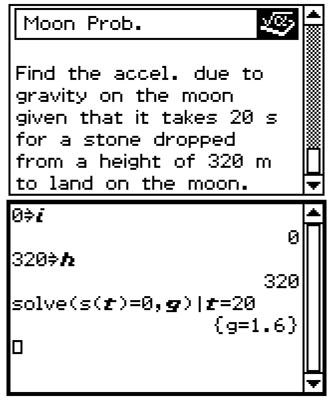
3. A ball is thrown upward from a height of 6 feet at 60 feet per second. How high does the ball go?

Solutions:

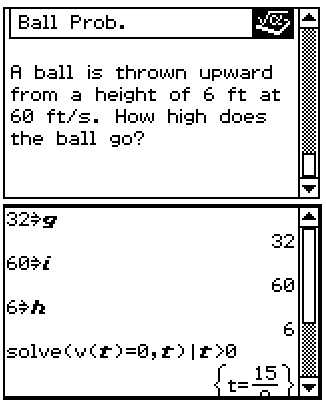
1. 5184 feet

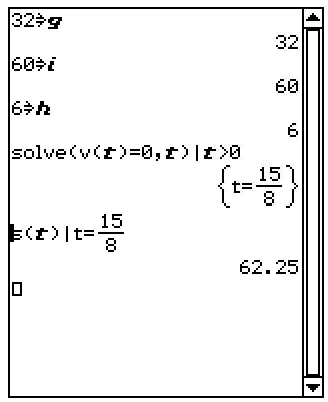


2. 1.6 meters per sec.



3. 62.25 feet





Comment to teachers: Should you desire to write this up as an eActivity assignment for your students, the example and exercises would look like: