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Homework 3 for the Physics for OI

This homework serves for training of drawing objects in the Mathematica and for theory repetition of the vertical throw and mechanical energy calculation.

Your task is to graphically express the time dependence of the height during the vertical throw of a body. Express graphically also the amount of potential and kinetic energy of the body at every moment.

Additional instructions and hints:

Dependence of the height on time can be evaluated by the following equation:

$$h = h_0 + v_0 t - \frac{1}{2} g t^2,$$

where h_0 is initial height, v_0 is initial velocity (upwards) and g is acceleration due to gravity.

Dependence of the velocity on time can be evaluated like

$$v = v_0 - gt$$

The total time needed for reaching the ground (which you will also need in your program) can be calculated as a positive root of quadratic equation resulting from the height dependence taking h=0.

$$0 = h_0 + v_0 t_{total} - \frac{1}{2} g t_{total}^2 \quad \Rightarrow \quad t_{total} = \frac{1}{g}(v_0 + \sqrt{v_0^2 + 2gh_0})$$

Relations for the kinetic and potential energy

$$KE = \frac{1}{2} m v^2 \qquad PE = mgh$$

where m is mass of the body, v is its velocity and h is its height above the ground. We assume that the ground is represented by the zero height.

Recommended functions and settings for the Mathematica:

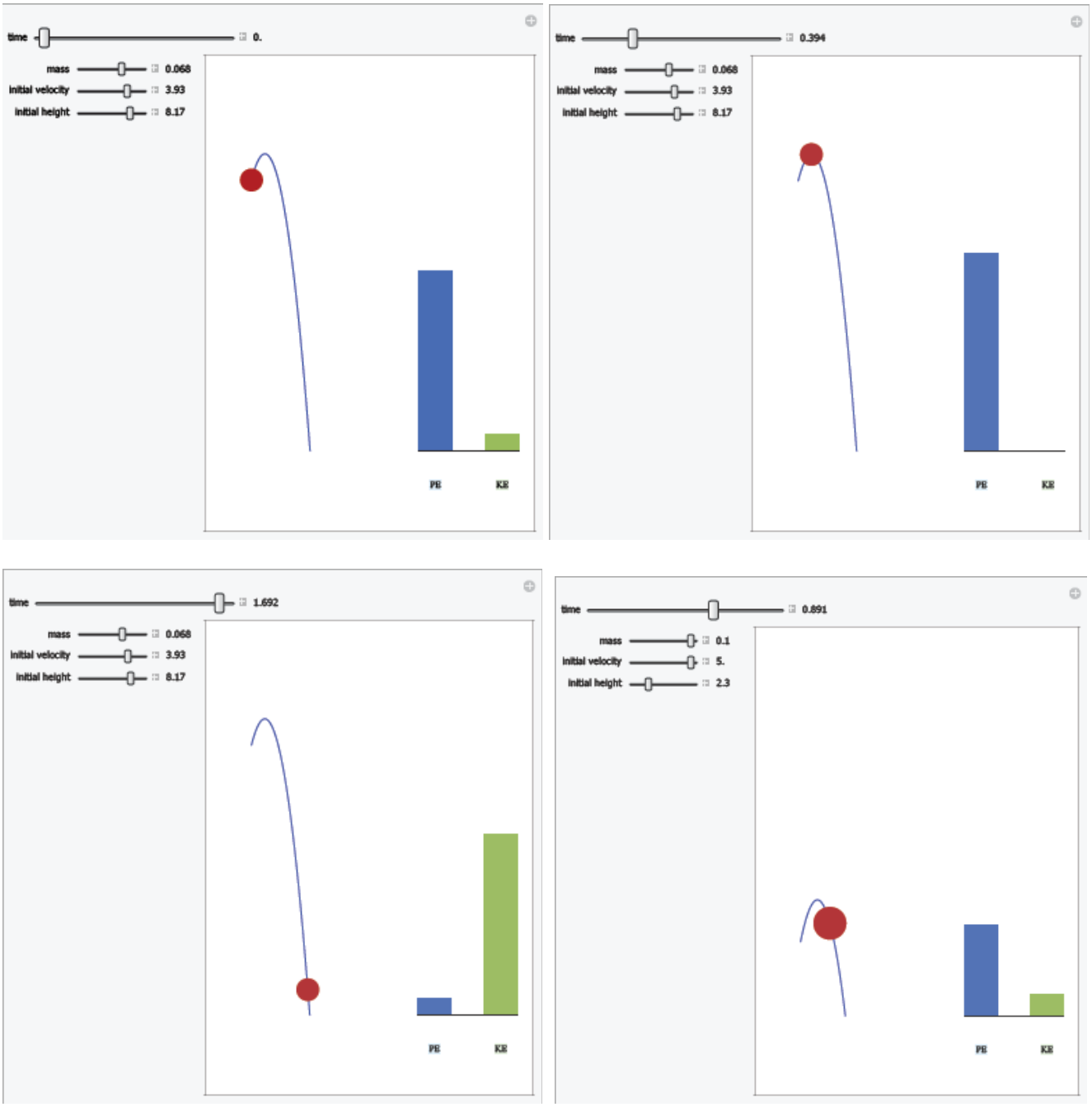
The *Manipulate* function will encapsulate the entire solution. The *Graphics* function will encapsulate all graphic objects inside the *Manipulate.*

The pictures below show one of possible graphical appearances. There are four manipulators:

1) Time varying from 0 to the total time needed for reaching the ground in steps of 0.001 s (the total time is rounded to multiples of 0.001 s.)
2) Mass varying from 0,001 to 0,1 kg in steps of 0.001 kg.
3) Initial velocity varying from 0 to 5 m/s in steps of 0.01 m/s.
4) Initial height varying from 0 to 10 m in steps of 0.01 m.

The manipulators 2 to 4 have *ImageSize* parameter set to *Tiny*. The graphics showing the "trajectory" use horizontal direction for the time and vertical direction for the height. The rectangles on the right represent the amount of potential and kinetic energy.

The first three pictures show the same configuration of parameters in various moments. The fourth one shows the output for changed parameters – notice the size of the body, which is proportional to its mass.



<u>Recommended shapes and functions for graphic objects:</u>
Curve representing the time dependence: *Line* in association with *Table*
Moving body: *Disk*, dependent in size on the mass
Energies: *Rectangle* with variable height according to the energy

<u>Miscellaneous functions and settings:</u>
Recommended *ImageSize* for the *Graphics* function is 300 x 450 and recommended *PlotRange* is (-1 to 8) and (-2 to 11.5).
For color settings you can use either *RGBColor* or direct color names (*Black, Blue, Red* etc.).
For manipulators you can use *ImageSize*, *ControlPlacement*, *Appearance*, *TrackedSymbols* and for time manipulator also *Dynamic* and *Round*.
The acceleration due to gravity is g= 9.81 m/s^2.

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