Iron Ball Falling to the Bottom of the Mariana Trench

Fluxion Example Description

1 Physical Background

In this example we consider the case of an iron ball falling in the Mariana Trench: the deepest known point in the ocean with a depth of about 11 km. The free fall in vacuum would take about 1 minute. But if we apply some more realistic conditions we see that the time of the fall is actually much longer. We start with the gravitational force acting on the ball:

$$F_g = -m \cdot \hat{g} \tag{1}$$

However, we also have the buoyancy force acting on the ball:

$$F_a = V \cdot \rho_w \cdot \hat{g} \tag{2}$$

and the frictional force, which we model as a quadratic drag

$$F_r = \frac{1}{2} \cdot \rho_w \cdot A \cdot v^2 \cdot c_w \tag{3}$$

The so called drag coefficient, c_w, for the ball is 0.45. The net force on the ball is therefore the sum of all three forces.

2 Simulation

In addition to the force equations given above, we specify the densities of water and iron (needed to calculate the volume and cross section from the mass) as $\rho_w = 997kg/m^3$ and $\rho_i = 7874kg/m^3$, respectively. You can try varying the ball mass to see the effect. The termination condition for the calculation has been set to be whenever $x \leq -11000m$ (that is, whenever the ball reaches the bottom of the trench). The associated fall time can now be read from the adjacent graph.

It may be interesting to note that the graph is a straight line - why?