Chapter 1

Simulation Solution

1.1 Smoothed Particle Hydrodynamics

1.1.1 PySPH

1.2 Code

1.3 Deformation of the Surface?

1.4 Calculating the Energy Transferred?

```
1 from pysph.sph.equation import Equation
2
3 class BlackHole2D(Equation):
4     def __init__(self, dest, sources, soft=0.05, t_hit=5.0, M=1.0)
    :
5         self.soft = soft # softening length to not divide by zero
6         self.t_hit = t_hit # time when the black hole crosses the
    origin
7         self.M = M # mass of black hole
8         super(BlackHole2D, self).__init__(dest, sources)
9
10     def initialize(self, d_idx, d_au, d_av):
11         d_au[d_idx] = 0.0
12         d_av[d_idx] = 0.0
13
14     # calculate the force due to the black hole
15     def loop(self, d_x, d_y, d_idx, d_au, d_av, t):
16         d_au[d_idx] += -self.M * d_x[d_idx] / pow((d_x[d_idx]**2 +
     self.soft**2 + (d_y[d_idx] + t - self.t_hit)**2),3.0/2.0)
17         d_av[d_idx] += -self.M * (d_y[d_idx] + t - self.t_hit) /
    pow((d_x[d_idx]**2 + self.soft**2 + (d_y[d_idx] + t - self.
    t_hit)**2),3.0/2.0)
```

Figure 1.1: Class for adding the acceleration due to the primordial black hole.

```
19 # Import the eqations
20 from pysph.sph.equation import Group
21 from pysph.sph.BlackHoleEquation import BlackHole2D

40 # Domain and reference values
41 Lx = 120.0; H = 15.0; Ly = 1.5*H
42 gy = -1.0
43 Vmax = np.sqrt(abs(gy) * H)
44 c0 = 10 * Vmax; rho0 = 1.0
45 p0 = c0*c0*rho0
46 gamma = 1.0
47
48 soft = 0.01
49 t_hit = 100.0
50 Mass = 1.0
51 tf = 150.0 # Simulation ends when the black hole reaches the
       bottom of the tank
52
53 # Reynolds number and kinematic viscosity
54 Re = 0; nu = 0.01 #Vmax*Ly/Re # Ideal fluid
55
56 # Numerical setup
57 nx = 100; dx = Lx/nx
58 ghost_extent = 5.5 * dx
59 hdx = 1.2

82 class BlackHole(Application):

171     def create_equations(self):
172         # Formulation for REF1
173         equations1 = [

194             # Main acceleration block
195             Group(equations=[

212                 # Add the black hole
213                 BlackHole2D(dest='fluid', sources=None, soft=soft,
        t_hit=t_hit, M=Mass)
214
215             ]),
216         ]
```

Figure 1.2: Modifications of the hydrostatic tank.