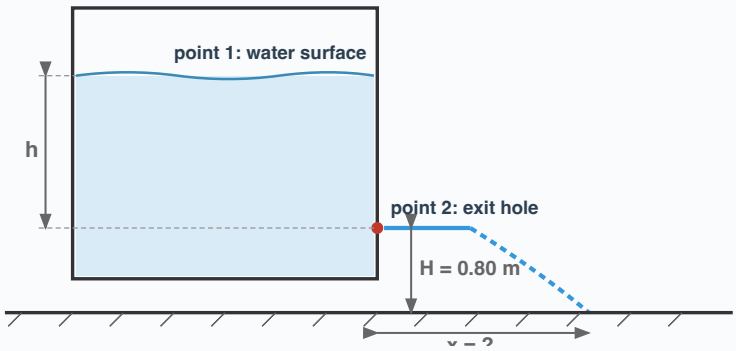
FREE RESPONSE — MULTIPLE REPRESENTATIONS

Time: ~25 minutes · Total: 13 points · Show all work; partial credit awarded.

Setup. A wide, open-topped tank with a small hole drilled in the side rests on a table. Water drains through the hole as a horizontal jet, then falls to the floor. The hole is at height **H = 0.80 m** above the floor, and at the moment shown the water surface inside the tank sits a distance *h* above the hole. Treat water as ideal (incompressible, inviscid). The tank's cross-section is much larger than the hole's, so the surface drops slowly. **Neglect air resistance once water leaves the hole.** Use g = 9.81 m/s².



(a) **3 points**

Apply Bernoulli's equation between point 1 (water surface) and point 2 (exit hole, just outside the tank). For *each* Bernoulli term at points 1 and 2 — pressure, kinetic-energy density, and gravitational-PE density — justify whether it cancels, is negligible, or remains. Show that the exit speed satisfies **v = √(2gh)**. State *every* assumption you used to apply Bernoulli's equation.

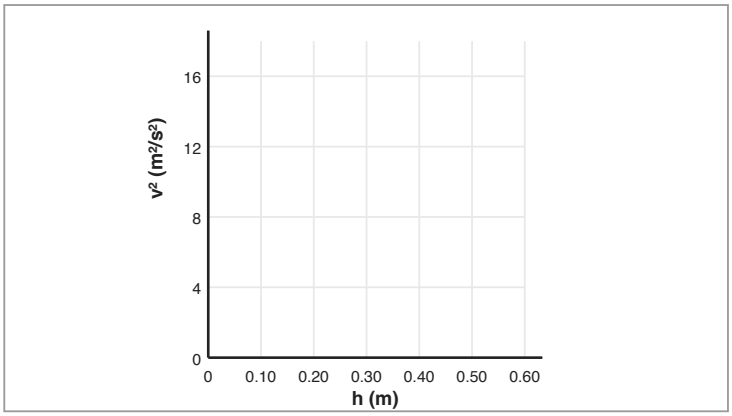
(b) **2 points**

Sketch a free body diagram of a small parcel of water just after it exits the hole (in the air, before reaching the floor). Label every force. Briefly justify which forces are present and which are absent.

(c) **3 points**

A student measures the exit speed v at four different water depths h:

h (m)	v (m/s)
0.10	1.40
0.20	1.98
0.40	2.80
0.60	3.43



(c1) Plot v^2 vs. h on the axes at right.

(c2) Use the slope of your line to find an experimental value of g. Show your slope calculation.

(c3) Explain why v^2 vs. h is preferred over v vs. h for extracting g from data.

(d) **2 points**

At a particular instant, h = 0.45 m. Find the exit speed v.

(e) **3 points**

Using your value of v from part (d) and the geometry shown in the figure on page 1: how far from the wall (horizontally) does the jet first hit the floor? Show your work and reasoning — identify any motion principle you use.