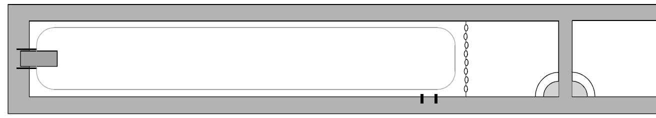
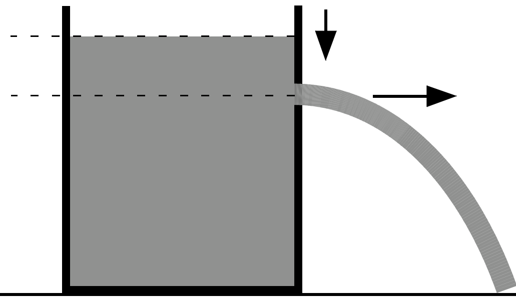
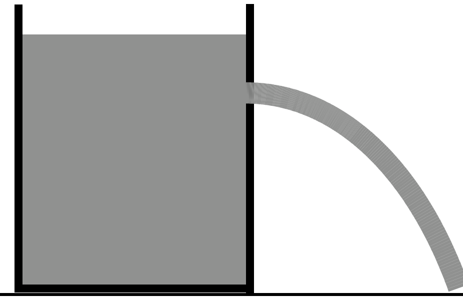
PhyzSpringboard X: Torricelli Fountain







THE FOUNTAIN

Water fills a container to a depth of 3.0 m. There is a hole in the container 2.0 m above the base. Water flows from the hole as shown in the diagram.

1. In the first diagram, label h_1 (the height of the hole), h_2 (the height of the top of the water), v_1 (the speed of the emerging water), v_2 (the speed of the falling water level in the container).

2. What is the speed of the water as it emerges from the hole?

a. Write Bernoulli's equation comparing fluid at the top of the container to fluid emerging from the hole.

$$P_1 + \rho g h_1 + 1/2 \rho v_1^2 = P_2 + \rho g h_2 + 1/2 \rho v_2^2$$

Safe assumptions: The atmospheric pressure (P_0) on the top of the water and the water emerging from the hole is the same. The hole is small compared to the water surface at the top of the container, so the water level in the container drops at a negligible rate (0 m/s).

b. What are the mathematical implications of the assumptions described above?

$P_1 = P_2$ $\quad\quad$ $v_1 = 0$

c. On the second diagram, label h, v_1, y (the vertical distance that the emerging water stream falls), and x (the horizontal distance the emerging stream travels).

c. Rewrite Bernoulli's equation with those assumptions imposed. Simplify as much as possible, and solve for the speed of the emerging water.

$1/2 v^2 = g \quad h$

$v = \quad (2g \quad h)$

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d. Substitute the numerical values into the equation to determine the speed of the emerging water.

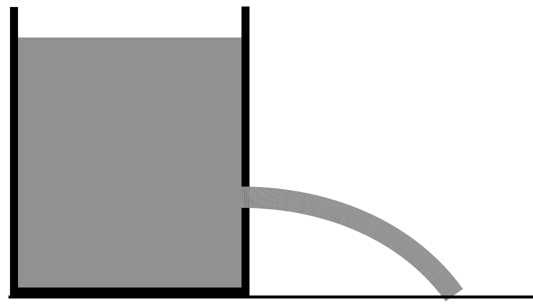
$v = \ (2g \ h) = \ (2 \cdot 9.8 \text{ m/s}^2 \cdot 1.0 \text{ m}) = 4.5 \text{ m/s}$

2. How far from the base of the container will the water land?

x: UM	y: UAM	$y = v_{y0}t + 1/2\ at^2$	$x = v_x t$
x = ?	y = 2.0 m	$t = \ (2y/a)$	$x = 4.5 \text{ m/s} \cdot \ (2 \cdot 2.0 \text{ m} / 9.8 \text{ m/s}^2)$
$v_x = 4.5$ m/s	$v_{y0} = 0$		x = 2.8 m
	$v_y = ?$		
t = ?	$a = 9.8 \text{ m/s}^2$		

SECOND STREAM

Another stream is opened 2.0 m below the surface of the water. (Remember that the water is 3.0 m above the base of the container.) How far from the base of the container will the water land?

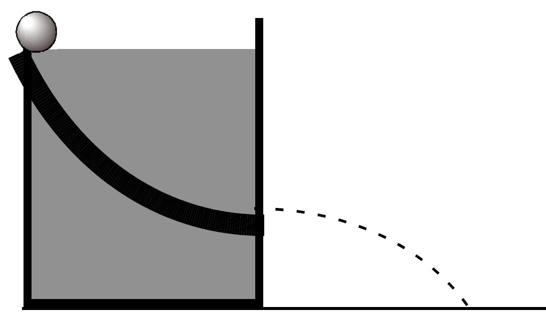


$v = \ (2g \ h) = \ (2 \cdot 9.8 \text{ m/s}^2 \cdot 2.0 \text{ m}) = 6.3 \text{ m/s}$

x: UM	y: UAM	$y = v_{y0}t + 1/2\ at^2$	$x = v_x t$
x = ?	y = 1.0 m	$t = \ (2y/a)$	$x = 6.3 \text{ m/s} \cdot \ (2 \cdot 1.0 \text{ m} / 9.8 \text{ m/s}^2)$
$v_x = 6.3$ m/s	$v_{y0} = 0$		x = 2.8 m
	$v_y = ?$		
t = ?	$a = 9.8 \text{ m/s}^2$		

RAMPING DOWN

1. A ramp is placed on the outside of the tank and a ball is rolled down and launched horizontally. How far from the base of the container will the ball land?



$KE_{TOP} = PE_{BOT}$

$1/2mv^2 = mgh$

$v = \ (2gh)$

$v = \ (2 \cdot 9.8 \text{ m/s}^2 \cdot 2 \text{ m}) = 6.3 \text{ m/s}$

x: UM	y: UAM	$y = v_{y0}t + 1/2\ at^2$	$x = v_x t$
x = ?	y = 1.0 m	$t = \ (2y/a)$	$x = 6.3 \text{ m/s} \cdot \ (2 \cdot 1.0 \text{ m} / 9.8 \text{ m/s}^2)$
$v_x = 6.3$ m/s	$v_{y0} = 0$		x = 2.8 m
	$v_y = ?$		
t = ?	$a = 9.8 \text{ m/s}^2$		

2. What is Torricelli's Law?

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