Worksheet for Exploration 15.1: Blood Flow and the Continuity Equation

Blood flows from left to right in an artery with a partial blockage. A blood platelet is shown moving through the artery. How does the size of the constriction (variable from 1 mm to 8 mm from each wall) affect the speed of the blood flow? Restart. Assume an ideal fluid **(position is given in millimeters and pressure is given in torr = mm of Hg)**. We can use the continuity equation and Bernoulli's equation to understand the motion:

Continuity: Av = constant   Bernoulli: $P + (1/2)\rho v^2 + \rho g y = \text{constant}$.

With a 2.0-mm constriction:

a. What is the platelet's speed before and after it passes through the constriction?

v_{before}=__________

v_{after}=__________

b. What is the platelet's speed while it passes through the constriction?

$v_{constriction}$=__________

Set the constriction to 8.0 mm.

c. Does the speed of the platelet before it reaches the constriction increase, decrease, or not change?

d. With the 8-mm constriction, is the speed of the platelet in the constriction faster, slower, or the same as with the 2-mm constriction?

e. Assume that the blood vessel and the blockage are cylindrical (circular cross-sectional area for both). Measure the radius of the artery and the radius of the flow area where the blockage is. Verify the equation of continuity to compare the 2-mm and 8-mm cases.

A_{out}=________ A_{in}=________

Now compare the 2-mm and 8-mm cases.

f. What is the pressure inside of and outside the constriction (use the white box to measure pressure)?

P_{in}=________ P_{out}=________

g. Does the pressure decrease or increase in the region where the blockage is?

h. This result, (g), is surprising to many students so let's figure out why: At the instant the platelet travels from the wide region to the narrower constricted region, what is the direction of acceleration?
    i. In addition to considering net acceleration of the platelet, also consider which side of the platelet accelerates more (or first) as it enters the constriction region.

i. What, then, is the direction of the force that the platelet feels?
    i. For parts (i) and (h) you should consider what causes the force on the platelet. Sketch the platelet and see if the force on the left side of it or right side of the platelet is greater.
    ii. Also, as the platelet enters the constriction which side has a greater force acting on it? What does this do to the shape of the platelet (not shown in animation).

j. What region should have a larger pressure?
    i. To determine this you should carefully consider the answers above and note that the pressure on the side of the platelet that has not yet entered the constriction remains constant. So what must happen on the constriction side to cause the acceleration you note?

k. Do the same analysis for the platelet as it leaves the constricted region and goes back to the unblocked artery (sketch a diagram to show the direction of acceleration and force).

l. Verify that Bernoulli's equation holds inside and outside the constricted region for the 2-mm and 8-mm cases (760 Torr = 760 mm of Hg = 1.01×10^5 Pa). The density of blood is 1050 kg/m^3.