Worksheet: Flow Rate and Continuity

In this worksheet, we will practice calculating the flow rate of a liquid given the dimensions of the channel that it is flowing in.

Q1: The Huka Falls on the Waikato River is one of New Zealand's most visited natural tourist attractions. On average, the river has a flow rate of about 300 000 L/s. At the gorge, the river narrows to 20 m wide and averages 20 m deep.

Question Video

- What is the average speed of the river in the gorge?

A 0.55 m/s

B 0.43 m/s

C 0.63 m/s

D 0.86 m/s

E 0.75 m/s

- What is the average speed of the water in the river downstream of the falls when it widens to 60 m and its depth increases to an average of 40 m?

A 0.32 m/s

B 0.40 m/s

C 0.24 m/s

D 0.082 m/s

E 0.13 m/s

Q2: The inside volume of a house is equivalent to that of a rectangular solid 13.0 m wide by 20.0 m long by 2.75 m high. The house is heated by a forced air gas heater. The main uptake air duct of the heater is a cylinder 0.300 m in diameter. What is the average speed of air in the duct if it carries a volume equal to that of the house's interior every 15 minutes?

Question Video

A 8.72 m/s

B 9.76 m/s

C 7.39 m/s

D 11.2 m/s

E 10.7 m/s

Q3: What is the average flow rate in cm^3/s of gasoline to the engine of a car traveling at 100 km/h if the car has an average fuel economy of 10.0 km/L?

A $1.61\ \text{cm}^3/\text{s}$

B $3.64\ \text{cm}^3/\text{s}$

C $4.80\ \text{cm}^3/\text{s}$

D $5.56\ \text{cm}^3/\text{s}$

E $2.77\ \text{cm}^3/\text{s}$

Q4: The flow rate of blood through a 2.00×10^{-6} m-radius capillary is $3.80 \times 10^9\ \text{cm}^3/\text{s}$.

- What is the speed of the blood flow?

A 3.02×10^{-2} cm/s

B 2.45×10^{-2} cm/s

C 2.86×10^{-2} cm/s

D 3.33×10^{-2} cm/s

E 2.22×10^{-2} cm/s

- Assuming all the blood in the body passes through capillaries, how many of them must there be to carry a total flow of 90.0 cm^3/s?

A 2.37×10^{10}

B 2.60×10^{10}

C 2.71×10^{10}

D 2.84×10^{10}

E 2.48×10^{10}

Q5: A fire hose with a 9.00-cm diameter carries 80.0 L of water per second.

What is the speed of water through the hose?

A 5.60 m/s

B 12.6 m/s

C 16.2 m/s

D 1.83 m/s

E 3.21 m/s

What is the flow rate through the hose?

A 0.872 m^3

B 0.800 m^3

C 0.906 m^3

D 0.700 m^3

E 0.780 m^3

Q6: A water jet with a diameter of 5 cm impacts normally on a vertical plate that requires an applied horizontal force of 31.4 N to hold it in its initial position. What is the speed of the water jet?

A 2 m/s

B 0.3 m/s

C 5 m/s

D 0.5 m/s

E 1 m/s

Q7: A water jet impacts normally on a fixed vertical plate. The diameter of the jet is 2.000 cm and its speed is 1.00 m/s. What is the force of the jet acting on the plate? Assume that friction and gravitational forces are negligible.

A 2.12 N

B 3.35 N

C 1.26 N

D 0.120 N

E 5.23 N

Q8: Water drains from a water tank through a hole in the flat base of the tank. The initial height of the water column in the tank is 4.00 m, which is reduced to 1.00 m in a time of 5.0 s. How much time is required to remove all water from the tank?

A 7.0 s

B 10 s

C 12 s

D 20 s

E 16 s

Q9: Consider a steady, incompressible flow with a velocity distribution given as $\mathbf{V} = (5x\mathbf{i} + 3y\mathbf{j} + Cz\mathbf{k})$, where C is a constant. What is the value of C so that the principle of mass conservation is satisfied?

A -3

B 1

C -8

D 2

E 32

Q10: Consider a steady, incompressible flow with a velocity distribution given as $\mathbf{V} = (ax\mathbf{i} + by\mathbf{j} + 0\mathbf{k})$, where a and b are constants. What is the relationship between a and b required to satisfy the principle of mass conservation?

A $a = 2b$

B $a = b^2$

C $a = -b$

D $a = b$

E $a = -2b$

Q11: What is the definition of a streamline?

A A line tangential to the locus of points of all the fluid particles that have passed through a given point.

B A family of curves, which are normal to the velocity vector of the flow.

C The locus of points of all the fluid particles that have passed through a given point.

D A family of curves that track the trajectories of fluid particles.

E A family of curves that are instantaneously tangent to the velocity vector of the flow.

Q12: Find the mass flow rate of steam at a pressure of 1.00 MPa and a temperature of 300°C. The steam flows through a 5.000 cm diameter pipe with an average speed of 20.0 m/s. Use a value of 18.47 g/mol for the molar mass of the steam.

A 0.152 kg/s

B 0.520 kg/s

C 1.22 kg/s

D 0.258 kg/s

E 1.65 kg/s

Q13: Consider a swimming pool that can hold 1.000×10^5 L of water.

Find the time required to fill the pool using a garden hose delivering water at a rate of 75.00 L/min.

A 22.22 min

B 3 360 min

C 1 333 min

D 58 200 min

E 80 000 min

- Find the time required to fill the pool by diverting into it a moderate-sized river that flows at a rate of 4.500×10^3 m^3/s.

A 0.04500 s

B 45.00 s

C 0.02222 s

D 0.4500 s

E 22.22 s

Q14: Water is moving at a speed of 1.50 m/s through a hose with an internal diameter of 1.800 cm.

- What is the flow rate of the water through the hose?

A 42.4 L/s

B 1.53 L/s

C 3 820 L/s

D 84.8 L/s

E 12.3 L/s

The fluid velocity in this hose's nozzle is 13.0 m/s. What is the nozzle's inside diameter?

A 0.208 cm

B 0.374 cm

C 0.611 cm

D 0.322 cm

E 0.456 cm

Q15: Water emerges vertically downward from a faucet that has a 1.600 cm diameter, moving at a speed of 0.400 m/s. Because of the construction of the faucet, there is no variation in speed across the stream.

What is the flow rate of water from the faucet?

A 3.22 cm^3/s

B 10.1 cm^3/s

C 20.1 cm^3/s

D 65.3 cm^3/s

E 80.4 cm^3/s

What is the diameter of the water stream at a point 0.200 m vertically below the faucet? Neglect any effects due to surface tension.

A 1.21 cm

B 0.512 cm

C 6.59 cm

D 1.02 cm

E 0.712 cm

Q16: A glucose solution being administered with an intravenous drip has a flow rate of

2.00

cm^3/min. What will the new flow rate be if the glucose is replaced by whole blood having the same density but a viscosity 2.30 times that of the glucose? Assume all other factors do not change.

A

0.560

cm^3/min

B

1.15

cm^3/min

C

0.870

cm^3/min

D

2.30

cm^3/min

E

1.95

cm^3/min

Q17: Angioplasty is a technique in which arteries partially blocked with plaque are dilated to increase blood flow. By what factor must the radius of an artery be increased to increase blood flow by a factor of 7.0?

A 2.6

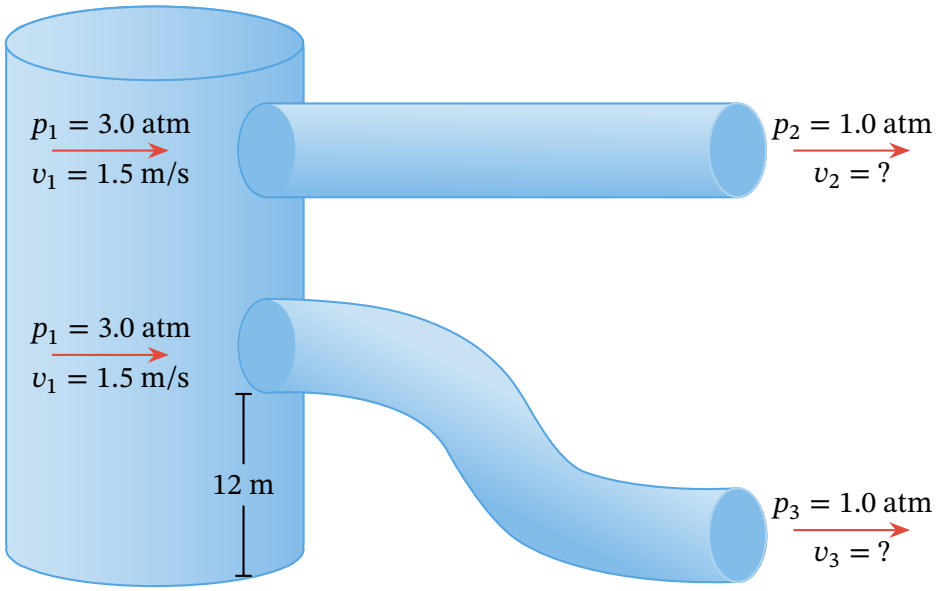
B 7.0

C 49

D 3.5

E 14

Q18: A water pumping station is connected to two pipes of constant diameter, as shown in the diagram. The pipes are of equal diameter. The water enters the pumping station at a pressure of 3.0 atm and a speed of $v_1 = 1.5$ m/s. One pipe drops through a vertical displacement of 12 m. Use a value of 1.00×10^3 kg/m^3 for the density of water through the pumping station and the pipes.



- What is the speed v_2 of water leaving the pipe that does not change height?

A 2.7 m/s

B 23 m/s

C 20 m/s

D 16 m/s

E 25 m/s

- What is the speed v_3 of water leaving the pipe that reduces its height?

A 2.7 m/s

B 23 m/s

C 25 m/s

D 16 m/s

E 20 m/s

Q19: A garden hose with a radius of 2.50 cm is used to fill a bucket, which has a volume of 50 liters, taking 60.0 seconds. An adjustable nozzle is attached to the hose to decrease the diameter of the opening, which increases the speed of the water. The hose is held horizontally, 1.5 meters vertically above level ground, and the nozzle diameter is decreased until water from the hose just reaches a flower bed that is 2.5 meters away, horizontally, from the nozzle.

What is the volume flow rate of the water through the nozzle when the nozzle radius is 2.50 cm?

A 4.1 L/s

B 0.42 L/s

C 0.69 L/s

D 0.83 L/s

E 1.3 L/s

What is the speed at which the water stream exits the hose when the nozzle radius is 2.50 cm?

A 0.024 m/s

B 2.4 m/s

C 4.2 m/s

D 0.42 m/s

E 0.042 m/s

At what speed must the water stream exit the hose for water from the hose to just reach the flower bed?

A 0.95 m/s

B 0.23 m/s

C 1.6 m/s

D 4.5 m/s

E 3.5 m/s

What nozzle diameter is required to produce a water stream that just reaches the flower bed?

A 1.7 cm

B 4.2 cm

C 2.7 cm

D 1.5 cm

E 0.23 cm