

Viscosity, Pressure & Hydraulics

KEY IDEAS

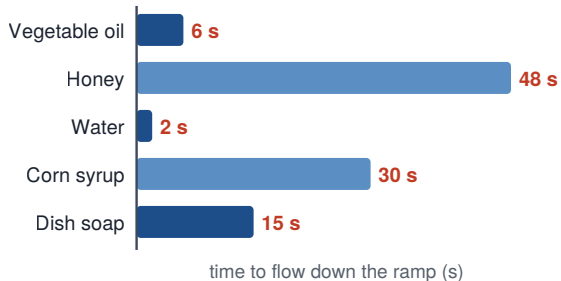
Viscosity: a fluid's resistance to flowing. Warming a liquid usually lowers its viscosity. **Pressure = force ÷ area** ($P = F/A$), measured in pascals: $1 \text{ Pa} = 1 \text{ N/m}^2$.

Pascal's principle: pressure applied to a fluid in a closed system is passed on **equally** in all directions. **Hydraulic** systems use liquids (incompressible); **pneumatic** systems use gases (compressible).

A Viscosity: the flow race

5 marks

Equal amounts of five liquids were poured down the same ramp and timed.



1. Rank the liquids from **most** viscous to **least** viscous. (2 marks)

2. The honey is warmed and the race is repeated. Predict how its time changes and explain.

3. Vegetable oil floats on water, but it's more viscous. Explain how viscosity and density are different.

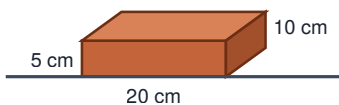
4. Why do cars in a Canadian winter need a motor oil that stays runny when cold?

B Pressure = force ÷ area

6 marks

The same 60 N brick rests three ways. Find the area on the ground ($1 \text{ m}^2 = 10\,000 \text{ cm}^2$) and the pressure. 1 mark each.

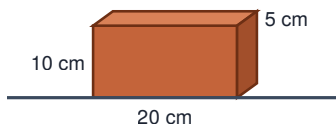
5. Brick P



Area: _____

Pressure: _____

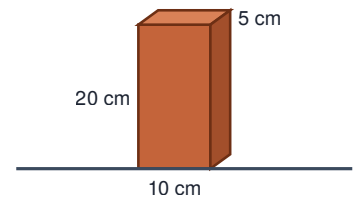
6. Brick Q



Area: _____

Pressure: _____

7. Brick R



Area: _____

Pressure: _____

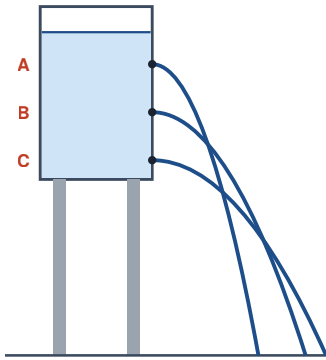
8. Which way gives the greatest pressure on the ground? Why?

9. Why can a person in high heels dent a wooden floor when the same person in flat shoes doesn't?

10. The air in a tire pushes with a pressure of 200 000 Pa on a patch of road 0.02 m^2 . What force does it exert? ($F = P \times A$)

C Pressure in solids, liquids and gases

4 marks



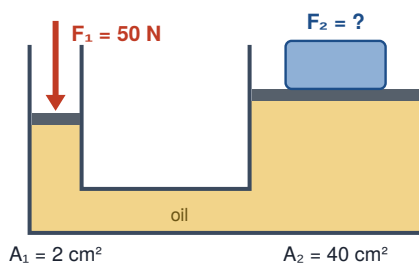
11. A 600 N hiker stands in deep snow. Her two boots touch 0.06 m^2 of snow; her snowshoes touch 0.4 m^2 . Find the pressure in each case and explain why snowshoes stop her sinking. (2 marks)

12. The tank has three holes, A, B and C. Which stream shoots out the farthest? Explain.

13. You can squeeze the air in a sealed syringe, but not the water. What does this tell you about gases and liquids?

D Pascal's principle: the hydraulic lift

8 marks



14. Find the pressure in the fluid, the output force F_2 , and how many times the force is multiplied. (3 marks)

15. A garage lift must hold up a 12 000 N car. The big piston is 600 cm^2 and the small one is 10 cm^2 . What force is needed on the small piston? (2 marks)

16. The small piston is pushed down 40 cm. How far does the big piston rise? What's the trade-off? (2 marks)

17. Why do hydraulic systems use a liquid such as oil instead of air?

E Hydraulic or pneumatic?

5 marks ($\frac{1}{2}$ each for 18–23)

	Device	Hydraulic or pneumatic?
18.	Car brakes	
19.	Bicycle tire pump	
20.	Excavator arm	
21.	Jackhammer	
22.	Dentist's chair	
23.	Nail gun	

24. Explain how pressing a car's brake pedal can stop all four wheels, using Pascal's principle. (2 marks)

F Spot the mistake

2 marks

25. A student says, "A sharp knife cuts better than a dull one because it pushes with more force." Explain the error.

Viscosity, Pressure & Hydraulics

ANSWER KEY

KEY IDEAS

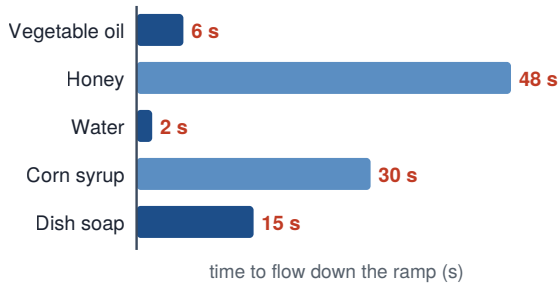
Viscosity: a fluid's resistance to flowing. Warming a liquid usually lowers its viscosity. **Pressure = force ÷ area** ($P = F/A$), measured in pascals: $1 \text{ Pa} = 1 \text{ N/m}^2$.

Pascal's principle: pressure applied to a fluid in a closed system is passed on **equally** in all directions. **Hydraulic** systems use liquids (incompressible); **pneumatic** systems use gases (compressible).

A Viscosity: the flow race

5 marks

Equal amounts of five liquids were poured down the same ramp and timed.



1. Rank the liquids from **most** viscous to **least** viscous. (2 marks)

Honey → Corn syrup → Dish soap → Vegetable oil → Water

2. The honey is warmed and the race is repeated. Predict how its time changes and explain.

Its time goes **down**. Heating makes a liquid less viscous, so it flows faster.

3. Vegetable oil floats on water, but it's more viscous. Explain how viscosity and density are different.

Density = mass per volume; **viscosity** = resistance to flowing. Oil is less dense but thicker.

4. Why do cars in a Canadian winter need a motor oil that stays runny when cold?

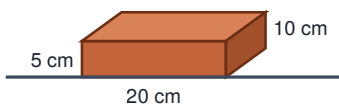
Cold makes oil more viscous. Thick oil flows slowly to the engine parts, so a low-viscosity winter oil protects them.

B Pressure = force ÷ area

6 marks

The same 60 N brick rests three ways. Find the area on the ground ($1 \text{ m}^2 = 10\,000 \text{ cm}^2$) and the pressure. 1 mark each.

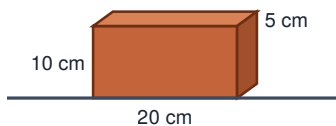
5. Brick P



Area: **$200 \text{ cm}^2 = 0.02 \text{ m}^2$**

Pressure: **$60 \div 0.02 = 3\,000 \text{ Pa}$**

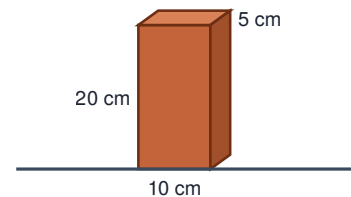
6. Brick Q



Area: **$100 \text{ cm}^2 = 0.01 \text{ m}^2$**

Pressure: **$60 \div 0.01 = 6\,000 \text{ Pa}$**

7. Brick R



Area: **$50 \text{ cm}^2 = 0.005 \text{ m}^2$**

Pressure: **$60 \div 0.005 = 12\,000 \text{ Pa}$**

8. Which way gives the greatest pressure on the ground? Why?

R (standing on its end, 12 000 Pa): smallest area for the same force.

9. Why can a person in high heels dent a wooden floor when the same person in flat shoes doesn't?

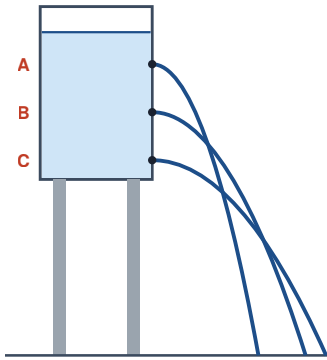
The heel's tiny area makes a much bigger pressure for the same weight.

10. The air in a tire pushes with a pressure of 200 000 Pa on a patch of road 0.02 m^2 . What force does it exert? ($F = P \times A$)

$F = 200\,000 \times 0.02 = 4\,000 \text{ N}$

C Pressure in solids, liquids and gases

4 marks



11. A 600 N hiker stands in deep snow. Her two boots touch 0.06 m^2 of snow; her snowshoes touch 0.4 m^2 . Find the pressure in each case and explain why snowshoes stop her sinking. (2 marks)

Boots: $600 \div 0.06 = 10\,000 \text{ Pa}$. Snowshoes: $600 \div 0.4 = 1\,500 \text{ Pa}$. Bigger area, less pressure.

12. The tank has three holes, A, B and C. Which stream shoots out the farthest? Explain.

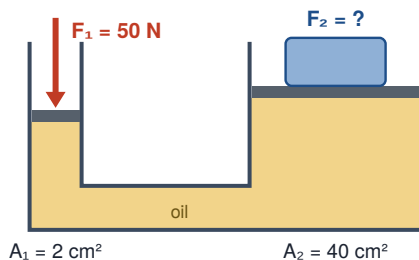
C, the bottom hole: pressure increases with depth, so water is pushed out hardest there.

13. You can squeeze the air in a sealed syringe, but not the water. What does this tell you about gases and liquids?

Gases are **compressible**; liquids are almost **incompressible**.

D Pascal's principle: the hydraulic lift

8 marks



14. Find the pressure in the fluid, the output force F_2 , and how many times the force is multiplied. (3 marks)

$P = 50 \div 2 = 25 \text{ N/cm}^2$. $F_2 = 25 \times 40 = 1\,000 \text{ N}$. The force is multiplied **20 times**.

15. A garage lift must hold up a 12 000 N car. The big piston is 600 cm^2 and the small one is 10 cm^2 . What force is needed on the small piston? (2 marks)

$P = 12\,000 \div 600 = 20 \text{ N/cm}^2$. $F_1 = 20 \times 10 = 200 \text{ N}$

16. The small piston is pushed down 40 cm. How far does the big piston rise? What's the trade-off? (2 marks)

$40 \times 2 = 80 \text{ cm}^3$ moved, so it rises $80 \div 40 = 2 \text{ cm}$. More force, **less distance**.

17. Why do hydraulic systems use a liquid such as oil instead of air?

Liquids are **incompressible**, so the push is passed on fully. Air would just squash.

E Hydraulic or pneumatic?

5 marks (½ each for 18–23)

	Device	Hydraulic or pneumatic?
18.	Car brakes	Hydraulic
19.	Bicycle tire pump	Pneumatic
20.	Excavator arm	Hydraulic
21.	Jackhammer	Pneumatic
22.	Dentist's chair	Hydraulic
23.	Nail gun	Pneumatic

24. Explain how pressing a car's brake pedal can stop all four wheels, using Pascal's principle. (2 marks)

The pedal's piston pressurizes the brake fluid; the pressure passes **equally** to bigger pistons at each wheel, which press the pads.

F Spot the mistake

2 marks

25. A student says, "A sharp knife cuts better than a dull one because it pushes with more force." Explain the error.

Same force, but the sharp edge's tiny **area** gives a much bigger **pressure** ($P = F \div A$).