Exercise walk-through

Fluids and Conservation Laws ▪ 8.4

eXercise

You must be able to

- apply **conservation of mass** with the **continuity equation** 连续性方程 $A_1 v_1 = A_2 v_2$
- apply **conservation of energy** with **Bernoulli's principle** 伯努利原理
- explain why a fluid speeds up through a narrow section and its pressure drops

Method — Continuity (conservation of mass)

$A_1 v_1 = A_2 v_2$: a **narrower** pipe forces the fluid to flow **faster**.

Method — Bernoulli (conservation of energy)

Where a fluid flows **faster**, its **pressure is lower**. This lift-and-spray effect explains aeroplane wings and perfume atomisers.

Method — Example

Flow narrowing from 0.02 m^2 to 0.005 m^2 with $v_1 = 1.0$ m s^{-1}:
$v_2 = \dfrac{0.02 \times 1.0}{0.005} = 4.0$ m s^{-1}.

Practice 2.1 ▪ 2 marks

Water flows through a pipe that narrows from 0.020 m^2 to 0.0050 m^2. If $v = 1.0$ m s^{-1} in the wide part, find the speed in the narrow part.

Solution 2.1

Worked steps

$$v_2 = \frac{A_1 v_1}{A_2} = \frac{0.020 \times 1.0}{0.0050} = 4.0 \text{ m s}^{-1}$$ M1 A1.

Practice 2.2 ▪ 1 mark

State what happens to the fluid pressure where the flow speeds up.

Solution 2.2

Method: Bernoulli (conservation of energy)

Worked steps

it drops (Bernoulli's principle) B1.

Practice 2.3 ▪ 1 mark

State the continuity equation.

Solution 2.3

Worked steps

$A_1 v_1 = A_2 v_2$ B1.

Exam-style 3.1 ▪ 1 mark

As a fluid flows into a narrower pipe, its speed

A decreases

B increases

C stays constant

D drops to zero

Solution 3.1

Method: Continuity (conservation of mass)

A decreases

B increases ✓

C stays constant

D drops to zero

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

Where a fluid flows faster, its pressure is

A higher

B lower

C unchanged

D zero

Solution 3.2

Method: Bernoulli (conservation of energy)

A higher

B lower ✓

C unchanged

D zero

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

Water (incompressible) flows at 2.0 m s^{-1} through a pipe of area 0.010 m^2 that narrows to 0.0040 m^2.

(a) Find the speed in the narrow section.

(b) Explain what happens to the pressure there.

Solution 3.3

Method: Bernoulli (conservation of energy)

Worked steps

(a) $v_2 = \dfrac{0.010 \times 2.0}{0.0040} = 5.0$ m s^{-1} M1 A1. (b) the pressure drops, since the fluid moves faster there (Bernoulli) B1.