

# 6.1 Exploring Accumulations of Change

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ **Total: 10 marks**

**KEY WORDS** accumulated change 累积变化 • accumulation 累积

## Objective

Build the skills to answer exam questions on **accumulation of change** — reading a total change as the area under a rate graph.

**You must be able to:**

- interpret the **area** under a rate-of-change graph as an **accumulated change** 累积变化
- treat area **above** the axis as positive and area **below** as negative
- attach correct **units** (rate unit  $\times$  time unit) to an accumulation

## 1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

### ■ Area under a rate graph is a total

If water flows in at a **rate**  $R(t)$  litres per minute, the total water added between  $t = 0$  and  $t = 5$  is the **area** under the  $R$ -vs- $t$  graph over  $[0, 5]$ . A rate graph that is a rectangle of height 3 L/min over 5 min accumulates  $3 \times 5 = 15$  L.

### ■ Splitting into simple shapes

If the rate graph is made of straight lines, find the area with triangles and rectangles. A rate rising linearly from 0 to 4 L/min over 6 min is a triangle: area  $= \frac{1}{2}(6)(4) = 12$  L.

### ■ Signed area

When a rate goes **negative** (water leaving), that area counts as a **loss**. Over a stretch where the graph is +8 area then  $-3$  area, the net accumulated change is  $8 - 3 = +5$ .

### ■ Units

The accumulation's unit is (rate unit)  $\times$  (time unit). A rate in L/min over minutes accumulates **litres**; a velocity in m/s over seconds accumulates **metres**.

## 2 Practice

Now apply the methods above.

**2.1** A tap runs at a constant 2.5 L/min for 8 minutes. How much water flows out? [1]

**2.2** A rate graph is a triangle: the rate rises linearly from 0 to 10 units/s over 4 s. Find the accumulated change. [2]

**2.3** Over one interval a quantity gains an area of 12 and over the next it loses an area of 5. State the net accumulated change. [1]

## 3 Exam-style questions

**3.1** The area under a velocity-vs-time graph represents [1]

- **A** acceleration
- **B** displacement
- **C** speed
- **D** force

**3.2** A machine consumes power at a rate  $P(t)$  kilowatts, shown as a graph made of straight segments: a rectangle of height 2 over  $0 \leq t \leq 3$  hours, then a triangle rising from 0 to 4 over  $3 \leq t \leq 5$  hours.

(a) Find the energy used over  $0 \leq t \leq 3$ . [1]

(b) Find the energy used over  $3 \leq t \leq 5$ . [2]

(c) State the total energy used, with units. [1]

**3.3** Sand is added to a pile at a rate that gives an accumulated area of 30 (kg) over the first hour, then removed at a rate giving an area of 8 (kg) over the next hour. State the net change in the pile's mass. [1]

---

## Solutions

---

**2.1**  $2.5 \times 8 = 20$  L.

**2.2** Triangle area  $= \frac{1}{2}(4)(10) = 20$  units.

**2.3**  $12 - 5 = 7$ .

**3.1 B** — the area under a velocity–time graph is displacement.

**3.2** (a)  $2 \times 3 = 6$  kWh. (b) triangle  $\frac{1}{2}(2)(4) = 4$  kWh. (c)  $6 + 4 = 10$  kWh.

**3.3**  $30 - 8 = 22$  kg.