LESSON 3.3.2

Using Graph Areas

and Gradients Physically

A graph can give more than a trend. Its slope and the area between the line and the horizontal axis can represent different physical quantities.

GRADIENT: A RATE OF CHANGE

$$\frac{\text{change in vertical quantity}}{\text{change in horizontal quantity}}$$

AREA: AN ACCUMULATED QUANTITY

Units multiply: vertical × horizontal

READ THE AXES BEFORE CHOOSING THE PHYSICS

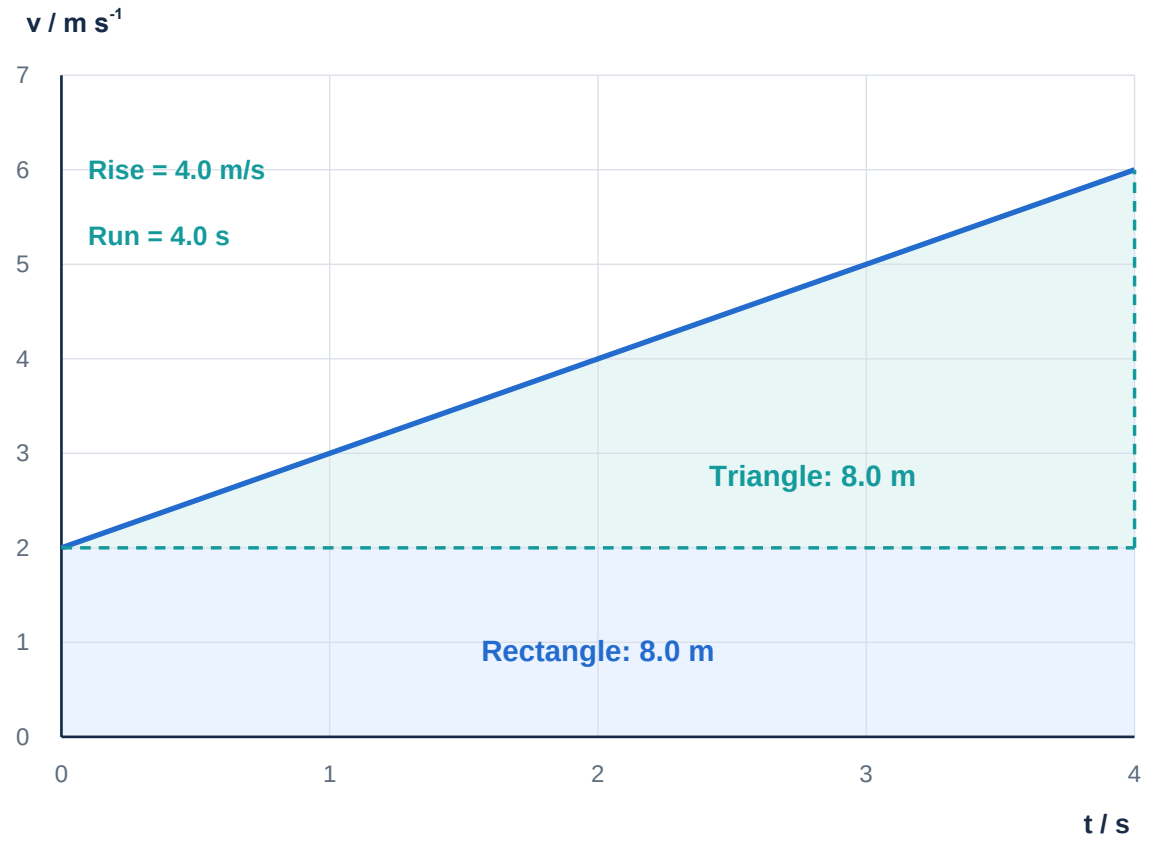
Vertical against horizontal	Operation	Physical meaning / unit
Displacement against time	Gradient	Velocity / m s^{-1}
Velocity against time	Gradient	Acceleration / m s^{-2}
Velocity against time	Signed area	Displacement / m
Force against displacement	Area	Work done / J
Force against time	Signed area	Impulse / N s
Current against time	Signed area	Charge transferred / C

For work, use the force component along the displacement. For signed areas, values below the horizontal axis subtract from the total.

Gradient units divide. Area units multiply. The axes decide the meaning.

1 One graph, two physical results

An object speeds up uniformly from 2.0 m/s to 6.0 m/s in 4.0 s. All velocities are positive.



GRADIENT GIVES ACCELERATION

$$a = \frac{\Delta v}{\Delta t} = \frac{6.0 - 2.0}{4.0 - 0} = 1.0 \text{ m s}^{-2}$$

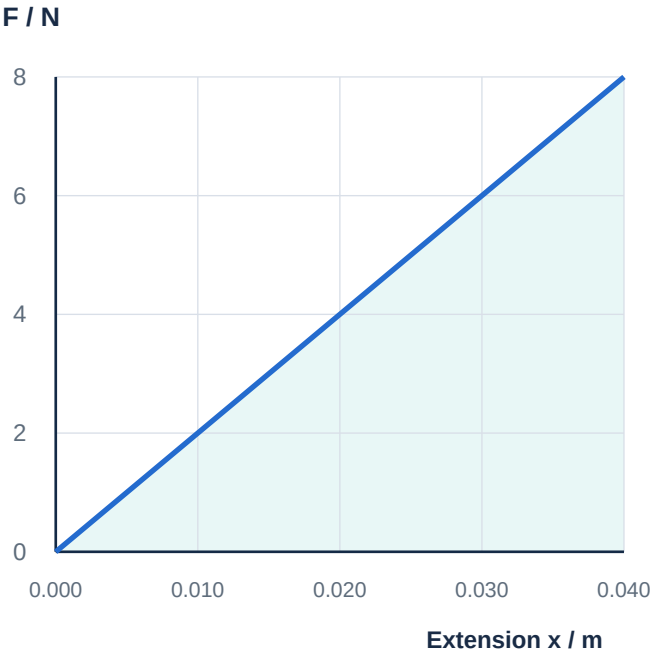
AREA GIVES DISPLACEMENT

$$s = (4.0 \times 2.0) + \frac{1}{2} \times 4.0 \times 4.0 = 16 \text{ m}$$

Here distance is also 16 m because the direction never reverses.

2 Area can measure transferred energy

A spring is stretched slowly from zero extension to 0.040 m. Its force rises linearly to 8.0 N.



WORK = TRIANGULAR AREA

$$W = \frac{1}{2} \times 8.0 \times 0.040$$

$$= 0.16 \text{ J}$$

Within the elastic range, the work done stretching the spring is stored as elastic strain energy.

CURVES: USE A TANGENT

Draw a tangent at the required point and find its gradient using a large triangle. This gives an instantaneous rate. A chord between two points gives an average rate over that interval.

AREAS: KEEP TRACK OF SIGNS

For velocity-time graphs, signed area gives displacement. Add the magnitudes of areas above and below zero for total distance. For curved graphs, estimate area with narrow trapezia.

QUICK SIGN CHECK

Velocity-time areas: +6 m and -2 m

Displacement = 4 m Total distance = 8 m

Sources: Pearson IAL Physics specification, Units 1-3; Student Practical Guide.

Lesson numbering follows the Jimlaoshi course sequence. Examples are illustrative.