

IB PHYSICS

A.1 Kinematics - Uniform Motion | HL Exam-Level Practice

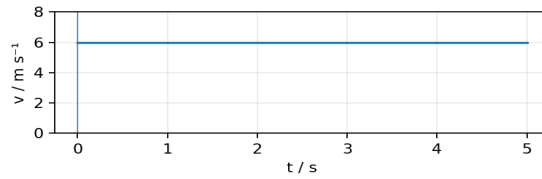
Name: _____

Date: _____

Instructions: Show relevant working. Use gradients and areas where appropriate. The final questions are multi-step but remain within typical IB Physics HL examination level.

1. Velocity-time graph

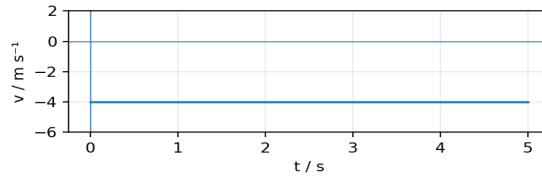
An object is initially at $s = -4.0$ m and moves as shown.



- (a) Determine the displacement after 5.0 s. [2]
- (b) Determine the final position. [2]
- (c) Sketch the corresponding position-time graph. [2]

2. Negative velocity

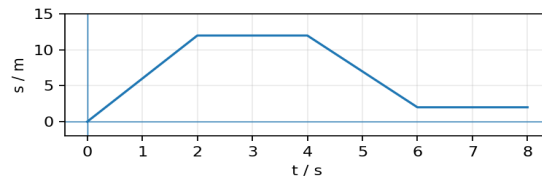
An object is initially at $s = 14$ m and has the velocity shown.



- (a) Determine the time at which it passes the origin. [2]
- (b) Determine its position at $t = 5.0$ s. [2]
- (c) Sketch the corresponding position-time graph. [2]

3. Interpreting a motion graph

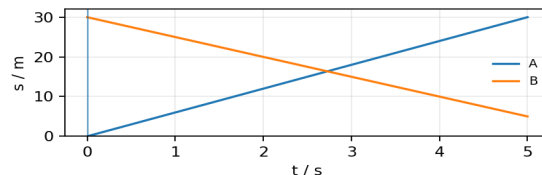
The graph shows the position of an object during 8.0 s.



- (a) Determine the velocity from 0 to 2.0 s. [2]
- (b) Describe the motion from 2.0 s to 4.0 s. [1]
- (c) Determine the velocity from 4.0 s to 6.0 s. [2]
- (d) Determine the total distance travelled. [2]
- (e) Determine the average velocity over 8.0 s. [2]

4. Two objects on one graph

Objects A and B move with constant velocities as shown.



- (a) Determine the velocity of A and of B. [4]
- (b) Determine the time and position at which they meet. [2]
- (c) Determine their relative velocity before they meet. [1]

5. Average speed

A car must cover 210 km in 3.0 h. During the first 1.25 h its average speed is 64 km h^{-1} .

- (a) Determine the remaining distance after 1.25 h. [2]
- (b) Calculate the average speed required for the remainder of the journey. [2]

6. Cyclists meeting

Cyclist A is at $s = 0$ km and moves at $+18 \text{ km h}^{-1}$. Cyclist B is at $s = 96$ km and moves at -24 km h^{-1} . They start simultaneously.

- (a) Write an expression for the position of each cyclist. [2]
- (b) Determine the time at which they meet. [2]
- (c) Determine their meeting position. [2]
- (d) Sketch both position-time graphs on the same axes. [2]

7. Delayed start

Runner A passes O at 5.0 m s^{-1} . Runner B passes O 15 s later in the same direction at 8.0 m s^{-1} .

- (a) Determine A's lead when B passes O. [1]
- (b) Determine how long after B starts it catches A. [2]
- (c) Determine the distance from O at which they meet. [2]
- (d) Sketch both motions on a position-time graph. [2]

8. Distance, displacement and averages

A particle moves from $s = -10$ m to $s = 26$ m and then returns to $s = 6$ m. The total time is 14 s.

- (a) Determine the displacement. [1]
- (b) Determine the total distance travelled. [2]
- (c) Determine the average velocity. [2]
- (d) Determine the average speed. [2]

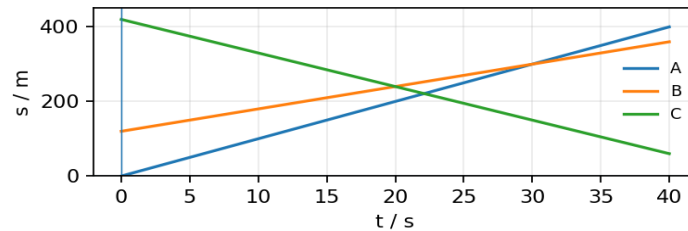
9. Reversal of direction

An object moves at $+9.0 \text{ m s}^{-1}$ for 6.0 s and then at -4.5 m s^{-1} for 8.0 s.

- (a) Sketch the velocity-time graph. [2]
- (b) Determine the total displacement. [2]
- (c) Determine the total distance travelled. [2]
- (d) Determine the average velocity and average speed. [3]

10. Three moving objects - HL exam level

The graph shows three objects moving with constant velocities.



- (a) Determine the velocity of each object. [3]
- (b) Determine the time and position of each pairwise encounter that occurs within the interval shown. [5]
- (c) State the chronological order of the encounters. [1]
- (d) Explain how the graph shows that two objects may have the same position but different velocities. [2]

11. Two trains - HL exam level

Two trains move towards each other. Their fronts are initially 1.50 km apart. Train A moves at 24 m s^{-1} and is 160 m long. Train B moves at 18 m s^{-1} and is 200 m long.

- (a) Determine the time at which the fronts meet. [2]
- (b) Determine the meeting position measured from A's initial front position. [2]
- (c) Determine the additional time until the trains have completely passed each other. [3]
- (d) Determine the total time from $t = 0$ until they have completely passed. [1]

12. Moving observer - HL exam level

A train moves east at 28 m s^{-1} . A passenger walks towards the front at 1.4 m s^{-1} relative to the train. A cyclist beside the track moves east at 7.0 m s^{-1} .

- (a) Determine the passenger's velocity relative to the ground. [2]
- (b) Determine the passenger's velocity relative to the cyclist. [2]
- (c) The passenger is initially 112 m behind the cyclist. Determine when the passenger is alongside the cyclist. [2]
- (d) State how (b) changes if the passenger walks towards the rear at the same walking speed. [2]

13. Delayed three-object encounter - HL exam level

At $t = 0$, runner A passes O at 6.0 m s^{-1} . Runner B is 120 m ahead and moves in the same direction at 4.0 m s^{-1} . At $t = 20$ s, cyclist C passes O at 12 m s^{-1} .

- (a) Determine when A catches B. [2]
- (b) Determine when C catches A. [3]
- (c) Determine when C catches B. [3]
- (d) State the chronological order of these encounters. [1]
- (e) Sketch the three position-time graphs on the same axes. [3]

14. Ferry crossing reference positions - HL exam level

Two boats move along the same straight river channel. At $t = 0$, boat A is at $s = -240 \text{ m}$ and moves at $+12 \text{ m s}^{-1}$. Boat B is at $s = 360 \text{ m}$ and moves at -8.0 m s^{-1} .

- (a) Determine the time at which the boats pass each other. [2]
- (b) Determine their common position. [2]
- (c) Determine the displacement of each boat up to this instant. [2]

15. Two-stage journey - HL exam level

A particle moves at $+7.0 \text{ m s}^{-1}$ for 12 s and then immediately moves at -5.0 m s^{-1} . Its initial position is $s = -20 \text{ m}$.

- (a) Determine its position after the first 12 s. [2]
- (b) Determine the additional time required to return to $s = 0$. [2]
- (c) Determine the total distance travelled when it reaches $s = 0$. [2]
- (d) Sketch the complete position-time graph. [2]

16. Relative motion - HL exam level

Car A moves east at 22 m s^{-1} . Car B is 360 m ahead and moves east at 14 m s^{-1} .

- (a) Determine the velocity of A relative to B. [1]
- (b) Determine the time taken for A to catch B. [2]
- (c) Determine the encounter position measured from A's initial position. [2]

17. Train and tunnel - HL exam level

A 180 m long train travels at 25 m s^{-1} towards a tunnel of length 620 m. At $t = 0$ the front enters the tunnel.

- (a) Determine the time for the front of the train to leave the tunnel. [2]
- (b) Determine the time from $t = 0$ until the entire train has left the tunnel. [2]
- (c) Explain why the distance used in (b) is greater than the tunnel length. [1]

18. Delayed departure - HL exam level

At 09:00 bus A leaves a station at 54 km h^{-1} . Bus B leaves the same station at 09:20 and follows the same route at 72 km h^{-1} .

- (a) Determine the distance travelled by A before B leaves. [2]
- (b) Determine the time after 09:20 at which B catches A. [2]
- (c) Determine the distance from the station where the buses meet. [2]