MOMENTUM

IB Physics HL

Kinematics - Set 1

A.1 | First assessment 2025 | Higher Level

Independent examination-style practice material

10 original problems

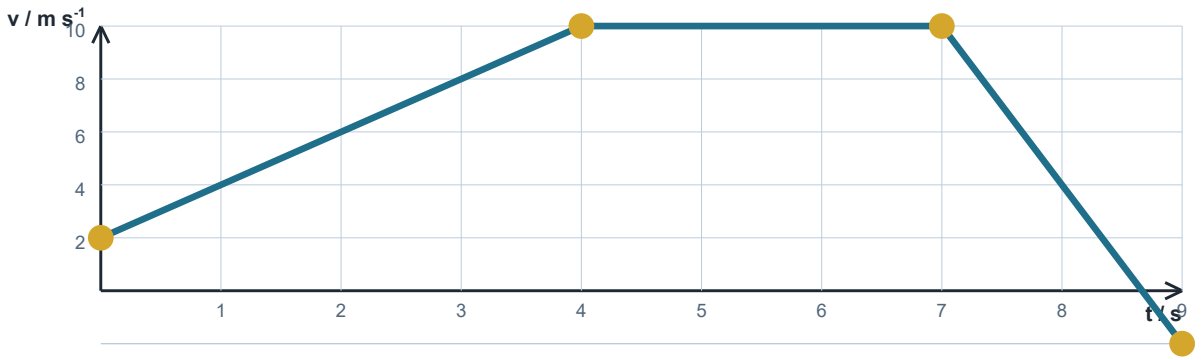
TASK 01

[1]

Reading a velocity-time record

Paper 1A style | IB code A.1

The graph shows the velocity v of a particle during a 9.0 s interval.



Velocity-time record

What is the average speed of the particle during the interval?

A. 6.00 m s^{-1} B. 6.89 m s^{-1} C. 6.96 m s^{-1} D. 7.11 m s^{-1}

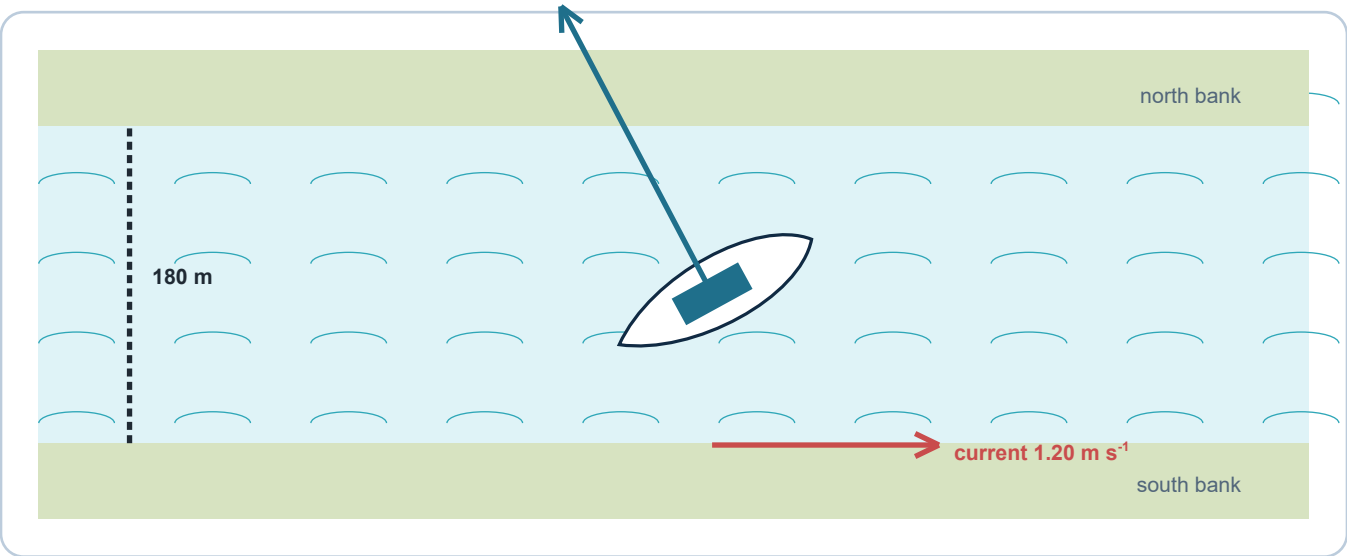
TASK 02

[1]

Crossing a river without drift

Paper 1A style | IB code A.1

A rescue boat moves at 2.50 m s^{-1} relative to the water. The river is 180 m wide and the current is 1.20 m s^{-1} towards the east. The boat must arrive at the point directly opposite its starting point.



Which pair gives the required heading, measured west of the straight-across direction, and the crossing time?

A. 25.6 degrees; 72.0 s B. 28.7 degrees; 82.1 s C. 28.7 degrees; 72.0 s D. 61.3 degrees; 82.1 s

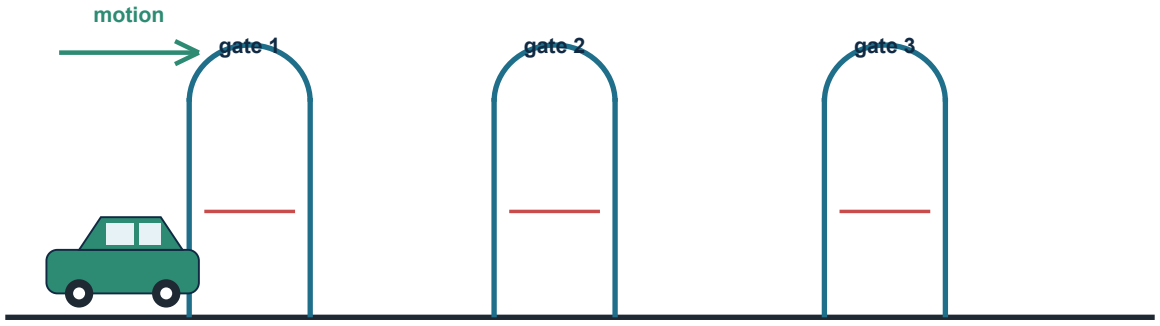
TASK 03

[8]

Acceleration from optical-gate data

Paper 1B style | IB code A.1

A cart is released from rest on a slightly inclined low-friction track. Its position x is measured from the release point. Each position has an uncertainty of ± 0.006 m; timing uncertainty is negligible.



Low-friction track with optical timing gates

t / s	0.30	0.50	0.70	0.90	1.10
x / m	0.077	0.202	0.396	0.650	0.974

(a) Explain why a graph of x against t^2 should be linear if the acceleration is constant. [2]

(b) Using the data, determine the acceleration of the cart. [4]

(c) State whether the data provide evidence of a significant position-zero offset. Justify your answer. [2]

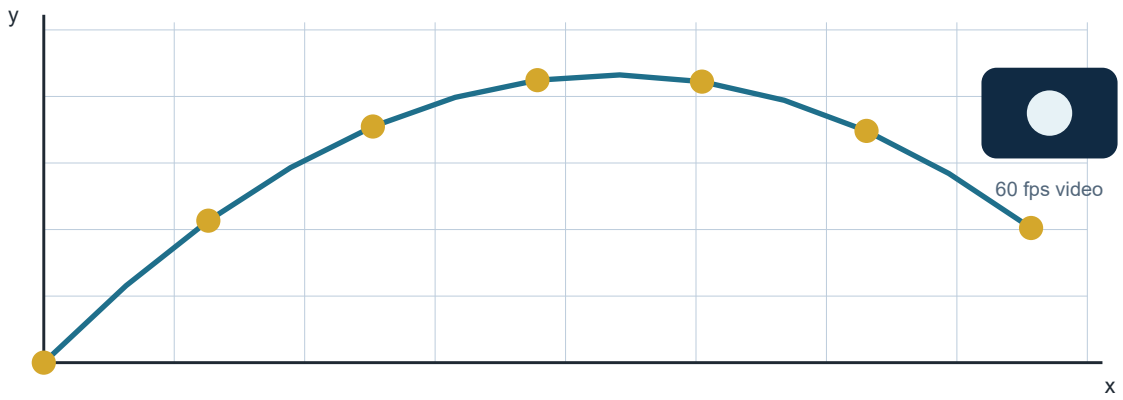
TASK 04

[9]

Testing a projectile model with video data

Paper 1B style | IB code A.1

A ball is launched in a laboratory. Video analysis gives the coordinates below, measured from the launch point. The x-axis is horizontal and the y-axis is vertically upwards. Each coordinate is uncertain by ± 0.010 m.



t / s	0.00	0.10	0.20	0.30	0.40	0.50	0.60
x / m	0.000	0.321	0.639	0.961	1.279	1.601	1.919
y / m	0.000	0.292	0.482	0.581	0.575	0.474	0.278

(a) Determine the horizontal component of the launch velocity. [2]

(b) Use successive y-values to estimate the magnitude of the vertical acceleration. [3]

(c) Determine the time and height of the highest point predicted by the fitted model. [2]

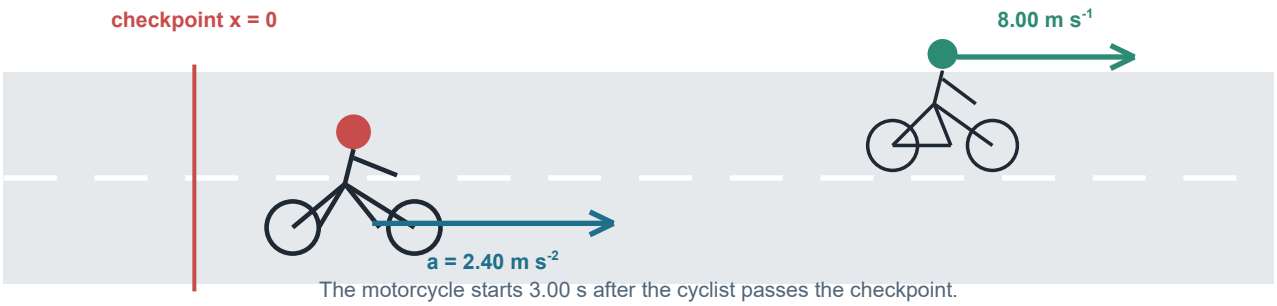
(d) Comment on whether the data show measurable air resistance. [2]

TASK 05
[7]

A delayed pursuit

Paper 2 style | IB code A.1

A cyclist passes a checkpoint at a constant speed of 8.00 m s^{-1}. Three seconds later, a stationary police motorcycle starts from the checkpoint. It accelerates uniformly at 2.40 m s^{-2} until reaching 18.0 m s^{-1} and then continues at that speed.



The motorcycle starts 3.00 s after the cyclist passes the checkpoint.

(a) Show that the motorcycle does not catch the cyclist while it is accelerating. [3]

(b) Determine the time after the cyclist passes the checkpoint at which the motorcycle catches the cyclist. [3]

(c) Determine the distance from the checkpoint at the catch. [1]

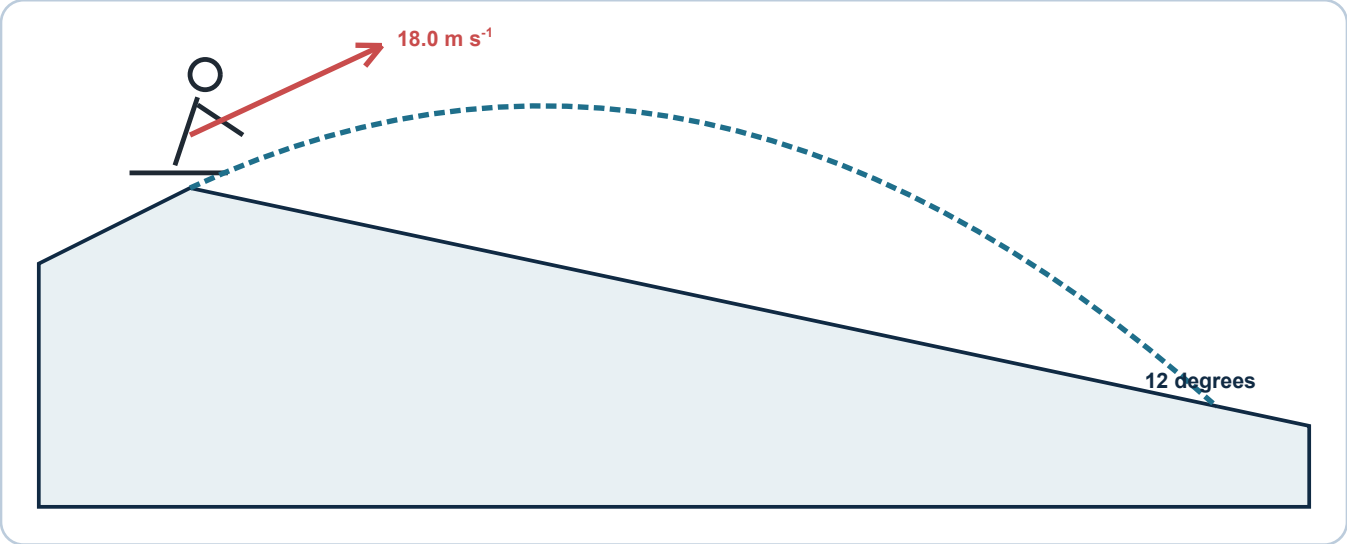
TASK 06

[8]

Projectile motion above a descending slope

Paper 2 style | IB code A.1

A skier leaves a ramp at 18.0 m s^{-1}, directed 25.0 degrees above the horizontal. The landing slope passes through the take-off point and descends at 12.0 degrees below the horizontal. Air resistance is negligible.



(a) Derive an expression for the non-zero time at which the skier intersects the slope. [3]

(b) Calculate the distance measured along the slope from take-off to landing. [2]

(c) Determine the skier's speed immediately before landing and the angle of the velocity below the slope. [3]

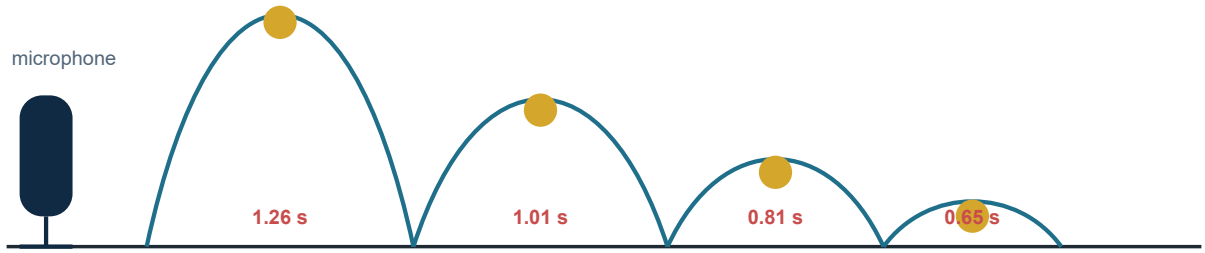
TASK 07

[8]

A bouncing ball recorded by a microphone

Paper 2 style | IB code A.1

A ball is dropped from rest. A microphone records the intervals between the first five impacts with a rigid horizontal floor as 1.26 s, 1.01 s, 0.81 s and 0.65 s. Assume the coefficient of restitution e is constant and air resistance is negligible.



(a) Explain why the ratio of successive time intervals is equal to e. [2]

(b) Determine e. [2]

(c) Estimate the original release height. [3]

(d) Predict the next impact interval. [1]

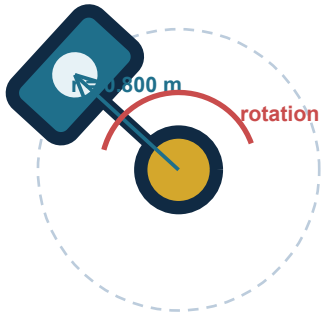
TASK 08

[7]

Kinematics of a rotating camera arm

Paper 2 style | IB code A.1

A camera is fixed to the end of a rigid arm of radius 0.800 m. Its angular position is $\theta = 0.400t^3 - 1.20t^2 + 2.00t$, where θ is in radians and t is in seconds.



(a) Determine the angular position, angular velocity and angular acceleration at $t = 2.00$ s. [3]

(b) Determine the tangential and radial components of the camera's acceleration at this instant. [2]

(c) Determine the magnitude and direction of the total acceleration relative to the inward radial direction. [2]

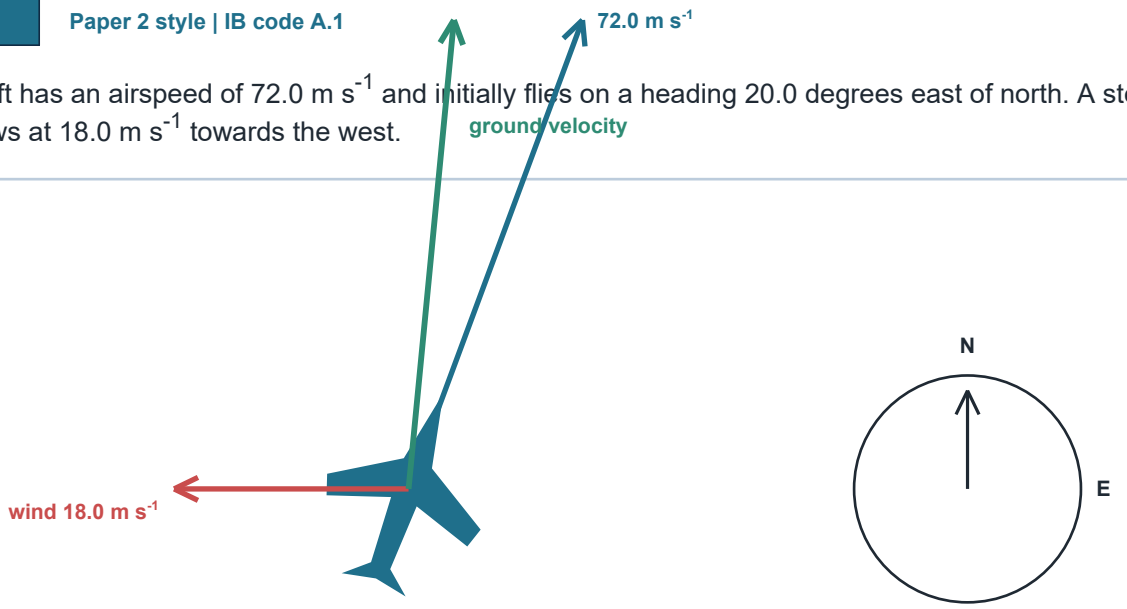
TASK 09

[8]

Aircraft navigation in a crosswind

Paper 2 style | IB code A.1

An aircraft has an airspeed of 72.0 m s^{-1} and initially flies on a heading 20.0 degrees east of north. A steady wind blows at 18.0 m s^{-1} towards the west.



Vectors are drawn schematically, not to scale.

(a) Determine the magnitude and direction of the aircraft's ground velocity. [3]

(b) Determine its displacement after 18.0 min. [2]

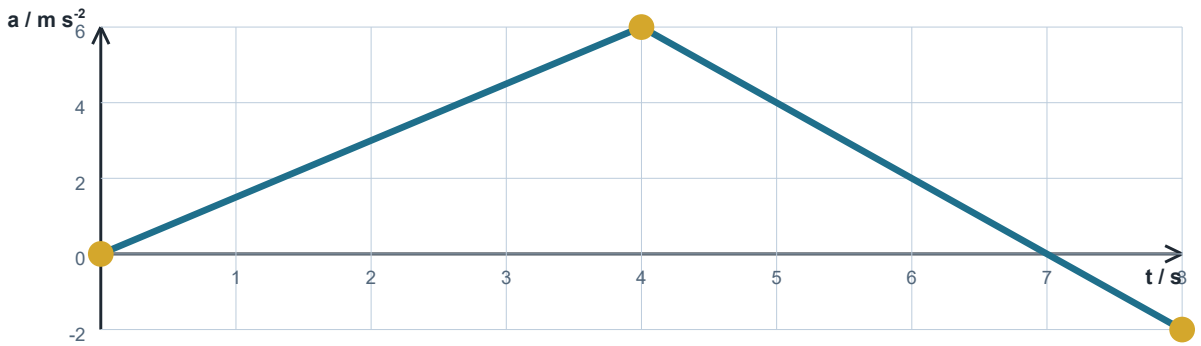
(c) The pilot now wishes to fly on a ground track due north. Determine the required heading and the time to travel 100 km north. [3]

TASK 10
[9]

Displacement and distance from an acceleration graph

Paper 2 style | IB code A.1

A particle moves along a straight line. At t = 0 its velocity is -5.00 m s^{-1} and its position is x = 0. The acceleration varies with time as shown.



(a) Determine the first time at which the particle is instantaneously at rest. [2]

(b) Determine the maximum velocity during the 8.00 s interval. [3]

(c) Determine the displacement during the interval. [2]

(d) Determine the total distance travelled during the interval. [2]