



TOPIC TEST • IB PHYSICS

Mechanics

Higher level

45 minutes

Instructions

- 5 questions, 30 marks, on A.1 to A.3 (HL: also A.4). Answer in the spaces provided.
- Total: 30 marks. Answer all questions.
- You need a clean copy of the IB physics data booklet and a calculator.
- Show your working: most marks go to the method, not to the final number.
- Sit it in one go, timed. Then mark it with the mark scheme, honestly.

Name

Date

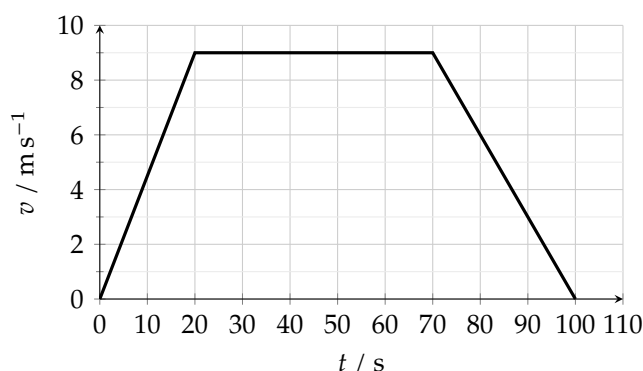
Score

Every question in this test is new, written by Pietro Meloni in the style of the current papers, to check one topic of the syllabus under timed conditions. It is not IB material and not endorsed by the IB.



Mark scheme and the other tests: scan the code

1. A funicular railway car travels along a straight track between two stations. The graph shows how the velocity v of the car varies with time t for one journey.



(a) Calculate the acceleration of the car during the first 20 s. [2]

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(b) Determine the distance between the two stations. [2]

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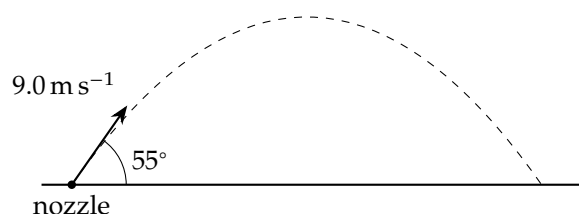
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(c) Describe the motion of the car between $t = 20$ s and $t = 100$ s. [2]

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2. A fountain in a city square has a nozzle at ground level. Water leaves the nozzle with a speed of 9.0 m s^{-1} at an angle of 55° above the horizontal. Treat each drop of water as a projectile and ignore air resistance in (a), (b) and (c).



(a) Show that the vertical component of the initial velocity of the water is about 7 m s^{-1} . [1]

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- (b) Calculate the maximum height reached by the water above the nozzle. [2]

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- (c) Calculate the horizontal distance from the nozzle to the point where the water lands on the ground. [2]

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- (d) In practice, air resistance acts on the drops. Explain why the water lands closer to the nozzle than the distance calculated in (c). [2]

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3. In a game of curling, a player releases a stone A of mass 19 kg with a speed of 2.0 m s^{-1} on horizontal ice. Stone A slides 10 m in a straight line and then hits a stationary stone B of the same mass head-on. The coefficient of dynamic friction between a stone and the ice is 0.015. Ignore air resistance.

- (a) Show that the deceleration of stone A as it slides is about 0.15 m s^{-2} . [2]

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- (b) Calculate the speed of stone A just before it hits stone B. [2]

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- (c) Immediately after the collision, stone A continues to move in the same direction with a speed of 0.12 m s^{-1} . Calculate the speed of stone B immediately after the collision. [1]

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- (d) Determine whether the collision is elastic. [2]

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4. A flywheel energy store contains a uniform solid disc of mass 24 kg and radius 0.50 m that rotates about a fixed axis through its centre. The moment of inertia of a uniform disc about this axis is $I = \frac{1}{2}MR^2$.

(a) Calculate the moment of inertia of the disc. [1]

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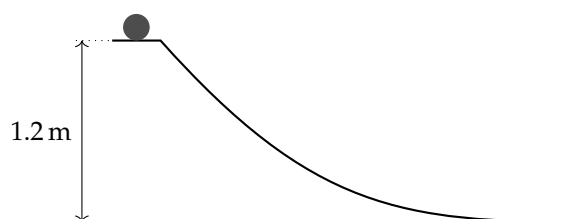
(b) Starting from rest, a motor applies a constant torque of 18 N m to the disc. Frictional torques are negligible compared with this torque. Calculate the time taken for the disc to reach an angular velocity of 240 rad s⁻¹. [2]

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(c) The motor is then disconnected. Because of friction in the bearings, the angular velocity of the disc falls from 240 rad s⁻¹ to 200 rad s⁻¹ in 15 minutes. Determine the average frictional torque on the disc. [2]

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5. In a science museum, a solid steel ball is released from rest at the top of a curved track. It rolls without slipping to the bottom of the track, 1.2 m vertically below the starting point. The moment of inertia of a solid sphere of mass M and radius R about an axis through its centre is $\frac{2}{5}MR^2$. Assume that no energy is dissipated as the ball rolls (the friction that prevents slipping does no work) and that air resistance is negligible.



(a) Show that the speed of the ball at the bottom of the track is about 4 m s⁻¹. [2]

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- (b) Calculate the fraction of the total kinetic energy of the ball at the bottom that is rotational. [1]

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- (c) The ball is replaced by a thin-walled hollow cylinder of the same mass and radius, which also rolls without slipping. Explain whether the cylinder reaches the bottom of the track with a greater or a smaller speed than the ball. [2]

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