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QUESTION WORKBOOK

Drag and terminal speed

Mechanics · Year 12

AQA 3.4.1.4 · CIE 3.2.1, 3.2.2, 3.2.3 · OCR A 3.2.2(a), 3.2.2(b), 3.2.2(c), 3.2.2(d)(i)

18 questions · 56 marks

PRINT EDITION

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SECTION A · Warm-up

A1 A cyclist travels along a straight, level road. Name two resistive forces that act on the moving cyclist and state the direction in which each acts. [3]

A2 Define terminal speed. [2]

A3 State how the drag force on an object depends on its speed, for motion through a fluid. [2]

A4 State what is meant by lift. [1]

A5 A car travels at its maximum speed along a straight, level road. State the relationship between the driving force and the total resistive force, and state the car's acceleration. [2]

A6 State one similarity and one difference between the friction between two solid surfaces and the drag on an object moving through air. [2]

SECTION B · Standard

B1 A skydiver of weight 750 N falls at terminal speed. State the size and direction of the drag force on them, and explain your reasoning. [3]

B2 A small sphere falls at terminal speed through a liquid. Its weight is 0.30 N and the upthrust on it is 0.05 N. Calculate the drag force on the sphere, and explain why it is not accelerating. [4]

B3 Describe the shape of the velocity–time graph for an object dropped from rest that reaches terminal speed, and explain the changing gradient. [3]

B4 A raindrop of mass 65 mg falls vertically. At one instant the drag force on it is 4.2×10^{-4} N. Taking $g = 9.81$ m s^{-2}, calculate the acceleration of the raindrop at this instant. [3]

B5 A skydiver can fall either spread out or head-first. Explain why the terminal speed is lower when the skydiver is spread out. [3]

B6 The engine of a car can deliver a maximum useful output power of 90 kW. At the car's top speed on a level road the total resistive force on it is 2.0 kN. (a) Calculate the top speed. (b) Explain why the car cannot travel faster than this speed. [4]

SECTION C · Stretch

C1 A parachutist is falling at terminal speed when the parachute opens. Explain, in terms of the forces, why the speed decreases and how a new, lower terminal speed is reached. [4]

C2 Assuming the drag force is proportional to the square of the speed, an object experiences a drag of 20 N at 5.0 m s^{-1}. Calculate the drag force at 10 m s^{-1}. [3]

C3 Explain why a heavier skydiver of the same shape and size reaches a higher terminal speed than a lighter one. [3]

C4 A trainee parachutist of total weight 850 N must land at no more than 5.5 m s^{-1}. With a particular canopy open, the drag force at speed v is given by $D = kv^2$, where $k = 24$ kg m^{-1}. Deduce whether this canopy is suitable. [4]

C5 A skydiver of mass 92 kg falls head-first with a terminal speed of 58 m s^{-1}. Assume the drag force is proportional to the square of the speed. Taking $g = 9.81$ m s^{-2}, determine the drag force and the acceleration of the skydiver at a speed of 29 m s^{-1}. [4]

C6 A cyclist starts from rest on a straight, level road and pedals so that the driving force stays constant. After some time she reaches her maximum speed, and she then stops pedalling. Air resistance increases with speed. Describe and explain, in terms of the forces acting, how her velocity changes throughout. [6]