



ANSWER BOOK

The Michelson–Morley experiment

Turning points · Year 13

AQA 3.12.3.1, 3.12.3.2

10 questions · 28 marks

NAVY EDITION

SECTION A · Warm-up

- A1** A half-silvered mirror splits one light beam along two equal arms at right angles to mirrors that return them; the recombined beams interfere, and the fringe pattern registers any difference in the two round-trip times. [2]
- A2** One: physical laws have the same form in all inertial frames. Two: the speed of light in free space is invariant, the same for every inertial observer. [2]
- A3** A frame of reference moving at constant velocity, without acceleration or rotation, in which Newton's first law holds: objects with no resultant force stay at rest or move uniformly. [2]

SECTION B · Standard

- B1** Across: cross-stream speed $\sqrt{(4.0^2 - 2.4^2)} = 3.2 \text{ m s}^{-1}$, so $t = 96/3.2 = 30 \text{ s}$. Along: $48/1.6 = 30 \text{ s}$. A medium's motion separates the two round trips, which is exactly what the interferometer's two arms were built to detect for light in the ether. [4]
- B2** $v/c = 10^{-4}$, so $\Delta t \approx (11/3.0 \times 10^8) \times 10^{-8} = 3.7 \times 10^{-16} \text{ s}$, a path difference of $c\Delta t = 1.1 \times 10^{-7} \text{ m}$, about a fifth of a wavelength of visible light, well within the instrument's sensitivity. [3]
- B3** Rotation swaps which arm lies along the supposed ether wind, reversing the predicted time difference between the arms. The fringes should therefore shift visibly as the apparatus turns, without needing the two arms to be perfectly equal in length. [3]
- B4** Six months apart, the Earth moves in opposite directions around the Sun, so its velocity through any ether must differ by twice the orbital speed. A null result at every season rules out the lucky case of the laboratory happening to be momentarily at rest in the ether. [3]

SECTION C · Stretch

- C1** Absolute motion cannot be detected: no measurement revealed the Earth's motion through any ether, so there is no privileged frame at rest. And the speed of light is invariant: the two beams' round trips tied exactly whatever the apparatus's motion or orientation, so the measured speed of light does not depend on the motion of source or observer. [4]

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- C2** It arrives at exactly c , not $1.40c$. The invariance of c means the speed of light is independent of the source's motion; the everyday addition of velocities is only a low-speed approximation and cannot be applied to light. [3]
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- C3** It was sensitive enough to see the predicted effect and cleanly saw nothing, so the absence is itself a measurement: it retired the ether, established the invariance of c , and supplied the experimental foundation on which special relativity was built. [2]
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